NMED MECS Comment 1: "GCC should elaborate on the method used to remove the slope failure…"

The slope failure occurred due to the mining process. The limestone resource was mined from the bottom of the slope and across it, proceeding uphill (Figure 1). Mining of the lower limestone removed the physical support for the upper portion, and it moved downhill (Figure 2). For safety reasons mining operations ceased in Quarry 1 when the upper limestone member started to move downhill.

To prevent this from occurring in the future the limestone resource will be mined out from the southerly side from the top to the bottom of the working face. This method will allow GCC personnel to safely remove the limestone that has the potential to move downslope. Following resource removal, the area will be backfilled and graded, with the elevation of the ridge being lowered. This will serve to reduce the overall slope gradient.

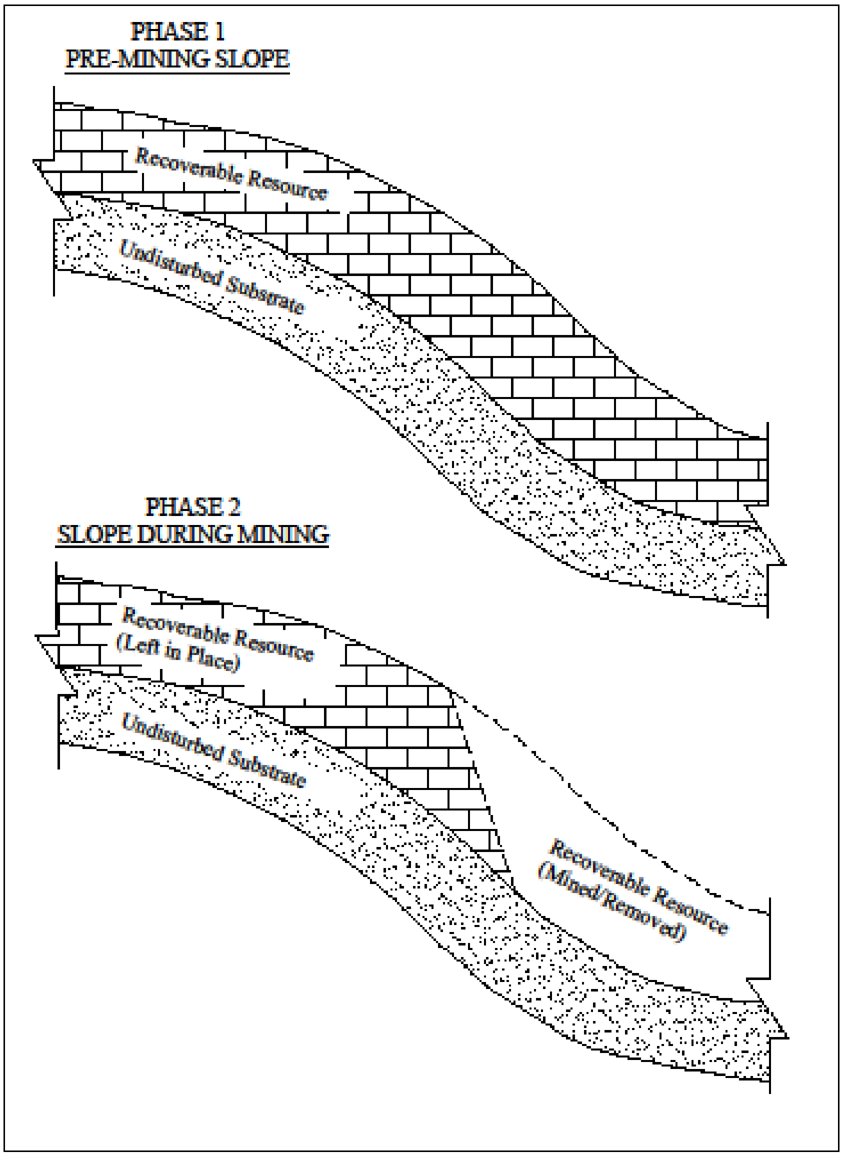


Figure 1. Slope before Mining (top) and Slope immediately after Mining the Toe of Slope (bottom)

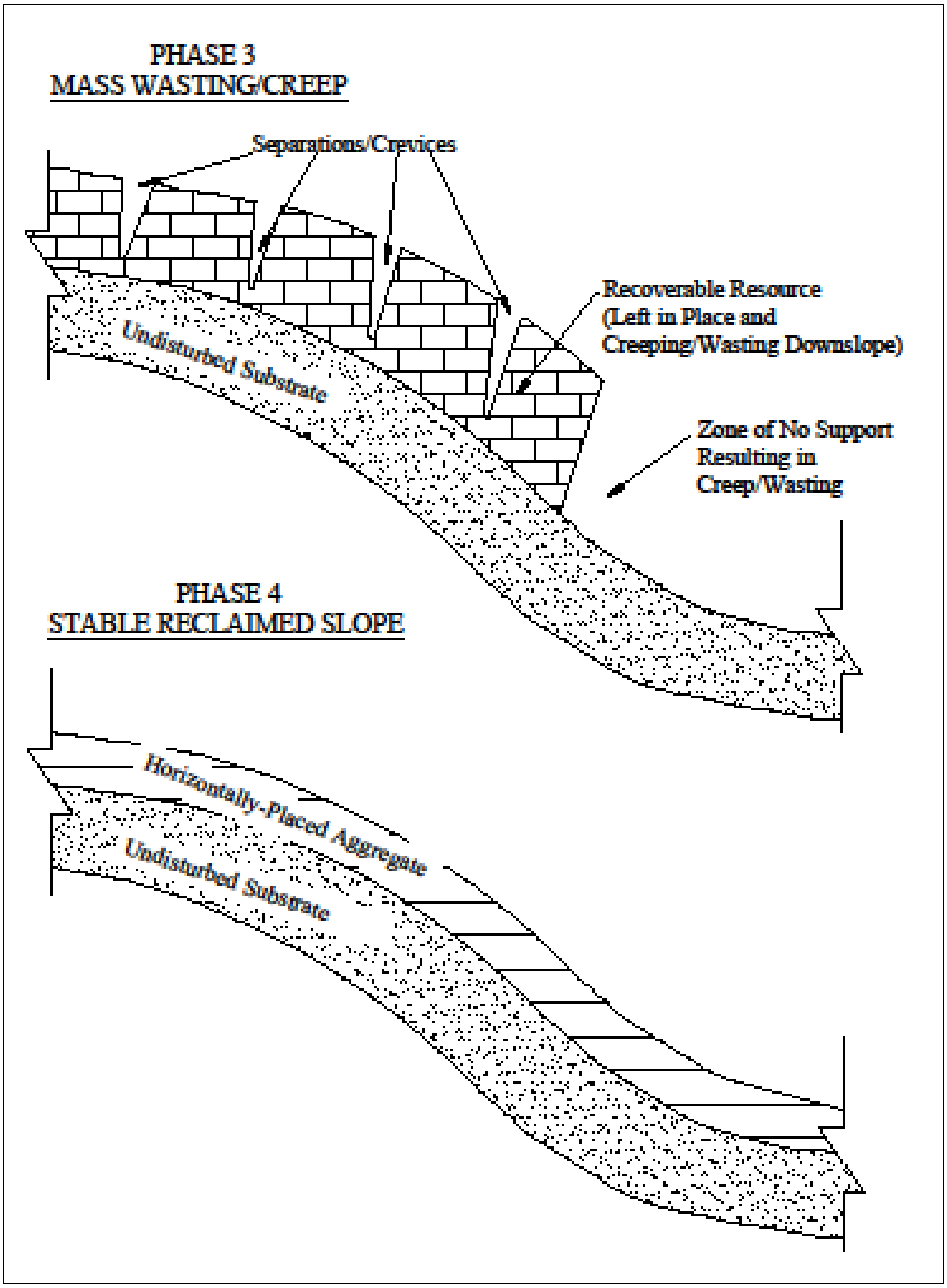


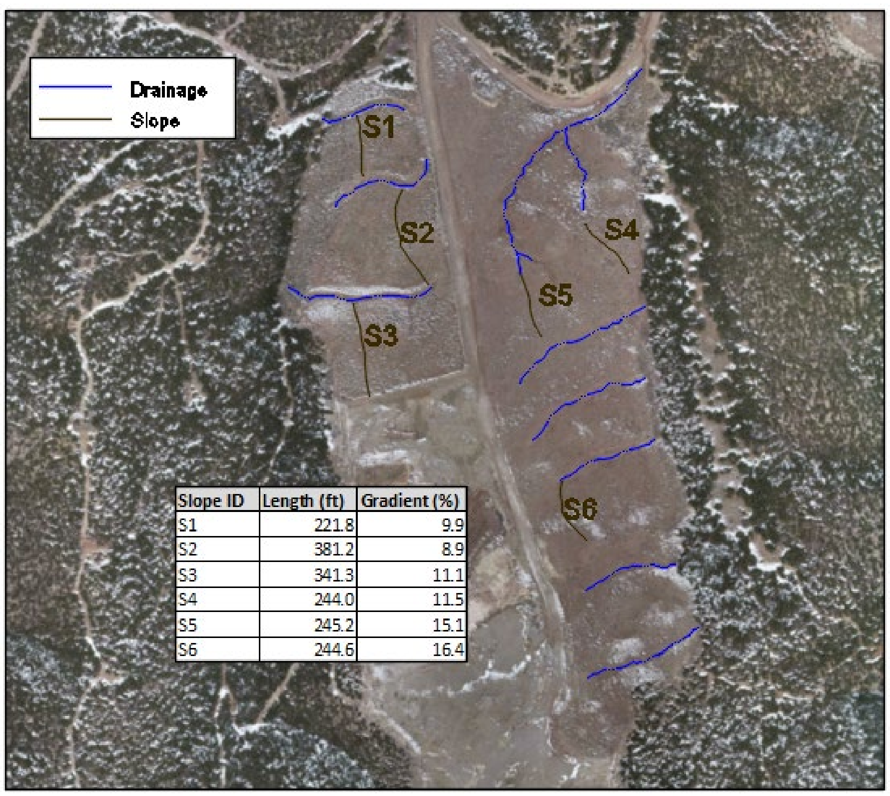
Figure 2. Slope becoming Unstable (top) and Stable Reclaimed Slope (bottom)

NMED MECS Comment 2: "It is likely that additional stormwater management will be needed to separate the area to be reclaimed from other operation areas…GGC (sic) should provide a figure or description of how this will be achieved."

Two small undisturbed areas are within the Quarry 1 reclaimed watershed and are located on the southwest (0.64 acre) and northwest (0.25 acre) corners. It is not practical to separate these small areas from the rest of the watershed. Otherwise, the Quarry 1 watershed is discrete and separated from other operational and undisturbed areas. These areas will include undisturbed land and some minor highwalls that will blend into the reclaimed landform.

NMED MECS Comment 3: "NMED recommends limiting slope lengths on reclaimed slopes to 200 feet in length."

We agree with the NMED that slope lengths should be limited to 200 ft or less when possible, specifically in steeper gradient areas. The proposed Quarry 1 PMT was specifically designed to minimize slope length, and there is only one small area with a low gradient slope that is over 200 ft long. The Quarry 1 Reclamation Plan, dated February 12, 2020, included a table of slope length - gradient ratios that result in RUSLE erosion rates comparable to background conditions. RUSLE calculations were carried down to a 15% gradient that yielded a maximum slope length of 273 ft. All other slopes in the design are shorter than 200-ft. The one longer slope is about 250-ft long at a 13% gradient which is stable based on RUSLE evaluation. Furthermore, there are examples of stable slopes longer than 200-ft at gradients of 16.4% or less within reclaimed areas at Tijeras Mine that support the post-mining topographic design in the Quarry 1 Reclamation Plan (Figure 3).



Slope ID	Length (ft)	Gradient (%)
S1	221.8	9.9
S2	381.2	8.9
S3	341.3	11.1
S4	244.0	11.5
S5	245.2	15.1
S6	244.6	16.4

Figure 3. Examples of Stable Slopes Over 200 Feet in Length Within Reclaimed Areas

MED MECS Comment 4: 'NMED recommends final as-built drawings of Quarry 1 be submitted following the completion of reclamation work. The final as-builts should note areas where the plan deviated from what is submitted herein.

GCC will survey the reclaimed Quarry 1 footprint after construction and create as-built topographic mapping. As-built and proposed mapping shall be compared, and substantial deviations shall be noted (i.e. Deviations greater than 2-feet).

NMED SWQB Comment 1: "To achieve short slope lengths and minimize surface erosion, the PMT requires a drainage density of 451 linear feet per acre. SWQB recommends that this drainage density be compared to the undisturbed drainage density of the surrounding area and that the reclamation plan discuss the potential impacts that may be associated with altering the drainage density."

Comparison with Background Drainage Density

Drainage density was measured at six undisturbed (background) watersheds near Quarry 1. The six watersheds range in size from 0.3 to 3.6 acres with drainage densities ranging from 162 ft/ac to 373 ft/ac (Figure 4). The proposed drainage density is about 20% higher than the largest background drainage density.

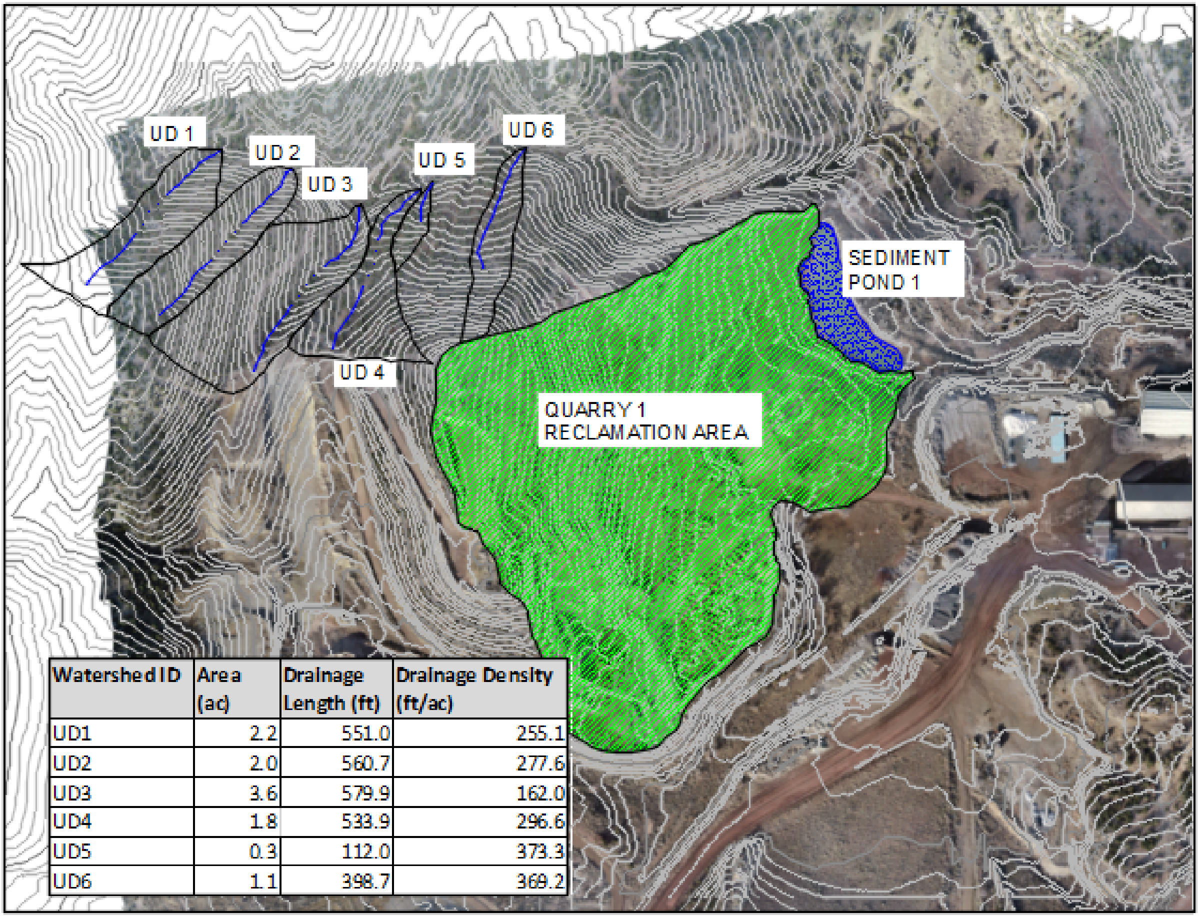
The Quarry 1 proposed drainage density is reasonable and conservative since the proposed slopes will be topdressed with Redbed soils. Redbed soils have a finer texture and less rock content than undisturbed topsoils resulting in them having a greater erosion potential. This higher soil erosion potential is the primary factor influencing increased drainage densities in the reclamation plan.

Reclaimed soils at Quarry 1 are more erodible than undisturbed surficial soils; therefore, the reclaimed slopes must be shorter and/or flatter than undisturbed slopes to prevent excessive soil loss. The Quarry 1 PMT design is bound at the top of the slope and the toe of the slope (Sediment Pond 1), leaving minimal flexibility to flatten the reclaimed slope. Thus, the reclaimed slopes must be shorter than undisturbed slopes to be within acceptable soil loss rates. Slope lengths were substantially reduced in the Quarry 1 PMT design by creating a complex topography that results in a higher drainage density.

Discussion of Earlier Mine Reclamation Studies

The SWQB comment suggests that a higher drainage density may increase flood peaks and steepen valley-side slopes and reference Elliot (1990). A review of Elliot (1990) determined that the Quarry 1 PMT design follows many of the recommendations and findings from this study.

- For instance, it was noted that many of the unstable reclaimed hillslopes had a convex profile as compared to stable undisturbed slopes with either concave or complex (convex to concave) slopes. The Quarry 1 PMT design avoids concave slopes and emphasizes concave and complex slopes as suggested in Elliot (1990).



Watershed ID	Area (ac)	Drainage Length (ft)	Drainage Density (ft/ac)
UD1	2.2	551.0	255.1
UD2	2.0	560.7	277.6
UD3	3.6	579.9	162.0
UD4	1.8	533.9	296.6
UD5	0.3	112.0	373.3
UD6	1.1	398.7	369.2

Figure 4. Undisturbed (Background) Drainage Density near Quarry 1

- It is suggested that reclaimed drainage density be increased somewhat above the pre-mining drainage density to accommodate the increase in runoff caused by mining (Schaefer, et al, 1979).
- It was noted that reclaimed land with a greater drainage density may increase flood peaks (Stiller, et al, 1980).
- It was noted that greater drainage density may increase valley-side hillslope gradients(Toy, et al, 1987).
- It was recommended that reclaimed land have a drainage density *at least* equal to the pre-mining drainage density and allowing for some additional drainage-network growth to adjust to new equilibrium conditions (Shaefer, et al, 1979).

Effects of Increasing Drainage Density.

Negligible effects (associated with increasing drainage density) are expected to landform stability and hydrologic response due to increasing the drainage density. This is due to the following factors:

- Small watershed area (27 acres).
- No major change to the overall slope aspect of Quarry 1.
- Total watershed relief is not significantly altered.
- Watershed shape and length are not significantly altered.
- Reclaimed drainages are oriented down the hill as with the undisturbed drainages.

- Ridge to drainage height (degree of incision) is small for reclaimed drainages, often between 1 and 4 feet.

The Elliot study was based on surface coal mines in Colorado that typically have major changes to hillslope aspect, watershed relief, and hypsometric curves. The post-mining topography designs for the areas that were studied by Elliot were relatively planar convex slopes. In contrast, the reclaimed Quarry 1 PMT is using a geomorphic design method that has runoff patterns and distances that approximate background conditions; thus, the application of Elliot (1990) is nominally relevant for Quarry 1.

Potential Impact Summary

The drainage density for the proposed Quarry 1 PMT design is somewhat higher than background conditions measured on site. The reclamation design avoids convex slopes, and long slope lengths where vegetation establishment is difficult. The Quarry 1 PMT contains numerous short hillslopes and small sub-drainages, that are designed to result in a stable, functional landform that will promote vegetation establishment. Though Elliot (1990) is more pertinent to surface coal mining, and less relevant here, the Quarry 1 PMT follows recommendations from that publication (i.e., drainage density at least as high as background, concave and complex slopes, avoids convex slopes). Since the drainage patterns and distances at Quarry 1 approximate background conditions, increasing drainage density by a moderate amount will have negligible effects on landform stability and hydrologic response.

NMED SWQB Comment 2: "SWQB recommends that the reclamation plan describes how it was determined that a curve number of 77 most accurately predicts runoff for the reclamation area.

A curve number (CN) 77 was chosen to reflect Fair to Good range conditions that are represented locally on-site in the Quarry 4 Natural Regrade reclamation area. The reclamation is expected to trend towards a grassy pasture with some woody shrub species. The vegetation cover is expected to be Fair, typically ranging from 15 to 40 percent depending upon timing and amount of growing season precipitation. Total cover typically varies between 30 to 70.

Redbed is a fine-grained soil, however, field observations indicate that it is not a true clay soil. The soil composition appears to be predominantly fine sands and silts, with insignificant amounts of clay. Redbed is assumed to have a hydrologic soil group trending between B and C. A CN of 77 falls within the range of curve numbers listed for arid and semiarid rangelands in TR-55 (USDA, 1986). A CN of 77 has been previously used to model other reclaimed drainages at the Tijeras quarry, including the Quarry 4 Natural Regrade (Carlson Software) reclamation area. These reclamation areas were constructed over 10-years ago and are stable with erosion being adequately controlled.

There are several other important factors that affect runoff modeling, namely: time of concentration, rainfall depth, rainfall distribution, and the unit hydrograph shape. Time of concentration was calculated from measured flow path distances. Rainfall was the 100-year, 24-hour depth (NOAA Atlas 14), and the NRCS New Mexico Type II-65 rainfall distribution was applied (instead of the Type II).

Modeling a 1-acre watershed at Tijeras with the 100-year, 24-hour storm with the New Mexico Type II-65 rainfall distribution produces a peak discharge that is 57 percent higher than using a standard Type II rainfall distribution. In contrast, a 1-acre watershed modeled with a Type II rainfall distribution produces a 100-year, 24-hour peak discharge of 1.61 cfs with a CN of 77, that increases by 30 percent when raising the CN to 85. The hydrologic inputs used in the Quarry 1 PMT design, primarily the aggressive rain curve, are considered to provide peak discharge estimates with ample conservatism for design, and on site observations of vegetation cover indicate that a CN of 77 is reasonable with successful revegetation establishment.

NMED SWQB Comment 3: "Before routing drainages D1, D25, and D28 through Sediment Pond 1, SWQB recommends that more detailed plans be developed to ensure that these drainages will not mobilize captured sediments and that other alternatives have been considered such as routing these drainages around the reclaimed sediment pond."

During construction of final reclamation (reclaiming of Sediment Pond 1 and re-routing the Quarry 1 drainages through the reclaimed pond footprint), the captured sediments in Sediment Pond 1 will be over-excavated, relocated outside of the reclaimed drainage flow paths, and replaced with clean fill. This will ensure that captured sediments are not mobilized after final reclamation.

SWQB recommended considering routing the Quarry 1 drainages around Sediment Pond 1. This option was examined and considered undesirable. Routing the Quarry 1 runoff around the pond would be accomplished with a diversion channel that is constructed across the slope, slightly upgradient from Sediment Pond 1. The diversion channel would be relatively low gradient; however, as the diversion channel wraps around Sediment Pond 1 the diversion gradient would steepen (as dictated by existing topography) resulting in a convex channel gradient with a knick point. Convex channel gradients in reclaimed channels are prone to instability and should be avoided if possible.

Discuss with GCC at the site inspection.

NMED SWQB Comment 4: "SWQB requests copies of annual inspection reports that include monitoring, evaluations, and repair work."

GCC will submit copies of the annual inspection reports that discuss monitoring, evaluations, and repair work.

MMD Comment 1: "GGC (sic) states that stormwater BMP's will remain in place while the reclamation is in process. Please describe these BMP's in more detail. Also, please discuss BMP's that will be in place after reclamation until vegetation has stabilized on the site."

There is no upgradient runon that will flow across the Quarry 1 reclamation; therefore, the BMP's used during construction and their potential benefits will include the following:

- Contour Furrows/Surface Roughening
    - Maximize water harvesting and infiltration;
    - Reduce overland flow velocity; and
    - Provide depositional environments to limit soil movement distance.
- Mulch-Straw, Hay, Wood Fiber or Rock
    - Selective use based on each slope's potential for soil erosion and mulch type determining timing of placement either before or after seeding;
    - Moderation of soil temperatures; and
    - Protection of soil from raindrop splash erosion until vegetation is established.

MMD Comment 2: "PLS/Sq Ft subtotals in Table 1-Reclamation Seed Mixture seem to be miscalculated. Please correct the subtotals."

The existing table contains significant errors. A corrected table is inserted here. Twenty (20) pure live seeds per square foot is the target density for broadcasting the seed. This is the highest density that was used in the reclamation test plots. The existing table used 40 PLS per square foot (the pounds of PLS that is provided in the current table is about 70 PLS per square foot); but planting at this rate is not recommended since it will adversely impact the expression of diversity contained in this mixture. The table can be adjusted for the size of the area to be reclaimed; it is currently set at 1.0 acres. Also, there are several species that are more expensive, that can be removed or substituted depending upon availability and cost.

Table 1 - Tijeras Permanent Reclamation Seed Mixture						**Total Seeds per Acre=**	**871,200**
Reclamation Area (Acres)=	**1.0**					**Pure Live Seeds per Square Foot=**	**20.0**
Species	**Common Name**	**Desired Species Composition (%)**	**Average No. Seeds/ Pound**	**No. of PLS / Acre**	**Pounds PLS/Acre**	**Pounds of PLS For Reclamation Area**	**PLS/Square Foot**
Graminoids							
Achnatherum hymenoides	Indian ricegrass	5.0%	161,920	43,560	0.27	0.27	1.0
Andropogon hallii	sand bluestem	5.0%	96,640	43,560	0.46	0.46	1.0
Bouteloua curtipendula	sideoats grama	5.0%	159,200	43,560	0.28	0.28	1.0
Bouteloua gracilis	blue grama	5.0%	724,400	43,560	0.07	0.07	1.0
Hesperostipa neomexicana	New Mexican feathergrass	5.0%	70,000	43,560	0.63	0.63	1.0
Pascopyrum smithii	Western wheatgrass	5.0%	113,840	43,560	0.39	0.39	1.0
Pleuraphis jamesii	James's galleta	5.0%	151,850	43,560	0.29	0.29	1.0
Pseudoroegneria spicata	bluebunch wheatgrass	5.0%	124,740	43,560	0.35	0.35	1.0
Sporobolus cryptandrus	sand dropseed	5.0%	5,600,080	43,560	0.01	0.01	1.0
Graminoid Subtotals (%, PLS/Acre, PLS Pounds/Acre, PLS/Square Foot)		**45.0%**		**304,920**	**2.75**	**3**	**9.0**
Forbs							
Achillea millifolium	western yarrow	3.5%	2,852,012	30,492	0.02	0.02	0.7
Dalea purpurea	Purple Prairie Clover	3.5%	293,000	30,492	0.11	0.11	0.7
Fallugia paradoxa	Apache plume	3.5%	480,000	30,492	0.07	0.07	0.7
Gaillardia aristata	Indian blanket flower	3.5%	186,436	30,492	0.17	0.17	0.7
Linum lewisii	Lewis (blue) flax	3.5%	294,848	30,492	0.11	0.11	0.7
Lupinus argenteus	silver mountain lupine	3.5%	126,000	30,492	0.25	0.25	0.7
Penstemon angustifolius	narrow-leaf penstemon	3.5%	313,000	30,492	0.10	0.10	0.7
Ratibida columnifera	coneflower	3.5%	737,104	30,492	0.05	0.05	0.7
Sphaeralcea coccinea	scarlet globemallow	3.0%	500,000	26,136	0.06	0.06	0.6
Forb Subtotals (%, PLS/Acre, PLS Pounds/Acre, PLS/Square Foot)		**31.0%**		**213,444**	**0.86**	**0.86**	**4.90**
Shrubs							
Atriplex canescens	four-wing saltbush	3.0%	44,203	26,136	0.6	0.60	0.6
Cercocarpus montanus	mountain mahogany	3.0%	47,406				
Chrysothamnus viscidiflorus	yellow rabbitbrush	3.0%	732,643	26,136	0.04	0.04	0.6
Ericameria nauseosa	rubber rabbitbrush	3.0%	652,500	26,136	0.05	0.05	0.6
Kraschenninikovia lanata	winterfat	3.0%	110,729	26,136	0.24	0.24	0.6
Purshia mexicana	New Mexico cliffrose	3.0%	64,267	26,136	0.41	0.41	0.6
Purshia tridentata	antelope bitterbrush	3.0%	17,193	26,136	1.53	1.53	0.6
Rosa woodsii	Wood's rose	3.0%	50,967	26,136	0.52	0.52	0.6
Shrub Subtotals (%, PLS/Acre, PLS Pounds/Acre, PLS/Square Foot)		24%		**156,816**	**2.87**	**2.87**	**3.60**
Combined Totals (%, PLS/Acre, PLS Pounds/Acre, PLS/Square Foot)		**100.0%**		**675,180**	**6.48**	**6.48**	**18**

MMD Comment 3: "Regarding rock/soil ratios for drainage design. Please discuss how rock and soil ratios will be measured, mixed, and verified. Also explain riprap sizing methods that will be used for riprap used for reclamation.

The riprap design has been revised to a traditional riprap gradation with a 6-inch Dmax and a 3-inch D50. Since Soil Riprap is no longer specified in this design there is no need to measure and mix rock and soil. Riprap sizing will be accomplished by passing rock through a screen (a.k.a. grizzly).

Other Changes to the Quarry 1 Plan (Not Based on Agency Comments)

1. WET modified the Channels D1, D20 and D24 alignments near Sediment Pond 1. In the previous submittal Channels D1, D20, and D24 were routed together and flowed into Sediment Pond 1 at a single inflow point (Figure 5). For this PMT Design, D20 and D24 are routed together and flow into Sediment Pond 1 separate from Channel D1 (Figure 6). This modification is an improvement for two reasons: 1) It removes a minor nick point at the mouth of D24; 2) It reduces the total watershed area (and thus erosion potential) by almost 50% at the downstream-most reach of D1.

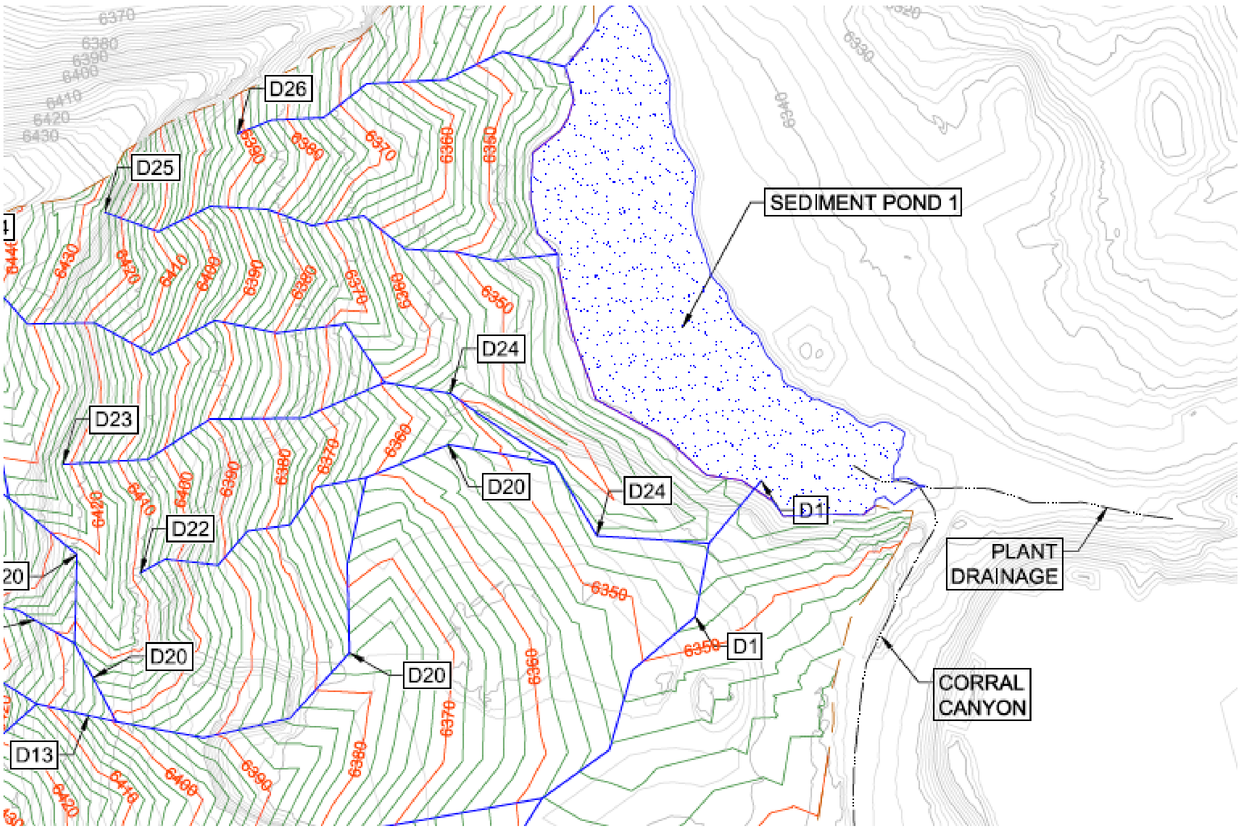


Figure 5. Previous Quarry 1 PMT Design with Channels D24 and D20 flowing into D1

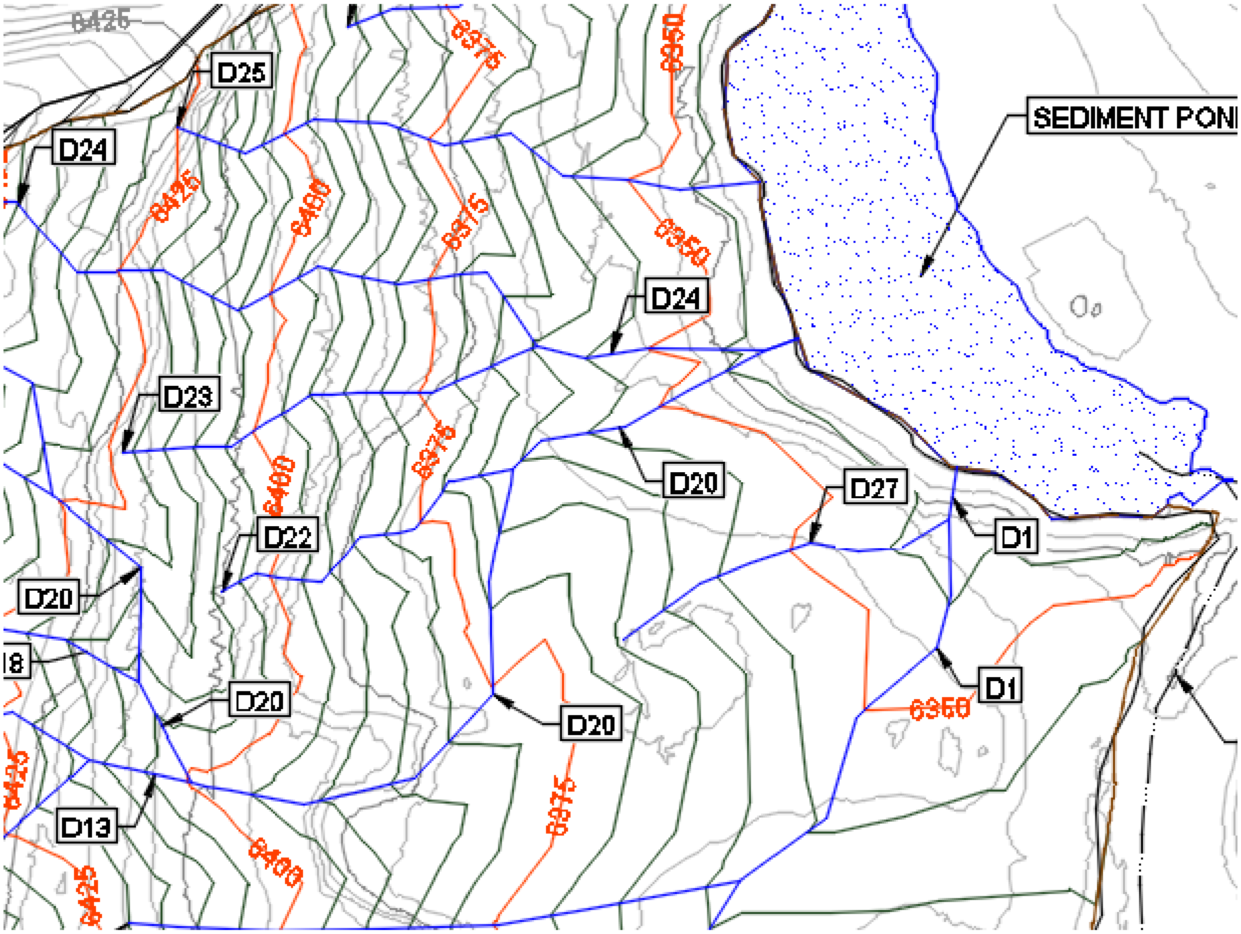


Figure 6. Current PMT Design with Channels D20 and D24 Flowing into Sediment Pond 1 separate from Channel D1

2. The third performance standard (regarding horizontal channel erosion) has been modified to reflect the new riprap channel design.