Draft of April 1, 2003

Amendment #1 to:

Monitoring the Effectiveness and Validating Response to the Road Related Mitigation Practices Implemented on the Pikes Peak Highway

Summary of Proposed Changes to the April 2001 Study Plan

We are proposing several modifications to the monitoring effort that will be implemented to verify the effectiveness of the Pikes Peak road mitigation practices. These modifications do not reduce the scope or completeness of the monitoring plan but are intended to address the changes made in the proposed action plan for construction of road mitigation practices implemented on the Pikes Peak Highway (Burke 2002) that were not known when the current study plan was written. The following documentation only addresses that portion of the study plan affected by design changes.

Effectiveness Monitoring

1) Stabilizing Cut and Fill Slopes:

No proposed changes.

2) Highway Surface Stabilization (p. 4 in Plan):

Since Highway Surface Stabilization practices have been reduced to a single option (paving) there is little need to develop a design matrix to incorporate multiple surface treatments. Instead we now propose monitoring 2 - 4 segments located between stations 538-692 and 823-1044 and measuring pre-treatment erosion rates as originally proposed. Paving between these stations is not scheduled to begin until 2007 (USDA Forest Service 2000). It is assumed that once paving is complete, the erosion rates that may have occurred prior to paving will be eliminated after paving. The effectiveness of treatment will assumed to be the complete elimination of the pre-treatment erosion rates. Paved road surfaces will not be monitored for erosion.

3) Armoring Drainage Channels:

No proposed changes.

4) Sediment Ponds and Traps (p. 6 in Plan):

Initially, we proposed to monitor trap effectiveness as the combination of measured sediment accumulation in the sediment ponds and by measuring suspended sediment concentrations entering and exiting the pond in concentrated discharge. The combination of sediment accumulation in the pond plus the sediment exiting the pond in the out flow was considered to estimate total sediment transport. We will still survey sediment accumulation in the ponds, as proposed. However, in the revised design of sediment ponds, the pond collects “all” the water and sediment; the sediment will presumably settle out in the pond with only the water percolating out of the pond through a porous berm. Assuming the pond retains all the discharge long enough for the sediment to settle out, measuring sediment accumulation in the pond will estimate total sediment movement. In the event the pond cannot retain all the storm flow delivered to it, we propose to install silt fences on the downhill side of the traps to measure sediment not captured in the pond and carried in any excess discharge over topping the berm and exiting the pond. A silt fence is proposed because any over flow that occurs will be diffuse and not concentrated. We will use the same measurement protocol for these silt fences as employed for the cut/fill slope analysis.

5) Energy Dissipaters (p. 7 in Plan):

In theory, there are no changes to what was proposed in the study plan with respect to monitoring the effectiveness of energy dissipaters. However, recent revisions of the mitigation design call for greater concentration of road drainage from very long stretches of pavement and ditch line (as much as 2 miles) into single culverts. This will further reduce the total number of post mitigation culverts, or discharge points. These culverts will discharge into shotcrete lined conveyance channels that discharge into the sediment ponds mentioned above. The change in design reduces the number of culverts, and therefore conveyance ditches, available for study, thus reducing post treatment monitoring opportunities. Five "untreated" diversion channels currently exist (pre treatment) but 5 treated channels, as originally designed, may not be available after implementation of the mitigation practices. We propose to follow the monitoring study plan, to the degree possible, but changes in the mitigation practices may reduce the available sample size.

Validation Monitoring

No proposed changes.

Summary

The monitoring plan will be implemented as designed with the exception that a few adjustment in the monitoring procedures, as noted, are necessitated in response to proposed changes in project design. The road will be paved rather than surfaced and that should significantly alter the potential for continued surface erosion to occur from the road surface, after treatment. Monitoring will still evaluate the effectiveness of that treatment in comparison to what has been the historical erosion rate from road surfaces. Sediment pond design has been altered but the monitoring will still focus on monitoring total sediment exported in the discharge water, and the effectiveness of the mitigation practices in reducing that export. In essence, this amendment does not alter the monitoring objectives, it addresses minor changes in the design of the techniques used to meet the objectives.

References

Burke, M. 2002. Pikes Peak Highway drainage, erosion and sediment control plan. USDA Forest Service. Phase 2 Report version 1.4. 18 pp.

USDA Forest Service. 2000. Decision notice and finding of no significant impact – Pikes Peak Highway drainage, erosion, and sediment control plan. Pike and San Isabel National Forests and Cimarron Comanche National Grassland. Pueblo, Colorado. 16 pp.

March 28, 2003

Tentative 2003/2004 Work Schedule for the Pikes Peak Highway Monitoring Study

Work Schedule (2003)

3 weeks Reconnaissance and Site Selection (Nankervis/Belz - begin Mid April)
1 week Training (2 person field crew (Nankervis - Early May)
4 weeks Installation (2 person crew - Mid May)
17 weeks Monitoring (2 person crew – begin Early June, periodic oversight by Nankervis)
2 weeks Stream Survey (Nankervis/Belz - Late September)
3 weeks Data Organization/Analysis (Nankervis/Belz - Before end of year 2003)
2 weeks Semi Annual Reports (Nankervis - Submitted before end of 2003 and again prior to 2004 field season)

Reconnaissance

We propose a 3-week reconnaissance/site selection period to initiate this study. This is a multifaceted monitoring plan that will require careful consideration each site selected, whether along the highway corridor or near a stream. It is important to have both

Training

It is expected that we will hire a 2-person crew to carry out the monitoring effort from May through September. Initially, one week of training should suffice to familiarize the crew with the study objectives, study area, equipment installation, field survey techniques, data organization, and safety issues.

Installation

Four weeks of crew time has been allotted to install the silt fences, rain gauges, and establish the stream channel cross sections and benchmarks. The crew will start the monitoring phase as soon as installation is complete.

Monitoring

The 2-person crew will monitor responses for the balance of the field season. This will include maintaining records that include hard copy and electronic field and associated Meta data, taking and cataloging photographs, and conducting the various field surveys as required in the amended study plan. Throughout this phase, periodic visits by Nankervis (estimated at about 1 day every 3 weeks, or as needed) will provide oversight, guidance, and quality control will occur.

Stream Survey

The first stream survey will serve as the template for all future validation monitoring in the stream channel, and will be done by Nankervis and Belz in 2003. In future years, we expect that with 2-3 days of training, the 2-person crew would perform this task.

Data Organization/Analysis

The 2-person field crew will be responsible for maintaining the necessary written, electronic, and photographic records over the course of the field season. Nankervis will be responsible for annual summarization and report writing. Belz will be responsible for analyzing survey data and registering sampling locations, surveyed with the total station, on the design drawings by Knight Piésold Consulting. IMI will provide oversight on the entire project.

Reporting

Nankervis will responsible for submitting semi-annual reports to IMI for review and approval. One report will be submitted by December 31 of the study year and summarize field activity and study results for that year, and as such represent the annual progress report. The second report will be submitted prior to the field season, or by May 1, and it will address proposed activities for that year and function as the yearly work plan.

IMI will retain oversight on the entire project. This will include review and approval of all work plans and progress reports. IMI will also review, on a periodic and as needed basis, all field efforts.

Draft of 4/09/01

Monitoring the Effectiveness and Validating Response to the Road Related Mitigation Practices Implemented on the Pikes Peak highway

Introduction

The proposed actions presented in the Pikes Peak Highway Drainage, Erosion and sediment Control Plan Environmental Assessment (Hydrosphere Resource Consultants, Inc. June 25, 1999) have been designed to achieve the following goals:

- Stabilize road surface materials, cut slopes and fill slopes
- Reduce runoff velocities and dissipate erosive energy
- Collect runoff in armored ditches and conveyance channels
- Reduce erosion and sediment deposition in drainage channels
- Retain sediment in traps and ponds to reduce downstream sedimentation.

This document is intended to address the monitoring effort that could be implemented to verify the effectiveness of the road mitigation practices. There are three separate aspects to this monitoring. The first is Implementation Monitoring, which is the verification that the mitigation practices were properly implemented. We assume that the City of Colorado Springs and the U.S. Forest Service will do the Implementation Monitoring and we also assume that the road mitigation practices will be properly implemented. Thus, Implementation Monitoring is not part o this plan. This plan has been developed as part of the Settlement Agreement between the Sierra Club and the United States Department of Agriculture – Forest Service in Sierra Club v. Venneman, Civil Action No. 98-M-662 (D. Colo.). It is recognized that that the total budget for this monitoring plan is $930,026.00. If it appears at any time that activities under this monitoring plan will exceed that budget, then the activities will have to be adjusted in order to ensure that the total budget will not be exceeded. Although the details of each aspect of this monitoring program are subject to changes according to local site conditions and the range of mitigation strategies applied on different portions of the Pikes Peak Highway, any proposal to significantly alter or reduce the scope or completeness of the monitoring plan must be presented in advance of such actions to the Sierra Club's designated representative, and the Sierra Club has the right to actively participate in the discussions regarding the proposed alterations. Similarly, the Sierra Club's representatives may participate in the process of site selection and data collection, and data analysis as desired, or obtain copies of the field data forms and the data collected under this monitoring project.

The second phase of the monitoring program can be called Effectiveness Monitoring, which is monitoring to determine if the mitigation practice implemented was effective, and if so how effective, in achieving the goals. The 5 major goals, or objectives, of the road intervention/mitigation practices are listed above. The effectiveness-monitoring plan will be designed to determine how well the mitigation practices implemented contribute to meeting those objectives. Validation Monitoring documents how the properly implemented intervention practices influence the riparian, wetland and aquatic system.

EFFECTVENESS MONITORING

The following describes the study design we propose to monitor the effectiveness of road mitigation practices, implemented by the city of Colorado Springs and intended to control erosion and manage the erosive energy of the discharge from the Pikes Peak road.

Objectives

The monitoring effort will assess the effectiveness of the intervention techniques in meeting the goals and objectives of the Pikes Peak Highway Drainage, Erosion, and Sediment Control Plan.

The proposed actions that will be taken to attain the on-site goals will include a variety of practices that include stabilizing downhill fill slopes, armoring drainage ditches and conveyance channels, employing energy dissipaters at culverts and in conveyance channels, constructing sediment ponds and traps to remove sediment from discharge waters, and highway surface stabilization. The Monitoring Plan focuses on the determination of the effectiveness of those proposed actions, or Best Management Practices (BMP's), in meeting the design goals for the practice. The following is a monitoring plan that addresses each of the 5 proposed actions intended to reduce erosion and sedimentation, and discharge energy.

Stabilizing cut and fill slopes:

Stability on cut and fill slopes, and erosion reduction, may be achieved by reestablishing natural vegetation or through the use of geosynthetic erosion control netting, gunite, shotcrete, riprap, or the construction of various types of retaining walls. The best monitoring approach is to determine the effectiveness of these practices in reducing cut and fill slope erosion and subsequent sediment transport. Silt fencing installed at the base of the cut or fill slope will catch and retain the eroded material, or sediment from the slope. Comparing the rate of eroded material being trapped, over time, at the base of treated and untreated cut and fill slopes is the best measure of the effectiveness of the mitigation practice in reducing erosion. The basic monitoring protocol would be to install a 30-foot silt fence at the base of the cut or fill slope. Periodic measurements would be made of the volume of accumulated material behind the fence (e.g. after spring snowmelt and again after each large rainfall event). If the silt fence fills to the point of reduced efficiency, either the fence can be replaced, cleaned out, or a new monitoring site selected.

The cut slopes above the road will be monitored in the following way. A silt fence will be placed across the base of the cut slope just above the ditch line. A second silt fence will be placed above the cut slope to trap what is being delivered to the cut slope from the hill slope above. This will allow separation of the actual contribution from the cut slope and the contribution from the hill slope. The design for monitoring cut slopes could consist of 2 fences for each of 3 cut slopes for each of 5 implemented stability practices or treatments (no treatment, vegetation, netting, gunite, and retaining walls) for a total of 30 silt fences located on 15 cut slopes. Adding an additional treatment increases the number of sites by three and the number of fences by 6. This is the basic sample design we propose, realizing that as we gather response data and develop an estimate of variability in response, we can revise the sampling scheme and increase or decrease replications. Implementation of the mitigation practices will be by road segment. It is proposed that in advance of implementation the “monitoring team” review the BMP’s that will be implemented and tailor the monitoring design for that road segment to fit the existing conditions. Monitoring design could also include distributing control and pre-treatment sample points in road segments that will be mitigated in future years thus increasing the opportunity for increasing the variation in site conditions that are monitored as well as the length of pre treatment data. The monitoring scheme has to be robust as well as accurate. The most significant cost associated with this type of monitoring is for the personnel doing the installation and taking measurements.

A somewhat different scheme is proposed for monitoring effectiveness of practices applied to fill slopes. Although it also includes the use of 2 silt fences per site, the first fence will be placed at the base of the fill slope to trap what exits the fill slope while a second fence will be off set from the first and placed at the base of the hill slope on which the fill slope resides (or at the boundary of the 150 foot corridor associated with the road right away, whichever is the shorter distance). This pattern will allow catching eroded material as it leaves the fill slope as well as trapping sediment being delivered off-site or down slope. In this way, not only will the “on-site” effectiveness of the erosion control practice be evaluated but an estimate will also be obtained of the amount of eroded material that would have been attenuated down slope. A working design for monitoring fill slopes could be 2 fences per site for each of three sites times 5 fill slope treatments for each of 2 road surface treatments (e.g. paved, non-paved) for a total of 60 silt fences on 30 sites.

Initially we would anticipate estimating erosion from measurements of the accumulation behind all fences 2 - 3 times per year. The estimates of erosion and sediment delivery (cut slope, fill slope, and that attenuated down slope to the streamside or boundary of the 150 foot corridor) as well as estimates of “natural movement” estimated from what is trapped in the silt fencing placed above cut slopes, will allow separation of natural hill slope movement, erosion from and transport from cut and fill slopes, transport down slope and the effect of intervention practices, or BMP’s. Again, the team selected to do the monitoring will need to have some discretion in matching this proposal to actual site conditions. It is assumed that an estimate of natural or background rates of sediment movement will be estimated from the material trapped in silt fences installed above cut slopes. If the hill slopes above the cut slopes are disturbed or do not adequately represent all slope/soil/cover conditions, additional control sites will need to be identified to help define back ground sediment movement on the undisturbed hill slopes. The degree to which alternate sites may be needed cannot be defined until the primary sample sites are selected. The goal in monitoring the effectiveness of cut and fill slope stabilization practices is two fold. First, under a like set of conditions, we need to determine the effectiveness of the mitigation practice implemented to reduce erosion from cut and fill slopes relative to sites with no intervention. Second, we need to document erosion rates from treated and untreated cut and fill slopes and have a basis for comparing those rates with erosion from undisturbed hill slopes. In terms of effectiveness monitoring, it is most important to understand the effect the intervention practice has on reducing erosion that would have occurred from the disturbed surface. By knowing the background erosion rates, the potential impact of the disturbance and its mitigation on watershed degradation can be evaluated and used to provide a basis for prioritizing treatments.

A two-person field crew is needed to complete the necessary installations and surveys. Assuming 90 silt fences are installed for this aspect of monitoring effort, it would require 45 crew days to survey accumulation behind the silt fences 3-times per season. The crew can also assist in the surveys of the drainage channels and road surfaces to be described later. In addition to the annual expense for the field crew, a small operating budget is needed annually for materials to install new silt fencing at new sites as implementation of BMP's moves to new locations on the road system and to replace existing material as fences are filled or damaged.

Highway Surface Stabilization:

Measures will be taken to stabilize the road surface and to increase the strength, stiffness, and durability of that surface and reduce erosion. Measuring erosion from a road being actively used and subject to periodic maintenance is complex and costly. Road maintenance practices may move material from one place to another on the road; cast it onto the fill slope, or into the ditch line. We propose to monitor road surface elevation, as a surrogate for erosion, to document treatment effectiveness in stabilizing the road surface. Proposed treatments to reduce erosion include paving with asphalt or application of a surface treatment such as Roadbind or PennzSuppress. Uniform road segments (uniform treatment, gradient, contributing area for flow, etc) will be selected and paired with a non-treated segment. Survey cross sections will be permanently established at 5 intervals along road segments selected for study (number of cross sections may vary with segment length, perhaps one cross section per 20 meters) and periodically surveyed to determine the degree of erosion or deposition occurring in the cross sections. Individual cross sections will be identified and documented by the placement of a 3-foot piece of rebar driven into the road surface at the edge of the fill slope. A second piece of rebar will be driven into the cut slope above the inside ditch line. A permanently located base line elevation point will be established for each road segment and used as a reference for each cross section. Monitoring will consist of surveying the surface elevation, relative to the benchmark, of the road bed cross section (at 30 cm intervals across the transect). The survey will include a cross sectional survey of the ditch (the use for which will be discussed later). Averaging surface elevations from the 5 cross sections and multiplying by the length of the segment will yield an estimate of surface elevation. Comparing changes in surface elevation using repeated measurements, over time or between maintenance activities, yields an estimate of volumetric change in surface elevation and provides an estimate of erosion. It is critical that any addition of gravel or other material to monitored road surfaces must be documented and included in the mass balance. All maintenance activity in monitored road segments should also be documented and considered in evaluating changes. Measurements before and after maintenance can be used to estimate maintenance effect**.** Initially there should be at least 2 road segments sampled for each road stabilization practice (e.g. none, Roadbind, PennzSuppress). This basic sample of 2 segments (10 cross sections) would be replicated for each treatment applied as well as for any stratification variables of concern such as the number of surface material types present, the presence or absence of prolonged freezing on the road segment, etc. Again the labor cost is the greatest component. We feel that 2 measurements of each cross-section, per year, are all that are required; one measurement as soon after snowmelt as possible and the other at the end of tourist use. It would be of value to take additional measurements before and after any planned maintenance, if crew time is available. This may be too imprecise a measure to warrant more frequent measurement, but over time it will index the effectiveness of surface stabilization practices on reducing the loss of road surface material. The labor force for the surveys can come from the crews identified for other tasks and not more than 5 crew days, per year, would be spent on this effort. We do not plan to consider paving as a treatment as one would not expect erosion would occur from a paved road. However, it should be one of the surfacing practices used to stratify monitoring of the effectiveness of other mitigation practices such as ditch armoring, fill slope stabilization**,** or discharge management. To facilitate locating the transects in the future, the location of all rebar pins and elevation control points should be spatially referenced and documented using a GPS system.

Armoring Drainage Channels:

Drainage channels, both roads ditches and conveyance channels below culverts, will be lined (armored) with riprap or concrete to control erosion and deposition of sediment. Effectiveness monitoring will consist of selecting a sample of lined and unlined drainage channels, establishing cross sections in the channels to be periodically surveyed, and using measured changes in cross sectional area to determine if erosion or deposition is reduced in armored channels relative to unarmored channel. Although the monitoring technique will be similar for both ditches and conveyance channels, the sample size will differ.

Monitoring road drainage ditches should be stratified by at least 2 slope gradients, at least 2 contributing area (or precipitation amount) scenarios, and allow for differences in parent or road surface material. As with the road surface erosion transects, we can propose establishing 5 transects per channel condition (lined, not lined). Initially, sample size could be based on 5 transects times 2 slope categories (3 percent slope or less, greater than 3 percent slope) times 2 contributing area/ precipitation regimes (e.g. frequent culverts, infrequent culverts or 8000 ft elevation, 12000 ft elevation) and 2 material types for a total of 80 cross sections. It is assumed that the ditches surveyed as part of the road surface surveys could represent a part or all of the samples needed for this assessment. Additional sites would be located to complete the slope/area/material matrix. This design could be simplified to focus only on a single set of 5 armored and 5 non-armored channels of uniform condition. In the future, if visual evidence indicates contributing area, precipitation amount, or road surface or parent material may influence effectiveness of the armoring, sampling could be stratified to partition those effects. The cost of rebar used in establishing the additional cross sections is minimal and existing crews will supply labor for the surveys. By anticipating which ditches will be lined in future years, the effectiveness of the practice in reducing erosion and deposition can be better defined by obtaining cross section information at both treated and control sites for several years prior to treatment.

More important is the establishment of cross sections and monitoring mitigation impacts on armored and non-armored conveyance channels. It is these channels that are being eroded into gullies and may contribute most significantly to the sediment load in the wetland, riparian, and aquatic system. To the degree possible, multiple cross sections should be established in as many of the conveyance channels as possible. Some of these channels may also be subject to the proposed energy dissipaters. Depending on the length of channel, 3 to 5 cross sections should be established to document the effect of discharge and sediment transport on "channel" geometry. Sample stratification, in this case, will be presence or absence of armoring. See section on energy dissipaters for the sampling intensity and monitoring sequence.

Sediment Ponds and Traps:

Sediment ponds and traps will be installed to intercept sediment prior to reaching the stream corridor. Effectiveness will be monitored in two ways. First the ponds/traps will be periodically surveyed to document the amount of material actually trapped or retained within them. Second, water samples will be collected from incoming and exiting water to document trap efficiency. Efficiency will be estimated as the difference in concentration of the water flowing into the pond with the concentration in the water going out of the pond. The initial assumption is that the ponds are not large enough to cause significant differences in inflow/outflow rates, except at the onset of storms or events. Comparing trap efficiency with the amount of material trapped will also be a measure of overall effectiveness of the traps in reducing total sediment delivery downstream.

The pond surveys will require the establishment of permanent transects that can be revisited and resurveyed as a means of defining the surface of the pond floor. Incremental changes in that surface are a measure of the volume of sediment retained. A survey, before and after pond cleaning can be used to estimate the volume or amount of material removed. It can be expected a field crew can survey 2 to 4 ponds per day. The proposed budget requests a two person crew, one quarter time, to complete this task and to assist with the other survey needs. Surveys should be completed after spring snowmelt and again after significant rainfall events, perhaps a total of 4-times per year.

Water samples to estimate trap efficiency can be "grab samples" from the inlet and outlet of the ponds collected by personnel on either of the two crews requested. This assumes they are on-site or near by when the event occurs and we recommend they get as many grab samples as possible when they are on site. To compensate for their potential absence and to insure some estimate of pond efficiency is obtained, we propose that two ISCO, or similar, automatic water samplers be purchased and placed at the inlet and outlet of one of the ponds. After collecting efficiency data from a few storms, or for one season, at one location, the samplers can be rotated to another pond. Over time, the efficiency of all ponds can be evaluated. Cost of the samplers is estimated at $4000.00 per unit. The field crews can do the sample analysis. Approximately 10 days will be expended on pond surveys, another 15 days on sediment sample analysis.

The crew that will assess the effectiveness of the energy dissipaters (below) will be measuring velocity (and discharge rates) as part of their effort. If they are able to monitor discharge, through the sediment ponds and traps, the discharge data can be combined with the sediment concentration data and a mass balance can be performed and the overall pond or trap effectiveness in reducing sediment transport can be determined. We also suggest that two Aqua Rods be purchased to record the water level or stage in the conveyance channels. The discharge measurements made by the field crew can be used to develop a discharge-rating curve and the continuously recording Aqua Rod data can be used to estimate discharge when the crew is not present. Two Aqua Rods cost approximately $2000.00. It can be expected that 10 crew days will be dedicated to discharge measurements.

Energy Dissipaters:

Energy dissipaters, lateral extensions, and perforated manifolds will be used to reduce flow velocity, and energy, at culvert exits and in conveyance channels. It may be possible to monitor effectiveness of these practices at all implementation sites. A one or two person crew, using a Price AA or Pygmy velocity meter can measure the velocity of flow exiting the culvert or in the channel above the dissipater. The velocity of flow can be measured just below the dissipater and again as the flow exits the 150-foot road corridor, or at the confluence with the stream. Differences in velocity between the three points may be adequate documentation of the effectiveness of treatment in reducing discharge velocity. More important is the effectiveness of the practice in reducing scour. It is apparent that some of the culvert discharges enter what have become gullies. We would also propose to monitor the conveyance channel cross sections in those gullies to determine if the reduction in velocity (assuming it occurs) is reflected in a reduction in channel scour. Cross sections, as for the armored channels, will be established at each velocity monitoring point as well as intermediate points. The combination of knowing the cross sectional area and velocity can be used to estimate discharge. A sampling of 5 treated and 5 untreated conveyance channels may be adequate to determine the effectiveness of the energy dissipaters, especially if 5 new sites (control) are added each year as 5 more are treated. Treated channels will be monitored for several years after treatment (long enough to document effect). If possible, stratification should also include presence or absence of armoring. Mitigation may include energy dissipaters and armoring such that the two cannot be separated. The two-person crew can be the same crew used to sample and survey sediment in the ponds and it is expected that a total of 30 crew days would be spent measuring discharge and surveying cross sections. The AA meter would have to be purchased at a cost of $2400.00.

Summary of Effectiveness Monitoring

Information from monitoring erosion on cut, fill, and undisturbed slopes should yield an estimate of current erosion rates from those sources. Monitoring the effectiveness of cut and fill slope stabilization practices in reducing those erosion rates will allow estimation of the reduction in erosion from those sources. Estimating sediment delivery from the hill slope to the corridor boundary or to the channel is also possible for undisturbed and treated and non-treated disturbance conditions. Although estimates of road erosion will also be made from changes in road surface elevation, this material will not be considered a separate source because it will be re-measured as part of the fill slope component or that which is retained in, or bypasses, the sediment traps. The sediment trapped in ponds, plus the estimate of bypass, most likely represents what comes off the cut slopes, roads, and from the ditch lines. Channel scour, below water diversions and above or below ponds or traps is also being estimated. The sediment concentration of the discharge water and therefore its sediment load, and its energy, as it exits the corridor and enters the stream are also being monitored. In total, the observations will allow determination of whether or not the mitigation practices being implemented are effective in achieving their purpose of retaining soil on-site and reducing sediment delivery to the channel. The monitoring will not document, or validate, the impact of the mitigation practices in-channel. However the effectiveness monitoring will allow estimation of the reduction in sediment delivery and discharge energy being delivered to the riparian/wetland/aquatic system that will occur as a result of the mitigation practices.

Data management, and real-time evaluation of monitoring design and technique is critical to long-term success of the effort. The “monitoring team” must provide an annual report at least one month prior to the next field season that summarizes the results of the previous year and outlines the proposed actions for the coming field season. In addition to addressing BMP effectiveness it should also address sample adequacy (sample size, sample frequency, sources of variability, etc). Three copies of this report will be provided to the designated representatives of the Sierra Club.

The two crews requested, if their time is dedicated to the project, can accomplish the fieldwork in approximately 100 crew days per year. An additional 15 crew days are needed for suspended sediment lab work. It can be expected an additional 15 crew days are needed for data base management. Effectiveness monitoring will require a total of 130 two-person crew days once the monitoring locations are established**.** Some additional help in the first two field seasons may be needed in order to establish all the monitoring sites in time to ensure that valid data are being collected in the second field season after this monitoring plan is approved.

The study design, as proposed here is generic and should be tailored to the specific site. However the cost estimate, derived for a study of this magnitude, appears reasonable. Most all of the cost is in labor and tradeoffs can be made between the frequencies of repeated measures versus the number of sites measured. More instrumentation can be added, or deleted, as the monitoring progresses. However, the basic monitoring protocol can be implemented and maintained for the funds requested. In addition, we have proposed to monitor precipitation at 1000-foot elevation zones, requiring 3 recording precipitation gauges at a cost of $1700.00 each.

VALIDATION MONITORING

Validating the effect the proposed road restoration practices have on aquatic, wetland, and riparian conditions is much more difficult than determining the effectiveness of the mitigation practice in reducing erosion and sedimentation on-site. On-site response to the mitigation practices should be direct, dramatic, and occur in real time. Off-site response is likely to be much more diffused, less dramatic, cumulative in nature, and subject to offsetting degradation from elsewhere in the watershed, all of which make detection of the mitigation response difficult. It would appear that the watersheds of concern have been subject to, and reflect the cumulative effect of, road related impacts that have been ongoing for over 80 years. If one assumes the existing degradation is the aggregate result of long-term road related discharge and sediment pulses, the interruption of those pulses as a result of road rehabilitation, might be too insignificant to be detectable in the near term. Because the off-site response to the road improvement practices can be expected to be subtle and occur over a long time frame, the choice of the metrics to be monitored to document change down stream is critical if Validation Monitoring is to have a reasonable chance of success in documenting long-term improvement in the aquatic, wetland, and riparian environments.

In 1994, Snyder and others (Snyder, et al 1994) proposed a Pikes Peak Highway Erosion and Sedimentation Study to the City of Colorado Springs. More recently, ERO Resources Corporation (1999) proposed a Water Quality Monitoring Plan for the watershed to Pikes Peak America's Mountain, operators of the Pikes Peak Highway. The water quality plan was proposed as a means of validating the effect of the proposed road mitigation practices on water quality related issues in the watershed. Some preliminary data was collected, as part of both proposals and preliminary results from both studies are not very conclusive in documenting the key parameters that should be monitored to document change. Based on those preliminary assessments and other observations in the watershed (Chavez et al 1993), it would appear that impacts from the Highway are most directly impacting channel morphology (dimension, pattern, and profile), particle-size distribution in the channel and bank material, bank stability, and vegetation diversity and composition. Preliminary observations from the above studies confirm there are differences in the channel geometry, particle size distribution, and vegetation between the disturbed and undisturbed systems and would propose that they represent the suite of indicators used to validate change, hopefully a change for the better. At this point, we are not proposing that either suspended sediment, bedload transport, water chemistry, or stream biota be intensively monitored. Although each of these can be considered extremely important indicators of watershed condition and stream health, they are costly to obtain, quite variable, climate dependent, and as the preliminary data indicated, difficult to differentiate as a function of disturbance.

A suite of tributaries in the Pikes Peak Watershed has been identified as either impacted or non-impacted by the presence and maintenance of the Pikes Peak Highway. ERO Resources Corporation (1999) identified North Catamount, South Catamount, Oil, and Boehmer Creeks as reference or non-impacted streams. Ski, Severy, East Fork of Beaver, North Fork of Crystal, and West Fork of Beaver Creeks were identified as stream systems impacted by the highway. We propose to use the same streams, and the same disturbance classification, for validation monitoring. We are assuming that the Effectiveness Monitoring program will result in an estimate of the reduction in sediment supply and the effect on discharge energy that occur following implementation of the road mitigation practices. Depending on the magnitude of the reduction in the amount of sediment delivered to the river system and changes in discharge energy, we may be able to document changes in channel morphology and riparian condition that also occur as a consequence.

Objective

The primary objective of the Validation Monitoring program will be to document whether or not the effect the road mitigation practices have on sediment and energy supplied to the aquatic, wetland, and riparian area contributes to or detracts from their long-term sustainability. Both reference and impaired sites will be monitored. As noted above, five streams have been identified as being impaired by road related impacts. Four streams are considered unimpacted by the road. Monitoring will occur in all nine streams with the expectation that any change in condition observed in the impaired watersheds that might be attributed to road mitigation practices will not be observed on the reference watersheds (i.e., those not influenced by the Highway or the mitigation practices). The absolute differences that may or may not exist between the four reference and five impaired stream systems, at the start of monitoring, will not necessarily be attributed to road related impacts. Instead, any long-term trends in convergence or divergence in condition that occurs following road mitigation will be evaluated as an indicator of mitigation response. No attempt will be made to document what factors, natural or human induced, have accounted for current "departure" in the aquatic, wetland, and riparian components of the disturbed and undisturbed watersheds. Validation monitoring will allow documentation of the influence that any reduction in sediment supply or discharge energy resulting from the road mitigation practices may have on current condition.

Monitoring design:

We propose that validation monitoring focus on a "Channel Reach" as the scale or scope of measurement. Within each reach selected, channel morphology, bed and bank particle size distribution, bank erosion, and vegetation diversity will be monitored and characterized. Two or more reaches will be selected in each of the nine streams identified above and the monitoring will be conducted in each stream reach for the entire 15-year study period. This will result in more pre-treatment data for some disturbed stream reaches and more post-treatment data in others, depending on the timing of road mitigation in the watersheds contributing to each of the streams. Most measurements will be taken only once a year, so sampling frequency will not be that intensive and cost will be minimal. The techniques proposed by Harrelson et al (1994) should be used to establish the stream channel reference sites. The selected stream reach should be at least one hundred meters in length, if conditions allow, and contain several meander lengths or riffle-pool-riffle complexes if existent. This will allow several measures of cross section, bank erosion, vegetation complexes, and at least one particle size count determination in each reach.

Two reaches should be selected in each of the nine streams. One of the reaches should be close to the Monitoring Site selected for the ERO resources Corporation (1999) water quality study. This will allow integration of data, assuming that study continues. Care must be taken to avoid impacting their monitoring site. The second study reach should be located as close to the road mitigation activity as possible, as long as the site is outside the 150-foot buffer zone associated with the road. The study reaches must be carefully selected. In the disturbed watershed, reaches should be selected that are impaired, as evidenced by absence of expected aquatic flora and fauna, degraded wetland or riparian area, sediment laden, etc. Reference reaches, in the undisturbed streams, should be selected to be similar in character to what might have been present at the disturbed reach, had it not been disturbed. Factors such as similar watershed area, channel gradient, geology, etc. should be selection criteria. Depending on the degree of departure in the impacted system, stream type may or may not be similar. A benchmark survey point, consisting of a permanent mark on a stable rock formation or a concrete piling, should be established for each reach and used as a reference location for the following measurements (Harrelson et al., 1994).

Channel Cross-sections:

Five channel cross-sections should be located and permanently referenced in each study reach following the selection and installation criteria in Harrelson et al. (1994). The purpose of the cross sections is to document any changes in channel cross sectional geometry as a means of assessing long-term channel stability. Five cross-sections per 100 m reach should provide an indication of change in geometry should it occur. In addition, longitudinal surveys of the channel thalweg between cross-sections can be made to document surface water and thalweg slope (Harrelson et al 1994). Over time, changes in width depth ratios, thalweg elevation, longitudinal profile or channel gradient, etc., resulting from road mitigation impacts on sediment supply or discharge energy, can be documented. The cross-sections will be surveyed each fall and changes in channel geometry documented. The bankfull discharge elevation will also be identified at each cross section survey and used to calculate the width depth ratio.

Pebble Counts:

If the road mitigation practices are effective in reducing the discharge energy and sediment delivery to the channel system, and no offsetting responses occur, we would expect the percentage of fine particles in the stream channel bed to reduce over time. Comparing the particle size distributions from successive particle size surveys, to document trends in the percent fines, will be useful in defining one aspect of the in-channel impact of the reduction in sediment supply or discharge energy. To help support this aspect of the validation monitoring, the particle size distribution of the material caught in silt fences (below disturbed an undisturbed conditions) and in sediment traps should determined and compared with what is determined to comprise the bed material. The Bevenger and King Pebble Count Procedure (Bevenger and King, 1995) will be used in the study reach to document percent fines. This survey would be done annually at all sites. The Bevenger and King Pebble count is taken along a zig-zag pattern that goes up the channel and crossing from bank to bank. We recommend 300 particles be sampled in each survey, one survey per reach, repeated annually in late summer. The advantage to this pebble count approach is that it will yield an average particle size distribution for the reach that will not be subject to periodic changes in morphology that might occur as a response to the effects of road mitigation.

Bank Erosion:

To some degree, the occurrence of bank erosion will be documented through the cross-section surveys if the channel is actively migrating laterally or down cutting. However, the bed and bank features should be displayed in a map of the reach (Harrelson et al., 1994) as well as through the use of permanent photo points. In each reach, measuring and comparing the lengths of the banks that are stable vs. actively eroding can quantify the proportion of eroding banks. These procedures will document the presence and extent of areas of bank erosion and other features such as vegetation complexes. If the study reach contains areas of significant bank erosion, bank pins can be installed to measure the lateral rate of erosion. Installation of such pins is only warranted if erosion appears to be active and severe in certain locations within the reach or if erosion begins to occur during the monitoring period. Over the long term, the five cross-sections located within a 100-meter reach should index channel and bank stability by documenting changes in channel geometry and location.

Vegetation:

Longitudinal transects monitoring vegetation composition, density, and cover should be established to document trends in specie composition and cover as the riparian and wetland areas heal. Plots can be established along the survey lines to document plant composition and density over time. As the wetland and riparian areas heal, the composition of willow and other species should increase. Hopefully the reference reaches located along the undisturbed streams will contain examples of the native vegetation complexes that can be used as a reference. Again the intent is not to determine the degree of departure that current conditions represent from what one might expect, but instead to document the evolution or transition that occurs as the disturbed streams respond to the effects of road mitigation.

Summary of Validation Monitoring

Nine separate streams have been identified in the Pikes Peak watershed. Five of the nine streams are considered disturbed as a result of the presence of the road while the other four are considered relatively pristine, or unimpacted. Monitoring with equal intensity is proposed for all nine streams. Two reference reaches will be located in each stream with five permanent cross sections established in each reach to document changes in channel geometry over time. A single, longitudinal, zigzag pebbles count will be taken in each reach, in each year to document changes in the percentage of fine particles. Longitudinal surveys of the channel profile between cross-sections will further document changes in channel geometry. The 5 cross-section locations can be used as the anchor points for permanent vegetation monitoring transects along the connecting banks. A map of the reach, and permanent photo points located at each cross-section, will provide control for assessing bank erosion, channel stability, and vegetation response. All parameters will be measured once a year and all sites established in year one or two (establishment costs will be slightly higher than re-measurement costs so the initial cost could be spread over two years). Analysis will be fairly simple and consist of comparing trends in the response of metrics between the disturbed reaches and the comparable undisturbed reaches, over time, as the mitigation of the road related disturbance factors continues. We assume that it will consume 1 crew day to survey each stream (two study reaches) each year and an additional 1/2-crew day to characterize the vegetation and take photos at each stream. In total, approximately 15 to 20 crew days will be spent on this aspect of the monitoring. Again, all reference points should be geo-referenced and documented using the GPS system. A total station survey instrument will be needed to do the surveying.

As noted above, this monitoring proposal opts away from sampling stream biota, water chemistry, suspended sediment, or bedload movement. The indicators or metrics chosen for monitoring, should respond “positively” to the effects of road mitigation. At the same time they are less costly to obtain and since we can assume that any changes in the aquatic, wetland, and riparian areas will take a long time to occur, and therefore document, a simple, less costly monitoring program has a better chance of being sustained. Also, simpler more straightforward measures are more easily replicated over time and require less technical skill to implement. If the proposed mitigation practices unexpectedly result in negative impacts on the channel, the metrics chosen for monitoring should reflect those responses as well. The reality is that the road mitigation practices may do exactly what they are designed to do on-site but not have the desired effect in-channel; at least not initially. For example, if sedimentation is reduced and cleaner water is delivered to the channel, sediment transport may not be reduced and it may even increase to the point where channel geometry is altered. The same would be true if flow volume at one discharge point is increased because the number of discharge points is decreased with the resultant flow increased at some points of diversion. In almost any scenario the in-channel effect will be slow to occur and over time the metrics chosen should be useful in documenting the change that does occur in a least cost approach.

As in the case of the effectiveness monitoring, the timely analysis and reporting of the data is crucial to evaluating the effects of the Highway on the resources of concern as well as the efficient design and implementation of the validation monitoring program. As part of the annual report mentioned under effectiveness monitoring, the “monitoring team” must summarize the results of the previous year’s monitoring and outline the proposed actions for the coming field season. This report should contain an evaluation of the adequacy of the selected metrics and sample adequacy (sample size, sample frequency, sources of variability, etc), and at least qualitatively link the observations at the validation scale to the mitigation actions undertaken and the results of the effectiveness monitoring.

SUMMARY OF EFFECTIVENESS AND VALIDATION MONITORING

It is expected that the Effectiveness Monitoring of the road mitigation practices will reduce the amount of sediment delivered to the aquatic, wetland, and riparian systems and that the relative amount can be documented. In addition, the energy of the road-related flow discharges should be reduced. That will also be documented. If necessary, mid-course recommendations on changes in mitigation practices could be made and adaptive management implemented. In addition, the fundamental response of the aquatic and near aquatic environment to those changes will be monitored and documented as well.

A Team Leader and a Project Manager will provide oversight to the monitoring program. They could be one in the same or they could represent the mechanism by which one organization has the lead responsibility for the monitoring effort (Project Management) and a second group could implements the monitoring plan. Making the assumption the project will be contracted to another Federal agency, to a University, or to the Private sector, overhead has been included in the cost estimates. One 6-month and one 3-month field crew will conduct field and laboratory measurements. Approximately 145 crew days have been committed to the sampling described in the monitoring plan. Approximately 20 crew days are in reserve for leave time, training, and unforeseen occurrences. **It is** likely that this reserve time, and possibly some additional help may be needed in the first two years in order to establish and document all of the specified monitoring sites. The timing of the installation of the effectiveness monitoring sites will depend on when the road reconstruction actions are initiated, but data collection from all the baseline (control) sites and all of the validation monitoring sites should begin in the first monitoring season. The entire monitoring plan should be in place by 30 June 2002, subject only to the constraint that not all of the mitigation techniques may be in place at that point, and thus not available for monitoring.

The need to rapidly implement the monitoring plan, when combined with the estimated equipment costs of approximately $25,000, means that the funding for this monitoring plan should probably not be equally distributed over the entire time period. Allocating a greater proportion of the total funds for the first portion of the monitoring period also makes sense because the initial data are critical to optimizing the design of later Highway mitigation efforts. The monitoring data collected in the last couple of years of the program will have much less potential utility, and it may make sense to begin scaling down the monitoring program according to the consistency and completeness of the data collected to that point. Hence the initial establishment of the monitoring program should not be constrained by the average annual cost that might be determined by dividing the total cost by the expected duration.

References

Bevenger, Gregory S. and Rudy M. King. 1995 A Pebble Count Procedure for Assessing Watershed Cumulative Effects. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Research Paper RM-RP-319. Fort Collins, CO 17pp.

Harrelson, Cheryl C., C. L. Rawlins, and John P. Potyondy. 1994. Stream Channel Reference Sites: an Illustrated Guide to Field Technique. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Genera Technical Report RM-245. Fort Collins, CO 59pp.

ERO Resources Corporation. 1999. Pikes Peak America's Water Quality Monitoring Plan. ERO Resources Corporation, Denver , CO Unpublished Report. 23pp plus Map and Appendix.

Snyder, Gail, Robin Anderson, and Thomas Huber. 1994. Pikes Peak Highway Erosion and Sedimentation Study. Report submitted to City of Colorado Springs, Department of Transportation. Prepared by University of Colorado. 123pp.

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Tentative Budget*

Year 1 – Equipment Needs

Water Samplers	2 @ $4000.00	$8000.00	
Silt Fence	1080 ft @ 0.30	$ 325.00	
Rebar	½ in @ 500 ft.	$ 500.00	
AA Meter	1	$2400.00	
Rain Gauges	3 @ $1700.00	$5100.00	
Aqua Rods	2 @ $1000.00	$2000.00	
Total Station	1 @ $10,000	$10,000.00	
GPS Unit	1 @ $12,000.	$12,000.00	
Total Equipment			$40,325.00

Labor in year 1	$40,000.00	
Overhead is	$12,400.00	
Total first year costs		$92,725.00

Year 2 – 15 Expenses

Labor plus overhead is the same	$52,400.00	
Equipment (12% of first year cost)	$4839.00	
Annual cost years 2-15	$57239.00	
Total cost for years 2-15		$801,346.00

There is about $39,000 left for inflation.

* It is assumed the budget is somewhat flexible in that is may be necessary to expend more money up-front to initiate the monitoring plan.