OGMCOAL DNR <ogmcoal@utah.gov>

Cottonwood Wilberg Mine- Proposed Sediment Control Calculations

Steve Christensen <stevechristensen@utah.gov> Mon, Nov 23, 2015 at 5:53 PM
To: Christine Belka <cbelka@osmre.gov>, Dave Wham <dwham@utah.gov>, Mike Herkimer <mherkimer@utah.gov>, Kim Shelley <kshelley@utah.gov>
Cc: OGMCOAL DNR <ogmcoal@utah.gov>, Daron Haddock <daronhaddock@utah.gov>, Keenan Storrar <kstorrar@utah.gov>, Cheryl Parker <cherylparker@utah.gov>

Good afternoon,

I've spoken to you about Pacificorp's proposal to remove their primary sediment pond during initial reclamation at the Cottonwood/Wilberg Mine during the 2016 construction season.

They're proposing to utilize deep pocks and gouging (in lieu of a sediment pond) to retain sediment on the site. I've attached their consultants report that provides the the calculations/estimates of soil loss (EarthFax Report 11_17_2017). They utilize a RUSLE calculation.
Given the significance of what they're proposing from a regulatory stand-point as well as from a precedent setting stand-point, I want to insure that all of the regulatory agencies are comfortable with the direction we ultimately take.

With the holidays coming on, I know that folks will be busy. However I'm hoping that perhaps in a month or two, we (i.e. OSM, DWQ and DOGM) could have a conference call/meeting and discuss the EarthFax report and see where we're at. The question at this point is primarily whether their approach (RUSLE) and assumptions are reasonable, and if not, what would be an alternative soil loss application to utilize?

Does that sound like a plan? Please give me a call if you have any questions.

Dave/Mike/Kim- Is there anyone else in your group that I should route this report to? Let me know if there are and I'll be happy to send it to them.

Regards,
Steve

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EarthFax Report 11_17_2017.pdf
3348K

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EarthFax

November 17, 2015

Dennis Oakley
Interwest Mining Company
15 North Main Street
Huntington, Utah 84528

Subject: Review of the Applicability of Deep Gouging for Reclamation of the Cottonwood/Wilberg Mine Complex

Dear Dennis:

Pursuant to your request, I have evaluated the applicability of deep gouging as a sediment-control method to be implemented during reclamation of the Cottonwood/Wilberg Mine complex in Emery County, Utah. This review was requested following receipt of comments from the Utah Division of Oil, Gas and Mining ("DOGM") regarding proposed revisions to your previously-approved reclamation plan.

Background

Prior to termination of mining operations, the Cottonwood/Wilberg Mine surface facilities occupied approximately 20 acres of disturbed land at the confluence of the left and right forks of Grimes Wash. The surface facilities included coal handling, electrical substation, equipment maintenance, material storage, and runoff- and sediment-control structures as well as parking areas. Two sedimentation ponds provided sediment control for the 20-acre disturbance: the North Pond (which discharged into the South Pond) and the South Pond (which was regulated by a UPDES permit). The sedimentation ponds were designed to trap and settle coal fines and other suspended solids prior to discharging into Grimes Wash (an ephemeral stream) outside the permitted disturbed area.

The DOGM-approved reclamation plan for the site was developed in the 1980's. This plan specified that the sedimentation ponds would remain in place for at least 2 years following initial site reclamation. The plan also specified that the culverts that convey runoff from undisturbed areas beneath the sedimentation ponds would remain in place until the ponds were removed. To preclude disturbed-area runoff from entering the primary reclamation channel, the plan indicated that contour and collection ditches would be installed to divert runoff away from the reclaimed undisturbed-area channel and toward the sedimentation ponds.

The currently-approved plan presented three primary concerns. First, accumulation of a relatively small amount of sediment in one of the contour ditches could result in runoff being inadvertently diverted out of the ditch and down the slope. The resulting erosion would likely cascade down the slope and cause other contour ditches to breach, thereby resulting in a potentially large erosive impact. Second, naturally-occurring sandstone lenses in the reclaimed slopes would make it infeasible to construct the contour ditches without the need for numerous drop structures. This could substantially increase the potential for failure of the diversion system and the effort required to maintain the reclaimed area. Finally, equipment access to repair these failed areas would likely create substantially more impact.

Given these concerns, Interwest proposed a modification of the reclamation plan through the use of deep gouging. This method has been successfully applied at several mine sites in Utah and was a major reason why the U.S. Office of Surface Mining Reclamation and Enforcement ("OSM") awarded Castle Gate Mining Company with the 2003 Excellence in Surface Coal Mining and Reclamation National Award. As noted in "The Practical Guide to Reclamation in Utah" prepared by DOGM,[1] "the process is repeated in a random and overlapping pattern, making it impossible for water to flow down slope." The gouges retain all precipitation, thereby precluding runoff and the generation of down-slope sediment. Gouging and the associated mulching also create a microenvironment that encourages rapid germination of seeds, thereby greatly enhancing revegetation success. Interwest's proposed modification also included removal of the existing sedimentation ponds when site regrading and gouging reached that area. This was proposed since (1) gouging would trap all precipitation and associated runoff, thereby making the ponds unnecessary and (2) if the ponds were to remain in place during reclamation, re-entry into the site to remove the ponds would cause substantial disturbance to an area that had already been reclaimed.

DOGM expressed concerns about the proposed changes to the approved reclamation plan primarily due to the requirements of R645-301-763.100 which states that "in no case will the siltation structures be removed sooner than two years after the last augmented seeding." DOGM also stated in their review that the agency did not consider deep gouges to comply with the regulatory definition of a "siltation structure." However, in an on-site meeting with DOGM representatives on October 27, 2015, agency personnel indicated a willingness to consider deep gouging as an appropriate sediment-control measure during reclamation if Interwest could show that this approach represents the Best Technology Currently Available. The purpose of this letter is to present the results of my evaluation in that regard and to specifically address issues raised by DOGM during aforementioned on-site meeting.

Deep Gouging Design Standard

The design standard for deep gouging is generally as stated in DOGM's reclamation guide.[1] The gouges are constructed using a trackhoe to excavate multiple shallow pits into a regraded, topsoiled, and mulched slope. Soil from each excavated pit is placed around the rim of the pit.

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[1] Wright, M.A. and S. White (eds.). n.d. The Practical Guide to Reclamation in Utah. Utah Division of Oil, Gas and Mining. Salt Lake City, Utah. Downloaded from https://fs.ogm.utah.gov/pub/MINES/Coal_Related/RecMan/Reclamation_Manual.pdf.

Field experience has indicated that individual pits have approximate surface diameters of 3 to 6 feet and approximate depths of 1.5 to 3 feet. Gouges are constructed in a random, overlapping pattern. Additional mulch is then added, together with a tackifier, during revegetation of the site. When completed, the area should be difficult to walk across.

Potential Inflow Volumes

Based on the formula for a truncated sphere, a uniform deep gouge with a surface diameter of 6 feet and a depth of 3 feet will have a volume of 56.5 cubic feet. Similarly, a uniform deep gouge with a surface area of 3 feet and a depth of 1.5 feet will have a volume of 7.1 cubic feet. This represents the typical volume range of deep gouges. Since the gouges are designed to retain all water, no overland flow will occur within the gouged area.

Data obtained from the National Weather Service Hydrometeorological Design Studies Center web site indicates that the 100-year, 24-hour storm produces 3.00 inches of precipitation[2] (see Attachment A). With a top surface area of 28.3 square feet, the 6-foot diameter deep gouge will capture 7.1 cubic feet of direct precipitation (assuming no infiltration). The smallest of the typical gouges (with a top diameter of 3 feet and a surface area of 7.1 square feet) will capture 1.8 cubic feet of direct precipitation during the same event (again assuming no infiltration). These volumes represent 12.5% and 25.0% of the capacity of the 6-foot and 3-foot diameter gouges, respectively (see Attachment B).

As a point of comparison, data provided in Attachment A indicate that the estimated precipitation depth resulting from the 1000-year, 24-hour event is 4.09 inches. The typical 6-foot and 3-foot diameter gouges would capture 9.6 cubic feet and 2.4 cubic feet of direct precipitation, respectively, from this event, representing 17.0% and 34.1%, respectively, of the capacity of the two typical gouge sizes. Thus, the typical gouges will have a sufficient volume to retain all direct precipitation without discharging.

As indicated previously, soil excavated during gouging of the soil is placed around the perimeter of the resulting pit. Thus, overland flow from undisturbed area immediately adjacent to the reclaimed area will generally be captured behind the uppermost gouges. In the event that this does not occur, this overland flow would discharge into the uppermost gouges at the boundary between the reclaimed and undisturbed areas.

The quantity of overland flow that could discharge from the undisturbed area into an uppermost gouge was estimated by multiplying the overland flow quantity by the contributing area. The depth of runoff was calculated for the 100-year, 24-hour precipitation event using an estimated curve number of 72 for the undisturbed area (based on a ground cover density of 53% as reported

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[2] National Weather Service Hydrometeorological Design Studies Center data base accessed at http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=ut.

by Mt. Nebo Scientific in their 2011 vegetation monitoring[3]). The contributing area to n uppermost gouge was estimated based on typical gouge diameters of 3 to 6 feet and overland flow lengths of 50 to 100 feet (the typical flow distance before channelization, based on field observation). The results of these calculations are presented in Attachment C. As indicated, the estimated maximum runoff into a large gouge is 40.0 cubic feet. Together with direct precipitation of 7.1 cubic feet, this represents a volume of 47.5 cubic feet of water in a gouge with a capacity of 56.5 cubic feet (i.e., 84% of the large gouge capacity). The maximum potential inflow into a small gouge (20.2 cubic feet) exceeds the capacity of a small gouge (7.1 cubic feet) by over 180%. Therefore, in order to ensure adequate holding capacity, I recommend that the row of gouges next to undisturbed area have a capacity of at least 50 cubic feet each. Under this condition, the gouges will have a sufficient capacity to retain overland flow from the adjacent undisturbed area without discharging.

Appropriateness of RUSLE as a Soil Erosion Model

The Revised Universal Soil Loss Equation ("RUSLE") was developed by the USDA Agricultural Research Service[4] as an outgrowth of the original Universal Soil Loss Equation ("USLE")[5]. Revisions to the original equation occurred primarily in the form of updated research to better define the variables that are used in the equation. These updates also included computerized algorithms for selecting and calculating the variables used in the equation. Although many other erosion-prediction models exist,[6] RUSLE remains widely used because of ease of use, availability of parameter values, reliable accuracy, and ready support from the U.S. Natural Resources Conservation Service ("NRCS"). In 1995, NRCS adopted RUSLE as the official tool for predicting soil erosion by water.[7] According to Renard et al.[4], "widespread use has substantiated the RUSLE's usefulness and validity."

The Universal Soil Loss Equation was originally developed for use on agricultural lands. Nonetheless, the soil erosion principles are equally applicable to construction and mining sites as long as research could support selection of appropriate values for the individual variables used in the equation. Significant research on appropriate input values for use on construction sites was

[3] Mt. Nebo Scientific, Inc. 2012. Vegetation Monitoring: Reference Areas. Project report prepared for Energy West Mining Company. Springville, Utah.
[4] Renard, K.G., G.R. Foster, G.A Weesies, D.K. McCool, and D.C. Yoder. 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE). Agriculture Handbook Number 703. USDA Agricultural Research Service. Tucson, AZ.
[5] Wischmeier, W.H. and D.D. Smith. 1960. A Universal Soil-Loss Equation to Guide Conservation Farm Planning. 7th International Congress on Soil Science. pp. 418-425.
[6] See http://soilerosion.net/doc/models_menu.html
[7] U.S. Natural Resources Conservation Service. 2002. National Agronomy Manual. U.S. Department of Agriculture. Washington, DC.

initially conducted at the Utah Water Research Laboratory and published in 1978.[8] This research was expanded and updated in 1984.[9]

OSM considered RUSLE to be sufficiently applicable to the prediction of soil loss from reclaimed mine sites that the agency was largely responsible for developing one of the original updates to the model (known as RUSLE, version 1.06).[10] This version of the computer program included updates to the table of RUSLE variables that were specifically developed for predicting soil loss from reclaimed mine sites. These updates were retained in future editions of the model, including the current edition (known as RUSLE2).

The appropriateness of RUSLE for use on reclaimed Western mine sites was evaluated in research conducted at Montana State University. Kapolka[11] studied revegetation success and soil loss in a reclaimed area of a talc mine in southwestern Montana at an elevation of about 8,500 feet. She evaluated uniform slope gradients ranging from 25% to 50% and topsoil thickness ranging from 0 to 18 inches. She concluded that RUSLE (version 1.06) generally underpredicted soil loss in the first year of reclamation, due primarily to the formation of rills prior to establishment of the initial vegetative cover (a condition that is precluded by deep gouging since all runoff is retained within the individual gouges). She also found that RUSLE generally overpredicted soil loss after the establishment of the initial vegetative cover.

To improve the effectiveness of RUSLE for predicting pre-revegetation soil loss, Kapolka[11] developed a rill formation factor to account for increased soil loss during the first year following reclamation. She concluded that "RUSLE is an effective tool to use for long term planning on reconstructed high altitude steep slopes." She also concluded that a support practice should be considered during the first year following reclamation.[12] Deep gouging is such a support practice.

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[8] Clyde, C.G., C.E. Israelsen, P.E. Packer, E.E. Farmer, J.E. Fletcher, E.K. Israelsen, F.W. Haws, N.V. Rao, and J. Hansen. Manual of Erosion Control Principles and Practices During Highway Construction. Hydraulics and Hydrology Series UWRL/H-78/02. Utah Water Research Laboratory. Utah State University. Logan, Utah.

[9] Israelsen, C.E. J.E. Fletcher, F.W. Haws, and E.K. Israelsen. 1984. Erosion and Sedimentation in Utah: A Guide for Control. Hydraulics and Hydrology Series UWRL/H-84/03. Utah Water Research Laboratory. Utah State University. Logan, Utah.

[10] Galetovic, J. R. 1988. Guidelines for the Use of the Revised Universal Soil Loss Equation (RUSLE) Version 1.06 on Mined Lands, Construction Sites, and Reclaimed Lands. U.S. Office of Surface Mining Reclamation and Enforcement. Denver, CO.

[11] Kapolka, N.M 1999. Effect of Slope Gradient and Plant Cover on Soil Loss on Reconstructed High Altitude Slopes. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Land Rehabilitation. Montana State University. Bozeman, MT.

[12] Kapolka, N.M and D.J. Dollhopf. 2001. Effect of Slope Gradient and Plant Growth on Soil Loss on Reconstructed Steep Slopes. International Journal of Surface Mining, Reclamation and Environment. Vol. 15, No. 2, pp. 86-99.

Winking[13] expanded on the work of Kapolka[11] by examining the effects of pitting (among other practices) on soil loss from the same reclaimed site investigated by Kapolka. The pits evaluated by Winking were hand dug with individual volumes of approximately 900 cubic centimeters (0.03 cubic foot). The pits were staggered in a checkerboard pattern with alternating rows of two and three pits and a distance between pits of about 11 feet. Notwithstanding the limited volume and extent of the pitting relative to standard deep gouging practice, Winking concluded that pitting of the soil surface was an effective erosion control practice that prevented rill formation and reduced sediment yields on steep slopes until vegetation could provide additional erosion protection. She also found that RUSLE predicted sediment yield on this reclaimed mine site to within 97% of measured sediment yield. This confirmed the conclusion of Kapolka[9] that RUSLE is an appropriate model for predicting soil erosion from reclaimed mine sites.

Given the extensive use of USLE and RUSLE, the acceptance of these models by both OSM and NRCS, the research that has been done to provide inputs appropriate to construction and mining sites, and the research that has verified the applicability of RUSLE to reclaimed mine sites, it is my opinion that RUSLE is an appropriate model for estimating soil loss from the reclaimed Cottonwood/Wilberg mine complex.

Predicted Sediment In-fill Rates

The predicted rate of soil loss from the reclaimed Cottonwood/Wilberg mine site was calculated using version 2 of RUSLE. The results of these calculations, presented in Attachment D, provide values for the following (with definitions provided by the RUSLE2 User's Reference Guide)[14]:

- Soil loss from eroding portion: Net removal of sediment from that portion of the overland flow path where detachment of soil particles occurs.
- Soil detachment: The separation of soil particles from the soil mass by raindrops, water falling from vegetation, and surface runoff.
- Conservation planning soil loss: A value that provides partial credit to deposition as soil that is "saved."
- Sediment delivery: The sediment yield for the site if the overland flow path ends at the site boundary.

[13] Winking, S.R. 2002. Effect of Mechanical and Biological Enhancements on Erosion at High Elevation Disturbed Lands. Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Land Rehabilitation. Montana State University. Bozeman, MT.
[14] USDA Agricultural Research Service, USDA Natural Resources Conservation Service, and Biosystems Engineering and Environmental Science Department (University of Tennessee). 2008. Draft User's Reference Guide, Revised Universal Soil Loss Equation Version 2 (RUSLE2). USDA Agricultural Research Service. Washington, DC.

The calculations presented in Attachment D are based on gouging of a reclaimed slope after backfilling, grading, mulching, and pocking. The largest typical gouge (with a surface diameter of 6 feet and a depth of 3 feet) was used to provide the greatest slope length. "Sediment delivery" is a value that is normally considered only when evaluating erosion on a watershed-wide basis. Therefore, for the sake of these calculations, the "conservation planning soil loss", which accounts for gouging and mulching, is assumed to be most representative of individual gouges prior to the vegetation taking hold.

According to Attachment D, the average amount of conservation planning soil loss realized at the bottom of a 6-foot diameter gouge will be 0.23 ton/ac/yr. The sediment eroded from the inside of a smaller diameter gouge will be less since the slope length is shorter. Furthermore, the rate at which sediment is eroded from the interior of a gouge will decrease with time as the slope length inside the gouge decreases. However, assuming that the erosion rate remains constant and that the unit weight of eroded sediment is 100 lb/ft^3, a period of over 9,000 years will be required for a small gouge to fill with sediment and more than 18,000 years will be required for a large gouge to fill with sediment (see Attachment D).

Conclusions

Based on the above evaluation, I have come to the following conclusions:

1. Deep gouging is effective at minimizing soil loss from reclaimed mine sites. When properly installed, the gouges retain all precipitation, thereby precluding runoff and the generation of down-slope sediment. As a result, deep gouging controls erosion at the source and enhances revegetation.
2. Typical gouges with approximate surface diameters of 3 to 6 feet and approximate depths of 1.5 to 3 feet, constructed in a random, overlapping pattern, are effective at retaining all direct precipitation from storm events with return periods of 100 years or less and all runoff from uphill, undisturbed areas resulting from similar events.
3. The Revised Universal Soil Loss Equation is an appropriate tool for estimating erosion from reclaimed mine sites.
4. The volume of typical indentations formed by deep gouging is sufficient that a period of at least 9,000 years is required before individual indentations will fill with sediment. During this time, vegetation is stabilizing the gouge as it fills, thus resulting in an erosionally-stable site long before the gouges fill with sediment.

Given these factors, I consider deep gouging to be the Best Technology Currently Available for reclamation of land that has been disturbed by mining activities in Utah.

I have appreciated the opportunity to be of assistance in this matter. Please contact me if you have any questions.

Sincerely,

Richard B. White, P.E.
President
EarthFax Engineering Group, LLC

Attachments

REGISTERED PROFESSIONAL ENGINEER
No. 168246
RICHARD B. WHITE
17 NOV 2015
STATE OF UTAH

ATTACHMENT A

Depth-Duration-Frequency Data for the
Cottonwood/Wilberg Mine Complex

NOAA Atlas 14, Volume 1, Version 5
Location name: Orangeville, Utah, US*
Latitude: 39.3214°, Longitude: -111.1248°
Elevation: 7621 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.139** (0.121-0.163)	**0.178** (0.156-0.211)	**0.246** (0.212-0.287)	**0.303** (0.259-0.356)	**0.391** (0.326-0.461)	**0.468** (0.383-0.554)	**0.558** (0.447-0.663)	**0.661** (0.514-0.792)	**0.826** (0.613-1.01)	**0.976** (0.698-1.22)
10-min	**0.211** (0.184-0.248)	**0.271** (0.237-0.321)	**0.374** (0.322-0.438)	**0.461** (0.394-0.542)	**0.595** (0.497-0.701)	**0.713** (0.583-0.843)	**0.849** (0.680-1.01)	**1.01** (0.783-1.21)	**1.26** (0.933-1.54)	**1.49** (1.06-1.85)
15-min	**0.262** (0.228-0.308)	**0.337** (0.294-0.397)	**0.463** (0.400-0.543)	**0.571** (0.488-0.672)	**0.738** (0.616-0.869)	**0.884** (0.723-1.04)	**1.05** (0.843-1.25)	**1.25** (0.971-1.50)	**1.56** (1.16-1.91)	**1.84** (1.32-2.29)
30-min	**0.352** (0.307-0.415)	**0.454** (0.396-0.535)	**0.624** (0.538-0.731)	**0.769** (0.658-0.905)	**0.994** (0.830-1.17)	**1.19** (0.973-1.41)	**1.42** (1.14-1.69)	**1.68** (1.31-2.01)	**2.10** (1.56-2.56)	**2.48** (1.77-3.09)
60-min	**0.436** (0.380-0.513)	**0.561** (0.490-0.662)	**0.773** (0.666-0.904)	**0.952** (0.814-1.12)	**1.23** (1.03-1.45)	**1.47** (1.21-1.74)	**1.75** (1.41-2.08)	**2.08** (1.62-2.49)	**2.60** (1.93-3.17)	**3.07** (2.19-3.82)
2-hr	**0.531** (0.465-0.614)	**0.671** (0.588-0.778)	**0.893** (0.779-1.03)	**1.09** (0.944-1.26)	**1.40** (1.19-1.63)	**1.68** (1.39-1.96)	**2.00** (1.62-2.35)	**2.37** (1.86-2.81)	**2.95** (2.22-3.58)	**3.49** (2.53-4.31)
3-hr	**0.599** (0.533-0.685)	**0.753** (0.668-0.864)	**0.969** (0.859-1.11)	**1.17** (1.02-1.34)	**1.47** (1.27-1.69)	**1.73** (1.47-2.00)	**2.05** (1.70-2.39)	**2.42** (1.97-2.85)	**3.01** (2.36-3.62)	**3.56** (2.69-4.35)
6-hr	**0.787** (0.708-0.884)	**0.978** (0.883-1.10)	**1.21** (1.09-1.36)	**1.41** (1.26-1.59)	**1.70** (1.50-1.91)	**1.95** (1.70-2.21)	**2.25** (1.93-2.57)	**2.59** (2.19-2.99)	**3.19** (2.62-3.75)	**3.73** (3.00-4.46)
12-hr	**0.995** (0.904-1.10)	**1.23** (1.12-1.36)	**1.50** (1.36-1.67)	**1.73** (1.56-1.93)	**2.05** (1.82-2.29)	**2.30** (2.03-2.58)	**2.57** (2.24-2.90)	**2.90** (2.50-3.30)	**3.49** (2.96-4.03)	**4.05** (3.38-4.74)
24-hr	**1.17** (1.05-1.30)	**1.45** (1.31-1.61)	**1.79** (1.61-1.99)	**2.06** (1.85-2.29)	**2.42** (2.17-2.70)	**2.70** (2.40-3.02)	**3.00** (2.64-3.35)	**3.29** (2.88-3.69)	**3.69** (3.18-4.17)	**4.09** (3.40-4.78)
2-day	**1.39** (1.26-1.54)	**1.73** (1.57-1.92)	**2.13** (1.93-2.37)	**2.47** (2.22-2.74)	**2.93** (2.62-3.24)	**3.29** (2.92-3.65)	**3.67** (3.23-4.09)	**4.05** (3.53-4.55)	**4.59** (3.93-5.19)	**5.01** (4.24-5.71)
3-day	**1.55** (1.41-1.73)	**1.94** (1.75-2.16)	**2.40** (2.17-2.68)	**2.78** (2.50-3.10)	**3.31** (2.95-3.69)	**3.73** (3.29-4.16)	**4.16** (3.65-4.65)	**4.61** (3.99-5.18)	**5.22** (4.45-5.92)	**5.71** (4.80-6.52)
4-day	**1.72** (1.56-1.93)	**2.15** (1.94-2.41)	**2.67** (2.41-2.99)	**3.10** (2.78-3.47)	**3.69** (3.29-4.13)	**4.16** (3.67-4.66)	**4.65** (4.07-5.21)	**5.16** (4.46-5.81)	**5.86** (4.98-6.64)	**6.41** (5.37-7.32)
7-day	**2.10** (1.89-2.35)	**2.63** (2.37-2.95)	**3.29** (2.95-3.68)	**3.83** (3.42-4.28)	**4.56** (4.04-5.11)	**5.15** (4.53-5.79)	**5.77** (5.03-6.51)	**6.41** (5.52-7.27)	**7.29** (6.18-8.34)	**8.00** (6.68-9.23)
10-day	**2.43** (2.19-2.71)	**3.04** (2.75-3.39)	**3.79** (3.41-4.22)	**4.39** (3.94-4.90)	**5.21** (4.64-5.82)	**5.85** (5.17-6.55)	**6.52** (5.71-7.32)	**7.19** (6.24-8.11)	**8.12** (6.93-9.23)	**8.85** (7.46-10.2)
20-day	**3.32** (2.99-3.69)	**4.17** (3.76-4.64)	**5.22** (4.69-5.81)	**6.05** (5.42-6.74)	**7.17** (6.38-7.99)	**8.05** (7.09-8.98)	**8.94** (7.82-10.0)	**9.86** (8.53-11.1)	**11.1** (9.47-12.6)	**12.1** (10.2-13.8)
30-day	**4.07** (3.67-4.52)	**5.10** (4.61-5.66)	**6.34** (5.70-7.03)	**7.30** (6.55-8.10)	**8.59** (7.65-9.54)	**9.57** (8.48-10.6)	**10.6** (9.30-11.8)	**11.6** (10.1-13.0)	**12.9** (11.1-14.6)	**14.0** (11.9-15.9)
45-day	**5.05** (4.58-5.60)	**6.33** (5.75-7.02)	**7.86** (7.10-8.72)	**9.06** (8.15-10.1)	**10.7** (9.52-11.9)	**11.9** (10.6-13.3)	**13.2** (11.6-14.7)	**14.5** (12.6-16.3)	**16.3** (14.0-18.4)	**17.7** (15.0-20.2)
60-day	**6.03** (5.45-6.68)	**7.59** (6.86-8.40)	**9.44** (8.50-10.4)	**10.9** (9.75-12.0)	**12.7** (11.4-14.1)	**14.2** (12.6-15.8)	**15.6** (13.7-17.5)	**17.1** (14.9-19.2)	**19.1** (16.4-21.6)	**20.6** (17.5-23.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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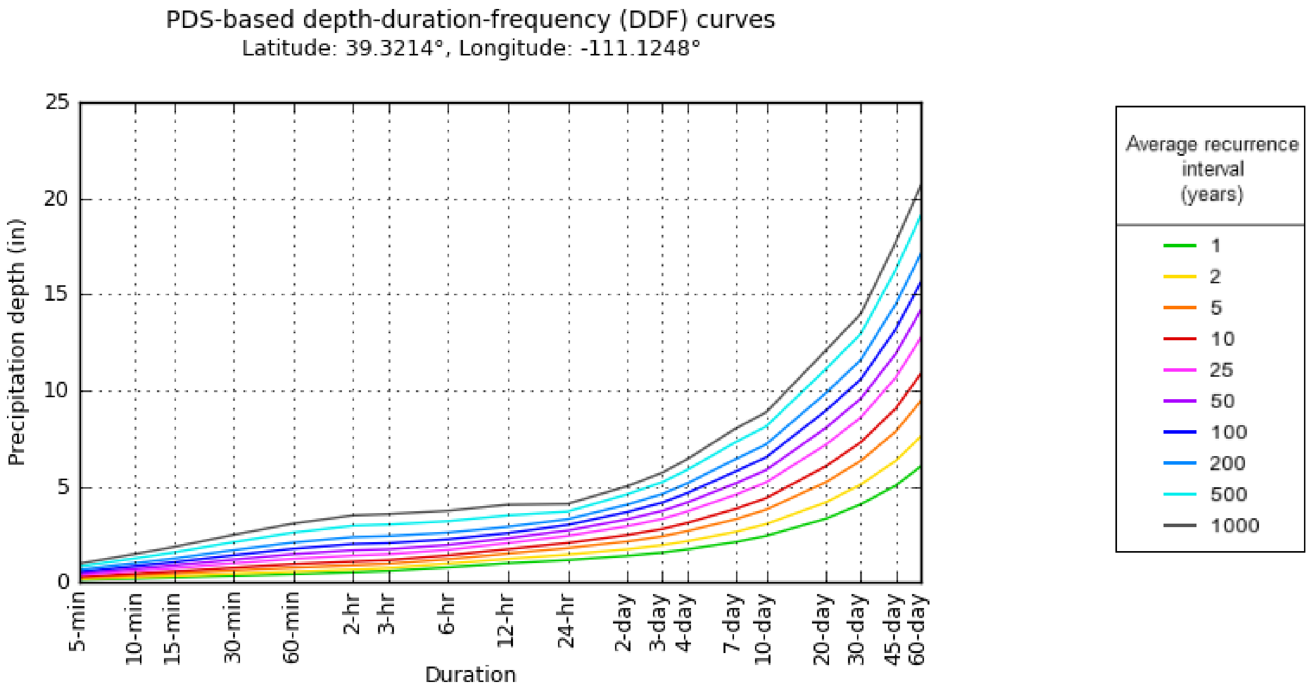
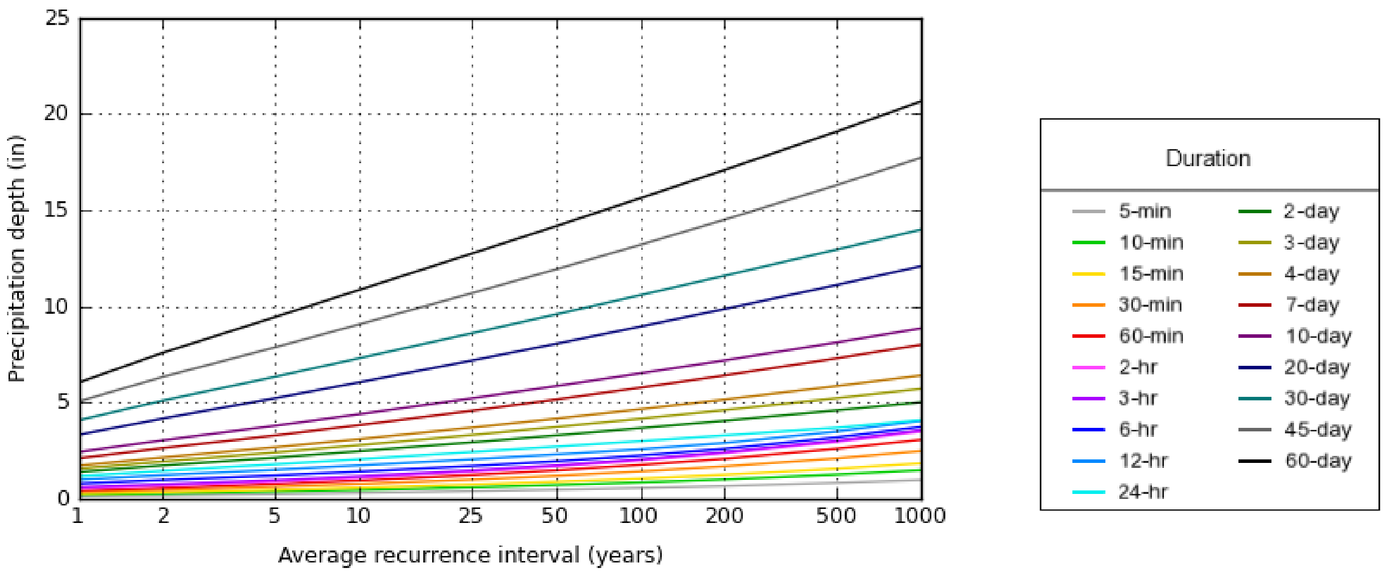
PF graphical





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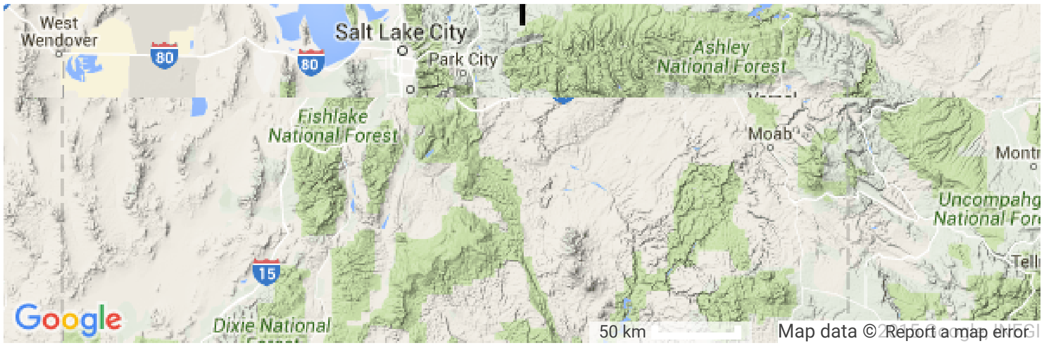
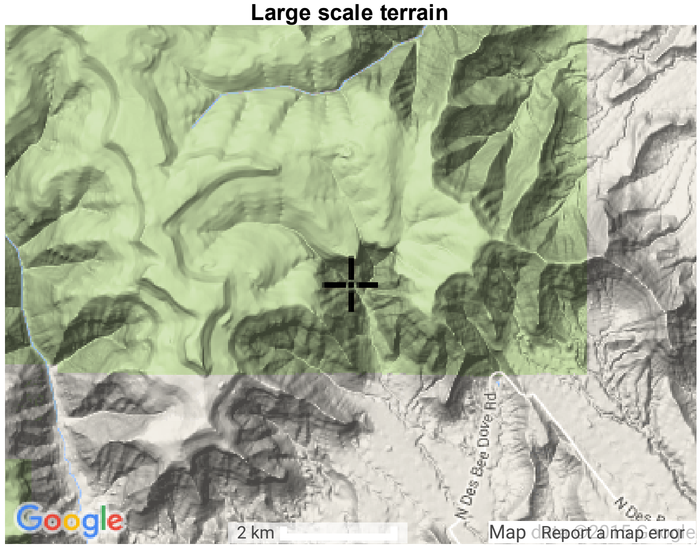
Maps & aerials

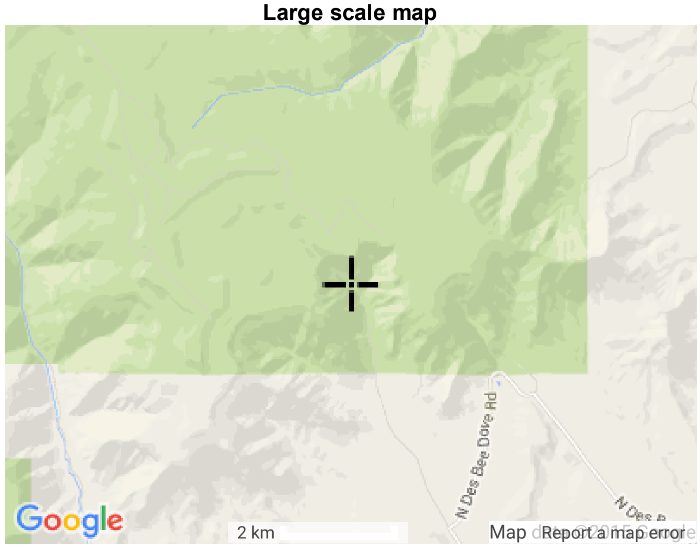
Small scale terrain



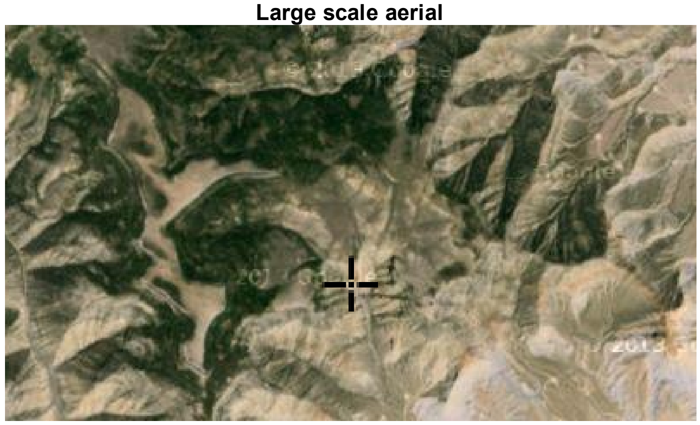
Large scale terrain



Large scale map



Large scale aerial



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ATTACHMENT B

Calculation of Direct Precipitation Volumes
Into Individual Gouges

Percent of Typical Gouge Volume Filled by Direct Precipitation
Cottonwood/Wilberg Reclaimed Site

Parameter	Large Gouge		Small Gouge	
	100-yr, 24-hr Precip	1000-yr, 24-hr Precip	100-yr, 24-hr Precip	1000-yr, 24-hr Precip
Gouge diameter =	6 ft	6 ft	3 ft	3 ft
Gouge depth =	3 ft	3 ft	1.5 ft	1.5 ft
Gouge area =	28.3 sf	28.3 sf	7.1 sf	7.1 sf
Precip depth =	3.00 in	4.09 in	3.00 in	4.09 in
Precip volume =	7.07 cf	9.64 cf	1.77 cf	2.41 cf
Gouge volume =	56.5 cf	56.5 cf	7.1 cf	7.1 cf
Percent of capacity =	12.5 %	17.0 %	25.0 %	34.1 %

ATTACHMENT C

Calculation of Overland Flow Volumes
Into Individual Gouges

Estimated Overland Flow Volume into Uppermost Gouges

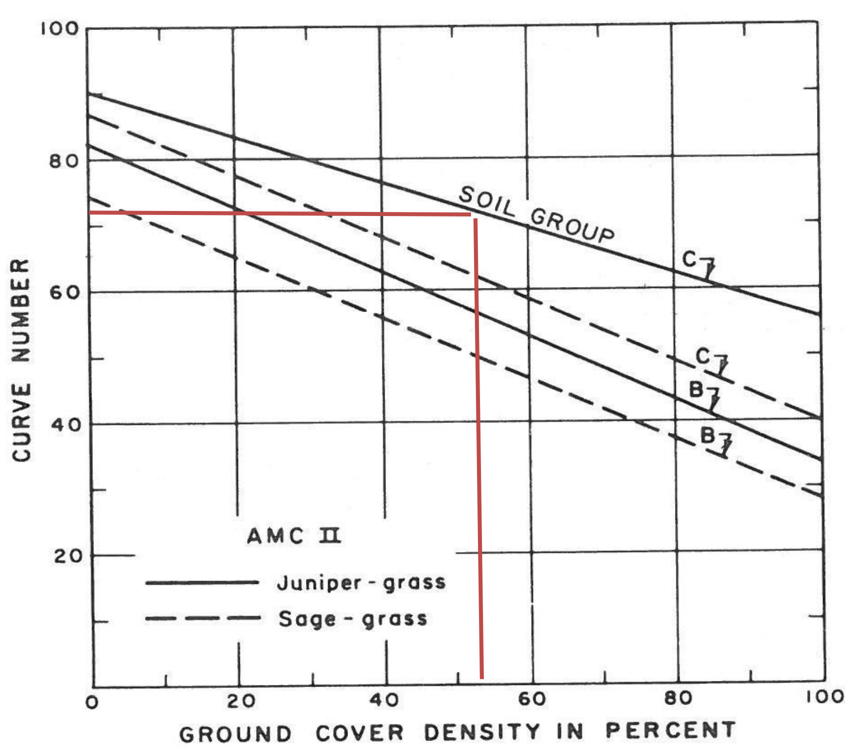
Cottonwood/Wilberg Reclaimed Site

Curve number =	72		S = 3.89
Avg. overland flow length =	50	ft	
Max. overland flow length =	100	ft	
Typical max. gouge dia. =	6	ft	
Typical min. gouge dia. =	3	ft	
Max. contributing area =	600	sq. ft.	
Min. contributing area =	150	sq. ft.	
100-yr, 24-hr precip =	3.00	in	
Runoff from the event =	0.81	in	

Max runoff to uppermost large gouge =	40.4	cubic ft
Max runoff to uppermost small gouge =	20.2	cubic ft
Avg runoff to uppermost large gouge =	20.2	cubic ft
Avg runoff to uppermost small gouge =	10.1	cubic ft

Note:

1. Curve number based on ground cover density of 53% (36% understory + 17% litter) as indicated by Mt. Nebo Scientific in their 2011 vegetation monitoring report. This curve number is based on an assumed Hydrologic Soil Group of "C". See the figure below from NEH, Part 630, Hydrology.



ATTACHMENT D

Results of RUSLE2 Calculations

RUSLE2 Worksheet Erosion Calculation Record

Info: RUSLE Slope #1 and #2 - Disturbed Area of Mine after backfilling, grading, pocking, and mulching.

Inputs:
Tract #: Disturbed Area
Owner name: Interwest Mining Company
Field name: Cottonwood Mine

Location: Utah\Emery County\UT_Emery_R_13
Soil: DZG2 Gerst-Strych-Rock outcrop complex, 30 to 65 percent slopes\Strych very cobbly loam 20%
Slope length (horiz): 2.7 ft
Avg. slope steepness: 50 %
##

Outputs:

Management	*Contouring*	*Strips / barriers*	*Diversion/terrace, sediment basin*	*Soil loss erod. portion, t/ac/yr*	*Soil detachment, t/ac/yr*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*	*Rock cover, %*
default	e. relative row grade 10 percent of slope grade	(none)	1 Water and Sediment Control Basin at bottom of RUSLE slope	0.41	0.41	0.23	0.018	26

Time Required to Fill Gouges With Sediment

Cottonwood/Willberg Reclaimed Site

RUSLE2 calculated sediment yield =	0.23	t/ac/yr
Assumed sediment unit weight =	100	lb/cf
Large gouge area =	28.3	sf
Large gouge volume =	56.5	cf
Time required to fill large gouge =	18,906	yr
Small gouge area =	7.1	sf
Small gouge volume =	7.1	cf
Time required to fill small gouge =	9,470	yr