APPENDIX B

Quadrat Photographs

M-VMU-2-T01A	
	
Q1	Q2
	
Q3	Q4

M-VMU-2-T01P	
	
Q1	Q2
	
Q3	Q4

M-VMU-2-T03P

	
Q1	Q2
	
Q3	Q4

M-VMU-2-T04P

Q1

Q2

Q3

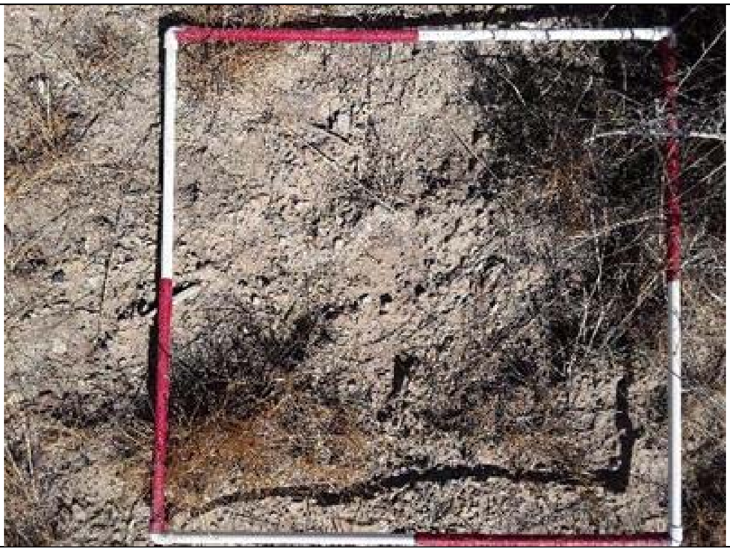
Q4

M-VMU-2-T05P	
	
Q1	Q2
	No photo
Q3	Q4

M-VMU-2-T06P

Q1

Q2



Q3

Q4

M-VMU-2-T07P

Q1

Q2

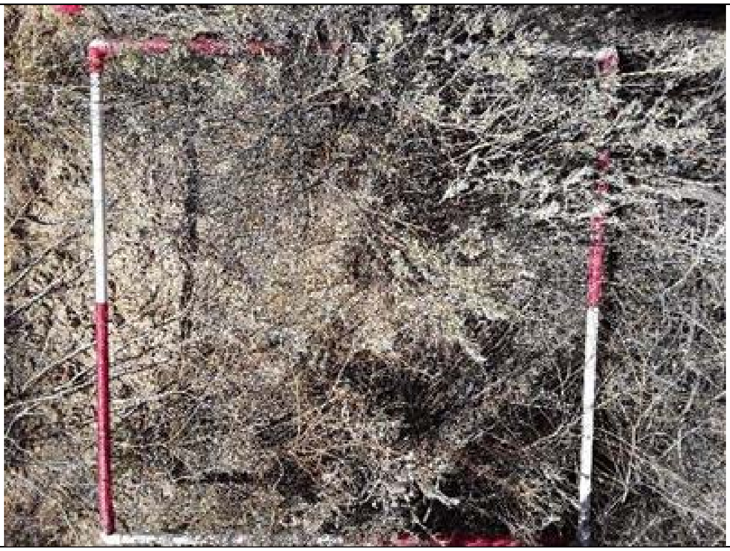
Q3

Q4

M-VMU-2-T08P

Q1

Q2



Q3

Q4

M-VMU-2-T09P


Q1


Q2


Q3


Q4

M-VMU-2-T10P

Q1

Q2

Q3

Q4

APPENDIX C

Vegetation Statistical Analysis

Table C-1: Equations for Vegetation Data Analysis

Attribute	Equation	Where
Sample Size / Count	$n = \sum samples$	n = number of samples ∑ = sum
Mean	$\bar{x} = \frac{\sum x}{n}$	$\bar{x}$ = sample mean ∑x = sum of values for variable n = number of samples
Standard Deviation	$s = \sqrt{\frac{\sum(\bar{x} - x)^2}{n-1}}$	s = standard deviation ∑ = sum $\bar{x}$ = sample mean n = number of samples
Variance	$s^2 = \frac{\sum (x_i - \bar{x})^2}{n-1}$	s^2 = variance ∑ = sum x_i = Value of variable for sample *i* $\bar{x}$ = sample mean n = number of samples
t-distribution	t = 1-α, v	t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom α = significance level (0.10) v = degrees of freedom (n-1)
90% Confidence Interval	$\bar{x} \pm t\frac{s}{\sqrt{n}}$	$\bar{x}$ = sample mean t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom s = standard deviation n = number of samples
N_{min} (Sample Adequacy - Normal Data)	$N_{min} = \frac{t^2 s^2}{(\bar{x}D)^2}$	N_{min} = number of samples required t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom s = standard deviation (s^2 = variance) $\bar{x}$ = sample mean D = the desired level of accuracy, which is 10 percent of the mean
Probaility of True Mean	$T = 1 - t\left(\frac{\sqrt{n(0.1xs)'^2}}{\bar{x}, 2, n, 1}\right)$	T = Probability the true value of the mean is within 10 percent of the mean for the sample size t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom n = number of samples s = standard deviation $\bar{x}$ = sample mean
one-sample, one-sided t test Method 3 (CMRP)	$t^* = \frac{\bar{x} - 0.9\,(technical\ std)}{s/\sqrt{n}}$	t* = calculated t-statistic $\bar{x}$ = sample mean s = standard deviation n = sample size
one-sample, one-sided sign test Method 5 (CMRP)	$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$	z = sign test statistic k = test statistic resulting from the number of values falling below 90% of the technical standard n = sample size
Relative Cover	$R_{cvr} = Cvr_{sp.}/Cvr_{Abs.}$	R_{cvr} = Calculated Relative Cover for a Species $Cvr_{sp.}$ = Mean Absolute Cover of a Perennial/Biennial Species $Cvr_{abs.}$ = Mean Absolute Perennial/Biennial Cover
Logarithmic Transformation	Y' = log(Y + k)	log = logarithmic function Y = attribute value k = constant, here we use 1

Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis

Plot	Transect	Quadrat	Raw Data			Transformed Data		
			2020 Perennial / Biennial Cover (%)	2020 Annual Forage Production (lbs/ac)	2020 Woody Plant Density (#/ac)	Log P/B Cover (2020)	Log AFP (2020)	Log WPD (2020)
M-VMU-2	M-VMU-2-T01A	1	0.0	0	2,698	0.00	0.00	3.43
		2	92.4	3,379		1.97	3.53	
		3	35.8	248		1.57	2.40	
		4	37.3	382		1.58	2.58	
	M-VMU-2-T01P	1	100.0	556	7,959	2.00	2.75	3.90
		2	27.8	270		1.46	2.43	
		3	29.8	280		1.49	2.45	
		4	44.1	509		1.65	2.71	
	M-VMU-2-T03P	1	30.2	101	1,079	1.49	2.01	3.03
		2	61.8	799		1.80	2.90	
		3	35.7	289		1.56	2.46	
		4	30.9	335		1.50	2.53	
	M-VMU-2-T04P	1	27.0	215	1,754	1.45	2.33	3.24
		2	78.0	1,800		1.90	3.26	
		3	30.0	855		1.49	2.93	
		4	41.0	278		1.62	2.45	
	M-VMU-2-T05P	1	26.5	1,026	5,666	1.44	3.01	3.75
		2	74.3	1,649		1.88	3.22	
		3	4.1	39		0.71	1.60	
		4	57.8	710		1.77	2.85	
	M-VMU-2-T06P	1	43.5	872	4,452	1.65	2.94	3.65
		2	31.3	265		1.51	2.42	
		3	23.1	205		1.38	2.31	
		4	25.1	144		1.42	2.16	
	M-VMU-2-T07P	1	26.1	422	1,079	1.43	2.63	3.03
		2	12.0	97		1.11	1.99	
		3	2.8	56		0.58	1.76	
		4	0.2	4		0.08	0.70	
	M-VMU-2-T08P	1	47.7	305	1,889	1.69	2.49	3.28
		2	28.3	614		1.47	2.79	
		3	85.6	736		1.94	2.87	
		4	23.1	254		1.38	2.41	
	M-VMU-2-T09P	1	10.9	74	540	1.08	1.88	2.73
		2	21.5	168		1.35	2.23	
		3	28.6	268		1.47	2.43	
		4	40.0	397		1.61	2.60	
	M-VMU-2-T10P	1	79.2	2,439	5,531	1.90	3.39	3.74
		2	23.5	140		1.39	2.15	
		3	105.1	3,127		2.03	3.50	
		4	39.5	764		1.61	2.88	

Mean	39.0	627	3264	1.46	2.47	3.38
Standard Deviation	26.8	794	2490	0.45	0.67	0.38
Count	40	40	10	40	40	10
Variance	718.7	630785	6202261	0.20	0.45	0.15
90% Confidence Interval	7.0	207	1295	0.12	0.17	0.20

Notes:

2020 Perennial / Biennial Cover (%) Data source is Appendix A, Table A-2; Perennial/biennial cover is the sum of individual perennial/biennial species cover estimates after excluding the annual forbs and grasses and noxious weeds

2020 Annual Forage Production (lbs/ac) Data source is Appendix A, Table A-5; Annual Forage Production is the sum of perennial/biennial species production after excluding annual forbs and grasses and noxious weeds; units are pounds of air dry forage per acre (lbs/ac)

2020 Woody Plant Density (#/ac) Data is derived from Appendix A, Table A-6; Woody Plant Density is the density of subshrubs, shrubs, cacti, or trees rooted within the belt transect, converted to stems per acre (#/ac)

Table C-3: 2020 Perennial/ Biennial Canopy Cover, Method 5 - CMRP

Transect	Quadrat	2020 Perennial / Biennial Cover (%)	90% of Technical Standard	P/B CVR minus TS
M-VMU-2-T01A	1	0.0	13.5	-13.5
	2	92.4	13.5	78.9
	3	35.8	13.5	22.3
	4	37.3	13.5	23.8
M-VMU-2-T01P	1	100.0	13.5	86.5
	2	27.8	13.5	14.3
	3	29.8	13.5	16.3
	4	44.1	13.5	30.6
M-VMU-2-T03P	1	30.2	13.5	16.7
	2	61.8	13.5	48.3
	3	35.7	13.5	22.2
	4	30.9	13.5	17.4
M-VMU-2-T04P	1	27.0	13.5	13.5
	2	78.0	13.5	64.5
	3	30.0	13.5	16.5
	4	41.0	13.5	27.5
M-VMU-2-T05P	1	26.5	13.5	13.0
	2	74.3	13.5	60.8
	3	4.1	13.5	-9.4
	4	57.8	13.5	44.3
M-VMU-2-T06P	1	43.5	13.5	30.0
	2	31.3	13.5	17.8
	3	23.1	13.5	9.6
	4	25.1	13.5	11.6
M-VMU-2-T07P	1	26.1	13.5	12.6
	2	12.0	13.5	-1.6
	3	2.8	13.5	-10.7
	4	0.2	13.5	-13.3
M-VMU-2-T08P	1	47.7	13.5	34.2
	2	28.3	13.5	14.8
	3	85.6	13.5	72.1
	4	23.1	13.5	9.6
M-VMU-2-T09P	1	10.9	13.5	-2.6
	2	21.5	13.5	8.0
	3	28.6	13.5	15.1
	4	40.0	13.5	26.5
M-VMU-2-T10P	1	79.2	13.5	65.7
	2	23.5	13.5	10.0
	3	105.1	13.5	91.6
	4	39.5	13.5	26.0
			k	6
			n	40
			z	-4.27
Standard one-tailed normal curve area (Table C-3; MMD, 1999)				0.4990
			P	0.0010

Notes:
P/B CVR = Perennial/Biennial Cover
TS = 90% of the Technical Standard for Perennial/Biennial Cover
P = 0.5-Area = prob of observing z; <=0.1 performance standard met
z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-4: 2020 Annual Forage Production, Method 5 - CMRP

Transect	Quadrat	2020 Annual Forage Production (lbs/ac)	90% of Technical Standard	FP minus TS
M-VMU-2-T01A	1	0.0	315	-315.0
	2	3379.0	315	3064.0
	3	248.0	315	-67.0
	4	382.0	315	67.0
M-VMU-2-T01P	1	556.0	315	241.0
	2	270.0	315	-45.0
	3	280.0	315	-35.0
	4	509.0	315	194.0
M-VMU-2-T03P	1	101.0	315	-214.0
	2	799.0	315	484.0
	3	289.0	315	-26.0
	4	335.0	315	20.0
M-VMU-2-T04P	1	215.0	315	-100.0
	2	1800.0	315	1485.0
	3	855.0	315	540.0
	4	278.0	315	-37.0
M-VMU-2-T05P	1	1026.0	315	711.0
	2	1649.0	315	1334.0
	3	39.0	315	-276.0
	4	710.0	315	395.0
M-VMU-2-T06P	1	872.0	315	557.0
	2	265.0	315	-50.0
	3	205.0	315	-110.0
	4	144.0	315	-171.0
M-VMU-2-T07P	1	422.0	315	107.0
	2	97.0	315	-218.0
	3	56.0	315	-259.0
	4	4.0	315	-311.0
M-VMU-2-T08P	1	305.0	315	-10.0
	2	614.0	315	299.0
	3	736.0	315	421.0
	4	254.0	315	-61.0
M-VMU-2-T09P	1	74.0	315	-241.0
	2	168.0	315	-147.0
	3	268.0	315	-47.0
	4	397.0	315	82.0
M-VMU-2-T10P	1	2439.0	315	2124.0
	2	140.0	315	-175.0
	3	3127.0	315	2812.0
	4	764.0	315	449.0
			k	21
			n	40
			z	0.47
Standard one-tailed normal curve area (Table C-3; MMD, 1999)				0.1808
			P	0.3192

Notes:
FP = Forage Production
TS = 90% of the Technical Standard for Annual Forage Production
P = 0.5-Area = prob of observing z; <=0.1 performance standard met
z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-5: Shrub Density by the Belt Transect Method, Method 3 - CMRP

$$t^* = \frac{\bar{x} - 0.9\,(technical\ std)}{s/\sqrt{n}}$$

	2020 Woody Plant Density (#/ac)
Mean (#/ac)	3,264
Standard Deviation (#/ac)	2,490
Sample Size	10
Technical Standard (#/ac)	150
t*	3.97
N_{min}	196
1-tail t (0.1, 9)	1.383

Notes:
#/ac = Number of shrubs, trees and/or cacti per acre
Decision Rules (reverse null)

t < t (1-a; n-1), failure to meet std*
t >= t (1-a; n-1), performance std met*
t from Appendix Table C-1 (MMD, 1999)

Figure C-1: Perennial/Biennial Cover (%) Descriptive Statistics and Normality, 2020

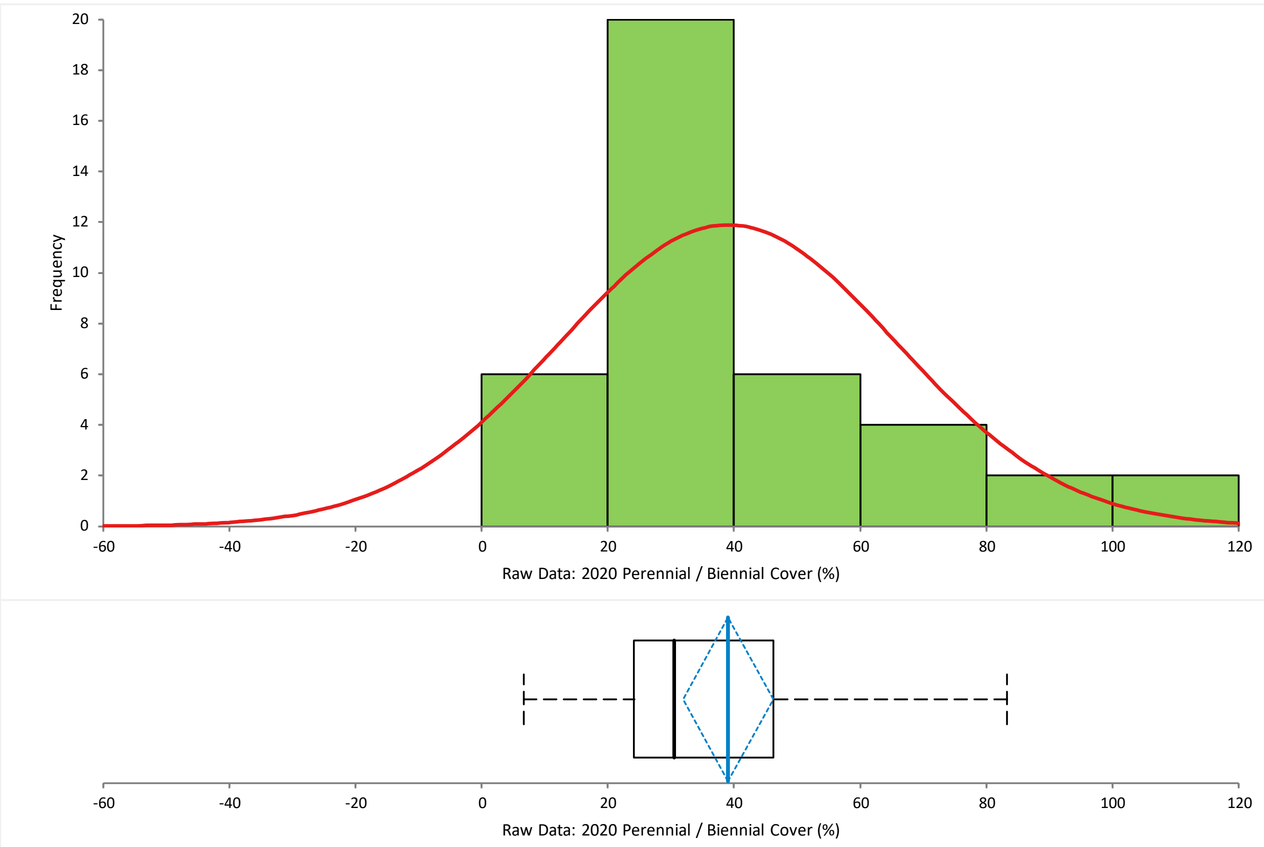
Distribution: Raw Data: 2020 Perennial / Biennial Cover

Analyse-it v5.65.7

Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis
Filter: No filter

Last updated 11 February 2021 at 12:50 by Ward, Dustin

Descriptives



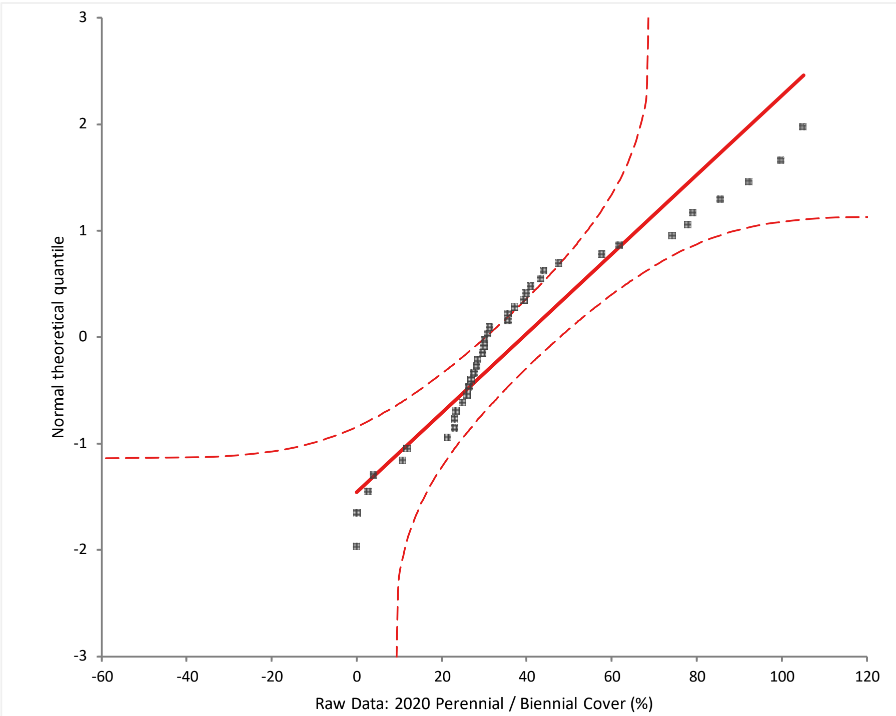
N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2020 Perennial / Biennial Cover (%)	39.0	31.9 to 46.2	4.2	26.8	0.9	0.34

	1st quartile	Median	3rd quartile
Raw Data: 2020 Perennial / Biennial Cover (%)	24.1	30.5	46.2

Figure C-1: Perennial/Biennial Cover (%) Descriptive Statistics and Normality, 2020

Normality



Shapiro-Wilk test

W statistic	0.90
p-value	0.0020 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-2: Perennial/Biennial Cover (Logarithmic Transformation) Descriptive Statistics and Normality, 2020

Distribution: Transformed Data: Log P/B Cover

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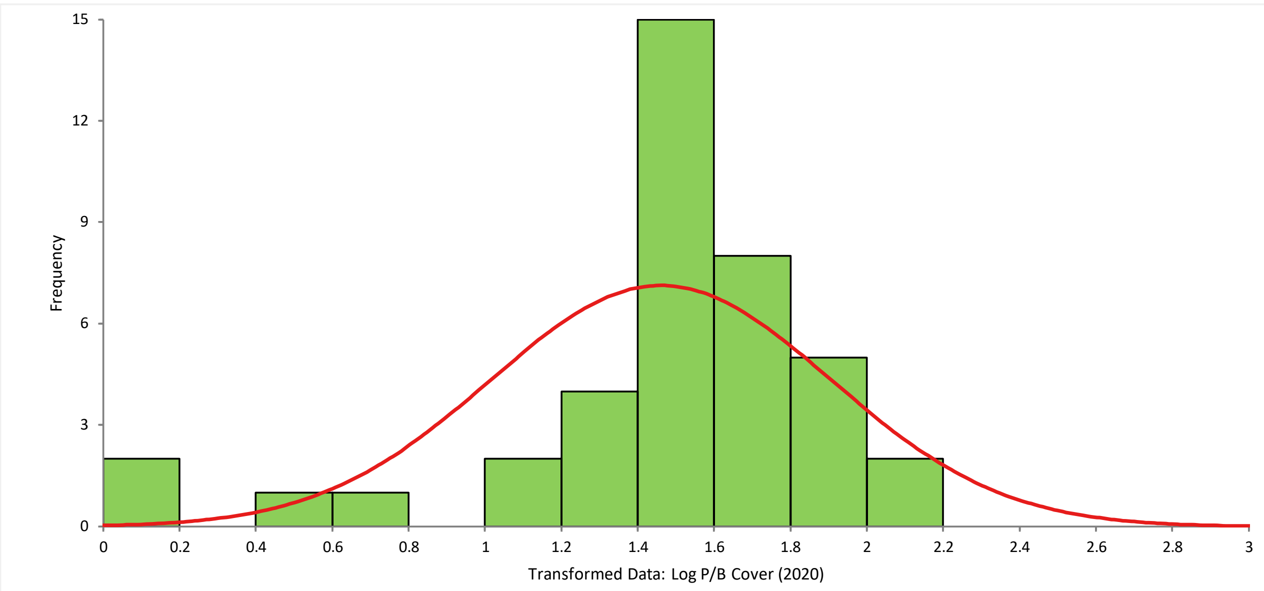
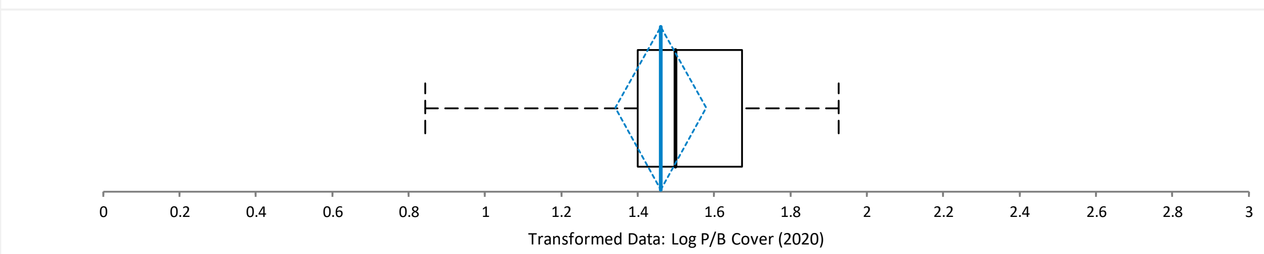
Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis
Filter: No filter

Last updated 11 February 2021 at 12:51 by Ward, Dustin

Descriptives





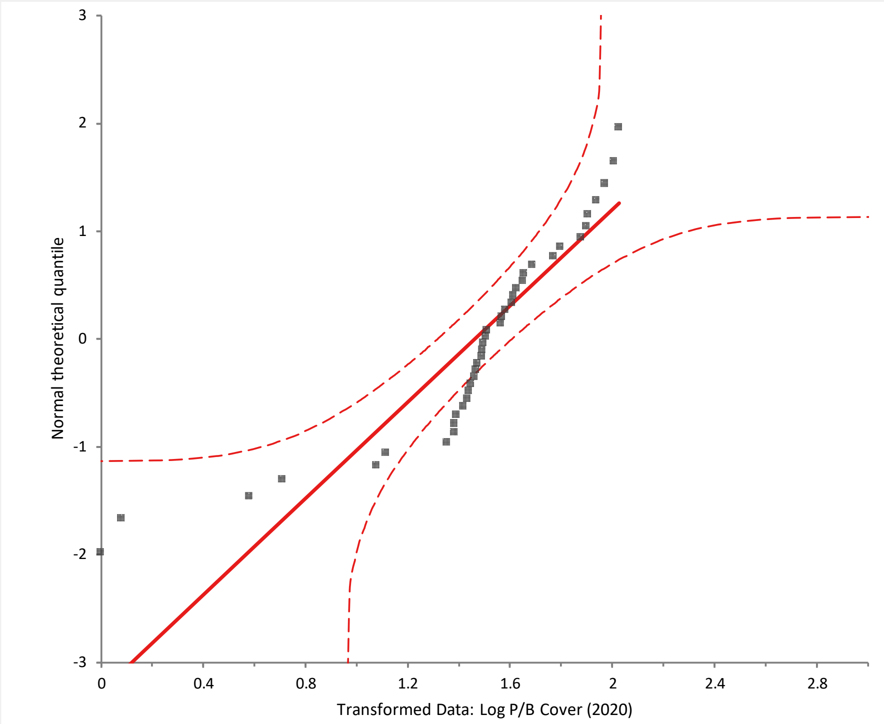
N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Transformed Data: Log P/B Cover (2020)	1.460	1.341 to 1.579	0.0707	0.447	-1.8	3.92

	1st quartile	Median	3rd quartile
Transformed Data: Log P/B Cover (2020)	1.400	1.498	1.674

Figure C-2: Perennial/Biennial Cover (Logarithmic Transformation) Descriptive Statistics and Normality, 2020

Normality



Shapiro-Wilk test

W statistic	0.81
p-value	<0.0001 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-3: Annual Forage Production (lbs/ac) Descriptive Statistics and Normality, 2020

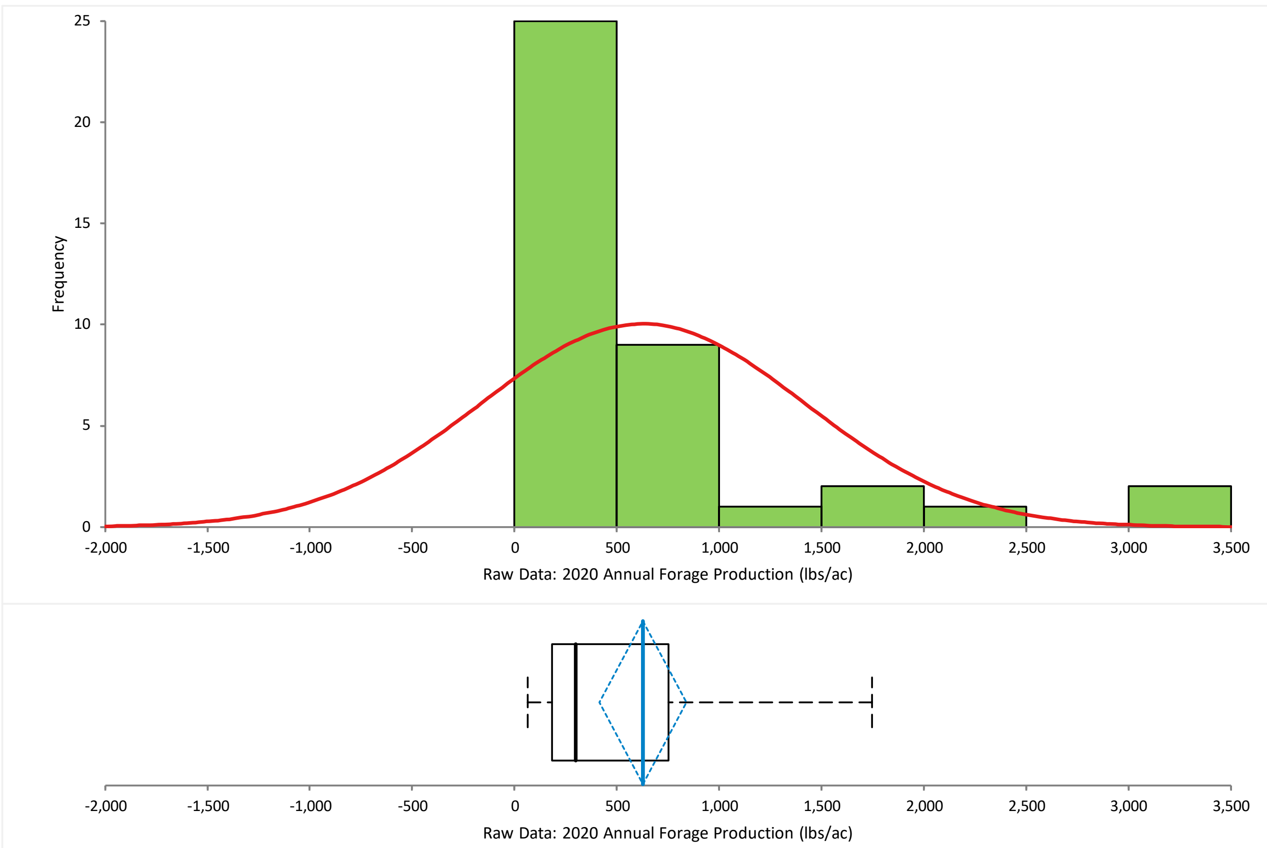
Distribution: Raw Data: 2020 Annual Forage Production

Analyse-it v5.65.7

Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis
Filter: No filter

Last updated 11 February 2021 at 12:52 by Ward, Dustin

Descriptives



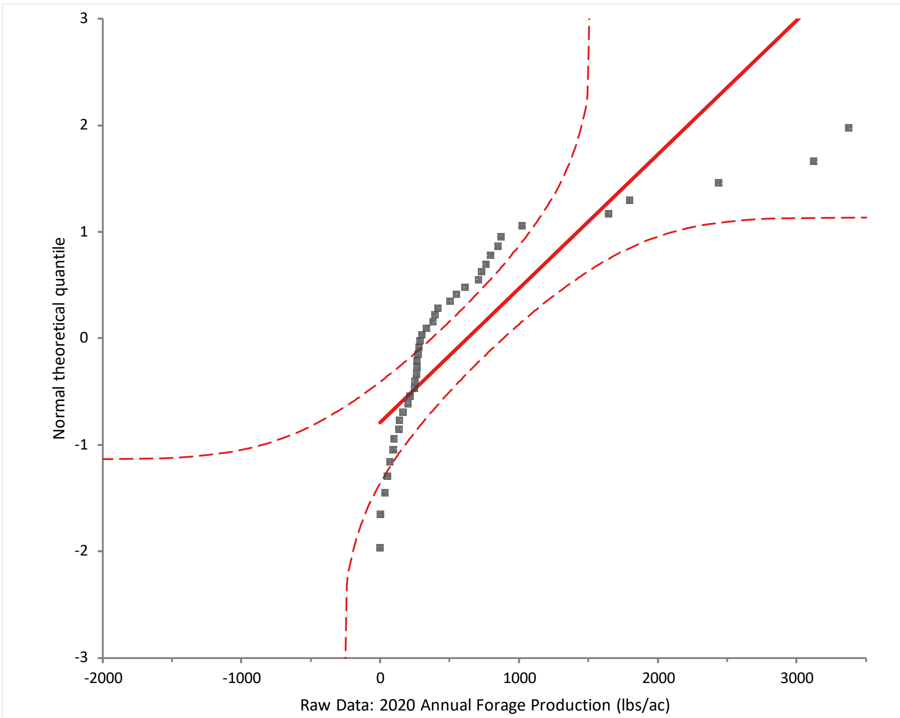
N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2020 Annual Forage Production (lbs/ac)	626.8	415.2 to 838.4	125.6	794.2	2.3	5.13

	1st quartile	Median	3rd quartile
Raw Data: 2020 Annual Forage Production (lbs/ac)	183.4	297.0	752.3

Figure C-3: Annual Forage Production (lbs/ac) Descriptive Statistics and Normality, 2020

Normality



Shapiro-Wilk test

W statistic	0.69
p-value	<0.0001 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

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Figure C-4: Annual Forage Production (Logarithmic Transformation) Descriptive Statistics and Normality, 2020

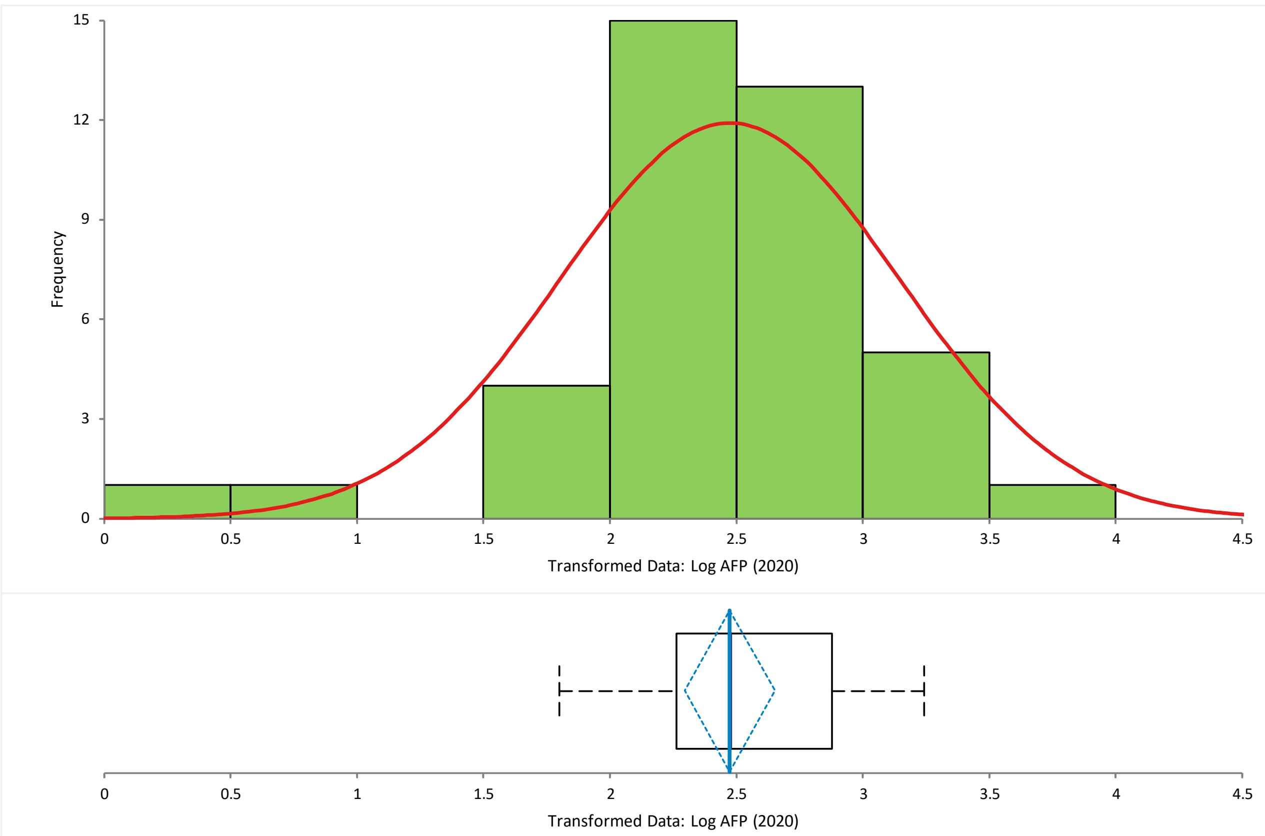
Distribution: Transformed Data: Log AFP

Analyse-it v5.65.7

Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis
Filter: No filter

Last updated 11 February 2021 at 12:53 by Ward, Dustin

Descriptives



N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Transformed Data: Log AFP (2020)	2.473	2.294 to 2.651	0.1059	0.670	-1.6	4.55

	1st quartile	Median	3rd quartile
Transformed Data: Log AFP (2020)	2.264	2.474	2.877

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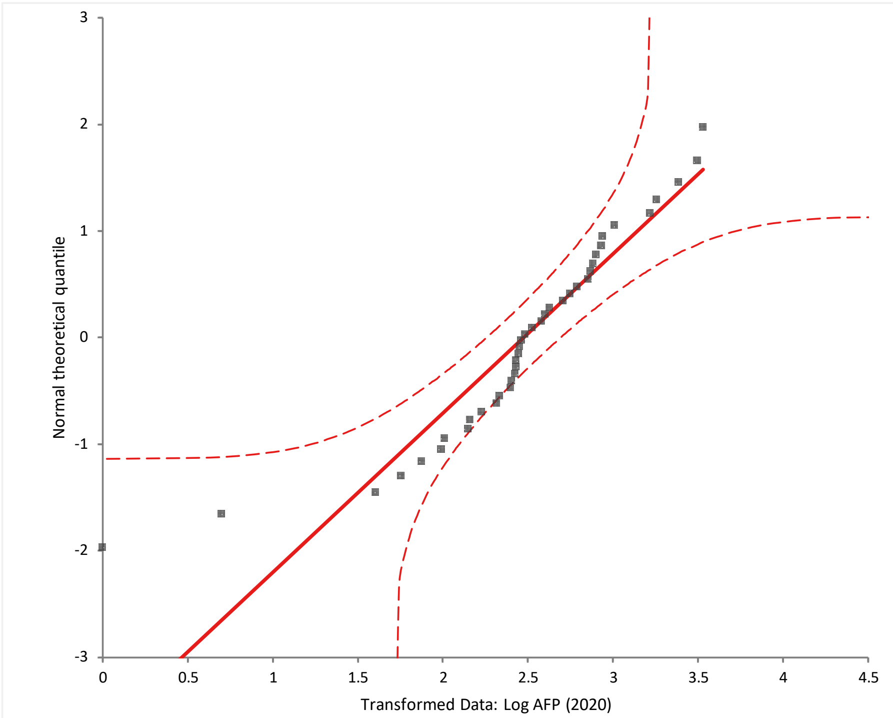
Figure C-4: Annual Forage Production (Logarithmic Transformation) Descriptive Statistics and Normality, 2020

Normality



Shapiro-Wilk test

W statistic	0.88
p-value	0.0004 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

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Figure C-5: Shrub Density (#/ac) by the Belt Transect Method Descriptive Statistics and Normality, 2020

Distribution: Raw Data: 2020 Woody Plant Density

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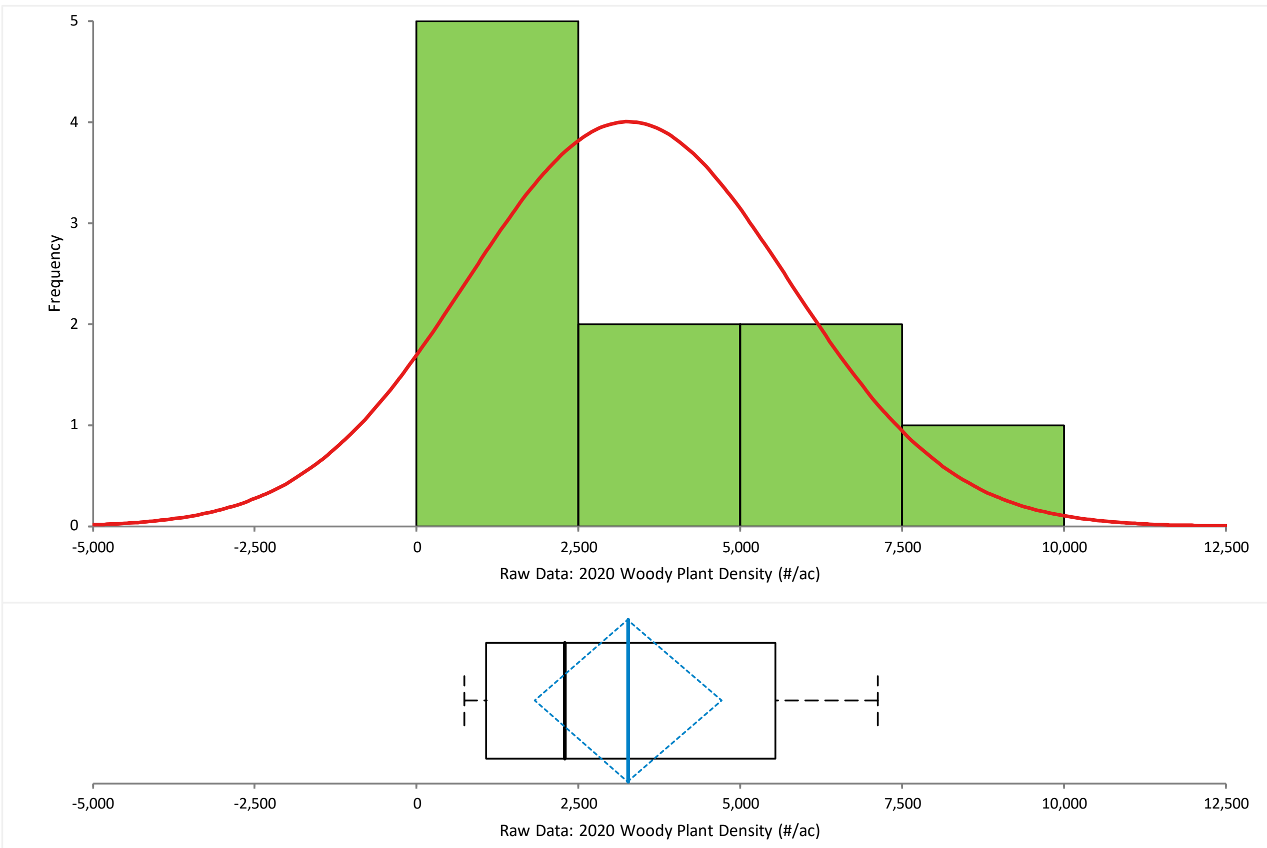
Table C-2: M-VMU-2 2020 Data for Normal Distribution and Variance Analysis
Filter: No filter

Last updated 11 February 2021 at 12:54 by Ward, Dustin

Descriptives



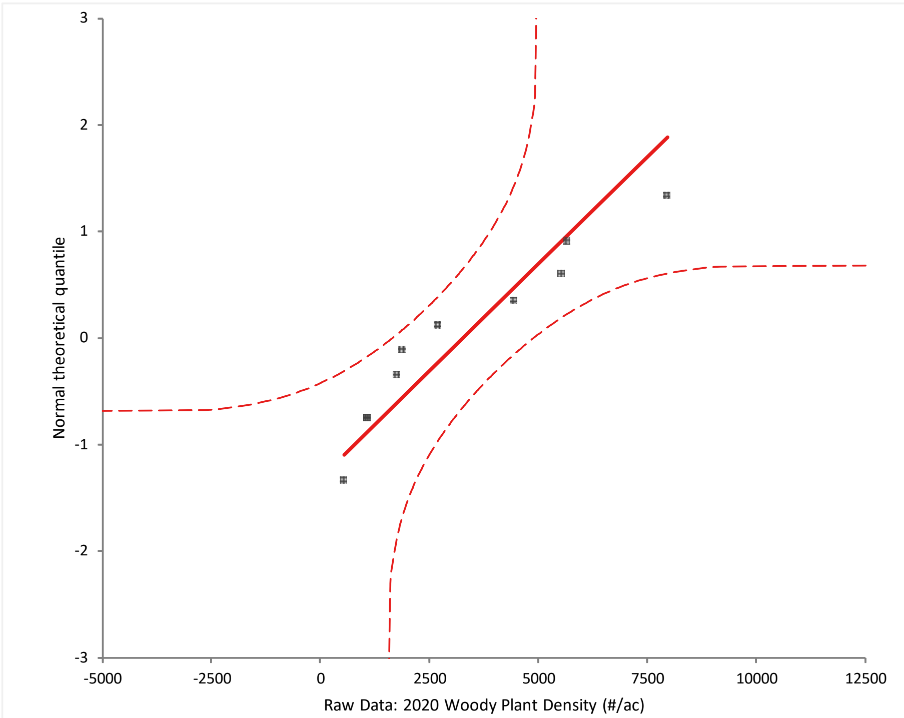
N	10

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2020 Woody Plant Density (#/ac)	3264.5	1820.8 to 4708.1	787.5	2490.4	0.7	-0.61

	1st quartile	Median	3rd quartile
Raw Data: 2020 Woody Plant Density (#/ac)	1079.2	2293.2	5541.9

Figure C-5: Shrub Density (#/ac) by the Belt Transect Method Descriptive Statistics and Normality, 2020

Normality



Shapiro-Wilk test

W statistic	0.90
p-value	0.2126 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Do not reject the null hypothesis at the 10% significance level.

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REPORT

Vegetation Management Unit 2 Vegetation Success Monitoring, 2021

McKinley Mine, New Mexico - Mining and Minerals Division Permit Area

Submitted to:

Chevron Environmental Management and Real Estate Company

Chevron Mining Inc. - McKinley Mine
24 Miles NW HWY 264
Mentmore, NM 87319

Submitted by:

Golder Associates USA Inc.

2440 Louisiana Boulevard NE, Suite 400,
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133-8105208

February 28,2022

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TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Mining was completed in New Mexico Mining and Minerals Division (MMD) jurisdictional lands at the McKinley Mine in 2007; most of the land is reclaimed, with only the facilities remaining. The lands mined and reclaimed included prelaw, initial-program, and permanent-program lands. Liability release has been completed on all prelaw and initial-program lands, and full bond release on a limited amount of permanent-program land.

Chevron Mining Inc. (CMI) is assessing the vegetation in the remaining permanent-program reclaimed areas in anticipation of future bond and liability releases. CMI understands the importance of returning the mined lands to productive traditional uses in a timely manner. In order to qualify for release, the lands must be in a condition that is as good as or better than the pre-mine conditions, stable, and capable of supporting the designated postmining land use of grazing and wildlife. To make that demonstration for bond and liability release, the reclaimed land must meet the revegetation success standards contained in Permit No. 2016-02. The extended period of responsibility before an application for bond and liability release can be submitted for a given area in the permit is at least ten years. Golder Associates USA Inc. (Golder) was retained to monitor and assess the success of the vegetation relative to these requirements.

1.1 Vegetation Management Unit 2

This report presents results from 2021 quantitative vegetation monitoring conducted in Vegetation Management Unit 2 (M-VMU-2), comprising about 1,518 acres within Area 11 (Figure 1). The elevation in this area ranges from about 6,700 to 7,000 feet above mean sea level. Permanent program reclamation in Area 11 started on lands disturbed after 1986, and reclamation generally was completed by 2013. Thus, reclamation age in the majority of M-VMU-2 ranges from approximately 9 to more than 30 years old. The configuration of the VMUs within the MMD Permit Area, shown on Figure 1 were developed in consultation with MMD. This section provides a general description of the reclamation activities that were implemented. Additional details of the reclamation for specific areas can be obtained through review of McKinley's annual reports.

1.2 Reclamation and Revegetation Procedures

Reclamation methods applied in Area 11 included grading of the spoils to achieve a stable configuration, positive drainage, and approximate original contour. Graded spoil monitoring was then conducted to verify that the upper 42 inches of spoil were suitable for plant growth. A minimum of 6 inches of top dressing (topsoil or topsoil substitute) were then applied over suitable spoils.

After topdressing placement, the surface was scarified in preparation for planting. Seeding was done using various implements that drilled and/or broadcast the seed. After the seeding, mulch consisting of either hay or straw was applied at a rate of about 2 tons/acre. The mulch was anchored 3 to 4 inches into the soil with a tractor-drawn straight coulter disc. The seeding was generally performed in the fall, which coincided with logical units for seeding that had been topdressed over the spring and summer. Seed mixes used at McKinley have varied over time but included both warm- and cool-season grasses, introduced and native forbs, and shrubs. The early seed mixes tended to emphasize the use of alfalfa and cool-season grasses. Over time the seed mixes shifted to include more warm-season grasses and a broader variety of native forbs.

1.3 Prevailing Climate Conditions

The amount and distribution of precipitation are important determinants for vegetation establishment and performance at the McKinley Mine. Once vegetation is established, the precipitation dynamics affect the amount of vegetation cover and biomass on a year-to-year basis with grasses and forbs showing the most immediate response. Precipitation has been monitored at the site since 2015, with the Rain 11 gauge capturing precipitation in VMU-2 (Figure 1).

Total annual precipitation measured at the South Tipple was 15.76 inches, well above the regional average of 11.8 inches at Window Rock (Table 1); the North Bluff gauge, however, recorded 8.67 inches of annual precipitation, which was consistent with the precipitation recorded at the other eight gauges across the mine indicating continuing drought. Higher than normal rainfall was recorded at the South Tipple in July and September, but it appears the precipitation was unique to the South Tipple area. Rain Gauge 11 located near the center of Area 11 recorded 6.07 inches of precipitation from late April to mid-November (the period this station operates), whereas the North Bluff gauge recorded approximately 5.95 inches of rain for the same period. Mine wide, the precipitation recorded during this time period was in the same range as what was recorded at Rain 11, except for the South Tipple gauge. Table 1 contains a summary of precipitation recorded at all the rain gauges.

Growing season precipitation provides additional context to evaluate vegetation performance in M-VMU-2. The departure of growing season precipitation (April through September) between these gauges and the Window Rock (1937-1999) long-term seasonal mean is illustrated in Figure 2. Growing season precipitation in M-VMU-2 has been below the long-term seasonal mean since 2018. These drought conditions increased in severity since 2019 with 2.35 inches less than the long-term seasonal mean in 2019 and 4.81 inches less in 2020. In 2021, growing season precipitation at the Rain 11 gauge recorded 1.51 inch less than Window Rock's normal (for this same time period).

1.4 Objectives

The intent of this report is to document the vegetation community attributes in M-VMU-2 and compare them to the Permit vegetation success criteria. Section 2 describes the vegetation monitoring methods that were used in 2021. Section 3 presents the results of the investigation with respect to ground cover, annual production, shrub density, and composition and diversity. Section 4 is a summary of the results for M-VMU-2 with emphasis on vegetation success.

2.0 VEGETATION MONITORING METHODS

Vegetation attributes on M-VMU-2 in Area 11 were quantified using the methods described in Section 6.5 of the Permit. Fieldwork was conducted at the end of the growing season, but prior to the first killing frost, which was conducted between September 18 and 19, 2021.

2.1 Sampling Design

A systematic random sampling procedure employing a transect/quadrat system was used to select sample sites within the reclaimed area. The proposed transect locations were reviewed with MMD in advance of sampling. A 50-square foot grid was imposed over the VMU to delineate vegetation sample plots, and random points created in a geographic information system were used to select plots for vegetation sampling. The locations of randomly selected vegetation plots are shown on Figure 3. In the field, the randomly selected transect locations were assessed in numerical order. If the transect location was determined to be unsuitable, the next alternative location was assessed for suitability. Unsuitable transects were those that fell on or would intersect roads, drainage ways, wildlife rock piles, or prairie dog colonies.

Transects originated from the southeastern corner of the vegetation plot. Each transect was 30 meters (m) long in a dog-leg pattern (Figure 4). Four 1-m^2 quadrats were located at pre-determined intervals along the transect for quantitative vegetation measurements. Each quadrat is considered an individual sample where measurements were made of production, total canopy, species canopy and basal cover, surface litter, surface rock fragments, and bare soil as discussed below.

2.2 Vegetation and Ground Cover

Relative and total canopy cover, basal cover, surface litter, rock fragments, and bare soil were estimated for each quadrat. Canopy cover estimates include the foliage and foliage interspaces of all individual plants rooted in the quadrat. Canopy cover is defined as the percentage of quadrat area included in the vertical projection of the canopy. The canopy cover estimates made on a species basis may exceed 100% in individual quadrats where the vegetation has multi-layered canopies. In contrast, the sum of the total canopy cover, surface litter, rock fragments, and bare soil does not exceed 100%.

Basal cover is defined as the proportion of the ground occupied by the crowns of grasses and rooting stems of forbs and shrubs. Basal cover estimates were also made for surface litter, rock fragments, and bare soil. Like the total cover estimates, the basal cover estimates do not exceed 100%. All cover estimates were made in 0.05% increments. Percent area cards were used to increase the accuracy and consistency of the cover estimates. Plant frequency was determined on a species-basis by counting the number of individual plants rooted in each quadrat.

2.3 Annual Forage and Biomass Production

Production was determined by clipping and weighing all annual (current year's growth) above-ground biomass within the vertical confines of a 1-m^2 quadrat. Grasses and forbs were clipped to within 5 centimeters (cm) of the soil surface, and the current year's growth was segregated from the previous year's growth (e.g., gray, weathered grass leaves and dried culms). For this sampling event, plants that were less than 5 cm tall or considered volumetrically insignificant were not collected. Production from shrubs was determined by clipping the current year's growth.

The plant tissue samples of every species collected were placed individually in labeled paper bags. The plant tissue samples were air-dried (> 90 days) until no weight changes were observed with repeated measurements on representative samples. The average tare weight of the empty paper bags was determined to correct the total sample weight to air-dry vegetation weights. The net weight of the air-dried vegetation was converted to a pounds per acre (lbs/ac) basis.

2.4 Shrub Density

Shrub density, or the number of plants per square meter, was determined using the frequency count data from the quadrats and the belt transect method (Bonham 1989). Shrub density was calculated from the quadrat data by dividing the total number of individual plants counted by the number of quadrats measured. The density per square meter was converted to density per acre.

Shrub density was also determined using a belt transect method (Bonham 1989). Shrub density was determined from a 1-meter wide; 30-meter long belt transect situated along the perimeter of the dog-legged transect (Figure 4). Shrubs rooted in the belt transect were counted on a species basis.

2.5 Statistical Analysis and Sample Adequacy

The procedures for financial assurance release as described in Coal Mine Reclamation Program (CMRP) Vegetation Standards (MMD 1999) and the Permit guided this statistical analysis. Statistical tests were performed using both Microsoft® Excel and Analyse-it (version 5.92), a statistical add-in for Excel. The normality of each dataset was first assessed using the Shapiro-Wilk test to determine the appropriate hypothesis test method (i.e., parametric versus nonparametric). Data were considered normal when the test statistic was significant (p-value > 0.10) for alpha (α) = 0.10. Thus, the null hypothesis that the population is normally distributed was accepted if the p--value > 0.10. In cases where the data were not normally distributed, a log transformation was applied to see if it normalized the data.

All hypothesis testing used to demonstrate that the vegetation success standards were met was conducted using a reverse null approach. Because vegetation performance at McKinley is compared to technical standards, the one-sample, one-sided t-test (CMRP Method 3) is used for normally distributed data to evaluate the mean and the one-sample, one-sided sign test (CMRP Method 5) to analyze the median of data that are not normal (MMD 1999; McDonald and Howlin 2013). The one-sided hypothesis tests using the reverse null approach were designed as follows:

Perennial/Biennial Canopy Cover

H_0 : Reclaim < 90% of the Technical Standard (15%)

H_a : Reclaim ≥ 90% of the Technical Standard (15%)

Annual Forage Production

H_0 : Reclaim < 90% of the Technical Standard (350 lbs/ac)

H_a : Reclaim ≥ 90% of the Technical Standard (350 lbs/ac)

Shrub Density

H_0 : Reclaim < 90% of the Technical Standard (150 stems per acre [stems/ac])

H_a : Reclaim ≥ 90% of the Technical Standard (150 stems/ac)

where H_0 is the null hypothesis, that the parameter mean of the reclaimed area is less than 90% of the technical standard and H_a is the alternative hypothesis, that the parameter mean of the reclaimed area is greater than or equal to 90% of the technical standard. All hypothesis tests were performed with a 90% level of confidence.

Under the reverse null test, the revegetation success standard is met when H_0 is rejected and H_a is accepted. The decision criteria at 90% confidence under the reverse null hypothesis are as follows:

One-sample, one-sided t-test – Method 3 (CMRP)

If $t^* < t_{(1-\alpha;\, n-1)}$, conclude failure to meet the performance standard

If $t^* \geq t_{(1-\alpha;\, n-1)}$, conclude that the performance standard was met

One-sample, one-sided sign test – Method 5 (CMRP)

If P > 0.10, conclude failure to meet the performance standard

If P ≤ 0.10, conclude that the performance standard was met

Statistical hypothesis testing was performed on perennial/biennial cover, annual forage production and shrub density (woody stem stocking) using the one-sample, one-sided t-test and the one-sample, one-sided sign test.

The hypotheses testing used the reverse null hypothesis bond release testing procedure as described in CMRP Vegetation Standards (MMD 1999).

Statistical adequacy is not required for vegetation success demonstrations at McKinley under the reverse null approach but is presented on the basis of the canopy cover, production, and shrub density data. The number of samples required to characterize a particular vegetation attribute depends on the uniformity of the vegetation and the desired degree of certainty required for the analysis.

The number of samples necessary to meet sample adequacy (N_{min}) was calculated assuming the data were normally distributed using Snedecor and Cochran (1967).

$$N_{min} = \frac{t^2 s^2}{(\overline{x}D)^2}$$

Where N_{min} equals minimum number of samples required, t is the two-tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom, s is the standard deviation of the sample data, $\overline{x}$ is the mean, and D is the desired level of accuracy, which is 10 percent of the mean.

In addition to N_{min}, the 90% confidence interval (CI) of the sample mean and the level of confidence that the sample mean is within 10 percent of the true mean are reported.

It is often impractical to achieve sample adequacy in vegetation monitoring studies based on Snedecor and Cochran’s equation, and a minimum sample number approach is taken. MMD recognizes the practical limitations of achieving statistical adequacy and has provided minimum sample sizes for various quantitative methods (MMD 1999). With normally distributed data where sample adequacy cannot be met because of operational constraints or for other reasons, 40 samples are often considered adequate. The 40--sample recommendation is based on an estimate of the number of samples needed for a t-test under a normal distribution (Sokal and Rohlf 1981). Schulz et al. (1961) demonstrated that 30 to 40 samples provide a robust estimate for most cover and density measurements with increased numbers of samples only slightly improving the precision of the estimate.

CMI collected 40 samples at the outset of sampling based on the guidance discussed above. The 40 samples came from ten transects each having four quadrats as described in Section 2.1. Each quadrat is considered a unique sampling unit. Additional analysis around sample adequacy was done to see the number of samples that would have been required for adequacy by the Snedecor and Cochran equation. Further analysis for sample adequacy of cover, production and density attributes was also demonstrated using a graphical stabilization of the mean method (Clark 2001).

The emphasis on statistical adequacy assumes that parametric tests of normally distributed data will be conducted to demonstrate compliance with the vegetation success standards. It is important to note that normally distributed data and sample adequacy are not required for hypothesis testing. Nonparametric hypothesis tests are used to analyze data that are not normally distributed. When sample adequacy is not achieved, it is appropriate to use the reverse null approach for hypothesis testing. The reverse null is also generally recommended to evaluate reclamation success whether N_{min} is met or not (MMD 1999). This is because the reverse null is more defensible (compared to the classic approach) where the rejection of the null hypothesis definitively concludes that the reclamation mean is greater the technical standard (McDonald and Howlin 2013).

3.0 RESULTS

The vegetation community in M-VMU-2 is well established and dominated by perennial plants. A representative photograph of the vegetation and topography in M-VMU-2 is shown in Figure 5. The vegetation cover levels in 2021 suggest that the site is progressing to achieve vegetation success standards for the Permit Area.

Vegetation success standards consist of four vegetative parameters: ground cover, productivity, diversity, and woody stem stocking (Table 2). The ground cover requirement for live perennial/biennial cover on the reclamation is 15%. The productivity requirement is 350 air-dry lbs/ac perennial/biennial annual production. The woody stem stocking success standard is 150 live woody stems/ac.

Diversity is evaluated against numerical guidelines for different growth forms and photosynthetic pathways of the vegetation. In summary, the diversity guideline required by MMD would be met if at least two shrub or subshrub species with individual relative cover values of 1%; at least two perennial warm-season grass species have individual relative cover levels of at least 1%; at least one perennial cool-season grass species has an individual relative cover level of at least 1%; and at least three perennial or biennial forb species have a combined relative cover of at least 1%. MMD (1999) allows for the use of biennial forbs because they are technically monocarpic (single-flowering) perennials that annually produce a significant amount of seed and therefore as a species, they persist in the reclaimed plant community. Relative cover is the average percent cover of a perennial/biennial species divided by the total perennial/biennial cover of the sampling unit.

Diversity is also demonstrated by evidence of colonization or recruitment of native (not-seeded) plants from adjacent undisturbed native areas. Table 3 summarizes the attributes for plants recorded in the quadrats in addition to those encountered or observed but not recorded in the formal quantitative monitoring of M-VMU-2. Recruitment of these native plant species is indicative of ecological succession and the capacity of the site to support a self-sustaining ecosystem.

For Phase III bond release applications, it must be demonstrated that the total annual production and total live cover of biennials and perennials equal or exceeds the approved standards for at least two of the last four years of the responsibility period. Shrub density and revegetation diversity must equal or exceed the approved standards during at least one of the two sampling years of the responsibility period (MMD 1999).

The field data for canopy and basal cover, density, production, and shrub density by the belt transect are included in Appendix A. Photographs of the quadrats are included in Appendix B. Appendix C provides the statistical analysis equations, summary data and statistical outputs for perennial/biennial canopy cover, annual forage production, and shrub density by the belt transect method.

3.1 Ground Cover

Perennial/biennial canopy cover was calculated by summing the perennial/biennial species cover estimates after excluding the annual forbs and grasses. Any recorded noxious weeds are excluded from perennial/biennial cover. Average total ground cover in M-VMU-2 is 41% comprised of 27.5%% total vegetation cover, 5.2% rock, and 8.3% litter on a canopy cover basis (Table 3). On a basal area basis, average ground cover is 27.6% with 3.2% vegetation, 6.0% rock, and 18.4% litter. Consistent with semi-arid rangelands the vegetation canopy cover in the individual quadrats varied, ranging from 2 to 75% (Table A-2).

The mean perennial/biennial canopy cover in 2021 was 22.5% (± 5.2% [90% CI]). The calculated minimum sample size needed to meet N_{min} was 220 samples for perennial/biennial canopy cover (Table 4). In 2020 the mean perennial/biennial canopy cover was 39.0% (± 7.0%) (Table 4).

Statistically, the perennial/biennial canopy cover data for M-VMU-2 were not normally distributed (Figure C-1). A log transformation of the perennial/biennial canopy cover data did not result in a normal distribution (Figure C-2). The calculated minimum sample size needed after the log transformation to meet N_{min} was 117 samples for total cover and 134 samples for perennial/biennial canopy cover (Table 4). Because N_{min} was not met and called for an unreasonable number of samples, the perennial/biennial canopy cover data were evaluated using a stabilization of the mean approach (Clark 2001). Figure 6 illustrates the stabilization of the mean for perennial/biennial canopy cover based on incrementally calculating the mean and 90% CIs for four samples from a single transect sequentially. The analysis suggests that mean perennial/biennial canopy cover was estimated to within the 90% CI of the estimated population mean beginning 12 samples with the 90% CI tightening to no greater than about ± 6% cover after 32 samples. This analysis suggests that 40 samples were more than adequate and collecting additional samples would not improve the precision of the canopy cover estimate.

Hypotheses testing was conducted using a one-sided, one-sample sign test using the reverse null (MMD 1999). The testing found nineteen perennial/biennial cover quadrats did not meet 90% of the performance standard (13.5%) resulting in the probability (P) of <0.4364 of observing a z value less than -0.16. Therefore, under the reverse null hypothesis we conclude the performance standard was not met for perennial/biennial canopy cover in 2021 (Table C-3). The cover standard was met in M-VMU-2 under the same statistical analysis methods in 2019 and 2020.

3.2 Production

Productivity for vegetation success is assessed for above-ground annual forage production, excluding annuals and noxious weeds in air dry pounds per acre (lbs/ac). Total annual production for all plant species is reported but not used in determining productivity success for the VMU. The 2021 annual forage production in M-VMU-2 was estimated to be 425 (± 167) lbs/ac with an annual total production of 523 (± 167) lbs/ac (Table 4). While the production mean exceeds the standard in 2021, production did not pass hypothesis testing as discussed below. Six perennial grasses contribute 284 lbs/ac of forage and five shrubs contribute 134 lbs/ac of browse indicating a diverse and productive rangeland (Table 3). Two native perennial grasses accounted for almost 262 lbs/ac of the annual forage production: James galleta (*Pleuraphis jamesii,* 158 lbs/ac) and Russian wildrye (*Psathrostachys juncea,* 104 lbs/ac). In 2021, rubber rabbitbrush (*Ericameria nauseosa*) accounted for nearly 78% (104 lbs/ac) of the shrub production with winterfat (*Krascheninnikovia lanata*) provided an additional 22 lbs/ac. The combined annual forage production in M-VMU-2 exceeds the vegetation success standard of 350 lbs/ac and is on the low end for comparable ecological sites of 430.5 to 794.2 lbs/ac (Parametrix 2012). The annual forage production of M-VMU-2 in 2019 (787 lbs/ac) and 2020 (627 lbs/ac) demonstrate the site's ability to exceed the minimum production values for comparable ecological sites.

The annual forage production data for M-VMU-2 were not normally distributed (Figure C-3). A log transformation of the annual forage production data did not result in a normal distribution (Figure C-4). The calculated minimum sample size needed to meet N_{min} at the 90% confidence level for annual forage production was estimated to be 652 samples (Table 4). Because N_{min} was not met and called for an unreasonable number of samples, the data were evaluated using a stabilization of the mean (Clark 2001). Figure 7 illustrates the stabilization of the estimated mean and 90% CI for annual forage production based on incrementally calculating the mean and 90% CIs for four samples from a single transect sequentially. The analysis suggests that mean annual forage production was highly variable across M-VMU-2 with broad 90% CIs for the entire dataset though the estimated population mean was captured beginning about the 12th sample. The 90% CI tightened to about ± 200 lbs/ac after 32 samples with no meaningful reduction in with the collection of additional data. This analysis suggests that collecting more than

40 samples may have decreased the variability of forage production to a small extent but given the number of low production quadrats and the high variability among samples, the collection of additional data may not have led to conclusion that production met the success target.

Hypotheses testing was conducted using a one-sided, one-sample sign test using the reverse null (MMD 1999). The testing found 23 production quadrats did not meet 90% of the performance standard (315 lbs/ac) resulting in the probability (P) of 0.1335 of observing a z value less than 1.11. Therefore, under the reverse null hypothesis we conclude the performance standard is unmet for annual forage production in 2021 (Table C-4). For M-VMU-2, the annual forage production standard was met in 2019 at 787 lbs/ac, but in 2020 at 627 lbs/ac it was not met due to exceptional drought resulting in a lower mean and increased variance.

3.3 Shrub Density

Shrub density ranged from an average of 989 (± 322) stems/ac based on the belt transect method to 1,315 (± 602) stems/ac for quadrat method (Table 4). In M-VMU-2, five shrub species were encountered along nine belt transects (Table A-6, data corrupted for one transect) compared to four species in the quadrats (Table 3), reflecting the increased area of analysis associated with the belt transects. Winterfat was the most encountered subshrub under both measurement methods.

The shrub density data by the belt transect method were normally distributed (Figure C-5) and the calculated minimum sample size needed to meet N_{min} at the 90% confidence level was estimated to be 196 samples (Table 4). Because N_{min} was not met and called for an unreasonable number of samples, the shrub density belt transect data were evaluated using a stabilization of the mean (Clark 2001). Figure 8 illustrates the stabilization of the mean for shrub density based on individual belt transect data. The corresponding variability around the mean is expressed by the 90% CIs for each successive analytical increment. These data suggest that the mean shrub density was estimated to within the 90% CI of the estimated population mean (n=9) after three samples, with the 90% CI tightening to no greater than about ± 500 stems/ac after four samples. The variability of the estimate slightly decreased with the collection of additional data, but not to a meaningful degree. This analysis suggests that the collection of additional data beyond 9 samples would not improve the precision of the estimate of shrub density, which is well above the performance standard.

Hypotheses testing was conducted using the one-sample, one-sided t-test (MMD 1999). The calculated t*-statistic for M-VMU-2 shrub density is 4.36, where the sample mean is 989 stems/ac with a standard deviation of 588, the technical standard is 150 stems/ac and the sample size is 9. The one-tail $t_{(0.1,\,9)}$ value is 1.397. Therefore, under the reverse null hypothesis ($t^* >= t_{(1-\alpha;\,n-1)}$), we conclude that the performance standard is met for shrub density (i.e., woody stem stocking) by the belt transect method (Table C-5).

3.4 Composition and Diversity

Diversity is assessed through comparing the relative cover of various life-forms, based on their duration to the perennial/biennial cover of the vegetation management unit. In this context, relative cover is the average percent cover of a perennial/biennial species divided by the mean perennial/biennial cover of the sampling unit. Relative canopy cover of individual species contributing to perennial cover are listed in Table 3.

Collectively, seven perennial grasses dominate the canopy cover in M-VMU-2 with a combined relative canopy cover of almost 89%. Russian wildrye and James' galleta are the two most prevalent grasses (Table 3). Four cool-season perennial grasses contribute almost 45% relative canopy cover and three warm-season perennial grasses contribute almost 44% relative canopy cover. Three perennial/biennial forbs contribute just over 3%

relative canopy cover in M-VMU---2. The collective contribution of three shrubs to perennial/biennial canopy cover is 13% relative cover, with rubber rabbitbrush and winterfat most prevalent.

Table 5 provides the diversity results for M-VMU-2 for 2019 through 2021 and is summarized below.

- The diversity standard for cool-season grasses is achieved by several species that exceed 1% relative cover including Russian wildrye (*Psathyrostachys juncea*, 35.92%), western wheatgrass (4.22%), and thickspike wheatgrass (*Elymus lanceolatus*, 3.83%).
- The diversity standard for warm-season grasses requires a minimum of two species with 1% relative cover each. This was not met in 2021. One grass, James' galleta, met the standard at 42.8% cover. Sand dropseed (*Sporobolus cryptandrus*) and blue grama (*Bouteloua gracilis*) contributed 0.67% and 0.17% relative cover respectively in 2021. The warm-season grass diversity standard was met in 2020 in M-VMU-2 but not in 2019 or 2021.
- The diversity standard for forbs requires a minimum of three non-annual forb taxa combining to contribute at least 1% relative cover. The combined relative cover of three non-annual forbs is 3.31% (Table 3). These forbs include rattlesnake weed (*Chamaesyce albomarginata*, 3.12%), scarlet globemallow (*Sphaeralcea coccinea*, 0.11%), and flatspine stickseed (*Lappula occidentalis,* 0.08%). Based on 2021 sampling, the combined relative cover for three non-annual forbs is greater than 1%, meeting the diversity standard for forbs on M-VMU-2 reclamation. The diversity standard for shrubs requires two species with a minimum relative cover of 1% for each species. The diversity standard for shrubs is achieved by rubber rabbitbrush (6.14%) and winterfat (4.33%).

The recruitment of native plants and establishment of seeded species within M-VMU-2 is indicative of ecological succession and the capacity of the site to support a diverse and self-sustaining ecosystem. Based on the 2021 vegetation monitoring, 102 different plant species were present within the reclamation areas of M-VMU-2 (Table 3). Species encountered included 45 forbs, 24 grasses and 33 shrubs, trees and cacti. Of the 45 forbs, 15 are considered annuals whereas the remaining 30 have variable durations or are purely perennial. Of the 24 grasses, 15 are cool-season perennials, six are warm-season perennials and three are cool-season annuals. Cacti and trees are rare on the reclamation, while shrubs and subshrubs are more common.

During the 2021 monitoring program, noxious weeds (NMDA 2020) were infrequently encountered on M-VMU-2. No Class C noxious weeds were recorded in the quadrats, but the Class B noxious weed cheatgrass (*Bromus tectorum*) saltcedar (*Tamarix ramosissima*) and Siberian elm (*Ulmus pumila*) was observed in the reclamation in 2021. The contribution of these species to the vegetation community is insignificant with densities much lower than native rangeland beyond the permit boundary. CMI continues to monitor for noxious weeds and actively controls them through husbandry practices that include annual services for weed control. Further, competition from desirable seeded and native species is expected to inhibit any substantial increase of noxious weeds in the reclamation.

4.0 SUMMARY

McKinley Mine's vegetation success standards for the post-mining land uses of grazing and wildlife are based on canopy cover, production, shrub density, and plant diversity (Table 2). The vegetation monitoring results for the past three years indicate that the vegetation community in M-VMU-2 is progressing having met the cover standard in the two previous years and shrub density standard three years in a row (Table 6). For 2021, M-VMU-2 exceeded success parameters for just shrub density but fell short on perennial/biennial cover, annual forage production and warm-season grass diversity. (Tables 5 and 6). A summary of the findings from the past three years are:

1. Despite the prolonged drought beginning in 2018 in M-VMU-2, the reclamation has been resilient and successful for shrub density, demonstrating a level permanence.
2. Below normal growing season precipitation from 2018 through 2020, and less so in 2021, resulted in more quadrats with low canopy cover and annual production and increased variability among samples. Even with estimated means above the technical standard, statistical hypothesis testing in 2020 and 2021 determined the performance standard was unmet for production in both years and for cover in 2021.
3. Drought also has affected the expression of forbs in 2020 and warm-season grasses in 2019 and 2021.

Overall, vegetation performance in M-VMU-2 is promising considering below-average precipitation for the past 5 years including a two-year drought in 2017 and 2018, the exceptional drought in 2020, and the spatial variability of moisture in 2021. The continued presence of feral horses, though less evident in 2021, is also likely to negatively affect cover and production, especially when forage is scarce. The performance of the vegetation under these conditions suggests that the reclaimed plant communities are resilient and capable of sustaining themselves under adverse conditions that are characteristic of this region. While the reclamation in M-VMU-2 is now clearly capable of meeting and sustaining the post-mining land use, CMI will evaluate the results of this sampling program to determine what is needed to achieve the revegetation success criteria towards bond release.

5.0 REFERENCES

Bonham, C.D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons. New York, NY.

Clark, D.L. 2001. Stabilization of the mean as a demonstration of sample adequacy. American Society for Surface Mining and Reclamation Annual Meeting. Albuquerque, NM. June 3-7, 2001. ASSMR, Lexington, KY.

Mining and Minerals Division (MMD). 1999. Coal Mine Reclamation Program Vegetation Standards. Santa Fe, NM. April 30.

McDonald, L., and S. Howlin. 2013. Evaluation and comparison of hypothesis testing techniques for bond release application. University of Wyoming, Laramie, WY.

Parametrix. 2012. Revegetation Success Standards Report: McKinley Mine – Response to OSM. Prepared by Jim Nellessen of Parametrix, Albuquerque, New Mexico. April 2012.

New Mexico Department of Agriculture (NMDA). 2020. New Mexico Noxious Weed List Update. New Mexico State University, Las Cruces, NM. June 2020.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry (2nd edit.). W. H. Freeman and Co., San Francisco.

Schulz, A. M., R. P. Gibbens, and L. F. DeBano. 1961. Artificial populations for teaching and testing range techniques. J. Range Management. 14:236-242.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods applied to experiments in agriculture and biology. 6th ed. Ames, Iowa: Iowa State University Press.

Tables

Table 1: South Mine Seasonal and Annual Precipitation (2015-2021)

Year	Station	Precipitation (inches)													
		January	February	March	April	May	June	July	August	September	October	November	December	Annual Total	Growing Season Total
2015	South Tipple	2.05	1.59	0.11	0.52	1.64	1.11	2.37	1.62	0.30	1.36	1.31	0.76	**14.74**	*7.56*
	Rain 9				0.50	1.38	1.22	2.88	1.25	0.22	1.13	0.99			*7.45*
	Rain 10				0.42	1.32	1.11	2.59	1.39	0.30	1.10	0.78			*7.13*
	Rain 11				0.48	1.88	1.02	2.80	1.69	0.26	0.97	1.08			*8.13*
2016	South Tipple	0.62	0.22	0.05	1.31	0.80	0.07	1.37	1.74	1.75	0.40	1.57	1.84	**11.74**	*7.04*
	Rain 9				0.22	0.62	0.45	1.24	0.50	1.05	1.05	0.00			*4.08*
	Rain 10				0.13	0.55	0.20	2.75	0.38	0.99	0.14	0.02			*5.00*
	Rain 11				0.28	0.77	0.64	1.61	0.42	1.09	0.09	0.04			*4.81*
2017	South Tipple	1.25	1.64	0.48	0.35	0.77	0.42	2.48	0.90	1.34	0.15	0.09	0.02	**9.89**	*6.26*
	Rain 9				1.20	1.02	0.01	0.82	1.40	1.64	0.37	0.91			*6.09*
	Rain 10				1.00	0.67	0.08	0.94	1.63	1.36	0.34	0.81			*5.68*
	Rain 11				1.23	1.16	0.05	0.86	2.00	1.85	0.34	0.49			*7.15*
2018	South Tipple	0.35	0.79	0.54	0.09	0.29	0.51	2.61	1.34	1.10	1.65	0.19	0.29	**9.75**	*5.94*
	Rain 9				0.07	0.27	0.25	2.16	0.74	0.67	1.31	0.00			*4.16*
	Rain 10				0.08	0.20	0.27	3.05	1.15	0.92	1.51	0.00			*5.67*
	Rain 11				0.09	0.29	0.26	1.92	1.00	0.89	1.45	0.00			*4.45*
2019	South Tipple	1.30	1.81	1.23	0.44	1.77	0.33	0.22	0.05	1.59	0.09	1.14	0.85	**10.82**	*4.40*
	Rain 9				0.16	1.36	0.24	0.46	0.37	1.84	0.05	0.07			*4.43*
	Rain 10				0.20	1.49	0.37	0.19	0.27	1.34	0.03	0.05			*3.86*
	Rain 11				0.20	1.50	0.19	0.44	0.20	1.72	0.06	0.08			*4.25*
2020	South Tipple	0.98	1.44	1.35	0.17	0.01	0.04	1.13	0.24	0.15	0.26	0.40	0.27	**6.44**	*1.74*
	Rain 9				0.16	0.02	0.11	0.60	0.06	0.14	0.08	0.45			*1.09*
	Rain 10				0.11	0.02	0.13	0.79	0.14	0.14	0.16	0.09			*1.33*
	Rain 11				0.22	0.00	0.05	0.63	0.69	0.20	0.30	0.41			*1.79*
2021	South Tipple	1.11	0.34	0.40	0.07	0.08	0.37	5.45	1.24	2.12	1.77	0.55	2.26	**15.76**	*9.33*
	No. Bluff	1.13	0.21	0.46	0.04	0.04	0.20	2.17	1.31	1.13	0.86	0.20	0.92	**8.67**	*4.89*
	Rain 9				0.00	0.10	0.27	1.81	1.22	1.11	0.78	0.00			*4.51*
	Rain 10				0.01	0.06	0.24	2.48	1.80	0.96	0.80	0.00			*5.55*
	Rain 11				0.00	0.07	0.18	2.10	1.31	1.43	0.98	0.00			*5.09*
Window Rock, Long-term normals		0.72	0.68	0.88	0.61	0.49	0.47	1.75	2.05	1.23	1.14	0.83	0.95	**11.80**	*6.60*

Notes:
Long-term averages are from Window Rock, Arizona Station (029410), 1937 to 1999 (Western Regional Climate Center, 2020).
Growing season total precipitation is between April and September

Table 2: Revegetation Success Standards for the Mining and Minerals Division Permit Area

Vegetative Parameter	Success Standard
Ground Cover	15% live perennial/biennial cover
Productivity	350 air-dry pounds per acre perennial/biennial annual production
Diversity	A minimum of 2 shrub or subshrub taxa contributing at least 1% relative cover each.
	A minimum of 2 perennial warm-season grass taxa contributing at least 1% relative cover each.
	A minimum of 1 perennial cool-season grass taxa contributing at least 1% relative cover.
	A minimum of 3 perennial/biennial forb taxa combining to contribute at least 1% relative cover.
Woody Stem Stocking	150 live woody stems per acre

Note:

Diversity criteria assessed for individual perennial/biennial species relative cover as agreed upon by MMD and CMI in June 2019.

Table 3: Vegetation Cover, Density, and Production by Species, M-VMU-2, 2021

Scientific Name	Common Name	Code	Mean Vegetation Cover (%)			Mean Density (#/m^2)	Mean Annual Production (lbs/ac)
			Canopy	Basal	Relative Canopy[a]		
Cool-Season Grasses (19)							
Annuals (3)							
Field brome	*Bromus arvensis*	BRAR5	--	--	--	--	--
Cheatgrass	*Bromus tectorum*	BRTE	--	--	--	--	--
Sixweeks fescue	*Vulpia octoflora*	VUOC	--	--	--	--	--
Perennials (15)							
Indian ricegrass	*Achnatherum hymenoides*	ACHY	0.21	<0.05	0.94	0.48	4
Crested wheatgrass	*Agropyron cristatum*	AGCR	--	--	--	--	--
Smooth brome	*Bromus inermis*	BRIN2	--	--	--	--	--
Bottlebrush squirreltail	*Elymus elymoides*	ELEL	--	--	--	--	--
Blue wildrye	*Elymus glaucus*	ELGL	--	--	--	--	--
Thickspike wheatgrass	*Elymus lanceolatus*	ELLA3	0.86	0.06	3.83	0.80	9
Thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	ELLAL	--	--	--	--	--
Slender wheatgrass	*Elymus trachycaulus*	ELTR7	--	--	--	--	--
Needle and thread	*Hesperostipa comata*	HECO26	--	--	--	--	--
Foxtail barley	*Hordeum jubatum*	HOJU	--	--	--	--	--
Colorado wildrye	*Leymus ambiguus*	LEAM	--	--	--	--	--
Western wheatgrass	*Pascopyrum smithii*	PASM	0.95	<0.05	4.22	3.05	5
Russian wildrye	*Psathyrostachys juncea*	PSJU3	8.09	1.15	35.92	2.33	104
Intermediate wheatgrass	*Thinopyrum intermedium*	THIN6	--	--	--	--	--
Tall wheatgrass	*Thinopyrum ponticum*	THPO7	--	--	--	--	--
Warm-Season Grasses (8)							
Perennials (6)							
Sideoats grama	*Bouteloua curtipendula*	BOCU	--	--	--	--	--
Buffalograss	*Bouteloua dactyloides*	BODA2	--	--	--	--	--
Blue grama	*Bouteloua gracilis*	BOGR2	<0.05	<0.05	0.17	0.08	<1
James' galleta	*Pleuraphis jamesii*	PLJA	9.64	1.04	42.81	5.68	158
Alkali sacaton	*Sporobolus airoides*	SPAI	--	--	--	--	--
Sand dropseed	*Sporobolus cryptandrus*	SPCR	0.15	<0.05	0.67	<0.05	4
Forbs (45)							
Annuals (17)							
fetid marigold	*Dyssodia papposa*	DYPA	0.13	<0.05	<0.01	3.93	4
Lambsquarters	*Chenopodium album*	CHAL7	--	--	--	--	--
Mealy goosefoot	*Chenopodium incanum*	CHIN2	--	--	--	--	--
Narrowleaf goosefoot	*Chenopodium leptophyllum*	CHLE4	--	--	--	--	--
Common sunflower	*Helianthus annuus*	HEAN3	--	--	--	--	--
Longleaf false goldeneye	*Heliomeris longifolia*	HELO6	--	--	--	--	--
Kochia	*Kochia scoparia*	KOSC	--	--	--	--	--
Fendler's desertdandelion	*Malacothrix fendleri*	MAFE	--	--	--	--	--
Woolly plantain	*Plantago patagonica*	PLPA2	--	--	--	--	--
Erect knotweed	*Polygonum erectum*	POER2	--	--	--	--	--
Little hogweed	*Portulaca oleracea*	POOL	<0.05	<0.05	<0.01	<0.05	<1
Russian thistle	*Salsola tragus*	SATR	4.66	0.55	<0.01	3.18	91
Unknown annual forb	*Unknown Annual Forb*	UNKAF	0.10	<0.05	<0.01	0.95	2
Cowpen Daisy	*Verbesena encelioides*	VEEN	0.07	<0.05	<0.01	0.78	3
Rough cocklebur	*Xanthium strumarium*	XAST	--	--	--	--	--
Perennials/Biennials (28)							
Common yarrow	*Achillea millefolium*	ACMI2	--	--	--	--	--
Musk thistle	*Carduus nutans*	CANU4	--	--	--	--	--
Rattlesnake weed	*Chamaesyce albomarginata*	CHAL11	0.70	<0.05	3.12	3.83	6
Rose heath	*Chaetopappa ericoides*	CHER	--	--	--	--	--
Horseweed	*Conyza canadensis*	COCA	--	--	--	--	--
Flixweed	*Descurainia sophia*	DESO	--	--	--	--	--
Redstem stork's bill	*Erodium cicutarium*	ERCI6	<0.05	<0.05	0.06	0.20	<1
Curlytop gumweed	*Grindelia nuda var. aphanactis*	GRNUA	--	--	--	--	--
Curly-cup gumweed	*Grindelia squarosa*	GRSQ	--	--	--	--	--
Showy goldeneye	*Heliomeris multiflora*	HEMU3	--	--	--	--	--
Manyflowered ipomopsis	*Ipomopsis multiflora*	IPMU	--	--	--	--	--
Flatspine stickseed	*Lappula occidentalis*	LAOC3	<0.05	<0.05	0.08	0.13	<1
Prickly lettuce	*Lactuca serriola*	LASE	--	--	--	--	--
Lewis flax	*Linum lewisii*	LILE	--	--	--	--	--
Purple aster	*Machaeranthera canescens*	MACA	--	--	--	--	--
Tanseyleaf tansyaster	*Machaeranthera tanacetifolia*	MATA	--	--	--	--	--
Unknown blazingstar specie	*Mentzelia species*	MENTZ	--	--	--	--	--
Alfalfa	*Medicago sativa*	MESA	--	--	--	--	--
Palmer's penstemon	*Penstemon palmeri*	PEPA8	--	--	--	--	--
Prostrate knotweed	*Polygonum aviculare*	POAV	--	--	--	--	--
Upright prairie coneflower	*Ratibida columnifera*	RACO3	--	--	--	--	--
Tall tumblemustard	*Sisymbrium altissimum*	SIAL2	--	--	--	--	--
Scarlet globemallow	*Sphaeralcea coccinea*	SPCO	<0.05	<0.05	0.11	0.30	<1
Emory's globemallow	*Sphaeralcea emoryi*	SPEM	--	--	--	--	--
Gooseberryleaf globemallow	*Sphaeralcea grossulariifolia*	SPGR2	--	--	--	--	--
Spear globemallow	*Sphaeralcea hastulata*	SPHA	--	--	--	--	--
Gray globemallow	*Sphaeralcea incana*	SPIN2	--	--	--	--	--
Yellow salsify	*Tragopogon dubius*	TRDU	--	--	--	--	--
Unknown perennial forb	*Unknown Perennial Forb*	UNKPF	<0.05	<0.05	0.01	<0.05	<1
Shrubs, Trees and Cacti (33)							
Perennials (33)							
Prairie sagewort	*Artemisia frigida*	ARFR4	--	--	--	--	--
White sagebrush	*Artemisia ludoviciana*	ARLU	--	--	--	--	--
Big sagebrush	*Artemisia tridentata*	ARTR2	<0.05	<0.05	<0.01	<0.05	<1
Tubercled saltbush	*Atriplex acanthocarpa*	ATAC	--	--	--	--	--
Four-wing saltbush	*Atriplex canescens*	ATCA	0.68	<0.05	3.00	0.05	8
Shadscale saltbush	*Atriplex confertifolia*	ATCO	--	--	--	--	--
Mat saltbush	*Atriplex corrugata*	ATCO4	--	--	--	--	--
Gardner's saltbush	*Atriplex gardneri*	ATGA	--	--	--	--	--
Mound saltbush	*Atriplex obovata*	ATOB	--	--	--	--	--
Unknown saltbush species	*Atriplex species*	ATRIP	--	--	--	--	--
Yellow rabbitbrush	*Chrysothamnus viscidiflorus*	CHVI	--	--	--	--	--
Russian olive	*Elaeagnus angustifolia*	ELAN	--	--	--	--	--
Longleaf jointfir	*Ephedra trifurca*	EPTR	--	--	--	--	--
Mormon tea	*Ephedra viridis*	EPVI	--	--	--	--	--
Slenderleaf buckwheat	*Eriogonum leptophyllum*	ERLE10	--	--	--	--	--
Rubber rabbitbrush	*Ericameria nauseosa*	ERNA	1.38	0.20	6.14	0.10	104
Apache plume	*Fallugia paradoxa*	FAPA	--	--	--	--	--
Broom snakeweed	*Gutierrezia sarothrae*	GUSA	--	--	--	--	--
Hairy false goldenaster	*Heterotheca villosa*	HEVI	--	--	--	--	--
Oneseed juniper	*Juniperus monosperma*	JUMO	--	--	--	--	--
Winterfat	*Krascheninnikovia lanata*	KRLA	0.98	0.07	4.33	0.15	22
Torrey wolfberry	*Lycium torreyi*	LYTO	--	--	--	--	--
Plains pricklypear	*Opuntia polyacantha*	OPPO	--	--	--	--	--
Mexican cliffrose	*Purshia mexicana*	PUME	--	--	--	--	--
Antelope bitterbrush	*Purshia tridentata*	PUTR2	--	--	--	--	--
Skunkbush sumac	*Rhus trilobata*	RHTR	--	--	--	--	--
Woods' rose	*Rosa woodsii*	ROWO	--	--	--	--	--
Narrowleaf willow	*Salix exigua*	SAEX	--	--	--	--	--
Greasewood	*Sarcobatus vermiculatus*	SAVE4	--	--	--	--	--
Threadleaf groundsel	*Senecio flaccidus*	SEFL3	--	--	--	--	--
Saltcedar	*Tamarix ramosissima*	TARA	--	--	--	--	--
Gray horsebrush	*Tetradymia canescens*	TECA	--	--	--	--	--
Banana yucca	*Yucca baccata*	YUBA	--	--	--	--	--

Cover Components	Canopy	Basal
Perennial/Biennial Vegetation Cover	22.5	2.6
Total Vegetation Cover	27.5	3.2
Rock	5.2	6.0
Litter	18.4	18.4
Bare Soil	72.3	72.3

Notes:

[a] = relative cover is the average percent cover of a perennial/biennial species divided by the total perennial/biennial cover

$\#/m^2$ = number of plants per square meter

lbs/ac = air-dry forage pounds per acre

-- = observed in VMU during monitoring, but not recorded in the quadrats

Pathway or growing season for the grasses is from Allred (2005)

Duration for plants is from the USDA Plants Database

Table 4: Summary Statistics for M-VMU-2

	2019	2020	2021
Total Vegetation Canopy Cover (%)			
Mean	31.1	37.2	27.5
Standard Deviation	21.9	23.8	19.4
90% Confidence Interval	5.7	6.2	5.0
Nmin[1]	144	117	141
Probability within true mean[2]	0.67	0.66	0.33
Perennial/Biennial Canopy Cover (%)			
Mean	24.9	39.0	22.5
Standard Deviation	23.4	26.8	19.8
90% Confidence Interval	6.1	7.0	5.2
Nmin[1]	258	134	220
Probability within true mean[2]	0.72	0.67	0.29
Basal Cover (%)			
Mean	1.6	2.0	3.2
Standard Deviation	1.2	1.4	5.1
90% Confidence Interval	0.3	0.4	1.3
Nmin[1]	168	144	701
Probability within true mean[2]	0.69	0.67	0.16
Annual Forage Production (lbs/ac)			
Mean	787	627	425
Standard Deviation	1,120	794	644
90% Confidence Interval	291	207	167
Nmin[1]	576	456	652
Probability within true mean[2]	0.81	0.79	0.2
Annual Total Production (lbs/ac)			
Mean	1,011	634	523
Standard Deviation	1,142	798	640
90% Confidence Interval	297	207	167
Nmin[1]	363	449	425
Probability within true mean[2]	0.76	0.78	0.22
Shrub Density (stems/acre) from Quadrats			
Mean	12,342	7,082	1,315
Standard Deviation	26,731	9,289	2,316
90% Confidence Interval	6,952	2,416	602
Nmin[1]	1,332	488	880
Probability within true mean[2]	0.91	0.79	0.14
Shrub Density (stems/acre) from Belt Transect			
Mean	2,671	3,264	989
Standard Deviation	2,567	2,490	588
90% Confidence Interval	1,335	1,295	322
Nmin[1]	310	196	122
Probability within true mean[2]	0.62	0.59	0.43

Notes:

1 Minimum number of samples required to obtain 90 percent probability that the sample mean is within 10 percent of the population mean

2 Probability the true value of the mean is within 10 percent of the mean for the sample size

Table 5: M-VMU-2 Results for Diversity, 2019 to 2021

Parameter[1]	Standard (% relative cover)	2019		2020		2021	
		Result	Species	Result	Species	Result	Species
Subshrub or shrubs			(8 spp.)		(5 spp.)		(4 spp.)
Shrub 1	≥ 1.0%	21.78%	Four-wing saltbush	21.47%	Rubber rabbitbrush	6.14%	Rubber rabbitbrush
Shrub 2	≥ 1.0%	9.69%	Rubber rabbitbrush	11.78%	Winterfat	4.33%	Winterfat
Shrub 3 (bonus)	--	6.33%	Winterfat	3.52%	Gardner's saltbush	3.00%	Four-wing saltbush
Perennial warm-season grasses			(6 spp.)		(3 spp.)		(3 spp.)
Grass 1	≥ 1.0%	22.26%	James' galleta	23.24%	James' galleta	42.81%	James' galleta
Grass 2	≥ 1.0%	0.99%	Blue grama	3.17%	Blue grama	0.67%	Sand dropseed
Grass 3 (bonus)	--	0.36%	Buffalograss	2.42%	Alkali sactaon	0.17%	Blue grama
Perennial cool-season grasses			(10 spp.)		(11 spp.)		(4 spp.)
Grass 1	≥ 1.0%	9.40%	Western wheatgrass	6.97%	Colorado wildrye	35.92%	Russian wildrye
Grass 2 (bonus)	--	9.09%	Colorado wildrye	6.94%	Slender wheatgrass	4.22%	Western wheatgrass
Perennial/biennial forbs		3.52%	(8 spp.)	**0.68%**	(5 spp.)	**3.31%**	(5 spp.)
Forb 1	**≥ 1.0% (combined)**	0.80%	Scarlet globemallow	0.31%	Purple aster	3.12%	Rattlesnake weed
Forb 2		0.75%	Flatspine stickseed	0.21%	Flatspine stickseed	0.11%	Scarlet globemallow
Forb 3		0.73%	Purple aster	0.10%	Upright prairie coneflower	0.08%	Flatspine stickseed
Forb 4 (bonus)		0.52%	Palmer's penstemon	0.05%	Palmer's penstemon	--	--

Notes:

-- = not applicable

Indicates an unmet parameter

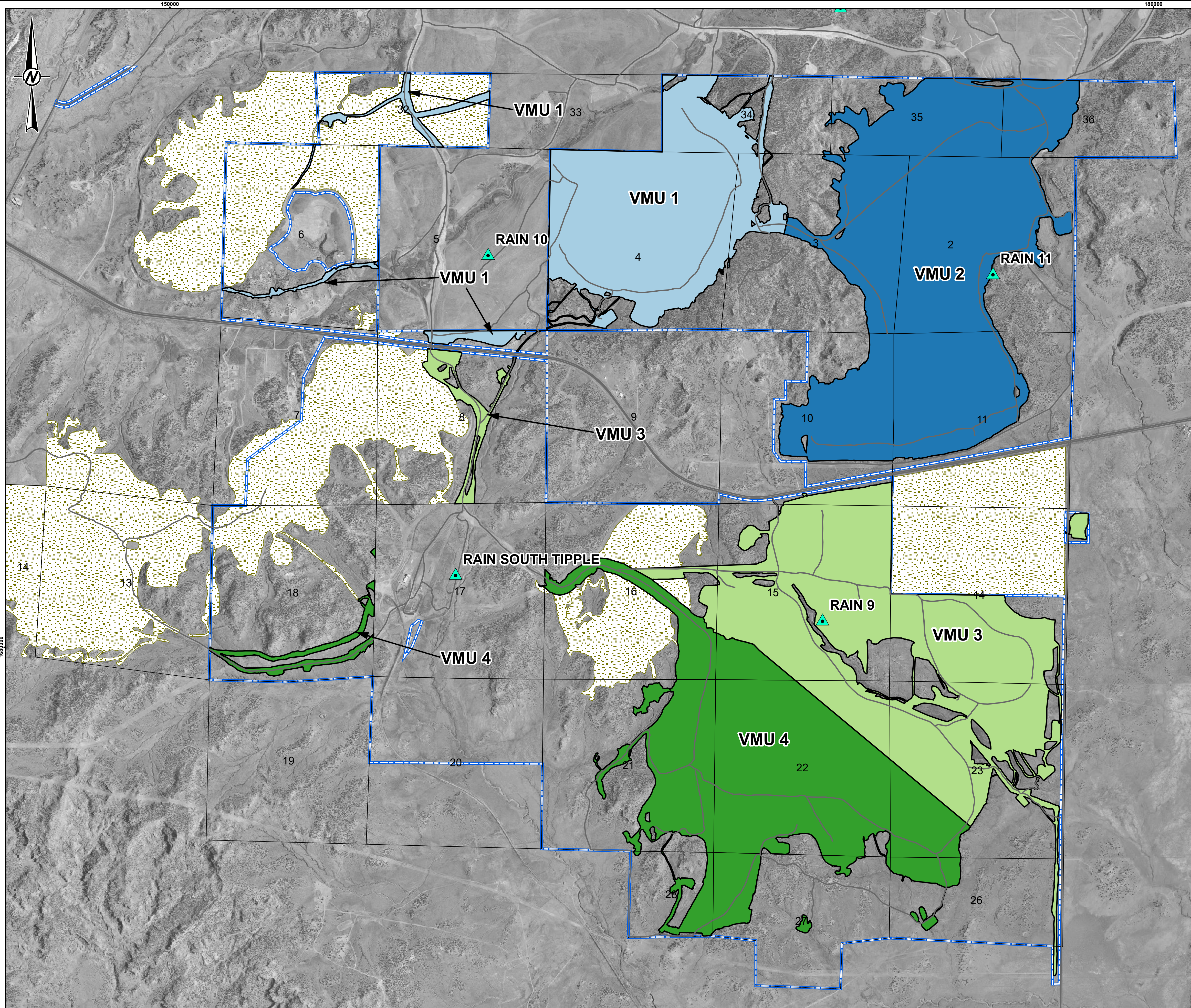
Table 6: M-VMU- 2 Statistical Analysis Results for Cover, Production, and Woody Plant Density, 2019 to 2021

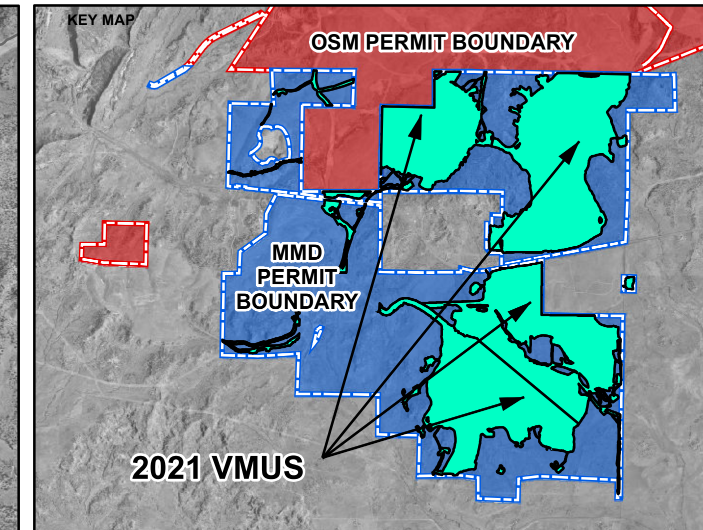
Vegetation Metric	Success Standard	Results		
		2019	2020	2021
Perennial/Biennial Cover	≥ 15%	24.9	39.0	22.5
Annual Forage Production	≥ 350 lb/ac	787	627	425
Woody Plant Density	≥ 150 stems/ac	2,671	3,264	989

Notes:

Hypothesis testing found the success standard was not met

Figures





LEGEND

- Rain Gauges
- Two-tracks, Roads and Highways
- MMD Permit Boundary
- PLSS - Sections
- Liability Release
- MMD VMU 1 (~ 839 acres)
- MMD VMU 2 (~ 1,518 acres)
- MMD VMU 3 (~ 1,284 acres)
- MMD VMU 4 (~ 1,238 acres)

0 3,000 6,000
1 inch = 3,000 feet Feet

NOTE(S)
1. VMU = VEGETATION MANAGEMENT UNIT FOR VEGETATION SAMPLING PLAN

REFERENCE(S)
COORDINATE SYSTEM: NAD 1927 STATEPLANE NEW MEXICO WEST FIPS 3003
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1927

CLIENT
CHEVRON MINING, INC. - MCKINLEY MINE
24 MILES, NW HWY 264
MENTMORE, NM 87319

PROJECT
MCKINLEY MINE - MMD PERMIT PHASE III BOND RELEASE,
2021 VEGETATION MONITORING

TITLE
2021 VEGETATION MANAGEMENT (2021) OVERVIEW

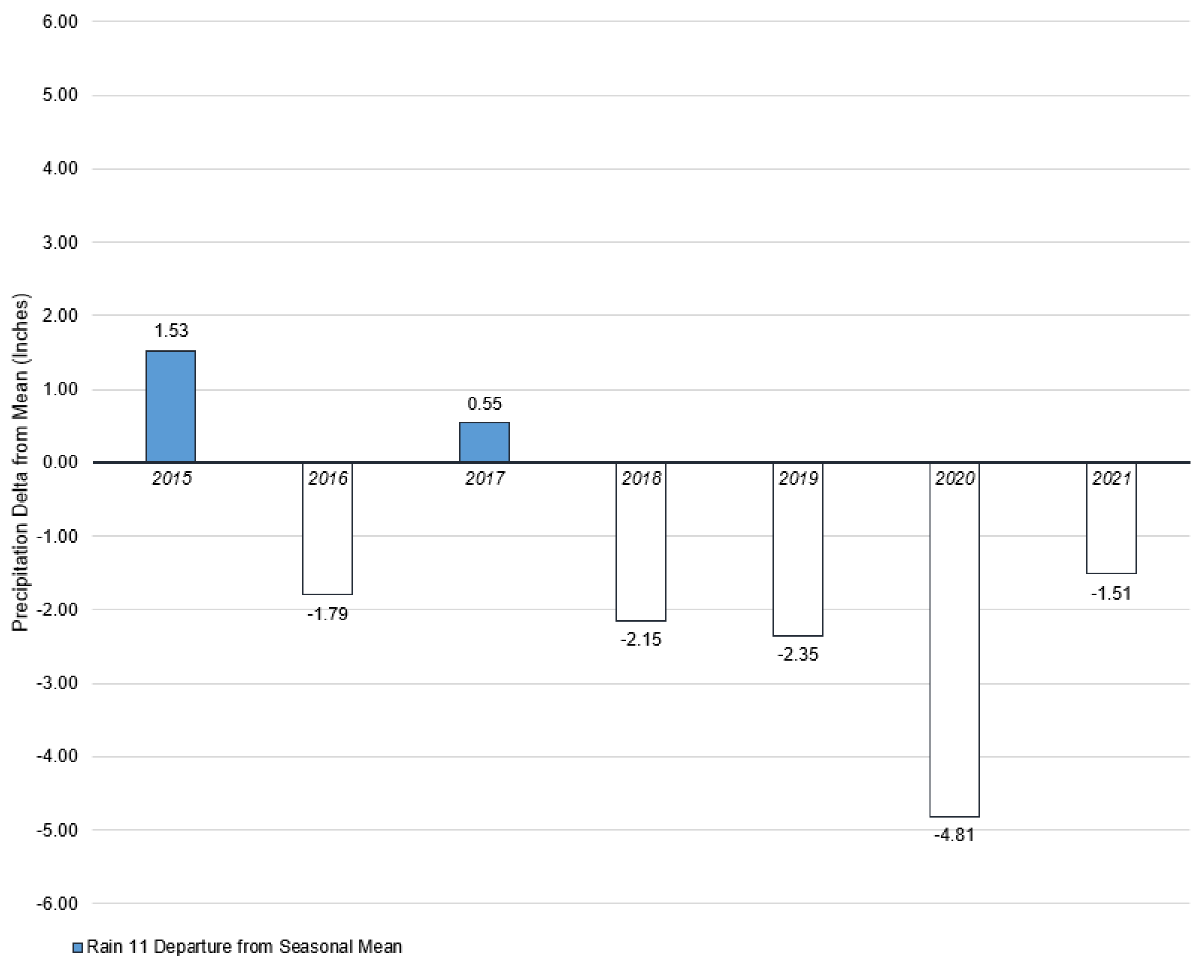
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-28
DESIGNED	GFD
PREPARED	GFD
REVIEWED	CD
APPROVED	KK

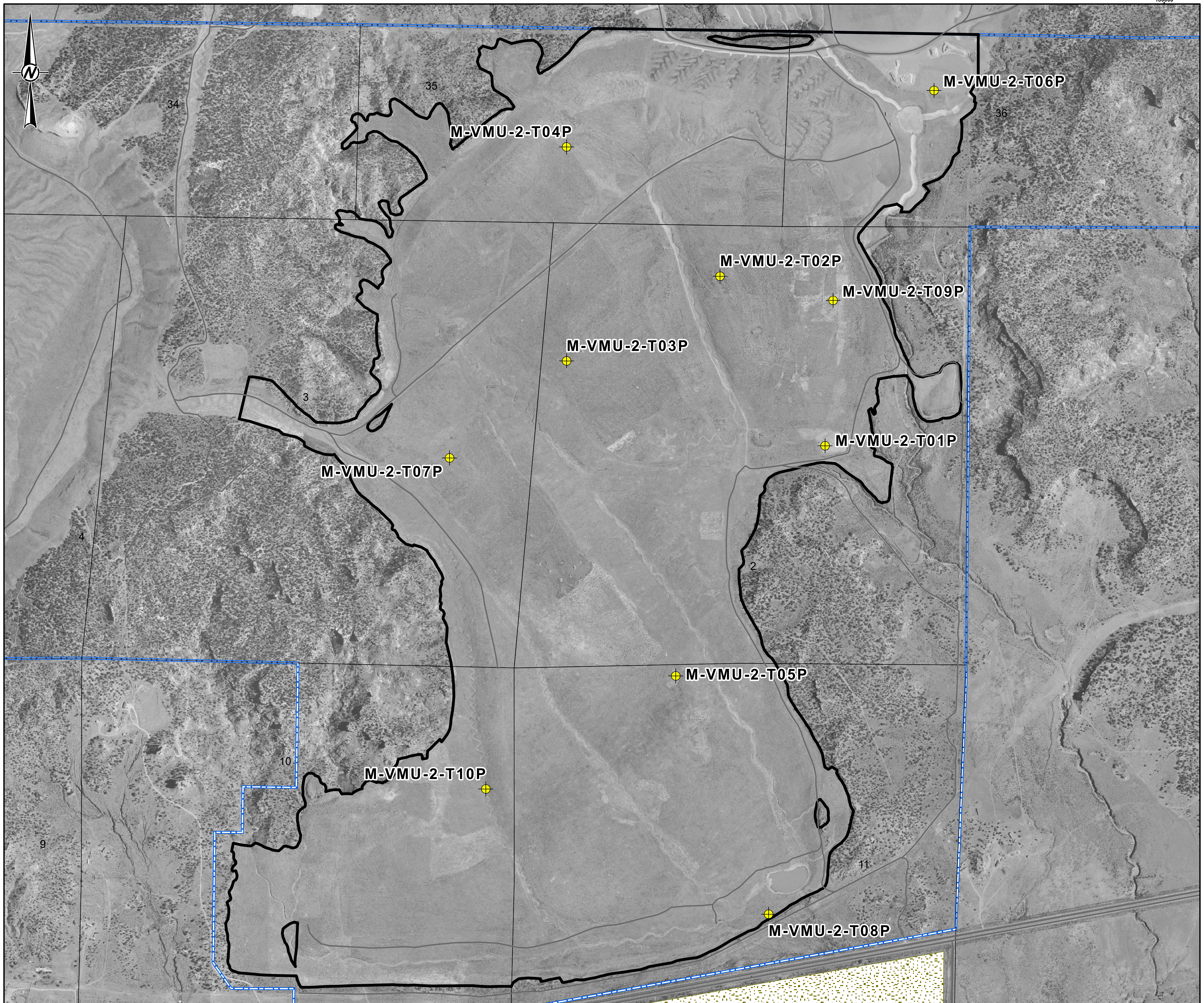
PROJECT NO.	CONTROL	REV.	FIGURE
1338105208	A001	1	1

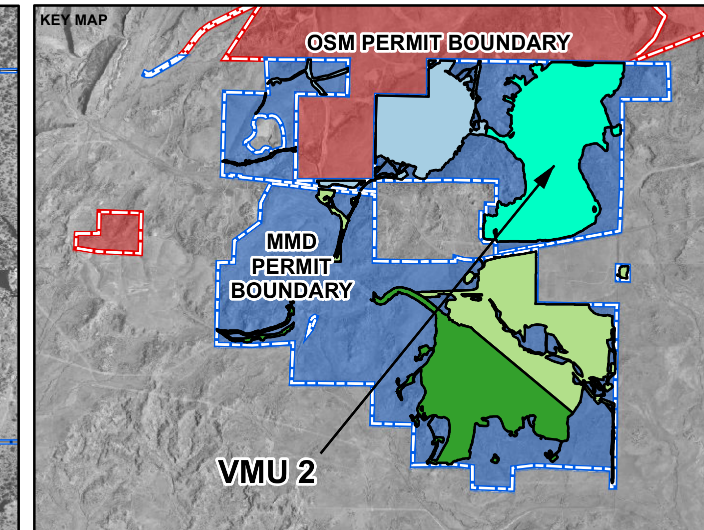
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Figure 2: Departure of Growing Season Precipitation from Long-Term Seasonal Mean at Window Rock; Rain 11 Gage



Long-term averages are from Window Rock, Arizona Station (029410) for 1937 to 1999 (Western Regional Climate Center, 2020).
Growing season total precipitation is the sum of monthly totals between April and September





LEGEND

- Primary Transect
- Two-tracks, Roads and Highways
- PLSS - Sections
- MMD VMU 2 (~ 1,518 acres)
- Liability Release
- MMD Permit Boundary

TRANSECT LABEL EXPLANATION:

M-VMU-1-T1P: MMD Permit Area; Vegetation Management Unit (VMU-#); Transect Number; Primary (P) or Alternate (A)

0 — 1,200 — 2,400

1 inch = 1,200 feet — Feet

NOTE(S)

1. KEY MAP SCALE IS DIFFERENT FROM OVERVIEW OF VMUS
2. TRANSECT LOCATIONS WERE CREATED IN ACCORDANCE WITH METHODS OUTLINED IN THE PERMIT

REFERENCE(S)

1. ORTHO SOURCE: CHEVRON, 2013

COORDINATE SYSTEM: NAD 1927 STATEPLANE NEW MEXICO WEST FIPS 3003
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1927

CLIENT
CHEVRON MINING, INC. - MCKINLEY MINE
24 MILES, NW HWY 264
MENTMORE, NM 87319

PROJECT
MCKINLEY MINE - MMD PERMIT PHASE III BOND RELEASE, 2021 VEGETATION MONITORING

TITLE
VEGETATION MONITORING TRANSECTS, 2021
VEGETATION MANAGEMENT UNIT 2

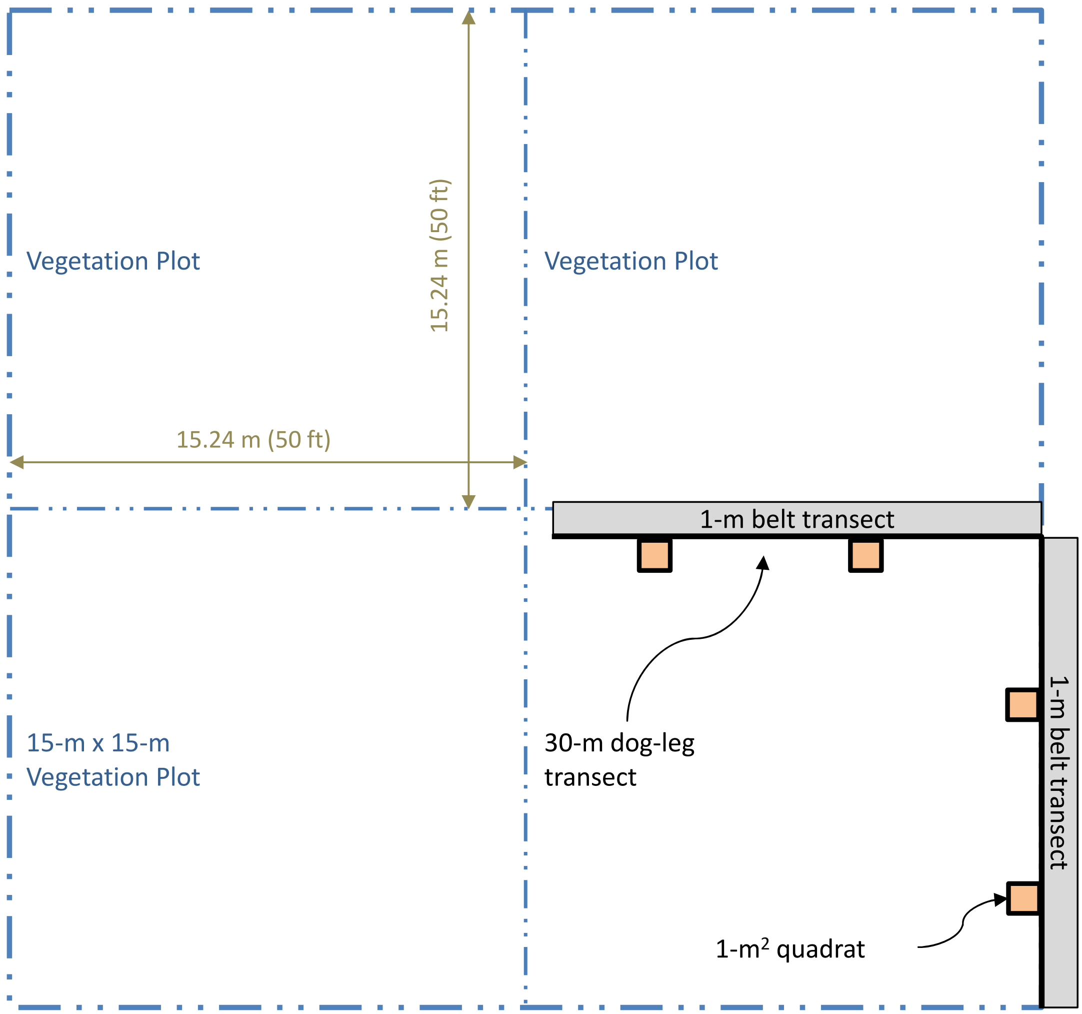
CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2022-02-28
DESIGNED	GFD
PREPARED	GFD
REVIEWED	CD
APPROVED	KK

PROJECT NO.	CONTROL	REV.	FIGURE
1338105208	A003	1	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Figure 4: Vegetation Plot, Transect, and Quadrat Layout



not to scale

Figure 5: Typical Grass-Shrubland Vegetation in M-VMU-2, September 2021

Figure 6: Stabilization of the Mean for Perennial/Biennial Cover - M-VMU-2, 2021

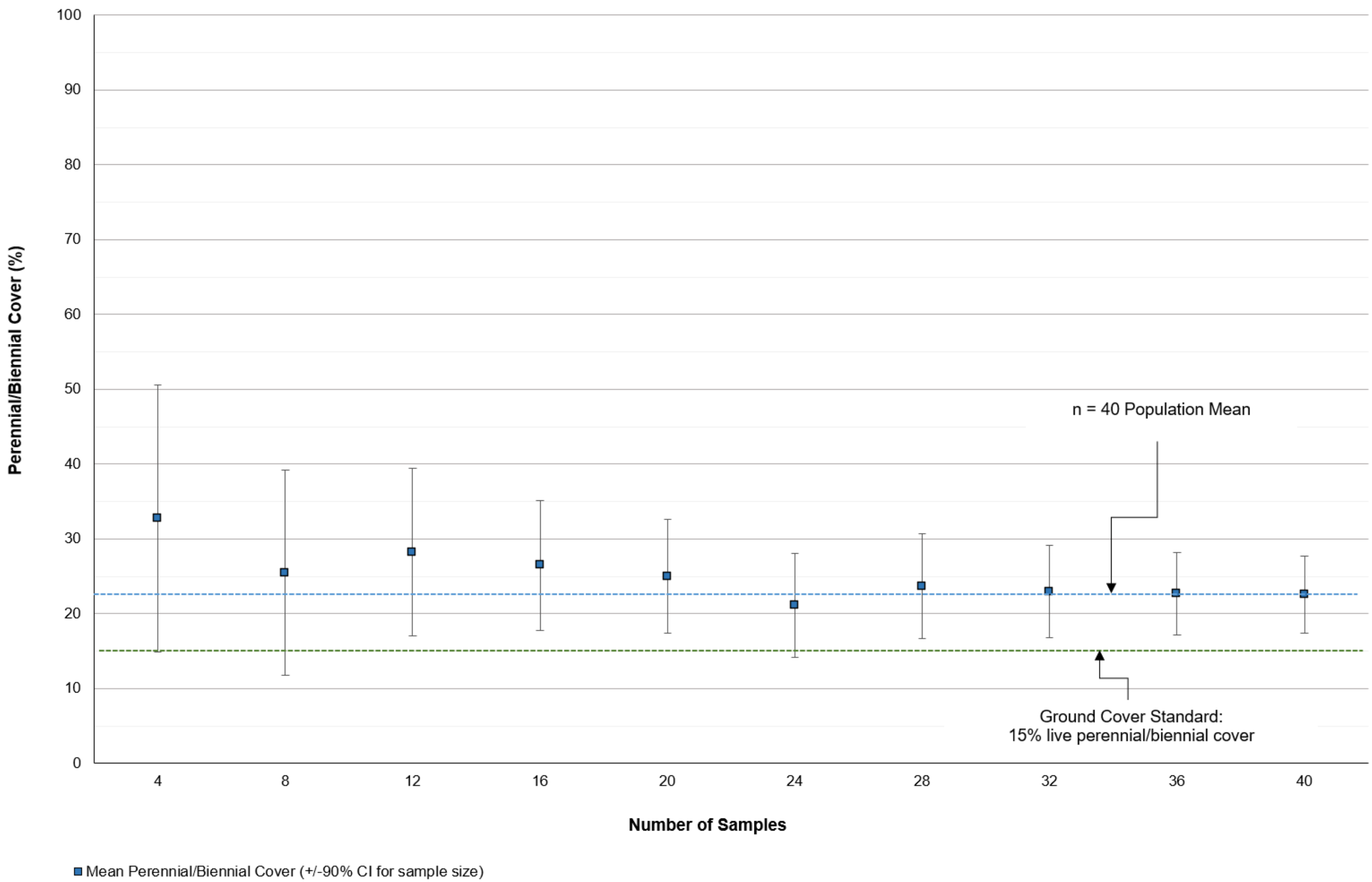


Figure 7: Stabilization of the Mean for Annual Forage Production - M-VMU-2, 2021

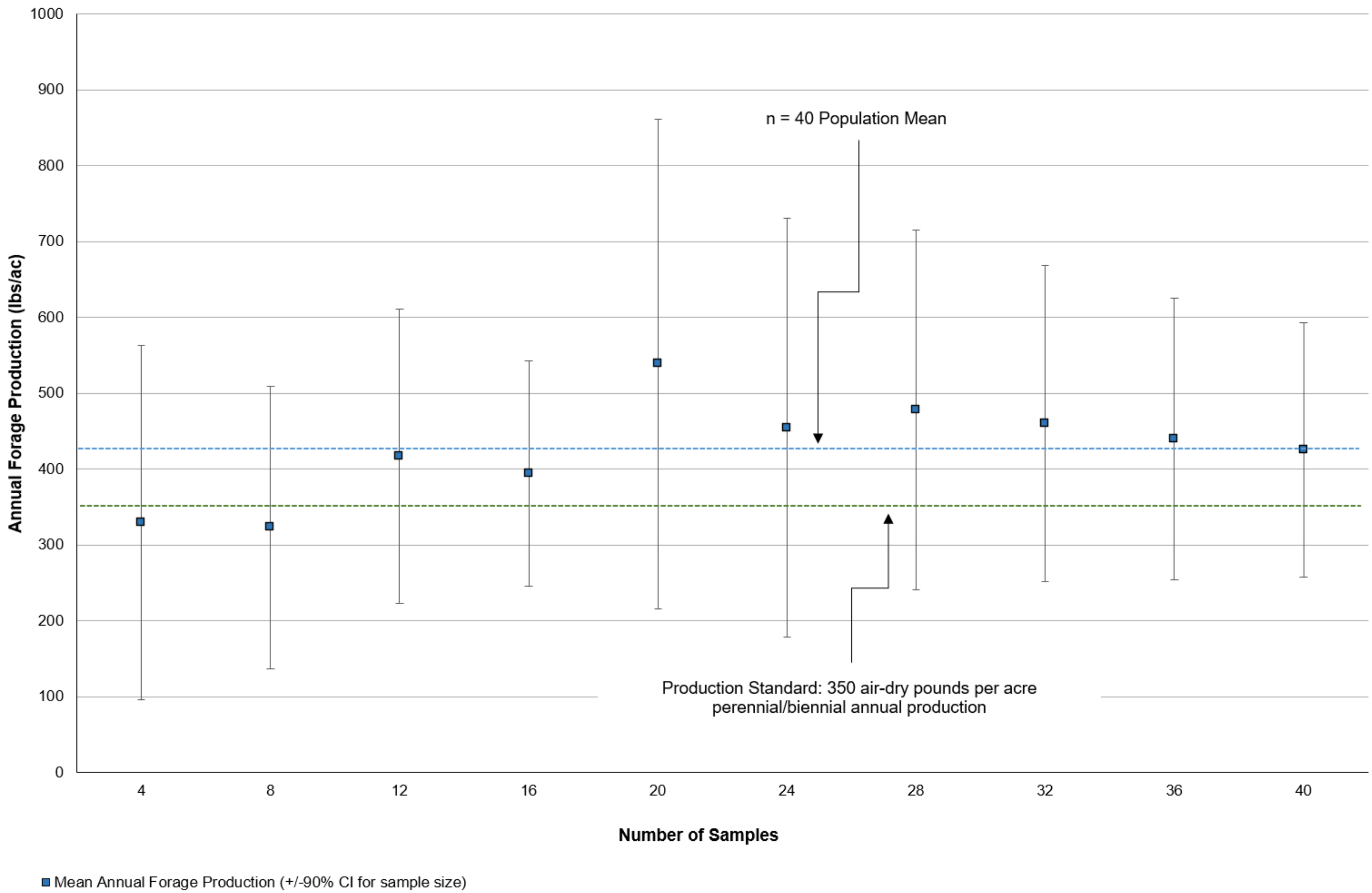
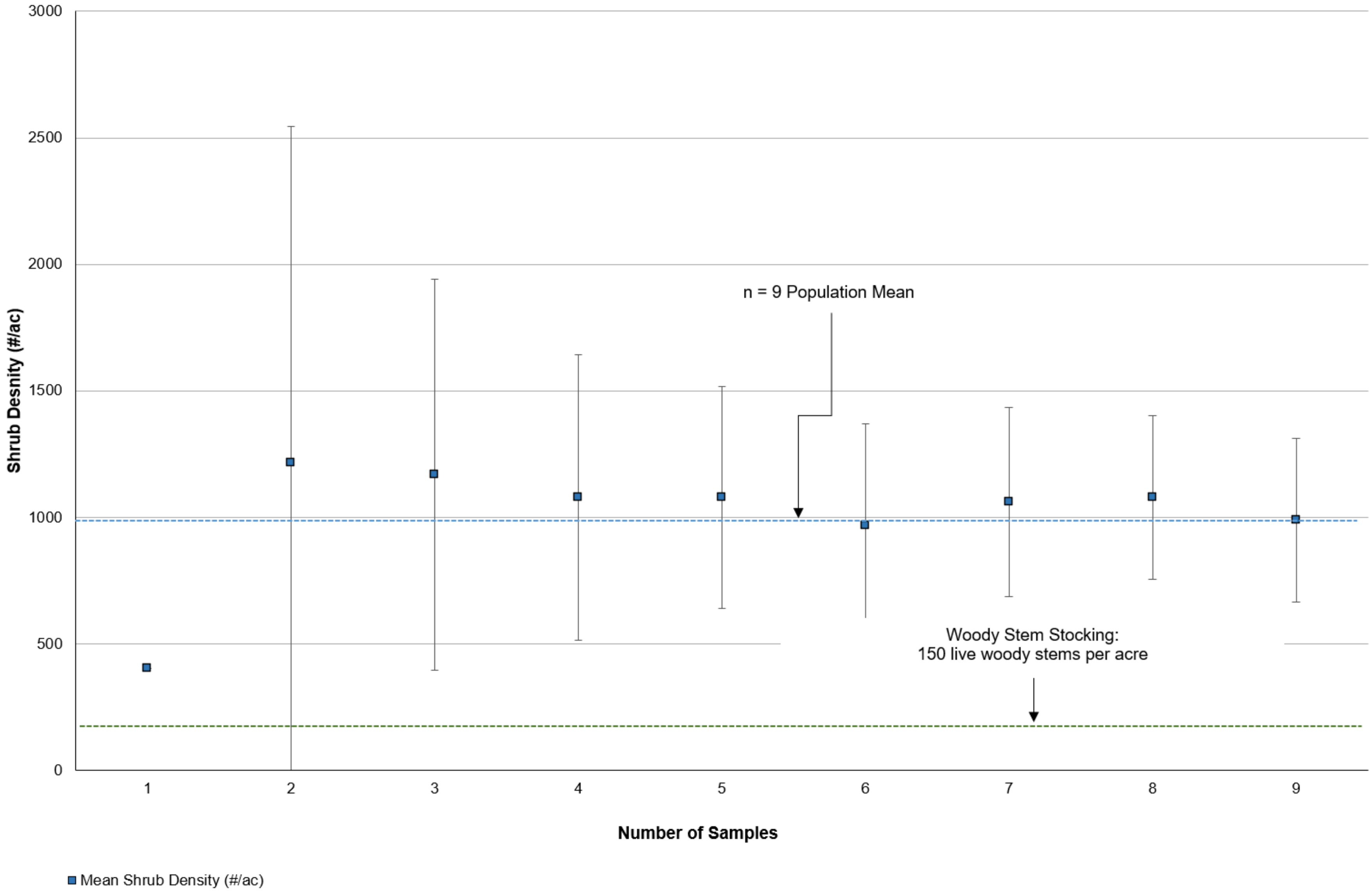


Figure 8: Stabilization of the Mean for Shrub Density - M-VMU-2, 2021



APPENDIX A

Vegetation Data Summary

Table A-1: M-VMU-2 Canopy Cover Data, 2021

Transect	M-VMU-2-T01P				M-VMU-2-T02P				M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T07P				M-VMU-2-T08P				M-VMU-2-T09P				M-VMU-2-T10P			
Quadrat	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Grasses																																								
Perennials																																								
ACHY	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	--	--	--	--	--	--	8.5	2.0	19.0	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.5	10.0	25.0	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5
PLJA	--	--	--	--	--	2.5	2.0	45.0	45.0	5.0	--	25.0	10.0	15.0	35.0	25.0	--	--	--	4.0	--	--	--	--	--	--	13.0	--	--	--	--	--	17.0	8.0	25.0	25.0	19.0	10.0	50.0	5.0
PSJU3	45.0	--	50.0	33.0	--	8.0	--	15.0	15.0	14.0	1.0	5.0	--	--	--	--	--	--	--	--	--	--	--	--	20.0	11.5	50.0	55.0	--	--	--	--	--	1.0	--	--	--	--	--	--
SPCR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.0	--	--	--	--	--	--	--	--	--	--	--
Forbs																																								
Annual																																								
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.3	5.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	--	--	--	--	--	--	--	--
SATR	0.1	--	< 0.1	0.5	--	--	--	--	--	1.0	1.0	--	--	--	--	--	0.3	0.5	--	--	14.0	55.0	32.0	50.0	--	--	--	--	11.0	--	< 0.1	12.0	6.0	--	--	3.0	< 0.1	--	--	--
UNKAF	--	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VEEN	0.1	2.0	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	0.2	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																																								
CHAL11	1.0	2.0	< 0.1	1.0	--	--	--	--	--	--	--	--	--	--	--	--	2.5	--	--	--	--	--	--	--	< 0.1	--	2.0	5.0	1.0	0.5	0.1	13.0	--	--	--	--	--	--	--	--
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	--	--	--
UNKPF	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																																								
Perennials																																								
ARTR2	--	--	--	--	--	--	--	--	--	--	--	--	--	< 0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.0	--	--	--	25.0	--	--	--	--	--	--	--	--	--	--	--	--
ERNA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	0.3	50.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	< 0.1	--	--	--	8.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	--	--	--	21.0	--	5.0	--	--	--	--	--	--	--
Cover Components																																								
Perennial/Biennial Vegetation Cover	46.0	2.0	50.1	34.0	3.5	10.5	2.0	60.0	60.0	27.0	1.0	30.0	10.0	15.0	35.0	25.0	9.0	10.3	75.0	6.5	--	--	5.0	2.0	20.0	11.5	70.0	86.3	12.0	9.0	23.1	32.0	22.0	9.0	25.0	25.0	20.0	10.0	50.0	5.5
Total Vegetation Cover	46.0	8.0	50.0	33.5	3.5	10.5	2.0	57.0	65.0	30.0	2.0	40.0	10.0	15.0	35.0	25.0	9.8	16.2	50.0	6.5	16.0	55.0	35.0	52.0	20.0	11.5	50.0	75.0	23.0	9.0	22.0	40.0	28.0	10.0	25.0	28.0	20.0	10.0	50.0	5.5
Rock	0.1	--	< 0.1	0.5	1.5	0.4	1.0	--	< 0.1	1.0	33.0	0.3	--	--	5.0	2.0	--	--	--	--	1.5	0.5	0.5	0.5	3.0	1.0	1.0	--	0.4	3.0	15.0	1.0	12.0	28.0	55.0	38.0	--	0.5	0.5	1.0
Litter	8.0	3.5	12.0	12.0	3.0	26.0	4.0	2.5	25.0	5.0	2.0	3.5	2.0	15.0	6.0	5.0	2.0	5.0	2.0	15.0	--	0.5	25.0	2.0	4.5	2.0	3.0	6.0	25.0	3.5	3.0	12.0	10.0	5.0	3.0	12.0	10.0	5.5	10.0	30.0
Base Soil	46.0	88.5	38.0	54.0	92.0	63.2	93.0	40.5	10.0	64.0	63.0	56.2	88.0	70.0	54.0	68.0	88.3	78.9	48.0	78.5	82.5	44.0	39.5	45.5	72.5	85.5	46.0	19.0	51.6	84.5	60.0	47.0	50.0	57.0	17.0	22.0	70.0	84.0	39.5	63.5

Notes:

Species codes defined in Table 3

Table A-2: M-VMU-2 Basal Cover Data, 2021

Transect	M-VMU-2-T01P				M-VMU-2-T02P				M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	3.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.5
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.5	10.0	25.0	1.0
PLJA	--	--	--	--	--	2.5	2.0	45.0	45.0	5.0	--	25.0	10.0	15.0	35.0	25.0	--	--	--	4.0
PSJU3	45.0	--	50.0	33.0	--	8.0	--	15.0	15.0	14.0	1.0	5.0	--	--	--	--	--	--	--	--
SPCR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Forbs																				
Annual																				
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	< 0.1	0.3	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SATR	< 0.1	--	< 0.1	< 0.1	--	--	--	--	--	< 0.1	< 0.1	--	--	--	--	--	< 0.1	< 0.1	--	--
UNKAF	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VEEN	< 0.1	0.3	< 0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	< 0.1	< 0.1	--	--
Perennials																				
CHAL11	1.0	2.0	< 0.1	1.0	--	--	--	--	--	--	--	--	--	--	--	--	2.5	--	--	--
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKPF	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ARTR2	--	--	--	--	--	--	--	--	--	--	--	--	--	< 0.1	--	--	--	--	--	--
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ERNA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.0	0.3	50.0	--
KRLA	--	--	--	--	--	< 0.1	--	--	--	8.0	--	--	--	--	--	--	--	--	--	--
Cover Components																				
Perennial/Biennial Vegetation Cover	46.0	2.0	50.1	34.0	3.5	10.5	2.0	60.0	60.0	27.0	1.0	30.0	10.0	15.0	35.0	25.0	9.0	10.3	75.0	6.5
Total Vegetation Cover	25.1	0.8	12.1	1.1	0.3	0.8	0.3	10.0	2.5	1.7	0.1	5.1	0.5	0.8	1.0	1.0	0.2	0.9	8.1	0.7
Rock	0.1	--	< 0.1	0.1	1.5	0.4	1.0	--	< 0.1	1.3	33.0	9.0	--	--	5.5	2.0	--	--	--	--
Litter	15.0	35.0	45.0	15.0	1.0	3.0	5.0	33.0	60.0	10.0	2.0	14.0	3.0	5.0	25.0	8.0	7.5	8.0	75.0	16.0
Base Soil	59.9	64.3	42.8	83.8	97.2	95.9	93.7	57.0	37.5	87.1	64.9	72.0	96.5	94.3	68.5	89.0	92.3	91.1	16.9	83.3

Transect	M-VMU-2-T06P				M-VMU-2-T07P				M-VMU-2-T08P				M-VMU-2-T09P				M-VMU-2-T10P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	--	--	5.0	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	5.0	--	--	--	--	--	--	8.5	2.0	19.0	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5
PLJA	--	--	--	--	--	--	13.0	--	--	--	--	--	17.0	8.0	25.0	25.0	19.0	10.0	50.0	5.0
PSJU3	--	--	--	--	20.0	11.5	50.0	55.0	--	--	--	--	--	1.0	--	--	--	--	--	--
SPCR	--	--	--	--	--	--	--	--	6.0	--	--	--	--	--	--	--	--	--	--	--
Forbs																				
Annual																				
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	< 0.1	--	--	--	--	--	--	--	--
SATR	0.3	0.5	10.0	11.0	--	--	--	--	0.1	--	< 0.1	0.1	0.1	--	--	0.1	< 0.1	--	--	--
UNKAF	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VEEN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																				
CHAL11	--	--	--	--	< 0.1	--	2.0	5.0	1.0	0.5	0.1	13.0	--	--	--	--	--	--	--	--
ERCI6	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	0.8	--	--	--	--	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	--	--	--
UNKPF	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ARTR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ATCA	--	--	--	2.0	--	--	--	25.0	--	--	--	--	--	--	--	--	--	--	--	--
ERNA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	--	5.0	--	--	--	21.0	--	5.0	--	--	--	--	--	--	--
Cover Components																				
Perennial/Biennial Vegetation Cover	--	--	5.0	2.0	20.0	11.5	70.0	86.3	12.0	9.0	23.1	32.0	22.0	9.0	25.0	25.0	20.0	10.0	50.0	5.5
Total Vegetation Cover	0.3	0.5	10.8	11.5	0.8	1.0	2.3	3.2	1.1	0.8	1.8	1.0	0.4	2.3	3.0	0.9	1.6	0.6	12.0	0.6
Rock	1.5	0.5	0.5	0.5	3.0	1.0	2.0	--	0.4	3.0	17.0	2.0	15.0	32.0	56.0	50.0	< 0.1	0.5	0.8	1.5
Litter	15.0	8.0	20.0	10.0	3.5	9.0	25.0	50.0	8.0	4.0	5.0	50.0	15.0	12.0	15.0	25.0	8.0	3.0	33.0	33.0
Base Soil	83.3	91.0	68.8	78.0	92.8	89.0	70.7	46.8	90.5	92.2	76.2	47.0	69.7	53.8	26.0	24.2	90.4	96.0	54.3	64.9

Notes:

Species codes defined in Table 3

T = Trace amount of cover; 0.033 is the trace value used for data analysis purposes

Table A-3: M-VMU-2 Frequency Data (counts), 2021

Transect	M-VMU-2-T01P				M-VMU-2-T02P				M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T07P				M-VMU-2-T08P				M-VMU-2-T09P				M-VMU-2-T10P			
Quadrat	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Grasses																																								
Perennials																																								
ACHY	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	--	--	--	--	--	--	23	2	3	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	21	66	32	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1
PLJA	--	--	--	--	--	5	4	23	15	3	--	27	28	33	18	6	--	--	--	7	--	--	--	--	--	--	8	--	--	--	--	--	5	3	24	8	4	4	1	1
PSJU3	16	--	7	8	--	2	--	7	3	4	1	2	--	--	--	--	--	--	--	--	--	--	--	--	7	10	5	20	--	--	--	--	--	1	--	--	--	--	--	--
SPCR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--
Forbs																																								
Annual																																								
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	9	148	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--
SATR	1	--	1	2	--	--	--	--	--	2	1	--	--	--	--	--	5	1	--	--	10	56	11	17	--	--	--	--	7	--	1	2	4	--	--	4	2	--	--	--
UNKAF	--	38	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
VEEN	1	13	2	--	--	--	--	--	--	--	--	--	--	--	--	--	5	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																																								
CHAL11	3	15	1	8	--	--	--	--	--	--	--	--	--	--	--	--	54	--	--	--	--	--	--	--	1	--	7	8	13	10	3	30	--	--	--	--	--	--	--	--
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5	--	--	--	--	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12	--	--	--
UNKPF	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																																								
Perennials																																								
ARTR2	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--
ERNA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	1	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	1	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	1	--	1	--	--	--	--	--	--	--

Notes:
Species codes defined in Table 3
The quadrat (plot) size is one square meter ($1m^2$; see Figure 4); plants rooted in the quadrat were counted on an individual basis

Table A-4: M-VMU-2 Aboveground Annual Production Data, 2021

Transect	M-VMU-2-T01P				M-VMU-2-T02P				M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T07P				M-VMU-2-T08P				M-VMU-2-T09P				M-VMU-2-T10P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses (g/m^2)																																								
Forage																																								
ACHY	--	--	--	--	7.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	11.3	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.3	--	--	--	--	--	--	18.2	2.6	15.7	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.8	16.7	0.6	1.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.6
PLJA	--	--	--	--	2.8	4.1	0.9	92.3	128.2	5.4	--	67.3	19.5	61.9	45.4	19.6	--	--	--	5.8	--	--	--	--	--	--	16.7	--	--	--	--	--	33.0	22.3	31.4	23.1	5.1	43.6	51.2	29.9
PSJU3	72.9	--	49.7	21.4	--	21.0	--	7.1	21.7	42.7	0.3	0.3	--	--	--	--	--	--	--	--	--	--	--	--	62.7	69.2	26.8	68.8	--	--	--	--	--	0.5	--	--	--	--	--	--
SPCR	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19.4	--	--	--	--	--	--	--	--	--	--	--
Forbs (g/m^2)																																								
Non-forage																																								
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	15.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	--	--
SATR	0.2	--	--	0.4	--	--	--	--	--	1.2	2.4	--	--	--	--	--	1.1	1.2	--	--	22.2	95.2	135.9	55.0	--	--	--	--	37.3	--	--	19.3	34.5	--	--	3.7	0.1	--	--	--
VEEN	--	10.9	0.8	--	--	--	--	--	--	--	--	--	--	--	--	--	0.4	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
UNKAF	--	8.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Forage																																								
CHAL11	0.5	1.6	--	0.6	--	--	--	--	--	--	--	--	--	--	--	--	2.9	--	--	--	--	--	--	--	0.9	--	1.0	1.5	2.1	1.1	0.2	13.2	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.7	--	--	--
Shrubs, Trees and Cacti (g/m^2)																																								
Forage																																								
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12.7	--	--	--	22.2	--	--	--	--	--	--	--	--	--	--	--	--
ERNA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	19.0	1.0	446.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	6.4	--	--	--	5.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	7.9	--	--	--	66.8	--	11.6	--	--	--	--	--	--	--
Total Air-dry Aboveground Annual Production (g/m^2)																																								
Non-forage	0.4	10.9	0.8	0.4	--	--	--	--	--	1.2	2.4	--	--	--	--	--	2.6	17.7	--	--	22.2	95.2	135.9	55.0	--	--	--	--	37.3	--	--	19.6	34.5	--	--	3.7	0.1	--	--	--
Forage	73.4	1.6	49.7	22.0	10.0	31.5	0.9	99.4	149.9	53.3	0.3	67.6	19.5	61.9	45.4	19.6	25.6	17.6	447.4	10.5	--	--	2.3	12.7	63.7	69.2	52.4	92.5	32.8	19.3	69.6	28.9	44.5	22.8	31.4	23.1	7.7	43.6	51.2	30.4
Total Production	73.8	12.5	50.5	22.4	10.0	31.5	0.9	99.4	149.9	54.4	2.7	67.6	19.5	61.9	45.4	19.6	28.2	35.3	447.4	10.5	22.2	95.2	138.2	67.7	63.7	69.2	52.4	92.5	70.1	19.3	69.6	48.5	79.0	22.8	31.4	26.8	7.8	43.6	51.2	30.4
Total Air-dry Aboveground Annual Production (lbs/ac)																																								
Non-forage	4	97	7	3	--	--	--	--	--	11	22	--	--	--	--	--	23	158	--	--	198	850	1212	491	--	--	--	--	332	--	--	175	308	--	--	33	1	--	--	--
Forage	655	14	443	197	90	281	8	887	1337	475	3	603	174	552	405	175	229	157	3991	94	--	--	20	113	568	617	467	825	293	172	621	258	397	204	280	206	69	389	457	272
Total Production	659	111	451	200	90	281	8	887	1337	486	24	603	174	552	405	175	252	315	3991	94	198	850	1233	604	568	617	467	825	625	172	621	432	705	204	280	239	70	389	457	272

Notes:
g/m^2 = grams per square meter
lbs/ac = pounds per acre
1 gram per square meter (g/m^2) is equal to 8.922 pounds per acre (lbs/ac)
Species codes defined in Table 3
Non-forage and forage determinations are based on the permit (e.g. plants of perennial and/or biennial duration are forage and plants of annual duration are non-forage; noxious weeds are non-forage)

Table A-5: M-VMU-2 Shrub Belt Transect Data, 2021

Transect	M-VMU-2-T01P	M-VMU-2-T02P	M-VMU-2-T03P	M-VMU-2-T04P	M-VMU-2-T05P	M-VMU-2-T06P	M-VMU-2-T07P	M-VMU-2-T08P	M-VMU-2-T09P	M-VMU-2-T10P
Shrubs, Trees and Cacti										
ATCA	0	4	1	4	0	3	2	2	2	data corrupted
ATCO	0	0	1	0	0	0	0	0	0	
EPTR	0	2	0	0	0	0	0	0	0	
ERNA	3	1	0	2	8	0	0	0	0	
KRLA	0	8	6	0	0	0	10	7	0	

Notes:

The shnrub belt transect area (plot) is 30m2 (1mx30m; see Figure 4); shrubs rooted in the belt transect were counted on an individual basis

Code	Scientific Name	Common Name
ATCA	*Atriplex canescens*	Four-wing saltbush
ATCO	*Atriplex confertifolia*	Shadscale saltbush
EPTR	*Ephedra trifurca*	Longleaf jointfir
ERNA	*Ericameria nauseosa*	Rubber rabbitbrush
KRLA	*Krascheninnikovia lanata*	Winterfat

APPENDIX B

Quadrat Photographs

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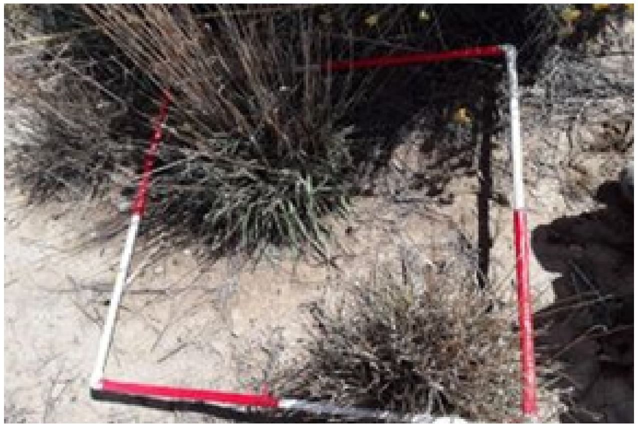
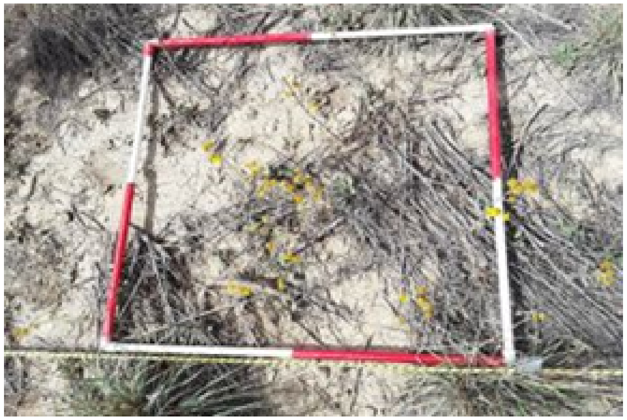
<tr><td></td><td></td></tr>
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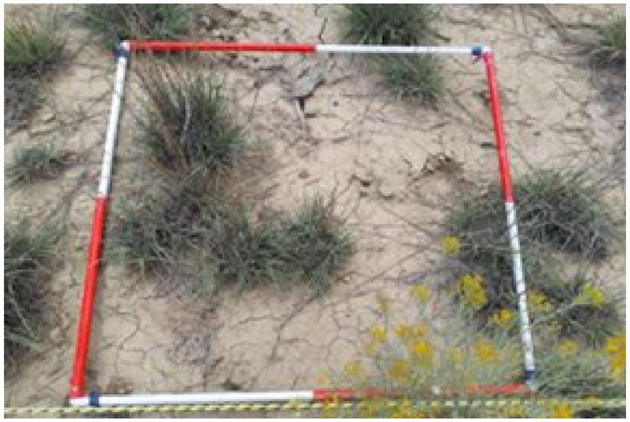
<tr><td></td><td></td></tr>
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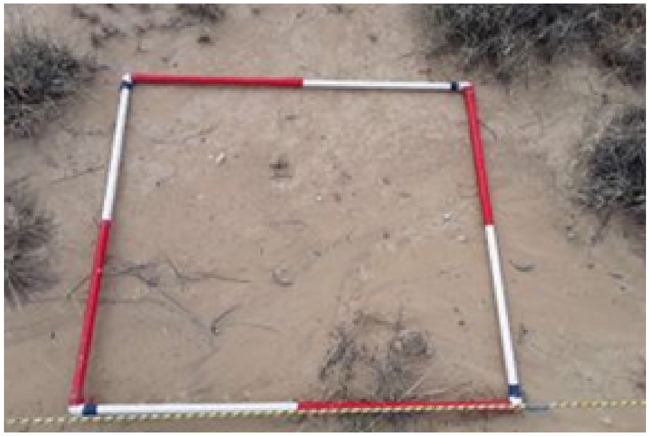
Q1

Q2



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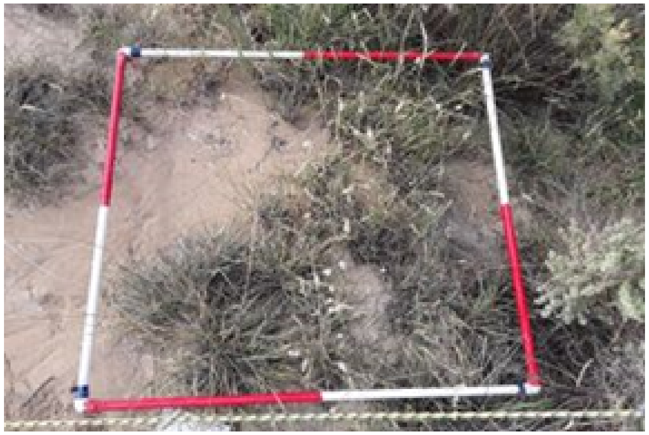

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	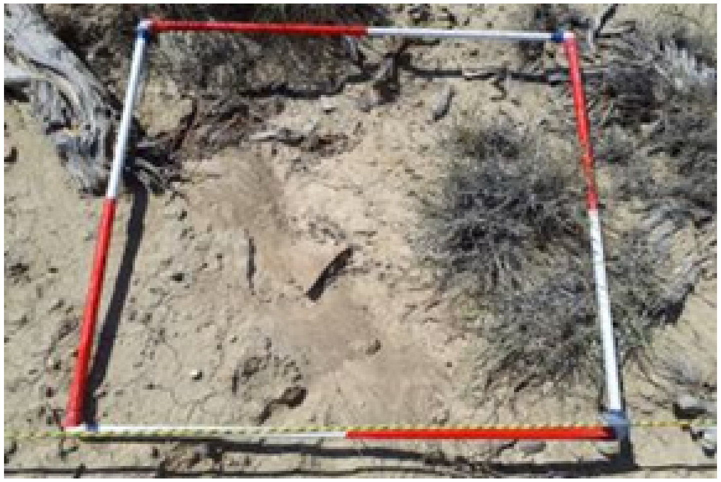
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Q1	Q2
	
Q3	Q4

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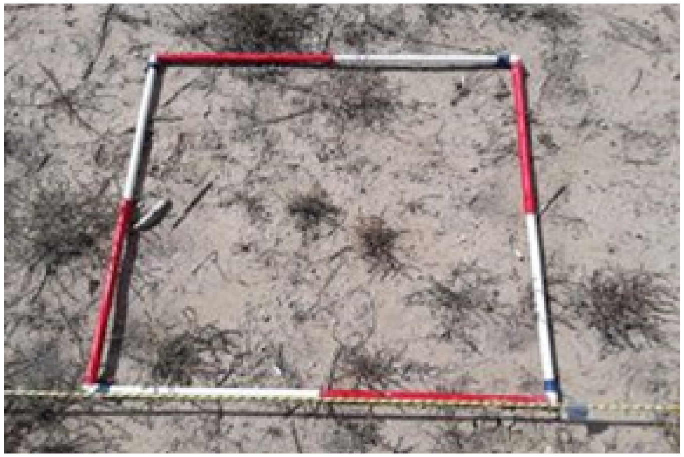

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Q4

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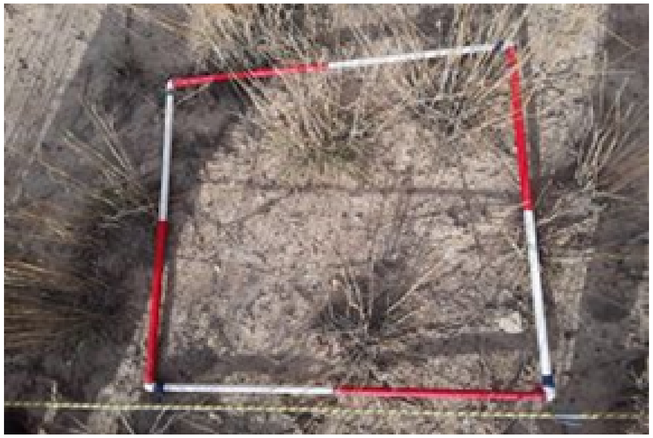	
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Q3	Q4

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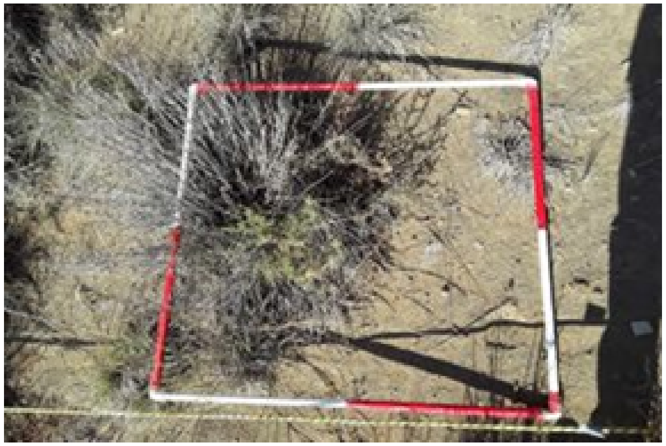	
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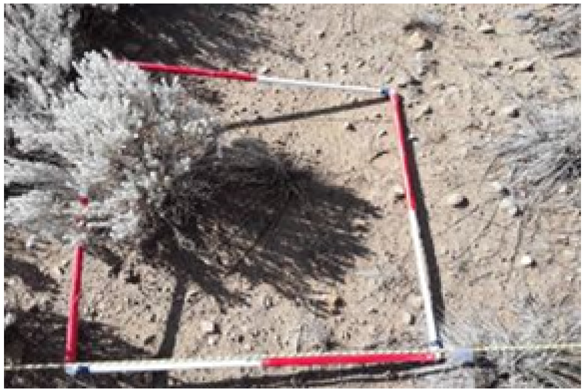	
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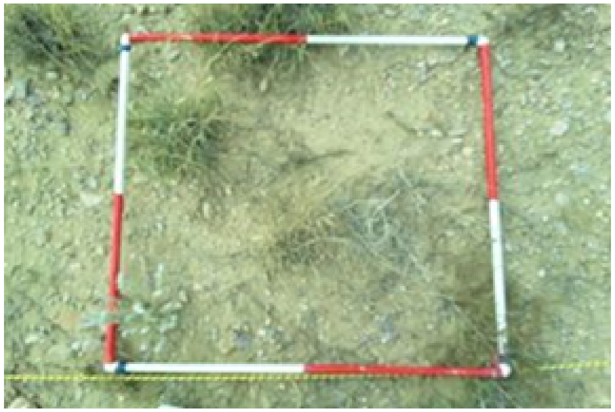
<tr><td></td><td></td></tr>
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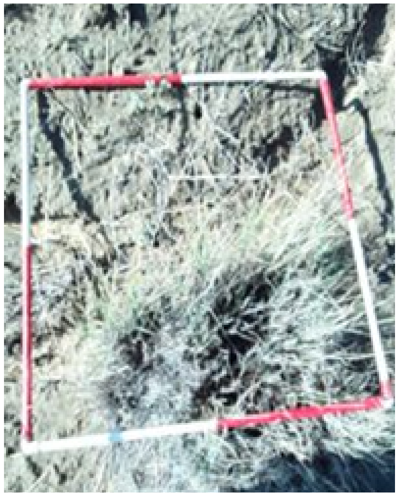	
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	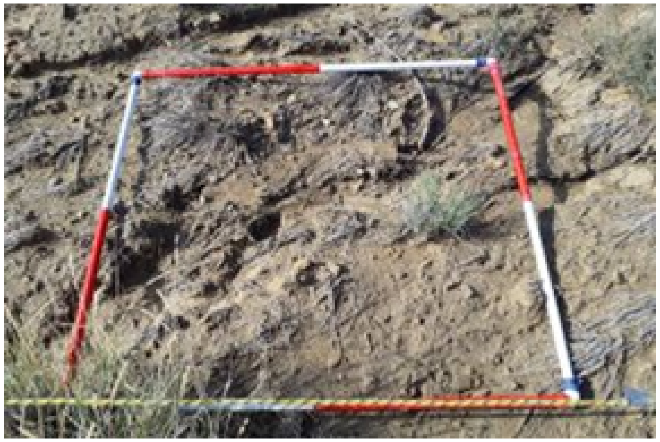
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APPENDIX C

Vegetation Statistical Analysis

Figure C-1: Distribution: Raw Data: 2021 Perennial / Biennial Cover (%)

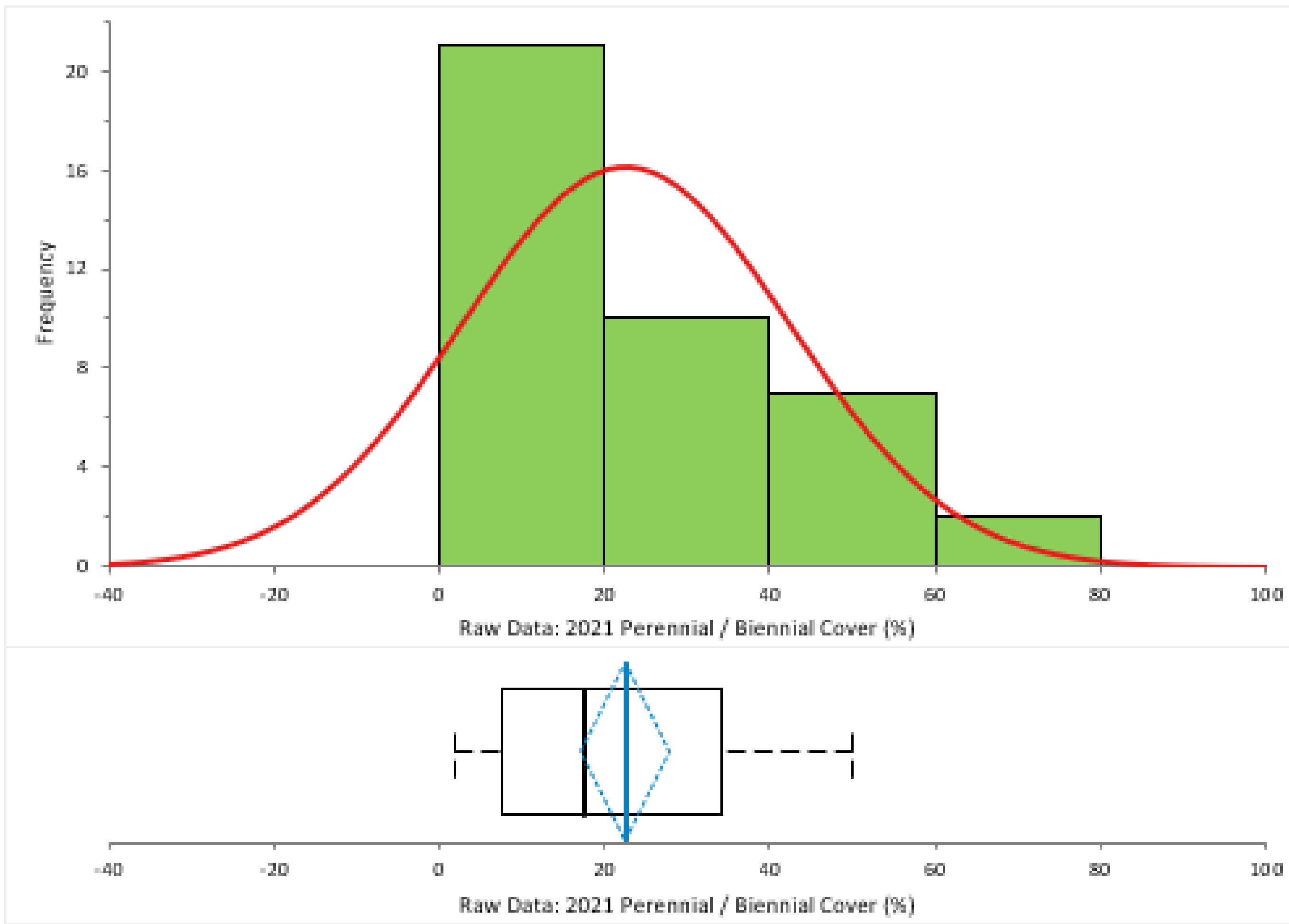
Analyse-it v5.68

Table C-2: M-VMU-1 2021 Data for Normal Distribution and Variance Analysis

Filter: No filter

Last updated 24 February 2022 at 15:53 by Buchanan, Nicholas

Descriptives

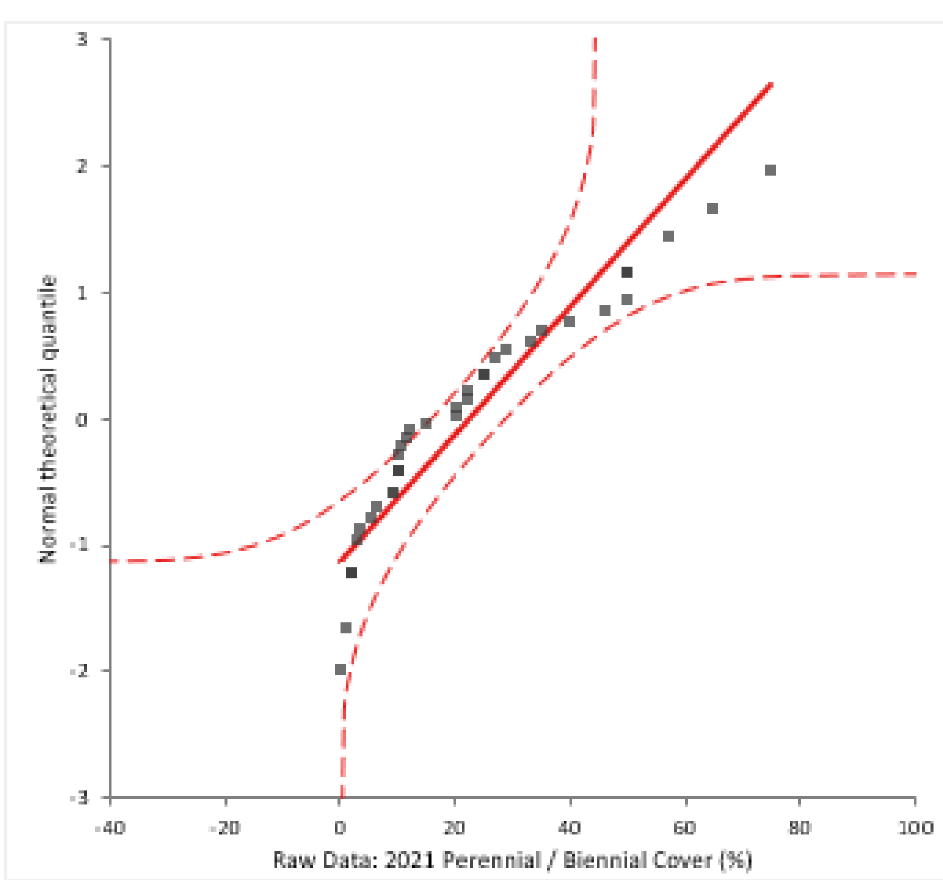


N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2021 Perennial / Biennial Cover (%)	22.51	17.23 to 27.80	3.136	19.83	0.9	0.00

	1st quartile	Median	3rd quartile
Raw Data: 2021 Perennial / Biennial Cover (%)	7.54	17.50	34.17

Normality



Shapiro-Wilk test

W statistic	0.89
p-value	0.0011 [1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-2: Distribution: Transformed Data: Log P/B Cover

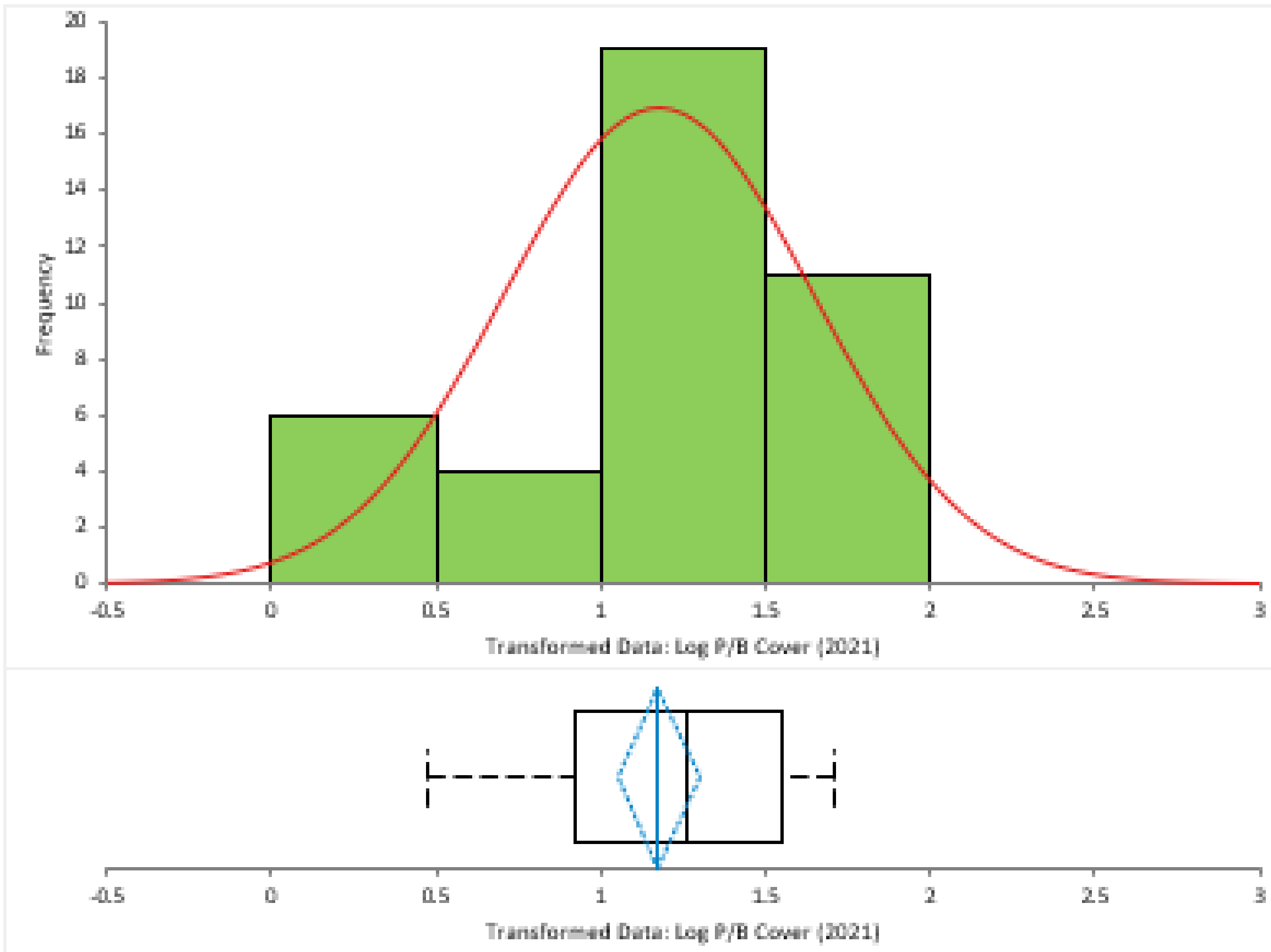
Analyse-it v5.68

Table C-2: M-VMU-1 2021 Data for Normal Distribution and Variance Analysis

Filter: No filter

Last updated 24 February 2022 at 15:54 by Buchanan, Nicholas

Descriptives

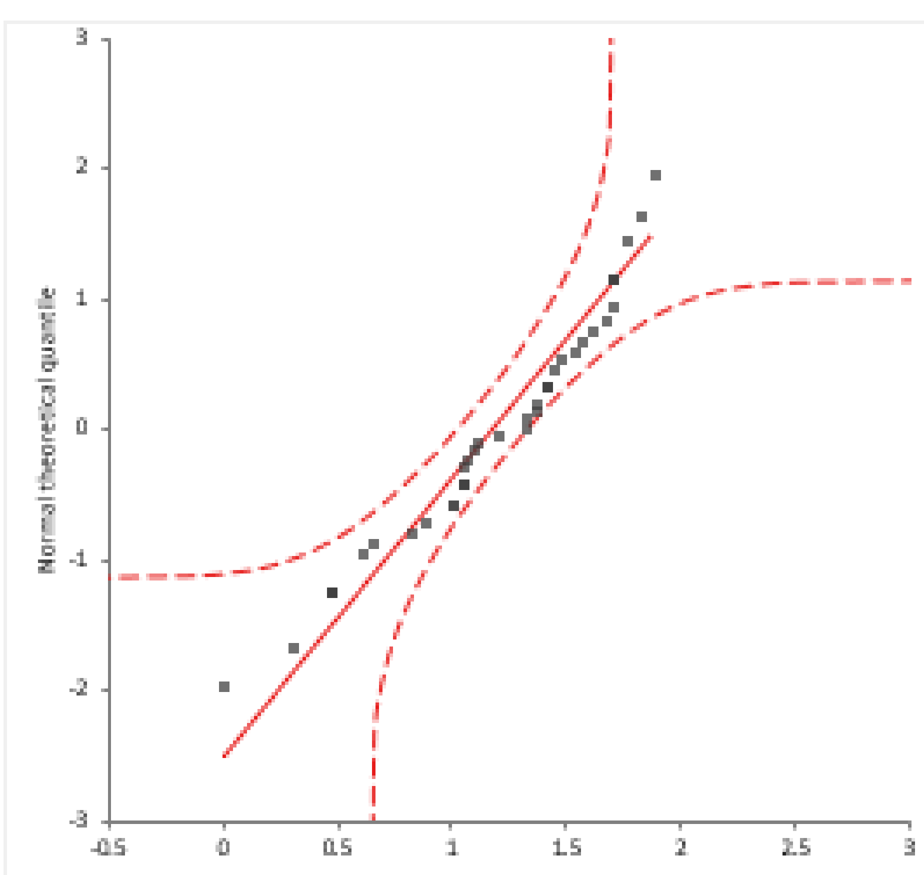


N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Transformed Data: Log P/B Cover (2021)	1.175	1.050 to 1.300	0.0743	0.470	-0.6	-0.39

	1st quartile	Median	3rd quartile
Transformed Data: Log P/B Cover (2021)	0.927	1.263	1.546

Normality



Shapiro-Wilk test

W statistic	0.95
p-value	0.0677[1]

H0: F(Y) = N(μ,σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ,σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-3: Distribution: Raw Data: 2021 Annual Forage Production

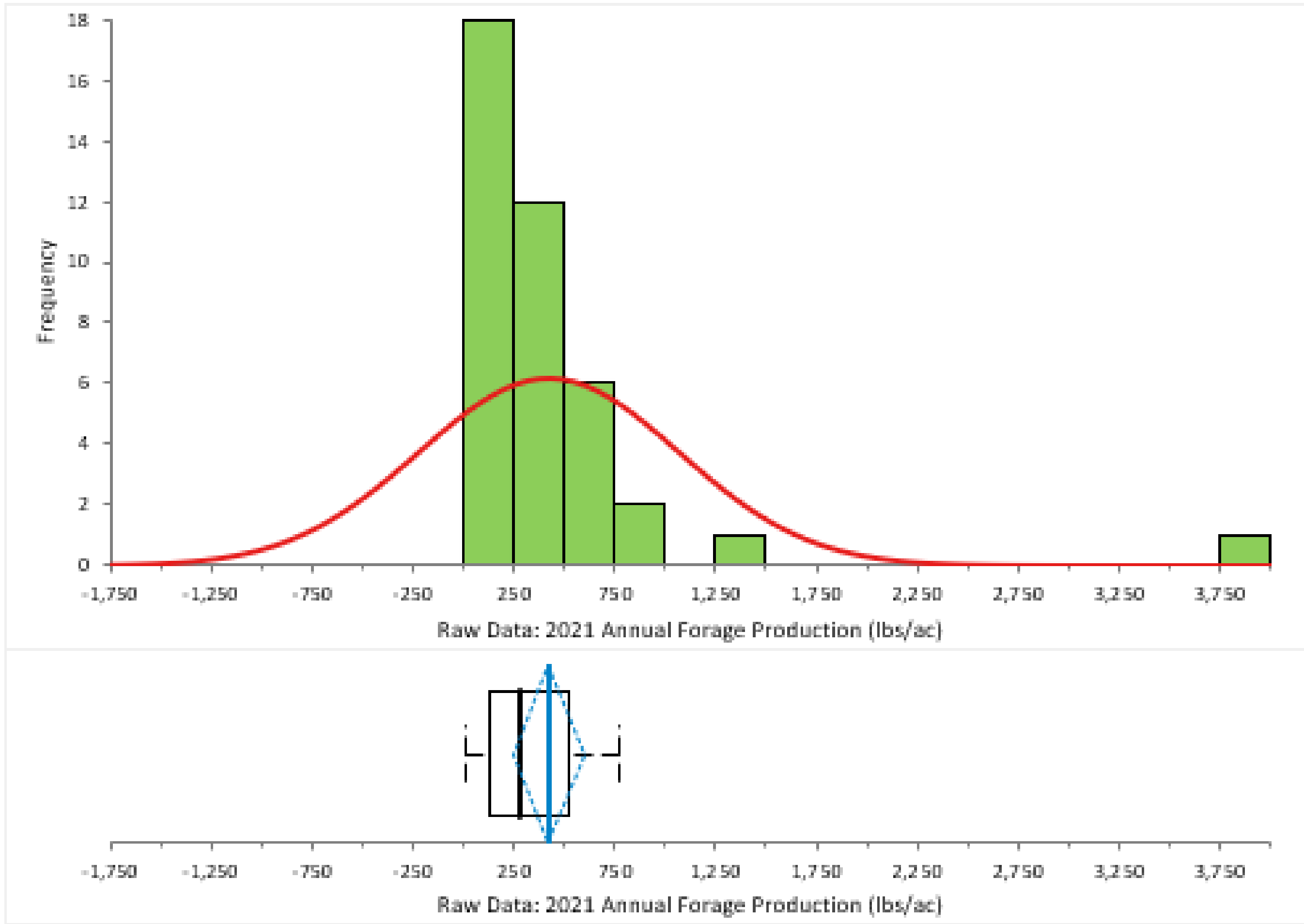
Analyse-it v5.68

Table C-2: M-VMU-1 2021 Data for Normal Distribution and Variance Analysis

Filter: No filter

Last updated 24 February 2022 at 15:55 by Buchanan, Nicholas

Descriptives

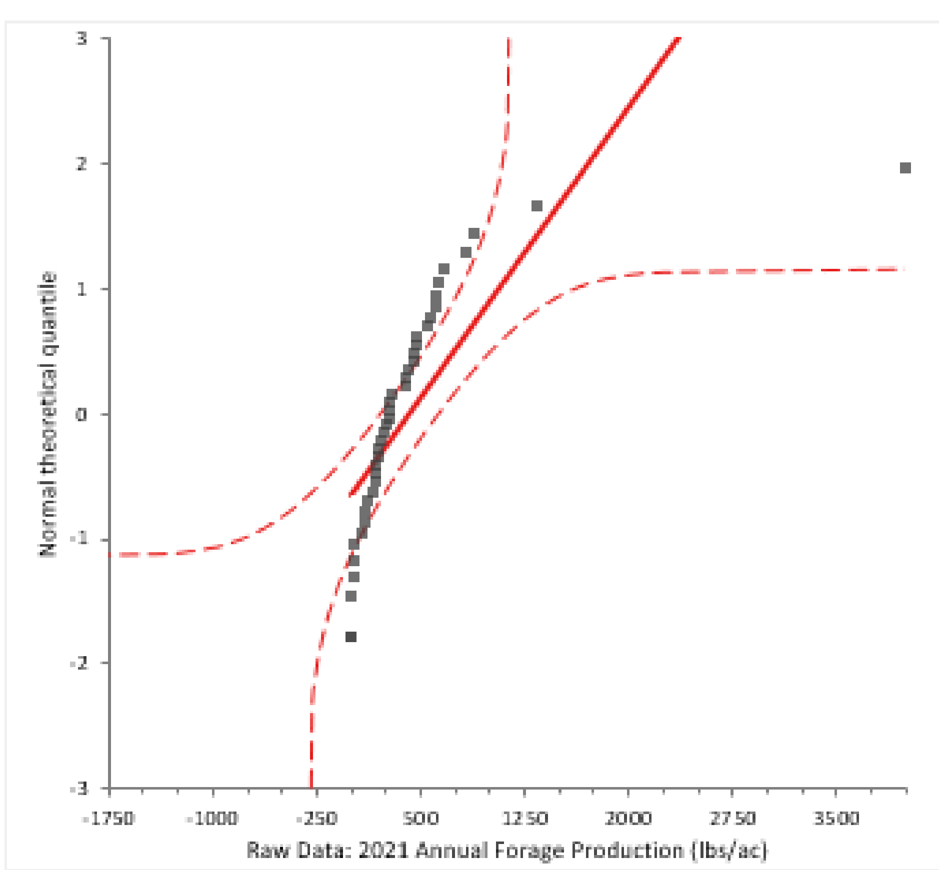


N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2021 Annual Forage Production (lbs/ac)	425.2	253.59923 to	101.84777	644.14185	4.6	25.02

	1st quartile	Median	3rd quartile
Raw Data: 2021 Annual Forage Production (lbs/ac)	131.33333	276	519.91667

Normality



Shapiro-Wilk test

W statistic	0.52
p-value	<0.0001[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

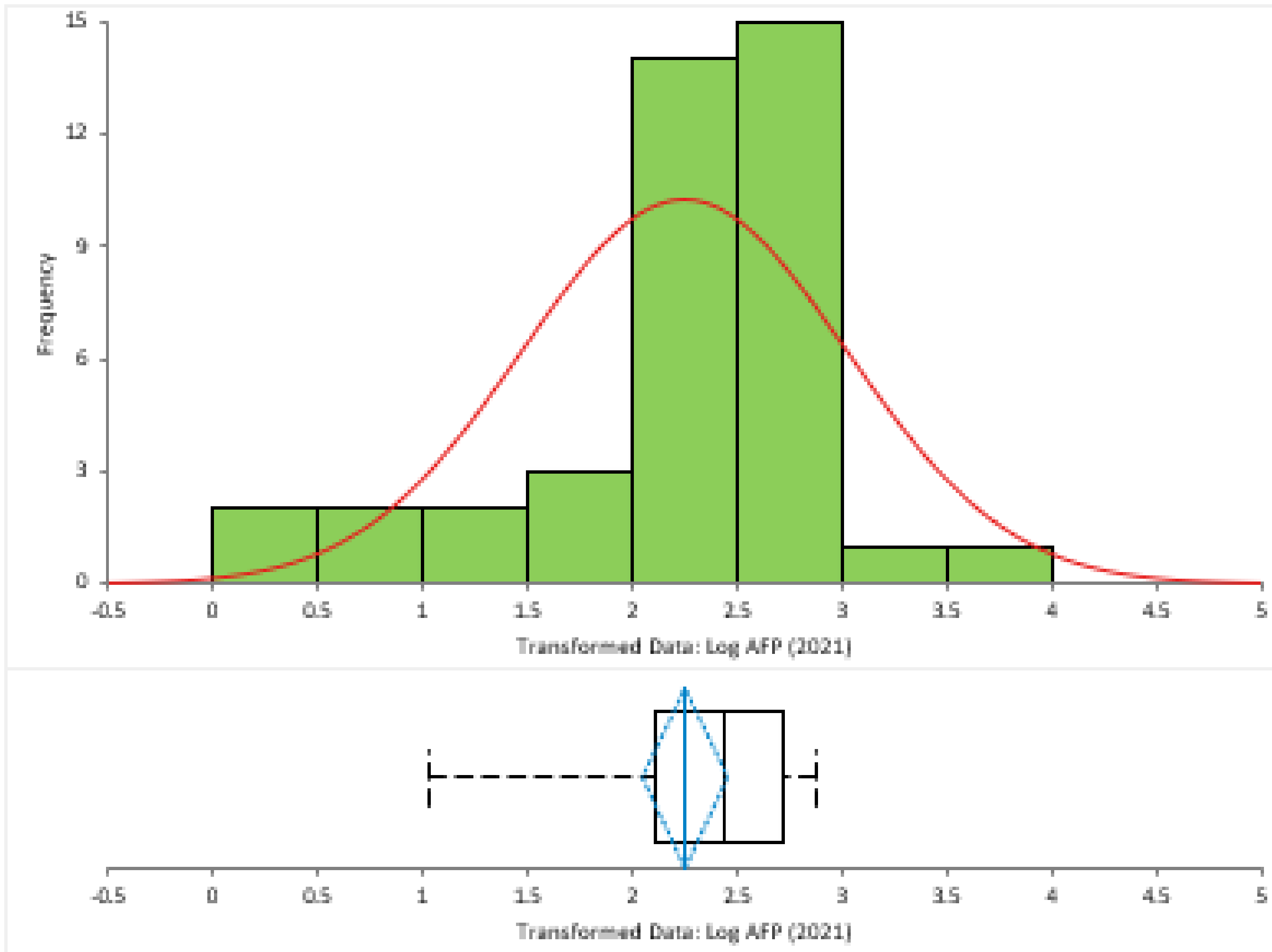
Figure C-4: Distribution: Transformed Data: Log AFP

Table C-2: M-VMU-1 2021 Data for Normal Distribution and Variance Analysis

Filter: No filter

Last updated 24 February 2022 at 15:55 by Buchanan, Nicholas

Descriptives

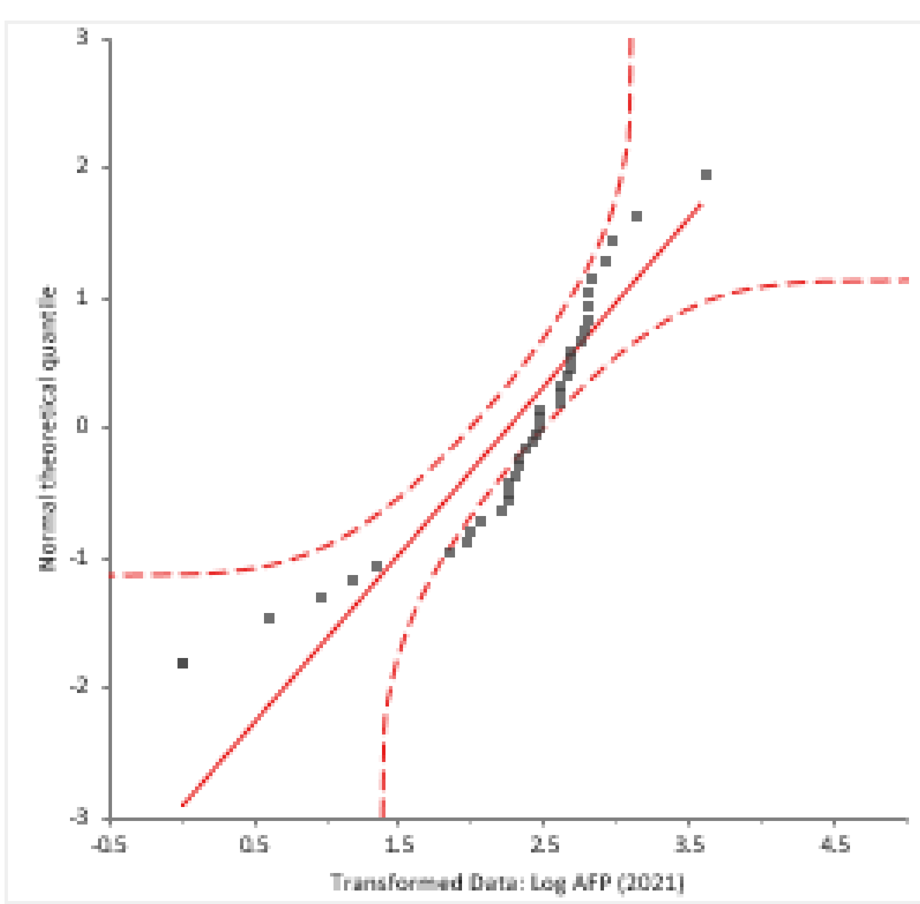


N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Transformed Data: Log AFP (2021)	2.251	2.045 to 2.458	0.1224	0.774	-1.5	2.47

	1st quartile	Median	3rd quartile
Transformed Data: Log AFP (2021)	2.116	2.442	2.716

Normality



Shapiro-Wilk test

W statistic	0.84
p-value	<0.0001†

H0: F(Y) = N(μ,σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ,σ)
The distribution of the population is not normal.
† Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-5: Distribution: Raw Data: 2021 Woody Plant Density

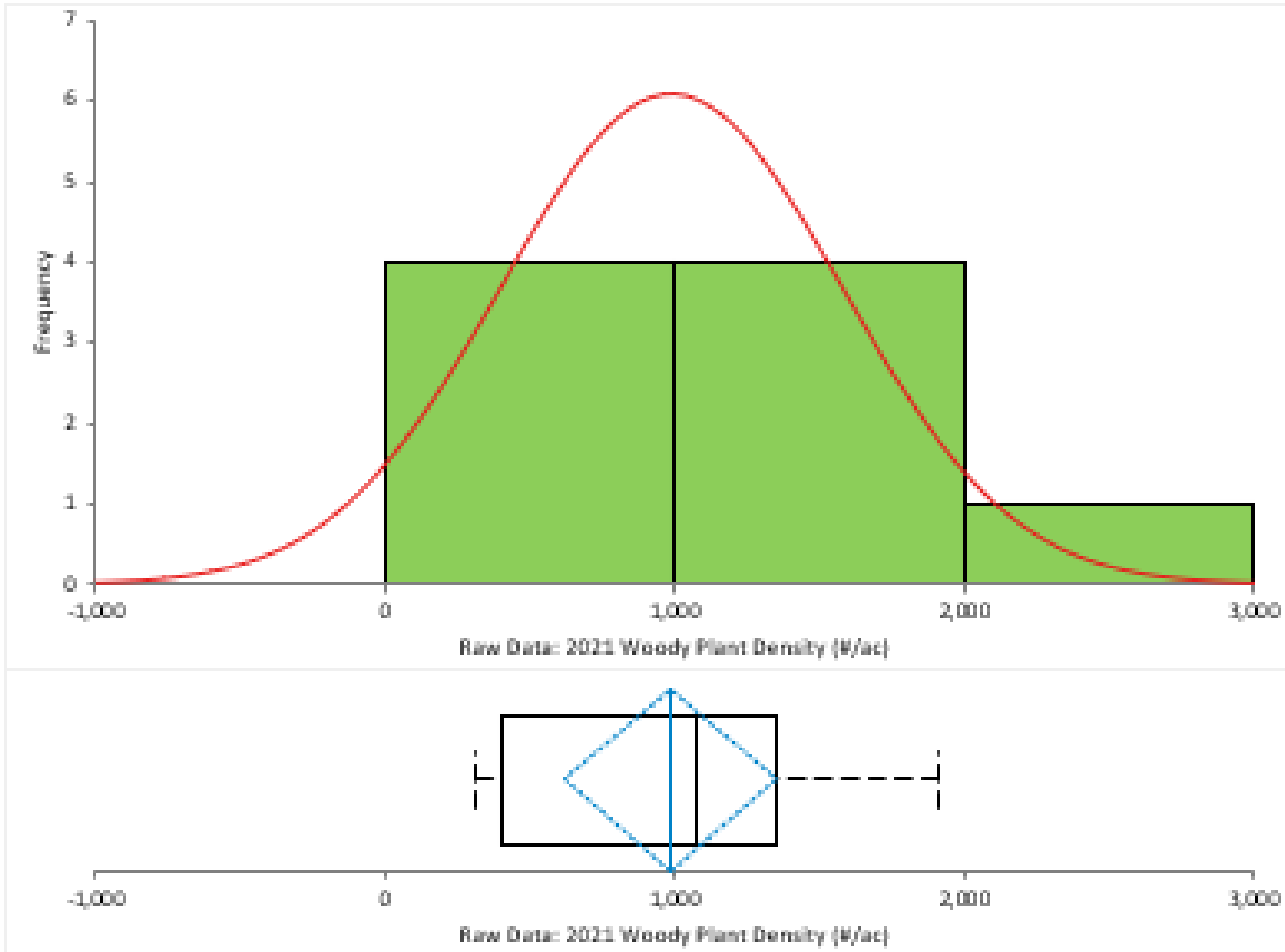
Analyse-it v5.68

Table C-2: M-VMU-1 2021 Data for Normal Distribution and Variance Analysis

Filter: No filter

Last updated 24 February 2022 at 15:55 by Buchanan, Nicholas

Descriptives

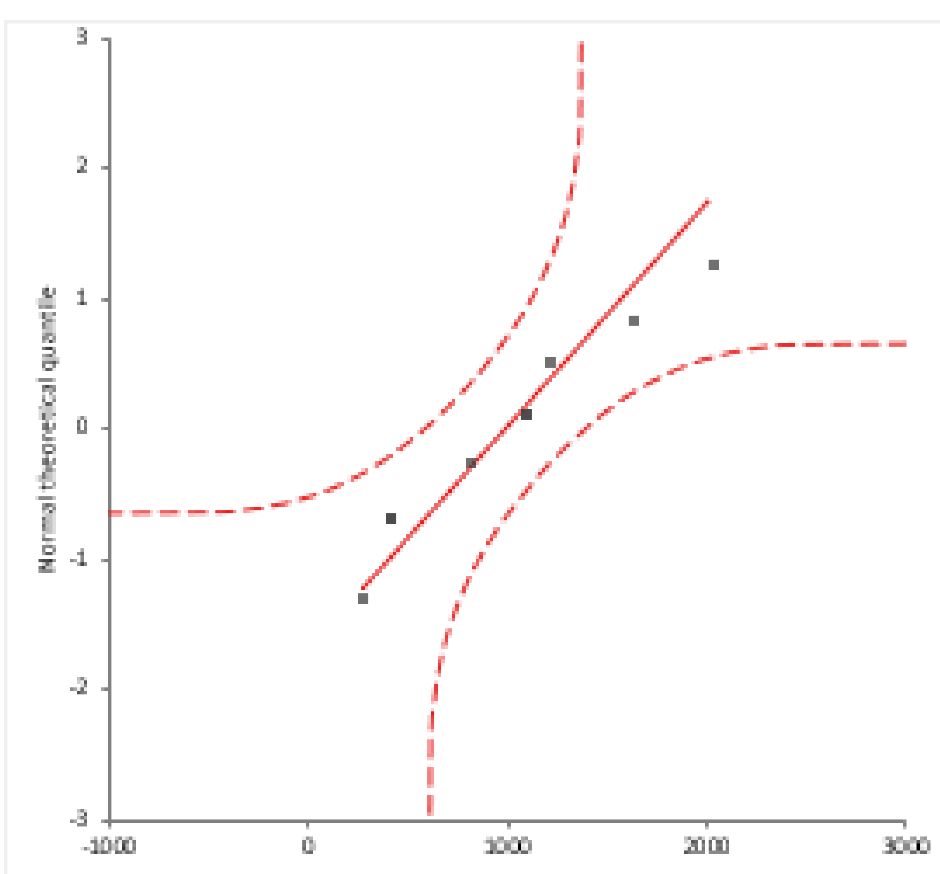


N	9

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
Raw Data: 2021 Woody Plant Density (#/ac)	989.23222	624.76378 to	195.9984	587.9952	0.5	-0.52

	1st quartile	Median	3rd quartile
Raw Data: 2021 Woody Plant Density (#/ac)	404.686	1079.162	1348.9533

Normality



Shapiro-Wilk test

W statistic	0.94
p-value	0.5772[1]

H0: F(Y) = N(μ,σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ,σ)
The distribution of the population is not normal.
[1] Do not reject the null hypothesis at the 10% significance level.

Table C-1: Equations for Vegetation Data Analysis

Attribute	Equation	Where
Sample Size / Count	$n = \sum samples$	n = number of samples ∑ = sum
Mean	$\bar{x} = \frac{\sum x}{n}$	$\bar{x}$ = sample mean ∑x = sum of values for variable n = number of samples
Standard Deviation	$s = \sqrt{\frac{\sum(\bar{x} - x)^2}{n-1}}$	s = standard deviation ∑ = sum $\bar{x}$ = sample mean n = number of samples
Variance	$s^2 = \frac{\sum (x_i - \bar{x})^2}{n-1}$	s^2 = variance ∑ = sum x_i = Value of variable for sample *i* $\bar{x}$ = sample mean n = number of samples
t-distribution	t = 1-α, v	t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom α = significance level (0.10) v = degrees of freedom (n-1)
90% Confidence Interval	$\bar{x} \pm t \frac{s}{\sqrt{n}}$	$\bar{x}$ = sample mean t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom s = standard deviation n = number of samples
N_{min} (Sample Adequacy - Normal Data)	$N_{min} = \frac{t^2 s^2}{(\bar{x}D)^2}$	N_{min} = number of samples required t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom s = standard deviation (s^2 = variance) $\bar{x}$ = sample mean D = the desired level of accuracy, which is 10 percent of the mean
Probability of True Mean	$T = 1 - t\left(\frac{\sqrt{n(0.1xs)'^2}}{\bar{x}, 2, n, 1}\right)$	T = Probability the true value of the mean is within 10 percent of the mean for the sample size t = two tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom n = number of samples s = standard deviation $\bar{x}$ = sample mean
one-sample, one-sided t test Method 3 (CMRP)	$t^* = \frac{\bar{x} - 0.9\,(technical\ std)}{s/\sqrt{n}}$	t* = calculated t-statistic $\bar{x}$ = sample mean s = standard deviation n = sample size
one-sample, one-sided sign test Method 5 (CMRP)	$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$	z = sign test statistic k = test statistic resulting from the number of values falling below 90% of the technical standard n = sample size
Relative Cover	$R_{cvr} = Cvr_{sp.}/Cvr_{Abs.}$	R_{cvr} = Calculated Relative Cover for a Species $Cvr_{sp.}$ = Mean Absolute Cover of a Perennial/Biennial Species $Cvr_{abs.}$ = Mean Absolute Perennial/Biennial Cover
Logarithmic Transformation	Y' = log(Y + k)	log = logarithmic function Y = attribute value k = constant, here we use 1

Notes: Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods applied to experiments in agriculture and biology. 6th ed. Ames, Iowa: Iowa State University Press.

Table C-2: M-VMU-2 2021 Data for Normal Distribution and Variance Analysis

Plot	Transect	Quadrat	Raw Data			Transformed Data		
			2021 Perennial / Biennial Cover (%)	2021 Annual Forage Production (lbs/ac)	2021 Woody Plant Density (#/ac)	Log P/B Cover (2021)	Log AFP (2021)	Log WPD (2021)
M-VMU-1	M-VMU-1-T01P	1	45.9	665	405	1.67	2.82	2.61
		2	2.0	14		0.48	1.18	
		3	49.9	443		1.71	2.65	
		4	33.0	197		1.53	2.30	
	M-VMU-1-T02P	1	3.5	90	2,023	0.65	1.96	3.31
		2	10.5	281		1.06	2.45	
		3	2.0	8		0.48	0.95	
		4	57.0	887		1.76	2.95	
	M-VMU-1-T03P	1	65.0	1,337	1,079	1.82	3.13	3.03
		2	29.0	475		1.48	2.68	
		3	1.0	3		0.30	0.60	
		4	40.0	603		1.61	2.78	
	M-VMU-1-T04P	1	10.0	174	809	1.04	2.24	2.91
		2	15.0	552		1.20	2.74	
		3	35.0	405		1.56	2.61	
		4	25.0	175		1.41	2.25	
	M-VMU-1-T05P	1	9.0	229	1,079	1.00	2.36	3.03
		2	10.3	157		1.05	2.20	
		3	50.0	3,991		1.71	3.60	
		4	6.5	94		0.88	1.98	
	M-VMU-1-T06P	1	2.0	0	405	0.48	0.00	2.61
		2	0.0	0		0.00	0.00	
		3	3.0	20		0.60	1.32	
		4	2.0	113		0.48	2.06	
	M-VMU-1-T07P	1	20.0	568	1,619	1.32	2.76	3.21
		2	11.5	617		1.10	2.79	
		3	50.0	467		1.71	2.67	
		4	75.0	825		1.88	2.92	
	M-VMU-1-T08P	1	12.0	293	1,214	1.11	2.47	3.08
		2	9.0	172		1.00	2.24	
		3	22.0	621		1.36	2.79	
		4	27.0	258		1.45	2.41	
	M-VMU-1-T09P	1	22.0	397	270	1.36	2.60	2.43
		2	10.0	204		1.04	2.31	
		3	25.0	280		1.41	2.45	
		4	25.0	206		1.41	2.32	
	M-VMU-1-T10P	1	20.0	69	data corrupted	1.32	1.85	NA
		2	10.0	389		1.04	2.59	
		3	50.0	457		1.71	2.66	
		4	5.5	272		0.81	2.44	
		Mean	22.5	425	989	1.17	2.24	2.91
		Standard Deviation	19.8	644	588	0.48	0.81	0.30
		Count	40	40	9	36	36	9
		Variance	393.3	414919	345738	0.23	0.65	0.09
		90% Confidence Interval	5.2	168	322	0.13	0.22	0.16

Notes:

2021 Perennial / Biennial Cover (%) Data from Appendix A, Table A-1

2021 Annual Forage Production (lbs/ac) Data from Appendix A, Table A-4

2021 Woody Plant Density (#/ac) Data is derived from Appendix A, Table A-5

Table C-3: 2020 Perennial/ Biennial Canopy Cover, Method 5 - CMRP

Transect	Quadrat	2021 Perennial / Biennial Cover (%)	90% of Technical Standard	P/B CVR minus TS
M-VMU-1-T01P	1	45.9	13.5	32.4
	2	2.0	13.5	-11.5
	3	49.9	13.5	36.4
	4	33.0	13.5	19.5
M-VMU-1-T02P	1	3.5	13.5	-10.0
	2	10.5	13.5	-3.0
	3	2.0	13.5	-11.5
	4	57.0	13.5	43.5
M-VMU-1-T03P	1	65.0	13.5	51.5
	2	29.0	13.5	15.5
	3	1.0	13.5	-12.5
	4	40.0	13.5	26.5
M-VMU-1-T04P	1	10.0	13.5	-3.5
	2	15.0	13.5	1.5
	3	35.0	13.5	21.5
	4	25.0	13.5	11.5
M-VMU-1-T05P	1	9.0	13.5	-4.5
	2	10.3	13.5	-3.3
	3	50.0	13.5	36.5
	4	6.5	13.5	-7.0
M-VMU-1-T06P	1	2.0	13.5	-11.5
	2	0.0	13.5	-13.5
	3	3.0	13.5	-10.5
	4	2.0	13.5	-11.5
M-VMU-1-T07P	1	20.0	13.5	6.5
	2	11.5	13.5	-2.0
	3	50.0	13.5	36.5
	4	75.0	13.5	61.5
M-VMU-1-T08P	1	12.0	13.5	-1.5
	2	9.0	13.5	-4.5
	3	22.0	13.5	8.5
	4	27.0	13.5	13.5
M-VMU-1-T09P	1	22.0	13.5	8.5
	2	10.0	13.5	-3.5
	3	25.0	13.5	11.5
	4	25.0	13.5	11.5
M-VMU-1-T10P	1	20.0	13.5	6.5
	2	10.0	13.5	-3.5
	3	50.0	13.5	36.5
	4	5.5	13.5	-8.0
			k	19
			n	40
			z	-0.16
			Standard one-tailed normal curve area (Table C-3; MMD, 1999)	0.0636
			P	0.4364

Notes:
P/B CVR = Perennial/Biennial Cover
TS = 90% of the Technical Standard for Perennial/Biennial Cover
P = 0.5-Area = prob of observing z; <=0.1 performance standard met
z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-4: 2020 Annual Forage Production, Method 5 - CMRP

Transect	Quadrat	2021 Annual Forage Production (lbs/ac)	90% of Technical Standard	FP minus TS
M-VMU-1-T01P	1	665.0	315	350.0
	2	14.0	315	-301.0
	3	443.0	315	128.0
	4	197.0	315	-118.0
M-VMU-1-T02P	1	90.0	315	-225.0
	2	281.0	315	-34.0
	3	8.0	315	-307.0
	4	887.0	315	572.0
M-VMU-1-T03P	1	1337.0	315	1022.0
	2	475.0	315	160.0
	3	3.0	315	-312.0
	4	603.0	315	288.0
M-VMU-1-T04P	1	174.0	315	-141.0
	2	552.0	315	237.0
	3	405.0	315	90.0
	4	175.0	315	-140.0
M-VMU-1-T05P	1	229.0	315	-86.0
	2	157.0	315	-158.0
	3	3991.0	315	3676.0
	4	94.0	315	-221.0
M-VMU-1-T06P	1	0.0	315	-315.0
	2	0.0	315	-315.0
	3	20.0	315	-295.0
	4	113.0	315	-202.0
M-VMU-1-T07P	1	568.0	315	253.0
	2	617.0	315	302.0
	3	467.0	315	152.0
	4	825.0	315	510.0
M-VMU-1-T08P	1	293.0	315	-22.0
	2	172.0	315	-143.0
	3	621.0	315	306.0
	4	258.0	315	-57.0
M-VMU-1-T09P	1	397.0	315	82.0
	2	204.0	315	-111.0
	3	280.0	315	-35.0
	4	206.0	315	-109.0
M-VMU-1-T10P	1	69.0	315	-246.0
	2	389.0	315	74.0
	3	457.0	315	142.0
	4	272.0	315	-43.0
			k	23
			n	40
			z	1.11
Standard one-tailed normal curve area (Table C-3; MMD, 1999)				0.3665
			P	0.1335

Notes:
FP = Forage Production
TS = 90% of the Technical Standard for Annual Forage Production
P = 0.5-Area = prob of observing z; <=0.1 performance standard met
z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-5: Shrub Density by the Belt Transect Method, Method 3 - CMRP

$$t^* = \frac{\bar{x} - 0.9\,(technical\ std)}{s/\sqrt{n}}$$

	2021 Woody Plant Density (#/ac)
Mean (#/ac)	989
Standard Deviation (#/ac)	588
Sample Size	9
Technical Standard (#/ac)	150
t*	4.36
N_{min}	122
1-tail t (0.1, 9)	1.397

Notes:

#/ac = Number of shrubs, trees and/or cacti per acre

Decision Rules (reverse null)

t < t (1-a; n-1), failure to meet std*

t >= t (1-a; n-1), performance std met*

t from Appendix Table C-1 (MMD, 1999)

GOLDER
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REPORT

Vegetation Management Unit 2
Vegetation Success Monitoring 2022

McKinley Mine, New Mexico - Mining and Minerals Division Permit Area

Submitted to:

Chevron Environmental Management and Real Estate Company

Chevron Mining Inc. - McKinley Mine
24 Miles NW HWY 264
Mentmore, NM 87319

Submitted by:

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February 28, 2023

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1.0 INTRODUCTION

Mining was completed in New Mexico Mining and Minerals Division (MMD) jurisdictional lands at the McKinley Mine in 2007; most of the land is reclaimed, with only the facilities remaining. The lands mined and reclaimed included prelaw, initial-program, and permanent-program lands. Liability release has been completed on all prelaw and initial-program lands, and full bond release on a limited amount of permanent-program land.

Chevron Mining Inc. (CMI) is assessing the vegetation in the remaining permanent-program reclaimed areas in anticipation of future bond and liability releases. CMI understands the importance of returning the mined lands to productive traditional uses in a timely manner. To qualify for release, the lands must be in a condition that is as good as or better than the pre-mine conditions, stable, and capable of supporting the designated postmining land use of grazing and wildlife. To make that demonstration for bond and liability release, the reclaimed land must meet the revegetation success standards contained in Permit No. 2016-02. The extended period of responsibility before an application for bond and liability release can be submitted for a given area in the permit is at least ten years. Golder Associates USA Inc. (Golder), a member of WSP USA, Inc (WSP), was retained to monitor and assess the success of the vegetation relative to these requirements.

1.1 Vegetation Management Unit 2

This report presents results from 2022 quantitative vegetation monitoring conducted in Vegetation Management Unit 2 (M-VMU-2), comprising about 1,518 acres within Area 11 (Figure 1). The elevation in this area ranges from about 6,700 to 7,100 feet above mean sea level. Permanent program reclamation in Area 11 started on lands disturbed after 1986, and reclamation generally was completed by 2013. Thus, reclamation age in the majority of M-VMU-2 ranges from approximately 9 to more than 30 years old. The configuration of the VMUs within the MMD Permit Area, shown on Figure 1 were developed in consultation with MMD. This section provides a general description of the reclamation activities that were implemented. Additional details of the reclamation for specific areas can be obtained through review of McKinley's annual reports.

1.2 Reclamation and Revegetation Procedures

Reclamation methods applied in Area 11 included grading of the spoils to achieve a stable configuration, positive drainage, and approximate original contour. Graded spoil monitoring was then conducted to verify that the upper 42 inches of spoil were suitable for plant growth. A minimum of 6 inches of top dressing (topsoil or topsoil substitute) were then applied over suitable spoils.

After topdressing placement, the surface was scarified in preparation for planting. Seeding was done using various implements that drilled and/or broadcast the seed. After the seeding, mulch consisting of either hay or straw was applied at a rate of about 2 tons/acre. The mulch was anchored 3 to 4 inches into the soil with a tractor-drawn straight coulter disc. The seeding was generally performed in the fall, which coincided with logical units for seeding that had been topdressed over the spring and summer. Seed mixes used at McKinley have varied over time but included both warm- and cool-season grasses, introduced and native forbs, and shrubs. The early seed mixes tended to emphasize the use of alfalfa and cool-season grasses. Over time the seed mixes shifted to include more warm-season grasses and a broader variety of native forbs.

1.3 Prevailing Climate Conditions

The amount and distribution of precipitation are important determinants for vegetation establishment and performance at the McKinley Mine. Once vegetation is established, the precipitation dynamics affect the amount of vegetation cover and biomass on a year-to-year basis with grasses and forbs showing the most immediate response. Precipitation has been monitored at the site since 2015, with the Rain 11 gauge capturing precipitation in VMU-2 (Figure 1).

Table 1 contains a summary of precipitation recorded at all the rain gauges for the South Mine. Total annual precipitation measured at the South Tipple was 17.82 inches, well above the regional average of 11.8 inches at Window Rock; the North Bluff gauge, which was down in January and February 2022, recorded 13.38 inches of annual precipitation. Precipitation patterns at the North Bluff gauge is generally consistent with the three remote gauges across the South Mine between April to November (the period the remote stations operate). The Rain 11 gauge, located near the center of Area 11, recorded 12.05 inches of precipitation whereas 12.21 inches were recorded at the North Bluff gauge for the same period. This is equivalent to about 40% above the long-term regional average measured at Window Rock.

Growing season precipitation provides additional context to evaluate vegetation performance in M-VMU-2. The departure of growing season precipitation (April through September) between the Rain 11 gauge and the Window Rock (1937-1999) long-term seasonal mean is illustrated in Figure 2. Growing season precipitation in M-VMU-2 has been below the long-term seasonal mean from 2018 to 2021 with a severe drought in 2020 when the site only received 20% of the normal growing season precipitation for the region. In 2022, mine-wide growing season precipitation was about 45% above the long-term average.

1.4 Objectives

The intent of this report is to document the vegetation community attributes in M-VMU-2 and compare them to the Permit vegetation success criteria. Section 2 describes the vegetation monitoring methods that were used in 2022. Section 3 presents the results of the investigation with respect to ground cover, annual production, shrub density, and composition and diversity. Section 4 is a summary of the results for M-VMU-2 with emphasis on vegetation success.

2.0 VEGETATION MONITORING METHODS

Vegetation attributes on M-VMU-2 in Area 11 were quantified using the methods described in Section 6.5 of the Permit. Fieldwork was conducted at the end of the growing season, but prior to the first killing frost, which was conducted between September 20 and 24, 2022.

2.1 Sampling Design

A systematic random sampling procedure employing a transect/quadrat system was used to select sample sites within the reclaimed area. The proposed transect locations were reviewed with MMD in advance of sampling. A 50-square foot grid was imposed over the VMU to delineate vegetation sample plots, and random points created in a geographic information system (GIS) were used to select plots for vegetation sampling. The locations of randomly selected vegetation plots are shown on Figure 3. In the field, the randomly selected transect locations were assessed in numerical order. If the transect location was determined to be unsuitable, the next alternative location was assessed for suitability. Unsuitable transects were those that fell on or would intersect roads, drainage ways, wildlife rock piles, or prairie dog colonies.

Transects originated from the southeastern corner of the vegetation plot. Each transect was 30 meters (m) long in a dog-leg pattern (Figure 4). Four 1-m^2 quadrats were located at pre-determined intervals along the transect for quantitative vegetation measurements. Each quadrat is considered an individual sample where measurements were made of production, total canopy, species canopy and basal cover, surface litter, surface rock fragments, and bare soil as discussed below.

2.2 Vegetation and Ground Cover

Relative and total canopy cover, basal cover, surface litter, rock fragments, and bare soil were estimated for each quadrat. Canopy cover estimates include the foliage and foliage interspaces of all individual plants rooted in the quadrat. Canopy cover is defined as the percentage of quadrat area included in the vertical projection of the canopy. The canopy cover estimates made on a species basis may exceed 100% in individual quadrats where the vegetation has multi-layered canopies. In contrast, the sum of the total canopy cover, surface litter, rock fragments, and bare soil does not exceed 100%.

Basal cover is defined as the proportion of the ground occupied by the crowns of grasses and rooting stems of forbs and shrubs. Basal cover estimates were also made for surface litter, rock fragments, and bare soil. Like the total cover estimates, the basal cover estimates do not exceed 100%. Percent area cards were used to increase the accuracy and consistency of the cover estimates. Plant frequency was determined on a species-basis by counting the number of individual plants rooted in each quadrat.

2.3 Annual Forage and Biomass Production

Production was determined by clipping and weighing all annual (current year's growth) above-ground biomass within the vertical confines of a 1-m^2 quadrat. Grasses and forbs were clipped to within 5 centimeters (cm) of the soil surface, and the current year's growth was segregated from the previous year's growth (e.g., gray, weathered grass leaves and dried culms). For this sampling event, plants that were less than 5 cm tall or considered volumetrically insignificant were not collected. Production from shrubs was determined by clipping the current year's growth.

The plant biomass samples of every species collected were placed individually in labeled paper bags. The plant tissue samples were air-dried (> 90 days) until no weight changes were observed with repeated measurements on representative samples. The average tare weight of the empty paper bags was determined to correct the total sample weight to air-dry vegetation weights. The net weight of the air-dried vegetation was converted to a pounds per acre (lbs/ac) basis.

2.4 Shrub Density

Shrub density, or the number of plants per square meter, was determined using the frequency count data from the quadrats and the belt transect method (Bonham 1989). Shrub density was calculated from the quadrat data by dividing the total number of individual plants counted by the number of quadrats sampled. The density per square meter was converted to density per acre.

Shrub density was also determined using a belt transect method (Bonham 1989). Shrub density was determined from a 1-meter wide; 30-meter-long belt transect situated along the perimeter of the dog-legged transect (Figure 4). Shrubs rooted in the belt transect were counted on a species basis.

2.5 Statistical Analysis and Sample Adequacy

The procedures for financial assurance release as described in Coal Mine Reclamation Program (CMRP) Vegetation Standards (MMD 1999) and the Permit guided this statistical analysis. Statistical tests were performed using both Microsoft® Excel and Analyse-it (version 5.56), a statistical add-in for Excel. The normality of each dataset was first assessed using the Shapiro-Wilk test to determine the appropriate hypothesis test method (i.e., parametric versus nonparametric). Data were considered normal when the test statistic was significant (p-value > 0.10) for alpha (α) = 0.10. Thus, the null hypothesis that the population is normally distributed was accepted if the p--value > 0.10. In cases where the data were not normally distributed, a log transformation was applied to see if it normalized the data.

All hypothesis testing used to demonstrate that the vegetation success standards were met was conducted using a reverse null approach. Because vegetation performance at McKinley is compared to technical standards, the one-sample, one-sided t-test (CMRP Method 3) is used for normally distributed data to evaluate the mean and the one-sample, one-sided sign test (CMRP Method 5) to analyze the median of data that are not normal (MMD 1999; McDonald and Howlin 2013). The one-sided hypothesis tests using the reverse null approach were designed as follows:

Perennial/Biennial Canopy Cover

H_0 : Reclaim < 90% of the Technical Standard (15%)

H_a : Reclaim ≥ 90% of the Technical Standard (15%)

Annual Forage Production

H_0 : Reclaim < 90% of the Technical Standard (350 lbs/ac)

H_a : Reclaim ≥ 90% of the Technical Standard (350 lbs/ac)

Shrub Density

H_0 : Reclaim < 90% of the Technical Standard (150 stems per acre [stems/ac])

H_a : Reclaim ≥ 90% of the Technical Standard (150 stems/ac)

where H_0 is the null hypothesis, that the parameter mean of the reclaimed area is less than 90% of the technical standard and H_a is the alternative hypothesis, that the parameter mean of the reclaimed area is greater than or equal to 90% of the technical standard. All hypothesis tests were performed with a 90% level of confidence.

Under the reverse null test, the revegetation success standard is met when H_0 is rejected and H_a is accepted. The decision criteria at 90% confidence under the reverse null hypothesis are as follows:

One-sample, one-sided t-test – Method 3 (CMRP)

If $t^* < t_{(1-\alpha;\ n-1)}$, conclude failure to meet the performance standard

If $t^* \geq t_{(1-\alpha;\ n-1)}$, conclude that the performance standard was met

One-sample, one-sided sign test – Method 5 (CMRP)

If P > 0.10, conclude failure to meet the performance standard

If P ≤ 0.10, conclude that the performance standard was met

Statistical hypothesis testing was performed on perennial/biennial cover, annual forage production and shrub density (woody stem stocking) using the one-sample, one-sided t-test and the one-sample, one-sided sign test. The hypotheses testing used the reverse null hypothesis bond release testing procedure as described in CMRP Vegetation Standards (MMD 1999).

Statistical adequacy is not required for vegetation success demonstrations at McKinley under the reverse null approach but is presented on the basis of the canopy cover, production, and shrub density data. The number of samples required to characterize a particular vegetation attribute depends on the uniformity of the vegetation and the desired degree of certainty required for the analysis.

The number of samples necessary to meet sample adequacy (N_{min}) was calculated assuming the data were normally distributed using Snedecor and Cochran (1967).

$$N_{min} = \frac{t^2 s^2}{(\overline{x}D)^2}$$

Where N_{min} equals minimum number of samples required, t is the two-tailed t-distribution value based on a 90% level of confidence with n-1 degrees of freedom, s is the standard deviation of the sample data, $\overline{x}$ is the mean, and D is the desired level of accuracy, which is 10 percent of the mean.

In addition to N_{min}, the 90% confidence interval (CI) of the sample mean and the level of confidence that the sample mean is within 10 percent of the true mean are reported.

It is often impractical to achieve sample adequacy in vegetation monitoring studies based on Snedecor and Cochran’s equation, and a minimum sample number approach is taken. MMD recognizes the practical limitations of achieving statistical adequacy and has provided minimum sample sizes for various quantitative methods (MMD 1999). With normally distributed data where sample adequacy cannot be met because of operational constraints or for other reasons, 40 samples are often considered adequate. The 40--sample recommendation is based on an estimate of the number of samples needed for a t-test under a normal distribution (Sokal and Rohlf 1981). Schulz et al. (1961) demonstrated that 30 to 40 samples provide a robust estimate for most cover and density measurements with increased numbers of samples only slightly improving the precision of the estimate.

CMI collected 40 samples based on the guidance discussed above. The 40 samples came from ten transects each having four quadrats as described in Section 2.1. Each quadrat is considered a unique sampling unit. Additional analysis around sample adequacy was done to see the number of samples that would have been required for adequacy by the Snedecor and Cochran equation. Further analysis for sample adequacy of cover, production and density attributes was also demonstrated using a graphical stabilization of the mean method (Clark 2001).

The emphasis on statistical adequacy assumes that parametric tests of normally distributed data will be conducted to demonstrate compliance with the vegetation success standards. It is important to note that normally distributed data and sample adequacy are not required for reverse-null hypothesis testing. Nonparametric hypothesis tests are used to analyze data that are not normally distributed. When sample adequacy is not achieved, it is appropriate to use the reverse null approach for hypothesis testing. The reverse null is also generally recommended to evaluate reclamation success whether N_{min} is met or not (MMD 1999). This is because the reverse null is more defensible (compared to the classic approach) where the rejection of the null hypothesis definitively concludes that the reclamation mean is greater than the technical standard (McDonald and Howlin 2013).

3.0 RESULTS

The vegetation community in M-VMU-2 is well established and dominated by perennial plants. A representative photograph of the vegetation and topography in M-VMU-2 is shown in Figure 5. The vegetation cover levels in 2022 suggest that the site has achieved the vegetation success standards for the Permit Area.

Vegetation success standards consist of four vegetative parameters: ground cover, productivity, diversity, and woody stem stocking (Table 2). The ground cover requirement for live perennial/biennial cover on the reclamation is 15%. The productivity requirement is 350 air-dry lbs/ac perennial/biennial annual production. The woody stem stocking success standard is 150 live woody stems/ac.

Diversity is evaluated against numerical guidelines for different growth forms and photosynthetic pathways of the vegetation. In summary, the diversity guideline required by MMD would be met if at least two shrub or subshrub species with individual relative cover values of 1%; at least two perennial warm-season grass species have individual relative cover levels of at least 1%; at least one perennial cool-season grass species has an individual relative cover level of at least 1%; and at least three perennial or biennial forb species have a combined relative cover of at least 1%. MMD (1999) allows for the use of biennial forbs because they are technically monocarpic (single-flowering) perennials that annually produce a significant amount of seed and therefore as a species, they persist in the reclaimed plant community. Relative cover is the average percent cover of a perennial/biennial species divided by the total perennial/biennial cover of the sampling unit.

Diversity is also demonstrated by evidence of colonization or recruitment of native (not-seeded) plants from adjacent undisturbed native areas. Table 3 summarizes the attributes for plants recorded in the quadrats in addition to those encountered or observed but not recorded in the formal quantitative monitoring of M-VMU-2. Recruitment of these native plant species is indicative of ecological succession and the capacity of the site to support a self-sustaining ecosystem.

For Phase III bond release applications, it must be demonstrated that the total annual production and total live cover of biennials and perennials equal or exceeds the approved standards for at least two of the last four years of the responsibility period. Shrub density and revegetation diversity must equal or exceed the approved standards during at least one of the two sampling years of the responsibility period (MMD 1999).

The field data for canopy and basal cover, density, production, and shrub density by the belt transect are included in Appendix A. Photographs of the quadrats are included in Appendix B. Appendix C provides the statistical analysis equations, summary data and statistical outputs for perennial/biennial canopy cover, annual forage production, shrub density by the belt transect method, and a species summary of all species observed from 2019 to 2022.

3.1 Ground Cover

Perennial/biennial canopy cover was calculated by summing the perennial/biennial species cover estimates after excluding the annual forbs and grasses. Any recorded noxious weeds are excluded from perennial/biennial cover. Average total ground cover in M-VMU-2 is 44.6% comprised of 33.9%% total vegetation cover, 5.0% rock, and 5.7% litter on a canopy cover basis (Table 3). Consistent with the variability observed in semi-arid rangelands, the vegetation canopy cover in the individual quadrats ranged from 0 to 96% (Table A-1). On a basal area basis, average ground cover is 21.4% with 3.3% vegetation, 6.4% rock, and 11.7% litter.

The mean perennial/biennial canopy cover in 2022 was 35.0% (± 6.8% 90% confidence interval [90% CI]). The calculated minimum sample size needed to meet N_{min} was 157 samples for perennial/biennial canopy cover (Table 4). In 2021 the mean perennial/biennial canopy cover was 22.5% (± 5.2%) (Table 4).

Applying the Shapiro -Wilks test to the 2022 perennial/biennial canopy indicated that the data for M-VMU-2 were not normally distributed (Figure C-1). A log transformation of the canopy cover data did not result in a normally distribution (Figure C-4). Thus, hypotheses testing was conducted on the raw data using Method 5 of the CRMP; the one-sample, one-sided sign test using the reverse null approach (MMD 1999).

The testing determined that thirty-two of the 40 production quadrats exceeded 90% of the performance standard (13.5%) resulting in the probability (P) of >0.50 of observing a z value less than 3.64. Therefore, under the reverse null hypothesis with a significance level of 10% we conclude the performance standard is met for perennial/biennial cover in 2022 (Table C-2). In M-VMU-2, this standard was met in three of the last four years (2019, 2020, and 2022).

Because N_{min} was not met and called for an unreasonable number of samples, the perennial/biennial canopy cover data were evaluated using a stabilization of the mean approach (Clark 2001). Figure 6 illustrates the stabilization of the estimated mean for perennial/biennial canopy cover based on grouping four sample increments associated with a single transect. The samples were analyzed in four sample increments to allow an estimation of variability. The corresponding variability around the mean is expressed by the 90% CIs for each successive analytical increment. These data suggest that the mean perennial/biennial cover was estimated to within the 90% CI of the estimated population mean (n=40) after 8 samples with the 90% CI tightening to ± 7% cover after 24 samples. This analysis suggests that 40 samples were more than adequate, and that the collection of additional data would not improve the precision of the estimate of perennial/biennial cover.

3.2 Production

Productivity for vegetation success is assessed for above-ground annual forage production, excluding annuals and noxious weeds in air dry pounds per acre (lbs/ac). Total annual production for all plant species is reported but not used in determining productivity success for the VMU. The 2022 annual forage production in M-VMU-2 was estimated to be 828 (± 197) lbs/ac with an annual total production of 854 (± 194) lbs/ac (Table 4). Ten perennial grasses contribute 689 lbs/ac of forage, and five shrubs contribute 95 lbs/ac of browse indicating a diverse and productive rangeland (Table 3). James galleta (*Pleuraphis jamesii,* 575 lbs/ac) accounted for over 80% of the production contributed from perennial grasses. The combined annual forage production in M-VMU-2 is high compared to regional ecological sites ranging from 430.5 to 794.2 lbs/ac (Parametrix 2012). The annual forage production of M-VMU-2 in 2019 (787 lbs/ac) and 2020 (627 lbs/ac) demonstrate the site's ability to exceed the minimum production values for comparable ecological sites.

The annual forage production data for M-VMU-2 were not normally distributed (Figure C-3) and a log transformation of the production data also did not result in a normal distribution (Figure C-4). As a result, the production data was tested against 90% of the technical standard, 315 lbs/acre, using Method 5, the non-parametric one sample, one sided sign test. Thirty-two of the 40 quads exceeded the 315 lbs/acre standard, resulting in the probability (P) of >0.50 of observing a z value less than 3.64. Therefore, under the reverse null hypothesis with a significance level of 10% we conclude the performance standard is met for annual forage production in 2022 (Table C-2). In M-VMU-2, this standard was also met in 2019 but was not met in 2020 and 2021 largely because of the high variability in production due to drought conditions.

The calculated minimum sample size needed to meet N_{min} at the 90% confidence level for annual forage production was estimated to be 238 samples (Table C-1). Because N_{min} was not met and called for an unreasonable number of samples, the data were evaluated using a stabilization of the mean (Clark 2001). Figure 7 illustrates the stabilization of the estimated mean and 90% CI for annual forage production based on incrementally calculating the mean and 90% CIs for four samples from a single transect sequentially. The analysis suggests that mean annual forage production was estimated to within the 90% CI of the estimated population mean (n=40) after the 20th sample. The 90% CI tightened to about ± 200 lbs/ac after 12 samples with no meaningful reduction in the CI with the collection of additional data. This analysis suggests that 40 samples were more than adequate, and that the collection of additional data would not improve the precision of the estimated average for annual forage production.

3.3 Shrub Density

Shrub density ranged from an average of 3,136 (± 1358) stems/ac based on the quadrat method to 2,509 (± 806) stems/ac for belt transect method (Table 4). In M-VMU-2, nine shrub species were encountered along ten belt transects (Table A-5) compared to three species in the quadrats (Table 3), reflecting the increased area of analysis associated with the belt transects. Four-wing saltbush (*Atriplex canescens*) was the most prevalent species observed on both the belt transect as well as in the quadrats.

The shrub density data by the belt transect method were normally distributed based on the Shapiro-Wilks test at a 10% significance level (Figure C-5) and the calculated minimum sample size needed to meet N_{min} at the 90% confidence level was estimated to be 128 samples (Table 4). Hypotheses testing was conducted using the one-sample, one-sided t-test (MMD 1999). The calculated t*-statistic for M-VMU-2 shrub density is 4.84, where the sample mean is 2509 stems/ac with a standard deviation of 1550 and the technical standard is 150 stems/ac. The one-tail $t_{(0.1, 9)}$ value is 1.383. Therefore, under the reverse null hypothesis ($t^* >= t_{(1-\alpha;\ n-1)}$), we conclude that the performance standard is met for shrub density (i.e., woody stem stocking) by the belt transect method (Table C-4).

Because N_{min} was not met and called for an unreasonable number of samples, the shrub density belt transect data were evaluated using a stabilization of the mean (Clark 2001). Figure 8 illustrates the stabilization of the mean for shrub density based on individual belt transect data. The corresponding variability around the mean is expressed by the 90% CIs for each successive analytical increment. These data suggest that the mean shrub density was estimated to within the 90% CI of the estimated population mean (n=9) after five samples, with the 90% CI tightening to about ± 1000 stems/ac after six samples. This analysis suggests that the collection of additional data beyond 10 samples would likely not improve the precision of the estimate of shrub density, which is well above the performance standard.

3.4 Composition and Diversity

Diversity is assessed through comparing the relative cover of various life-forms, based on their duration to the perennial/biennial cover of the vegetation management unit. In this context, relative cover is the average percent cover of a perennial/biennial species divided by the mean perennial/biennial cover of the sampling unit. Relative canopy cover of individual species contributing to perennial cover are listed in Table 3.

Collectively, ten perennial grasses dominate the canopy cover in M-VMU-2 with a combined relative canopy cover of almost 82%. James' galleta was the most dominant grass species (Table 3). Six cool-season perennial grasses contribute approximately 10% relative canopy cover and four warm-season perennial grasses contribute almost 71% relative canopy cover. Nine perennial/biennial forbs contribute just over 7% relative canopy cover in M-

VMU-2. The collective contribution of three shrubs to perennial/biennial canopy cover is 11% relative cover, with four-wing saltbush and winterfat (*Krascheninnikovia lanata*) most prevalent.

Table 5 provides the diversity results for M-VMU-2 for 2019 through 2022 and the results for 2022 are summarized below.

- The diversity standard for cool-season grasses is achieved by two species that exceed 1% relative cover including Russian wildrye (*Psathyrostachys juncea*, 4.77%) and thickspike wheatgrass (*Elymus lanceolatus*, 3.56%).
- The diversity standard for warm-season grasses requires a minimum of two species with 1% relative cover each. This was met by James' galleta at 64.03% cover as well as blue grama (*Bouteloua gracilis*, 4.27%). The warm-season grass diversity standard was met in 2020 but not in 2019 or 2021.
- The diversity standard for forbs requires a minimum of three non-annual forb taxa combining to contribute at least 1% relative cover. The combined relative cover of three non-annual forbs is 6.58 % (Table 3). These forbs include rattlesnake weed (*Chamaesyce albomarginata*, 4.73%), manyflowered ipomopsis (*Ipomopsis multiflora*, 1.00%), and ragleaf bahia *(Bahia diessecta,* 0.85%). Based on 2022 sampling, the combined relative cover for three non-annual forbs is greater than 1%, meeting the diversity standard for forbs.
- The diversity standard for shrubs requires two species with a minimum relative cover of 1% for each species. The diversity standard for shrubs is achieved by four-wing saltbush (8.34%) and winterfat (2.68%).

The recruitment of native plants and establishment of seeded species within M-VMU-2 is indicative of ecological succession and the capacity of the site to support a diverse and self-sustaining ecosystem. Based on the 2022 vegetation monitoring, 107 different plant species were present within the reclamation areas of M-VMU-2 (Table A-6). Species encountered included 46 forbs, 28 grasses, and 33 shrubs, trees, and cacti. Of the 46 forbs, 15 are considered annuals whereas the remaining 31 have variable durations or are purely perennial. Of the 28 grasses, 19 are cool-season perennials, six are warm-season perennials and three are cool-season annuals. Cacti and trees are rare on the reclamation, while shrubs and subshrubs are more common.

During the 2022 monitoring program, noxious weeds (NMDA 2020) were infrequently observed on M-VMU-2. The contribution of these species to the vegetation community is insignificant with densities much lower than native rangeland beyond the permit boundary. CMI continues to monitor for noxious weeds and actively controls them through husbandry practices that include annual services for weed control. Further, competition from desirable seeded and native species is expected to inhibit any substantial increase of noxious weeds in the reclamation.

4.0 SUMMARY

McKinley Mine's vegetation success standards for the post-mining land uses of grazing and wildlife are based on canopy cover, production, shrub density, and plant diversity (Table 2). The vegetation monitoring results for the past four years indicate that the vegetation community in M-VMU-2 has met the annual forage production stand in two years, the ground cover standard in three out of the last four years and the shrub density standard four years in a row. For 2022, M-VMU-2 exceeded success parameters for shrub density, perennial/biennial cover, annual forage production and diversity. (Tables 5 and 6). A summary of the findings from the past four years are:

1) The reclamation has demonstrated resilience and permanence by meeting the revegetation performance standards during the responsibility period in according to MMD's guidance.

2) Performance standards for annual forage production and total live cover of biennials and perennials have been achieved in two of the last four years. Shrub density standards were met in the past four years and diversity exceeded the approved standards in 2022.

3) In all years, average perennial/biennial cover and annual forage production were well above the numeric performance standards; however, statistical hypothesis testing in 2020 and 2021 did not demonstrate that the standards were met because highly variable data, largely due to drought conditions in those and proceeding years.

4) The diversity data for M-VMU-2 clearly illustrates precipitation affect species expression as dry conditions impacted forbs in 2020 and warm-season grasses in 2019 and 2021.

5) Based on the vegetation monitoring results over the past four years, the M-VMU-2 reclamation appears eligible for Phase III bond release.

Overall, vegetation performance in M-VMU-2 is encouraging considering below-average precipitation in 5 of the past 8 years including years including two dry years in 2018 and 2019, and the exceptional drought in 2020. The performance of the vegetation under these conditions suggests that the reclaimed plant communities are resilient and capable of sustaining themselves under adverse conditions that are characteristic of this region. Based on the Phase III bond release criteria, CMI believes the reclamation in M-VMU-2 is now clearly capable of meeting the post-mining land use and is eligible for bond release.

5.0 REFERENCES

Bonham, C.D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons. New York, NY.

Clark, D.L. 2001. Stabilization of the mean as a demonstration of sample adequacy. American Society for Surface Mining and Reclamation Annual Meeting. Albuquerque, NM. June 3-7, 2001. ASSMR, Lexington, KY.

Mining and Minerals Division (MMD). 1999. Coal Mine Reclamation Program Vegetation Standards. Santa Fe, NM. April 30.

McDonald, L., and S. Howlin. 2013. Evaluation and comparison of hypothesis testing techniques for bond release application. University of Wyoming, Laramie, WY.

Parametrix. 2012. Revegetation Success Standards Report: McKinley Mine – Response to OSM. Prepared by Jim Nellessen of Parametrix, Albuquerque, New Mexico. April 2012.

New Mexico Department of Agriculture (NMDA). 2020. New Mexico Noxious Weed List Update. New Mexico State University, Las Cruces, NM. June 2020.

Sokal, R.R. and F.J. Rohlf. 1981. Biometry (2nd edit.). W. H. Freeman and Co., San Francisco.

Schulz, A. M., R. P. Gibbens, and L. F. DeBano. 1961. Artificial populations for teaching and testing range techniques. J. Range Management. 14:236-242.

Snedecor, G.W. and W.G. Cochran. 1967. Statistical methods applied to experiments in agriculture and biology. 6th ed. Ames, Iowa: Iowa State University Press.

Tables

Table 1: South Mine Seasonal and Annual Precipitation (2015-2022)

Year	Station	Precipitation (inches)													
		January	February	March	April	May	June	July	August	September	October	November	December	Annual	Growing Season
2015	South Tipple	2.05	1.59	0.11	0.52	1.64	1.11	2.37	1.62	0.30	1.36	1.31	0.76	**14.74**	*7.56*
	Rain 9				0.50	1.38	1.22	2.88	1.25	0.22	1.13	0.99		9.57	*7.45*
	Rain 10				0.42	1.32	1.11	2.59	1.39	0.30	1.10	0.78		9.01	*7.13*
	Rain 11				0.48	1.88	1.02	2.80	1.69	0.26	0.97	1.08		10.18	*8.13*
2016	South Tipple	0.62	0.22	0.05	1.31	0.80	0.07	1.37	1.74	1.75	0.40	1.57	1.84	**11.74**	*7.04*
	Rain 9				0.22	0.62	0.45	1.24	0.50	1.05	1.05	0.00		5.13	*4.08*
	Rain 10				0.13	0.55	0.20	2.75	0.38	0.99	0.14	0.02		5.16	*5.00*
	Rain 11				0.28	0.77	0.64	1.61	0.42	1.09	0.09	0.04		4.94	*4.81*
2017	South Tipple	1.25	1.64	0.48	0.35	0.77	0.42	2.48	0.90	1.34	0.15	0.09	0.02	**9.89**	*6.26*
	Rain 9				1.20	1.02	0.01	0.82	1.40	1.64	0.37	0.91		7.37	*6.09*
	Rain 10				1.00	0.67	0.08	0.94	1.63	1.36	0.34	0.81		6.83	*5.68*
	Rain 11				1.23	1.16	0.05	0.86	2.00	1.85	0.34	0.49		7.98	*7.15*
2018	South Tipple	0.35	0.79	0.54	0.09	0.29	0.51	2.61	1.34	1.10	1.65	0.19	0.29	**9.75**	*5.94*
	Rain 9				0.07	0.27	0.25	2.16	0.74	0.67	1.31	0.00		5.47	*4.16*
	Rain 10				0.08	0.20	0.27	3.05	1.15	0.92	1.51	0.00		7.18	*5.67*
	Rain 11				0.09	0.29	0.26	1.92	1.00	0.89	1.45	0.00		5.90	*4.45*
2019	South Tipple	1.30	1.81	1.23	0.44	1.77	0.33	0.22	0.05	1.59	0.09	1.14	0.85	**10.82**	*4.40*
	Rain 9				0.16	1.36	0.24	0.46	0.37	1.84	0.05	0.07		4.55	*4.43*
	Rain 10				0.20	1.49	0.37	0.19	0.27	1.34	0.03	0.05		3.94	*3.86*
	Rain 11				0.20	1.50	0.19	0.44	0.20	1.72	0.06	0.08		4.39	*4.25*
2020	South Tipple	0.98	1.44	1.35	0.17	0.01	0.04	1.13	0.24	0.15	0.26	0.40	0.27	**6.44**	*1.74*
	Rain 9				0.16	0.02	0.11	0.60	0.06	0.14	0.08	0.45		1.62	*1.09*
	Rain 10				0.11	0.02	0.13	0.79	0.14	0.14	0.16	0.09		1.58	*1.33*
	Rain 11				0.22	0.00	0.05	0.63	0.69	0.20	0.30	0.41		2.50	*1.79*
2021	South Tipple	1.11	0.34	0.40	0.07	0.08	0.37	5.45	1.24	2.12	1.77	0.55	2.26	**15.76**	*9.33*
	No. Bluff	1.13	0.21	0.46	0.04	0.04	0.20	2.17	1.31	1.13	0.86	0.20	0.92	**8.67**	*4.89*
	Rain 9				0.00	0.10	0.27	1.81	1.22	1.11	0.78	0.00		5.29	*4.51*
	Rain 10				0.01	0.06	0.24	2.48	1.80	0.96	0.80	0.00		6.35	*5.55*
	Rain 11				0.00	0.07	0.18	2.10	1.31	1.43	0.98	0.00		6.07	*5.09*
2022	South Tipple	0.36	0.74	1.25	0.00	0.01	0.66	3.68	5.36	1.51	2.92	0.59	0.74	**17.82**	*11.22*
	No. Bluff	--	--	0.59	0.03	0.00	1.24	3.13	4.66	1.27	1.40	0.48	0.58	**13.38**	*10.33*
	Rain 9				0.00	0.00	0.51	2.38	4.05	1.02	1.77	0.41		10.14	*7.96*
	Rain 10				0.00	0.00	0.69	3.57	4.27	1.02	1.83	0.33		11.71	*9.55*
	Rain 11				0.00	0.00	0.56	3.30	4.62	1.09	1.97	0.51		12.05	*9.57*
Window Rock, Long Term		0.72	0.68	0.88	0.61	0.49	0.47	1.75	2.05	1.23	1.14	0.83	0.95	**11.80**	*6.60*

Notes:
Long-term averages are from Window Rock, Arizona Station (029410), 1937 to 1999 (Western Regional Climate Center, 2020).
Growing season total precipitation is between April and September
-- Rain gauge malfunction

Table 2: Revegetation Success Standards for the Mining and Minerals Division Permit Area

Vegetative Parameter	Success Standard
Ground Cover	15% live perennial/biennial canopy cover
Productivity	350 air-dry pounds per acre perennial/biennial annual production
Diversity	A minimum of 2 shrub or subshrub taxa contributing at least 1% relative cover each.
	A minimum of 2 perennial warm-season grass taxa contributing at least 1% relative cover each.
	A minimum of 1 perennial cool-season grass taxa contributing at least 1% relative cover.
	A minimum of 3 perennial/biennial forb taxa combining to contribute at least 1% relative cover.
Woody Stem Stocking	150 live woody stems per acre

Table 3: Vegetation Cover, Density, and Production by Species, M-VMU-2, 2022

Common Name	Scientific Name	Code	Mean Vegetation Cover (%)			Mean Density (#/m^2)	Mean Annual Production (lbs/ac)
			Canopy	Basal	Relative Canopy[a]		
Cool-Season Grasses (6)							
Perennials (6)							
Indian ricegrass	*Achnatherum hymenoides*	ACHY	<0.05	<0.05	0.07	<1	<1
Thickspike wheatgrass	*Elymus lanceolatus*	ELLA3	1.25	0.13	3.56	2	28
Slender wheatgrass	*Elymus trachycaulus*	ELTR7	0.15	<0.05	0.41	<1	2
Needle and thread	*Hesperostipa comata*	HECO26	0.26	<0.05	0.71	1	5
Western wheatgrass	*Pascopyrum smithii*	PASM	0.28	<0.05	0.79	1	4
Russian wildrye	*Psathyrostachys juncea*	PSJU3	1.72	0.19	4.78	2	33
Warm-Season Grasses (4)							
Perennials (4)							
Sideoats grama	*Bouteloua curtipendula*	BOCU	0.09	<0.05	0.25	<1	2
Blue grama	*Bouteloua gracilis*	BOGR2	1.54	0.13	4.27	3	32
James' galleta	*Pleuraphis jamesii*	PLJA	23.05	2.54	64.03	33	575
Alkali sacaton	*Sporobolus airoides*	SPAI	0.96	0.07	2.65	1	9
Forbs (13)							
Annuals (4)							
fetid marigold	*Dyssodia papposa*	DYPA	0.1	<0.05	--	<1	1
Little hogweed	*Portulaca oleracea*	POOL	<0.05	<0.05	--	<1	<1
Russian thistle	*Salsola tragus*	SATR	0.6	<0.05	--	1.0	24
Cowpen Daisy	*Verbesena encelioides*	VEEN	<0.05	<0.05	--	<1	1
Perennials/Biennials (9)							
Bahia dissecta	***Ragleaf bahia***	**BADI**	**0.31**	**<0.05**	**0.85**	**<1**	**3**
Rattlesnake weed	*Chamaesyce albomarginata*	CHAL11	1.71	<0.05	4.74	16	27
Chenopod	*Chenopodiaceae*	CHENOP	<0.05	<0.05	<0.05	<1	1
Redstem stork's bill	*Erodium cicutarium*	ERCI6	<0.05	<0.05	<0.05	<1	<1
Manyflowered ipomopsis	*Ipomopsis multiflora*	IPMU	0.36	<0.05	1.00	<1	5
Flatspine stickseed	*Lappula occidentalis*	LAOC3	<0.05	<0.05	<0.05	1	<1
Purple aster	*Machaeranthera canescens*	MACA	0.13	<0.05	0.37	<1	5
Scarlet globemallow	*Sphaeralcea coccinea*	SPCO	<0.05	<0.05	0.07	<1	<1
Yellow salsify	*Tragopogon dubius*	TRDU	<0.05	<0.05	<0.05	<1	1
Shrubs, Trees and Cacti (3)							
Perennials (3)							
Four-wing saltbush	*Atriplex canescens*	ATCA	3.00	0.14	8.34	<1	70
Mormon tea	*Ephedra viridis*	EPVI	0.05	<0.05	0.14	<1	<1
Winterfat	*Krascheninnikovia lanata*	KRLA	0.97	<0.05	2.68	<1	25
Cover Components							
Perennial/Biennial Vegetation Cover			36.0	3.3			
Total Vegetation Cover			33.9	3.3			
Rock			5.0	6.4			
Litter			5.7	11.7			
Bare Soil			55.4	78.7			

Notes:
[a] = relative cover is the average percent cover of a perennial/biennial species divided by the total perennial/biennial cover of the sampling unit
-- = this parameter is not calculated for this attribute
#/ac = number of plants per acre
lbs/ac = air-dry forage pounds per acre
Bold species are newly observed this year

Table 4: Summary Statistics, M-VMU-2

Vegetation Metric	Year 2019	2020	2021	2022	Technical Standard
Total Vegetation Canopy Cover (%)[2]					
Mean	31.1	37.2	27.5	33.9	None
Standard Deviation	21.9	23.8	19.4	23.9	
90% Confidence Interval	5.7	6.2	5	6.2	
Nmin[1]	144	117	141	141	
Perennial/Biennial Canopy Cover (%)[3]					
Mean	24.9	39.0	22.5	35.0	15.0
Standard Deviation	23.4	26.8	19.8	26.1	
90% Confidence Interval	6.1	7	5.2	6.8	
Nmin[1]	258	134	220	157	
Basal Cover (%)					
Mean	1.6	2.0	3.2	3.3	None
Standard Deviation	1.2	1.4	5.1	3.1	
90% Confidence Interval	0.3	0.4	1.3	0.8	
Nmin[1]	168	144	701	244	
Annual Forage Production (lbs/ac)[4]					
Mean	787	627	425	828	350
Standard Deviation	1,120	794	644	759	
90% Confidence Interval	291	207	167	197	
Nmin[1]	576	456	652	238	
Annual Total Production (lbs/ac)[5]					
Mean	1,011	634	523	854	None
Standard Deviation	1,142	798	640	745	
90% Confidence Interval	297	207	167	194	
Nmin[1]	363	449	425	216	
Shrub Density (stems/acre) from Quadrats					
Mean	12,342	7,082	1,315	3,136	None
Standard Deviation	26,731	9,289	2,316	5,223	
90% Confidence Interval	6,952	2,416	602	1,358	
Nmin[1]	1,332	488	880	787	
Shrub Density (stems/acre) from Belt Transect					
Mean	2,671	3,264	989	2,509	150
Standard Deviation	2,567	2,490	588	1,550	
90% Confidence Interval	1,335	1,295	322	806	
Nmin[1]	310	196	122	128	

Notes:

1 Minimum sample number to obtain 90% probability that the samples mean is within 10% of the population mean

2 Total canopy cover for all species

3 Mean canopy cover not including annuals or noxious weeds.

4 Annual forage production in air dry (lbs/ac) not including annuals or noxious weeds.

5 Total production in air dry (lbs/ac) including annuals or noxious weeds.

Hypothesis testing found the success standard was not met

Table 5: Results for Diversity, 2019 to 2022, M-VMU-2

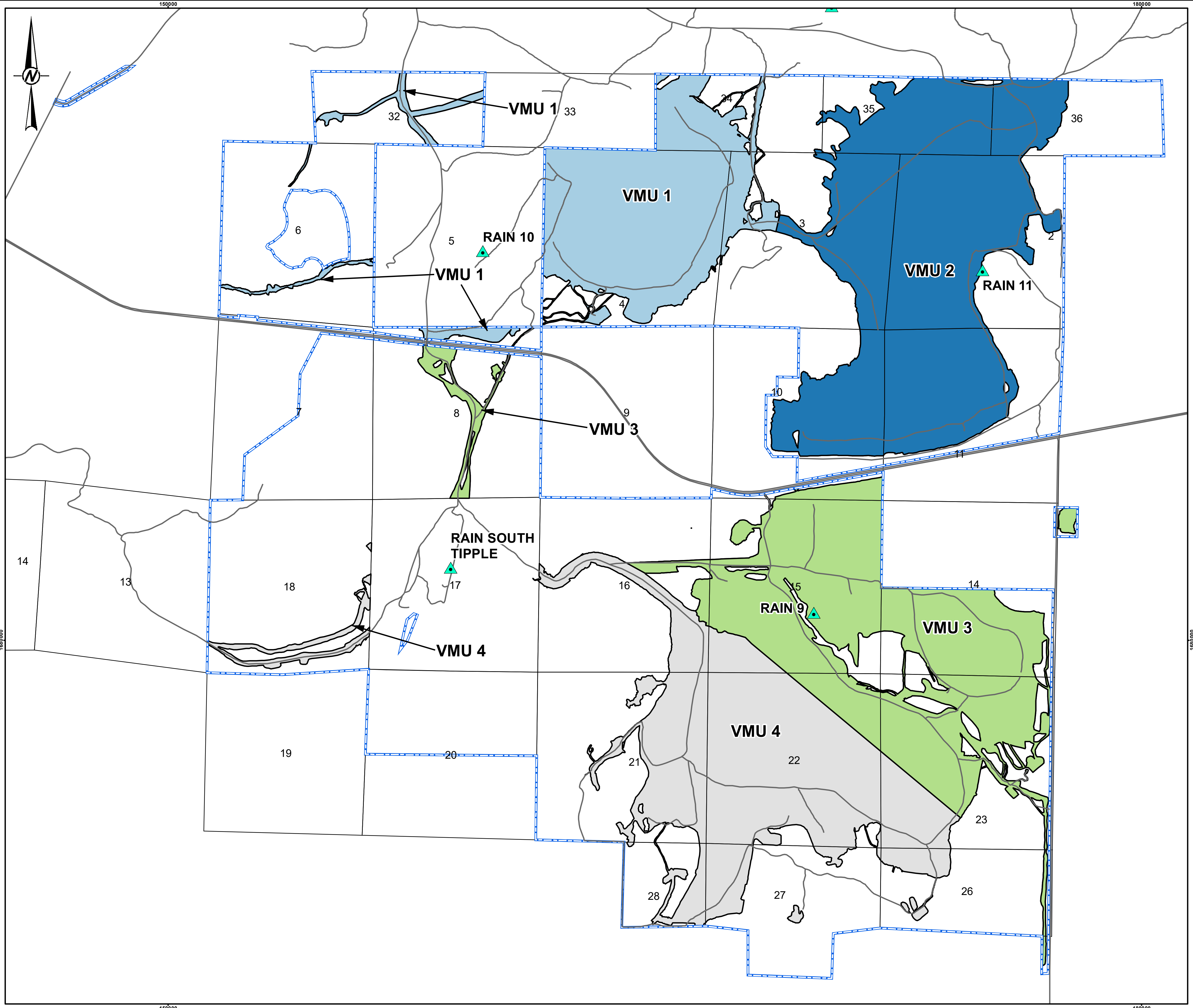
Diversity Component	Standard (% relative cover)	2019		2020		2021		2022	
		Result	Species	Result	Species	Result	Species	Result	Species
Subshrub or shrubs			**(8 spp.)**		**(5 spp.)**		**(4 spp.)**		**(2 spp.)**
Shrub 1	≥ 1.0%	21.78%	Four-wing saltbush	21.47%	Rubber rabbitbrush	5.28%	Rubber rabbitbrush	8.34%	Four-wing saltbush
Shrub 2	≥ 1.0%	9.69%	Rubber rabbitbrush	11.78%	Winterfat	4.11%	Winterfat	2.68%	Winterfat
Shrub 3 (bonus)	--	6.33%	Winterfat	3.52%	Gardner's saltbush	2.84%	Four-wing saltbush	--	--
Perennial warm-season grasses			**(6 spp.)**		**(3 spp.)**		**(3 spp.)**		**(3 spp.)**
Grass 1	≥ 1.0%	22.26%	James' galleta	23.24%	James' galleta	40.61%	James' galleta	64.03%	James' galleta
Grass 2	≥ 1.0%	0.99%	Blue grama	3.17%	Blue grama	0.63%	Sand dropseed	4.27%	Blue grama
Grass 3 (bonus)	--	0.36%	Buffalograss	2.42%	Alkali sactaon	0.16%	Blue gramma	2.65%	Alkalai sacaton
Perennial cool-season grasses			**(10 spp.)**		**(11 spp.)**		**(4 spp.)**		**(2 spp.)**
Grass 1	≥ 1.0%	9.40%	Western wheatgrass	6.97%	Colorado wildrye	34.08%	Russian wildrye	4.77%	Russian wildrye
Grass 2 (bonus)	--	9.09%	Colorado wildrye	6.94%	Slender wheatgrass	4.00%	Western wheatgrass	3.56%	Thickspike wheatgrass
Perennial/biennial forbs		**3.52%**	**(8 spp.)**	**0.68%**	**(5 spp.)**	**3.21%**	**(5 spp.)**	**6.95%**	**(10 spp.)**
Forb 1	≥ 1.0% combined	0.80%	Scarlet globemallow	0.31%	Purple aster	2.96%	Rattlesnake weed	4.73%	Rattlesnake weed
Forb 2		0.75%	Flatspine stickseed	0.21%	Flatspine stickseed	0.11%	Scarlet globemallow	1.00%	Manyflowered ipomopsis
Forb 3		0.73%	Purple aster	0.10%	Upright prairie coneflower	0.08%	Flatspine stickseed	0.85%	Ragleaf bahia
Forb 4 (bonus)	--	0.52%	Palmer's penstemon	0.05%	Palmer's penstemon	0.05%	Redstem stork's bill	0.37%	Purple Aster

Notes:

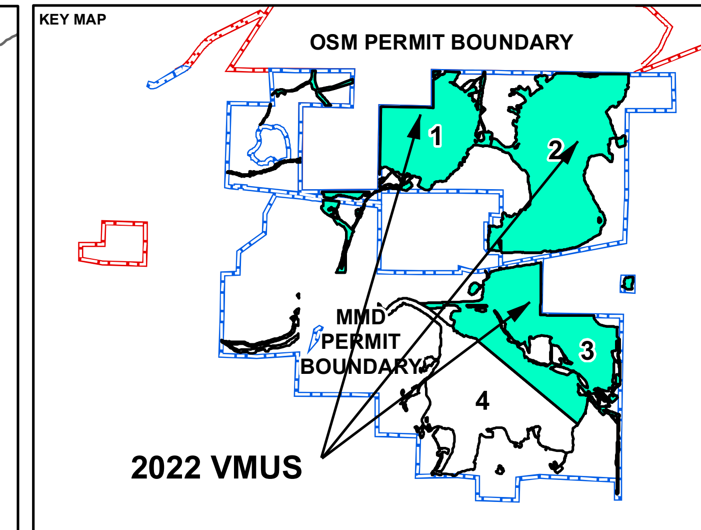
-- = not applicable

Indicates an unmet parameter

Figures



KEY MAP



LEGEND

- Rain Gauges
- Two-tracks, Roads and Highways
- MMD Permit Boundary
- PLSS - Sections
- Liability Release
- MMD VMU 1 (~ 839 acres)
- MMD VMU 2 (~ 1,518 acres)
- MMD VMU 3 (~ 1,284 acres)

0 3,000 6,000
1 inch = 3,000 feet FEET

NOTE(S)
1. VMU = VEGETATION MANAGEMENT UNIT FOR VEGETATION SAMPLING PLAN
2. VMU4 IS PENDING BOND RELEASE

REFERENCE(S)
1. ORTHOIMAGE: CHEVRON, 2013

COORDINATE SYSTEM: NAD 1927 STATEPLANE NEW MEXICO WEST FIPS 3003
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1927

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT

PROJECT
MCKINLEY MINE - MMD PERMIT PHASE III BOND RELEASE,
2022 VEGETATION MONITORING SAMPLING PLAN

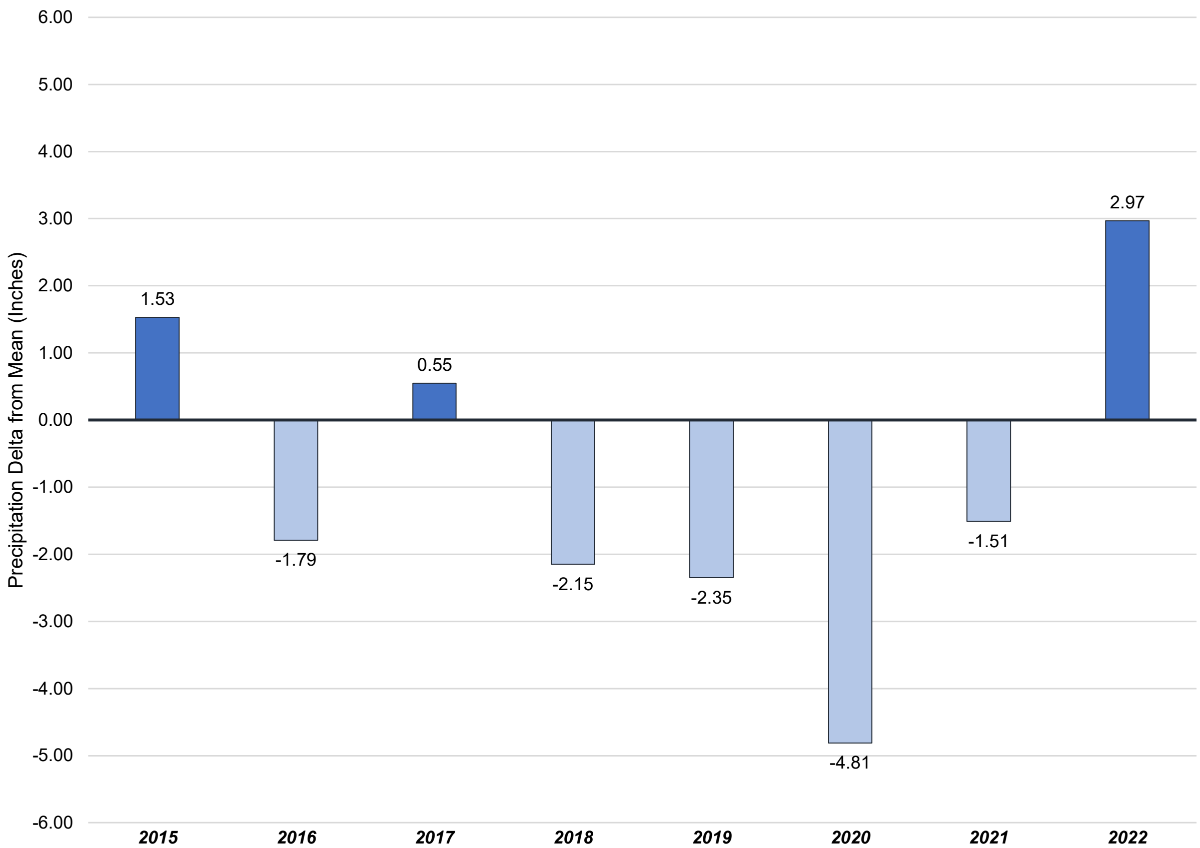
TITLE
GENERAL OVERVIEW OF THE MCKINLEY MMD PERMIT AREA VEGETATION MANAGEMENT UNITS (VMU), 2022

CONSULTANT
[redacted]

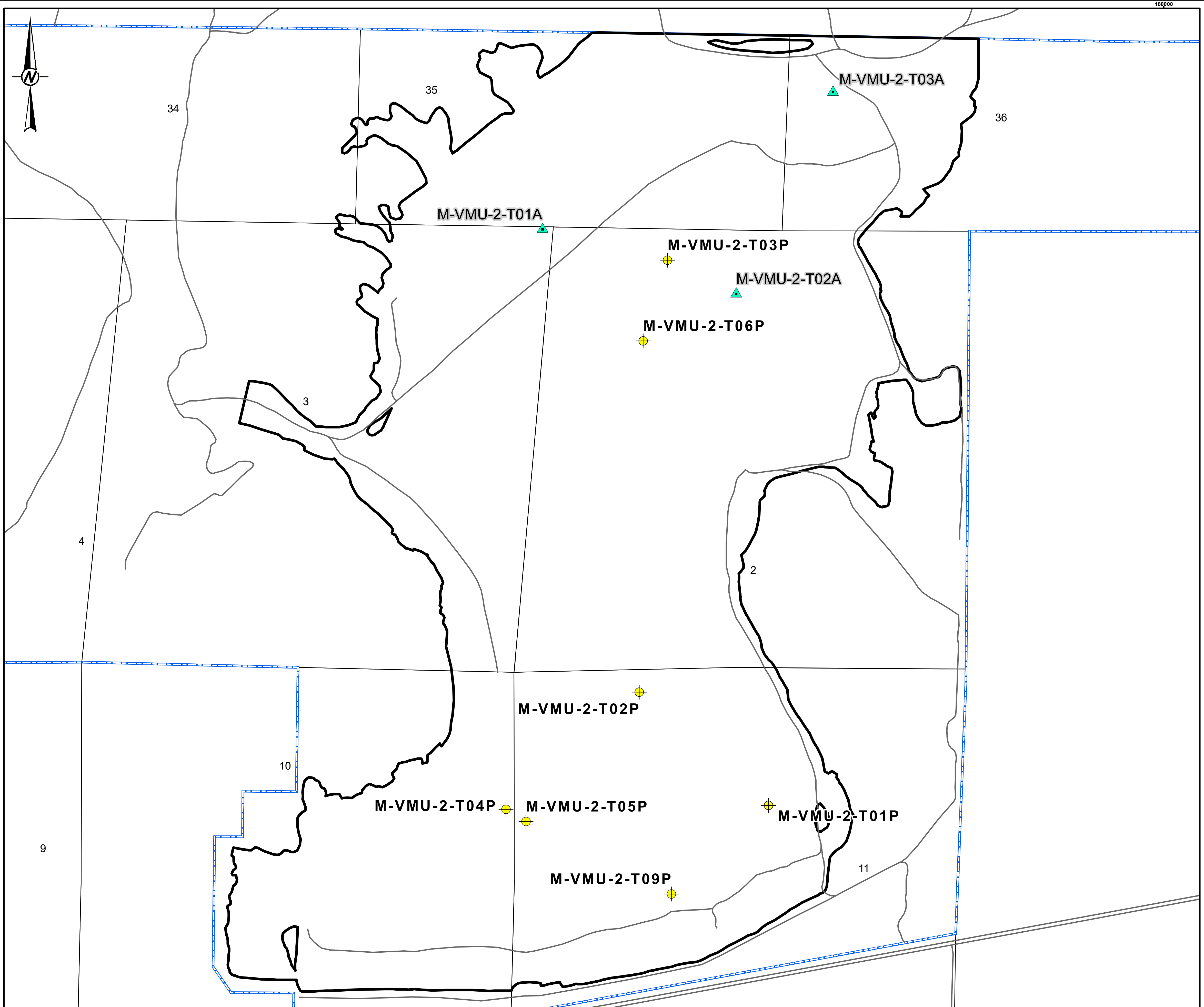
YYYY-MM-DD	2023-02-02
DESIGNED	GFD
PREPARED	AFS
REVIEWED	CD
APPROVED	DR

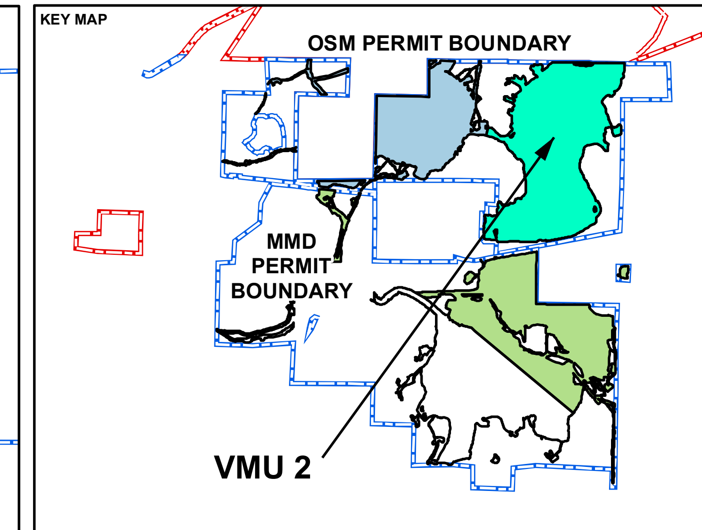
PROJECT NO.	CONTROL	REV.	FIGURE
133-8105209	B001	0	1

Figure 2: Departure of Growing Season Precipitation from Long-Term Seasonal Mean at Window Rock, NM; Rain 11 Gauge



Notes:
Long-term averages are from Window Rock, Arizona Station (029410) for 1937 to 1999 (Western Regional Climate Center, 2020).
Growing season total precipitation is the sum of monthly totals between April and September
Source data is in Table 1





LEGEND

- Primary Transect
- Alternate Transect
- Two-tracks, Roads and Highways
- PLSS - Sections
- MMD VMU 2 (~ 1,518 acres)
- Liability Release
- MMD Permit Boundary

TRANSECT LABEL EXPLANATION:

M-VMU-1-T1P

- MMD Permit Area
- Vegetation Management Unit (VMU-#)
- Transect Number
- Primary (P) or Alternate (A)

0 1,200 2,400

1 inch = 1,200 feet FEET

NOTE(S)

1. KEY MAP SCALE IS DIFFERENT FROM OVERVIEW OF VMUS
2. TRANSECT LOCATIONS WERE CREATED IN ACCORDANCE WITH METHODS OUTLINED IN THE PERMIT

REFERENCE(S)

1. ORTHOIMAGE: CHEVRON, 2013

COORDINATE SYSTEM: NAD 1927 STATEPLANE NEW MEXICO WEST FIPS 3003
PROJECTION: TRANSVERSE MERCATOR
DATUM: NORTH AMERICAN 1927

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT

PROJECT
MCKINLEY MINE - MMD PERMIT PHASE III BOND RELEASE
2022 VEGETATION MONITORING

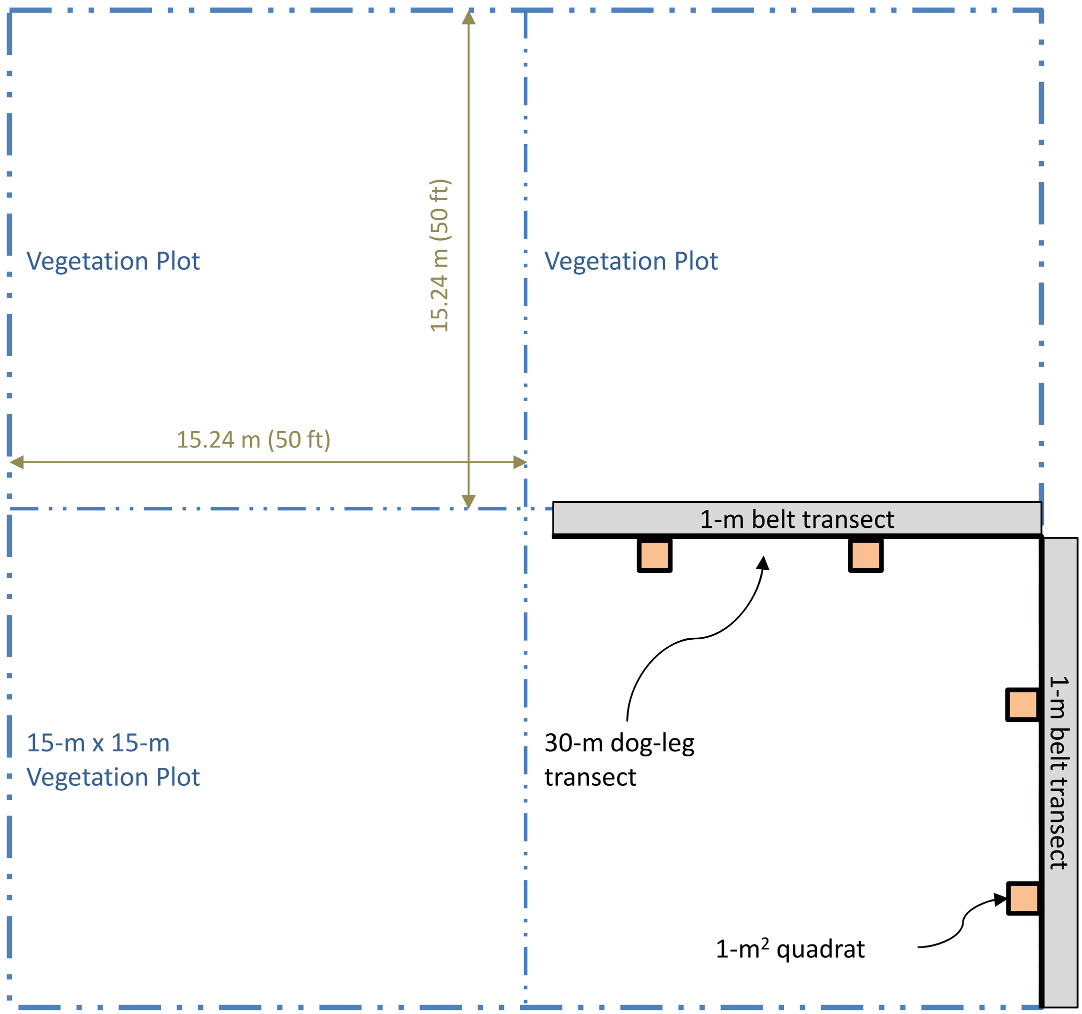
TITLE
VEGETATION MONITORING TRANSECTS 2022, VEGETATION MANAGEMENT UNIT 2

CONSULTANT
[redacted]

YYYY-MM-DD	2023-02-03
DESIGNED	GFD
PREPARED	AFS
REVIEWED	CD
APPROVED	DR

PROJECT NO.	CONTROL	REV.	FIGURE
133-8105209	B003	0	3

Figure 4: Vegetation Plot, Transect, and Quadrat Layout



not to scale

Figure 5: Typical Grass-Shrubland Vegetation in M-VMU-2, September 2022

Figure 6: Stabilization of the Mean for Perennial/Biennial Cover - M-VMU-2, 2022

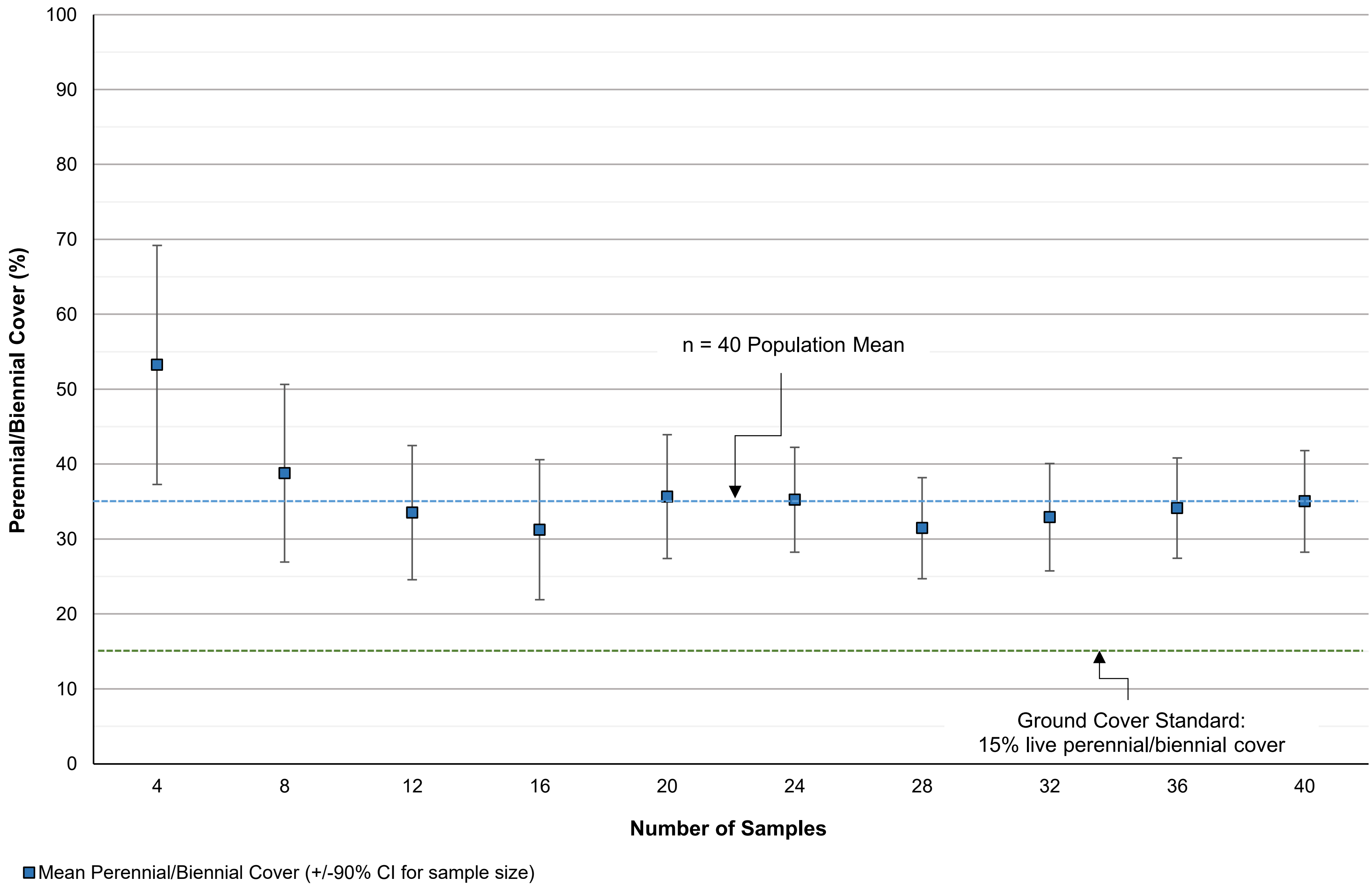


Figure 7: Stabilization of the Mean for Annual Forage Production - M-VMU-2, 2022

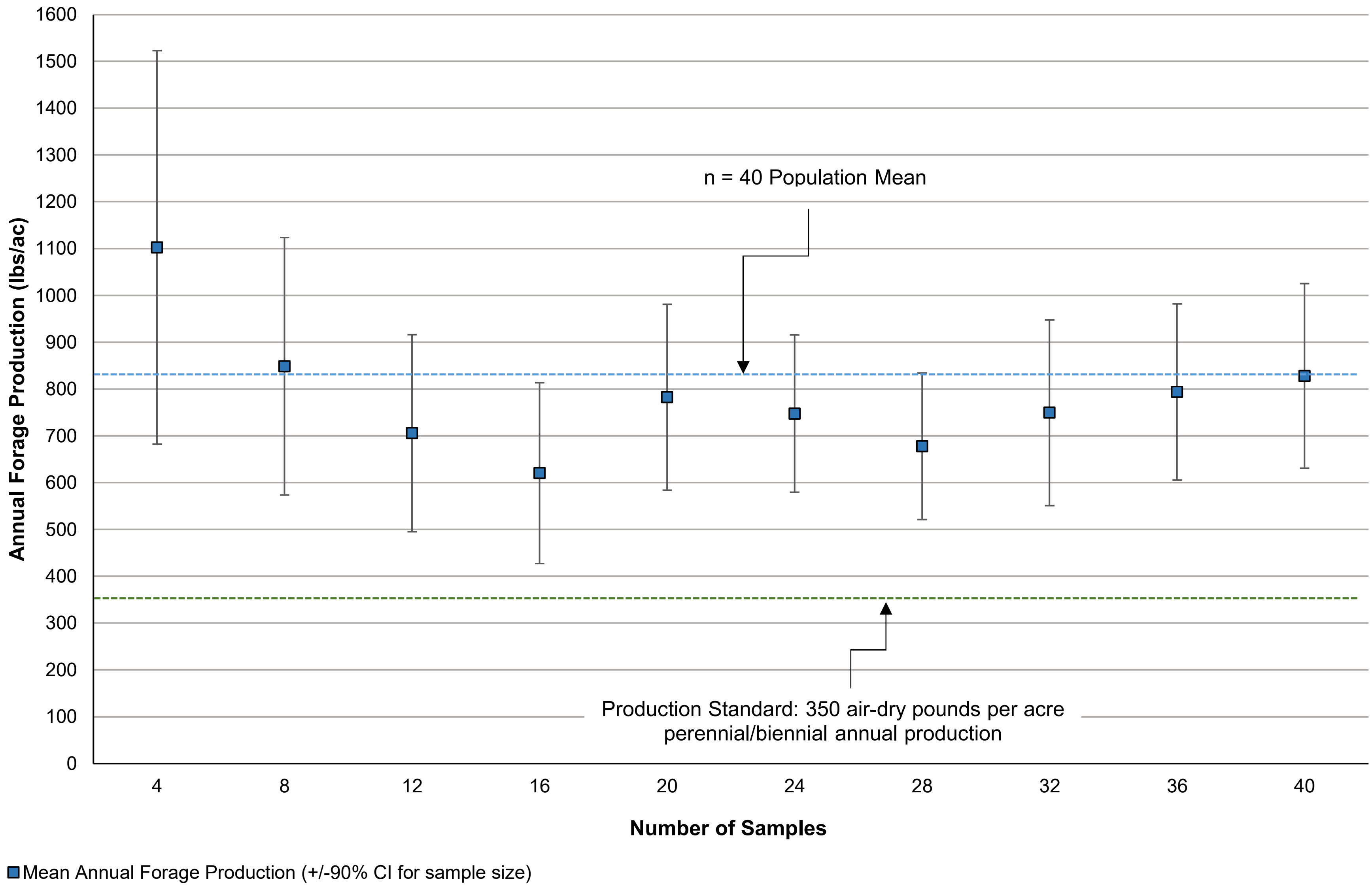
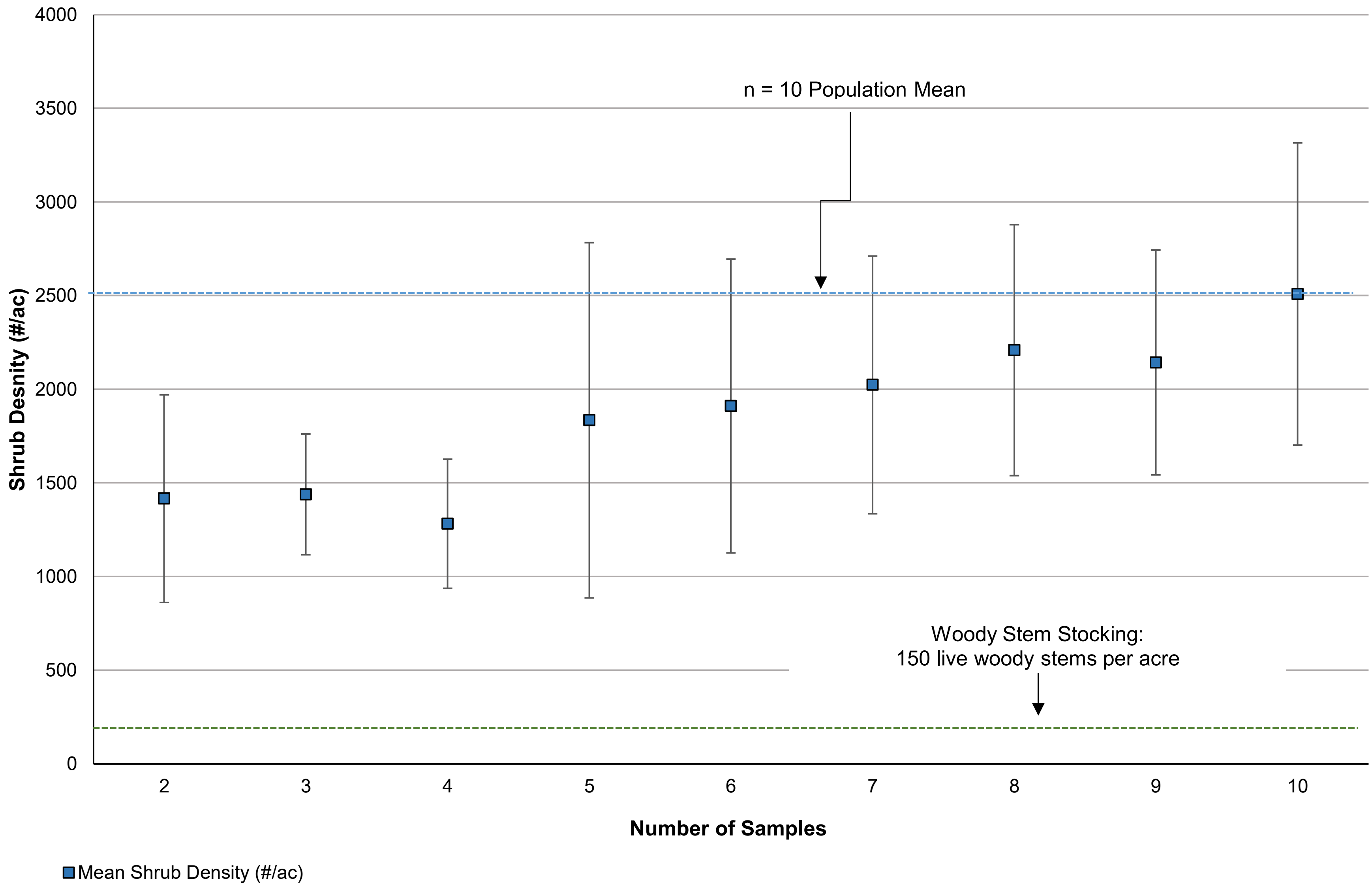


Figure 8: Stabilization of the Mean for Shrub Density - M-VMU-2, 2022



APPENDIX A

Vegetation Data Summary

Table A-1: M-VMU-2 Canopy Cover Data, 2022

Transect	M-VMU-2-T01A				M-VMU-2-T01P				M-VMU-2-T02A				M-VMU-2-T02P				M-VMU-2-T03A			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	30.0	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	2.8	--	--	--	--	--	--	3.0
HECO26	--	3.0	--	--	--	7.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	1.5	0.8	--	--	1.5	--	--	--
PLJA	78.0	38.0	35.0	58.0	7.0	0.1	25.0	26.0	30.0	2.0	25.0	9.5	--	--	6.0	1.0	26.5	46.0	13.0	17.0
PSJU3	--	--	--	--	--	--	--	--	--	3.0	6.5	1.5	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	3.0	--	0.5	11.5	--	--	--	--	--	--	12.0	--	11.0	--
BOCU	--	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--
SPAI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	16.0	5.0
Forbs																				
Annual																				
POOL	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--
SATR	0.3	--	--	--	7.2	2.5	--	--	--	--	--	--	0.7	5.0	2.0	0.5	--	--	--	0.1
VEEN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	4.0	--	0.1	--	--	--	--
Perennials																				
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TRDU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MACA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.3	--	--	--	--
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	12.0	--	--	--	--	--
CHAL11	--	--	--	1.0	0.5	7.0	0.3	4.5	--	--	--	--	--	--	3.0	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14.0	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	24.0	--	4.0	5.5	10.0	42.0
EPVI	--	--	--	--	--	--	--	--	2.0	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	12.0	5.0	--	--	--	--	--	--	--	--	--	1.5	--	0.9	--	--
Cover Components																				
Perennial/Biennial Vegetation Cover	78.0	41.0	35.0	59.0	19.5	19.1	28.3	30.5	32.5	17.0	31.5	11.0	4.3	0.8	75.0	17.8	44.0	52.4	50.0	67.0
Total Vegetation Cover	78.0	41.0	32.0	57.5	26.0	18.0	26.0	30.0	32.5	15.0	30.0	10.0	5.0	9.3	65.0	17.5	41.0	50.0	48.0	62.0
Rock	0.3	10.0	1.0	0.3	15.0	0.5	0.3	9.5	3.0	5.0	0.2	1.8	3.0	15.0	0.0	1.3	3.0	0.5	1.5	3.0
Litter	2.0	3.0	5.5	5.5	3.5	7.5	4.5	12.0	2.0	2.0	5.5	10.0	3.0	0.1	20.0	15.0	4.0	3.5	6.0	7.5
Base Soil	19.8	46.0	61.5	36.8	55.5	74.0	69.3	48.5	62.5	78.0	64.3	78.3	89.0	75.6	15.0	66.3	52.0	46.0	44.5	27.5

Transect	M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T09P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	0.3	0.8	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	20.0	--	--	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HECO26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	5.5	--	1.8	--	--	--	--	--	--	--	--
PLJA	47.0	25.0	12.5	18.0	5.0	--	--	23.0	96.0	6.5	45.0	--	42.0	7.0	25.0	--	--	73.0	24.0	7.0
PSJU3	--	--	--	--	--	--	--	--	--	--	--	--	12.0	16.0	4.0	24.0	--	--	--	--
BOGR2	--	--	10.0	12.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOCU	3.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPAI	--	--	4.0	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	12.0	--	--
Forbs																				
Annual																				
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SATR	--	--	--	--	--	--	0.0	0.1	--	--	--	4.5	--	--	--	--	--	--	0.1	--
VEEN	--	--	--	--	--	--	--	--	--	1.0	--	--	--	--	--	--	--	--	--	--
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																				
ERCI6	--	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	0.1	--	--
LAOC3	--	--	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	0.5	--	--
TRDU	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5	--	--
MACA	--	--	--	--	--	--	4.0	--	--	--	--	--	--	--	--	--	--	--	--	--
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHAL11	--	--	--	--	--	--	--	--	5.0	5.5	0.1	--	--	--	--	--	23.8	15.5	--	0.5
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	0.1	0.5	--	--	--	--	--	--	--	6.0	--	--	25.0	--	--	--	--	--	--
EPVI	--	--	0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	--	1.8	--	--	--	--	1.3	--	--	--	--	13.8	1.5	0.1	--
Cover Components																				
Perennial/Biennial Vegetation Cover	50.0	25.1	27.0	30.3	5.0	0.0	6.5	23.8	101.1	17.6	51.1	3.0	74.0	48.0	29.0	24.0	37.5	104.1	24.1	7.5
Total Vegetation Cover	50.0	25.0	25.0	28.0	5.0	0.0	6.5	23.0	96.0	15.0	50.0	7.5	74.0	47.0	28.0	24.0	36.5	90.0	24.0	7.3
Rock	4.0	25.0	--	0.3	5.0	60.0	0.0	8.0	--	0.3	0.1	4.5	--	1.5	--	12.5	0.5	0.3	2.0	3.5
Litter	5.0	6.0	25.0	7.0	4.5	1.0	4.0	9.0	4.0	0.5	4.0	2.0	1.1	2.0	4.0	4.5	8.0	9.0	0.5	4.0
Base Soil	41.0	44.0	50.0	64.8	85.5	39.0	89.5	60.0	--	84.3	46.0	86.0	24.9	49.5	68.0	59.0	55.0	0.8	73.5	85.3

Notes:
Species codes defined in Table A-6

Table A-2: M-VMU-2 Basal Cover Data, 2022

Transect	M-VMU-2-T01A				M-VMU-2-T01P				M-VMU-2-T02A				M-VMU-2-T02P				M-VMU-2-T03A			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.0	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	0.3
HECO26	--	0.3	--	--	--	0.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	<0.1	<0.1	--	--	0.2	--	--	--
PLJA	10.0	4.0	6.0	12.5	0.4	<0.1	2.5	2.5	3.0	0.1	2.5	0.8	--	--	0.5	0.1	2.5	0.5	1.3	2.0
PSJU3	--	--	--	--	--	--	--	--	--	0.3	0.8	0.2	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	0.3	--	0.1	1.0	--	--	--	--	--	--	1.0	--	1.0	--
BOCU	--	--	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--
SPAI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.5	0.1
Forbs																				
Annual																				
POOL	--	--	--	--	--	--	--	0.0	--	--	--	--	--	--	--	--	--	--	--	--
SATR	<0.1	--	--	--	0.1	0.1	--	--	--	--	--	--	0.0	0.0	0.1	0.1	--	--	--	<0.1
VEEN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0	--	0.0	--	--	--	--
Perennials																				
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TRDU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MACA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.1	--	--	--	--
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0	--	--	--	--	--
CHAL11	--	--	--	0.1	0.1	0.1	0.0	0.0	--	--	--	--	--	--	0.0	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2.0	--	0.5	0.1	0.1	0.3
EPVI	--	--	--	--	--	--	--	--	0.5	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	0.5	0.8	--	--	--	--	--	--	--	--	--	0.1	--	0.1	--	--
Cover Components																				
Perennial/Biennial Vegetation Cover	10.0	4.3	6.0	12.6	1.0	1.4	2.8	2.5	3.6	1.5	3.3	0.9	0.3	0.0	5.5	0.5	4.2	0.6	3.9	2.6
Total Vegetation Cover	10.0	4.3	6.0	12.6	1.1	1.5	2.8	2.6	3.6	1.5	3.3	0.9	0.3	0.0	5.6	0.5	4.2	0.6	3.9	2.6
Rock	1.5	13.0	6.5	0.5	5.5	3.0	0.8	11.0	3.5	5.0	0.3	2.3	3.0	20.0	0.1	1.5	4.0	4.0	4.3	4.3
Litter	30.0	13.0	5.0	2.0	8.0	2.0	5.5	7.5	10.0	3.0	5.0	4.5	5.0	0.1	70.0	7.0	9.0	50.0	7.0	5.5
Base Soil	58.5	69.7	82.5	85.0	85.4	93.6	91.0	78.9	83.0	90.6	91.5	92.4	91.7	79.9	24.4	91.0	82.8	45.4	84.9	87.6

Transect	M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T09P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	<0.1	0.1	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	2.0	--	--	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HECO26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	0.3	--	0.8	--	--	--	--	--	--	--	--
PLJA	5.0	2.5	1.3	2.5	0.2	--	--	3.0	10.0	0.8	4.0	--	5.0	0.8	2.0	--	--	8.0	2.5	0.5
PSJU3	--	--	--	--	--	--	--	--	--	--	--	--	1.2	2.0	0.5	2.5	--	--	--	--
BOGR2	--	--	0.9	1.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOCU	0.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPAI	--	--	0.5	0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	0.5	--	--
Forbs																				
Annual																				
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SATR	--	--	--	--	--	--	<0.1	<0.1	--	--	--	0.1	--	--	--	--	--	--	<0.1	--
VEEN	--	--	--	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																				
ERCI6	--	--	--	--	--	--	--	--	0.0	--	--	--	--	--	--	--	--	0.0	--	--
LAOC3	--	--	--	--	--	--	--	--	--	0.0	--	--	--	--	--	--	--	0.0	--	--
TRDU	--	--	--	--	--	--	0.2	--	--	--	--	--	--	--	--	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0	--	--
MACA	--	--	--	--	--	--	0.1	--	--	--	--	--	--	--	--	--	--	--	--	--
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHAL11	--	--	--	--	--	--	--	--	0.3	0.0	0.0	--	--	--	--	--	0.3	0.1	--	0.1
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	0.0	0.0	--	--	--	--	--	--	--	0.5	--	--	2.0	--	--	--	--	--	--
EPVI	--	--	0.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	--	0.1	--	--	--	--	0.1	--	--	--	--	0.1	0.1	0.0	--
Cover Components																				
Perennial/Biennial Vegetation Cover	5.3	2.5	2.7	3.5	0.2	--	0.4	3.1	10.3	1.1	4.5	0.9	8.2	4.8	2.5	2.5	0.4	8.8	2.5	0.6
Total Vegetation Cover	5.3	2.5	2.7	3.5	0.2	--	0.4	3.1	10.3	1.1	4.5	1.0	8.2	4.8	2.5	2.5	0.4	8.8	2.5	0.6
Rock	20.0	27.0	0.1	0.4	5.5	60.0	0.5	12.5	--	0.3	0.8	5.0	1.0	1.8	--	13.0	--	6.0	2.1	4.5
Litter	30.0	15.0	12.0	3.5	9.5	1.0	1.5	4.0	60.0	0.8	5.0	1.8	24.0	3.0	5.0	4.0	10.0	23.0	0.6	3.5
Base Soil	44.7	55.5	85.3	92.6	84.8	39.0	97.6	80.4	29.7	97.8	89.8	92.3	66.8	90.5	92.5	80.5	89.6	62.2	94.8	91.5

Notes:
Species codes defined in Table 3

Table A-3: M-VMU-2 Frequency Data (counts), 2022

Transect	M-VMU-2-T01A				M-VMU-2-T01P				M-VMU-2-T02A				M-VMU-2-T02P				M-VMU-2-T03A				M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T09P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																																								
Perennials																																								
ACHY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	3	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	66	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	11	--	--	--	--	--	--	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HECO26	--	6	--	--	--	24	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	3	1	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	12	--	9	--	--	--	--	--	--	--	--
PLJA	22	19	120	97	4	5	33	48	26	3	59	33	--	--	22	4	21	133	62	25	34	17	56	41	2	--	--	34	48	5	82	--	20	35	55	--	--	54	72	12
PSJU3	--	--	--	--	--	--	--	--	--	5	15	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4	9	6	29	--	--	--	--
BOGR2	--	--	--	--	--	--	24	--	4	47	--	--	--	--	--	--	4	--	20	--	--	--	16	22	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOCU	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SPAI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	8	7	--	--	7	1	--	--	--	--	--	--	--	--	--	--	--	--	--	10	--	--
Forbs																																								
Annual																																								
POOL	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SATR	1	--	--	--	11	5	--	--	--	--	--	--	1	2	8	4	--	--	--	1	--	--	--	--	--	--	7	1	--	--	--	2	--	--	--	--	--	--	1	--
VEEN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																																								
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	1	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--	--	38	--	--
TRDU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3	--	--
MACA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHAL11	--	--	--	23	6	38	7	36	--	--	--	--	--	--	10	--	--	--	--	--	--	--	--	--	--	--	--	--	7	29	5	--	--	--	--	--	33	409	--	6
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																																								
Perennials																																								
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	1	1	3	2	--	1	1	--	--	--	--	--	--	--	2	--	--	1	--	--	--	--	--	--
EPVI	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	2	1	--	--	--	--	--	--	--	--	--	1	--	1	--	--	--	--	--	--	--	--	1	--	--	--	--	1	--	--	--	--	7	1	1	--

Notes:
Species codes defined in Table 3

Table A-4: M-VMU-2 Air-dry Aboveground Annual Production Data (g/m^2), 2022

Transect	M-VMU-2-T01A				M-VMU-2-T01P				M-VMU-2-T02A				M-VMU-2-T02P				M-VMU-2-T03A			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOCU	--	--	--	--	--	--	--	--	--	1.5	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	--	--	--	--	4.8	--	0.6	13.7	--	--	--	--	--	--	69.2	--	30.3	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	29.8	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	5.6	--	--	--	--	--	--	5.3
HECO26	--	7.4	--	--	--	15.0	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	--	--	--	1.6	0.6	--	--	5.0	--	--	--
PLJA	166.0	71.9	69.4	179.0	10.5	2.0	99.5	81.3	41.7	13.3	58.2	27.6	--	--	11.0	1.3	97.2	152.9	41.3	50.3
PSJU3	--	--	--	--	--	--	--	--	--	7.3	19.7	3.9	--	--	--	--	--	--	--	--
SPAI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32.2	4.7
Forbs																				
Annual																				
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	3.1	--	0.3	--	--	--	--
POOL	--	--	--	--	--	--	--	0.0	--	--	--	--	--	--	--	--	--	--	--	--
SATR	2.2	--	--	--	32.2	9.8	--	--	--	--	--	--	2.8	6.6	6.8	1.0	--	--	--	0.4
VEEN	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Perennials																				
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13.2	--	--	--	--	--
CHAL11	--	--	--	0.7	1.8	5.7	0.7	2.6	--	--	--	--	--	--	1.4	--	--	--	--	--
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ERCI6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	23.6	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MACA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	3.3	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TRDU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	70.3	--	13.5	16.8	28.0	92.7
EPVI	--	--	--	--	--	--	--	--	0.6	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	29.0	13.8	--	--	--	--	--	--	--	--	--	2.2	--	2.0	--	--
Total Air-dry Aboveground Annual Production (g/m2)																				
Non-forage	2.2	--	--	--	32.2	9.8	--	--	--	--	--	--	2.8	9.6	6.8	1.3	--	--	--	--
Forage	166.0	79.3	69.4	179.7	41.3	36.6	105.0	83.9	42.8	35.9	77.9	31.5	7.1	0.6	125.6	30.3	185.0	171.6	131.8	153.0
Total Production	168.3	79.3	69.4	179.7	73.5	46.4	105.0	83.9	42.8	35.9	77.9	31.5	9.9	10.2	132.4	31.6	185.0	171.6	131.8	153.3
Total Air-dry Aboveground Annual Production (lbs/ac)																				
Non-forage	19.8	--	--	--	286.8	87.4	--	0.4	--	--	--	--	24.7	85.9	60.6	11.6	--	--	--	3.4
Forage	1481.3	707.5	619.0	1602.8	368.5	326.1	936.8	748.3	382.1	319.9	694.8	280.9	63.3	5.1	1120.7	270.7	1650.4	1531.3	1176.3	1364.6
Total Production	1501.1	707.5	619.0	1602.8	655.3	413.5	936.8	748.7	382.1	319.9	694.8	280.9	88.1	91.0	1181.2	282.3	1650.4	1531.3	1176.3	1368.0

Transect	M-VMU-2-T03P				M-VMU-2-T04P				M-VMU-2-T05P				M-VMU-2-T06P				M-VMU-2-T09P			
Quadrat	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Grasses																				
Perennials																				
ACHY	--	--	--	--	--	--	1.1	1.0	--	--	--	--	--	--	--	--	--	--	--	--
BOCU	5.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
BOGR2	--	--	13.6	13.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
ELLA3	--	--	--	--	--	--	--	--	--	--	--	--	94.3	--	--	--	--	--	--	--
ELTR7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
HECO26	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PASM	--	--	--	--	--	--	--	--	--	4.4	--	5.2	--	--	--	--	--	--	--	--
PLJA	83.8	47.3	44.0	39.5	7.1	--	--	69.7	367.4	13.7	131.4	--	122.8	31.1	81.0	--	--	260.1	66.3	38.4
PSJU3	--	--	--	--	--	--	--	--	--	--	--	--	7.1	57.9	11.4	40.3	--	--	--	--
SPAI	--	--	5.8	0.4	--	--	--	--	--	--	--	--	--	--	--	--	--	0.0	--	--
Forbs																				
Annual																				
DYPA	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
POOL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SATR	--	--	--	--	--	--	1.3	0.1	--	--	--	42.8	--	--	--	--	--	--	0.4	--
VEEN	--	--	--	--	--	--	--	--	--	4.0	--	--	--	--	--	--	--	--	--	--
Perennials																				
BADI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
CHAL11	--	--	--	--	--	--	--	--	0.7	7.2	0.4	--	--	--	--	--	14.0	85.6	--	0.7
CHENOP	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.1	--	--
ERCI6	--	--	--	--	--	--	--	--	0.4	--	--	--	--	--	--	--	--	0.0	--	--
IPMU	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
LAOC3	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	--	--	--	0.5	--	--
MACA	--	--	--	--	--	--	19.0	--	--	--	--	--	--	--	--	--	--	--	--	--
SPCO	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.0	--	--
TRDU	--	--	--	--	--	--	2.6	--	--	--	--	--	--	--	--	--	--	--	--	--
Shrubs, Trees and Cacti																				
Perennials																				
ATCA	--	0.5	3.3	--	--	--	--	--	--	--	20.1	--	--	69.5	--	--	--	--	--	--
EPVI	--	--	0.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
KRLA	--	--	--	--	--	--	15.6	--	--	--	--	9.9	--	--	--	--	33.3	3.7	2.2	--
Total Air-dry Aboveground Annual Production (g/m2)																				
Non-forage	--	--	--	--	--	--	1.3	--	--	4.0	--	42.8	--	--	--	--	--	--	--	--
Forage	89.6	47.7	66.9	53.1	7.1	--	38.3	70.8	368.1	25.7	151.8	15.1	224.2	158.4	92.4	40.3	47.4	355.0	68.5	39.1
Total Production	89.6	47.7	66.9	53.1	7.1	--	39.6	70.8	368.4	29.7	151.8	57.9	224.2	158.4	92.4	40.3	47.4	355.0	68.8	39.1
Total Air-dry Aboveground Annual Production (lbs/ac)																				
Non-forage	--	--	--	--	--	--	11.3	0.6	3.2	36.0	--	382.0	--	--	--	--	--	0.1	3.4	--
Forage	799.4	425.7	596.8	474.1	63.4	--	341.7	631.2	3283.8	228.9	1354.0	134.8	1999.9	1412.9	824.5	359.2	422.5	3167.3	610.7	348.9
Total Production	799.4	425.7	596.8	474.1	63.4	--	353.0	631.8	3287.0	264.9	1354.0	516.8	1999.9	1412.9	824.5	359.2	422.5	3167.4	614.1	348.9

Notes:

g/m^2 = grams per square meter

lbs/ac = pounds per acre

1 gram per square meter (g/m^2) is equal to 8.922 pounds per acre (lbs/ac)

Species codes defined in Table 3

Non-forage and forage determinations are based on the permit (e.g. plants of perennial and/or biennial duration are forage and plants of annual duration are non-forage; noxious weeds are non-forage)

Table A-5: M-VMU-2 Shrub Belt Transect Data, 2022

Transect	M-VMU-2-T01A	M-VMU-2-T01P	M-VMU-2-T02A	M-VMU-2-T02P	M-VMU-2-T03A	M-VMU-2-T03P	M-VMU-2-T04P	M-VMU-2-T05P	M-VMU-2-T06P	M-VMU-2-T09P
Shrubs, Trees and Cacti										
ATCA	7	1	1	5	27	11	3	7	9	10
ATCO	1	--	--	--	--	--	1	--	--	--
ATCO4	4	--	--	--	--	--	--	--	2	--
EPVI	--	--	1	--	--	--	--	--	--	--
ERNA	1	--	--	--	--	--	--	--	--	--
KRLA	--	4	8	1	3	6	16	19	1	33
PUTR2	--	1	--	--	--	--	--	--	--	--
ARFR4	--	--	1	--	--	--	--	--	--	--
GUSA	--	2	--	--	--	--	--	--	--	--

Code	Scientific Name	Common Name
ATCA	*Atriplex canescens*	Four-wing saltbush
ATCO	*Atriplex confertifolia*	Shadscale saltbush
ATCO4	*Atriplex corrugata*	Mat saltbush
EPVI	*Ephedra viridis*	Mormon tea
ERNA	*Artemisia frigida*	Prairie sagewort
KRLA	*Gutierrezia sarothrae*	Broom snakeweed
PUTR2	*Purshia tridentata*	Antelope bitterbrush
ARFR4	*Scientific Name*	Common Name
GUSA	*Atriplex canescens*	Four-wing saltbush

Table A-6 : Species Observed 2019-2022, M-VMU-2

Common Name	Scientific Name	Code
Cool-Season Grasses (22)		
Annuals (3)		
Field brome	*Bromus arvensis*	BRAR5
Cheatgrass	*Bromus tectorum*	BRTE
Sixweeks fescue	*Vulpia octoflora*	VUOC
Perennials (19)		
Achnatherum hymenoides	*Indian ricegrass*	ACHY
Crested wheatgrass	*Agropyron cristatum*	AGCR
Sideoats grama	*Bouteloua curtipendula*	BOCU
Blue grama	*Bouteloua gracilis*	BOGR2
Smooth brome	*Bromus inermis*	BRIN2
Bottlebrush squirreltail	*Elymus elymoides*	ELEL
Blue wildrye	*Elymus glaucus*	ELGL
Thickspike wheatgrass	*Elymus lanceolatus*	ELLA3
Thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	ELLAL
Slender wheatgrass	*Elymus trachycaulus*	ELTR7
Needle and thread	*Hesperostipa comata*	HECO26
Foxtail barley	*Hordeum jubatum*	HOJU
Colorado wildrye	*Leymus ambiguus*	LEAM
Western wheatgrass	*Pascopyrum smithii*	PASM
Pleuraphis jamesii	*James' galleta*	PLJA
Russian wildrye	*Psathyrostachys juncea*	PSJU3
Alkali sacaton	*Sporobolus airoides*	SPAI
Intermediate wheatgrass	*Thinopyrum intermedium*	THIN6
Tall wheatgrass	*Thinopyrum ponticum*	THPO7
Warm-Season Grasses (6)		
Perennials (6)		
Sideoats grama	*Bouteloua curtipendula*	BOCU
Buffalograss	*Bouteloua dactyloides*	BODA2
Blue grama	*Bouteloua gracilis*	BOGR2
James' galleta	*Pleuraphis jamesii*	PLJA
Alkali sacaton	*Sporobolus airoides*	SPAI
Sand dropseed	*Sporobolus cryptandrus*	SPCR
Forbs (46)		
Annuals (15)		
Lambsquarters	*Chenopodium album*	CHAL7
Mealy goosefoot	*Chenopodium incanum*	CHIN2
Narrowleaf goosefoot	*Chenopodium leptophyllum*	CHLE4
fetid marigold	*Dyssodia papposa*	DYPA
Common sunflower	*Helianthus annuus*	HEAN3
Longleaf false goldeneye	*Heliomeris longifolia*	HELO6
Kochia	*Kochia scoparia*	KOSC

Table A-6 : Species Observed 2019-2022, M-VMU-2

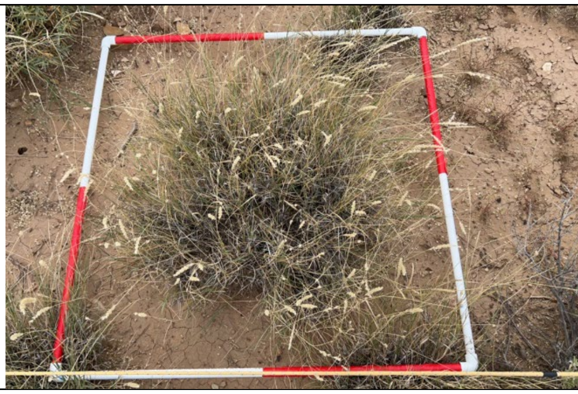
Common Name	Scientific Name	Code
Fendler's desertdandelion	*Malacothrix fendleri*	MAFE
Woolly plantain	*Plantago patagonica*	PLPA2
Erect knotweed	*Polygonum erectum*	POER2
Little hogweed	*Portulaca oleracea*	POOL
Russian thistle	*Salsola tragus*	SATR
Unknown annual forb	Unknown Annual Forb	UNKAF
Cowpen Daisy	*Verbesena encelioides*	VEEN
Rough cocklebur	*Xanthium strumarium*	XAST
Perennials/Biennials (31)		
Common yarrow	*Achillea millefolium*	ACMI2
Bahia dissecta	*Ragleaf bahia*	BADI
Musk thistle	*Carduus nutans*	CANU4
Rattlesnake weed	*Chamaesyce albomarginata*	CHAL11
Chenopod	*Chenopodiaceae*	CHENOP
Rose heath	*Chaetopappa ericoides*	CHER
Horseweed	*Conyza canadensis*	COCA
Flixweed	*Descurainia sophia*	DESO
Redstem stork's bill	*Erodium cicutarium*	ERCI6
Curlytop gumweed	*Grindelia nuda var. aphanactis*	GRNUA
Curly-cup gumweed	*Grindelia squarosa*	GRSQ
Showy goldeneye	*Heliomeris multiflora*	HEMU3
Manyflowered ipomopsis	*Ipomopsis multiflora*	IPMU
Flatspine stickseed	*Lappula occidentalis*	LAOC3
Prickly lettuce	*Lactuca serriola*	LASE
Lewis flax	*Linum lewisii*	LILE
Purple aster	*Machaeranthera canescens*	MACA
Tanseyleaf tansyaster	*Machaeranthera tanacetifolia*	MATA
Unknown blazingstar species	*Mentzelia* species	MENTZ
Alfalfa	*Medicago sativa*	MESA
Palmer's penstemon	*Penstemon palmeri*	PEPA8
Prostrate knotweed	*Polygonum aviculare*	POAV
Upright prairie coneflower	*Ratibida columnifera*	RACO3
Tall tumblemustard	*Sisymbrium altissimum*	SIAL2
Scarlet globemallow	*Sphaeralcea coccinea*	SPCO
Emory's globemallow	*Sphaeralcea emoryi*	SPEM
Gooseberryleaf globemallow	*Sphaeralcea grossulariifolia*	SPGR2
Spear globemallow	*Sphaeralcea hastulata*	SPHA
Gray globemallow	*Sphaeralcea incana*	SPIN2
Yellow salsify	*Tragopogon dubius*	TRDU
Unknown perennial forb	Unknown Perennial Forb	UNKPF

Table A-6 : Species Observed 2019-2022, M-VMU-2

Common Name	Scientific Name	Code
Shrubs, Trees and Cacti (33)		
Perennials (33)		
Prairie sagewort	*Artemisia frigida*	ARFR4
White sagebrush	*Artemisia ludoviciana*	ARLU
Big sagebrush	*Artemisia tridentata*	ARTR2
Tubercled saltbush	*Atriplex acanthocarpa*	ATAC
Four-wing saltbush	*Atriplex canescens*	ATCA
Shadscale saltbush	*Atriplex confertifolia*	ATCO
Mat saltbush	*Atriplex corrugata*	ATCO4
Gardner's saltbush	*Atriplex gardneri*	ATGA
Mound saltbush	*Atriplex obovata*	ATOB
Unknown saltbush species	*Atriplex species*	ATRIP
Yellow rabbitbrush	*Chrysothamnus viscidiflorus*	CHVI
Russian olive	*Elaeagnus angustifolia*	ELAN
Longleaf jointfir	*Ephedra trifurca*	EPTR
Mormon tea	*Ephedra viridis*	EPVI
Slenderleaf buckwheat	*Eriogonum leptophyllum*	ERLE10
Rubber rabbitbrush	*Ericameria nauseosa*	ERNA
Apache plume	*Fallugia paradoxa*	FAPA
Broom snakeweed	*Gutierrezia sarothrae*	GUSA
Hairy false goldenaster	*Heterotheca villosa*	HEVI
Oneseed juniper	*Juniperus monosperma*	JUMO
Mat saltbush	*Atriplex corrugata*	KRLA
Torrey wolfberry	*Lycium torreyi*	LYTO
Plains pricklypear	*Opuntia polyacantha*	OPPO
Mexican cliffrose	*Purshia mexicana*	PUME
Antelope bitterbrush	*Purshia tridentata*	PUTR2
Skunkbush sumac	*Rhus trilobata*	RHTR
Woods' rose	*Rosa woodsii*	ROWO
Narrowleaf willow	*Salix exigua*	SAEX
Greasewood	*Sarcobatus vermiculatus*	SAVE4
Threadleaf groundsel	*Senecio flaccidus*	SEFL3
Saltcedar	*Tamarix ramosissima*	TARA
Gray horsebrush	*Tetradymia canescens*	TECA
Banana yucca	*Yucca baccata*	YUBA

APPENDIX B

Quadrat Photographs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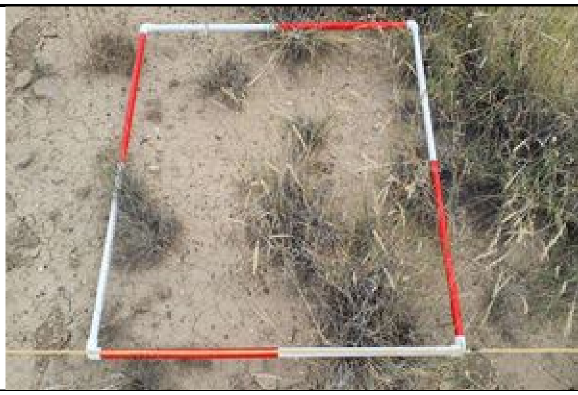	
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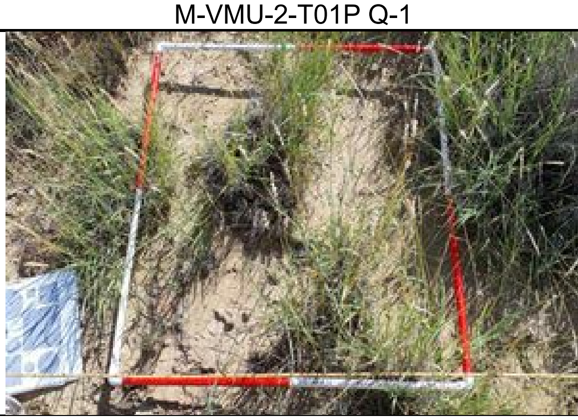	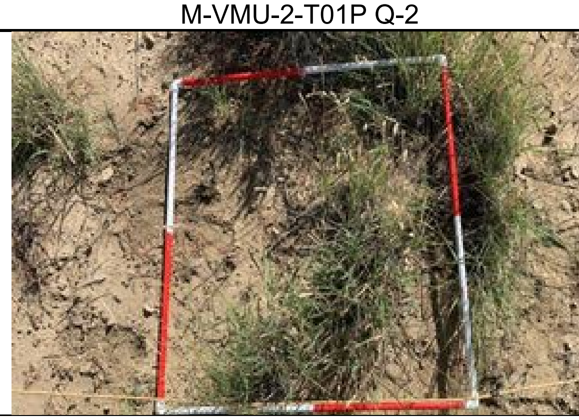
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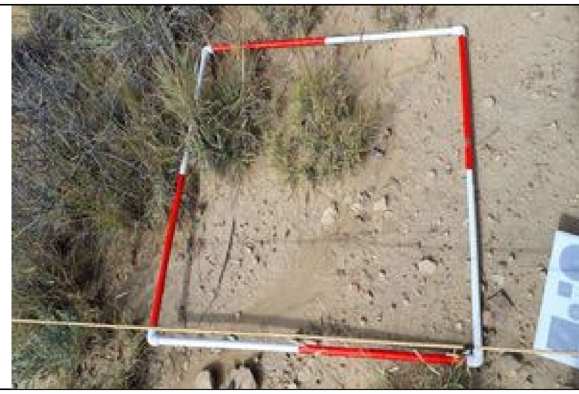

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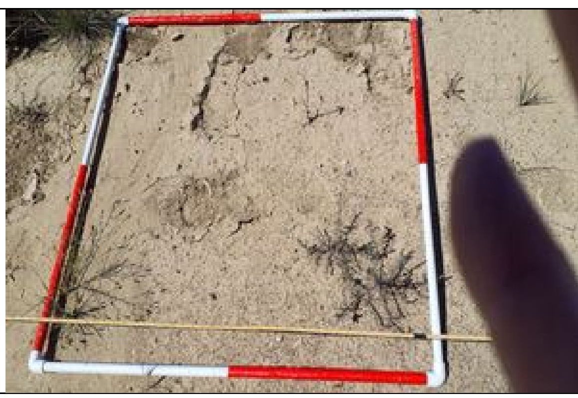
M-VMU-2-T02A Q-3

M-VMU-2-T02A Q-4



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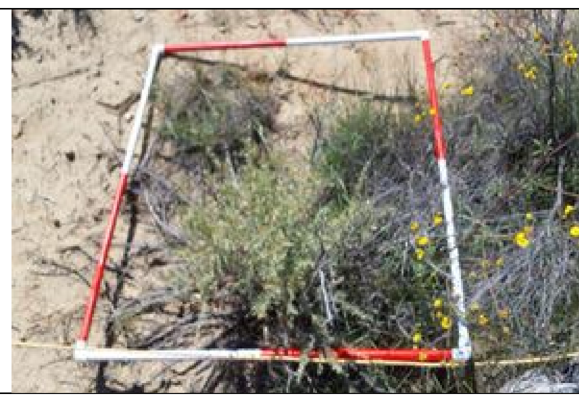

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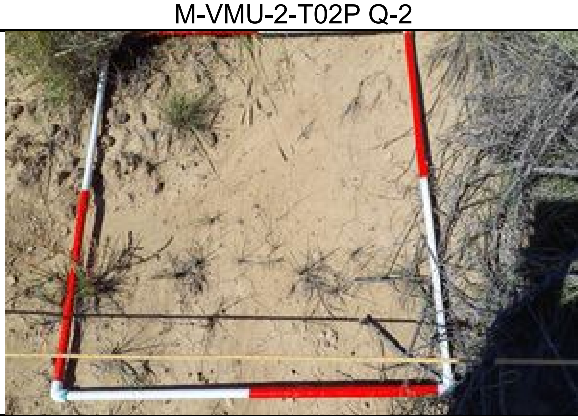

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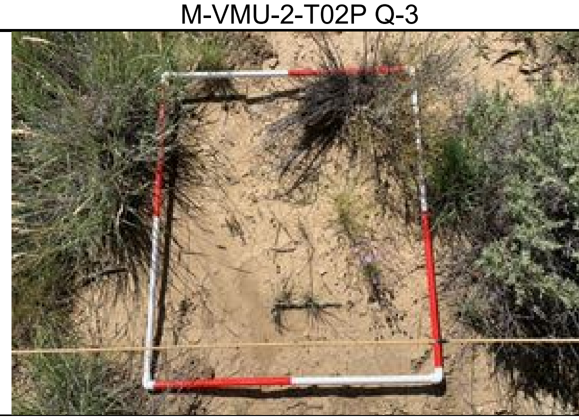
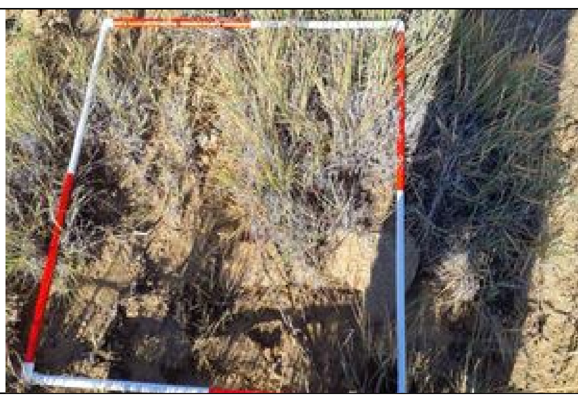


M-VMU-2-T02P Q-4

	
M-VMU-2-T03A Q-1	M-VMU-2-T03A Q-2
	
M-VMU-2-T03A Q-3	M-VMU-2-T03A Q-4
	
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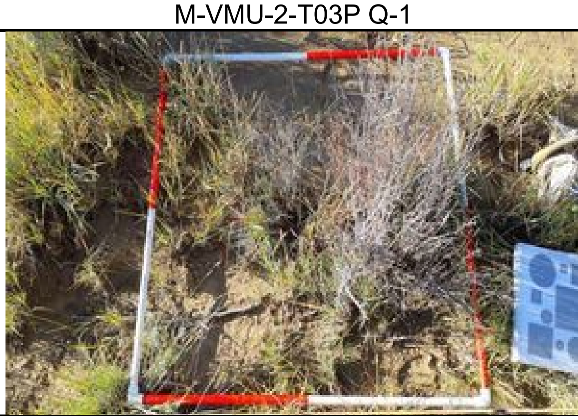	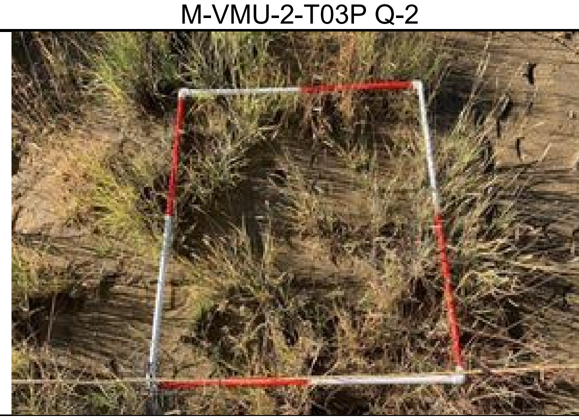
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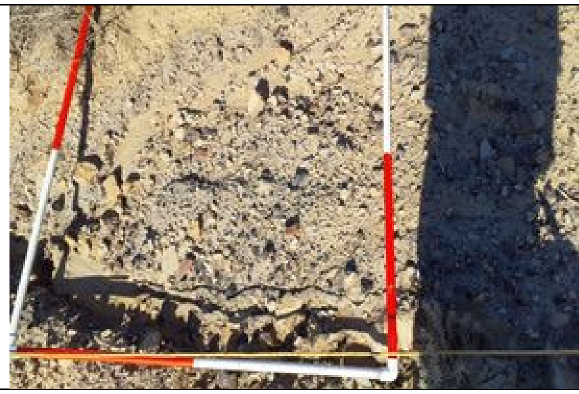
M-VMU-2-T04P Q-1



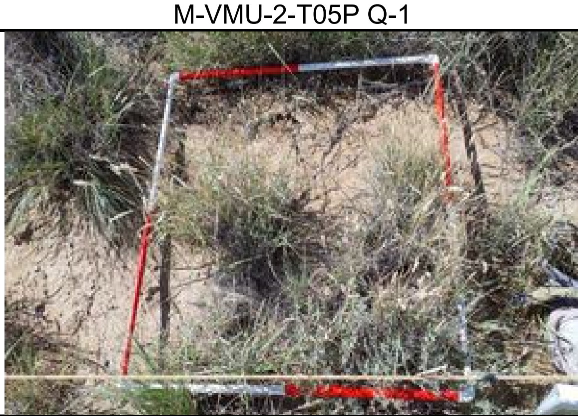
M-VMU-2-T04P Q-2

M-VMU-2-T04P Q-3

M-VMU-2-T04P Q-4

M-VMU-2-T05P Q-1

M-VMU-2-T05P Q-2



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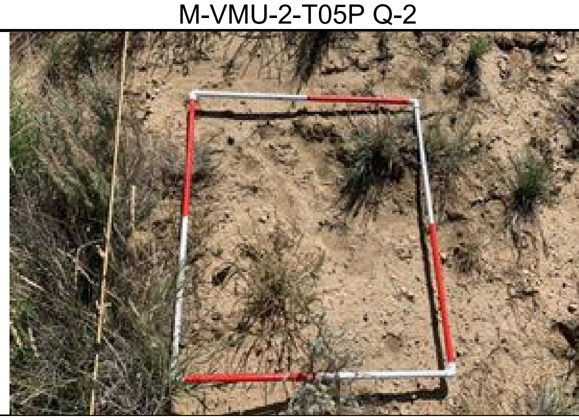
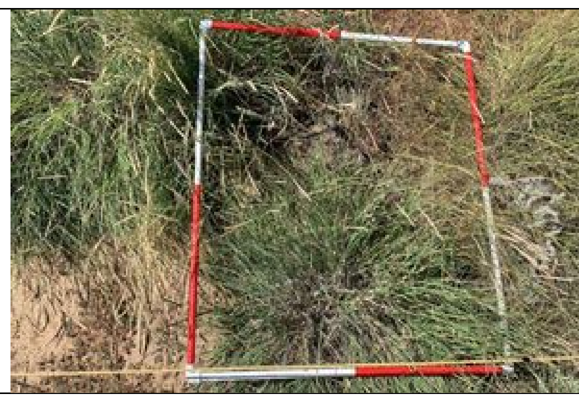
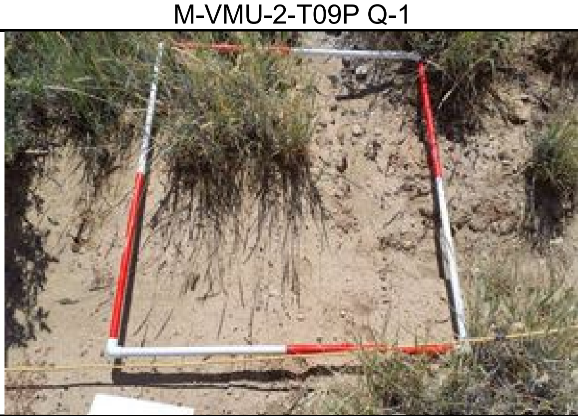


M-VMU-2-T05P Q-4

	
M-VMU-2-T06P Q-1	M-VMU-2-T06P Q-2
	
M-VMU-2-T06P Q-3	M-VMU-2-T06P Q-4
	
M-VMU-2-T09P Q-1	M-VMU-2-T09P Q-2
	
M-VMU-2-T09P Q-3	M-VMU-2-T09P Q-4

APPENDIX C

Vegetation Statistical Analysis

Table C-1. M-VMU-2 2022 Data for Normal Distribution and Variance Analysis

Transect	Quadrat	Perennial/ Biennial Cover (%)	Annual Forage Production (lbs/ac)	Woody Plant Density (#/ac)	Log P/B Cover	Log AFP	Log WPD
M-VMU-2-T01	1	78	1481	1754	1.90	3.17	3.24
	2	41	708		1.62	2.85	
	3	35	619		1.56	2.79	
	4	59	1603		1.78	3.21	
M-VMU-2-T02P	1	19	368	1079	1.31	2.57	3.03
	2	19	326		1.30	2.51	
	3	28	937		1.47	2.97	
	4	31	748		1.50	2.87	
M-VMU-2-T03P	1	33	382	1484	1.53	2.58	3.17
	2	17	320		1.26	2.51	
	3	32	695		1.51	2.84	
	4	11	281		1.08	2.45	
M-VMU-2-T04P	1	4	63	809	0.72	1.81	2.91
	2	1	5		0.26	0.78	
	3	75	1121		1.88	3.05	
	4	18	271		1.27	2.43	
M-VMU-2-T05P	1	44	1650	4047	1.65	3.22	3.61
	2	52	1531		1.73	3.19	
	3	50	1176		1.71	3.07	
	4	67	1365		1.83	3.14	
M-VMU-2-T06P	1	50	799	2293	1.71	2.90	3.36
	2	25	426		1.42	2.63	
	3	27	597		1.45	2.78	
	4	30	474		1.49	2.68	
M-VMU-2-T07P	1	5	63	2698	0.78	1.81	3.43
	2	0	0		0.00	0.00	
	3	7	342		0.88	2.53	
	4	24	631		1.39	2.80	
M-VMU-2-T08P	1	101	3284	3507	2.01	3.52	3.55
	2	18	229		1.27	2.36	
	3	51	1354		1.72	3.13	
	4	3	135		0.60	2.13	
M-VMU-2-T09P	1	74	2000	1619	1.88	3.30	3.21
	2	48	1413		1.69	3.15	
	3	29	824		1.48	2.92	
	4	24	359		1.40	2.56	
M-VMU-2-T10P	1	38	423	5800	1.59	2.63	3.76
	2	104	3167		2.02	3.50	
	3	24	611		1.40	2.79	
	4	8	349		0.93	2.54	
Mean		35.0	828.3	2509	1.40	2.67	3.33
Standard Deviation		26.1	758.9	1550	0.45	0.66	0.27
Count		40	40	10	40	40	10
Variance		680	575931	2402779.9	0.20	0.44	0.07
90% Confidence Interval		6.8	197.4	806.3	0.20	0.44	0.08

Notes:
2022 Data are found in Appendix A

Table C-2: 2022 Perennial/ Biennial Canopy Cover, Method 5 - CMRP

Transect	Quadrat	2022 Perennial / Biennial Cover (%)	90% of Technical Standard	P/B CVR minus TS
M-VMU-2-T01	1	78.0	13.5	64.5
	2	41.0	13.5	27.5
	3	35.0	13.5	21.5
	4	59.0	13.5	45.5
M-VMU-2-T02P	1	19.5	13.5	6.0
	2	19.1	13.5	5.6
	3	28.3	13.5	14.8
	4	30.5	13.5	17.0
M-VMU-2-T03P	1	32.5	13.5	19.0
	2	17.0	13.5	3.5
	3	31.5	13.5	18.0
	4	11.0	13.5	-2.5
M-VMU-2-T04P	1	4.3	13.5	-9.2
	2	0.8	13.5	-12.7
	3	75.0	13.5	61.5
	4	17.8	13.5	4.3
M-VMU-2-T05P	1	44.0	13.5	30.5
	2	52.4	13.5	38.9
	3	50.0	13.5	36.5
	4	67.0	13.5	53.5
M-VMU-2-T06P	1	50.0	13.5	36.5
	2	25.1	13.5	11.6
	3	27.0	13.5	13.5
	4	30.3	13.5	16.8
M-VMU-2-T07P	1	5.0	13.5	-8.5
	2	0.0	13.5	-13.5
	3	6.5	13.5	-7.0
	4	23.8	13.5	10.3
M-VMU-2-T08P	1	101.1	13.5	87.6
	2	17.6	13.5	4.1
	3	51.1	13.5	37.6
	4	3.0	13.5	-10.5
M-VMU-2-T09P	1	74.0	13.5	60.5
	2	48.0	13.5	34.5
	3	29.0	13.5	15.5
	4	24.0	13.5	10.5
M-VMU-2-T10P	1	37.5	13.5	24.0
	2	104.1	13.5	90.6
	3	24.1	13.5	10.6
	4	7.5	13.5	-6.0
			k	8
			n	40
			z	-3.64
Standard one-tailed normal curve area (Table C-3; MMD, 1999)				0.5000
			P	0.0000

Notes:
P/B CVR = Perennial/Biennial Cover
TS = 90% of the Technical Standard for Perennial/Biennial Cover
P = 0.5-Area = prob of observing z; <=0.1 performance standard met
z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-3: 2022 Annual Forage Production, Method 5 - CMRP

Transect	Quadrat	2022 Annual Forage Production (lbs/ac)	90% of Technical Standard	FP minus TS
M-VMU-2-T01	1	1481	315	1166.3
	2	708	315	392.5
	3	619	315	304.0
	4	1603	315	1287.8
M-VMU-2-T02P	1	368	315	53.5
	2	326	315	11.1
	3	937	315	621.8
	4	748	315	433.3
M-VMU-2-T03P	1	382	315	67.1
	2	320	315	4.9
	3	695	315	379.8
	4	281	315	-34.1
M-VMU-2-T04P	1	63	315	-251.7
	2	5	315	-309.9
	3	1121	315	805.7
	4	271	315	-44.3
M-VMU-2-T05P	1	1650	315	1335.4
	2	1531	315	1216.3
	3	1176	315	861.3
	4	1365	315	1049.6
M-VMU-2-T06P	1	799	315	484.4
	2	426	315	110.7
	3	597	315	281.8
	4	474	315	159.1
M-VMU-2-T07P	1	63	315	-251.6
	2	0	315	-315.0
	3	342	315	26.7
	4	631	315	316.2
M-VMU-2-T08P	1	3284	315	2968.8
	2	229	315	-86.1
	3	1354	315	1039.0
	4	135	315	-180.2
M-VMU-2-T09P	1	2000	315	1684.9
	2	1413	315	1097.9
	3	824	315	509.5
	4	359	315	44.2
M-VMU-2-T10P	1	423	315	107.5
	2	3167	315	2852.3
	3	611	315	295.7
	4	349	315	33.9
			k	8
			n	40
			z	-3.64
Standard one-tailed normal curve area (Table C-3; MMD, 1999)				0.5000
			P	0.0000

Notes:
FP = Forage Production
TS = 90% of the Technical Standard for Annual Forage Production
P = 0.5-Area = prob of observing z; <=0.1 performance standard met

z value calculation:

$$z = \frac{(k+0.5)-0.5n}{0.5\sqrt{n}}$$

Table C-4: Shrub Density by the Belt Transect Method, Method 3 - CMRP

$$t^* = \frac{\bar{x} - 0.9\,(technical\ std)}{s/\sqrt{n}}$$

	2022 Woody Plant Density (#/ac)
Mean (#/ac)	2,509
Standard Deviation	1,550
Sample Size	10
Technical Standard	135
t*	4.84
1-tail t (0.1, 9)	1.383
2-tail t (0.1, 9)	1.833

Notes:
#/ac = Number of shrubs, trees and/or cacti per acre

Decision Rules (reverse null)

t < t (1-a; n-1), failure to meet std*
t >= t (1-a; n-1), performance std met*
t from Appendix Table C-1 (MMD, 1999)

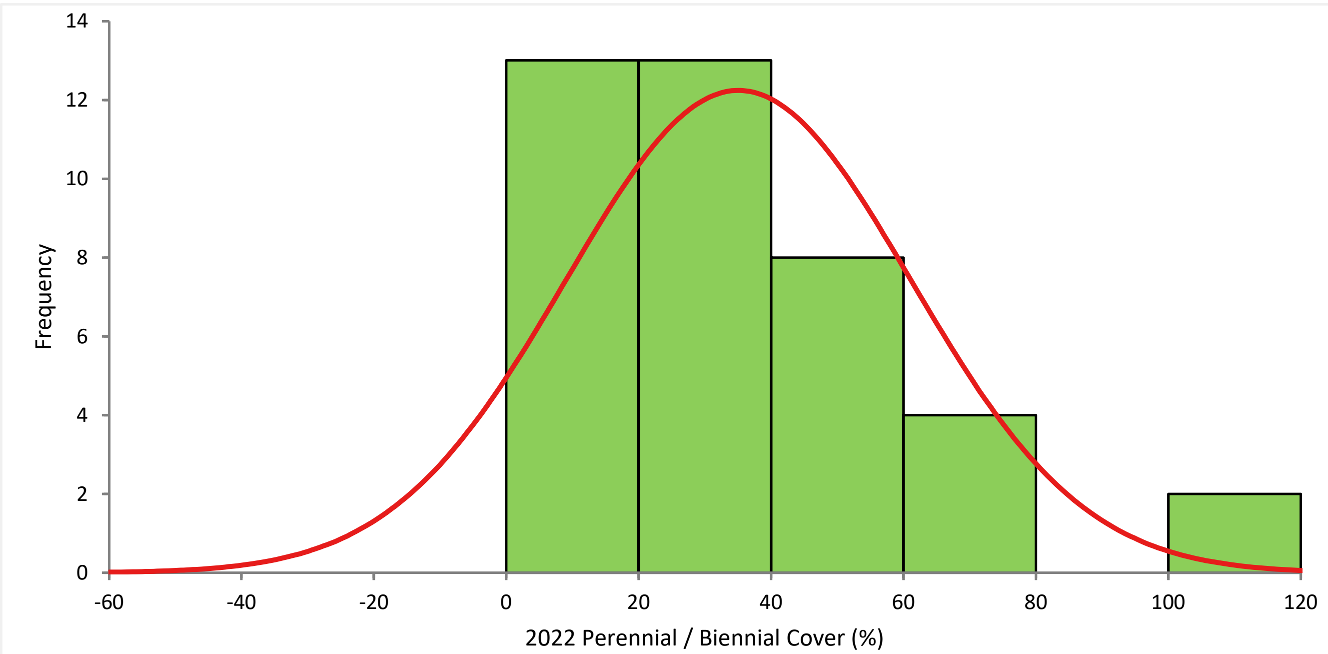
Figure C-1 2022 M-VMU-2 Perennial / Biennial Cover

Analyse-it v5.68

Filter: No filter

Last updated 12 January 2023 at 14:57 by Buchanan, Nicholas

Descriptives



N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
2022 Perennial / Biennial Cover (%)	35.0	28.1 to 42.0	4.12	26.1	0.9	0.60

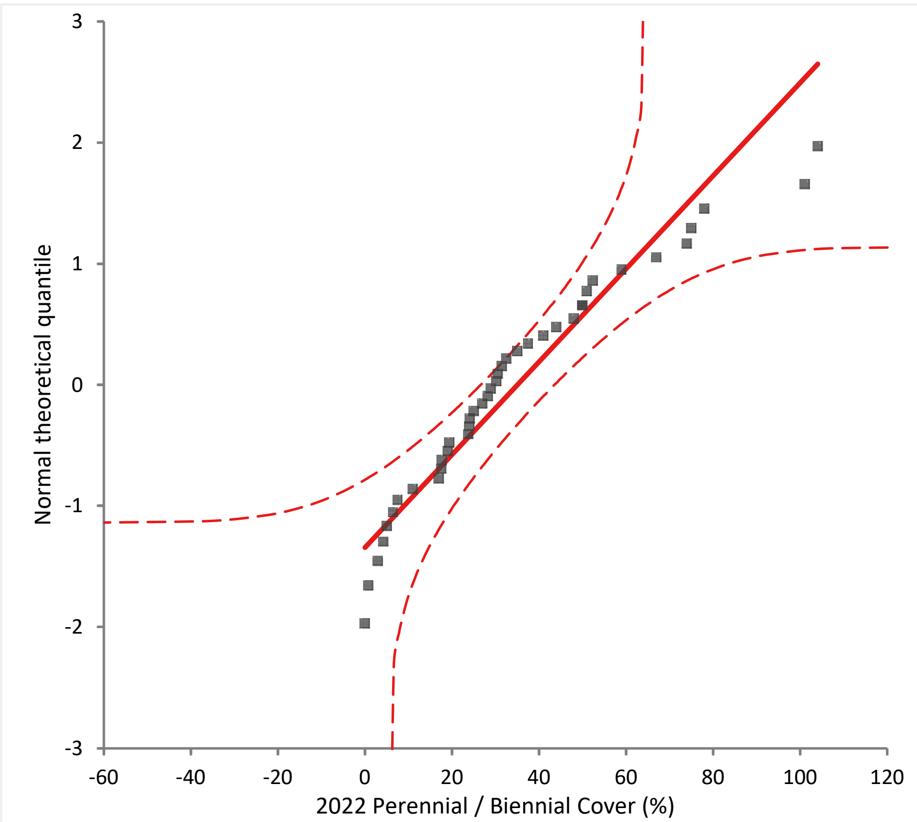
	1st quartile	Median	3rd quartile
2022 Perennial / Biennial Cover (%)	17.6	29.6	50.0

Figure C-1 2022 M-VMU-2 Perennial / Biennial Cover

Filter: No filter

Last updated 12 January 2023 at 14:57 by Buchanan, Nicholas

Normality



Shapiro-Wilk test

W statistic	0.93
p-value	0.0112[1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

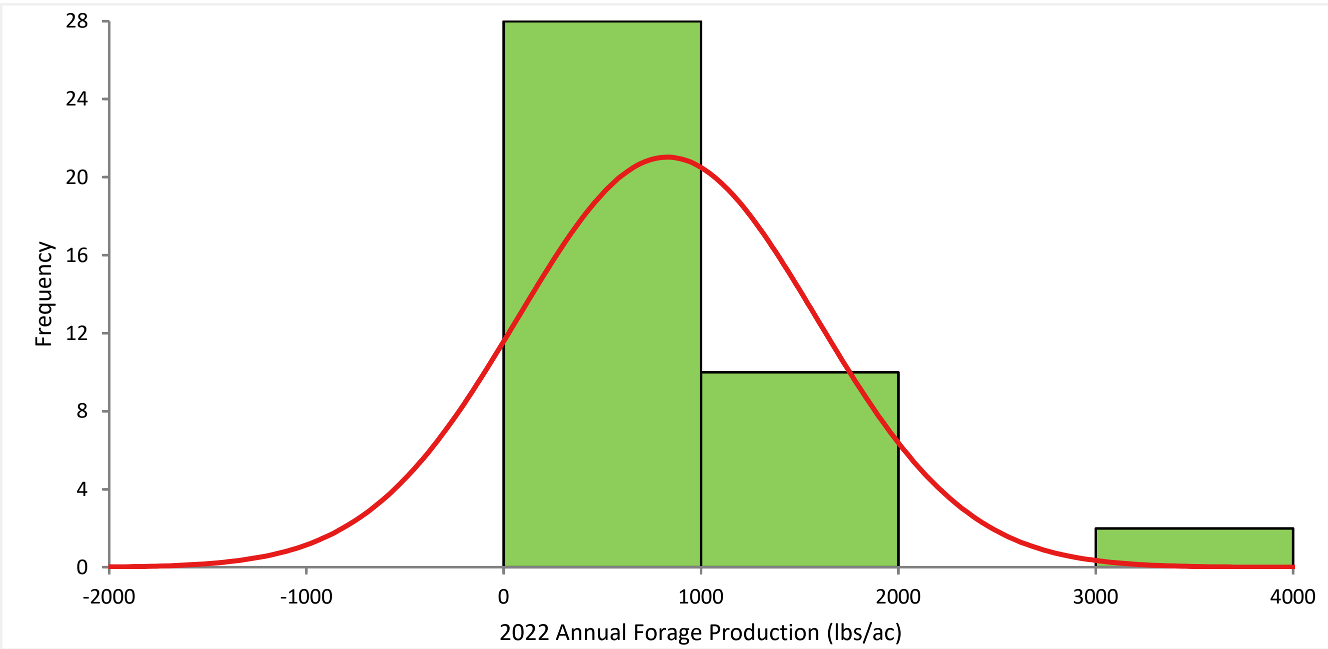
Figure C-2 2022 M-VMU-2 Annual Forage Production

Analyse-it v5.68

Filter: No filter

Last updated 12 January 2023 at 14:59 by Buchanan, Nicholas

Descriptives



N	40

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
2022 Annual Forage Production (lbs/ac)	828.3	626.1 to 1030.4	119.99	758.9	1.7	3.28

	1st quartile	Median	3rd quartile
2022 Annual Forage Production (lbs/ac)	332.6	614.8	1279.9

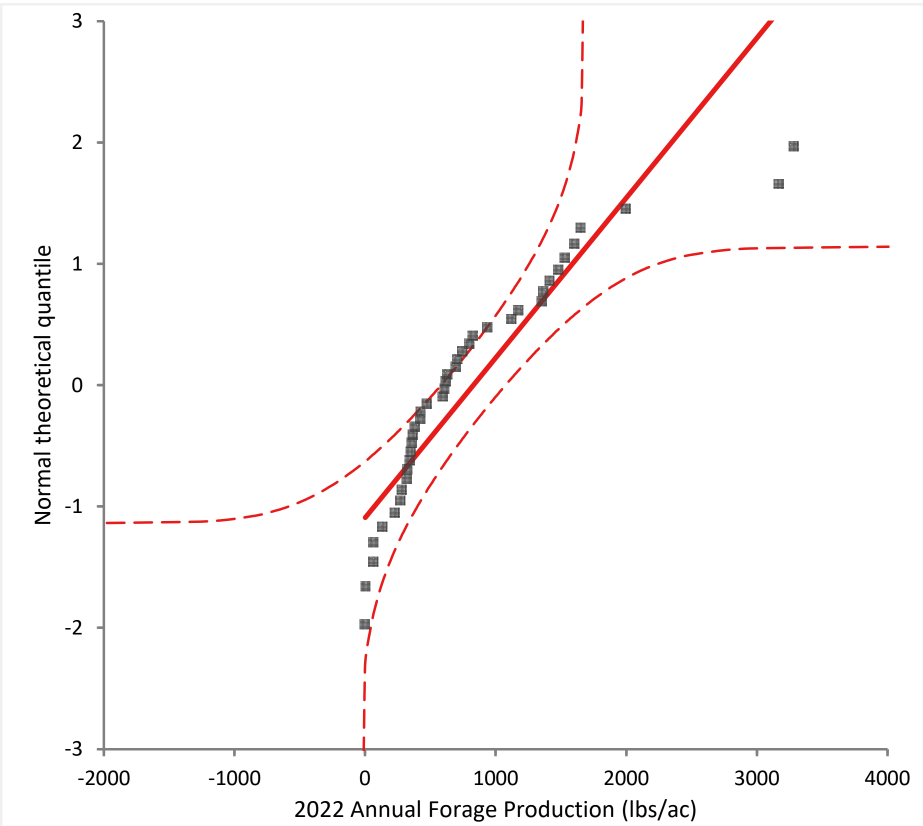
Figure C-2 2022 M-VMU-2 Annual Forage Production

Analyse-it v5.68

Filter: No filter

Last updated 12 January 2023 at 14:59 by Buchanan, Nicholas

Normality



Shapiro-Wilk test

W statistic	0.83
p-value	<0.0001[1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

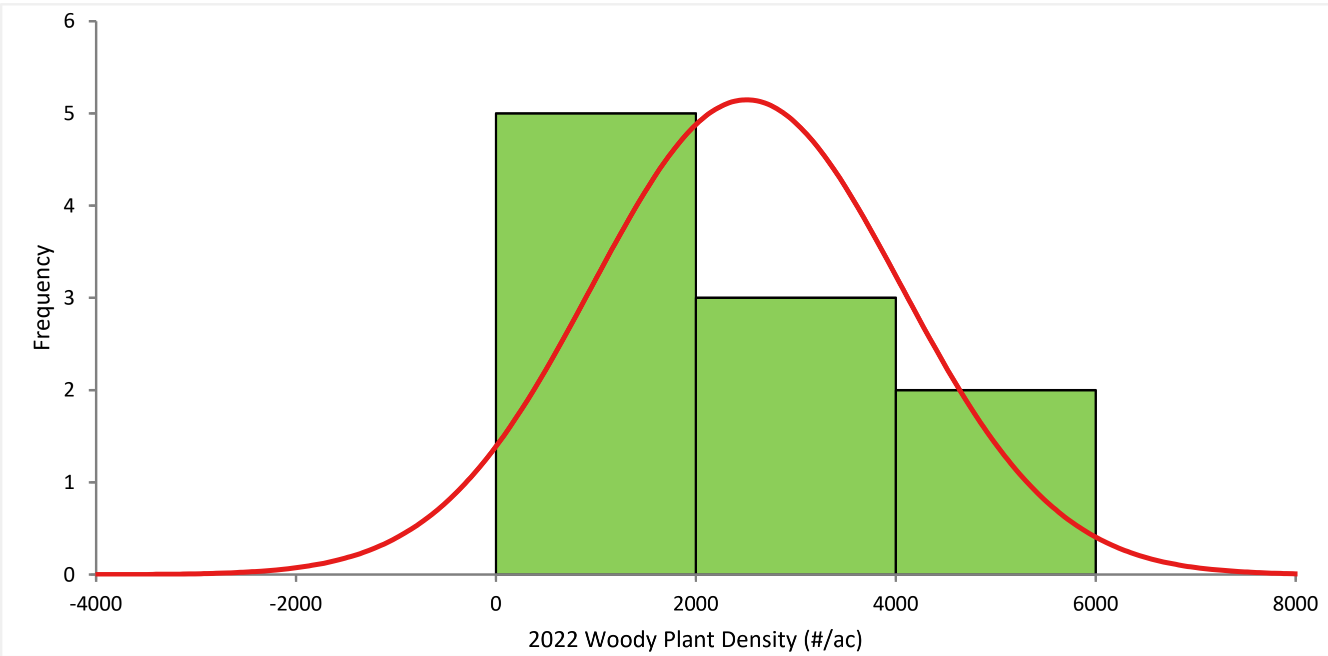
Figure C-3 2022 M-VMU-2 Woody Plant Density

Analyse-it v5.68

Filter: No filter

Last updated 2 February 2023 at 16:42 by Buchanan, Nicholas

Descriptives



N	10

	Mean	90% CI	Mean SE	SD	Skewness	Kurtosis
2022 Woody Plant Density (#/ac)	2509.05	1610.49 to 3407.61	490.182	1550.09	1.1	0.90

	1st quartile	Median	3rd quartile
2022 Woody Plant Density (#/ac)	1450.12	2023.43	3552.24

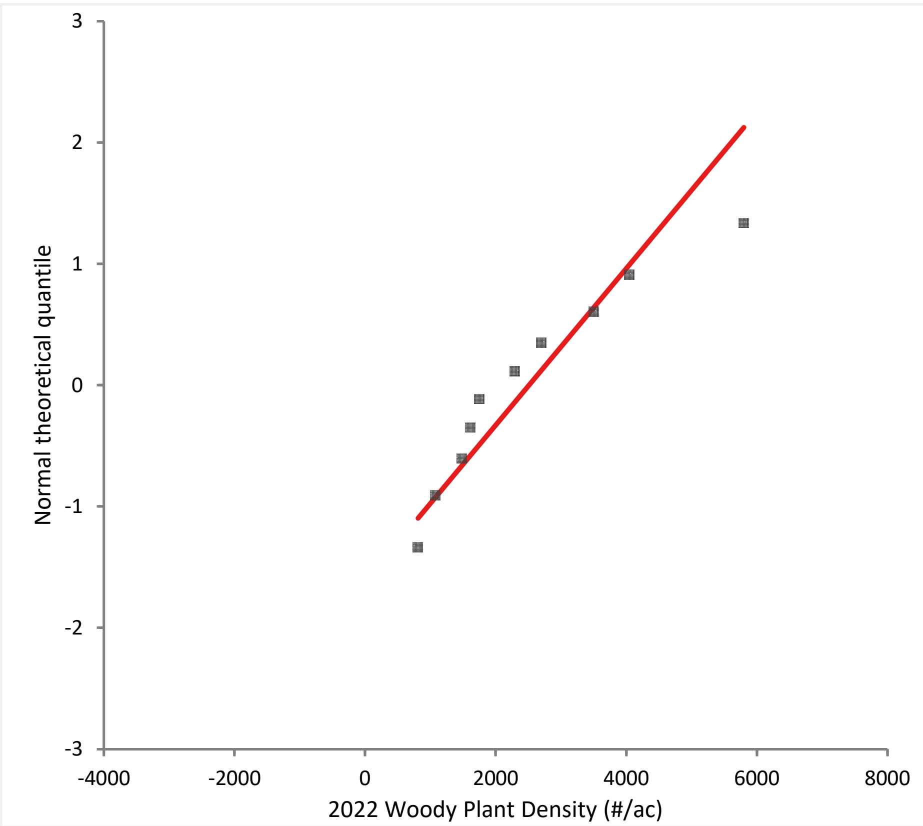
Figure C-3 2022 M-VMU-2 Woody Plant Density

Analyse-it v5.68

Filter: No filter

Last updated 2 February 2023 at 16:42 by Buchanan, Nicholas

Normality



Shapiro-Wilk test

W statistic	0.91
p-value	0.2580[1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

[1] Do not reject the null hypothesis at the 10% significance level.

Figure C-4 2022 M-VMU-2 Log Perennial/Biennial Cover

Analyse-it v5.68

Filter: No filter

Last updated 12 January 2023 at 15:02 by Buchanan, Nicholas

Descriptives

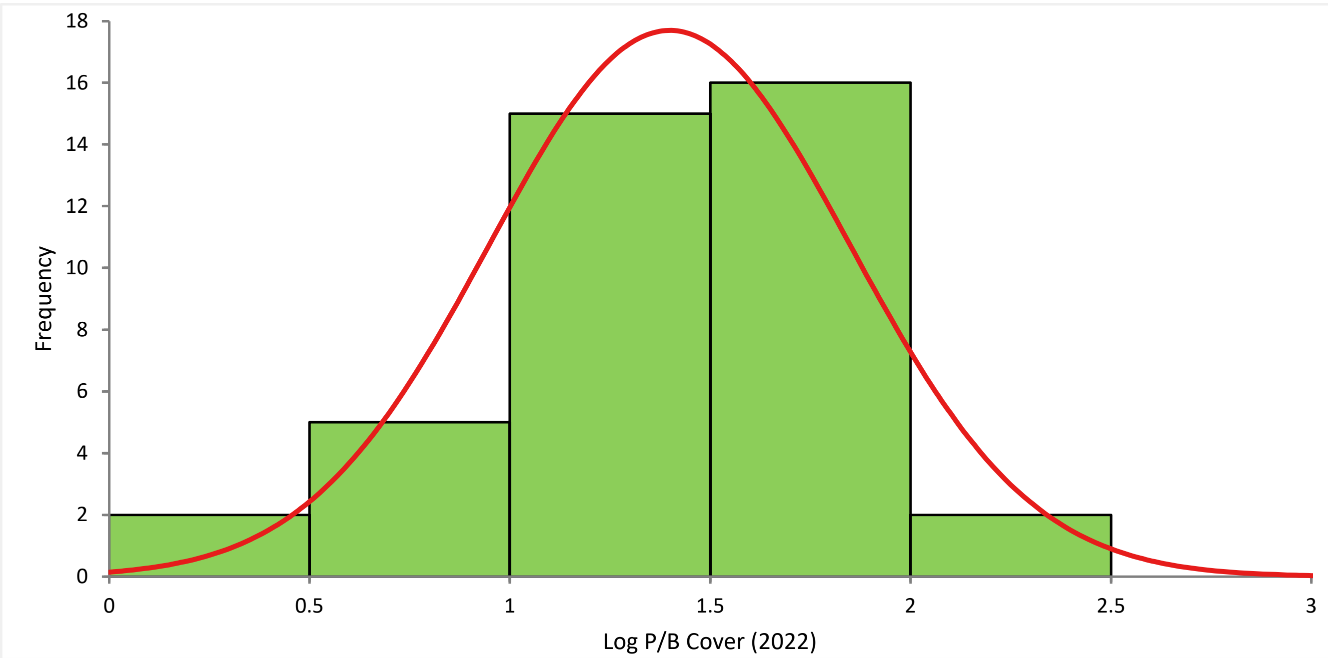


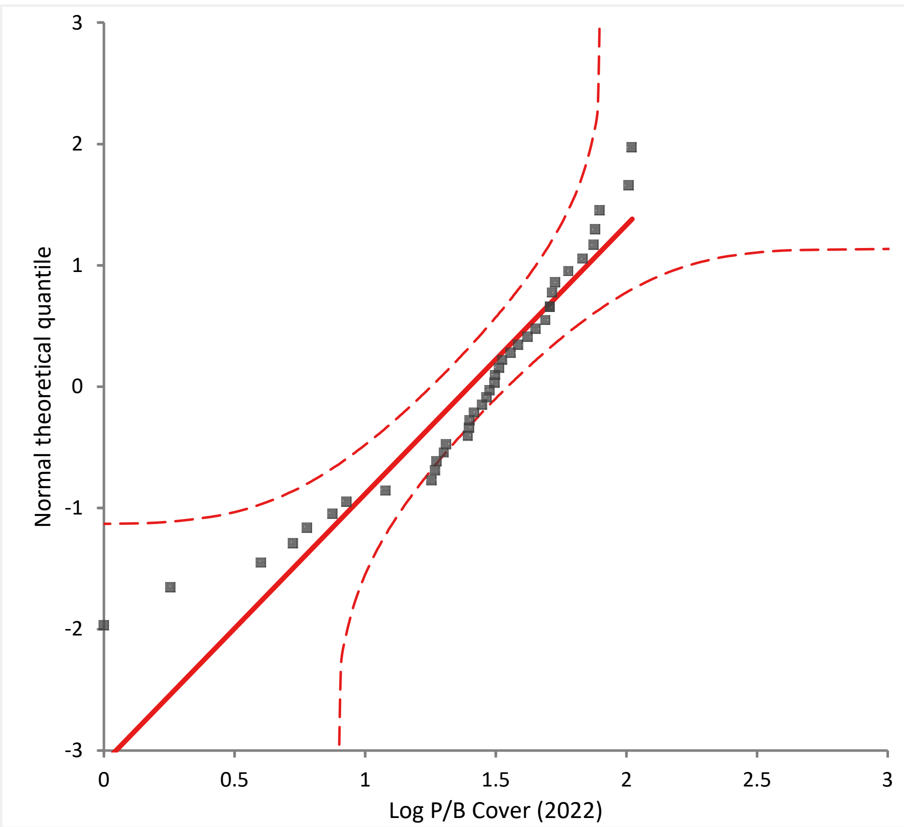
Figure C-4 2022 M-VMU-2 Log Perennial/Biennial Cover

Analyse-it v5.68

Filter: No filter

Last updated 12 January 2023 at 15:02 by Buchanan, Nicholas

Normality



Shapiro-Wilk test

W statistic	0.90
p-value	0.0015[1]

H0: F(Y) = N(μ, σ)
The distribution of the population is normal with unspecified mean and standard deviation.
H1: F(Y) ≠ N(μ, σ)
The distribution of the population is not normal.
[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

Figure C-5 2022 M-VMU-2 Log Annual Forage Production

Analyse-it v5.68

Filter: No filter

Last updated 31 January 2023 at 13:21 by Buchanan, Nicholas

Descriptives

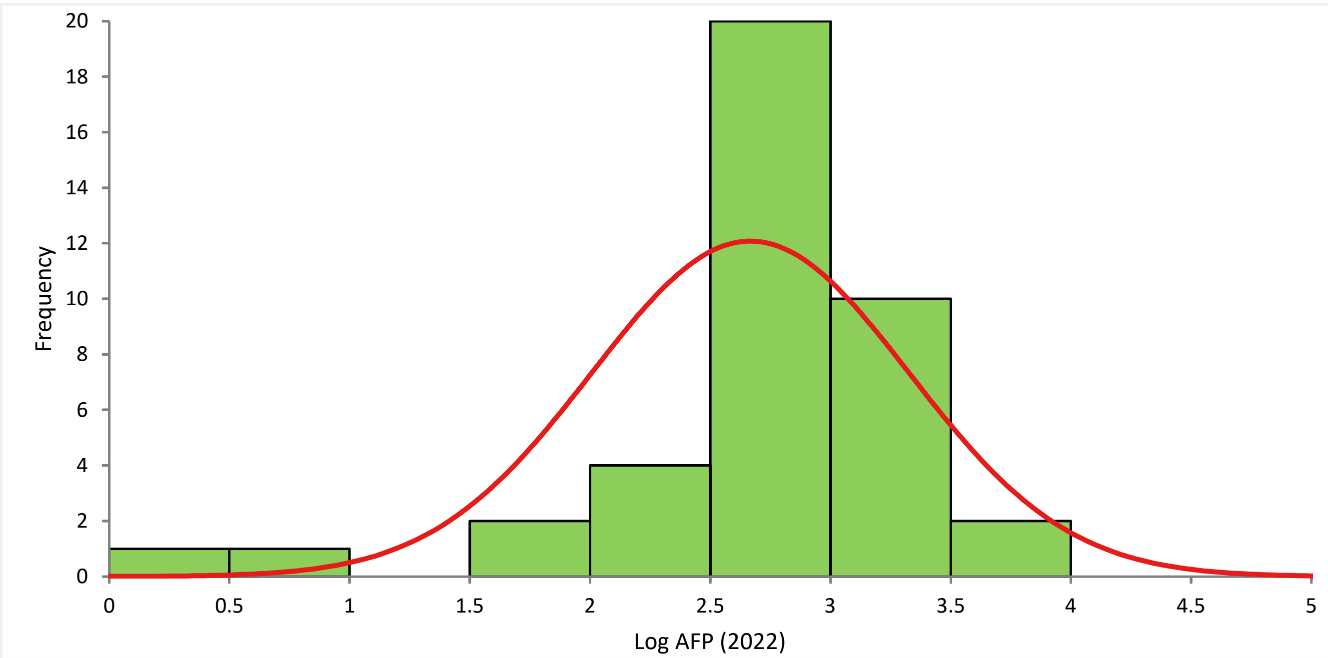


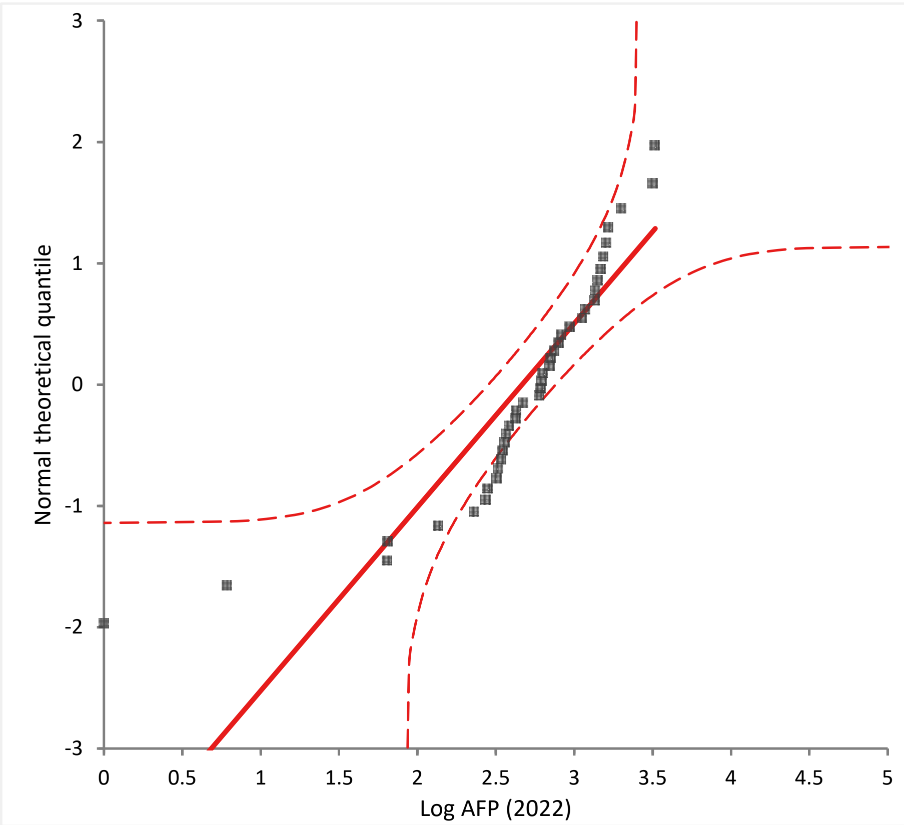
Figure C-5 2022 M-VMU-2 Log Annual Forage Production

Analyse-it v5.68

Filter: No filter

Last updated 31 January 2023 at 13:21 by Buchanan, Nicholas

Normality



Shapiro-Wilk test

W statistic	0.79
p-value	<0.0001 [1]

H0: F(Y) = N(μ, σ)

The distribution of the population is normal with unspecified mean and standard deviation.

H1: F(Y) ≠ N(μ, σ)

The distribution of the population is not normal.

[1] Reject the null hypothesis in favour of the alternative hypothesis at the 10% significance level.

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Appendix 9: Area 11, Bond Release Application, Groundwater and Surface Water Evaluation

AREA 11

BOND RELEASE APPLICATION

GROUNDWATER AND SURFACE WATER EVALUATION

CHEVRON MINING INC. – MCKINLEY MINE

NEAR GALLUP, NEW MEXICO

July 10, 2023

Project #: 476-014-012

SUBMITTED BY: Trihydro Corporation

1252 Commerce Drive, Laramie, WY 82070

SOLUTIONS YOU CAN COUNT ON.
PEOPLE YOU CAN TRUST.

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1.0 INTRODUCTION

This report documents the surface water and groundwater assessment at the McKinley Mine (Mine), operated by Chevron Mining Inc., required for bond release. Portions of the McKinley Mine operate under the New Mexico Mining and Minerals Division (MMD) Permit No. 2016-02 and this report was prepared in accordance with MMD Permit 2016-02, Section 3.0, Baseline and Background Information as well as the New Mexico Administrative Code (NMAC) 19.8.14.1412, Requirement to Release Performance Bonds. Requirements for Probable Hydrologic Consequences (PHC) and the Cumulative Hydrologic Impact Assessment (CHIA) are provided in MMD Permit 2016-02, Section 3.0.

The mine is located approximately 24 miles northwest of Gallup, New Mexico. The mine began operations in the early 1960s and ceased operations in 2009. Since that time, the Mine has been in various phases of reclamation including grading to post-mine topography, placement of topsoil, and revegetation. A portion of the Mine, identified as Area 11, is now eligible for bond release. Trihydro Corporation (Trihydro) began collecting and managing water quality and quantity data starting in October 2012. This report provides an evaluation of water data from 2013 through 2022 because data during this time period are representative of post-mining conditions and are the most complete dataset available.

This report includes information for surface and groundwater to support bond release including the following.

- A map with surface water monitoring stations and long-term groundwater monitoring wells. The map also shows National Pollutant Discharge Elimination System (NPDES) Permit No. NN0029386 outfalls affiliated with the proposed bond-release area and other nearby areas.
- Long-term groundwater and surface water monitoring data with comparison to baseline information, effluent standards and the approved PHC determination.

A summary of the hydrologic setting and protection requirements for the Mine are included in this report in Section 2.0. A summary of available impoundment water quality is presented in Section 3.0. Sections 4.0 and 5.0 review the long-term chemical and physical characteristics of Defiance Draw and its tributary that runs through the mine and the groundwater wells, respectively.

2.0 HYDROLOGIC SETTING AND PROTECTION

2.1 GEOLOGIC SETTING AND CLIMATE

The Mine is located in the southwest corner of the San Juan Basin in a structural sub-basin known as the Gallup Sag. The San Juan Basin, which is roughly circular in shape, occupies much of northwestern New Mexico, a narrow strip of northeastern Arizona, and a small portion of southwestern Colorado. The basin is bordered on the north by the San Juan Mountains, on the east by the Nacimiento Uplift, on the south by several uplifts including the Lucero Uplift and Zuni Uplift, and on the west by the Defiance Monocline, which separates it from the Black Mesa Basin.

The sedimentary rocks in the San Juan Basin are predominantly of Mesozoic age with some Tertiary rocks outcropping in the central basin and some Paleozoic and Pre-Cambrian rocks upturned along the basin margins. The sediments increase in thickness toward the basin's center. The geology in the vicinity of Gallup and McKinley County is comprised of Middle to Upper Jurassic (175-145 million years old) and Quaternary (less than 1-million years old) rocks. Older rocks, the Triassic River deposits of the Chinle Group, are exposed in the plains to the south and Cretaceous rocks form the high ridges. The rock formations include sandstone, shale, limestone, coal, and mudstone.

The San Juan Basin is characterized by low surface relief. Most of the basin is a relatively featureless plain with wide shallow valleys and some low mesas and cuestas. Elevations in the area range from 5,000 feet above mean sea level (ft amsl) in the north to 7,000 ft amsl in the south. A prominent north-south trending range, the Chuska Mountains, occurs along the western part of the basin with elevations exceeding 9,500 ft amsl. The Mt. Taylor volcanic area, with elevations up to 10,000 ft amsl, occurs within the southeast corner of the basin. The margins of the basin are characterized by hogback ridges, which are associated with the tectonic uplifts defining the basin boundaries.

The majority of the Mine is located in the Puerco River Drainage Basin with a small portion of the mine located in the San Juan River Drainage. The main drainages or watersheds in the mine are the headwaters of Defiance Draw (DD) and its tributary, Defiance Draw Tributary (DDT), Tse Bonita Wash (TBW), Coal Mine Wash (CMW) and its tributary, Coal Mine Wash Tributary (CMWT), and an unnamed tributary to Black Creek. A small portion of the mine lease area is in the headwaters of Deer Springs Wash and Black Springs Wash (both in the San Juan River Drainage Basin). Of the drainage basins listed above, DD is the largest drainage basin with an area of 27.5 square miles. TBW is the drainage basin that encompasses the highest percentage within the mine boundary at 35.0%.

As presented in Mine Permit No. 2016-02, Section 3.4, groundwater resources within the mine fall into three main types: alluvial, bedrock, and aquifer. Alluvial and bedrock groundwater resources are discontinuous, of poor physical and chemical quality, and of limited extent. The first major deep aquifer is the Gallup Sandstone Aquifer. The aquifer lies well below the zone of mining impact and is overlain by several impermeable shale members. Most recharge to the Gallup Sandstone comes from the Chuska Mountains to the northwest of the Mine. In addition to these three types, groundwater may also be found in spoil material above bedrock.

The Mine climate is semi-arid with an average annual precipitation of approximately 11 inches (in.) per year. More than half the annual precipitation typically falls during the months of July through October. Precipitation often occurs as rainfall from intense, localized thunderstorms that occur sporadically in the region. This can result in high suspended solids levels in the runoff. In addition, the soil chemistry and geomorphology contribute to the high levels of dissolved solids, salinity, and alkalinity. Within the general area of the mine, runoff due to precipitation events occurs in the form of surface runoff. Natural drainages or watersheds convey or temporarily store the runoff as it is routed to the Puerco River or San Juan River.

Precipitation data nearest to Area 11 is reported from the meteorological monitoring station at the mine, South Tipple, located approximately 1,300 feet east of the south mine facility. Precipitation station Rain 11 (Figure 2-1) is located near the eastern boundary of Area 11 and operates between late April and mid-November. Precipitation from the Rain 11 station was not necessary for this evaluation. It should be noted that the average precipitation during the Rain 11 operating period (April to November) was approximately 20% higher at the South Tipple station than the Rain 11 station during the reporting period. This difference was particularly evident in data from 2021 where approximately 120% more precipitation was recorded at the South Tipple station than the Rain 11 station. Some of the difference is likely due to partial operating months (April and November) at the Rain 11 station and the localized nature of summer thunderstorms.

Table 2-1 provides the monthly and annual precipitation data from South Tipple and Rain 11 for the reporting period. Average monthly precipitation at the South Tipple station ranged from 0.35 in. in April to 2.20 in. in July during the 10-year evaluation period. On average, most of the precipitation is received between July and October. The month with the highest 1-month precipitation total was July 2021 with 5.45 in. Precipitation data are referenced throughout the report to help explain some of the observations presented for surface and groundwater stations.

2.2 HISTORICAL WATER QUALITY DATA

Groundwater resources within the mine include alluvial, bedrock, Gallup Sandstone Aquifer, and spoil.

Alluvial groundwater is present in some fill and low-lying soils at the Mine. Wells penetrating the alluvial groundwater are designed to monitor the quality and quantity of shallow groundwater in alluvial valley-fill sediments. Valley-fill sediments in the Mine area serve as a reservoir for meteoric water to reside. Because the area is semi-arid and annual precipitation is limited, the presence of alluvial groundwater is generally dependent on rainfall and, to a lesser extent, snowfall quantities.

In 1980, five bedrock wells (MBR1, MBR2, MBR3, MBR4, and MBR5) were installed approximately 50-feet (ft) below the Green Coal Seam to monitor groundwater below this unit. The Green Coal Seam was the lower-most recoverable coal seam at the mine. These monitoring wells, referred to as McKinley bedrock wells, were located in and around the major drainage watersheds throughout the mine. Three of the original five wells (MBR1, MBR3, and MBR4) were mined through and not replaced. The active bedrock monitoring wells include MBR2 and MBR5, neither of which are in the vicinity of Area 11.

The original 1980 Geohydrology Associates Inc. (GAI) baseline groundwater report concluded that bedrock wells had little potential as a meaningful groundwater resource. The transmissivity of the bedrock deposits was less than 6 square feet per day (ft^2/day) and not capable of maintaining a sustained yield of 1 gallon per minute (gpm). Even though groundwater was present, none of the strata had sufficient continuity to be considered an aquifer. The findings from the 1980 GAI report and the discussions below indicate that minimal impacts to the quality and quantity of this resource by mining and reclamation operations have occurred.

Five water wells (1, 2, 3, 3A, and 4) have been completed in the Gallup Sandstone Aquifer throughout the Mine area. These wells were used as primary water sources for mine activities and reclamation. The wells now provide domestic water, dust-control water, or are monitoring wells. Because of the impermeability of the shale units overlying the Gallup Sandstone Aquifer and the geologic structure in the area, the Gallup Sandstone Aquifer can be under artesian conditions. Moreover, due to the presence of the overlying shales, there is no hydraulic connection between the underlying Gallup Sandstone and the mined strata. There are no Gallup Sandstone Aquifer wells near the bond release area.

Five spoil recharge wells (2G2, 4A, 9A, 9S, and 11) were constructed in the Mine area. Two spoil wells (4A and 9A on MMD lands) were installed in 1990; of these two wells, only 9A remains. Well 4A was not monitored after 2015 following approval by MMD to discontinue monitoring this well because the land at the well location had a full bond and liability release. Well 4A was abandoned October 29, 2018. In April 2013, three additional spoil recharge wells were constructed and designated as wells 2G2 (on Office of Surface Mining Reclamation and Enforcement [OSMRE] lands), 11, and 9S (on MMD lands). Spoil recharge wells were installed throughout the mine in reclaimed areas to determine chemical presence and groundwater properties. These wells were terminated at bedrock and their screens encompassed the spoil interval immediately above bedrock. Spoil Well 11 is the only spoil recharge well in the vicinity of Area 11.

Groundwater monitoring is required by MMD Permit Number 2016-02 and OSMRE Permit Number NM-0001K to be reported quarterly. The Mine began operations in the early 1960s, before the passage of the Surface Mine Control and Reclamation Act and other regulations governing coal mining on Indian lands. At that time, baseline surface and groundwater quality and quantity data were not required before mining. As a result, comparisons cannot be made with pre-mining watershed conditions of the Mine as a single unit. However, the 1980 GAI report, which was incorporated into the Mine permits, provides surface and groundwater quality and quantity data that can be referenced for evaluating trends since that time. There are no baseline groundwater data applicable to the Mine site.

Surface water has been monitored since the early 1980s through active and passive surface water monitoring stations, although the number and locations of stations have evolved over time. The currently monitored active surface water stations are located in and around the major drainage watersheds throughout the Mine and include the DD, TBW, DDT6, CMW, and CMWT watersheds. Station CMW is used to monitor flow and water quality from a relatively undisturbed drainage; the data from this station are used as background information and to contrast against other station data from disturbed watersheds.

2.3 APPLICABLE PROTECTION STANDARDS

2.3.1 SURFACE WATER COMPARISON

Stormwater runoff from the Mine drains through impoundments and/or hydraulic control structures before discharging into Defiance Draw, a tributary to the Puerco River segment from the Arizona border to the Gallup wastewater treatment plant in McKinley County. Data collected from the disturbed stations are compared to data collected at the undisturbed CMW station, which are considered background data. The comparison is used to determine impacts from mining activities.

2.3.2 NPDES REQUIREMENTS

The Mine operates under NPDES Permit No. NN0029386 which was last renewed July 1, 2017. A renewal application was submitted to the United States Environmental Protection Agency (USEPA) on December 27, 2021, and the Mine is currently operating under the current permit pending approval of the renewal application. As required under NPDES Permit No. NN0029386, the Mine submitted an updated Sediment Control Plan on September 5, 2017 and is currently awaiting approval. Until then, the Mine is operating under the current Sediment Control Plan dated March 15, 2013.

All watersheds within the mine are classified as Western Alkaline, and in accordance with NPDES Permit No. NN0029386, reclamation inspections are conducted quarterly within the drainage basins associated with the Sediment Control Plan and inspection findings are summarized in quarterly reports. Additionally, discharge sampling is conducted at NPDES outfalls. There are several watersheds and NPDES outfalls located within Area 11. Outfalls are shown on Figure 2-1. The Mine will continue conducting quarterly reclamation inspections and sampling discharge through final bond release.

2.3.3 GROUNDWATER PROTECTION STANDARDS

The New Mexico Administrative Code (NMAC) provides groundwater standards to protect all groundwater of the State of New Mexico which has an existing total dissolved solids (TDS) concentration of 10,000 mg/l or less, for present and potential future use as domestic and agricultural water supply (NMAC 20.6.2.3103).

Groundwater standards are numbers that represent the pH range and maximum concentrations of water contaminants in the groundwater which still allow for the present and future use of ground water resources. Quantitative criteria for these groundwater sources that correspond with available data from the Mine are listed below (NMAC 20.6.2.3103).

Analyte	Upper Limit (unless otherwise indicated)
pH	6.0-9.0 s.u.
Fluoride	1.6 mg/L
Nitrate as N	10 mg/L
Nitrite as N	1 mg/L
Selenium	0.05 mg/L
Chloride	250 mg/L
Iron	1 mg/L
Manganese	0.2 mg/L
Sulfate	600 mg/L
TDS	1000 mg/L
Zinc	10 mg/L

Criteria listed for chloride, iron, manganese, sulfate, TDS, zinc, and pH represent the maximum concentration for domestic water supply.

2.3.4 SURFACE WATER PROTECTION STANDARDS

The NMAC provides surface water standards to protect surface water resources of the State of New Mexico for present and potential future use as livestock watering or supporting wildlife habitats (NMAC 20.6.4.900).

Surface water standards are numbers that represent the maximum concentrations of water contaminants in the surface water which still allow for the present and future use of surface water resources. Quantitative criteria for these surface water sources that correspond with available data from impoundments in the Mine are listed below (NMAC 20.6.4.900).

Analyte	Upper Limit (unless otherwise indicated)
Arsenic, dissolved	200 µg/L
Boron, dissolved	5,000 µg/L
Cadmium, dissolved	50 µg/L
Chlorine residual	11 µg/L
Chromium, dissolved	1,000 µg/L
Cobalt, dissolved	1,000 µg/L
Copper. Dissolved	500 µg/L
Cyanide, total	5.2 µg/L
Lead, dissolved	100 µg/L
Mercury, dissolved	10 µg/L
Nitrite + Nitrate	132 mg/L
Selenium, dissolved	50 µg/L
Selenium, total recoverable	5 µg/L
Vanadium, dissolved	100 µg/L
Zinc, dissolved	25,000 µg/L
Radium 226 + Radium 228	30 pCi/L
Tritium	20,000 pCi/L
4,4’-DDT and derivatives	0.001 µg/L
E. coli	2,507 MPN/100 mL

2.4 PROTECTION OF HYDROLOGICAL BALANCE

The Mine permit includes preventative and remedial measures for any potential adverse hydrologic consequences identified in the PHC determination. The Permit includes sections on the PHC determination, groundwater and surface water monitoring plans, general plans to address possible hydrologic consequences, and a CHIA, as provided by the MMD/OSMRE. Related permit sections are summarized below. A copy of the active and approved Permit Section 3.4 is provided as Appendix A.

2.4.1 PHC DETERMINATION

The current and approved PHC determination is provided in Permit No. 2016-02, Section 3.4.4 of Appendix A. The PHC first reviews the possible impacts of the impoundments on other surface waters, which are reviewed here for the purposes of a PHC update. There are three impoundments in Area 11: 11-8, 11-10, and 12-9. Assumptions for and analysis of runoff to the impoundments and consumptive losses from the impoundments are provided. The impoundments have no negative impacts on regional water quantity and should enhance local property use for livestock and wildlife. The PHC also acknowledges and evaluates the possible impact from impoundment stormwater discharge on downstream water chemistry. Review of available data indicated identifiable impact as related to pre- and post-mine monitoring stations along Defiance Draw and its tributaries. Lastly, the PHC considers the possible impacts of the groundwater, located in the alluvial, bedrock, and Gallup Sandstone Aquifer. This last item will be further discussed in report Section 5.4.3.

2.4.1.1 SURFACE WATER QUANTITY

Surface water quantity may be increased on the reclaimed areas through the construction of small depressions and impoundments, which is discussed further in Section 3.0. These impoundments will be used to provide water for livestock and wildlife and to create small riparian habitats for small mammals, birds and reptiles. Small depressions and three permanent impoundments occur in the Area 11 bond release area. The amount of post-mining runoff as compared to the pre-mining runoff to the Puerco River drainage will be minimally diminished by the harvesting of the water in the impoundments and other riparian areas. This reduction of runoff is supported by the hydrologic model included in the Baseline/Background – Hydrologic Information Volume (BBHIV) of the permit application. However, the impact on the Puerco River drainage will be negligible due to the small percentage of the drainage area that the Mine comprises.

2.4.1.2 SURFACE WATER QUALITY

For a short time following reclamation of an area there may be a slight increase in the levels of total dissolved solids, sulfates, and other soluble elements in the overburden. This increase will eventually lessen as the runoff leaches the overburden. This potential slight increase is documented by the collection and analysis of surface water runoff during the permit term as described in Section 6.2. The long-term surface water PHC is described below.

Surface water physical quality will be improved through the stabilization of the reclamation areas and the construction of small depressions and impoundments. These actions will result in lower suspended solids and total settleable solids in the runoff from the disturbed areas. This is supported by the hydrologic models presented in the BBHIV of the

Permit. The models show that the per-acre sediment yields from the mining and post-mining areas will be less than the pre-mining areas.

The Mine has been reclaimed with soils that meet suitability criteria that promote plant establishment. These soils, in combination with vegetation, would be expected to result in runoff with better effluent quality with regard to levels of dissolved solids, salinity, and alkalinity.

2.4.1.3 GROUNDWATER QUANTITY

2.4.1.3.1 GALLUP SANDSTONE AQUIFER

As discussed above, the Gallup Sandstone Aquifer is used as the primary source of water for the Mine and for the McKinley County area. This aquifer occurs 400 to 1,000 feet below the lowest coal seam to be recovered and has no local recharge features. The recharge area for this aquifer is located to the north of Mine in the Chuska Mountains. As noted in the Technical Analyses and Environmental Assessment performed by the OSMRE on Permit No. NM- 0001 B/3-1 OP, and adopted by the director of MMD, there may be a small amount of draw down due to usage associated with coal mining activities, but this draw down is insignificant in comparison to the City of Gallup and Navajo Nation consumption impacts.

The Permit contains information on the potentiometric surface of the Gallup Sandstone Aquifer.

2.4.1.3.2 ALLUVIAL AQUIFERS

As discussed above, the alluvial water is practically nonexistent, occurring generally in close proximity to the arroyos, and in direct relation to the rate and amount of runoff in the arroyo. This water soaks into the sides and bottoms of the arroyos during runoff events. This type of recharge occurs principally during snowmelt and the summer runoff season. Recharge through direct infiltration onto the rest of the alluvial fans located away from arroyos is very limited. The only instance where this type of groundwater will be affected by the mining operations is where alluvial areas are actually mined. The hydrologic impact on this groundwater source will be complete removal of the resource when encountered during mining. However, due to the limited areal extent of the resource, any impacts would be considered negligible.

2.4.1.3.3 BEDROCK AQUIFERS

As discussed above, the bedrock water quantity is minimal in extent, consisting only as small pockets of perched water in the various stratums being excavated in the mining process. The quantity and areal extent of these pockets of water are not of sufficient quantity or quality to be considered usable. This water is normally observed as seepage from the highwall or small amounts of water on the pit floor. The mining operation results in removal of this insignificant groundwater source.

2.4.1.4 GROUNDWATER QUALITY

Gallup Sandstone Aquifer

As is noted above in the discussions on groundwater quantity, there will be no impact by mining on the recharge zones of the Gallup Sandstone Aquifer. Due to this, there will also be no impact on the quality of the Gallup Sandstone Aquifer by the mining operations.

Alluvial Aquifers

The alluvial water quality, in undisturbed areas, will continue to be influenced primarily by the amount of runoff in the arroyos and characteristics of the soils in the area of infiltration. There will be minimal impacts on the quality of this resource by the mining operations.

Bedrock Aquifers

The bedrock water encountered during mining will be removed in the mining process. This removal will have no effect on the water present in areas not affected by mining. This is due to the low transmissivity associated with this type of water.

2.4.2 SURFACE AND GROUNDWATER MONITORING PLANS

Per Section 6.3.2.1 of the Permit, surface-water monitoring is conducted at five stations in the DD, TBW, DDT6, CMW, and CMWT watersheds at the mine. Groundwater monitoring is conducted from the following sources: alluvial groundwater, bedrock groundwater, Gallup Sandstone Aquifer, and spoil recharge groundwater. Sample analytes required by the permit include alkalinity, bicarbonate, boron, calcium, carbonate, chloride, fluoride, iron, magnesium, manganese, field pH, nitrate, phosphate, phosphorous, potassium, selenium, sodium, sulfate, total dissolved solids, total suspended solids, and zinc. The exact analyte list is water-source dependent.

2.4.3 CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT (CHIA)

A CHIA was prepared by the OSMRE/MMD in 1995 for the Mine. The following summarizes possible surface and groundwater impacts/material damages concluded by the CHIA.

- Surface water use in the area is primarily stock watering with some irrigation. There are no permitted water rights holders downstream of the mining operation in the cumulative impact area. Indicator parameters related to hydrologic concerns in the basin are TDS and TSS concentrations.
- Cumulative impacts to the quantity of the flow in the Puerco River are insignificant.
- Cumulative impacts to the quality (TDS and TSS) of flows in the Puerco River are minimal and should not cause significant changes in baseline conditions. No material damage to the hydrologic balance is expected.
- Groundwater is an important source of water in the Gallup area. The major groundwater pumping centers are at the Santa Fe and Yah-ta-hey well fields, both completed in the Gallup Sandstone Aquifer and operated by the city of Gallup. Other users of the Gallup Sandstone Aquifer include the McKinley and Mentmore mines northwest of Gallup. Shallow groundwater is not widely used owing to the relatively poor quality and small well yields.
- Cumulative impacts related to groundwater quality are not expected. Groundwater quality in terms of TDS and sulfate has not been demonstrated to change significantly and the poor physical properties of the near-surface deposits are not greatly altered by mining.
- Groundwater quantity in the Gallup Sandstone Aquifer may be affected by the cumulative impacts of mining, particularly if declared water rights are fully used by the Mine. Calculations of water-level drawdowns indicate that the Yah-ta-hey well field could experience up to 3 feet of drawdown attributable to mining activities; this does not constitute material damage. No material damage, based upon a criterion of a decline of 25% of available head, is predicted as a result of surface coal mining.

3.0 IMPOUNDMENT WATER MONITORING SUMMARY

There are three permanent impoundments located in the vicinity of Area 11 as shown on Figure 2-1. Three permanent impoundments are located within Area 11, specifically 11-8, 11-10, and 12-9. Discussion follows regarding these impoundments to expand upon the overall hydrologic balance in the greater Area 11. All of the permanent impoundments were built as sediment ponds to store stormwater runoff from disturbed areas within the Defiance Draw watershed. As discussed in Section 2.3.2 above, discharge data have already been reviewed and assessed and are not included in the following discussion.

Additionally, small depressions were built in accordance with 19.8.20.2055 C. Small depressions 11-5 and 11-6 are two of these structures and are shown on Figure 2-1. Small depression 11-6 will be reclaimed at the same time as an adjacent topsoil stockpile. These structures provide opportunistic water for livestock and wildlife and add diversity to the vegetation. Because of their small size, no water monitoring was required. Since they are small (less than one acre-ft), there would be minimal impact from small depressions to the water quantity leaving the mine. The small depressions do not pose any additional impacts to the PHC assessment in the Permit.

3.1 IMPOUNDMENT DATA

Impoundments 11-8, 11-10, and 12-9 have consistently held water. Impoundments 11-8, 11-10, and 12-9 are recharged by surface runoff and had sufficient water for sampling once during the reporting period. Results of the single sampling event for the three monitoring locations are presented in Table 3-1. The following section includes water-quality data from the impoundments and a comparison to regulatory standards. There is no comparison to baseline water quality given the limited temporal data set. A discussion regarding the PHC is provided in Section 3.2.3.

3.2 ASSESSMENT OF IMPOUNDMENT DATA

Since the impoundments were only sampled once during the reporting period, there is no water quality data comparison to the baseline water quality. Section 3.2.2 provides a comparison to the regulatory standards.

3.2.1 COMPARISON TO BASELINE WATER QUALITY

A comparison to baseline water quality data is not included in this discussion since there is no baseline data.

3.2.2 COMPARISON TO REGULATORY STANDARDS

There was one water-quality sampling event for the impoundments in which samples were analyzed and the results compared against the standards for livestock watering and supporting wildlife habitats (NMAC 20.6.4.900). These results may be found in Table 3-1.

3.2.3 COMPARISON TO PROBABLE HYDROLOGIC CONSEQUENCES

The PHC indicates that runoff to the affected segment of the Puerco River may be minimally diminished due to the harvesting of water in the impoundments and other riparian areas. Given that most of the impoundments in Area 11 vicinity rarely hold water, the impact to the amount of runoff to the Puerco River is likely negligible as most of the water would not have reached the river, even in the absence of the impoundments. The PHC also acknowledges discharge as having a possible short-term consequence on downstream physical water quality. However, there is no water quality data for this comparison.

4.0 LONG-TERM MONITORING

Area 11 is located in the Puerco River Drainage Basin, with possible influence on ephemeral streams that only carry water following storm events. There are no stream discharge or water quality sampling locations in Area 11.

4.1 SURFACE WATER DATA

4.1.1 DISCHARGE DATA

There are no stream discharge sampling locations within Area 11. Therefore, this section does not include stream discharge data or a comparison to baseline discharges.

4.1.2 STREAM WATER QUALITY DATA

There are no stream water quality sampling locations within Area 11. Therefore, this section does not include stream water quality data or a comparison to baseline water quality and regulatory standards.

4.1.3 COMPARISON TO PROBABLE HYDROLOGIC CONSEQUENCES

The PHC determination (Permit Section 3.4.4) acknowledges the possible consequence of stormwater on downstream water chemistry. Because there are no stream discharge data from Area 11, a comparison to the PHC is not included. Full discussion of the surface water quality from each of the mine watersheds is included in the 2022 McKinley Mine Annual Hydrology Report (Trihydro 2023).

5.0 LONG-TERM GROUNDWATER MONITORING

Groundwater at the Mine is monitored from four sources: alluvial, bedrock, Gallup Sandstone Aquifer, and spoil. A summary of data for the four groundwater sources is provided below followed by a comparison of results to baseline water quality, regulatory standards, and the PHC, as applicable. Depth to water data for the groundwater sources are presented in Table 5-1. Tabulated water quality data for the groundwater sources are presented in Table 5-2 with an assortment of temporal plots in Appendix C.

5.1 ALLUVIAL GROUNDWATER

Alluvial wells are located in and around major drainage watersheds throughout the Mine. Since water levels in these wells are dependent on direct precipitation, the depth to groundwater and the saturated thickness in wells vary to some degree based on rain and snowfall.

In 2016, OSMRE and MMD approved a permit modification to monitor only seven alluvial wells. Four of these wells have historically been considered recharging (DT2A, DT2B, TB2B2, and TB3D) whereas the remainder of the wells (CMC, D2C, and D3B2) have historically been dry. The alluvial wells being dry is consistent with the PHC.
Wells DT2A and DT2B are in Area 11. However, neither well has had sufficient water for sampling since 2016 and alluvial groundwater is not included in the groundwater quality discussion. Significant chemical parameters from sampling events prior to the alluvial wells becoming dry are included in the Groundwater Quality Summary 2013-2022 (Table 5-2). Upon the ultimate stages of bond release, the two alluvial wells will be plugged and abandoned in accordance with NMAC 19.27.4.30.C.1.

5.2 GALLUP SANDSTONE AQUIFER

Five water wells (1, 2, 3, 3A, and 4) have been completed in the Gallup Sandstone Aquifer throughout the Mine area. These wells were used as primary water sources for mine activities and reclamation. The wells now provide domestic water, dust-control water, or are only monitored. Because of the impermeability of the shale units overlying the Gallup Sandstone Aquifer and the geologic structure in the area, the Gallup Sandstone Aquifer can be under artesian conditions. Moreover, due to the presence of the overlying shales, there is no hydraulic connection between the underlying Gallup Sandstone and the mined strata. None of the five Gallup Sandstone wells are located in the vicinity of Area 11.

5.3 SPOIL GROUNDWATER

Five spoil recharge wells (2G2, 4A, 9A, 9S, and 11) were constructed in the Mine area. Two spoil wells (4A and 9A on MMD lands) were installed in 1990; of these two wells, only 9A remains. Well 4A was not monitored after 2015 following approval by MMD to discontinue monitoring this well because the land at the well location had a full bond and liability release. Well 4A was abandoned October 29, 2018. In April 2013, three additional spoil recharge wells were constructed and designated as wells 2G2 (on OSMRE lands), 11, and 9S (on MMD lands). Spoil recharge wells were installed throughout the mine in reclaimed areas to determine chemical presence and groundwater properties. These wells were terminated at bedrock and their screens encompassed the spoil interval immediately above bedrock. To date, only Well 11 has contained sufficient groundwater for sampling.

5.3.1 WATER LEVELS

Water level and saturated thickness are presented in Table 5-1 for Well 11. Depth to groundwater in Well 11 has been relatively stable since 2013. Saturated thickness plotted with precipitation since 2013 is presented on Figure 5-1. The figure shows that reductions in saturated thickness in Well 11 are likely unrelated to precipitation.

5.3.2 WATER QUALITY

Sampling of spoil recharge Well 11 has been conducted quarterly for multiple parameters. Significant chemical parameters are included in the Groundwater Quality Summary 2013-2022 (Table 5-2). Appendix B presents select temporal plots for Well 11 based on available 2013 to 2022 data.

Examination of the analytical data and temporal plots for the reporting period associated with Well 11 indicate the following.

- Alkalinity is a useful parameter when discussing bicarbonate and carbonate trends below. Alkalinity and bicarbonate concentrations have been relatively stable since 2017 at Well 11. Nearly all the alkalinity present in bedrock groundwater is attributable to bicarbonate as carbonate is a relatively minor component. These results were expected given the neutral to slightly basic pH of the groundwater. Field pH values have consistently ranged between 6.8 and 7.4 SU at Well 11 and has shown a generally inverse relationship to alkalinity over the reporting period as shown on the temporal plot in Appendix B-1a.

- Dissolved calcium, magnesium, sodium, and potassium are plotted together on the temporal plot in Appendix B-1b. Dissolved magnesium and sodium concentrations have been stable in Well 1 since 2013. Dissolved calcium and sodium have fluctuated in Well 11 since 2016.

- The calculated ion balance percentages have been consistently less than 10%, other than two anomalous values in April 2022 and September 2022 (Table 5-2).
- Chloride, sulfate, and TDS are plotted together on the temporal plot in Appendix B-1c. Chloride concentrations at Well 11 have been relatively stable since 2013 except for a spike in February 2018. Sulfate concentrations at Well 11 have been relatively stable throughout the reporting period. Total dissolved solids concentrations at Well 11 have varied between approximately 6,000 mg/L and 8,000 mg/L since 2013.
- Total and dissolved iron and manganese are plotted together on the temporal plot in Appendix B-1d. Total and dissolved iron concentrations in Well 11 have varied between 2 and 12 mg/L since 2013. Total and dissolved manganese concentrations in Well 11 have varied between 1 and 4 mg/L since 2013.
- Fluoride, boron, and zinc are plotted together on the temporal plot in Appendix B-1e. Fluoride, boron, and zinc concentrations have all been relatively stable. Fluoride has been below or slightly above the detection limit (0.5 mg/L) except for spikes in April 2015, August 2020, October 2020, and January 2021.
- Phosphate concentrations have been at or below the detection limit in Well 11 since 2013 except for one anomalous value in June 2017 (Table 5-2).

Examination of the previously discussed analytical trends suggests that water-quality concentrations have remained relatively consistent since 2013 at Well 11. Overall, these trends support the presumption that impacts from mining and reclamation operations on groundwater have not occurred or are limited. Reductions in water levels in Well 11 are likely due to the prolonged drought conditions in the region.

5.4 ASSESSMENT OF GROUNDWATER DATA

5.4.1 COMPARISON TO BASELINE WATER QUALITY

There are no baseline groundwater data from pre-mining conditions available for comparison to current groundwater quality data. Therefore, this comparison is not included in this report.

5.4.2 COMPARISON TO REGULATORY STANDARDS

Water quality from the bedrock aquifer and Gallup Sandstone Aquifer were assessed against the regulatory standards established for the maximum allowable concentrations of groundwater of 10,000 mg/L TDS or less (NMAC 20.6.2.3103). Table 5-2 include these standards at the bottom, allowing for easy comparison to water quality data from Well 11, with bolded values indicating exceedances. Only the following monitored constituents are regulated by the referenced standards: fluoride, nitrate and nitrite as N, and selenium for human health standards and chloride, iron, manganese, sulfate, TDS, zinc, and pH for domestic water supply. There were no exceedances of water quality from Well 11 for standards associated with chloride, fluoride, nitrate, nitrite, pH, selenium, sulfate, TDS, and zinc.

5.4.3 COMPARISON TO PROBABLE HYDROLOGIC CONSEQUENCES

Data establish that bedrock groundwaters are of poor quality that cannot be used for beneficial purposes. Data also show, however, that they have had no deleterious effect on established surface or groundwater uses. Upon the final stages of bond release, wells will be plugged and abandoned in accordance with NMAC 19.27.4.30.C.1.

6.0 SURFACE AND GROUNDWATER ASSESSMENT SUMMARY

As required for bond release of long-term surface and groundwater monitoring, water quality and quantity data are provided in this report. Evaluation of the data was presented in three separate sections to confirm that mining activities at the McKinley Mine have not disturbed the hydrologic balance in or around the site. In each of the sections, data were assessed with respect to baseline data, regulatory standards, and the PHC determination, as applicable. The following provides a brief summary of those findings.

6.1 LONG-TERM ASSESSMENT OF IMPOUNDMENTS

Three permanent impoundments are located within Area 11. Additionally, only three impoundments in the vicinity of Area 11 were sampled once during the reporting period and therefore, have not been included in this discussion.

6.2 LONG-TERM ASSESSMENT OF SURFACE WATER

There are no surface water sampling locations within Area 11 and therefore, a comparison of surface water quality to background water quality data (CMW) has not been included in this discussion.

6.3 LONG-TERM ASSESSMENT OF GROUNDWATER

Comparison of groundwater quality from Well 11 to water quality standards indicate that water quality in the spoil recharge zone is below water quality standards for the regulated analytes fluoride, nitrate and nitrite as N, chloride, TDS, zinc, and pH. The PHC does not address the spoil recharge zone. Upon the final stages of bond release, the spoil well will be plugged and abandoned.

7.0 REFERENCES

Geohydrology Associates, Inc. (GAI). 1980. Hydrology Study of the McKinley Mine.

National Pollutant Discharge Elimination System (NPDES) Permit No. NN0029386. 2017. July 1.

New Mexico Administrative Code (NMAC). 2022. Title 20, Environmental Protection Chapter 6, Water Quality Part 4: Standards for Interstate and Intrastate Surface Waters. April 23.

New Mexico Administrative Code (NMAC). 2017. Title 19, Natural Resources and Wildlife Chapter 27, Underground Water Part 4: Well Driller Licensing; Construction, Repair, and Plugging of Wells. June 30.

New Mexico Administrative Code (NMAC). 2007. Title 20, Environmental Protection Chapter 6, Water Quality Part 2: Ground and Surface Water Protection. June 1.

Trihydro Corporation (Trihydro). 2023. McKinley Mine – 2022 Annual Report Hydrology Section. February 27.

TABLES

TABLE 2-1. PRECIPITATION DATA, SOUTH TIPPLE AND RAIN 11
MCKINLEY MINE, CHEVRON MINING INC.
NEAR GALLUP, NEW MEXICO

Month	2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		Average (2013-2022)	Maximum (2013-2022)
	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	Rain 11 (in)	S. Tipple (in)	S. Tipple (in)	S. Tipple (in)
January	--	1.38	--	0.04	--	2.05	--	0.62	--	1.25	--	0.35	--	1.30	--	0.98	--	1.11		0.36	0.94	2.05
February	--	0.15	--	0.06	--	1.59	--	0.22	--	1.64	--	0.79	--	1.81	--	1.44	--	0.34		0.74	0.88	1.81
March	0.00	0.39	--	0.73	--	0.11	--	0.05	--	0.48	--	0.54	--	1.23	--	1.35	--	0.4		1.25	0.65	1.35
April	0.33	0.23	0.05	0.36	0.48	0.52	1.23	1.31	0.28	0.35	0.09	0.09	0.20	0.44	0.16	0.17	0.00	0.07	0.00	0.00	0.35	1.31
May	0.00	0	0.25	0.14	1.88	1.64	1.16	0.80	0.77	0.77	0.29	0.29	1.50	1.77	0.02	0.01	0.07	0.08	0.00	0.01	0.55	1.77
June	0.12	0.05	0.00	0	1.02	1.11	0.05	0.07	0.64	0.42	0.26	0.51	0.19	0.33	0.11	0.04	0.18	0.37	0.56	0.66	0.36	1.11
July	3.75	1.8	1.06	0.85	2.80	2.37	0.86	1.37	1.61	2.48	1.92	2.61	0.44	0.22	0.60	1.13	2.10	5.45	3.30	3.68	2.20	5.45
August	2.80	2.53	1.47	1.44	1.69	1.62	2.00	1.74	0.42	0.90	1.00	1.34	0.20	0.05	0.06	0.24	1.31	1.24	4.62	5.36	1.65	5.36
September	2.21	3.03	2.17	2.12	0.26	0.3	1.85	1.75	1.09	1.34	0.89	1.1	1.72	1.59	0.14	0.15	1.43	2.12	1.09	1.51	1.50	3.03
October	0.54	0.58	0.32	0.36	0.97	1.36	0.34	0.40	0.09	0.15	1.45	1.65	0.06	0.09	0.08	0.26	0.98	1.77	1.97	2.92	0.95	2.92
November	0.53	1.67	0.03	0.09	1.08	1.31	0.49	1.57	0.04	0.09	0.00	0.19	0.08	1.14	0.45	0.40	0.00	0.55	0.51	0.59	0.76	1.67
December	--	0.2	--	1.53	--	0.76	--	1.84	--	0.02	--	0.67	--	0.85	--	0.27	--	2.26		0.74	0.91	2.26

Total Annual Precipitation

Year	2013		2014		2015		2016		2017		2018		2019		2020		2021		2022		Rain 11 Average	S. Tipple Average
Total (inches)	--	12.01	--	7.72	--	14.74	--	11.74	--	9.89	--	10.13	--	10.82	--	6.44	--	15.76	--	17.82	--	11.71
Apr-Nov (inches)	10.28	10.28	5.35	5.36	10.18	10.23	7.98	9.01	4.94	6.50	5.90	7.78	4.39	5.63	1.62	2.40	6.07	11.65	12.05	14.73	6.88	8.36

Notes:
-- - precipitation station not operating due to freezing temperatures
(green shading) Partial operating month
in - inches
Apr - April
Nov - November

TABLE 3-1. PERMANENT IMPOUNDMENT WATER QUALITY DATA
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Impoundment ID	Date Sampled	Arsenic, dissolved µg/L	Boron, dissolved µg/L	Cadmium, dissolved µg/L	Chlorine Residual µg/L	Chromium, dissolved µg/L	Cobalt, dissolved µg/L	Copper, dissolved µg/L	Cyanide, total µg/L	Lead, dissolved µg/L	Mercury, dissolved µg/L	Nitrate + Nitrite mg/L	Selenium, dissolved µg/L	Selenium, total recoverable µg/L	Vanadium, dissolved µg/L	Zinc, dissolved µg/L	Adjusted gross alpha pCi/L	Radium 226 + Radium 228 pCi/L	Tritium pCi/L	4,4'-DDT and derivatives µg/L	E. coli MPN/100 mL
11-8	12/7/2022	1.3	ND (40)	ND (0.5)	ND (50)	ND (1.0)	ND (6.0)	3.6	ND (5.0)	1.80	ND (0.2)	ND (1)	ND (1)	7	ND (50)	13	0	2.291	40.5	ND (0.05)	<1
11-10	12/7/2022	ND (1.0)	ND (40)	ND (0.5)	ND (50)	ND (1.0)	ND (6.0)	4.1	ND (5.0)	0.67	ND (0.2)	ND (1)	1.2	6.2	ND (50)	ND (10)	0	1.524	32.9	ND (0.05)	<10
12-9	12/7/2022	ND (1.0)	ND (40)	ND (0.5)	ND (50)	ND (1.0)	ND (6.0)	4.2	ND (5.0)	ND (0.5)	ND (0.2)	ND (1)	ND (1)	2.1	ND (50)	ND (10)	27.7	0.608	-32.8	ND (0.05)	<1
Water Quality Standards		200	5,000	50	11	1,000	1,000	500	5.2	100	10	132	50	5	100	25,000	15	30	20,000	0.001	2,507

TABLE 5-1. DEPTH TO WATER AND SATURATED THICKNESS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Location	Year	DTW	Well Depth	Saturated Thickness
		ft bmp	ft bmp	ft
WELL 11	2013	56.61	86.65	30.04
	2014	56.02	86.65	30.64
	2015	54.93	86.65	31.73
	2016	55.52	86.65	31.13
	2017	57.15	86.65	29.51
	2018	57.67	86.65	28.98
	2019	57.90	86.65	28.75
	2020	57.64	86.65	29.02
	2021	57.78	86.65	28.87
	2022	57.38	86.65	29.27

Notes:
DTW - depth to water
ft - feet
bmp - below measuring point

TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Alkalinity mg/L $CaCO_3$	Bicarbonate mg/L $CaCO_3$	Boron, Total mg/L	Calcium, Dissolved mg/L	Calcium, Total mg/L	Carbonate mg/L $CaCO_3$	CAT_AN_BAL %	Chloride mg/L	Fluoride mg/L	Hardness, Total mg/L $CaCO_3$	Iron, Dissolved mg/L	Iron, Total mg/L	Magnesium, Dissolved mg/L
DT2A	3/20/2013	703	703		113	117	ND (2)		27.6	ND (0.5)			0.57	48.4
DT2A	5/23/2013	726	726		118	103	ND (2)		45.4	ND (0.5)		**11.9**	18.1	50.7
DT2A	8/21/2013	636	636		68.9	71.7	ND (2)		10.1	0.53		0.21	1.97	30.4
DT2A	11/7/2013	647	647		75.4	86.6	ND (2)		14			ND (0.2)	26.2	33.2
DT2A	2/12/2014	678	678		89	89.3	ND (2)	6.2	15.9			ND (0.2)	1.01	37.8
DT2A	4/15/2014	677	677		92.2	87.5	ND (2)	10.2	14.6			ND (0.2)	2.02	39.1
DT2A	8/21/2014	655	655		84.4	85	ND (2)	10.4	17.2		406	ND (0.2)	0.29	35.8
DT2A	8/21/2014	660	660		84.5	86.1	ND (2)		16.4		373	ND (0.2)	0.479	35.8
DT2A	11/5/2014	670	670		82.2	82.5	ND (2)	6.1	17.2		403	ND (0.2)	0.815	35.2
DT2A	2/10/2015	670	670		77	78.2	ND (2)	4.1	14.2		328	ND (0.2)	0.081	32.8
DT2A	4/29/2015	635	635		69.4	66.9	ND (2)	4.2	9.8		314	ND (0.2)	0.29	29.8
DT2A	4/29/2015	645	645		68.1	70.8	ND (2)	6.1	9.2		299	0.0369	1.21	29.2
DT2A	9/1/2015	652	652		56.1	63.6	ND (2)	6.4	13.1		303	ND (0.2)	19.8	24.3
DT2A	11/3/2015	603	603		59.1	61.2	ND (2)	2.7	11.6		274	ND (0.2)	4.04	25.4
DT2A	2/24/2016	604	604		60.3	62.3	ND (2)	5.8	13.5		309	ND (0.2)	2.28	25.8
DT2A	5/24/2016	587	587		49.5	50.9	ND (2)	5.3	11.6		235	ND (0.2)	0.219	22.2
DT2B	3/20/2013	855	855		126	127	ND (2)		41.8	ND (0.5)		0.384	ND (0.2)	58.1
DT2B	5/23/2013	832	832		132	140	ND (2)		46	0.66		0.553	2.32	63
DT2B	5/23/2013	824	824			140	ND (2)		48	0.65		0.393	1.09	
DT2B	5/23/2013													
DT2B	5/23/2013													
DT2B	8/21/2013	781	781		151	165	ND (2)		44.8	0.74		0.0988	7.28	75.6
DT2B	11/7/2013	797	797		130	129	ND (2)		35.9			ND (0.2)	0.191	64.1
DT2B	2/12/2014	820	820		130	138	ND (2)	1.4	40.4			ND (0.2)	2.75	63.5
DT2B	4/15/2014	811	811		129	124	ND (2)	3.8	31.5			ND (0.2)	0.28	63.1
DT2B	8/21/2014	849	849		145	148	ND (2)	2.9	46.7		682	ND (0.2)	2.8	71.5
DT2B	10/22/2014	851	851		154	164	ND (2)	1.3	44		776	ND (0.2)	1.27	74.8
DT2B	2/10/2015	889	889		163	174	ND (2)	1.8	43		725	0.0944	0.705	78.3
DT2B	4/29/2015	881	881		158	149	ND (2)	3.3	36.1		735	ND (0.2)	2.65	76.8
DT2B	9/1/2015	894	894		119	157	ND (2)	0.0	42.7		987	0.323	17.6	56.7
DT2B	11/3/2015	910	910		97.4	107	ND (2)	3.0	32.4		514	0.594	2.57	46.5
DT2B	2/24/2016	906	906		103	125	ND (2)	8.6	30.2		605	ND (0.2)	47.3	48.2
Well 11	8/21/2013	1,820	1,820	0.261		144	ND (2)		36	ND (0.5)		0.566	2.64	
Well 11	8/21/2013													
Well 11	11/7/2013	1,890	1,890	0.271		168	ND (2)		39.3	ND (0.5)		0.254	2.99	
Well 11	11/7/2013	1,940	1,940	0.271		168	ND (2)		36.8	ND (0.5)		0.267	2.51	
Well 11	2/12/2014	1,860	1,860	0.253	142	139	ND (2)	6.8	37.2	ND (0.5)		0.979	3.91	47.6
Well 11	4/15/2014	1,850	1,850	0.25	160	149	ND (2)	2.6	35.1	ND (0.5)		0.655	3.09	53.1
Well 11	8/21/2014	1,820	1,820	0.267	148	144	ND (2)	7.1	35.2	ND (0.5)	568	0.0782	1.73	48.4
Well 11	10/22/2014	1,840	1,840	0.253	147	148	ND (2)	1.9	40.2	ND (0.5)	616	**2.93**	4.6	48.9
Well 11	10/22/2014	1,850	1,850	0.254	148	146	ND (2)	2.5	39.7	ND (0.5)	551	**3.64**	3.74	49.3
Well 11	2/10/2015	1,890	1,890	0.258	146	146	ND (2)	2.4	36.2	0.29	618	0.141	2.25	48

TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Magnesium, Total mg/L	Manganese, Dissolved mg/L	Manganese, Total mg/L	Station ID	Date Sampled	Nitrogen, Nitrate mg/L	Nitrogen, Nitrite mg/L	pH, Field SU	Phosphate mg/L	Phosphorus, Total mg/L	Potassium, Total mg/L	Selenium, Dissolved mg/L
DT2A	3/20/2013	49.7	0.0096	0.012	DT2A	3/20/2013	**39.6**		7.6		ND (0.1)	1.10	
DT2A	5/23/2013	43.7	0.13	0.350	DT2A	5/23/2013	**48.4**	ND (0.05)	7.6		0.52	4.98	
DT2A	8/21/2013	31.1	0.0055	0.034	DT2A	8/21/2013	9.5		7.9		ND (0.1)	1.05	
DT2A	11/7/2013	38.3	0.0071	0.338	DT2A	11/7/2013	**14.6**	ND (0.05)	7.6	7.1	0.425	3.46	ND (0.02)
DT2A	2/12/2014	37.7	0.0069	0.012	DT2A	2/12/2014	**20.4**	ND (0.05)	7.6	ND (0.31)	ND (0.1)	1.13	
DT2A	4/15/2014	37.9	0.0033	0.033	DT2A	4/15/2014	19	ND (0.05)	7.5	ND (0.31)	ND (0.1)	1.16	
DT2A	8/21/2014	36.1	0.0048	0.008	DT2A	8/21/2014	**18.6**	ND (0.05)	7.9	ND (0.31)	0.0087	1.04	ND (0.02)
DT2A	8/21/2014	36.3	0.0052	0.012	DT2A	8/21/2014	**19.1**	ND (0.05)	7.9	ND (0.31)	0.0123	1.13	ND (0.02)
DT2A	11/5/2014	35.4	0.0062	0.013	DT2A	11/5/2014	22	ND (0.05)	7.8	ND (0.31)	0.0108	1.32	ND (0.02)
DT2A	2/10/2015	33.3	0.0024	0.003	DT2A	2/10/2015	**14.4**	ND (0.05)	8.1	ND (0.31)	0.0102	1.04	ND (0.02)
DT2A	4/29/2015	29.1	0.0023	0.008	DT2A	4/29/2015	7.4	ND (0.05)	8.0	ND (0.31)	0.009	1.07	ND (0.02)
DT2A	4/29/2015	30.6	0.0015	0.022	DT2A	4/29/2015	7.2	ND (0.05)	8.0	ND (0.31)	0.0134	1.24	ND (0.02)
DT2A	9/1/2015	27.9	0.0679	0.363	DT2A	9/1/2015	8.8	ND (0.05)	7.6	ND (0.31)	0.256	4.88	ND (0.02)
DT2A	11/3/2015	26.4	0.0097	0.070	DT2A	11/3/2015	8.2	0.018	7.8	ND (0.31)	0.0819	1.62	ND (0.02)
DT2A	2/24/2016	26.1	0.0097	0.069	DT2A	2/24/2016	**11.9**	ND (0.05)	8.3	ND (0.31)	0.0427	1.44	ND (0.02)
DT2A	5/24/2016	22.9	0.002	0.004	DT2A	5/24/2016	9	ND (0.05)	8.0	ND (0.31)	ND (0.1)	1.73	ND (0.02)
DT2B	3/20/2013	59.2	**0.405**	0.333	DT2B	3/20/2013	**16.4**		7.6		ND (0.1)	3.6	
DT2B	5/23/2013	65.1	**0.333**	0.865	DT2B	5/23/2013	**14.2**	0.025	7.6		ND (0.1)	4.2	
DT2B	5/23/2013	65.1	**0.311**	0.726	DT2B	5/23/2013	**13.6**	0.022	7.7		0.0818	4.0	
DT2B	5/23/2013				DT2B	5/23/2013					ND (0.1)		
DT2B	5/23/2013				DT2B	5/23/2013					0.0471		
DT2B	8/21/2013	77.7	0.111	1.110	DT2B	8/21/2013	**23.5**		7.6		0.27	5.1	
DT2B	11/7/2013	63.9	0.149	0.181	DT2B	11/7/2013	**15.7**	ND (0.05)	7.6	ND (0.31)	ND (0.1)	3.8	ND (0.02)
DT2B	2/12/2014	65.5	**0.258**	0.472	DT2B	2/12/2014	**12.4**	ND (0.05)	7.6	ND (0.31)	0.101	3.9	
DT2B	4/15/2014	61.3	0.165	0.193	DT2B	4/15/2014	**13.7**	0.058	7.6	ND (0.31)	ND (0.1)	3.4	
DT2B	8/21/2014	72.2	**0.524**	0.667	DT2B	8/21/2014	7.3	ND (0.05)	7.7	ND (0.31)	0.0967	4.3	ND (0.02)
DT2B	10/22/2014	77.3	**0.375**	0.631	DT2B	10/22/2014	5.4	0.074	7.6	ND (0.31)	0.0561	4.2	ND (0.02)
DT2B	2/10/2015	81.4	**0.573**	0.929	DT2B	2/10/2015	4.3	ND (0.05)	7.8	ND (0.31)	0.0526	4.5	0.0073
DT2B	4/29/2015	72.8	**0.706**	0.668	DT2B	4/29/2015	6.1	ND (0.05)	7.8	ND (0.31)	0.0969	4.0	ND (0.02)
DT2B	9/1/2015	72.5	**0.34**	1.000	DT2B	9/1/2015	3.5	ND (0.05)	7.6	11.2	0.51	6.3	ND (0.02)
DT2B	11/3/2015	50.6	**0.409**	0.635	DT2B	11/3/2015	4	0.1	7.8	ND (0.31)	0.0996	3.7	ND (0.02)
DT2B	2/24/2016	56.9	**0.496**	1.310	DT2B	2/24/2016	5.5	0.11	7.8	1.6	1.14	9.0	ND (0.02)
Well 11	8/21/2013	48.7	**0.678**	0.664	Well 11	8/21/2013	1.8		7.0		ND (0.1)	15.4	
Well 11	8/21/2013				Well 11	8/21/2013					0.0464		
Well 11	11/7/2013	55.8	**1.48**	1.520	Well 11	11/7/2013	ND (0.1)	ND (0.05)	6.9	ND (0.31)	ND (0.1)	18.7	
Well 11	11/7/2013	55.8	**1.52**	1.530	Well 11	11/7/2013	ND (0.1)	ND (0.05)	6.9	ND (0.31)	ND (0.1)	18.2	
Well 11	2/12/2014	46.8	**0.649**	0.651	Well 11	2/12/2014	ND (1)	ND (0.5)	7.0	ND (0.31)	ND (0.1)	15.5	
Well 11	4/15/2014	49.9	**0.8**	0.766	Well 11	4/15/2014	ND (0.1)	ND (0.5)	7.0	ND (0.31)	ND (0.1)	15.7	
Well 11	8/21/2014	47.3	**0.715**	0.732	Well 11	8/21/2014	ND (0.5)	ND (0.5)	7.3	ND (0.31)	0.0143	15.4	ND (0.02)
Well 11	10/22/2014	49.6	**0.806**	0.848	Well 11	10/22/2014	ND (1)	ND (0.5)	7.1	ND (0.31)	0.0618	16.5	ND (0.02)
Well 11	10/22/2014	49	**0.809**	0.814	Well 11	10/22/2014	ND (1)	ND (0.5)	7.1	ND (0.31)	0.0406	16.1	ND (0.02)
Well 11	2/10/2015	48.3	**0.761**	0.748	Well 11	2/10/2015	ND (1)	ND (0.25)	7.3	0.28	0.0525	15.9	ND (0.02)

TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Selenium, Total mg/L	Sodium, Dissolved mg/L	Sodium, Total mg/L	Sodium Adsorption Ratio %	Sulfate mg/L	Zinc, Dissolved mg/L	Zinc, Total mg/L	Total Dissolved Solids mg/L	Turbidity NTU
DT2A	3/20/2013	ND (0.02)		551		**824**			2,180	
DT2A	5/23/2013	ND (0.02)		626		**881**			2,310	
DT2A	8/21/2013	ND (0.02)		448		589			1,480	
DT2A	11/7/2013	ND (0.02)		442		547			1,390	
DT2A	2/12/2014	ND (0.02)		453		586			1,570	
DT2A	4/15/2014	ND (0.02)	488	455		514			1,650	
DT2A	8/21/2014	ND (0.02)	476	479		574			1,580	
DT2A	8/21/2014	ND (0.02)	488	477		550			1,600	
DT2A	11/5/2014	ND (0.02)	439	434		541			1,580	
DT2A	2/10/2015	0.0048	424	440	10.2	510			1,440	
DT2A	4/29/2015	0.0059	415	418	10.3	481			1,300	
DT2A	4/29/2015	ND (0.02)	404	405	10.5	487			1,280	
DT2A	9/1/2015	ND (0.02)	500	518	14.0	563			1,650	
DT2A	11/3/2015	ND (0.02)	352	355	9.6	408			1,380	
DT2A	2/24/2016	0.0116	360	351	9.8	356			1,230	
DT2A	5/24/2016	ND (0.02)	353	375	10.5	342			1,290	
DT2B	3/20/2013	ND (0.02)		897		**1,690**			3,440	
DT2B	5/23/2013	ND (0.02)		969		**1,780**			3,640	
DT2B	5/23/2013	ND (0.02)		1010		**1,760**			3,540	
DT2B	5/23/2013									
DT2B	5/23/2013									
DT2B	8/21/2013	ND (0.02)		1110		**2,220**			3,650	
DT2B	11/7/2013	ND (0.02)		942		**1,560**			3,300	
DT2B	2/12/2014	ND (0.02)		946		**1,760**			3,510	
DT2B	4/15/2014	ND (0.02)		910		**1,590**			3,190	
DT2B	8/21/2014	ND (0.02)	1,010	1020		**1,850**			3,930	
DT2B	10/22/2014	ND (0.02)	1,000	967		**1,950**			3,820	
DT2B	2/10/2015	ND (0.02)	1,040	1060	16.8	**2,000**			4,040	
DT2B	4/29/2015	ND (0.02)	982	1020	16.0	**1,800**			3,290	
DT2B	9/1/2015	ND (0.02)	886	983	16.7	**1,590**			3,340	
DT2B	11/3/2015	ND (0.02)	788	811	16.4	**1,420**			2,630	
DT2B	2/24/2016	ND (0.1)	820	810	16.7	**1,040**			2,400	
Well 11	8/21/2013	ND (0.02)		2,380		**3,960**		0.0138	6,400	
Well 11	8/21/2013									
Well 11	11/7/2013	ND (0.02)		2,320		**3,510**		0.0152	7,130	
Well 11	11/7/2013	ND (0.02)		2,360		**3,570**		0.0141	7,200	
Well 11	2/12/2014	ND (0.02)		2,210		**4,400**		0.0152	7,760	
Well 11	4/15/2014	ND (0.02)		2,260		**4,110**		0.011	8,300	
Well 11	8/21/2014	ND (0.02)	2,380	2,350		**3,320**		0.0141	6,940	
Well 11	10/22/2014	ND (0.02)	2,100	2,210		**3,830**		0.0249	5,610	
Well 11	10/22/2014	ND (0.02)	2,070	2,370		**3,200**		0.0196	5,570	
Well 11	2/10/2015	0.0065	2,270	2,250	41.6	**3,500**		0.0154	7,990	

TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Alkalinity mg/L $CaCO_3$	Bicarbonate mg/L $CaCO_3$	Boron, Total mg/L	Calcium, Dissolved mg/L	Calcium, Total mg/L	Carbonate mg/L $CaCO_3$	CAT_AN_BAL %	Chloride mg/L	Fluoride mg/L	Hardness, Total mg/L $CaCO_3$	Iron, Dissolved mg/L	Iron, Total mg/L	Magnesium, Dissolved mg/L
Well 11	4/29/2015	1,870	1,870	0.236	143	139	ND (2)	3.9	31.3	0.46	598	0.231	4.16	48.4
Well 11	9/1/2015	1,780	1,780	0.251	138	139	ND (2)	1.6	38.1	ND (0.5)	669	0.359	3.59	45.5
Well 11	11/5/2015	1,850	1,850	0.228	143	141	ND (2)	5.2	37.2	ND (0.5)	598	**3.09**	5.34	47.3
Well 11	2/24/2016	1,860	1,860	0.253	151	141	ND (2)	0.3	35.8	ND (0.5)	614	**1.2**	2.92	49.8
Well 11	5/24/2016	1,850	1,850	0.268	145	153	ND (2)	1.2	34.9	ND (0.5)	591	0.885	1.99	48.9
Well 11	7/28/2016	1,560	1,560	0.255	141	145	ND (50)	1.5	35.6	ND (0.5)	597	0.915	2.01	46.7
Well 11	11/9/2016	1,930	1,930	0.256	151	151	ND (5)	43.7	33.7	ND (0.5)	612	0.59	1.5	51.3
Well 11	3/1/2017	2,030	2,030	0.26	225	239	ND (5)	6.1	38	ND (0.5)	861	0.724	4.12	69.9
Well 11	6/8/2017	2,000	2,000	0.273	216	221	ND (5)	4.1	38.8	ND (0.5)	807	**6.23**	10.9	67.8
Well 11	8/23/2017	2,020	2,020	0.244	246	242	ND (5)	1.6	39.6	ND (0.5)	860	**6.87**	7.68	74.2
Well 11	11/14/2017	2,020	2,020	0.239	227	226	ND (5)	3.1	40.8	ND (0.5)	849	**6.51**	9.42	75.4
Well 11	2/21/2018	2,000	2,000	0.229		242	ND (5)	3.1	106	ND (0.5)	771	**3.47**	7.59	
Well 11	5/3/2018	2,060	2,060	0.239		263	ND (5)	1.4	38.1	ND (0.5)	949	**5.15**	7.92	
Well 11	8/2/2018	2,010	2,010	0.26		266	ND (5)	5.8	38.8	ND (0.5)	939	**8.08**	9.61	
Well 11	11/14/2018	2,070	2,070	0.252		266	ND (5)	4.8	30.8	ND (0.5)	1070	**8.17**	9.4	
Well 11	3/7/2019	2,100	2,100	0.231		243	ND (5)	2.6	35.7	ND (0.5)	1090	**7.53**	7.98	
Well 11	5/14/2019	2,030	2,030	0.252		265	ND (5)	1.6	38.2	ND (0.5)	1000	**5.12**	10.9	
Well 11	8/19/2019	2,080	2,080	0.256		290	ND (8)	0.6	31.1	ND (0.5)	1230	**7.3**	8.68	
Well 11	8/20/2019	2,060	2,060	0.253		158	ND (8)	8.6	41.8	ND (0.5)	610	0.638	2.34	
Well 11	11/12/2019	2,080	2,080	0.241		261	ND (8)	0.4	38.7	ND (0.5)	1180	**3.68**	9.95	
Well 11	11/13/2019	2,050	2,050	0.26		160	ND (8)	0.2	36.1	ND (0.5)	516	0.619	3.15	
Well 11	2/18/2020	2,030	2,030	0.263		244	ND (8)	2.9	38.2	ND (0.5)	987	**10.1**	5.6	
Well 11	2/19/2020	2,020	2,020	0.233		157	ND (8)	1.0	33.8	ND (0.5)	684	0.559	1.79	
Well 11	5/12/2020	2,050	2,050	0.259		255	ND (8)	4.1	38.4	ND (0.5)	1040	0.954	3.8	
Well 11	5/13/2020	2,040	2,040	0.257		156	ND (8)	1.8	32.7	ND (0.5)	669	0.418	2.01	
Well 11	8/31/2020	2,000	2,000	0.24		190	ND (8)	0.2	40	0.54	1000	**2.2**	2.9	
Well 11	9/1/2020	2,100	2,100	0.25		160	ND (8)	0.9	53	ND (0.5)	670	0.18	0.74	
Well 11	10/21/2020	2,100	2,100	0.28		220	ND (8)	2.9	35	0.29	960	**2.8**	12	
Well 11	10/22/2020	2,200	2,200	0.27		160	ND (8)	3.8	52	ND (0.5)	660	0.97	0.68	
Well 11	1/20/2021	1,900	1,900	0.26		230	ND (8)	4.4	39	0.39	1200	**2.7**	13	
Well 11	1/21/2021	1,900	1,900	0.3		160	ND (8)	5.7	46	0.81	710	0.53	1.9	
Well 11	5/5/2021	1,435	1,369	0.26		150	66.2	0.6	34	ND (0.5)	590	0.28	1.8	
Well 11	8/10/2021	2,036	2,036	0.27		160	ND (5)	5.9	35	ND (0.5)	620	0.55	1.8	
Well 11	11/10/2021	2,020	2,020	0.26		140	ND (5)	1.7	33	ND (0.5)	570	0.78	1.9	
Well 11	2/9/2022	2,056	2,056	0.26		170	ND (5)	7.0	34	ND (0.5)	680	0.12	1.5	
Well 11	4/26/2022	2,093	2,093	0.28		200	ND (5)	103.3	34	ND (0.5)	760	**1.7**	11	
Well 11	9/26/2022	2,051	2,051	0.28		170	ND (5)	105.7	33	ND (0.5)	660	**1.5**	2.3	
Well 11	11/10/2022	1,943	1,943	0.23		170	ND (5)	3.69	33	ND (0.5)	680	0.89	3.2	
Water Quality Standards		None	None	None	None	None	None	None	250	1.6	None	1	None	None

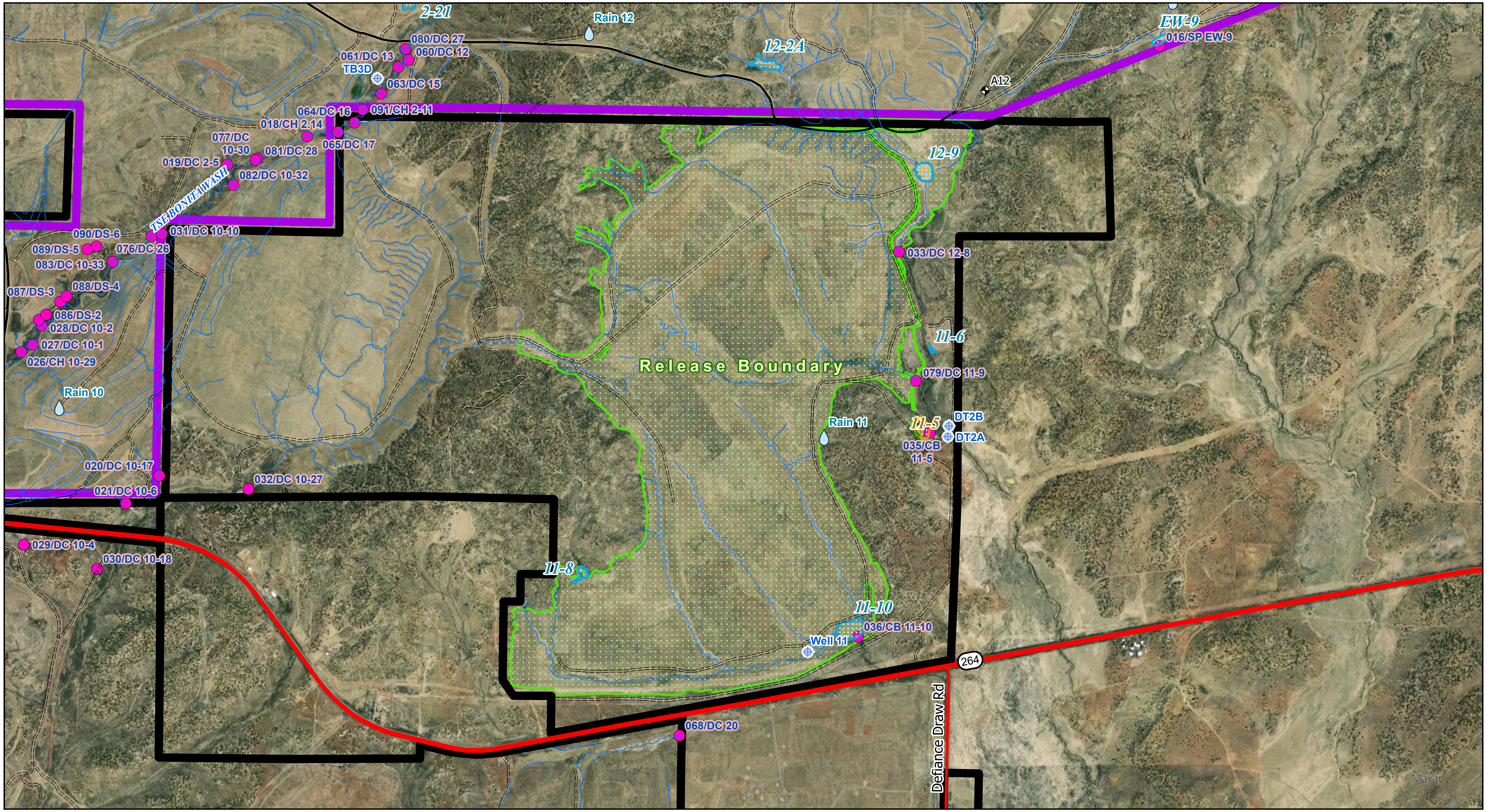
TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Magnesium, Total mg/L	Manganese, Dissolved mg/L	Manganese, Total mg/L	Station ID	Date Sampled	Nitrogen, Nitrate mg/L	Nitrogen, Nitrite mg/L	pH, Field SU	Phosphate mg/L	Phosphorus, Total mg/L	Potassium, Total mg/L	Selenium, Dissolved mg/L
Well 11	4/29/2015	47.4	**0.726**	0.733	Well 11	4/29/2015	ND (0.1)	ND (0.5)	7.4	ND (0.31)	0.0418	15.6	ND (0.02)
Well 11	9/1/2015	46.1	**0.74**	0.738	Well 11	9/1/2015	ND (0.1)	ND (0.05)	7.2	ND (0.31)	0.0279	15.7	0.0103
Well 11	11/5/2015	46.6	**0.953**	0.949	Well 11	11/5/2015	ND (0.1)	ND (0.05)	7.2	ND (0.31)	0.0189	17.9	ND (0.02)
Well 11	2/24/2016	47.8	**0.797**	0.754	Well 11	2/24/2016	ND (0.1)	ND (0.05)	7.4	ND (0.31)	0.0282	15.5	ND (0.02)
Well 11	5/24/2016	50.7	**0.798**	0.807	Well 11	5/24/2016	ND (0.1)	ND (0.05)	7.3	ND (0.31)	0.0146	15.4	ND (0.02)
Well 11	7/28/2016	46.7	**0.751**	0.762	Well 11	7/28/2016	ND (0.1)	ND (0.05)	7.1	ND (0.31)	0.0141	15.2	ND (0.02)
Well 11	11/9/2016	51.1	**0.814**	0.807	Well 11	11/9/2016	ND (0.1)	ND (0.05)	7.1	ND (0.31)	0.0141	21.5	ND (0.02)
Well 11	3/1/2017	73.4	**2.25**	2.460	Well 11	3/1/2017	0.23	ND (0.05)	7.1	ND (0.31)	ND (0.1)	19.5	ND (0.02)
Well 11	6/8/2017	69.5	**2.13**	2.210	Well 11	6/8/2017	0.077		6.7	3410	0.0459	21.0	ND (0.02)
Well 11	8/23/2017	75.1	**2.68**	2.680	Well 11	8/23/2017	ND (0.1)	ND (0.05)	6.9	ND (0.31)	0.05	22.4	ND (0.02)
Well 11	11/14/2017	75.2	**2.48**	2.520	Well 11	11/14/2017	ND (0.1)	ND (0.05)	7.0	ND (0.31)	0.0515	23.9	ND (0.02)
Well 11	2/21/2018	73.6	**2.57**	2.760	Well 11	2/21/2018	ND (0.1)	ND (0.05)	7.0	ND (0.31)	ND (0.1)	19.9	
Well 11	5/3/2018	78.7	**2.72**	3.19	Well 11	5/3/2018	0.083		6.7	ND (0.31)	0.0439	19.6	
Well 11	8/2/2018	82.5	**3.14**	3.21	Well 11	8/2/2018	ND (0.1)	ND (0.25)	6.9	0.26	0.0555	19.8	
Well 11	11/14/2018	83	**3.11**	3.21	Well 11	11/14/2018	0.068	ND (0.05)	7.2	ND (0.31)	0.0621	21	
Well 11	3/7/2019	76.6	**3.5**	2.93	Well 11	3/7/2019	ND (0.1)	ND (0.1)	7.4	ND (0.31)	0.0654	17	
Well 11	5/14/2019	86.6	**3.53**	3.3	Well 11	5/14/2019	ND (0.1)	ND (0.1)	7.2	ND (0.31)	0.0579	19.6	
Well 11	8/19/2019	89.6	**3.27**	3.69	Well 11	8/19/2019	ND (0.1)		6.8	ND (0.31)	0.0416	21.5	
Well 11	8/20/2019	52.6	**0.958**	0.973	Well 11	8/20/2019	ND (0.1)	ND (0.05)	7.0	ND (0.31)	ND (0.1)	18.1	
Well 11	11/12/2019	78.8	**2.86**	3.09	Well 11	11/12/2019	ND (0.1)	ND (0.05)	7.2	ND (0.31)	0.0506	18.5	
Well 11	11/13/2019	52.7	**0.932**	0.958	Well 11	11/13/2019	ND (0.1)	ND (0.05)	7.5	ND (0.31)	0.0398	16.3	
Well 11	2/18/2020	77.1	**2.56**	2.72	Well 11	2/18/2020	ND (0.1)		6.9	ND (0.31)	0.0359	19.3	
Well 11	2/19/2020	52.7	**0.946**	0.881	Well 11	2/19/2020	ND (0.1)	ND (0.05)	7.2	ND (0.31)	ND (0.1)	16	
Well 11	5/12/2020	78.7	**2.44**	2.85	Well 11	5/12/2020	ND (0.1)	ND (0.1)	6.9	ND (0.31)	ND (0.1)	18.5	
Well 11	5/13/2020	52.1	**0.865**	0.906	Well 11	5/13/2020	ND (0.1)	ND (0.05)	7.4	ND (0.31)	ND (0.1)	15.2	
Well 11	8/31/2020	60	**2.3**	2.4	Well 11	8/31/2020	ND (0.1)		6.9	ND (0.31)	ND (0.1)	16	
Well 11	9/1/2020	53	**1**	1	Well 11	9/1/2020	0.093		7.2	ND (0.31)	ND (0.1)	16	
Well 11	10/21/2020	66	**2.2**	2.4	Well 11	10/21/2020	ND (0.1)		6.8	ND (0.31)	0.04	18	
Well 11	10/22/2020	50	**0.94**	1	Well 11	10/22/2020	ND (0.1)		7.3	ND (0.31)	ND (0.1)	18	
Well 11	1/20/2021	71	**2.2**	2.5	Well 11	1/20/2021	ND (0.1)		7.3	ND (0.31)	0.061	18	
Well 11	1/21/2021	57	**0.9**	0.97	Well 11	1/21/2021	ND (0.1)		7.4	ND (0.31)	ND (0.1)	17	
Well 11	5/5/2021	54	**0.96**	0.9	Well 11	5/5/2021	ND (0.5)	ND(0.5)	7.4	ND(2.5)	ND(0.05)	17	
Well 11	8/10/2021	54	**0.98**	0.94	Well 11	8/10/2021	ND (0.5)	ND(0.5)	6.9	ND(2.5)	ND (0.1)	17	
Well 11	11/10/2021	52	**0.89**	0.92	Well 11	11/10/2021	ND (0.5)	ND(0.5)	7.1	ND(2.5)	ND (0.05)	15	
Well 11	2/9/2022	62	**1.7**	1.5	Well 11	2/9/2022	ND (0.5)	ND(0.5)	7.2	ND(2.5)	ND (0.25)	17	
Well 11	4/26/2022	64	**1.3**	1.8	Well 11	4/26/2022	ND (0.5)	ND(0.5)	7.0	ND(2.5)	0.3	17	
Well 11	9/26/2022	57	**0.91**	0.94	Well 11	9/26/2022	ND (0.5)	ND(0.5)	7.2	ND(2.5)	ND (0.05)	16	
Well 11	11/10/2022	60	**0.81**	0.81	Well 11	11/10/2022	ND (1.0)	ND (1.0)	7.5	ND (2.5)	0.079	15	
Water Quality Standards		None	0.2	None	Water Quality Standards		10	1	6.0 - 9.0	None	None	None	None

TABLE 5-2. GROUNDWATER QUALITY SUMMARY (2013-2022)
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO

Station ID	Date Sampled	Selenium, Total mg/L	Sodium, Dissolved mg/L	Sodium, Total mg/L	Sodium Adsorption Ratio %	Sulfate mg/L	Zinc, Dissolved mg/L	Zinc, Total mg/L	Total Dissolved Solids mg/L	Turbidity NTU
Well 11	4/29/2015	ND (0.02)	2,240	2,280	41.3	**3,470**		0.019	5,720	
Well 11	9/1/2015	ND (0.02)	2,230	2,260	42.1	**3,340**		0.0143	7,840	
Well 11	11/5/2015	ND (0.02)	2,150	2,130	39.8	**3,690**		0.0093	7,780	
Well 11	2/24/2016	ND (0.02)	2,350	1,970	42.4	**3,430**		0.0141	7,250	
Well 11	5/24/2016	ND (0.02)	2,200	2,160	40.3	**3,620**		0.0067	6,970	
Well 11	7/28/2016	ND (0.02)	2,140	2,150	39.9	**3,610**		0.0064	7,010	
Well 11	11/9/2016	ND (0.02)	2,170	2,190	38.9	**3,710**		0.0071	5,980	
Well 11	3/1/2017	ND (0.02)	2,370	2,330	108.3	**4,610**		0.0192	7,260	
Well 11	6/8/2017	ND (0.02)	2,200	2,250	33.5	**4,480**		0.017	8,660	
Well 11	8/23/2017	ND (0.02)	2,510	2,450	36.0	**4,020**		0.0278	7,500	
Well 11	11/14/2017	ND (0.02)	2,390	2,410	35.1	**4,410**		0.015	3,870	
Well 11	2/21/2018	ND (0.02)		2,500	36.1	**4,030**	0.0167	0.0152	8,000	
Well 11	5/3/2018	ND (0.02)		2,290	36.10	**4,230**	0.012	0.0247	8,790	
Well 11	8/2/2018	ND (0.05)		2,570	31.81	**4,150**	0.0191	0.0297	6,420	
Well 11	11/14/2018	ND (0.05)		2,390	32.78	**3,650**	0.0184	0.0199	8,620	
Well 11	3/7/2019	ND (0.05)		2,220	31.80	**4,390**	0.02	0.0143	7,660	
Well 11	5/14/2019	ND (0.05)		2,430	33.13	**4,120**	0.0181	0.0169	8,250	
Well 11	8/19/2019	ND (0.05)		2,460	32.37	**4,330**	0.0171	0.0202	9,090	
Well 11	8/20/2019	ND (0.05)		2,280	40.12	**3,620**	0.0117	0.0188	7,390	
Well 11	11/12/2019	ND (0.05)		2,240	31.19	**3,050**	0.0244	0.0302	8,540	
Well 11	11/13/2019	ND (0.05)		2,220	38.89	**3,620**	0.0162	0.0185	7,760	
Well 11	2/18/2020	ND (0.05)		2,350	33.58	**4,140**	0.0194	0.025	8,460	
Well 11	2/19/2020	ND (0.05)		2,000	35.25	**3,430**	0.0177	0.0113	5,990	
Well 11	5/12/2020	ND (0.05)		2,470	37.88	**3,950**	0.0235	0.022	6,120	
Well 11	5/13/2020	ND (0.05)		2,140	34.66	**3,520**	0.0108	0.007	7,350	
Well 11	8/31/2020	0.018		2,200	40.25	**3,700**	0.021	0.016	7,900	
Well 11	9/1/2020	ND (0.05)		2,300	35.63	**3,500**	0.013	0.0096	7,300	
Well 11	10/21/2020	ND (0.05)		2,200	33.40	**3,800**	0.021	0.021	**13,000**	
Well 11	10/22/2020	ND (0.05)		2,200	38.90	**3,700**	0.0099	0.01	3,100	
Well 11	1/20/2021	ND (0.05)		2,200	32.51	**3,500**	0.018	0.02	8,100	
Well 11	1/21/2021	ND (0.05)		2,400	41.46	**4,600**	0.014	0.0089	7,500	
Well 11	5/5/2021	ND (0.001)		2,200	39.17	**3,400**	0.023	ND(0.01)	7,480	
Well 11	8/10/2021	ND (0.005)		2,300	40.12	**3,700**	ND (0.05)	ND(0.05)	7,400	
Well 11	11/10/2021	ND (0.005)		2,500	45.80	**3,500**	0.012	ND(0.01)	7,500	
Well 11	2/9/2022	ND (0.005)		2,300	38.37	**4,000**	0.03	0.017	8,140	
Well 11	4/26/2022	ND(0.001)		2,500	39.24	**3,500**	0.018	ND(0.05)	7,740	
Well 11	9/26/2022	ND (0.005)		2,600	44.05	**3,300**	0.013	ND(0.01)	6,580	
Well 11	11/10/2022	ND (0.005)		2,300	38.61	**3,500**	0.047	ND(0.01)	7,840	
Water Quality Standards		0.05	None	None	None	600	None	10	10,000	None

FIGURES



EXPLANATION

NPDES OUTFALL (JAN. 2019)	DRAINAGE	POND
WATER WELL	HIGHWAY	SMALL DEPRESSION
STREAM MONITORING STATION	ANCILLARY ROAD	MMD BOUNDARY
WEATHER MONITORING STATION	TWO TRACK TRAIL	AREA 11 RELEASE AREA

N

0 2,000'

Trihydro CORPORATION
1252 Commerce Drive
Laramie, WY 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

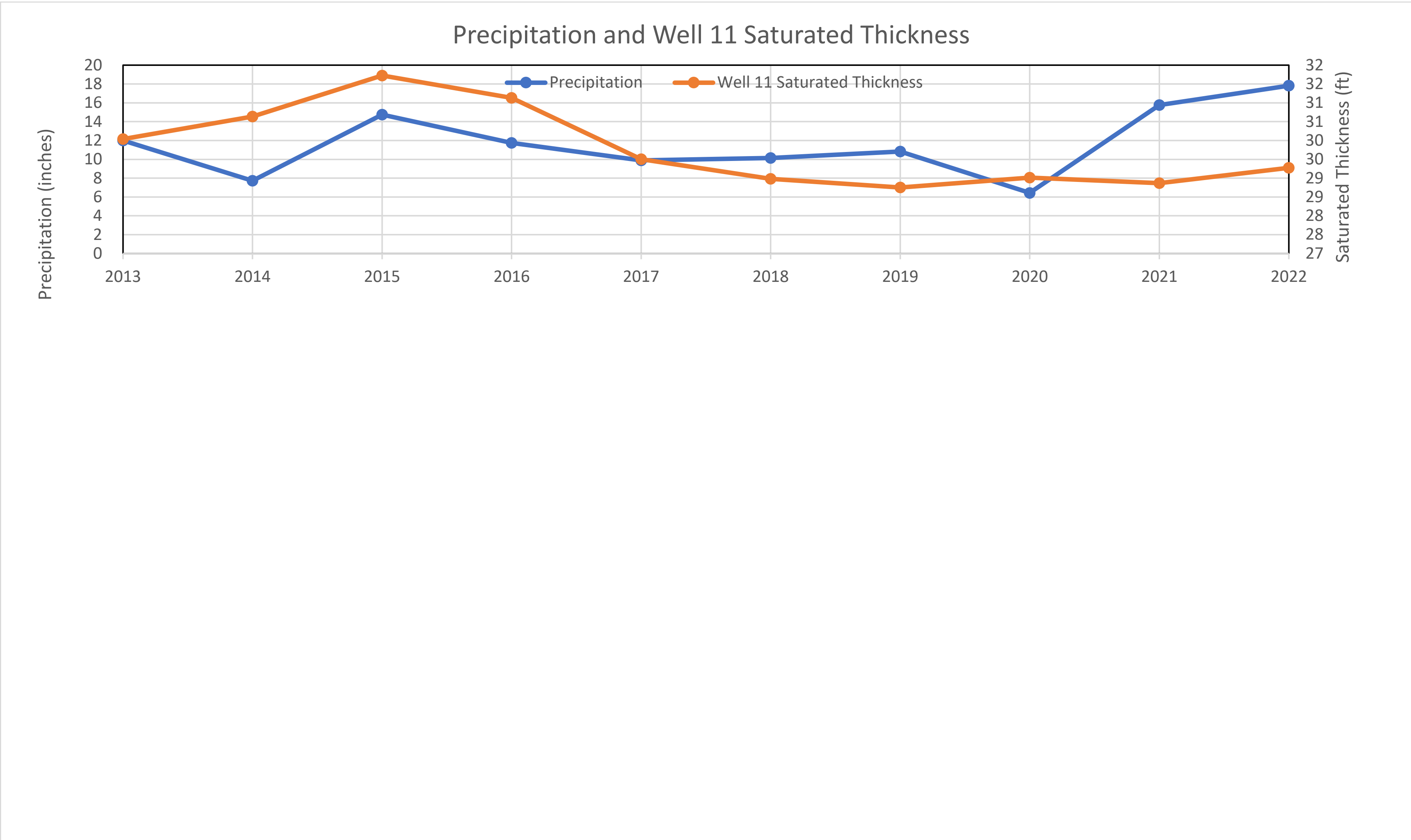
FIGURE 2-1

AREA 11 PROPOSED BOND RELEASE AREAS

CHEVRON MINING INC.
MCKINLEY MINE
MCKINLEY COUNTY, NEW MEXICO

Drawn By: BR	Checked By: TH	Scale: 1" = 2,000'	Date: 7/6/23	File: 2_Area11

FIGURE 5-1. SATURATED THICKNESS AND PRECIPITATION
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO



APPENDIX A

MCKINLEY MINE PERMIT SECTION 3.4, HYDROLOGY INFORMATION

3.4 HYDROLOGY INFORMATION

3.4.1 BACKGROUND

GENERAL INFORMATION

The McKinley Mine area is semiarid with annual precipitation averaging 11 inches. Normally, more than half of the annual precipitation falls during the months of July through October. Generally, this precipitation is received as rainfall from intense, localized thunderstorms that occur sporadically in the area.

The average annual pan evaporation rate is 70 to 75 inches which, when adjusted for pond conditions is 47 to 50 inches. Water quickly evaporates from surface reservoirs and to a very limited extent infiltrated upper soil zones. A study completed by P&M and provided in the Baseline/Background - Soil Information volume contains detailed information documenting the nature of the soil-water deficit.

In 1979/1980 a hydrology study of the McKinley Mine was conducted by Geohydrology Associates, Inc. In 1983, Geohydrology Associates, Inc. provided P&M with the computations for the unit hydrographs provided in the 1981 report. In 1980, a report entitled "A Literature Review Mined-Land Sediment Control and the Dryland Fluvial System" was prepared for P&M by the Research Institute of Colorado. Copies of these reports are located in the hydrology background volume.

SURFACE WATER RESOURCES

All surface water flows in the mine area are ephemeral. There are no known streams containing biological communities per CSMC Rule 80-1 Part 20-57(c) downstream of the mine within reasonable distances. Undisturbed area surface water quality is moderately poor relative to chemical quality, and extremely poor relative to physical quality. Surface runoff from the McKinley Mine indicates suspended solids contents for flow events ranging from 6,000 milligrams per liter to just under 250,000 milligrams per liter.

The rainfall patterns (intense localized thunderstorms) that occur in this geographic area, in combination with the inherent geomorphological characteristics, result in extremely high soil erosion rates. This in turn equates to tremendous suspended solids levels in the runoff. The soil chemistry and geomorphology contribute to the high levels of dissolved solids, salinity and alkalinity. Additional discussions concerning surface water resources are provided in Section 4.7.

GROUNDWATER RESOURCES

Groundwater resources within the mine fall into three main types: alluvial, bedrock and aquifer. Alluvial and bedrock groundwater resources are discontinuous, of poor physical and chemical quality and of limited extent.

The first major deep aquifer in the area is the Gallup Sandstone Aquifer. This aquifer lies well below the zone of mining impact and is overlain by several impermeable shale members. Most recharge to the Gallup Sandstone comes from the Chuska Mountains to the northwest of McKinley Mine. Additional discussions concerning ground water resources are provided in Section 4.7.

3.4.2 WATER RIGHTS

SURFACE

A search of the records of surface water rights maintained by the State Engineer's Office shows that within the McKinley Mine Lease boundary, the only known existing surface water rights are owned by P&M. These rights, File 3294, approved December 14, 1972, have a diversion point on the Tse Bonita Wash at the northeast corner of the NE¼, NE¼, Sec 5, T16N, R20W, and are for 20 acre-feet per year. There are no other owners of surface water rights recorded within five miles of the lease boundary.

GROUNDWATER

Groundwater rights in the Gallup basin were not required prior to declaration of that basin on March 5, 1980. Since then, P&M has made the following declarations:

- (SE¼, SW¼, NW¼, Sec 17, T16N, R20W) 1,005.2 ac-ft/annum (File No. G-87)
- (NE¼, SW¼, SW¼ Sec 29, T17N, R20W) 634 ac-ft/annum (File No. G-88)
- (SE¼, NW¼, SW¼ Sec 5, T16N, R20W) 795.8 ac-ft/annum (FileG89)
- (NE¼, SW¼, NW¼ Sect 17, T16N, R20W) 6.5 ac-ft/annum (File No. G-90)
- (NW¼, SW¼, NW¼ Sec 26, T16N, R20W) 29 ac-ft/annum (File No. G-91)
- (NE¼, NE¼, SW¼ Sec 4 T16N, R20W) 16.1 ac-ft/annum (File No.G-92)
- (108°56'40"; 35°41'38") 16.1 ac-ft/annum (File No. G-93)
- (108°54'35"; 35°40'52") 16.1 ac-ft/annum (File No. G-94)
- (SW¼, NW¼, SE¼ Sec 14, T16N, R20W) 16.1 ac-ft/annum (File No. G-95)

3.4.3 HYDROLOGIC MODELING

The Baseline/Background - Hydrologic Information volume (BBHIV) contains modeling information which characterizes and contrasts surface water quality and quantity for medium sized watersheds in undisturbed, disturbed, and reclaimed conditions.

3.4.4 PROBABLE HYDROLOGIC CONSEQUENCES (PHC)

SURFACE WATER QUANTITY

Surface water quantity may be increased on the reclaimed areas through the construction of small impoundments. These impoundments will be used to provide water for livestock and wildlife and to create small riparian habitats for small mammals, birds and reptiles. The amount of postmining runoff as compared to the premining runoff to the Puerco River drainage will be minimally diminished by the harvesting of the water in the impoundments and other riparian areas. This reduction of runoff is supported by the hydrologic model included in the BBHIV of this application. However, the impact on the Puerco River drainage will be negligible due to the small percentage of the drainage area that the McKinley Mine comprises.

SURFACE WATER QUALITY

For a short term following reclamation of an area there may be a slight increase in the levels of total dissolved solids, sulfates, and other soluble elements in the overburden. This increase will eventually lessen as the runoff leaches the overburden. This potential slight increase will be documented by the collection and analysis of surface water runoff during the permit term as described in Section 6.3. The long term surface water PHC is described below.

Physical Quality

Surface water physical quality will be improved through the stabilization of the reclamation areas and the creation of small post-mining impoundments. These actions will result in lower suspended solids and total settleable solids in the runoff from the disturbed areas. This is supported by the hydrologic models presented in the BBHIV of this application. The models show that the per acre sediment yields from the mining and postmining areas will be less than the premining areas.

Chemical Quality

Surface water chemical quality will be unaffected or could possible improve by minimizing the potential of runoff coming into contact with potentially acid or toxic materials (PATFM). These materials consist of those uncovered during the mining operations, native soil materials that are of poor quality, and naturally occurring exposed coal seams. The PATFM Management program, which is discussed in Sections 5.2 and 6.6, will identify graded spoil areas that have acid or toxic materials present in or near the top 48 inches (rooting zone) of spoil. Areas identified through this program will be mitigated prior to revegetation. These actions will prevent the degradation of the surface water quality within the mine and improve the effluent levels of dissolved soilds, salinity, and alkalinity.

GROUNDWATER QUANTITY

Gallup Sandstone Aquifer

As discussed above, the Gallup Sandstone Aquifer that is used as the primary source of water for the mine and for the McKinley County area. This aquifer occurs 400 to 1,000 feet below the lowest coal seam to be recovered and has no local recharge features. The recharge area for this aquifer is located to the north of McKinley Mine in the Chuska Mountains. As noted in the Technical Analyses and Environmental Assessment performed by the OSMRE on Permit No. NM- 0001B/3-10P, and adopted by the director of MMD, there may be a small amount of draw down due to usage associated with coal mining activities, but this draw down is insignificant in comparison to the City of Gallup and Navajo Nation consumption impacts.

To further substantiate this information and to show current information pertaining to the Gallup Sandstone formation, P&M has developed a revised structure map of the Gallup Sandstone formation. This map has been included in this application as Exhibit 3.4-1. It should be noted that this map supplements or supersedes information provided in the BBHIV pertaining to the Gallup Sandstone formation. The changes made in the Gallup Sandstone Structure map are based on information collected from the drill logs for the four Gallup Sandstone Aquifer wells in use at McKinley Mine, therefore only the information in the immediate vicinity of the Mine has been modified.

In addition P&M has developed a new map showing the current potentiometric surface of the Gallup Aquifer. This map has been included in this application as Exhibit 3.4-2. Elevations of the potentiometric surface of the Gallup Sandstone Aquifer have been modified to reflect the current static water levels for the four Gallup Sandstone Aquifer wells in use at McKinley Mine. As with Exhibit 3.4-1, only the information in the immediate vicinity of the Mine has been modified. P&M has been unable to gather information on any of the other wells in the area due to a lack of ownership. Therefore, the information provided is the most complete and accurate available.

Alluvial Aquifers

As discussed above, the alluvial water is practically nonexistent, occurring generally in close proximity to the arroyos, and in direct relation to the rate and amount of runoff in the arroyo. This water soaks into the sides and bottoms of the arroyos during runoff events. This type of recharge occurs principally during snowmelt and the summer runoff season. The only instance where this type of groundwater will be affected by the mining operations, is where alluvial areas are actually mined. The hydrologic impact on this groundwater source will be complete removal of the resource when encountered during mining. However, due to the limited areal extent of the resource, any impacts would be considered negligible.

Bedrock Aquifers

As discussed above, the bedrock water quantity is minimal in extent, consisting only as small pockets of perched water in the various stratums being excavated in the mining process. The quantity and areal extent of these pockets of water are not of sufficient quantity or quality to be considered usable. This water is normally observed as seepage from the highwall or small amounts of water on the pit floor. The mining operation results in removal of this insignificant groundwater source.

GROUNDWATER QUALITY

Gallup Sandstone Aquifer

As is noted above in the discussions on groundwater quantity, there will be no impact by mining on the recharge zones of the Gallup Sandstone Aquifer. Due to this, there will also be no impact on the quality of the Gallup Sandstone Aquifer by the mining operations.

Alluvial Aquifers

The alluvial water quality, in undisturbed areas, will continue to be influenced primarily by the amount of runoff in the arroyos and characteristics of the soils in the area of infiltration. There will be minimal impacts on the quality of this resource by the mining operations.

Bedrock Aquifers

The bedrock water encountered during mining will be removed in the mining process. This removal will have no effect on the water present in areas not affected by mining. This is due to the low transmissivity associated with this type of water.

3.4.5 CUMULATIVE HYDROLOGIC IMPACT ASSESSMENT

The Cumulative Hydrologic Impact Assessment (CHIA) completed by the Radian Corporation for the Office of Surface Mining as part of the Technical Analyses and Environmental Assessment by OSMRE on Permit No. NM-0001B/3-10P, and adopted by the Director of MMD, covers all of the areas to be mined by this application and is still valid. Included below is a brief synopsis of the conclusions of the CHIA:

- Surface-water use in the area is primarily stock watering with some irrigation. There are no permitted water rights holders downstream of the mining operation in the cumulative impact area. Indicator parameters related to hydrologic concerns in the basin are total dissolved solids and total suspended soilds (TSS) concentrations.

- Cumulative impacts to the quantity of the flow in the Puerco River are insignificant.

- Cumulative impacts to the quality (TDS and TSS) of flows in the Puerco River are minimal and should not cause significant changes in baseline conditions. No material damage to the hydrologic balance is expected.

- Ground water is an important source of water in the Gallup area. The major ground water pumping centers are at the Santa Fe and Yah-ta-hey well fields, both completed in the Gallup Sandstone and operated by the city of Gallup. Other users of the Gallup Aquifer include the McKinley and Mentmore mines north west of Gallup. Shallow ground water is not widely used owing to the relatively poor chemical quality and small well yields.

- Cumulative impacts related to ground-water quality are not expected: ground-water quality in terms of TDS and sulfate has not been demonstrated to change significantly and the poor physical properties of the near-surface deposits are not greatly altered by mining.

  Ground-water quantity in the Gallup aquifer may be affected by the cumulative impacts of mining, particularly if declared water rights are fully used by P&M. Calculations of water-level drawdowns indicate that the Yah-ta-hey well field could experience up to 3 feet of drawdown attributable to mining activities; this does not constitute material damage. No material damage, based upon a criterion of a decline of 25% of available hydraulic head, is predicted as a result of surface coal mining.

Thus, based upon the report, P&M feels that any impacts which have or will occur on the hydrologic systems at the McKinley Mine are insignificant.

3.4.6 DEVELOPED WATER RESOURCES

All identified developed water resources in the proposed permit area and within 1000 feet of the proposed permit boundary are shown on Exhibit 3.4-3 and are listed in Tables 3.4-1 and 3.4-2. A total of 55 developed water resources were identified:

- 18 wells;
- 20 impoundments;
- 10 storage tanks;
- 2 cisterns;

- 2 windmills;
- 1 spring;
- 1 watering trough; and
- 1 pipeline.

Thirty one of the developed water resources are within the permit boundary and 23 are within 1000 feet of the permit boundary. One developed water resource, the NTUA pipeline, is located both outside and inside the proposed permit area.

SURFACE WATER RESOURCES

Developed surface water resources in the proposed permit area and within 1000 feet of the proposed permit boundary consist of 18 impoundments and 2 cisterns. The 18 impoundments are used for harvesting water from precipitation events. The two cisterns are associated with Impoundment 31. Table 3.4-1 provides a listing of these structures along with their associated coordinates.

Thirteen of the impoundments (Nos. 12, 13, 14, 15, 16, 17, 19, 22, 23, 24, 31, 32, and 33) and the two cisterns are located within the proposed permit area. Of these developed water resources, only ten impoundments (Nos. 12, 13, 14, 15, 16, 17, 19, 22, 23, and 24) will be disturbed during the life of operations in this application. These impoundments will be replaced with stock ponds as shown on Exhibit 5.6-2 during final reclamation.

TABLE 3.4-1
DEVELOPED SURFACE WATER RESOURCES

ID#	DESCRIPTION	NORTHING	EASTING
11	Impoundment	1,697,985	177,374
12	Impoundment	1,694,686	174,879
13	Impoundment	1,693,735	175,646
14	Impoundment	1,692,544	176,124
15	Impoundment	1,692,011	174,862
16	Impoundment	1,691,236	174,871
17	Impoundment	1,691,052	175,149
19	Impoundment	1,686,502	172,716
22	Impoundment	1,684,310	172,871
23	Impoundment	1,684,253	175,964
24	Impoundment	1,682,725	175,078
31	Impoundment	1,680,006	176,880
31A	Cistern	1,679,694	177,031
31B	Cistem	1,679,779	177,337
32	Impoundment	1,675,475	176,282
33	Impoundment	1,672,150	173,462
34	Impoundment	1,673,635	162,954
35	Impoundment	1,671,459	165,024
37	Impoundment	1,670,010	168,053
38	Impoundment	1,669,920	171,666

Four impoundments (Nos. 34, 35, 37, and 38) located outside the permit area are located downslope of Area 9 mining activities and could be impacted temporarily as mining progresses to the east. However, the decrease in recharge capacity to the impoundments will be short term and minimal since post mining contours are designed to recreate original drainage patterns and only a portion of the drainage area to the impoundments will be disturbed. Impoundment 11 will not be affected by mining because it is located on the Navajo Indian Reservation and is upslope of Area 11 mining activities.

GROUND WATER RESOURCES

Developed ground water resources in the proposed permit area and within 1000 feet of the proposed permit boundary consist of 18 wells, 2 impoundments, 10 storage tanks, 1 spring, 2 windmills, 1 watering trough, and the NTUA water pipeline. These water resources are listed in Table 3.4-2 along with their associated coordinates.

Six water storage tanks (Nos. 1A, 5A, 6A, 10A, 20A, 20B), 1 impoundment (No. 10B), 1 watering trough (No. 36), and 2 windmills (Nos. 4A and 10C) are located off the proposed permit area and will not be disturbed.

Location of the NTUA pipeline (No. 39) is shown on Exhibit 3.4-3. The pipeline crosses within the proposed permit area on the eastern boundary parallel to County Road 1. This area will not be disturbed by mining operations.

Storage Tanks 8A, 18A, 21A and 26A and Impoundment 8B are located within the proposed permit area. These storage facilities will not be disturbed by mining operations and will be left in place for post mining use.

A hand dug, concrete-lined gallery known as Claw Springs (No. 9) is the only known bedrock ground water resource identified in the permit area. This site was developed by the Navajo Tribe for use by area residents and their livestock. Claw Springs consists of a concrete-lined water trough, a hand pump, and an overhead loading facility. The facility is in dire need of repair and is not usable in its present condition. Information (e.g. well depth, quantity, and rate of discharge) was not available from the Navajo Tribe. Water samples were collected on February 6, 1990 by P&M. Analytical results from the February 6, 1990 sample and initial sampling conducted in 1980 are provided in the BBHIV.

Table 3.4-3 contains information that has been gathered concerning the intended use, static water level, date measured, date sampled, source of water, and depth drilled for all developed water wells in and within 1000 feet of the proposed permit boundary. Five of the water wells (Nos. 25, 27, 28, 29 and 30) have been plugged with drilling fluids in accordance with New Mexico State Engineer Office guidelines. The remaining 13 wells (Nos. 1, 2, 3, 4, 5, 6, 7, 8, 10, 18, 20, 21, and 26) will not be disturbed by mining activities.

TABLE 3.4-2
DEVELOPED GROUND WATER RESOURCES

WELL ID#	DESCRIPTION	NORTHING	EASTING
1	NTUA Well 18T516	1,698,339	148,768
1A	Water Tank	1,698,359	147,870
2	NTUA Well 18T517	1,698,732	149,891
3	NTUA Well 18T551	1,698,889	154,286
4	Well (Bald)	1,695,175	148,601
4A	Windmill	1,695,407	148,429
5	Well (Mag 7A)	1,688,099	152,022
5A	Water Tank	1,687,746	151,867
6	Well (Mag 7B)	1,689,405	154,430
6A	Water Tank	1,689,321	154,364
7	Well (CDK)	1,691,754	157,629
8	NTUA Well 16T550	1,691,632	167,573
8A	Water Tank	1,691,706	167,649
8B	Impoundment	1,691,748	167,525
9	Claw Spring	1,696,185	168,751
10	NTUA Well 14T509	1,697,936	176,244
10A	Water Tank	1,698,031	176,265
10B	Impoundment	1,697,989	176,015
10C	Windmill	1,697,923	176,109
18	Well (Wilhelm)	1,687,316	177,471
18A	Water Tank	1,687,162	177,429
20	Well (Blackhat)	1,685,759	166,462
20A	Water Tank	1,685,965	166,005
20B	Water Tank	1,685,853	166,178
21	Well (McAvoy)	1,684,677	169,126
21A	Water tank	1,684,724	168,982
25	Well (plugged)	1,683,897	171,649
26	Well (South Tipple)	1,683,897	157,875
26A	Water Tank	1,682,480	157,803
27	Well (plugged)	1,681,514	168,621
28	Well (plugged)	1,681,435	169,841
29	Well (plugged)	1,681,158	168,729
30	Well A-61 (plugged)	1,680,417	168,646
36	Watering Trough	1,670,895	164,471
39	NTUA Water Pipeline	See Exhibit 3.4-3	

Water samples from Wells 7 and 26 were collected on June 20, 1990 by P&M. Analytical results for the two June 20 samples plus NTUA Wells 14T-509 and 16T-550 are provided in the BBHIV.

Wells 7 and 21 are deep wells drilled into the Gallup aquifer by P&M for mine use. Well 26 is a Gallup aquifer well that was developed by a private business prior to P&M purchasing the property around the well. These wells and two storage tanks (Nos. 21A and 26A) will be left in place for post mining use to replace plugged wells. Well construction details for Wells 7 and 26, (a.k.a Well #1 and Well #3) and Gallup aquifer Wells #2 and #3A, which are Gallup aquifer wells drilled by P&M on the North Mine area, have been included as Figures 1 through 4 following this section.

TABLE 3.4-2
SUMMARY OF WATER WELL RESOURCE INFORMATION

WELL ID#	WELL NAME	INTENDED USE OF WATER	STATIC WATER LEVEL	DATE MEASURED	DATE SAMPLED	SOURCE OF WATER	DEPTH DRILLED
1	18T516	HC	488.0	11-23-87	*	GD	1600
2	18T517	HC	448.0	11-23-87	*	GD	1680
3	18T551	HC	493.6	06-09-88	*	GDM	1750
4	Bald	HC	*	*	*	G	700
5	Mag 7A	HC	530	*	*	G	777
6	Mag 7B	HC	*	*	*	G	900**
7	CDK	WHR	503	Sep-77	06-20-90	G	1055
8	16T550	HC	684	08-14-69	04-23-70	GD	1363
10	14T509	HC	36	04-04-59	05-16-66	G	477
18	Wilhelm	HC	*	*	*	G	400
20	Blackhat	HC	Dry	Oct-88	*	G	455
21	McAvoy	HC	*	*	*	G	*
25	Section 15 (plugged)	HC	185	05-15-90	*	G	460
26***	South Tipple 1	HC/WHR	332	Sep-75	06-20-90	G	930
27	Section 15 (plugged)	HC	240	05-14-90	*	G	460
28	Section 15 (plugged)	HC	165	05-15-90	*	G	360
29	Section 15 (plugged)	HC	200	05-15-90	*	G	450
30	Section 15 (plugged)	HC	200	05-14-90	*	G	340

NOTES: HC = Human Consumption, WHR = Watering Haulroads, G = Gallup , D = Dakota, M = Morrison
* = Data not Available, ** = Estimated by John Engles, P&M Land Agent, *** = Measured capacity of South Tipple was 1.75 to 2.00 gallons per minute per linear foot.

ALTERNATE WATER SOURCES

If the Gallup Sandstone aquifer were to be determentally affected by mining, P&M has identified alternate water sources that could be developed to replace existing sources. Information was obtained from Mr. John W. Shomaker, geohydrologist, with John W. Shomaker, Inc. of Santa Fe and Albuquerque.

Alternate water sources available from aquifers that underlie the Gallup Sandstone include the aquifer comprised of the Dakota Sandstone and the Westwater Canyon

Member of the Morrison Formation, and the sequence of sandstone beds of the San Rafael Group, including the Cow Springs Sandstone and the Entrada Sandstone. At still greater depth, the San Andres Limestone-Glorieta Sandstone aquifer is likely to be usable for water supply.

A Dakota-Westwater well is likely to be similar to the City of Gallup's Allan No. 1 or Lewis No. 1 North Well, near Yah-Ta-Hey. These wells reached the base of the Westwater at about 3,450 and 3,200 feet, and had one-day specific capacities of 0.38 and 0.18 gpm per foot of drawdown, respectively. Water quality is indicated by specific conductance, which was 1,260 μmhos for the Allan well, and 1,030 μmhos for the Lewis well.

Drilling depths would depend on location within the P&M lands, but would be on the order of 2,000 feet. Locations as far north and east as possible are likely to provide the best well-yield.

The San Rafael Group aquifer consists of several hundred feet of fine-grained sandstone; drilling depth would be about 3,400 feet to fully penetrate the Entrada. Specific capacity is likely to be similar to that of the Westwater Canyon, but water quality may be somewhat poorer. Analysis of the logs of the Kerr-McGee No. 1 Santa Fe well, about 12 miles southeast of the McKinley Mine, indicated salinity equivalent to about 2,100 mg/l sodium chloride, but a well at the mine would be very close to the Entrada outcrop and water quality can be expected to be better.

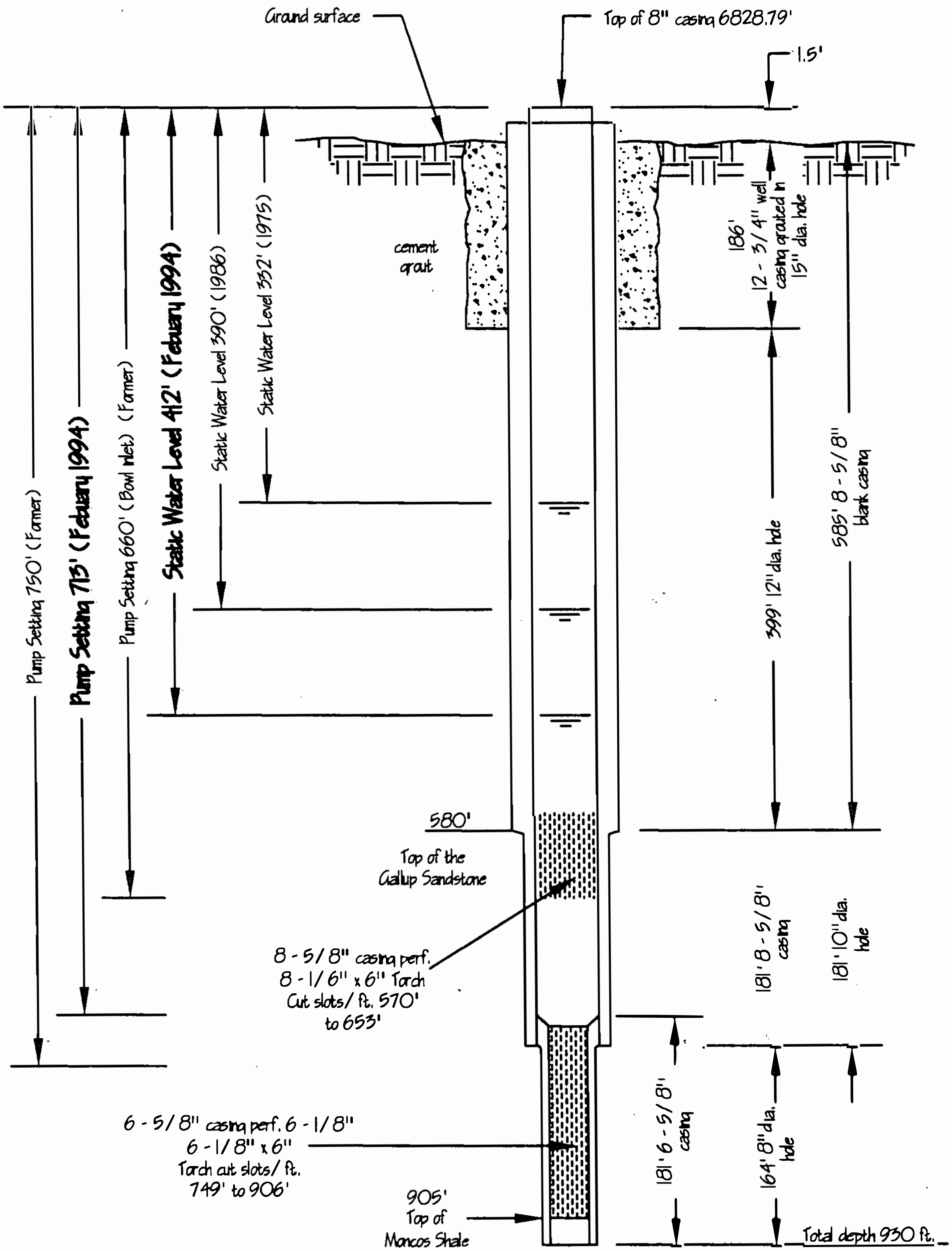
The San Andres-Glorieta aquifer could be completed in a well about 4,000 feet deep. Yield is difficult to estimate, but a specific capacity of 0.1 gpm/ft is a reasonable expectation. Water quality is not known, although in the Kerr-McGee well, the upper part of the aquifer had an apparent salinity equivalent to 4,000 mg/l sodium chloride.

TRANSFER OF WELLS

During this permit term, no water wells are anticipated to be transferred from P&M's control for usage by any other parties. However, should a transfer be contemplated, P&M will apply for approval by both the director of MMD and the State Engineer for the transfer of the well in question.

3.4.7 STREAM BUFFER ZONES

At the McKinley Mine - South there are no channels that are considered to be intermittent; thus, no stream buffer zones are required.



REVISION	DATE	APP'D

P&M

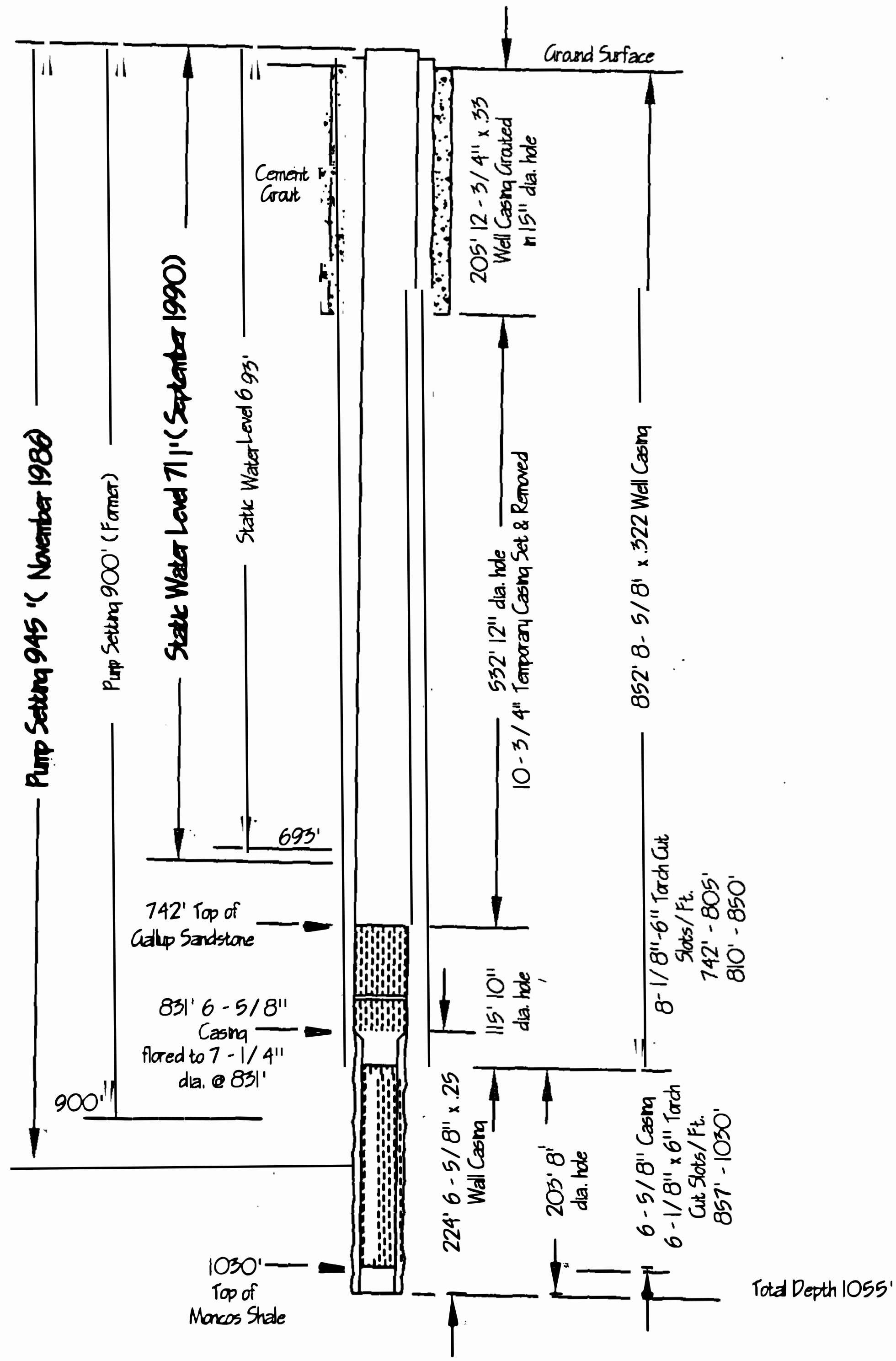
The Pittsburg & Midway Coal Mining Co.

A Chevron Company

McKINLEY MINE

FIGURE
WELL NO. 1
SCHEMATIC DIAGRAM

Drawn By: A.GRASS
Date Drawn: 2/8/96
Checked By:
Approved By:
Scale: NONE
Drawing No: 0490-1



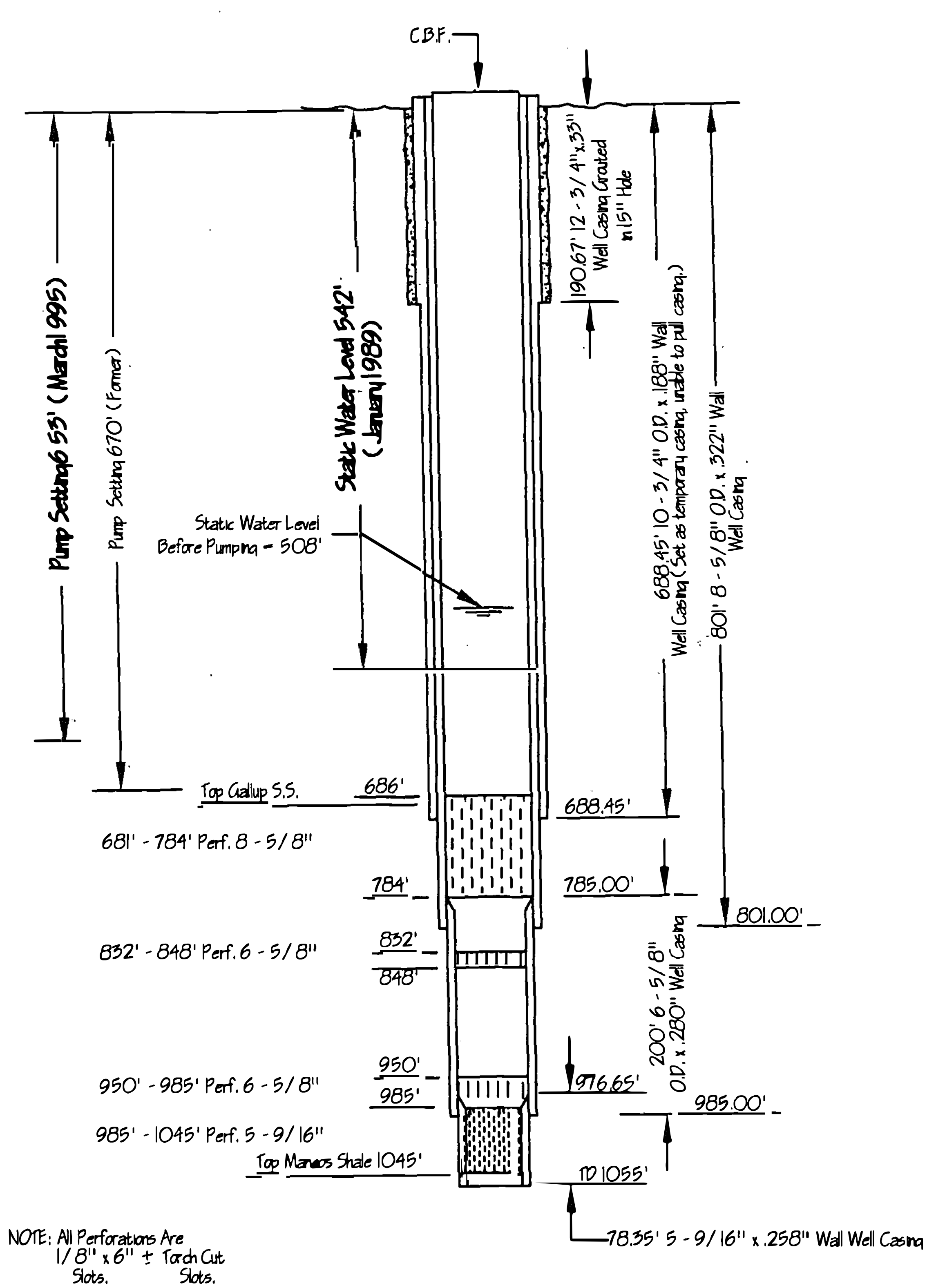
REVISION	DATE	APP'D

P&M

The Pittsburg & Midway Coal Mining Co.
A Chevron Company
McKINLEY MINE

FIGURE [illegible]-2
WELL No. 2
SCHEMATIC DIAGRAM

Drawn By: A.GRASS
Date Drawn: 2/8/96
Checked By:
Approved By:
Scale: NONE
Drawing No: 0490-2



REVISION	DATE	APP'D

P&M

The Pittsburg & Midway Coal Mining Co.
A Chevron Company
McKINLEY MINE

FIGURE [illegible]-3
WELL No. 3
SCHEMATIC DIAGRAM

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Date Drawn: 2/8/96
Checked By:
Approved By:
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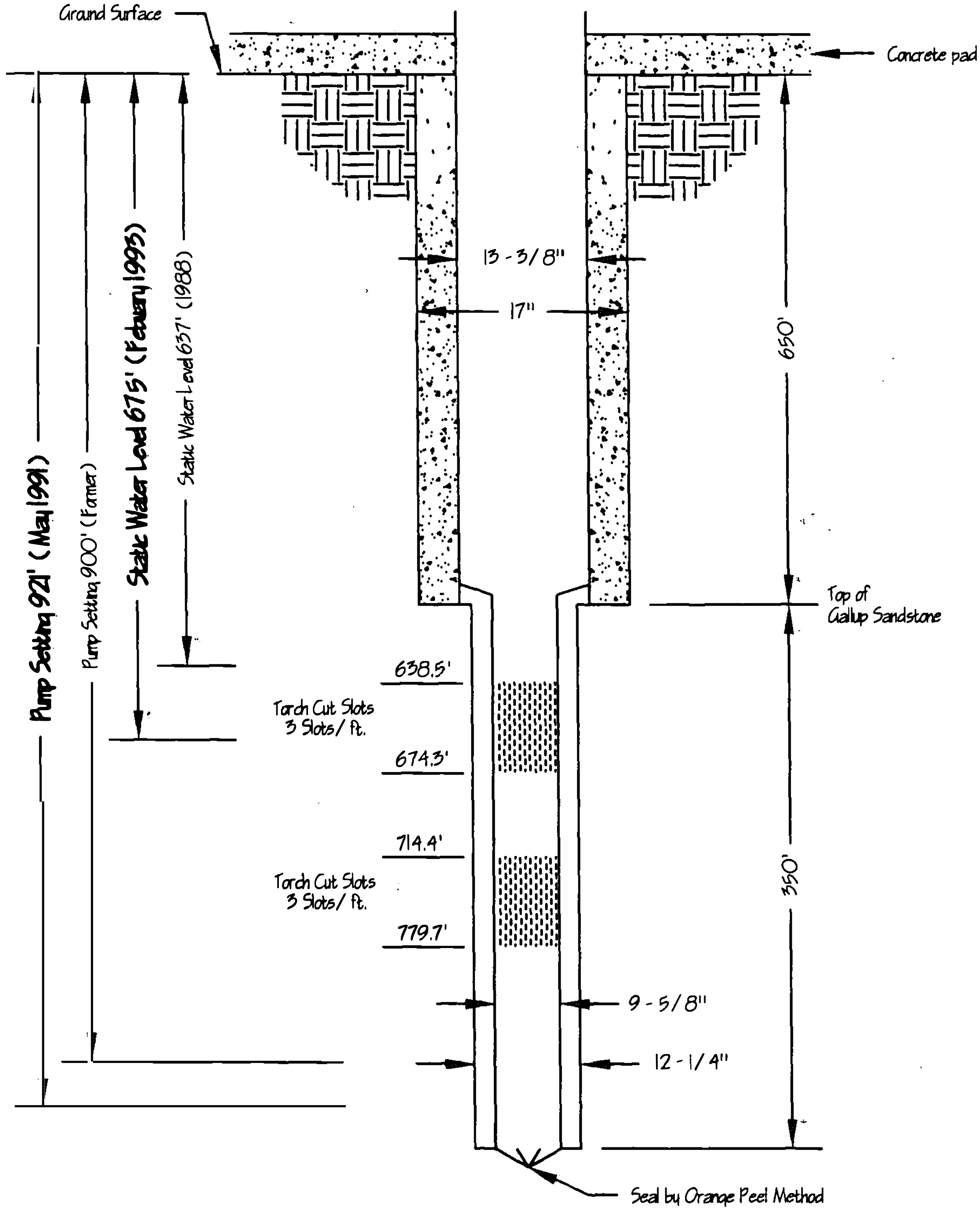
Drawing No: 0490-3



REVISION	DATE	APP'D

P&M

The Pittsburg & Midway Coal Mining Co.
A Chevron Company
McKINLEY MINE

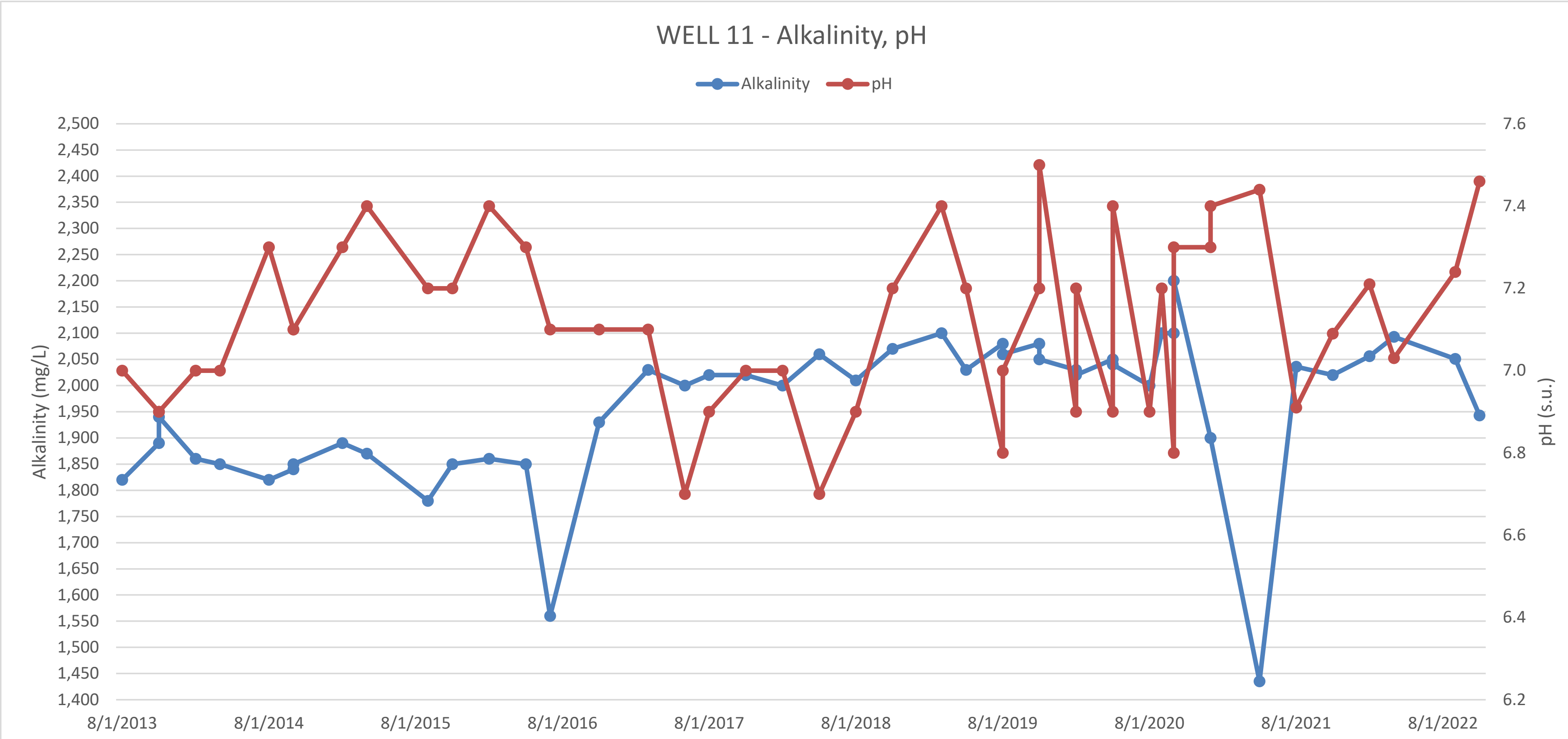
FIGURE [redacted]-4
WELL NO. 3A
SCHEMATIC DIAGRAM

Drawn By: A.GRASS
Date Drawn: 2/8/96
Checked By:
Approved By:
Scale: NONE
Drawing No: 0490-4

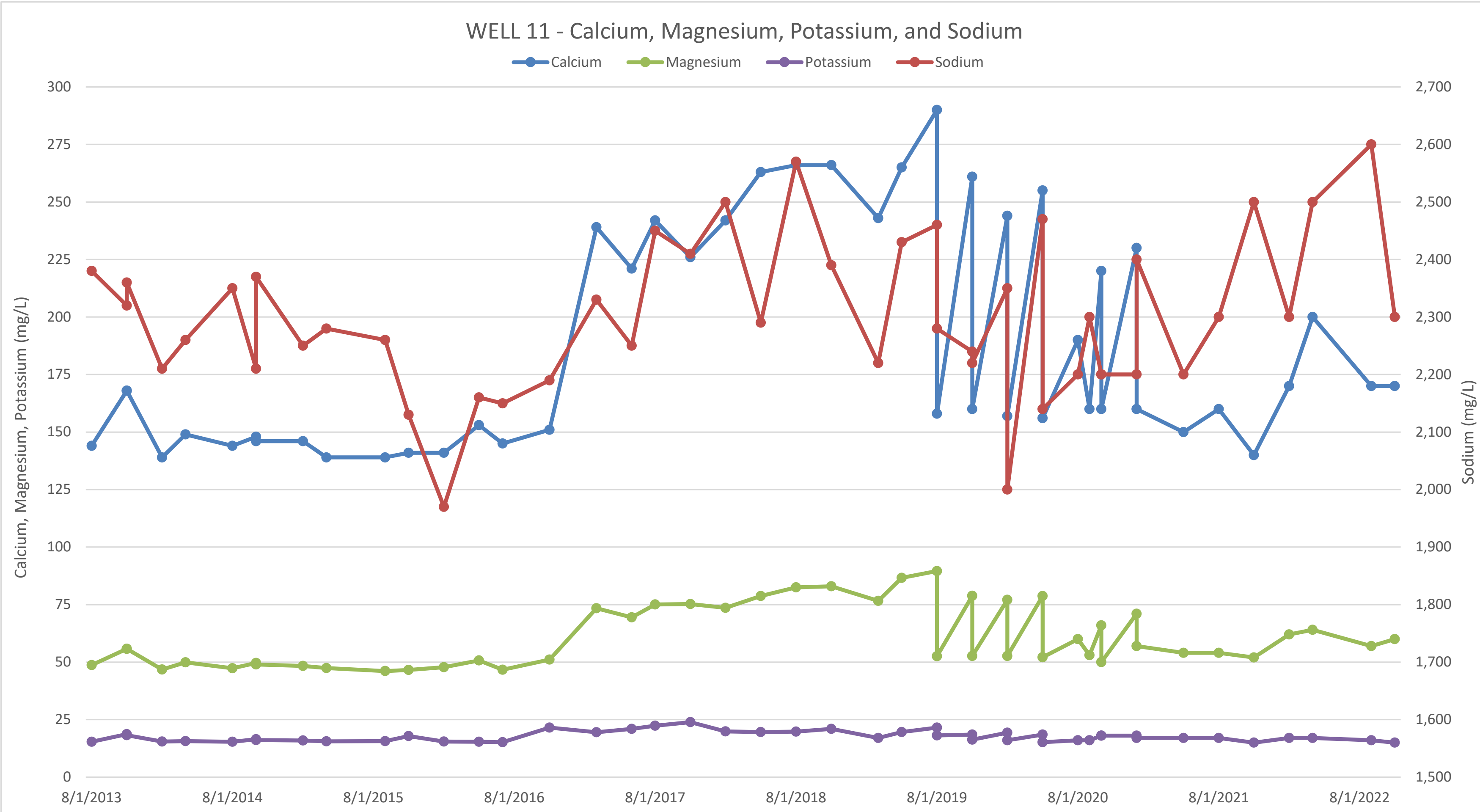
APPENDIX B

GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS

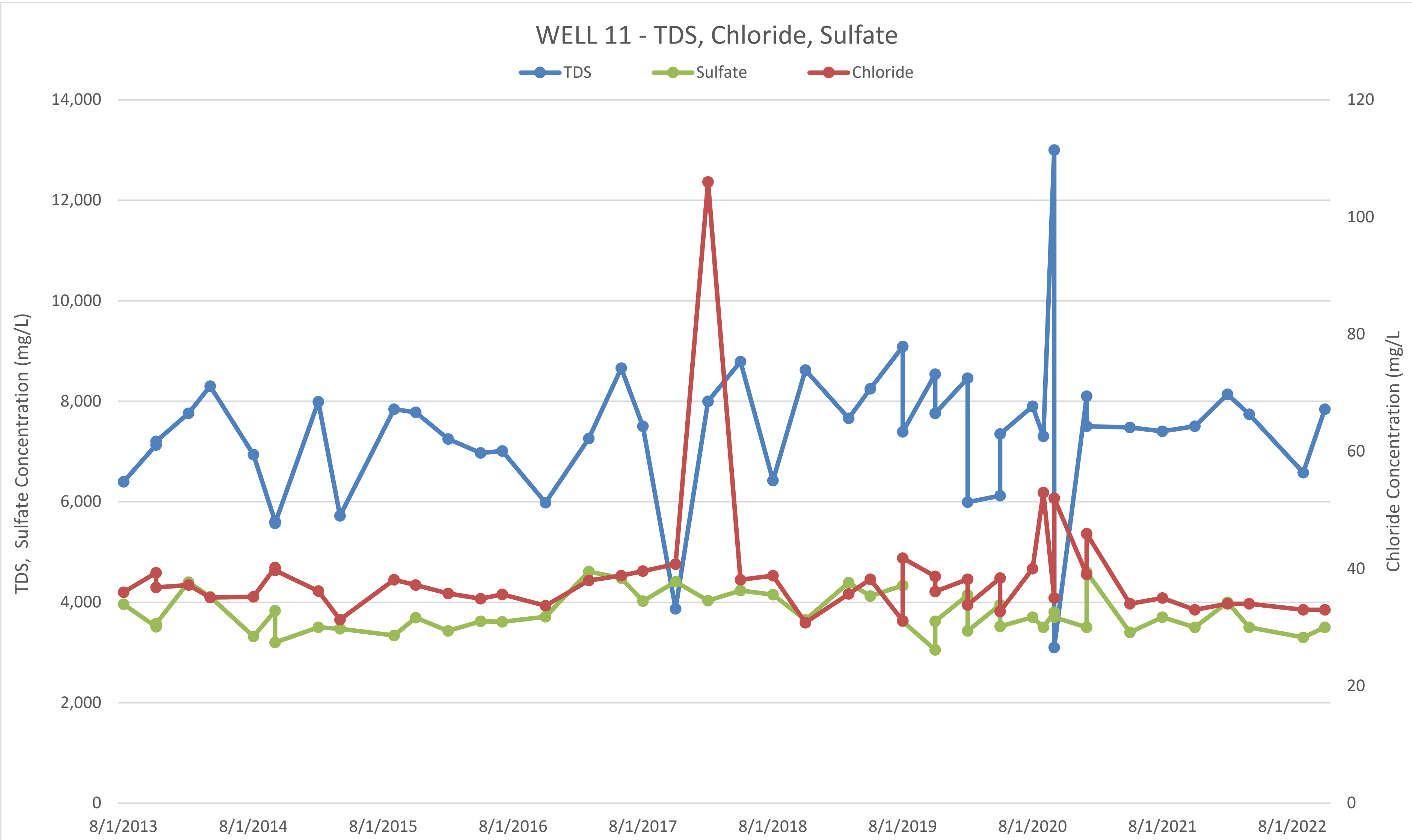
APPENDIX B-1a. GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO



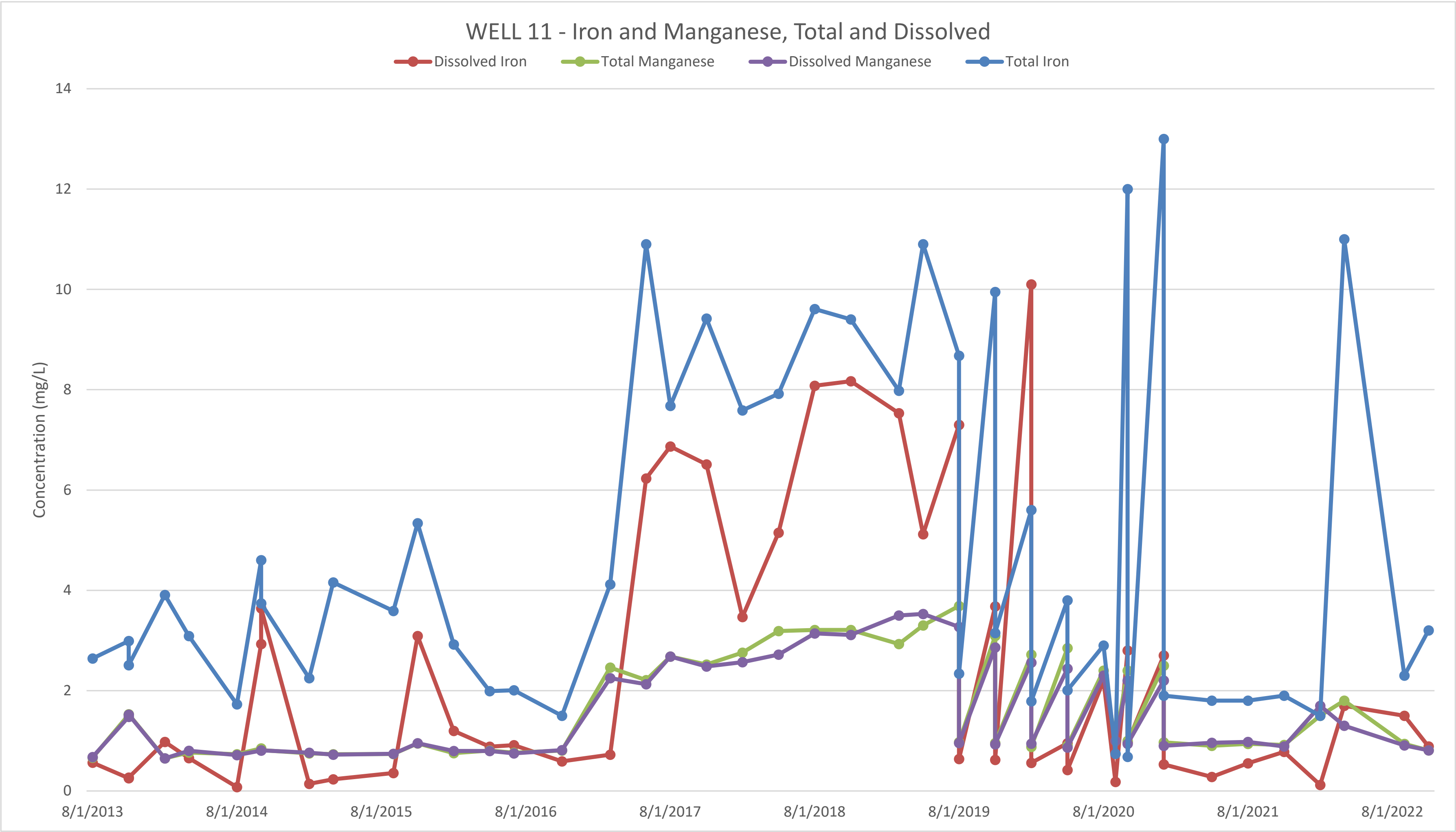
APPENDIX B-1b. GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO



APPENDIX B-1b. GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO



APPENDIX B-1d. GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO



APPENDIX B-1e. GROUNDWATER QUALITY DATA: WELL 11 TEMPORAL PLOTS
CHEVRON MINING, INC., MCKINLEY MINE
NEAR GALLUP, NEW MEXICO