Appendix 4A

Watershed Erosion Prediction Project Modeling

Watershed Erosion Prediction Project (WEPP) Modeling
Smoky Canyon Mine
Panels F and G Extension Area

Introduction

Quantifying the amount of soil erosion by water from any given land surface, or quantifying the amount of sediment that would be contributed from an eroded surface to a given stream channel on a storm, annual, or long term basis, is not possible to do with any degree of certainty. The USFS commonly estimates water erosion and sedimentation with a model titled: *Water Erosion Prediction Project* (WEPP), and its various use-specific, stand-alone modules.

The WEPP soil erosion model has been developed by an interagency group of scientists including the USFS, Agricultural Research Service, Natural Resource Conservation Service (NRCS), BLM, and Geological Survey (USDA 2000). This model incorporates processes such as infiltration, runoff, soil detachment, transport and deposition, plant growth, senescence, residue decomposition, effects of tillage processes, and soil consolidation to evaluate erosion and sediment delivery potential. Actual erosion rates are highly variable due to large variations in local topography, climate, soil properties, and vegetative properties.

For the Smoky Canyon Mine Panel F and G Extension Area Environmental Impact Statement (EIS) the WEPP model was used to estimate erosion from the proposed major mine disturbances, and the stand-alone WEPP:Road module, titled "*Interface for Predicting Forest Road Runoff, Erosion and Sediment Delivery*", was used to estimated sedimentation to nearby streams from the proposed transportation alternatives. Custom climate parameters that are characteristic of the area were input into the WEPP module to approximate the most accurate climate conditions.

Model Descriptions, Assumptions, and Inputs

Complete documentation for both the WEPP program itself, and the road module, can be found at http://forest.moscowfsl.wsu.edu/fswepp/. Brief descriptions of the two are provided below. The WEPP documentation states that the accuracy of predicted values obtained by the model or its use-specific modules "are, at best, within plus or minus fifty percent." For this reason, the actual values obtained from the model for this EIS and presented herein should not be the focus of the analysis; instead the relative magnitudes should be used as a means of comparing the various alternatives.

Disturbed WEPP

The Disturbed WEPP (USDA 2000) model was utilized to represent erosion predictions for reclaimed areas during both interim vegetation establishment and at the completion of successful revegetation. Details specific to the Disturbed WEPP model can be found on the website http:/forest.moscowfsl.wsu.edu/fswepp/docs/distweppdoc.html. It should be noted that the WEPP model is not designed for mining disturbance areas of this type or size and the program does not have provisions to allow for the implementation of BMP's, the degree of coarse fragments in the soil, or other variables which influence erosion and sedimentation.

Input data utilized in WEPP analysis includes 4 different soil textures, 8 different vegetation scenarios, various slope values, length of slope, percent cover, and a model time length of up to 30 years. WEPP simulates the conditions that impact erosion such as vegetation canopy, surface residue, and the soil water content for every day in a multiple-year run (USDA 2000). For each day that has a precipitation event, WEPP determines whether the event is rain or snow, and calculates the infiltration and runoff, routing the runoff over the surface and calculating the erosion or deposition rates for at least 100 points on the hill slope. It then calculates the average sediment yield from the hill slope.

The WEPP models for all disturbed areas for the Proposed Action and Alternatives were run with local climate data in order to take into account annual precipitation patterns, elevation, and temperatures to more accurately calculate the effects of runoff. The Rock:Clime subroutine in WEPP was used to generate a local precipitation and termperature data set by applying adjustments to the program's internal Palisades Dam, Idaho, weather data to better match the reported 30-35 inches of annual precipitation at Smoky Canyon. Analyses are based on 30 years of climate data. Mean annual averages are predicted using the probability of precipitation, type of precipitation, number of storm events, the upland erosion rate and the sediment leaving the profile.

Baseline Disturbed WEPP input parameters for both interim and successful revegetation conditions identify the dominant soil textures in the area as loam and silt loam. Horizontal slope lengths of 50 and 100 feet were utilized for all of the model alternatives. Reclaimed and regraded slopes would be less than 33 percent, with rock cover estimated at 20 or 40 percent, depending upon location.

Modeling for interim revegetation was calculated using 40 percent cover, which is approximately equivalent to the presence of short prairie grass. Interim revegetation conditions also include the establishment of cover crops on temporary growth medium stockpiles.

WEPP prediction parameters for successfully reclaimed mining areas include the baseline parameters identified above, and an average of 70 percent vegetation cover consisting of short prairie grass and tall prairie bunch grasses, which is consistent with the components of the revegetation seed mix.

WEPP:Road

WEPP:Road, was designed to predict erosion and subsequent sediment yield from forest roads based upon general information on climate, soil, road surface, local topography, drain spacing, road design, and ditch condition. These inputs differ in some instances than those required for the main WEPP program described above. Module-specific documentation for the WEPP:Road module can be found on the internet at: http://forest.moscowfsl.wsu.edu/fswepp/docs/wroadimg.html.

WEPP:Road presumes three flow segments (a travelway/ditch component, a fill slope, and a forested buffer) to derive average annual sediment yield, in pounds to the nearest stream channel. WEPP:Road does not account for any mass failures, culvert failures, cut slope erosion, or erosion from cross-drain channel structures. It presumes that fill slopes have a 50-

percent vegetated ground cover, and that there is a forested buffer between the road fill and the stream channel that has a 100-percent vegetation/litter ground cover. Essentially, WEPP calculates erosion from the road surface and the fill slope, and then uses the buffer slope characteristics to route the eroded material to the stream channel. The sediment delivery ratio varies depending upon the buffer length and slope. The closer a road segment is to a stream, and the larger the road is, the more likely it would be for it to contribute sediments, according to WEPP:Road. Research on sediment transport from forest roads in central Idaho (Ketcheson and Megahan, 1996) shows that source of the eroded material (i.e. fill slopes, cross drains, etc.) also affects transport distances; Seyedbagheri (1996) reported that road size (width, cut/fill lengths, volume of material) affects both unit erosion rate and transport distance.

WEPP:Road allows the user to choose a graveled road surface. This type of surfacing, which is proposed for all road alternatives herein, is one of the more effective treatments in regard to erosion control from roads. Otherwise, the model does not consider any other erosion or sediment control BMPs that may serve to reduce erosion or sediment loading (with the exception of the important BMP of fill slope vegetation, which WEPP:Road assumes as a given). In sum, WEPP:Road assumptions do not always closely match conditions for the proposed roads; in some cases causing an overestimation of sedimentation and in other cases, an underestimation.

For this analysis, the specific inputs to the WEPP:Road module were determined based on the following sources: Chapter 2 road design information (road width, fill slope gradient, surfacing; and road shape/ditch configuration); conceptual design road footprints provided by Simplot (fill slope length and road gradient); soil mapping (USDA 1976; USDA 1990) (to place individual reaches in one of four soil categories allowed by the model); and topographic mapping (buffer length and slope). Model iterations were made over a 15-year period to represent the approximate life of these roads, but it is generally shown that the first year or so after construction represents the greatest erosion potential (Ketcheson and Megahan, 1996). The same climate parameters that were used in Disturbed WEPP were used for WEPP:Road.

WEPP Modeling Results

Erosion from Mine Disturbances

WEPP model predictions for existing conditions indicate that the potential for erosion of a 20-year-old forest on 45 to 55 percent slopes over a 30-year period of time is 3 percent, indicating that one out of 30 years would have erosion. For the same age forest on slope values of 15 to 25 percent, or slopes of 0 to 15 percent, would still only incur erosion approximately 3 percent of the time, or one year out of 30. Changing vegetation for the same slope classes indicates that shrub and grass cover could have erosion occur 70 percent of the time over the 30-year period, or 21 out of 30 years.

Existing slope values in the study area range from 0 to 55 percent, with only 19 percent of the area having slopes less than 20 percent. Approximately 10 percent of the area is in the 45 to 55 percent slope range, and 26 percent is in the 35 to 45 percent slope range. A significant portion of the area contains map units with a wide range of slopes, from 10 to 55 percent, or consists of rock outcrop or disturbed area. Slope values for reclaimed slopes under the Proposed Action and Alternatives would have a range of 1 to 45 percent slope with the majority of reclaimed areas incorporating a gentle 3:1 (Horizontal:Vertical) slope surface during regrading and reclamation activities. Vegetation in the area consists of mixed forests, shrubs, and grasses. WEPP predictions for existing conditions indicate that there would be a 0 to 3 percent probability of erosion, with an average annual upland erosion rate of 0.04 tons per acre.

WEPP predictions for interim vegetation establishment on disturbed mine areas indicate that there would be a 47 to 67 percent chance of erosion during the first three years of reclamation, with an annual upland erosion rate ranging from 0.472 to 1.420 tons per acre. The average annual upland erosion rate for all WEPP model runs for interim vegetation establishment is 0.78 tons per acre.

Disturbed WEPP predictions for successfully established vegetation on areas of reclaimed mine disturbance indicate an annual upland erosion rate that would range from 0.027 to 0.458 tons per acre, with a 17 to 40 percent potential for this degree of erosion to occur. The average annual upland erosion rate for all WEPP model runs for successful vegetation establishment is 0.17 tons per acre.

Sedimentation to Streams from Road Disturbances

The following table shows the WEPP:Road results for the Proposed Action roads and Alternative roads. These numbers show the estimated quantity of eroded material that would make its way through the buffer and into the stream; the predicted quantities of eroded material are also calculated by WEPP:Road, but are not presented directly here. The last row of this table provides a range of values that are +/- 50 percent, which represents the level of model accuracy. As noted above, for these applications of the model, the range is likely to be even greater because the road design differs significantly from model assumptions.

SEDIMENTATION TO STREAMS FROM ROAD EROSION (TONS OF SEDIMENT, ANNUAL AVERAGE)

STREAM	P.A. PANEL F HAUL	P.A. WEST HAUL	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT. 5	ALT. 6	ALT. 7	ALT. 8
SOUTH FORK SAGE	1.45	0.5	1.10	0	0	3.5	3.5	0.05	0	1.00
LOWER SAGE*	0.15	0	1.20	1.70	1.70	0	0	0	0.05	0
MANNING	0	0	0	3.75	3.75	0.90	0.90	0	0	0
DIAMOND	0	0	0	0	0	0	0	0	0	0
DEER	0	31.95	0	2.05	5.00	21.55	35.5	1.55	0	7.50
NATE	0	0	0	4.05	4.05	0	0	0	0	0
WELLS	0	0	0	0.05	0.05	0	0	0	2.60	0
CROW**	0	0	0	3.3	2.50	0	0	0	1.15	0
TOTAL	1.60	32.45	2.30	14.90	17.05	25.95	39.90	1.60	3.80	8.50
RANGE	0.8-2.4	16.22-48.67	1.15-3.45	7.45-22.35	8.52-25.58	12.98-38.92	19.95-59.85	0.80-2.4	1.9-5.7	4.25-12.75

*Contributed to Sage Creek downstream of South Fork Sage; does not include quantities listed for South Fork Sage.

**Includes quantities contributed directly to Crow Creek or to one of the small, unnamed tributaries to it; does not include quantities listed for the other named tributaries listed in the table.

Additional Analysis Using WEPP Results

Mine Disturbances

Erosion control is an effective long-term solution to conserve soil resources, whereas sediment control is a short-term remedy to minimize the impact of unavoidable erosion that occurs during the construction period. Calculated erosion figures as determined from the Disturbed WEPP model (USDA 2000) would be reduced or eliminated with implementation of applicable BMPs. Implementation of BMPs would reduce potential for water erosion, control sediment collected in surface runoff, and mitigate the potential effects of erosion and sedimentation. BMPs utilized would consist of measures for sediment collection, erosion control, runon/runoff collection, soil stabilization, slope stabilization on reclaimed areas, seeding and revegetation, overburden dump construction, and range management, including:

- Use of concurrent reclamation techniques and placement of topsoil/growth medium on a prepared surface to provide a suitable seed bed.
- Avoiding the creation of flat or concave surfaces on overburden surfaces to reduce infiltration.
- The placement of check dams in diversion ditches to break the momentum of surface water runoff and reduce the flow velocities.
- Grading slopes to 3H:1V or less in order to reduce the soil loss associated with steeper slopes.
- Regraded areas would be ripped and scarified to reduce soil compaction.
- Reclaimed areas may be fenced as needed to protect vegetation from livestock grazing during the first few years of establishment.

These methods stabilize the reclaimed slopes and facilitate achievement of post-reclamation objectives.

Road Disturbances

In order to account for the fact that a number of BMPs that would be implemented on the proposed roads could either reduce erosion, or reduce the amount of eroded material that can potentially pass through the buffer (by using sediment control up-gradient of the buffer), additional analysis beyond WEPP:Road modeling was done. First, the literature was searched to find documentation on effectiveness of various BMPs used in the most relevant types of applications and in an analogous environment.

Ketcheson and Megahan (1996) showed that forest roads in central Idaho that included maximum, intensive erosion control practices reduced erosion rates by 66 percent over similar roads with more typical erosion control. The USFS (1981) reported sediment traps below roads in Idaho that were estimated at 80 percent efficiency, and numerous other individual treatments with percent reduction in erosion of between 10 and 60. Numerous other authors have reported reductions in sedimentation from roads due to BMPs in the range of 75 to 88 percent (Burns et al, 1995; Burroughs and King, 1989; Belt et al 1992). Seyedbagheri (1996) provided qualitative and quantitative effectiveness information for road BMPs based upon many other researchers' work in Idaho; those results were wide-ranging, but the report generally showed that BMPs are effective. The roads for which these kinds of analyses are available are generally small scale forest roads rather than the very wide haul roads with large areas and volumes of disturbance, which are proposed here. Though the proposed alternate access roads and the proposed alternate conveyor road would have much smaller footprints than the haul roads, they too, are larger than most of the forest roads analyzed in the literature.

Next, using the above effectiveness information as a guide, a percent reduction assumption was made to apply to the Simplot Proposed Action and Alternative roads. As noted above, the scale of road disturbance is related to both unit erosion and transport, so BMPs may be inherently less effective than on smaller scale roads. Similarly, the rugged topography of many of the alternatives would also strain BMPs. Also as noted, WEPP:Road already accounted for graveling, fill slope vegetation cover, and cross drain use. Alternatively, Simplot's use of silt fences, sediment traps, windrows, etc., and a maintenance/inspection schedule that may be better than typical for forest roads, all need to be counted for their potential to reduce sediment loading. An estimate that the calculated erosion (not sedimentation) rates predicted by WEPP:Road could be reduced by 70 percent on haul roads and 75 percent on access roads due to BMPs not otherwise accounted for in the model seems reasonable.

One or the other of those percentage reductions were applied to each road reach in the analysis. Once reduced erosion rates, by reach, were determined, they were further reduced to account for the deposition in the buffer zone between the road and the stream. This latter reduction was done by applying the same percent reduction that resulted from the original WEPP:Road analysis. For example, if a given annual erosion rate on a haul road, as calculated by WEPP:Road, was 5,000 lbs, that number would be reduced to 1,500 lbs. If, in the original analysis, the entire 5,000 lbs was deposited in the buffer, with a resultant sediment loading of 0 lbs, the 1,500 lbs would similarly be reduced to 0. But, if the original analysis showed that 3,000 of the 5,000 eroded lbs reached the stream, the 1,500 lbs would be reduced by the same factor, with the final estimate of 900 lbs reaching the stream from that segment. The results of this analysis are given in the following table, which is also contained in Section 4.3 of the EIS. The implications of these results are described for each road in the appropriate EIS subsection.

REVISION OF SEDIMENT LOADING TO STREAMS FROM ROAD EROSION WITH BMP IMPLEMENTATION (TONS OF SEDIMENT, ANNUAL AVERAGE)

STREAM	P.A. PANEL F HAUL	P.A. WEST HAUL	ALT. 1	ALT. 2	ALT. 3	ALT. 4	ALT.5	ALT.6	ALT. 7	ALT. 8
SOUTH FORK SAGE	0.45	0.15	0.35	0	0	1.05	1.05	0	0	0.20
LOWER SAGE*	0.05	0	0.35	0.50	0.50	0	0	0	0	0
MANNING	0	0	0	1.20	1.10	0.25	0.25	0	0	0
DIAMOND	0	0	0	0	0	0	0	0	0	0
DEER	0	8.30	0	0.60	1.50	6.45	9.35	0.40	0	1.9
NATE	0	0	0	1.20	1.20	0	0	0	0	0
WELLS	0	0	0	0	0	0	0	0	0.65	0
CROW**	0	0	0	1.00	0.75	0	0	0	0.30	0
TOTAL	0.50	8.45	0.70	4.5	5.05	7.75	10.65	0.40	0.95	2.1
RANGE	0.25-0.75	4.22-12.67	0.35-1.05	2.25-6.75	2.52-7.58	3.88-11.62	5.32-16.00	0.20-0.60	0.48-1.42	1.05-3.15

*Contributed to Sage Creek downstream of South Fork Sage; does not include quantities listed for South Fork Sage.

**Includes quantities contributed directly to Crow Creek or to one of the small, unnamed tributaries to it; does not include quantities listed for the other named tributaries listed in the table.

Discussion of Results

It should be noted that the Disturbed WEPP model does not have provisions to allow for the implementation of BMPs, the degree of other coarse fragments in the soil, or other mitigative variables, which influence erosion and sedimentation. Disturbed WEPP also describes all vegetation in cropland format, which is not directly comparable to reclamation conditions. Rock fragment content over 50 percent is not accepted by WEPP. Above 50 percent, WEPP assumes there is not further impact from increased rock content. Many of the soils in the study area have naturally high coarse fragment content, which is not considered when running WEPP.

The sediment quantities estimated to enter streams from roads presented in the two relevant tables above should not be taken as specific values, but should be used to compare the alternatives. However, some sedimentation to area streams from the Proposed Action and from all alternatives should be expected. Although the BMPs may minimize or reduce this potential, it is not reasonable to expect that all sediment from mining operations and transportation routes can be kept from streams.

References

Belt, George H., O'Laughlin, Jay, and Merrill, Troy. June 1992. Design of Forest Riparian Buffer Strips for the Protection of Water Quality: Analysis of Scientific Literature. University of Idaho. Idaho Forest, Wildlife and Range Policy Analysis Group. Report No. 8.

Burns, Richard G., Huendo, Lucas Madrigal, and Neary, Daniel G. 1995. Low Cost Methods to Control Sedimentation from roads. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM:GTR-266, p. 121-127.

Burroughs, Edward R., Jr. and John G. King. July 1989. Reduction of Soil Erosion on Forest Roads. USDA Forest Service Intermountain Research Station General Technical Report INT-264.

Ketcheson, Gary L. and Megahan, Walter F. May 1996. Sediment Production and Downslope Sediment Transport from Forest Roads in Granitic Watersheds. USDA Forest Service Intermountain Research Station Research Paper INT-RP-486.

Seyedhagheri, Kathleen. October 1996. Idaho Forestry Best Management Practices: compilation of Research on Their Effectiveness. USFS Intermountain Research Station. General Technical Report INT-GTR-339.

USFS. October 1981. Guide for Predicting Sediment Yields From Forested Watersheds. Northern Region & Intermountain Region: Soil and Water Management.

US Department of Agriculture (USDA). 1976. Soil survey of the Star Valley area, Wyoming – Idaho, parts of Lincoln County, Wyoming and Bonneville and Caribou Counties, Idaho. Prepared by the US Department of Agriculture Natural Resource Conservation Service and Forest Service. In cooperation with Wyoming Agricultural Experiment Station and Idaho Agricultural Experiment Station.

US Department of Agriculture (USDA). 1990. Soil survey of the Caribou National Forest, Idaho. US Department of Agriculture Forest Service in cooperation with. US Department of Agriculture Natural Resource Conservation Service and. University of Idaho College of Agriculture.

United States Department of Agriculture (USDA). 2000. Disturbed WEPP, WEPP Interface for Disturbed Forest and Range Runoff, Erosion and Sediment Delivery. USDA Forest Service, Rocky Mountain Research Station and San Dimas Technology and Development Center. Draft February 2000. PDF file downloaded from the website, January 18, 2005. http:/forest.moscowfsl.wsu.edu/fswepp/docs/distweppdoc.html