Revegetation Success Plan

ST. CLOUD MINING – SAN PEDRO MINE

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1.0 INTRODUCTION

St. Cloud Mining contracted Cedar Creek Associates, Inc. (Cedar Creek) to develop a methodology for determining revegetation success for the San Pedro Mine in Santa Fe County, New Mexico. This methodology defines procedures and protocols to be utilized for revegetation success evaluations pursuant to mandates of Title 19, Chapter 10, Part 5 of the Mining Act Rules set forth by the MMD (New Mexico Mining and Minerals Division). The purpose of this document is to facilitate a determination of a revegetated unit's ability to meet post-mining land use considerations. This document defines site-specific success standard development, protocols for monitoring, and success evaluations to be used at the mine. Revegetation success at the San Pedro mine will address desirable vegetative cover, woody plant density, and diversity by comparison to technical standards representative of the pre-existing vegetation communities.

2.0 BASIS FOR REVEGETATION TECHNICAL STANDARDS

Review of baseline vegetation studies for the San Pedro Mine and relevant scientific references were referenced to develop refutation success criteria for the site. The following sections present the most suitable of these criteria for vegetative ground cover, woody plant density, and diversity.

Vegetative Ground Cover Standard. Table 1 displays the baseline vegetation survey results from the San Pedro Mine (Metric Corporation 1992). There were three communities identified in the project area:

1. Blue Grama / Broom Snakeweed
2. Pinyon / Juniper / Blue Grama
3. Gambel Oak / Prairie Junegrass

Since the Blue Grama / Broom Snakeweed baseline vegetation community is the only herbaceous dominated community (similar to the reclamation), this community will serve as a suitable comparison for revegetation success. The total cover of the Blue Grama / Broom Snakeweed community was 43.60%, with desirable cover (exclusive of noxious and nuisance weeds) comprising 43.60%. The success criterion for cover is 75% of the baseline desirable cover (43.60%), therefore the technical standard for the reclamation at the San Pedro Mine site is 32.70%.

Woody Plant Density Standard. Hoenes and Bender (2012) measured native shrub density in Juniper Scrub and Grassland communities of central New Mexico and found them to exhibit approximately 200 shrubs per acre on average. In addition, similar woody plant density standards for grazing areas have been accepted by the MMD for surrounding mines. Therefore, 200 shrubs per acre would be the success criterion for the revegetation areas at the San Pedro Mine.

Diversity. The plant lifeforms observed within the Pinyon / Juniper / Blue Grama community during the baseline study were cool season grasses, warm season grasses, perennial forbs, annual forbs, shrubs, sub-shrubs, cacti, and trees. Cacti and trees are not expected to inhabit young reclamation. Therefore, the diversity success criterion will require the following lifeforms observed on the reclamation unit at the San Pedro Mine:

1. cool season grasses
2. warm season grasses
3. perennial forbs
4. annual forbs
5. shrubs
6. sub-shrubs

Table 1 San Pedro Mine

Baseline Study Vegetation Results

		Scientific Name	Common Name	Blue Grama / Broom Snakeweed	Pinyon / Juniper / Blue Grama	Gambel Oak / Prairie Junegrass
		Area Sampled -->				
Grasses and Grass-likes						
N	P	*Agropyron smithii*	Western Wheatgrass	0.26	0.05	-
N	P	*Aristida purpurea*	Purple Threeawn	-	0.11	-
N	P	*Bouteloua gracilis*	Blue Grama	17.33	3.97	-
I	A	*Bromus tectorum*	Cheatgrass	-	0.26	-
N	P	*Carex gereyi*	Elk Sedge	-	-	0.80
N	P	*Hilaria jamesii*	Galleta	1.35	0.03	-
N	P	*Koeleria cristata*	Prairie Junegrass	-	0.69	9.40
N	P	*Muhlenbergia montana*	Mountain Muhly	-	-	0.35
N	P	*Sitanion hystrix*	Bottlebrush Squirreltail	1.78	0.31	-
N	P	*Sporobolus airoides*	Alkali Sacaton	-	0.81	-
N	P	*Stipa comata*	Needle and Thread	-	-	0.15
N	P	*Stipa lobata*	Littleawn Needlegrass	-	-	2.95
Forbs						
N	P	*Arabis fendleri*	Fendler Rockcress	-	0.08	-
N	P	*Artemisia ludoviciana*	Louisiana Sagewort	-	-	0.85
N	P	*Asclepias sp.*	Milkweed	-	0.04	-
N	P	*Astragalus mollissimus*	Woolly Milkvetch	0.18	-	-
N	P	*Erigeron divergens*	Spreading Fleabane	0.35	-	-
N	P	*Eriogonum jamesii*	James' buckwheat	-	0.33	0.30
N	P	*Euphorbia fendleri*	Spurge	0.01	-	-
N	P	*Heuchera rubescens*	Alumroot	-	-	0.15
N	P	*Hymenoxys argentea*	Perkysue	-	0.13	-
I	A	*Kochia scoparia*	Burningbush	0.05	-	-
N	A	*Lappula redowskii*	Stickweed	0.04	-	-
N	P	*Lepidium montanum*	Mountain Pepperweed	-	-	0.30
N	P	*Lesquerella pinetorum*	Bladderpod	-	0.13	-
N	P	*Leucelene ericoides*	Babywhite Aster	0.30	-	-
N	P	*Penstemon sp.*	Penstemon	-	0.01	-
N	P	*Sphaeralcea coccinea*	Scarlet Globemallow	0.25	0.14	-
I	P	*Taraxacum officinale*	Dandelion	-	-	0.15
N	P	*Thelesperma montanum*	Greenthread	-	-	0.30
N	P	*Zinnia grandiflora*	Rocky Mountain Zinnia	-	0.01	-
		Unidentifiable Annual Forb		0.02	-	-
Shrubs, Sub-shrubs, Cacti & Trees						
N	P	*Artemisia frigida*	Fringed Sagebrush	-	0.50	-
N	P	*Cercocarpus montanus*	Mountain Mahogany	-	-	5.00
N	P	*Corypantha vivipara*	Corypantha	-	0.05	-
N	P	*Gutierrezia sarothrae*	Broom Snakeweed	12.28	0.06	-
N	P	*Holodiscus dumosa*	Rock Spirea	-	-	2.85
N	P	*Juniperus monosperma*	One-seed Juniper	-	1.61	-
N	P	*Opuntia imbricata*	Cane Cholla	1.05	0.06	-
N	P	*Opuntia polyacantha*	Plains Pricklypear	0.80	0.23	-
N	P	*Pinus edulis*	Two-needle Pinyon	-	14.00	2.15
N	P	*Prunus virginiana*	Choke Cherry	-	-	0.50
N	P	*Quercus gambelii*	Gambels Oak	-	1.84	10.50
N	P	*Quercus undulata*	Wavyleaf Oak	-	-	1.90
N	P	*Ribes cereum*	Wax Current	-	0.28	-
N	P	*Ribes inerme*	Gooseberry	-	-	4.85
N	P	*Ribes leptanthum*	Trumpet Gooseberry	-	-	0.15
N	P	*Yucca baccata*	Banana Yucca	-	0.11	-
			Grass and Grass-like Cover	20.72	6.23	13.65
			Forb Cover	1.20	0.87	2.05
			Shrub, Sub-shrub, Cactus & Tree Cover	14.13	18.74	27.90
			Total Plant Cover	**36.05**	**25.84**	**43.60**
			Desirable Plant Cover	**35.98**	**25.58**	**43.60**

N = Native, I = Introduced, X = Noxious P = Perennial, B = Biennial, A = Annual

3.0 FINAL REVEGETATION EVALUATION PROTOCOLS

The proposed monitoring schedule and procedures associated with evaluating the revegetation success at the San Pedro Mine are detailed below.

3.1 Schedule

Revegetation success will be evaluated at the end of the growing season (September) in 2022 and 2023.

3.2 Revegetation Evaluation Methodology

Success evaluation will involve sampling of ground cover and woody plant density within the San Pedro Mine revegetation with consideration for success criteria. Sampling for ground cover will be accomplished utilizing the point-intercept procedure using modern instrumentation (e.g. lasers or optics) along transects of 100 intercepts each. Long belt transects or total population enumeration will be used for woody plant density determination.

The first step of the vegetation protocol will be to obtain samples of the ground cover and woody plant density from the revegetated unit to be evaluated. Sampling will occur during the peak biomass period of the year (late summer) and sampling locations will be determined utilizing a systematic (bias-free) method with a random start. This systematic procedure also provides proportionate representation from across each reclaimed unit for such characteristics as aspect.

Sample Site Location. The systematic procedure for sample location in both the revegetated unit and the reference area will occur in the following stepwise manner. First, a fixed point of reference will be selected for the area to facilitate location of the systematic grid in the field. Second, a systematic grid of appropriate dimensions will be selected to provide a reasonable number (e.g., 20) of coordinate intersections which could be used for the initial set of sample sites. Third, a scaled representation of the grid will be overlain on field maps of the target unit extending along north/south and east/west lines. Fourth, the initial placement of this grid will be implemented by selection of two random numbers (an X and Y distance) to be used for locating the first coordinate from the fixed point of reference, thereby making the effort unbiased. Fifth, where an excess number of potential sample points (grid intersections) is indicated by overlain maps, the excess will be randomly chosen for elimination (unless it is later determined that additional samples are necessary for meeting sampling adequacy). Sixth, utilizing a GPS, the sample points will be located in the field.

Ground Cover Determination. Ground cover at each sampling site will be determined utilizing the point-intercept methodology (Bonham, 1989) as illustrated on Figure 1. First, a transect of 10 meters in length or longer will be extended from the starting point of each sample site toward the direction of the next site to be sampled. Then, at each one-meter interval along the transect, a laser point bar or optical point bar will be situated vertically above the ground surface, and a set of 10 readings recorded as to hits on vegetation (by species),

litter, rock, or bare soil. Hits will be determined at each meter interval by activating a battery of 10 specialized lasers situated along the bar at 10-centimeter intervals and recording the variable intercepted by each of the narrow (0.02") focused beams (see Figure 1). If an optical point bar is used, intercepts will be recorded by fine crosshairs situated at standard intervals. In either situation, a total of 100 intercepts per transect will be recorded resulting in 1 percent cover per intercept.

Woody Plant Density Determination. If the population of woody plants appears to be sufficiently homogenous across the revegetated unit, density will be determined through a systematic sampling protocol utilizing 2 meters X 50 meters belts, co-located with the cover transects. If the population appears to be too heterogeneous, enumeration of the entire population, may be the only reliable means available to determine density of woody plants. Newly establishing woody plant communities are often so inherently variable that no sampling protocols presently known to the scientific community are practical or cost-effective to obtain a viable estimate of the population's parameters. All shrubs, trees, and cacti rooted within the boundaries of these belts (or population enumeration) will be counted and classified according to species. Seedlings (one-year old plants) will not be counted toward the total as this age class has extraordinarily high mortality rates.

Sample Adequacy. A minimum sample size of fifteen (15) samples will be collected from each discrete unit for both vegetative cover and woody plant density. For monitoring purposes, sample adequacy is not required. Adequacy of sampling will be achieved when, for each discrete unit, the number of samples actually collected (n) provides a level of precision within 10% of the true mean with 90% confidence (n_{min}), i.e., when $n_{min} \leq n$. Then n_{min} is calculated as follows:

$$n_{min} = (t^2 s^2) / (0.1x)^2$$

n = the number of actual samples collected with a minimum of 15 in each unit;
t = the value from the t distribution for 90% confidence with n-1 degrees of freedom;
s^2 = the variance of the estimate as calculated from the initial samples;
x = the mean of the estimate as calculated from the initial samples.

As indicated above, this formula provides an estimate of the sample mean to within 10% of the true population mean (μ) with 90% confidence. Calculations of the mean and variance will be based on total vegetation ground cover exclusive of litter. For bond release evaluations, if the initial 15 samples do not provide an adequate estimate of the mean (e.g., the inequality above is false), additional samples will be collected until a maximum of 40 samples has been achieved. Since sampling adequacy is not required (nor recommended) for woody plant density, one density belt will be co-located with each ground cover transect, but adequacy shall not be tested for this variable. Resulting data can then be considered reasonable for the evaluation purposes intended.

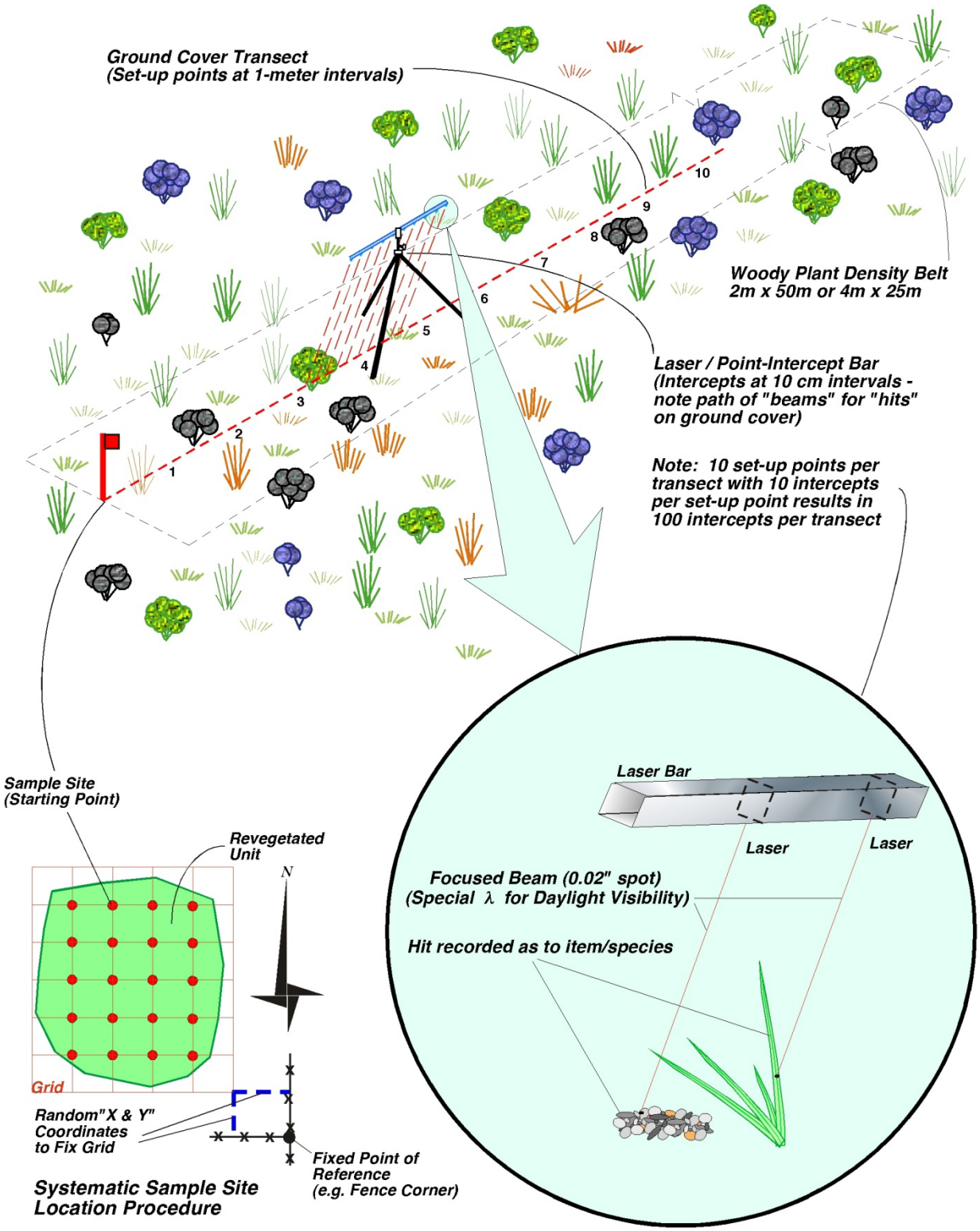

Figure 1

Sampling Procedure at a Systematic Sample Site Location

4.0 REVEGETATION SUCCESS DEMONSTRATION

Revegetation success of the revegetated unit(s) will be assessed against performance standards for (1) vegetative ground cover, (2) woody plant density and (3) diversity. Revegetation efforts will be considered successful when standards have been met at the end of the 12-year responsibility period.

1. Vegetative Ground Cover Standard

The desirable vegetative ground cover (exclusive of noxious or nuisance weeds) in the revegetated unit equals or exceeds the technical standard of 32.70%.

2. Woody Plant Density Standard

The density of live shrubs, trees, and cacti rooted within the boundaries of the revegetated unit equals or exceeds a success criterion of 200 plants per acre.

3. Diversity

The diversity success criterion will require the following lifeforms observed on the reclamation unit at the San Pedro Mine:

1. cool season grasses
2. warm season grasses
3. perennial forbs
4. annual forbs
5. shrubs
6. sub-shrubs

4.1 Ground Cover Success Demonstration

If sample adequacy is achieved on the revegetated unit, a direct mathematical comparison may be used to evaluate success in comparison with the technical standard. The ground cover standard will be met if the revegetated area mean meets or exceeds 32.70% (exclusive of noxious or nuisance weeds).

If sample adequacy is not achieved after 40 samples are collected, a reverse null approach will be used to demonstrate success. The demonstration of success will utilize the central limit theorem which assumes approximate normality when a sufficiently large number of samples are collected (>30). A one-sided, one sample, reverse–null t-test is considered appropriate and the decision rules for this test are as follows:

If $t^* < t(1-a; n-1)$, conclude failure to meet the performance standard, and

If $t^* \geq t(1-a; n-1)$, conclude that the performance standard was met (for $a = 0.1$).

4.2 Woody Plant Density Success Demonstration

The woody plant density standard will be met if either the sample mean (regardless of adequacy) or the population mean (if total enumeration is used) meets or exceeds 200 woody plants per acre. A simple mathematical comparison will be utilized because the variability of woody plant density routinely exhibits excessive variation to the point that parametric comparison statistics cannot be employed.

4.3 Diversity Success Demonstration

The diversity success criterion will be met if the following lifeforms are observed on the reclaimed unit: cool season grasses, warm season grasses, perennial forbs, annual forbs, shrubs and sub-shrubs. A simple tally of required lifeforms observed in the reclamation will be used to demonstrate success.

4.4 Reporting

A revegetation evaluation report will be prepared in 2022 and 2023 for final success demonstration by December 15 of each year.

5.0 REFERENCES

Bonham, Charles D. 1989. Measurements for Terrestrial Vegetation. John Wiley & Sons. 338 pp.

Hoenes, B. D. and L. C. Bender. 2012. Factors influencing foraging habitats of mule deer (Odocoileus hemionus) in the San Andres Mountains, New Mexico. The Southwestern Naturalist, Vol. 57, No. 4 pp. 370-379.

Metric Corporation. 1992. Survey of Vegetation and Wildlife at San Pedro Mine Property. Santa Fe County, New Mexico.