REPORT

UNITED STATES NATURAL RESOURCES (USNR) TEST PLOT –

ANNUAL REPORT NO. 2

LITTLE ROCK AND TYRONE MINES

Submitted To: Freeport-McMoRan Tyrone
P.O Box 571
Tyrone, NM 88065

Submitted By: Golder Associates Inc.
5200 Pasadena Avenue N.E., Suite C
Albuquerque, NM 87113 USA

April 26, 2018 **Project No. 123-80014**

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1.0 INTRODUCTION

The Little Rock Mine is permitted as an existing mine under Mining Act Permit No. GR007RE and Discharge Permit 1236 (DP-1236). The best available materials for reclamation at the Little Rock mine is overburden composed of Precambrian Granite. In early 2014, Freeport McMoRan Tyrone Inc. (Tyrone) proposed to build test plots on a portion of the United States National Resource (USNR) reclamation area to evaluate the use of Precambrian Granite from the Little Rock pit. The test plot was tentatively approved by the New Mexico Mining and Minerals Division (MMD) and the New Mexico Environment Department (NMED) prior to construction with the understanding that formal approval was pending further consideration.

In November 2014, Tyrone prepared a work plan for the USNR test plots to facilitate technical discussion with the MMD and NMED (FMI, 2014). The Agencies requested that Tyrone modify the work plan to include enhanced erosion and vegetation monitoring and consider the application of amendments. The USNR test plot work plan was conditionally approved and is intended to meet the requirements of Condition 8.P.1 (b) of Revision 14-1 to Permit GR007RE and Condition 33 of DP-1236. The intent of this submittal is to document the results of the erosion and vegetation monitoring. The test plots construction started in 2014 and they were seeded in the spring of 2015.

1.1 Background

The Little Rock Test Plots were originally constructed on the 7A Stockpile at the Tyrone Mine using Precambrian Granite overburden from the Copper Mountain Pit. When the Little Rock Test Plot work plan was originally developed (2001 with major revisions in 2004) it was impractical to access the overburden from the Little Rock pit because mining had not started and the haul road to Tyrone was not constructed. Copper Mountain materials were used because of their similarity to the overburden from the Little Rock pit and the availability of materials and a test location (i.e., the 7A stockpile). Once mining at Little Rock commenced, it was possible to construct test plots using overburden from the Little Rock pit. The USNR reclamation area provided an opportunity to test the overburden material from the Little Rock pit and further refine and demonstrate material handling techniques and reclamation specifications.

1.2 Objectives

The primary goal for the USNR test plot program is to evaluate vegetation success and erosion for the Little Rock Precambrian granite. Tyrone hypothesized that multiple year delays in seeding the Precambrian Granite on the 7A test plots, combined with drought conditions, contributed to unacceptable vegetation establishment (Golder, 2014). Thus, the major performance criterion to be assessed at the USNR test plots is vegetation performance. These test plots will further inform Tyrone about the implications of surface armoring on seedling establishment over time. The second objective of the test plots is to quantify erosion on the Precambrian Granite cover materials. This report is intended to meet the annual reporting requirements of Condition 8.P.1 (b) of Revision 14-1 to Permit GR007RE and Condition 33 of DP-1236.

2.0 USNR TEST PLOT DESIGN AND REVEGETATION

Reclamation of the USNR Leach Stockpile area involved removal of the residual leached ore materials primarily from drainage areas, minor regrading of the site to tie into bedrock drainages, and installation of a nominal 3-foot thick cover of Precambrian Granite from the Little Rock Mine. The construction and material handling methods were described in the as-built report (Golder, 2017). The layout and design of the test plot treatments are discussed in Section 2.1. The revegetation techniques are summarized in Section 2.2.

2.1 Test Plot Layout and Design

The two acre test plot included four treatments, which were approximately a half acre each. A control and three treatments were proposed for the USNR test plots. The major treatments involve changes in the seed mix and the timing of mulching. The treatments are described below:

- Control (conventional seed mix and mulching)
- Mulch prior to seeding with conventional seed mix
- Conventional mulch with alternative seed mix
- Mulch prior to seeding with alternative seed mix

Figure 1 illustrates the layout and configuration of the USNR test plots. The finished slope gradients on the test plot ranged from about 3:1 to 4:1 with slope lengths ranging from about 150 to 180 feet. The cover thickness exceeded three feet on the test plot (Golder, 2017).

2.2 Revegetation

The plots were revegetated in a manner consistent with requirements of Appendix C of Permit GR007RE, with some minor variations related to the seed mix and the timing of the mulching, which are described below. The revegetation operations were performed by the Freeport-McMoRan seeding crew on June 4 and 5, 2015. Operationally, the revegetation procedures included: 1) scarification and seedbed preparation, 2) seeding, and 3) mulching and crimping.

2.2.1 Scarification and Seeding

Scarification was performed on the contour at a depth of 8-12 inches. The seed was drilled and broadcast simultaneously using a modified rangeland drill with depth control bands, packer wheels, agitators and augers, and picker wheels. The light and fluffy seeds were allowed to fall freely behind the drill and were covered using chain drags pulled behind the drill. Compact seeds were drilled to promote proper seed placement.

2.2.2 Seed Mix

Two seed mixes were applied on USNR test plots. The conventional seed mix was modified slightly from the primary seed mix in Appendix C of the MMD permit modification 06-3 to accommodate the availability of seed and included 4 warm season grass, 5 cool season grass, 3 forb, and 4 shrub species (Table 1). An alternative seed mix deviated from the typical seed mix in Appendix C of Permit GR007RE to include a number of experimental species native to the Desert Southwest region. The alternative seed mix was comprised of 10 warm season grass, 6 cool season grass, 10 forb, and 6 shrub species (Table 2). For reference the number of seeds per square foot were similar for both seed mixes, but the experimental mix contained some species with larger seeds.

Table 1. Conventional Seed Mix used at the USNR Test Plots

Species	Common Name	lbs/ac
Warm Season Grass		
Bothriochloa barbinodis	Cane bluestem	0.30
Bouteloua curtipendula	Sideoats gramma	1.25
Bouteloua gracilis	Blue grama	0.25
Leptochloa dubia	Green sprangletop	0.40
Cool Season Grass		
Achnatherum hymenoides	Indian ricegrass	1.50
Agropyron dasystachyum	Streambank wheatgrass	1.00
Elymus elymoides	Bottlebrush squirreltail	1.25
Koeleria macrantha	Prairie Junegrass	0.10
Sporobolus cryptandrus	Sand dropseed	0.05
Shrubs		
Atriplex canescens	Fourwing saltbush	0.75
Chilopsis Linearis	Desert willow	0.75
Ericameria nauseosa	Rubber rabbit brush	0.30
Krascheninikovia lanata	Winterfat	0.50
Forbs		
Dalea candida	White prairie clover	0.40
Linum lewisii	Blue flax	0.12
Ratibida columnaris	Prairie coneflower	0.20
	PLS (lbs/acre)	**9.12**

Note: lbs/ac = pounds per acre, PLS = pure live seed

Table 2. Alternative Seed Mix used at the USNR Test Plots

Species	Common Name	lbs/ac
Warm Season Grass		
Aristida purpurea var. longiseta	Fendler threeawn	0.25
Bothriochloa barbinodis	Cane bluestem	0.10
Bouteloua curtipendula	Sideoats grama	1.00
Bouteloua rothrockii	Rothrock's grama	0.05
Eragrostis intermedia	Plains lovegrass	0.05
Heteropogon contortus	Tanglehead	0.25
Muhlenbergia montana	Mountain muhly	0.03
Schizachyrium scoparium	Little bluestem	0.90
Sporobolus airoides	Alkali sacaton	0.05
Sporobolus giganteus	Giant dropseed	0.05
Cool Season Grass		
Elymus elymoides	Bottlebrush squirreltail	1.00
Elymus glaucus	Blue wildrye	0.40
Hesperostipa neomexicana	New Mexico feathergrass	3.00
Poa secunda	Sandberg bluegrass	0.05
Sporobolus cryptandrus	Sand dropseed	0.02
Thinopyrum intermedium	Intermediate wheatgrass	1.00
Shrubs		
Acacia constricta	Whitethorn acacia	1.00
Acacia greggii	Catclaw acacia	2.00
Atriplex canescens	Fourwing saltbush	1.50
Encelia virginensis	Virgin River brittlebush	0.25
Ericameria nauseosa	Rubber rabbitbrush	0.20
Robinia neomexicana	New Mexico locust	2.50
Forbs		
Achillea millefolium var. occidentalis	Western yarrow	0.01
Artemisia ludoviciana	White sagebrush	0.05
Baileya multiradiata	Desert marigold	0.05
Erigeron speciosus	Aspen fleabane	0.05
Isocoma tenuisecta	Burroweed	0.05
Lotus rigidus	Deervetch	0.10
Oenothera pallida	Pale evening primrose	0.10
Penstemon palmeri	Palmer's penstemon	0.20
Senna covesii	Coues' cassia	0.25
Sphaeralcea coccinea	Scarlet globemallow	0.10
	PLS (lbs/acre)	**16.61**

Note: lbs/ac = pounds per acre, PLS = pure live seed

2.2.3 Mulching

Conventionally, Tyrone has applied mulch after seed placement. At the USNR, the timing of seeding and mulching varied among the test plot treatments. Mulch was applied prior to seeding on half the area and after seeding on the other half. Mulch was applied at a rate of approximately 2-tons/ac. The mulch was then crimped 3 to 4 inches into the cover using a disc harrow with straight coulter discs spaced approximately 6 to 8 inches apart. The crimping operation was performed on the contour.

3.0 EROSION MONITORING

Erosion is the detachment and movement of soil by wind or water. Soil erosion rates vary temporally in response to a number of controlling factors. The major factors affecting erosion include the amount, duration, and intensity of rainfall, soil physical characteristics, nature of the soil surface, vegetation, litter, and rock cover, and the gradient, shape, and length of slope. Soil erosion at mine sites is typically predicted using models that incorporate these factors (Toy and Foster, 1998). Because erosion is episodic, short-term measurements are typically poorly correlated to the long-term prediction provided by models (Weltz et al., 1998). For instance, erosion rates are expected to be highest during the vegetation establishment period and may not reflect long-term rates. Similarly, variations in weather events can strongly affect the erosion process. Because of the large size of the plots, sediment traps were considered impractical as a means to measure erosion. Soil erosion was measured using a portable erosion meter (McCool et al., 1981; Kincaid and Williams, 1966). The erosion measurements were made using the erosion meter described in Golder (2009).

The erosion transects were installed and baseline monitoring was conducted in June 2016. Subsequent monitoring episodes were conducted after the summer rains in December 2016 and November 2017 to assess changes in surface topography. Figure 1 shows the location of the erosion monitoring stations. Cross-section plots of the relative changes in the ground surface from the baseline measurements in 2016 are included in Appendix A (Figures A-1 to A-2). Photographs of the monitoring locations compared to the baseline conditions are included in Appendix B.

Changes in soil surface elevations were evaluated assuming each erosion meter station represents a separate sample. For each station, the average change in surface elevation from the initial baseline measurement was calculated using points that intersected soil, rock fragments, and litter. Positive changes in surface elevation indicate degradation and negative changes indicate aggradation. The four individual stations on each transect were averaged to determine the change in elevation for each transect. The two transects were averaged to estimate the change in surface elevation for the test plot as a whole considering that the vegetation was not substantively different among the mulching treatments.

3.1 Changes in Surface Elevation and Erosion

The relative changes in ground surface elevation were minimal considering that the test plots is still in the vegetation establishment phase. In 2017, the relative change in the ground surface from baseline was 2.9 mm on the north transect and 1.9 mm on the south transect (Table 3). The average change in elevation for the test plot transects was 2.4 mm. The change in elevation for the test plot after the first monitoring event in 2016 was 1.3 mm, thus the average surface elevation increased about 1.1 mm in 2017 (Table 4). The total estimated accumulation on the test plot was about 15.7 tons/ac for the measurement period (Table 5).

Table 3. Average Change in Ground Surface Elevation of the USNR Erosion Transects

	Individual Transects		Test Plot
	North (mm)	South (mm)	(mm)
2016	0.9	1.7	1.3
2017	2.9	1.9	2.4

Note:
Negative values indicate an average loss of materials;
Positive values indicate average accumulation of materials

Table 4. Cumulative and Annual Average Change in Ground Surface Elevation

MARGINAL CHANGE IN ANNUAL AVERAGE GROUND SURFACE ELEVATION				
Transect	2016	2017	Cumulative	Two-Year Average
	(mm)			(mm/yr)
North and South Average	1.3	1.1	2.4	1.2

Note:
Negative values indicate surface degradation; Positive values indicate surface aggradation

Table 5. Cumulative and Annual Average Soil Loss or Accumulation

ANNUAL AVERAGE SOIL LOSS OR ACCUMULATION				
Transect	2016	2017	Cumulative	Two-Year Average
	(tons/acre)			(t/ac/y)
North and South Average	-8.5	-7.2	-15.7	-7.8

Note:
Positive values indicate erosion; Negative values indicate accumulation
Erosion values assume a 1 mm change in elevation = 6.5 tons/acre

Examination of the station cross-sections suggests that very minor rill erosion has occurred (Figure A-1 and A-2). These data suggest some of the 2016 rills filled in 2017. The minimal evidence of erosion in 2017 is likely related to the erosion resistance of these materials and lack of large magnitude storms in 2017 (Figure 2).

The erosion transects were constructed and baseline conditions were measured about 1 year after seeding and mulching. The amount of surface aggradation or degradation that occurred during the period between mulching and the baseline measurement (i.e., summer of 2015) is impossible to quantify. Thus, the erosion estimates provided in this section do not represent the entire period of reclamation. Because the straw mulch was largely intact through the summer of 2015 and persisted locally with diminishing effectiveness into 2016, we believe that the actual erosion is likely to be somewhat, but probably not substantially higher.

4.0 VEGETATION MONITORING

Vegetation attributes on the test plots were evaluated qualitatively in 2017 with emphasis on plant establishment. Because weather conditions have an important impact on plant establishment, the precipitation records from the Little Rock meteorological station are provide in this section. Table 6 lists the monthly and annual precipitation for 2015, 2016, and 2017. Compared to the long-term regional records (Ft Bayard with about 16 inches), annual precipitation was somewhat, but not drastically below average for 2015; slightly above average for 2016; and well below average in 2017. For 2017, nearly every month was below average except for January and February, which were wet. July 2017 was near normal. The daily distribution of precipitation is shown in Figure 2. Thus, the prevailing precipitation in 2017 is considered dry from a regional perspective.

Table 6. Monthly and Annual Precipitation at the Little Rock Met Station

	2015	2016	2017
January	2.22	1.03	3.22
February	0.44	0.31	1.54
March	0.82	0.00	0.17
April	0.31	0.54	0.03
May	0.52	0.15	0.07
June	1.14	0.61	0.98
July	2.40	2.43	3.29
August	2.57	5.53	1.85
September	1.14	3.34	0.16
October	0.25	0.27	0.26
November	1.15	0.26	0.07
December	1.44	2.54	0.30
Annual	**14.40**	**17.01**	**11.94**

The vegetation on all of the treatments is performing well for this stage of reclamation. The average plant density exceeded 1 plant/square foot and the canopy cover levels are increasing compared to Year 1 (Golder, 2017). The status of the vegetation in 2017 is depicted in Figures 3 through 6 for the various mulching and seeding treatments. There were no discernable differences in canopy cover on the plots that were seeded either before or after mulching (Figures 7 and 8).

Species composition varied among the experimental and conventional seed mix treatments, although the early stage of reclamation made definitive identification of some species difficult. Table 7 lists the species identified during a pedestrian survey in early 2018. The future quantitative vegetation studies required in 2018 and 2020 will better define species response of the conventional and experimental seed mix treatments.

Table 7. Plant species observed on the USNR test plot in February 2018.

SCIENTIFIC NAME	COMMON NAME	Experimental	Conventional
GRASSES			
Aristida adscensionis	Six-weeks threeawn		V
Bothriochloa barbinodis	Cane bluestem		S
Bouteloua curtipendula	Sideoats grama	S	S
Bouteloua gracilis	Blue grama	V	S
Chloris virgata	Feather fingergrass	V	
Elymus elymoides	Bottlebrush squirreltail	S	S
Leptochloa dubia	Green sprangletop	V	
Pleuraphis jamesii	Galleta	V	
Sporobolus cryptandrus	Sand dropseed	S	
Unknown grasses		V	V
FORBS			
Achellea millefolium	Yarrow	S	
Artemesia ludoviciana	Louisiana sage	S	V
Baileya multiradiata	Desert Marigold	S	
Conyza canadensis	Horseweed	V	V
Eriogonum polycladon	Annual pink buckwheat	V	V
Heliomeris multiflora	Showy goldeneye	V	
Heterotheca subaxillaris	Telegraph plant	V	V
Melilotus officinalis	Yellow sweet clover	V	V
Penstemon palmeri	Palmer penstemon	S	
Phaseolus angustissimus	Slimleaf limabean	V	V
Psilostrophe tagetina	Paper daisy		V
Salsola tragus	Russian Thistle	V	
Machaeranthera gracilis	Slender goldenweed	V	
Unknown, basal leaves only		V	
SHRUBS & TREES			
Senecio flaccidus	Threadleaf groundsel	V	V
Brickellia californica	California brickelbush	V	V
Chilopsis linearis	Desert willow	V	
Encelia virginensis	Brittlebush	S	
Ericameria nauseosa	Rubber Rabbitbrush	S	S

Notes: S = seeded; V =volunteer

5.0 REFERENCES

Freeport-McMoRan (FMI). 2014. United States Natural Resources (UNSR) Test Plot Work Plan: Condition 8.G of Permit Revision 97-1 of GR007RE and Condition 33 of Discharge Permit-1236 (DP-1236). Freeport-McMoRan Tyrone. November 26, 2014.

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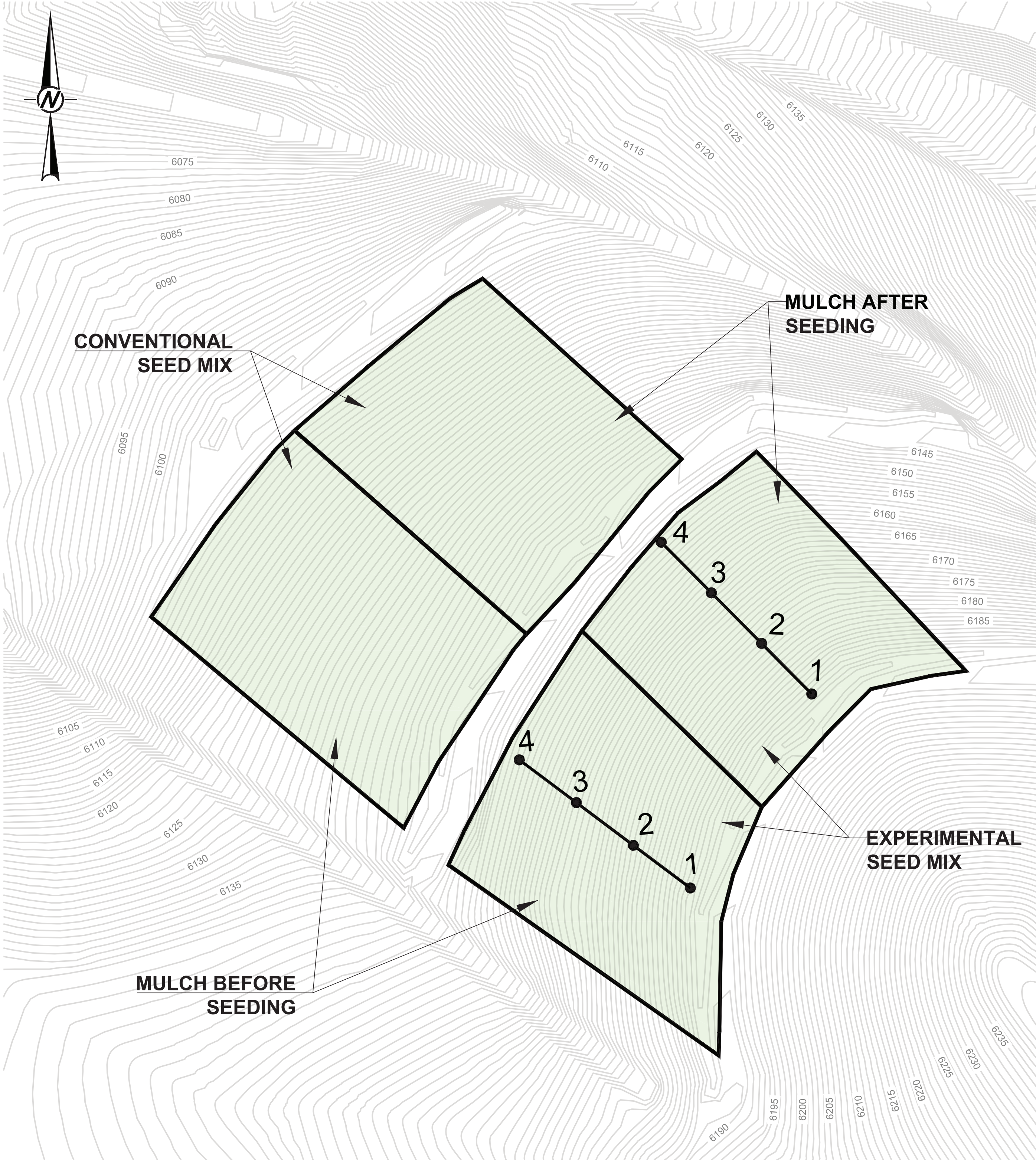
Kincaid, D.R., and G. Williams. 1966. Rainfall Effect on Soil Surface Characteristics Following Range Improvement Treatments. J. Range Manage. 19: 346-351.

McCool, D.K., M.G. Dossett, and S.J. Yecha. 1981. A Portable Rill Meter for Field Measurement of Soil Loss. Erosion and Sediment Transport Measurement, Proc of the Florence Symp. IAHS Publ. no. 133 pp. 479-484.

Toy, T.J., and G. R. Foster. 1998. Guidelines for the use of the Revised Universal Soil Loss Equation (RUSLE v. 1.06) on mined lands, construction sites, and reclaimed lands. J.R. Galetovic (ed.) Office of Surface Mining, Denver, CO.

Weltz, M.A., M.R. Kidwell, and H.D. Fox. 1998. Influence of Abiotic and Biotic Factors in Measuring and Modeling Soil Erosion on Rangelands: State of knowledge. J. Range Manage. 51:482-495.Sanchez and Wood 1987.

FIGURES



LEGEND

TEST PLOT BOUNDARY

4 3 2 1

TRANSECT LOCATION WITH STATIONS AT 40 FEET APART, STATION 1 AT 10 FEET FROM CREST OF SLOPE.

REFERENCE(S)

TOPOGRAPHY PROVIDED BY FREEPORT McMoRAN TYRONE INC.

0 40 80

1" = 80' FEET

CLIENT FREEPORT McMoRan TYRONE INC. GRANT COUNTY, NEW MEXICO	PROJECT USNR TEST PLOT REPORT

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-02-22
DESIGNED	LM
PREPARED	CM
REVIEWED	LM
APPROVED	LM

TITLE

USNR TEST PLOT LAYOUT

PROJECT NO.	PHASE	REV.	FIGURE
123-80014	--	--	1

Path: \\albuquerque\Cad\2012 Projects\12380014\USNR Test Plots\Production\ | File Name: 12380014A0004.dwg

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0 1 in

Figure 2:
Daily Precipitation at the Little Rock Met Station

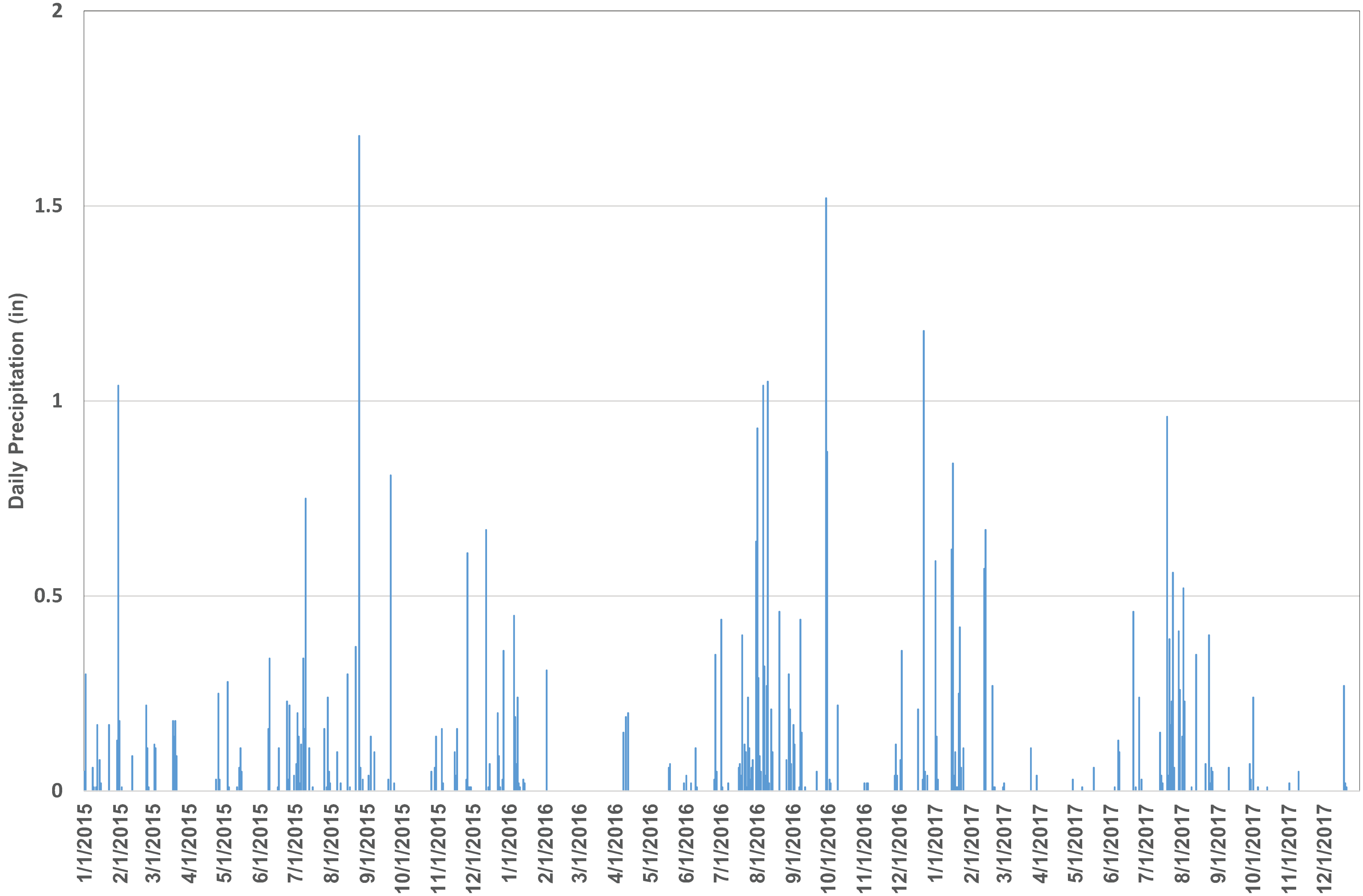


Figure 3. Vegetation status on the mulch before seeding conventional seed mix. (September 2017)

Figure 4. Vegetation status on the mulch after seeding conventional seed mix. (September 2017)

Figure 5. Vegetation status on the mulch after seeding experimental seed mix. (Sept. 2017)

Figure 6. Vegetation status on the mulch before seeding experimental seed mix. (September 2017)

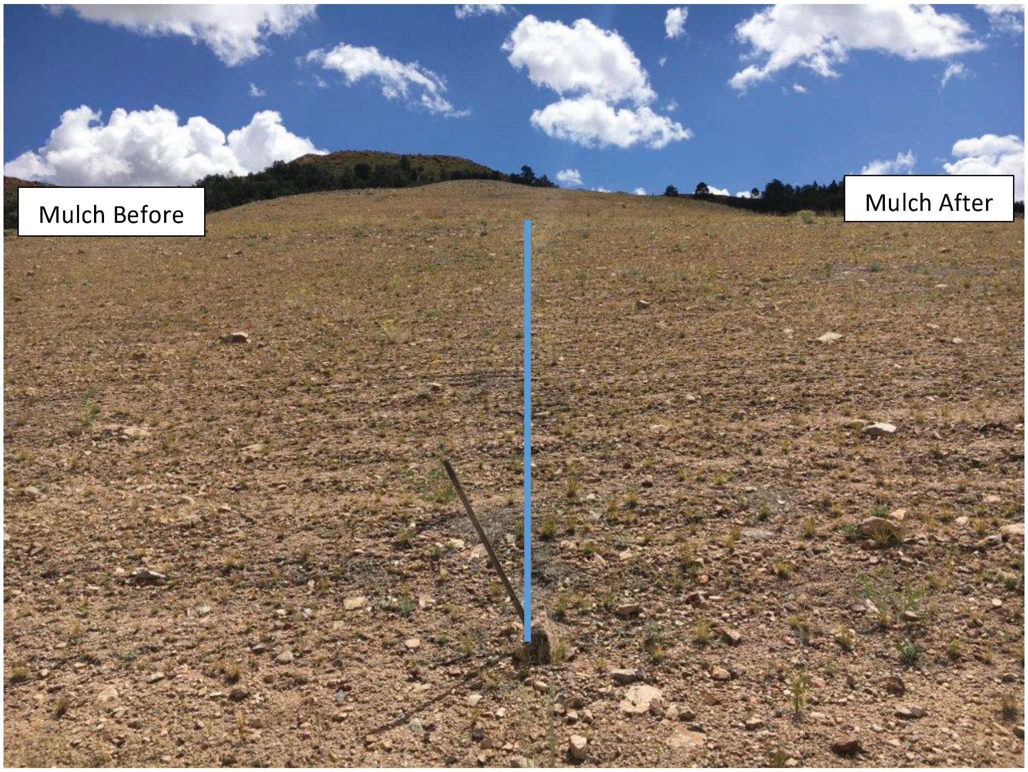


Figure 7. Comparison of experimental seed mix with mulch before (left) and mulch after seeding (right).

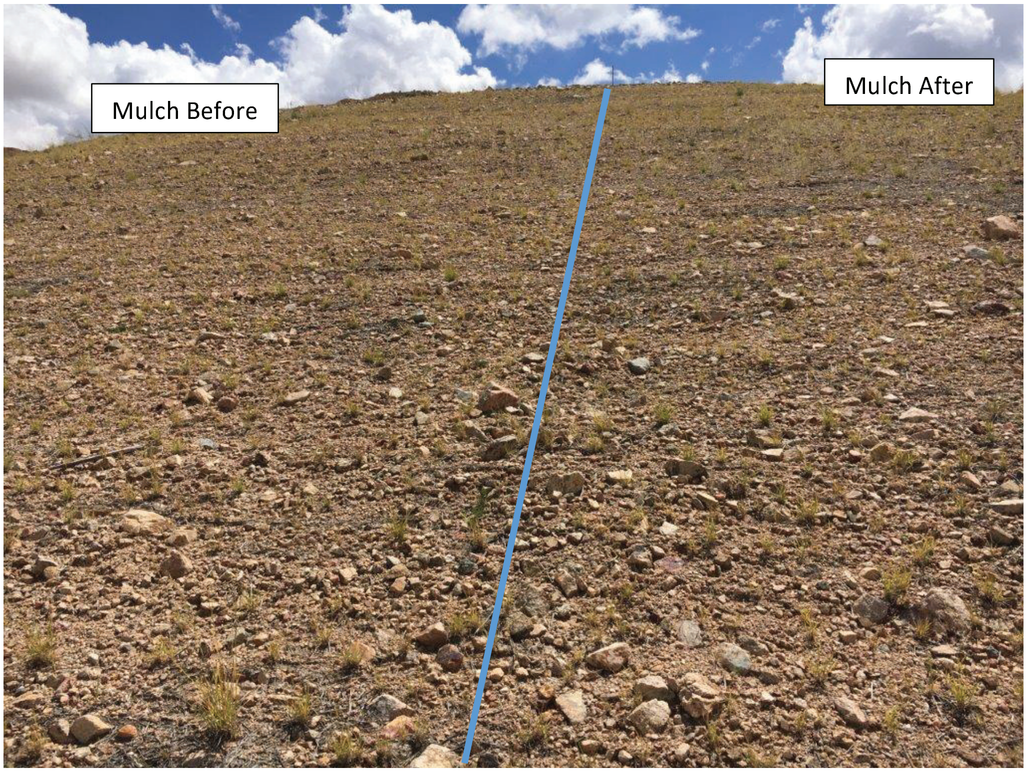


Figure 8. Comparison of conventional seed mix with mulch before (left) and mulch after seeding (right).

APPENDIX A
EROSION STATION CROSS-SECTIONS

FIGURE - A-1
EROSION TRANSECT CROSS-SECTIONS
USNR-NORTH

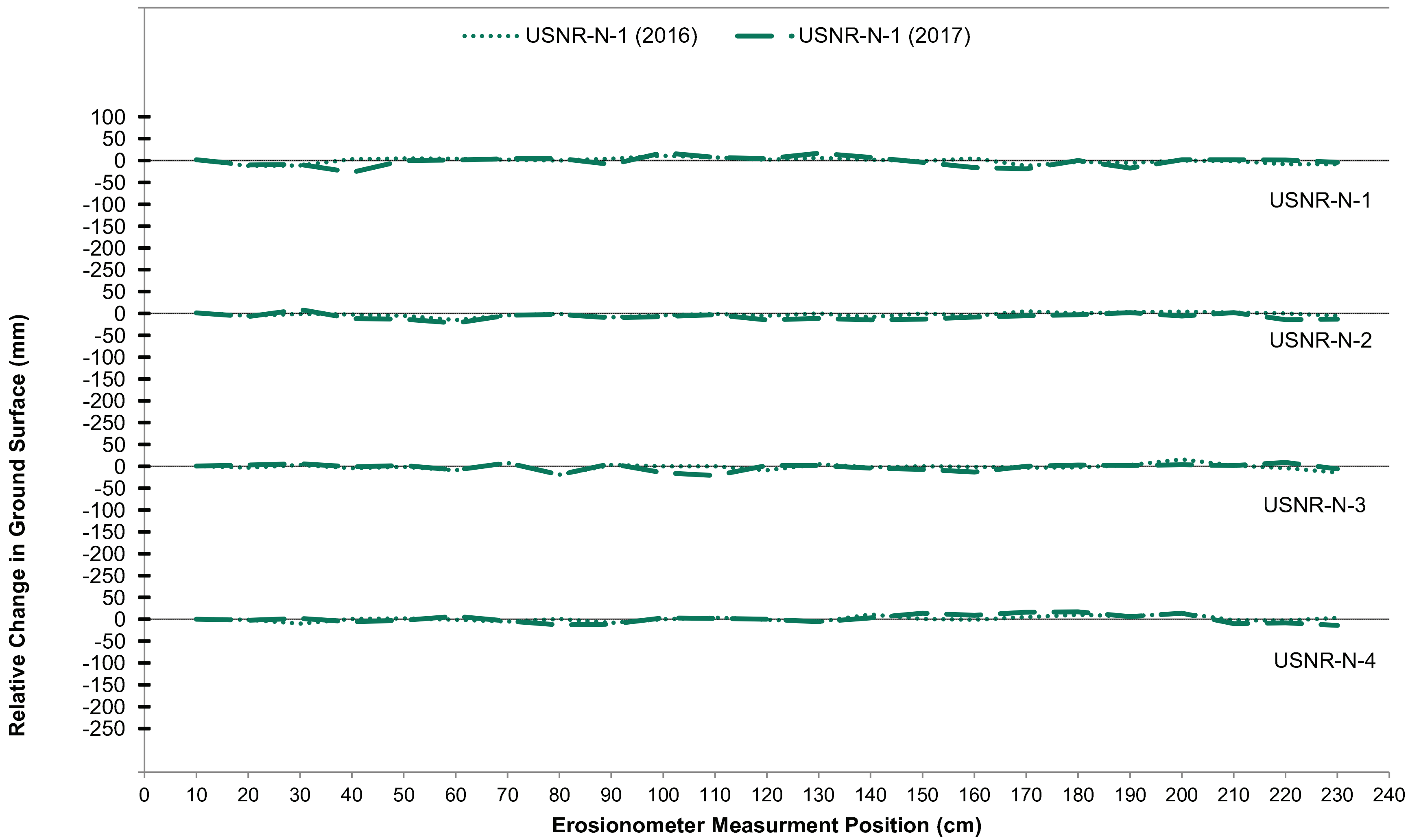
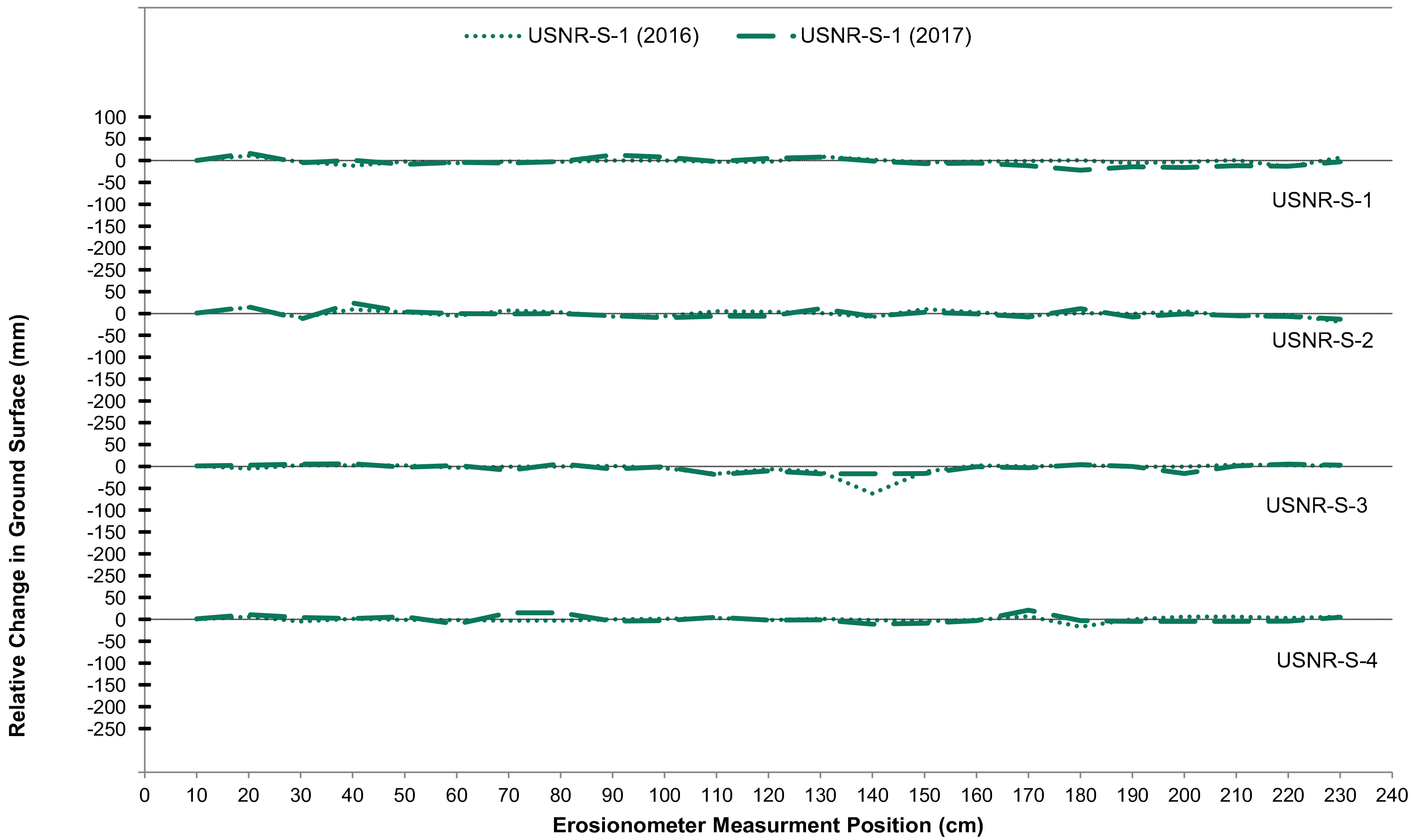


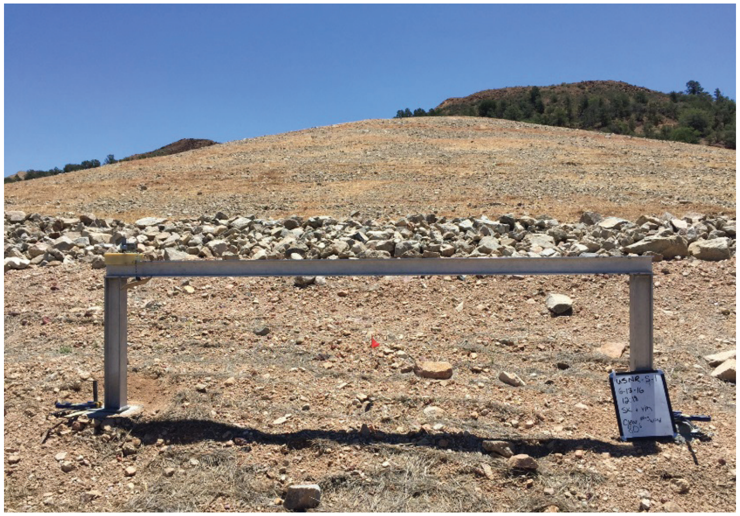
FIGURE - A-2
EROSION TRANSECT CROSS-SECTIONS
USNR-SOUTH



APPENDIX B
EROSION TRANSECT PHOTOGRAPHS

	
Transect Location: USNR-N-1 Date: 6/13/16	**Transect Location:** USNR-N-1 Date: 11/30/17
	
Transect Location: USNR-N-2 Date: 6/13/16	**Transect Location:** USNR-N-2 Date: 11/30/17

	
Transect Location: USNR-N-3 Date: 6/13/16	**Transect Location:** USNR-N-3 Date: 11/30/17
	
Transect Location: USNR-N-4 Date: 6/13/16	**Transect Location:** USNR-N-4 Date: 11/30/17



Transect Location:
USNR-S-1 Date: 6/13/16

Transect Location:
USNR-S-1 Date: 11/30/17

Transect Location:
USNR-S-2 Date: 6/13/16

Transect Location:
USNR-S-2 Date: 11/30/17

	
Transect Location: USNR-S-3 Date: 6/13/16	**Transect Location:** USNR-S-3 Date: 11/30/17
	
Transect Location: USNR-S-4 Date: 6/13/16	**Transect Location:** USNR-S-4 Date: 11/30/17

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Inc.
5200 Pasadena Avenue N.E., Suite C
Albuquerque, NM 87113 USA
Tel: (505) 821-3043
Fax: (505) 821-5273