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Recommendations for Restoration and Rehabilitation of Turbidity and Sediment Impacts to the Sylvan Pass Hydrologic System

Yellowstone National Park

Natural Resource Report NPS/NRPC/NRR—2008/054

ON THE COVER
Floroscene dye in Mammoth Crystal Springs, Yellowstone National Park
Photograph by: David Susong, U.S. Geological Survey, 2005

Recommendations for Restoration and Rehabilitation of Turbidity and Sediment Impacts to the Sylvan Pass Hydrologic System

YELLOWSTONE NATIONAL PARK

Natural Resource Report NPS/NRPC/NRR—2008/054

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Executive Summary

This report represents the consensus findings of an independent team of hydrogeologists, hydrologists, and a wetlands scientist on the source of sediment causing turbidity that has been and continues to be discharged through the Sylvan Pass Hydrologic System to Mammoth Crystal Springs. The team offers recommendations to remediate and restore the system to as close a naturally functioning system as possible. There is consensus that a strong correlation exists between past and current turbidity events observed in ground water discharge, and down gradient surface water bodies in Sylvan Gulch, and sediment generated by rock quarrying and gravel crushing operations (an anthropogenic source) located at Sylvan Pass in Yellowstone National Park.

The team recommends that temperature, specific conductance, turbidity, stage, and climate data continue to be collected by the existing monitoring system. In addition, interim strategies that are relatively non-intrusive and can be easily incorporated as a part of the final restoration plan for Sylvan Pass should be implemented. The approaches that are favored are those that utilize practices and structures that will reduce the infiltration of surface water into the talus over suspected discharge points of the sediment. The focus is primarily in areas where washing of gravel is believed to have occurred or where subsequent investigations and mapping can determine that these activities probably occurred. Also favored is further encapsulation of the remaining crusher fines at the site where a more easily mobilized clay size component of the material is more abundant.

The team further recommends that the aquatic habitats of Mammoth Crystal Springs be restored as soon as possible. This should be done after completion of the road realignment project and after it has been determined that the release of residual anthropogenic fines from the disturbed site and those fines currently lodged in talus will no longer accumulate in the Mammoth Crystal Springs pond.

Introduction

The Water Resources Division was charged by Yellowstone National Park (YELL) management with organizing and coordinating a group of groundwater and wetland scientists and an engineer in an effort to evaluate restoration and remediation options for the surface water and groundwater that have been impacted by sediment discharges to the Sylvan Pass Hydrologic System. The team consisted of the following individuals:

Pete Penoyer – Hydrogeologist, National Park Service Water Resources Division
Gary Rosenlieb – Hydrologist, National Park Service Water Resources Division
Dr. Kevin Noon – Wetland Scientist, National Park Service Water Resources Division
Mike Wireman – Regional Ground Water Expert, USEPA Region 8, Denver, Colorado
John Thackston – Senior Hydrogeologist, URS Corporation

The team traveled to Sylvan Pass and conducted a site inspection on October 11, 2007. On October 12, a panel discussion was convened among the team and YELL staff at Park Headquarters at Mammoth Hot Springs to discuss the observations made during the field trip and site restoration and remedial/mitigation options for Mammoth Crystal Springs (MCS).

Background

This report is one of several that have been prepared concerning the fate and extent of fine sediment, its transport and potential deposition, and the associated turbidity imparted to ground and surface waters that flow through Sylvan Gulch below Sylvan Pass. Previous investigations by Cornforth Consultants (2005), Heasler (2005a, 2005b), Heasler et al. (2005, 2006, 2007), preliminary study results from sediment coring of MCS by a team led by Montana State University researchers (2007), various trip reports (Rosenlieb et al., 2006, 2007), data collected by a hydrologic monitoring network installed by the USGS in 2006, and a compilation and synthesis of information from all of these reports by Penoyer and Rosenlieb (2007) were reviewed by the expert team and affirm the general conceptual model. That is, multiple lines of evidence now indicate a strong correlation exists between recent elevated turbidity events observed in groundwater discharge to Mammoth Crystal Springs (that are sometimes also apparent down stream on Middle Creek) and an anthropogenic source of the sediment. Bioassessments and water quality sampling of Middle Creek and Mammoth Crystal Spring conducted by YELL staff (2002-2005) indicate that the increased sediment load in groundwater discharge has drastically impaired the water quality in this tributary drainage of Middle Creek. In particular, the aquatic invertebrate assemblage of Mammoth Crystal Springs had become highly degraded, largely due to the high percentage of silt cover (>75%) (Arnold and Koel, 2006).

The Sylvan Pass Hydrologic System is located seven miles inside the East Entrance of YELL and approximately 60 miles west of Cody, WY (Figure 1). Subsurface (groundwater) flow best

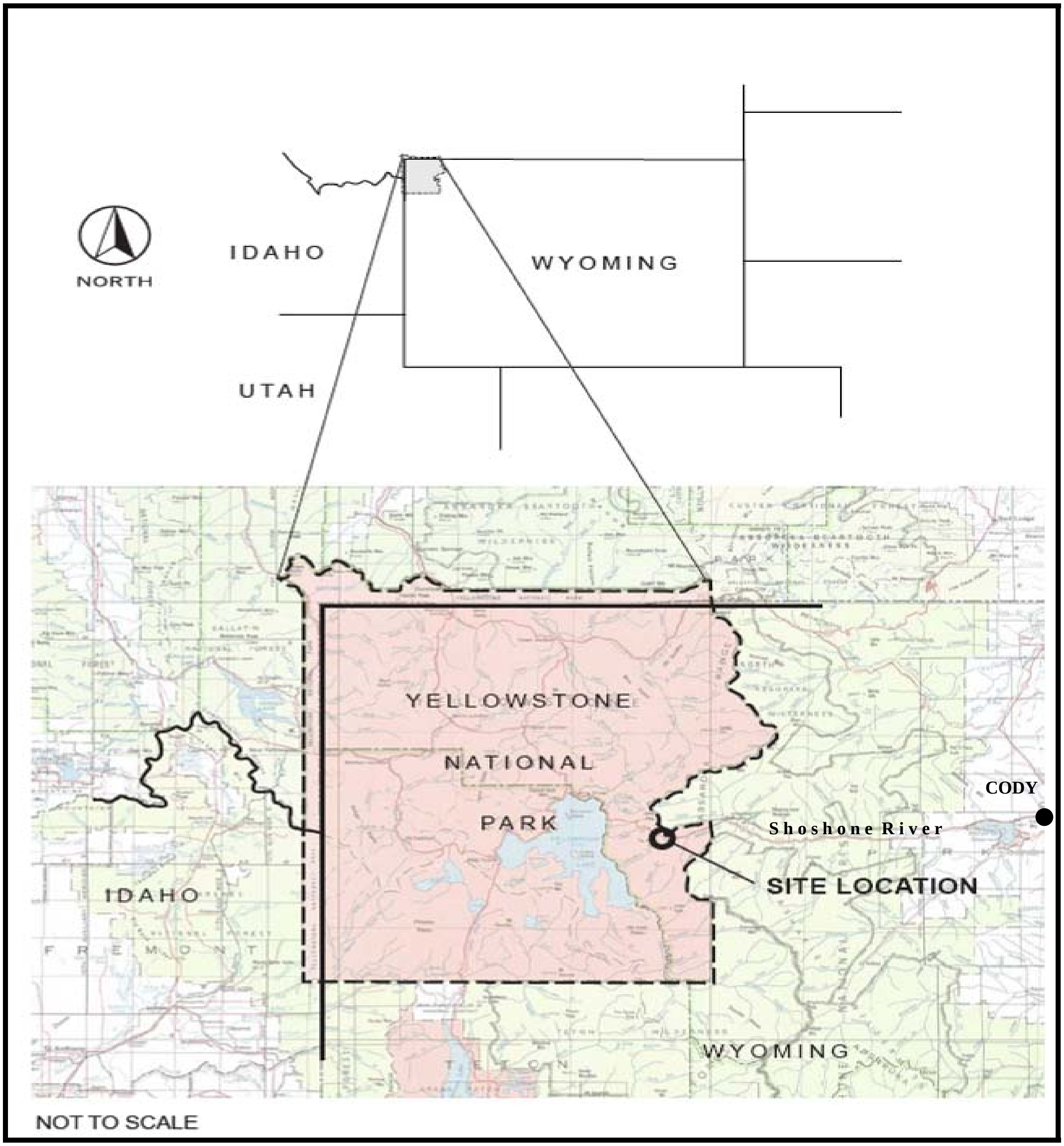


Figure 1. Vicinity and site location map for the Sylvan Pass Hydrologic System (modified from Conforth Consultants, 2005).

characterizes the site (Figure 2), which is situated within a talus-filled glacial valley (Sylvan Gulch) that heads at Sylvan Pass. Water movement at the surface is largely absent across the coarse talus below the pass. Instead, groundwater flows through Sylvan Gulch predominately by way of an underground stream along the bedrock surface/contact at the base of the talus. Dye tracing indicates the underground flow through the coarse talus beneath the pass is rapid and in a southeastward direction (Heasler, 2005a). In addition to key site topographic features, Figure 2

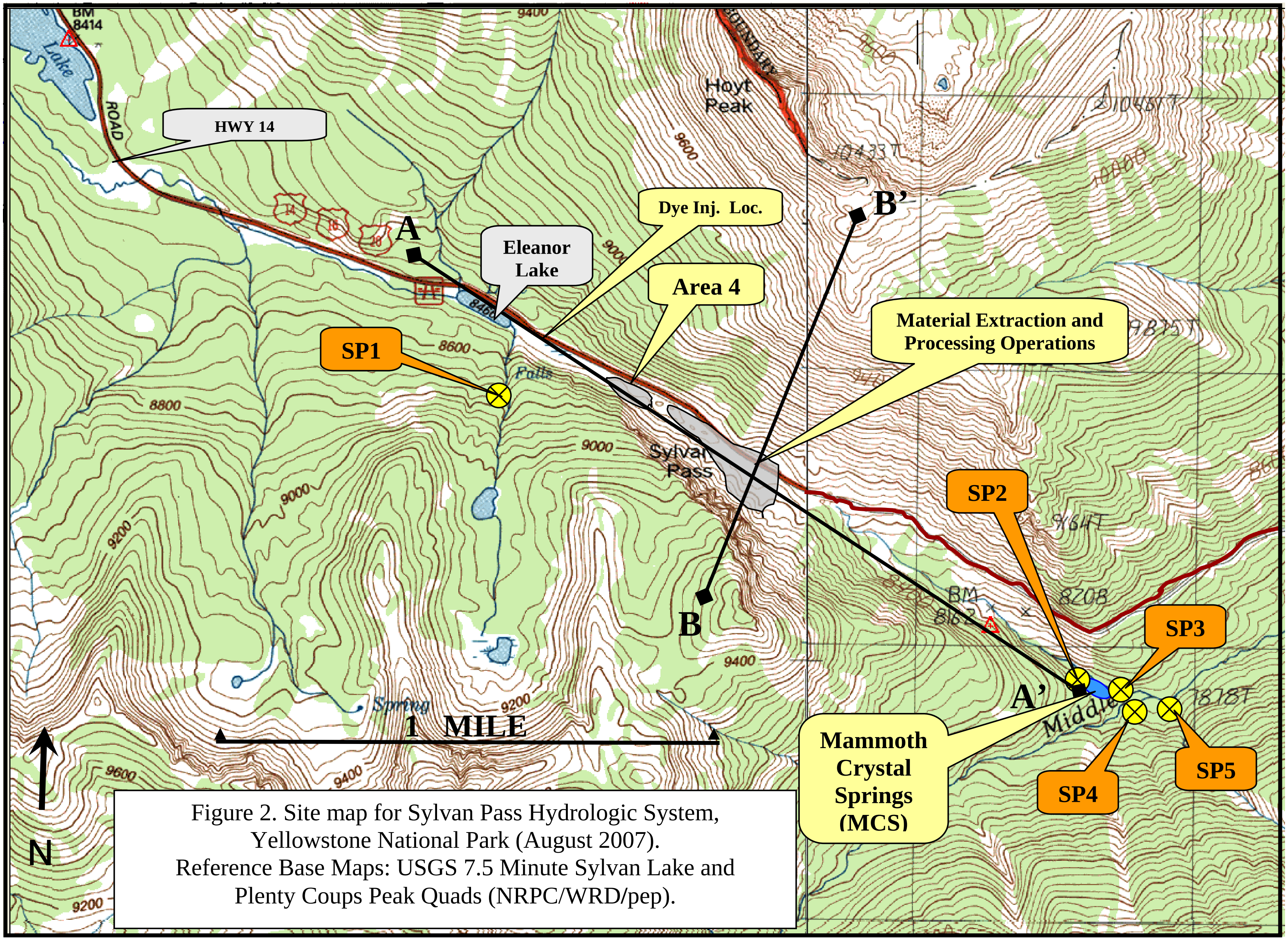


Figure 2. Site map for Sylvan Pass Hydrologic System, Yellowstone National Park (August 2007).
Reference Base Maps: USGS 7.5 Minute Sylvan Lake and Plenty Coups Peak Quads (NRPC/WRD/pep).

also depicts the surface water stations (SP1 – SP5) used to monitor the hydrologic system.

Also based on dye test results, this NW to SE flow occurs beneath the topographic divide of Sylvan Pass and likely originates at a bedrock divide (high) nearly 1 mile away on the NW side of the pass. A bedrock divide is inferred near Eleanor Lake. The underground stream discharges via contact spring (talus on volcanic bedrock) to a spring pond, or Mammoth Crystal Springs (MCS) located on the SE side of the pass.

MCS and its short, unnamed, outflow stream are tributary to Middle Creek, which is tributary to the north fork of the Shoshone River. The interpretation of site subsurface conditions resulting from dye tracing and other site studies is depicted in the conceptual site hydrogeologic model shown in Figures 3A and 3B.

Historic and more recent rock quarrying and crushing operations for road aggregate at Sylvan Pass, along with disposal of waste fines at/near the top of the pass, has impacted the hydrologic system by increasing significantly the suspended sediment load that is transported by groundwater through the talus and subsequently discharged to surface water (MCS) on the NE side of the pass. While historic increases in sediment loads and turbidity appear to coincide with discharges of highly turbid wash water from gravel processing operations first noticed and reported in 2004 (Heasler et al., 2005), some anthropogenic sediment loading to the system continues to occur since gravel washing was discontinued. This elevated turbidity and sediment loading occurs in association with slug flows from spring runoff and more intense summer precipitation events (Penoyer and Rosenlieb, 2007; Heasler and Jaworowski, 2007).

Multiple lines of evidence suggest that remobilization of fines deposited in the talus from previous discharges best explains the turbid ground water discharges that continue to be observed at the crystal springs. The turbidity plumes emanating from the groundwater- charged talus result in short-term exceedances of Clean Water Act standards in Sylvan Gulch and have significantly degraded the benthic ecology of the MCS pond. Two sediment events were recorded in 2007, one of lower turbidity and more prolonged during spring runoff in May and one of short duration but higher turbidity (slug flow) following a two-day period of high-intensity precipitation on the pass in July.

Since 1992, YELL has used Sylvan Pass as the source of crushed gravel for about 60% of its road construction projects. Gravel washing began at Sylvan Pass in 1998, with water supplied by 4000 gallon capacity trucks. Gravel washing occurred in 1998 through 2001 and again in 2003-2004. In 2004, a pipeline was constructed from Sylvan Lake to the washing facility near the top of the pass. Water was pumped from Sylvan Lake at a reported rate of 250 gpm (Cornforth Consultants, 2005). The waste water from the gravel washing was discharged to Area 4 located south of the road about 1500 feet southeast of Eleanor Lake. The exact location, schedule, or times that waste water discharges occurred to Area 4 are unknown; however, gravel mining and washing on the pass was limited to a few months each summer. Mitigation efforts enacted to date include the stabilization of coarser fines and “reject” materials that were stored in Area 4 above a bowl-shaped bottom layer of predominately compacted silt and clay fines (1-2 meters thick) separated by geotextile membrane. A chronology of events is presented in Appendix B.

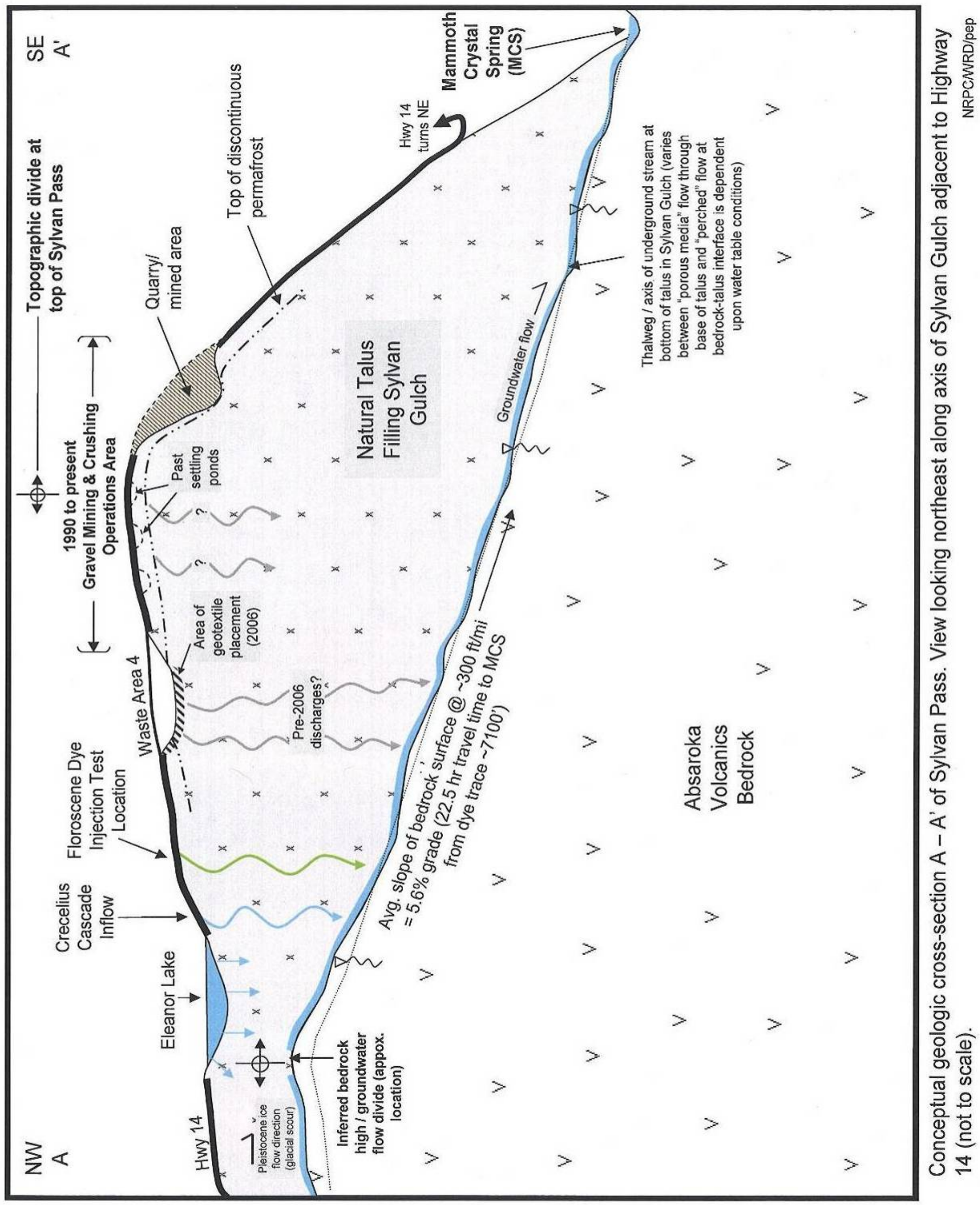
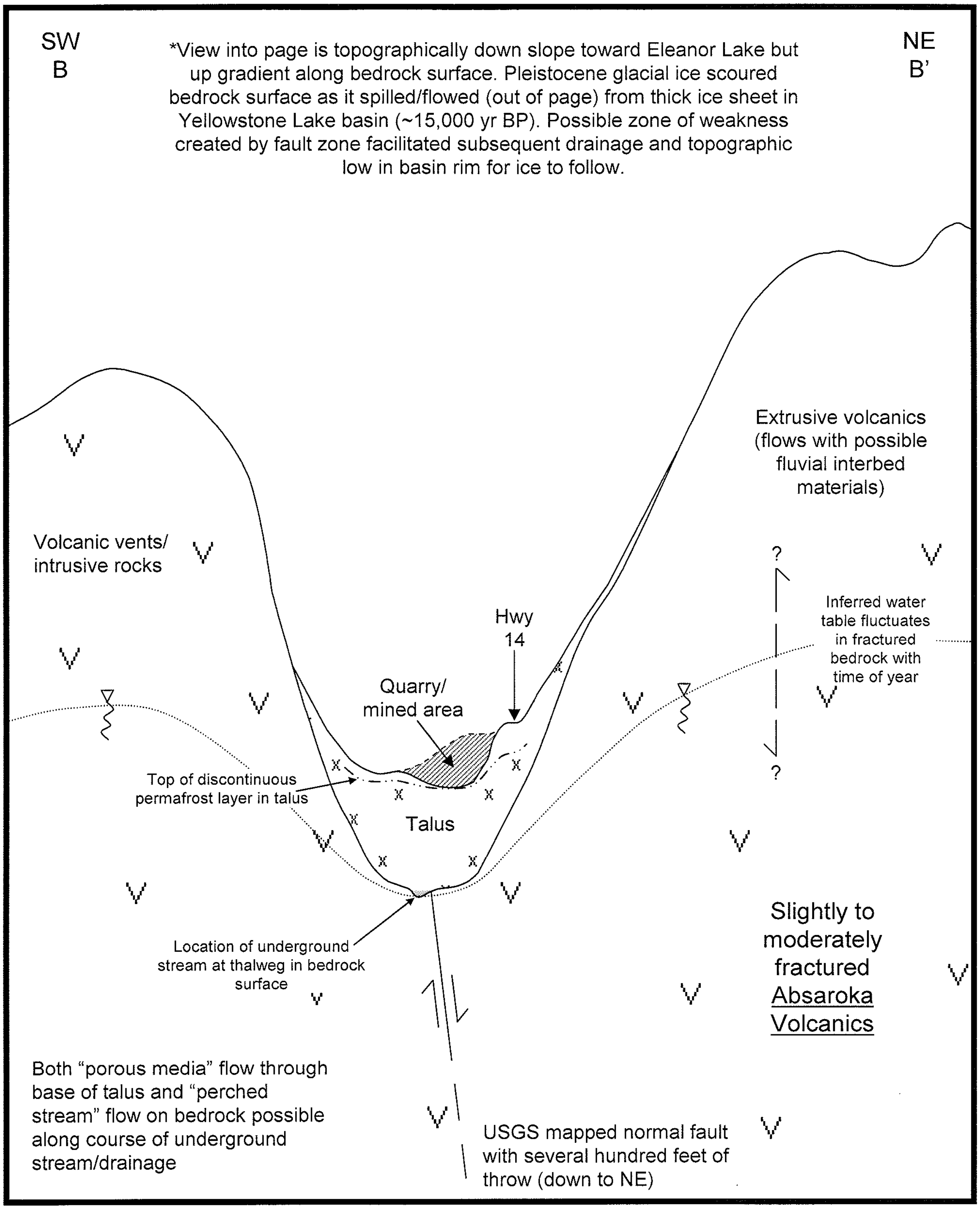


Figure 3A. Conceptual model along NW – SE transect (Penoyer, 2007).



Conceptual geologic cross section B – B'. View looking northwest along axis of Sylvan Gulch from Sylvan Pass (not to scale). NRPC/WRD/pep

Figure 3B. Conceptual Model along SW – NE transect (Penoyer, 2007).

Purpose

The team was charged with analyzing and providing recommendations to address the following three questions regarding restoration of the Sylvan Pass system:

1. If releases of residual fines continue either from the underlying talus and/or from the past site operational areas/waste disposal areas, what additional short term effects and long term effects are we likely to see and what special mitigation/restoration techniques or precautions could be taken to reduce those discharges over the short or long term as they relate to:

   a. The entire construction-disturbed area on Sylvan Pass
   b. The sediment previously discharged and now contained in the talus-filled valley
   c. The Mammoth Crystal Springs wetland and aquatic habitats
   d. Downstream receiving waters such as Middle Creek

2. Should interim mitigation measures be implemented on the Mammoth Crystal Springs inflow/outflow to prevent impacts to the Middle Creek tributary of the Shoshone River? If so, what can be done to limit further discharges?

3. Are there one or more feasible and cost-effective technologies that are readily evident for mitigating one or more impacts to the components of the hydrologic system?

This report provides a summary of the consensus recommendations provided by the team. Full letter reports from Messrs. Wireman and Thackson are included in this report in Appendix A.

Discussion

As previously indicated, the team concurs with and affirms the general conceptual model depicted in Figures 3A and 3B for the Sylvan Pass Hydrologic System. However, while useful to describe the general sources and movement of the anthropogenic sediment load, the model currently has limitations in its ability to describe the exact distribution (spatial location, depth, thickness or volume), condition (moisture content and consistency, etc.), and mobility of the remaining sediment residing in the talus as "residual fines". Due to the cost of obtaining subsurface samples of fines (e.g., drilling exploratory boreholes in talus) and the uncertainties of where to look (cost effectively), the condition and distribution of subsurface fines is largely unknown and may only be inferred from incomplete recollections of turbid water discharge locations. Thus, it is not fully understood how their subsurface condition or distribution may enhance or retard remobilization of sediment from the talus vadose zone into the saturated portion of the talus aquifer or "stream zone" at the talus-bedrock contact. Such movement of fines would be expected during periods of increased infiltration from snowmelt or rainfall but their ease of remobilization and volume are difficult to ascertain. Data indicate that precipitation events greater than 0.2 to 0.3 inches per hour cause significant turbidity events (Heasler, 2005b)

Because of these uncertainties, the team believes that the existing hydrologic monitoring system should be maintained and that at least two to three more years monitoring of the system should occur to determine if the turbidity and sediment loads will, in fact, decline over time. This will indicate if the system is cleansing itself through a natural flushing process. In the interim, however, the team believes that strategies that are relatively non-intrusive and can be easily incorporated as a part of the final restoration plan for the pass should be implemented. Favored approaches include those that utilize practices and structures that will reduce the infiltration of surface water into the talus over suspected discharge points of the sediment. They would be applied primarily in areas where washing of gravel is believed to have occurred or where subsequent investigations and mapping can determine that there was a good likelihood that these activities did occur. Also favored are the further stabilization and/or encapsulation of the remaining crusher (floor) fines at the site where a more easily mobilized clay size component (fraction) of the material is more abundant.

Strategies considered, but rejected, by the team at this time are those that would attempt to accelerate the transport of the sediment through the system by water flushing. It was felt that without additional definitive knowledge about the location of sediment in the system these options ran a high risk of causing additional undesirable impacts, such as disintegration of the permafrost and permanent damage to the ground water transport system. There are also source water issues, including the transportation of sufficient infiltration water volumes to make flushing effective and selection of the best test infiltration locations given limited knowledge of past discharge sites and the unknown subsurface distribution of permafrost.

Several issues and questions related to restoration of the site overall and, specifically the pond at MCS, were discussed. At this time, the emergent and submergent vegetation of the pond has been smothered by several centimeters of silty clay, and no regeneration of any vegetation has occurred except for transient crust layers of algae. If left alone over several hundred years, the organic matter will accumulate enough on top of the recently deposited gray silty clay to support

vascular plants. It was agreed that this uppermost silty clay layer should be removed as soon as possible in order to expose the existing organic layer. Once the light gray, silty clay is removed, the vascular plants and other biota should recolonize the pond within two to three growing seasons.

Therefore, a primary objective in restoration of the spring pond is to remove the silty clay sediment as soon as possible. As long as this sediment remains, all biotic and abiotic functional values are lost. With no plants, fish, and other wildlife species present, no carbon is added to the stream system, and the absorption and adsorption of excess nutrients or filtering of suspended solids, usually done by plants, do not occur.

Conclusions

Historic gravel mining and crushing operations at Sylvan Pass, coupled with similar, more recent operations since 1997 that involved gravel washing, associated waste water discharges to talus, and the disposal of waste fines (across the Sylvan Pass area generally and at Waste Area 4 in particular), have significantly increased the sediment loading to the Sylvan Pass Hydrologic System. These operations have resulted in the mobilization of waste fines into talus and the likely melting of holes in the permafrost that underlies much of the Sylvan Pass which has impacted groundwater and its discharge to surface waters in the Middle Creek drainage. Unknown amounts of anthropogenic fines remain lodged in the talus from past discharges, only to be remobilized with subsequent natural "flushing" of the hydrologic system from spring snowmelt and summer precipitation events.

Observations of occasional, anomalous, or elevated turbidity and a fine suspended sediment load in groundwater discharge to Mammoth Crystal Springs and downstream areas will likely continue until surface fines at the site are fully stabilized (or removed) and past releases of waste fines now lodged in the underlying talus have been flushed through the system. Currently it is not possible to attribute proportional contributions from these two sources or to know if there is any sediment contribution from those fines currently residing above the talus but disposed during past site operations. The duration of additional sediment-laden groundwater discharges to the Sylvan Pass Hydrologic System from past discharges depends on the form, volume, and mobility of residual waste fines residing in the subsurface (talus) and includes the extent to which natural flushing events are able to cleanse the system. The effectiveness of attempts to stabilize, under present environmental conditions, waste fines covering the surface and to a depth of several feet across the site from past site operations (including disposal) will also be a factor in eliminating future sediment discharges.

Recommendations

The team's recommendations focus on three issues:

1. Initiate near term surface reclamation measures to reduce infiltration and percolation of snowmelt and rain water and control runoff in order to minimize remobilization of residual fines by targeting the most likely source areas.

2. Evaluate expansion of the geosynthetic cover (coupled with compacted fines) to the entire operations area where one or more meters of fines remain above talus.

3. Continue surface water monitoring to determine if the reclamation efforts and natural flushing has/will largely take care of the residual, clay-in-talus, sediment source problem that leads to recurring sediment loading of the Middle Creek drainage.

The monitoring period should be used to document whether the sedimentation rates at MCS have, in fact, abated and to develop a restoration strategy (investigate and evaluate technologies, their implementation measures and feasibilities, etc.) that best allows for the rejuvenation of the aquatic systems in MCS.

Specific Recommendations for Issue 1

Regarding the continuing release of residual anthropogenic fines from the site (surface and near surface disturbed area), as a whole, and those fines currently lodged in talus at depth from previous discharges of turbid waste water:

1. Continue monitoring for two to three years to determine if the residual fines will be largely flushed out of the aquifer under natural conditions (normal springtime flows and storm events). During turbidity events, determine as best as possible, the relationship between turbidity values and suspended sediment concentrations to approximate the sediment mass being discharged to downstream receiving waters. Calculate the mass of the light gray sediment (deposited largely since operations began in 1992) discharged to MCS using sediment thickness data from core.

2. Estimate, as best as possible, the volumes of fines that have been discharged through the pumping of turbid wash water discharges to the talus, and map the locations of these discharge sites, as these may be the primary sources (at depth) for continued release of fines from the talus.

3. A comprehensive surface reclamation plan should be developed in conjunction with the final road design, including the entire operations-disturbed area. The objectives would be to reduce the amount of and slow the velocity of water infiltration across the site to minimize fines mobilization, particularly in areas where fine-grained sediment resides in the subsurface talus (e.g., eastern parts of Area 4 where no subsurface liner exists). Specific measures to consider are:

- Determine the area underlain by geotextile in Area 4 and how it relates to past discharge sites so that any uncovered, former discharge sites may be lined as well.

- Incorporate engineered measures (geosynthetic fabric/cover material) to reduce the rate of infiltration in those turbid wash water discharge/high infiltration areas.

- Include on-site reclamation measures to divert surface runoff away from any of the identified potential source (discharge) areas.

- Evaluate the feasibility of a geotextile cover coupled with compaction of fines as a restoration/mitigation option across all of those areas where crusher fines remain near the top of the pass. Alternatively, concentrate the remaining fines into a smaller area where they can be better stabilized and contained more readily by a geotextile cover/bottom liner fabric (e.g., expanded Area 4 to southeast as necessary).

4. Apply stable and radioactive water isotope investigation methods to help differentiate base flow from rainfall or snowmelt event water that recharges the talus aquifer and discharges at MCS. Determine their relative contributions to the hydrologic system groundwater discharge at MCS from the longer duration (longer flowpath), fractured bedrock, aquifer flow system and the shorter term precipitation and snowmelt infiltration events that rapidly infiltrate and recharge the talus aquifer.

Specific Recommendations for Issue 2

Mitigation and restoration measures to implement at MCS and Middle Creek:

1. Determine if interim mitigation measures to reduce outflow of suspended clay sediment from MCS to Middle Creek are likely to be effective in reducing current levels of turbidity (observed as short term, slug flow events) or are likely to be effective only during low flows when turbidity is generally not an issue.

2. Determine if restoration of the MCS pond is feasible at all or should not be attempted for several years. The temporal loss of functional values will be significant; however, if it was determined that it would not be economically practicable to dredge the fines from the MCS pond now and then have to dredge the pond later, since there is a high probability that fines will continue to leach from the talus.

3. Restore the aquatic habitats of MCS as soon as possible after it has been determined that the release of residual anthropogenic fines (from the site disturbed area, from the completion of the road realignment project, and those fines currently lodged in talus) will no longer be released and accumulate in the MCS pond. Several approaches to removing the sediment from the pond were discussed with park staff. One alternative is to pump wet sediment to the main road and into settling tanks to be drained and disposed of. Another method would involve filtering a sediment slurry through various materials or filter fabric at the outfall of the pond. Another option is to pump the pond dry and hand shovel the fines into buckets and into a disposal tank located on the abandoned trail located 15 yards above the pond. The long monitoring period (prior to the decision to

restore the pond) should allow for an extensive analysis of these and other alternative restoration methods.

4. Until restoration is completed, the MCS pond is essentially a detention basin for fines and water moving out of the talus above. The total peak flows and sediment quantities that enter the pond should be identified and an evaluation made as to whether the outfall of the pond should be raised in order to discourage scouring and dispersion of sediment downstream and to determine if the detention basin function (holding fines in place and catching additional fines) of the pond can be improved until it is restored.

5. Follow a phased mitigation approach in addressing the MCS sedimentation problem with the near term focuses being surface reclamation of the Sylvan Pass site and continued monitoring to determine its effectiveness and any reduction in sediment loads through natural flushing of the hydrologic system.

Specific Recommendations for Issue 3

Identification of feasible mitigation technologies:

1. Evaluate sediment loading mitigation technologies (e.g., enhanced/stimulated flushing of sediment contained in the talus, subsurface drilling with fluid injection, other sediment control/mitigation-related construction activities, etc.) to avoid additional undesirable short term effects to MCS and the additional melting of permafrost. The longer term effects of various mitigation approaches are also uncertain, and it is recommended they be avoided at the present time until the attenuation of current sediment loads carried by the system is better understood.

2. Defer performing more risky and costly subsurface treatment of talus and employ other, simpler, less intrusive methods to mitigate the sedimentation problem.

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Appendix A

Letter Reports

Letter from U.S.E.P.A.

Ref: EPR-EP

November 2, 2007

Letter report – *Summary of observations, findings and recommendations related to the turbidity plumes discharging to Mammoth Crystal Springs, Yellowstone National Park*

Prepared by Mike Wireman; Regional Ground Water Expert, USEPA Region 8, Denver, Colorado

INTRODUCTION

This report provides a summary of my observations; findings and recommendations related to the turbidity plumes that periodically discharge to Mammoth Crystal Springs (MCS) located in the bottom of Sylvan Gulch in the east-central part of Yellowstone National Park (YNP). MCS discharges at or near the contact between talus and underlying bedrock. The discharge from MCS collects in a small (< 1 acre) pond that was created by damming below the MCS discharge point. Overflow from the pond is conveyed by a channel in Sylvan Gulch to Middle Creek (north fork of the Shoshone River). The turbidity plumes result in temporary exceedance of Clean Water Act standards in Sylvan Gulch and have significantly degraded the ecology of the pond associated with MCS. The plumes have reached Middle Creek and the Shoshone River. The turbidity discharges are thought to be associated with gravel mining and processing on Sylvan Pass.

The National Park Service (NPS) is currently coordinating an effort to determine the cause of the high turbidity discharges and evaluate restoration and remediation options for the surface and ground waters that have been impacted by the high turbidity plumes. On October 11 and 12, 2007 the NPS hosted a site visit and panel discussion. On October 11 scientists and engineers from the NPS, YNP, US EPA and URS Corporation visited Sylvan Pass and MCS. On October 12 a panel

discussion was convened at YNP headquarters in Mammoth to discuss the observations made during the field trip and to discuss restoration and remedial options for MCS. This letter report is based on the October 11-12 visit and a review of available reports.

BACKGROUND

Sylvan Pass (elevation ~ 8500 feet) is located about 7 miles west of the East entrance to YNP. The pass is on the divide between the Yellowstone Lake drainage to the west and the Middle Creek drainage to the east. Middle Creek flows northeastward to its confluence with the south fork of the Shoshone River. MCS is located about 1.25 miles east of Sylvan Pass at an elevation of approximately 8100 feet.

Since the last glacial retreat talus has accumulated in the valley between Sylvan Pass and MCS. The thickness of the talus is unknown and likely varies (tens to hundreds of feet) along the strike of the valley. Permafrost occurs within the talus beneath the pass. The permafrost appears to be widespread but there are probably vertical and / or lateral "windows" in the frozen ground. Samples of the permafrost collected by Cornforth Consultants were typically clear, though occasionally were observed to have fine grained sediments trapped in the ice.

A road over Sylvan pass was first constructed in 1903. The current road was constructed in 1929. In 1964 the andesite volcanic rock on the pass was first mined to supply crushed aggregate for resurfacing of the East Entrance road. Since 1992 the YNP has used Sylvan Pass as the source of crushed gravel for about 60% of its road construction projects. Gravel washing began at the Sylvan Pass facility sometime between 1996 and 1998, with water being supplied by 4000 gallon trucks. Gravel washing occurred in 1999 through 2001 and again in 2004. In 2004 a pipeline was constructed from Sylvan Lake (west of Sylvan Pass) to the washing facility. Water was pumped from Sylvan Lake a reported rate of 250 gpm (Cornforth Consultants, 2005). The waste water from the gravel washing was discharged to "Area 4" located south of the road about 2000 feet east of Eleanor Lake. The exact schedule and times that waste water discharge occurred is unknown, however gravel mining on the pass was limited to a few months each summer. Table 1 summarizes data from Cornforth Consultants regarding the volume of gravel produced during the years that gravel washing occurred at the Sylvan Pass facility.

Table 1 – Crushed gravel production during years that washing occurred

Year	Volume of gravel produced (Tons)
1996-98	182,000
1999-2000	167,475
2001	189,200
2002-2003	NONE
2004	111,400
TOTAL	650,075

As shown in Table 1 approximately 650,075 tons of gravel were washed between 1992 and 2004. According to Cornforth Consultants (2005) washing specifications required 0.53 gallons of water per ton. Based on this estimate an estimated 344,539 gallons of water required for washing between 1996 and 2004. It should be noted that water used for gravel washing was recycled, so there is some uncertainty associated with this estimate.

The discharge water from the gravel washing operation was very high in total suspended solids. One turbidity value is reported for the discharge into area 4 – 6836 NTU (Cornforth Consultants, 2005). It is reported that the washing waste water infiltrated very quickly into the talus. In 2005, based on recommendations included in the Conforth Consultants report, a permeable geotextile liner was placed in area 4 and 3 to 5 feet of compacted gravel processing reject material was placed on top of the liner. Placement of the liner was intended to filter fine material included in the washing waste water.

<u>CONCEPTUAL MODEL</u>

Hydrogeology - Numerous reports (Cornforth Consultants, 2005; Penoyer, 2007; Heasler and Jaworowski, 2007; Heasler, 2005) provide data and information regarding the ground water flow system that occurs within the talus deposits that have filled the valley between Eleanor Lake and MCS. The talus deposits comprise a highly porous and permeable aquifer. A tracer test conducted by the USGS in June 2005 demonstrated that ground water flows very quickly thorough the talus. Floroscene dye, injected about 200 meters east of Eleanor Lake (west of Sylvan Pass) arrived at MCS, a distance of 1.4 miles in 22.5 hours. This represents a ground water flow velocity (at least for the leading edge of the dye) of more than 7800 feet per day. The floroscene dye was not detected in Eleanor Lake, west of (and downhill) the injection location. This indicates that ground water that occurs

in the talus west of Sylvan Pass flows eastward. Based on the high flow velocities, it is unlikely that there is any significant saturated thickness in the talus deposits.

Mammoth Crystal Springs hydrology - Mammoth Crystal Springs is apparently the primary discharge location for the highly permeable talus aquifer. Discharge data for MCS are limited. Heasler (2005) reports that discharge ranged from 15.33 cfs to 1.37 cfs between June 3, 2005 and August 24, 2005 with the peak discharge occurring on June 21 and the minimum discharge on August 11. Cornforth Consultants (2005) reports that discharge varied between 4 cfs and .5 cfs between July 24, 2005 and September 11, 2005. The likely sources of recharge to the talus aquifer include infiltration of rain and snowmelt, infiltration of water from Crecelius Cascade and baseflow from the fractured andesite that underlies the talus. The relative importance of each of these sources is unknown. The limited discharge data indicate a “flashy” hydrograph with the peak associated with snowmelt. The discharge at Crecelius Cascade is equal to approximately 40 to 60% of the MCS discharge. Base-flow to MCS is probably less than 0.5 cfs.

Eleanor Lake is also a possible source of recharge to the aquifer as it apparently is located at the ground-water flow system divide between ground water that flows eastward in the talus and ground water that flows westward into the Yellowstone Lake drainage basin. Meltwater from permafrost is another possible source of recharge. However, recharge from this source is not likely to be very significant. Cornforth Consultants (2005) estimated that melting permafrost may have contributed less than 5% of the total discharge at MCS.

Turbidity - The discharge of waste water from gravel washing and the disposal of reject material has very likely resulted in a large amount of clay sized particles being introduced into the talus beneath area 4 and in the vicinity of the washing plant. The subsurface distribution of this material is unknown; however the residual fines that are stored in the talus are the likely source of the turbidity plumes that discharge periodically at MCS.

Turbidity data for MCS are summarized as follows:

a. High turbidity was first observed at MCS in August 2004.The turbidity plume was first noticed by a fisherman on the Middle Fork below Sylvan gulch. Yellowstone national park staff traced the plume upstream to MCS. This plume occurred prior to the geotextile liners being placed in area 4 and prior to discontinuation of gravel washing. No turbidity measurements were obtained from this plume.

b. High turbidity was also observed at MCS in 2005. As reported in Heasler (2005b) turbidity was measured 25 times at the inlet to MCS between May 18 and August 22, 2005. Values ranged from 1.29 to 34.57 NTU. Turbidity exceeded 10 NTUs on 5 occasions: May 18, May 25, June 22, July 21 and August 18.
c. As reported in Penoyer (2007) a significant turbidity spike occurred on July 27, 2007, with the NTU value exceeding 260. This spike occurred about 20 hours after an intense rains storm (> 2 inches) on Sylvan Pass.

A review of available turbidity and precipitation data clearly indicate a relationship between turbidity plumes at MCS and spring run-off and intense summer rain storms. Heasler (2005b) suggests that rainstorms in excess of 0.2 inches per hour will result in increased turbidity at MCS. The turbidity breakthrough curves at MCS indicate that the turbidity discharges as a slug indicating rapid mobilization and transport with minimal dispersion.

In June 2006 researchers from Montana State University obtained seven cores from the pond that collects discharge from MCS. The cores were logged for stratigraphy and age dated using ^{210}Pb and ^{14}C. X-ray diffraction was also run on selected sediments from the cores. These tests revealed the existence of a light gray clay sediment consistent with the mineralogy and color of fines in waste area 4. Age dating indicates initial deposition of these recent fine grained sediments began at approximately the same time as gravel quarrying was started on the pass.

CONCLUSIONS

Based on the site visit and panel discussion, review of available reports and discussions with NPS scientists, I concur with the conceptual model that is presented in Penoyer and Rosenlieb (2007). This letter report describes my understandings and findings with respect to the hydrogeologic conceptual model for MCS and the historic gravel mining and processing operations on Sylvan Pass.

RECOMMENDATIONS

1. **Don't do anything too intrusive –** Since the gravel mining has been discontinued at Sylvan Pass it is advisable to focus on further developing the conceptual model (including collection of new data) and continued operation of the current monitoring system. It is possible that the residual fines may be largely flushed out of the aquifer under natural conditions. The current hydrologic monitoring network should be left in place for another two to

three years and data collection should continue as currently designed. During this period some additional studies and data collection should be conducted as described in recommendations 2-4 below.

2. **Stable and radioactive water isotope sampling** - Stable and radioactive water isotope data can be used to help determine the primary source of water that recharges the talus aquifer and discharges at MCS. A greater certainty about the primary sources of water that comprise the discharge at MCS would be helpful with regard to selecting a remedy. Stable water isotopes that would be useful for this investigation include ^{18}O and deuterium. Water samples should also be collected for tritium analysis. Water samples should be collected four times during the course of the annual hydrograph from the following locations: MCS discharge, MCS pond, Crecelius Cascade, Eleanor Lake and Sylvan Gulch below MCS. The initial samples should be analyzed for ^{18}O, deuterium and tritium. The following three samples from each location will only need to be analyzed for ^{18}O and tritium. In addition a single sample should be collected from the following: snow from Sylvan pass; rain from Sylvan pass, permafrost and the Middle Fork. These samples should be analyzed for ^{18}O, deuterium and tritium. Samples can be analyzed for ^{18}O and deuterium at the INSTAAR lab in Boulder, CO. Samples collected for tritium analysis can be analyzed at the USGS lab in Menlo Park, CA. The cost for analysis for ^{18}O and deuterium is approximately $50.00 per sample and the cost for tritium analysis is approximately $100.00. Based on these costs, the total cost for analysis of all isotope samples is approximately $3600.00.
3. **Determination of lined area in Area 4** - It is unknown if all of area 4 was lined with a permeable geotextile liner. It is also unknown exactly where the wash water was discharged within area 4. If possible it should be determined exactly where discharge occurred. The portion of area 4 was that was lined should be also be determined with more accuracy. Specifically it should be determined if there are areas where wash waters were discharged that have not been lined.
4. **Estimate mass of fines in talus** - The total mass of fine grained sediments that was delivered to the subsurface in the talus beneath area 4 should be estimated. While it is recognized that this estimate may have significant uncertainty,

<u>INTERIM MEASURES</u>

I would advise that the NPS consider the feasibility and cost of the following interim measures. If determined to be useful and cost effective, these measures

could be implemented during the period of monitoring and data collection recommended above.

a. Install a permeable geotextile on any portion of area 4 that was not lined in 2005.
b. Install a permeable geotextile on the area occupied by the crusher / washing facility. This area is another potential source of fines that can be transported into the talus.
c. Remove sediment from the MCS pond. Based on advice from the biologist / wetlands expert, the NPS should consider the feasibility and advantages of removing the fines that have accumulated to date in the MCS pond.
d. A preliminary level design for a pilot test that would evaluate the feasibility and usefulness of artificially flushing the talus with trucked in water in order to shorten the time needed to mobilize and transport the residual fines through the talus aquifer. This concept would need to consider the constraints presented by the potential melting of permafrost and the likelihood of delivering flushing water to the mass of residual sediments.

Letter from URS Corp

October 26, 2007

Gary Rosenlieb
Chief, Water Operations Branch
National Park Service
1201 Oakridge Drive, Suite 250
Fort Collins, CO 80525

Subject: Sediment Control and Restoration of Mammoth Crystal Springs

Dear Mr. Rosenlieb:

The purpose of this letter is to provide responses to the questions in your letter to me dated September 24, 2007, which requested that I assist Yellowstone National Park, along with a team of specialists, with the assessment of restoration feasibility and options for the Sylvan Pass Hydrologic System.

Background Information and URS Scope of Work

As requested, I participated in a workshop that was held at Yellowstone National Park Headquarters at Mammoth on October 11 and 12, 2007. I reviewed the NPS briefing package provided by you and Pete Penoyer, which provides the background, site setting, and questions the NPS needs to address for the Sylvan Pass System. As suggested, I also accessed these files and additional reports provided by the NPS on the FTP site, which I downloaded before October 5th when they were deleted from that site.

As summarized from the briefing paper, the Sylvan Pass Area Hydrologic System (System) consists of a talus filled glacial valley that heads at Sylvan Pass and serves as a ground water flow path to Mammoth Crystal Springs (MCS), the headwaters of a tributary of the Middle Fork of the Shoshone River. Historic and current rock quarrying and crushing operations for road aggregate at the top of Sylvan Pass, along with disposal of waste fines along the top of the Pass, has impacted the System by the transport of sediment through the talus to Mammoth Crystal Springs. Our primary objective at the workshop was to consider and answer the following issues:

1. If releases of residual fines continues either from the underlying talus and/or from the past site operational areas/waste disposal areas, what additional short term effects and long term effects are we likely to see, and what special mitigation/restoration techniques or precautions could be taken to reduce those discharges over the short or long term as they relate to:

   - the entire construction-disturbed area on Sylvan Pass
   - the sediment contained in the talus filled valley
   - the Mammoth Crystal Springs wetland and aquatic habitats
   - downstream receiving waters, such as Middle Creek

2. Should interim mitigation measures be implemented on the Mammoth Crystal Springs inflow/outflow to prevent impacts to the Middle Creek tributary of the Shoshone River? If so, what can be done to limit further discharges?

3. Are there feasible and cost-effective technologies that are readily evident for mitigating one or more impacts to the components of the hydrologic system?

Observations and Recommendations

First, I wish to re-state my agreement with the conceptual hydrogeologic model described in the NPS briefing package. The previous data collection and studies conducted by the NPS and consultants provide a comprehensive characterization of the hydrologic system and sources of the sediment problem. With the large amount of available information, it is possible to develop a reasonable plan for mitigating, rather than exacerbating, the impacts to MCS, aquatic habitat and downstream water quality.

<u>Issue # 1</u>

As we discussed in the workshop, the volume of silt and clay-size material contributed by the aggregate mining, crushing and washing operations are unknown but may be approximated. It is uncertain how much of this fine grained material could be re-mobilized into the hydrologic system beneath the talus and downstream by intense storm events in the future. Nonetheless, as was discussed in the workshop, it would be possible to better define the boundaries of areas into which the fine grained material was introduced by the aggregate mining and processing. It is likely that sediment-filled pore spaces at depth below these areas will continue to be the primary sources of down-gradient sedimentation unless engineering measures are taken to reduce the rate of infiltration in those areas. Without reducing the rate of infiltration and percolation of storm water through the fine-grained sediment source areas, it is likely that elevated levels of fine-grained sediment and turbidity will continue to impact MCS and downstream. Nonetheless, even with current state of ground disturbance at Sylvan Pass, the natural flushing processes resulting from stormwater recharge and groundwater flowing through the talus will cause sedimentation and turbidity in MCS to decrease through time.

A comprehensive surface reclamation plan should be developed in conjunction with the final road design and grading plan for the highway project. This reclamation plan should include the entire construction-disturbed area of Sylvan Pass. A major objective of this plan would be to reduce the amount of water infiltration and deep percolation in areas where potentially-mobile fine grained sediment continues to reside in the subsurface talus. The most likely potential sources of future fine grained sediment loading to the MCS and downstream lie below the areas of the aggregate mining and washing operations where no subsurface liner now exists. These areas include the eastern portion of Waste Area 4, which has a history of excavation and influx of fine grained material mixed with water and crushed gravel, and the other nearby areas that received seepage of turbid water from water management ponds. Reducing the rate of infiltration percolating through those source areas will also reduce the undesirable effect of permafrost melting in the talus, which probably exacerbated the fine-grained sediment transport problems.

As an early step in the reclamation planning, the extent of these source areas should be mapped as accurately as possible based on the available records of the mining project. This map will provide an important basis for reclamation of the area of mining disturbance on the talus. Again,

the key focus of the initial site reclamation should be to reduce infiltration of water in the identified potential source areas. Infiltration rates can be reduced through re-grading of the land surface to divert storm runoff and snowmelt away from the source areas. In addition, constructing a low-permeability engineered cover system over the potential source areas will reduce infiltration rates in those areas and thus will probably mitigate the sedimentation. This cover system should be designed to resist destruction from freeze-thaw cycles and erosion over the long term.

Issue # 2

As we discussed during the workshop, it is probably not feasible to restore the wetland and aquatic habitats of MCS until the sedimentation rates in those areas during storm events have substantially decreased from current levels. Interim mitigation measures for reducing the outflow of sediment from MCS are not likely to be effective in reducing current level of impacts to the Middle Creek tributary of the Shoshone River. Available measures for trapping or filtering sediment near the MCS outflow to Middle Creek would only be effective during low flow periods, not during storm events. It appears unrealistic to attempt to control the sediment entrained in high storm runoff flows from MCS by employing filtering fences, or even by raising a small dam consisting of bags containing the "Chitisan" media we discussed. Rather, it is preferable in this situation to follow a phased approach to addressing the MCS sedimentation problem. The initial phase of restoration should focus on reducing sedimentation by employing surface reclamation measures to reduce infiltration and percolation, as described above, with continued monitoring. Continuing the current surface water monitoring program at MCS and downstream is necessary to evaluate the effectiveness of the surface reclamation at Sylvan Pass for reducing the sedimentation rates.

Issue # 3

We discussed several possible alternatives for more-intensive flushing or subsurface treatment of the fine-grained sediment sources deeper in the talus during the site visit. Stream flow diversions or pumping from nearby ponds could be directed into certain areas to enhance the natural flushing of sediment from the talus. Examples of engineering measures to stabilize the fine grained sediment could include drilling and injecting sand into the tailing pore spaces at depth, or creating subsurface barriers to reduce the ground water flow velocities during major storm events. Reducing the maximum ground water flow velocities in areas containing residual fine sediments would reduce turbidity in MCS.

Unfortunately any activity to stimulate flushing of the sediment from the tailing or subsurface drilling, fluid injection, construction work into the talus could create additional undesirable effects to MCS. For instance, increasing water inflows or fluid injection into the talus could locally melt permafrost, which could increase sedimentation in MCS during the construction period and for some time thereafter. The longer term effects of such efforts are uncertain. It is even possible that more aggressive subsurface treatment measures could permanently reduce the ground water discharge that supports MCS. Therefore, it is more prudent to defer performing additional subsurface treatment of the talus and employ other simpler, less intrusive methods to mitigate this sedimentation problem.

In conclusion, I recommend that restoration efforts should first focus on employing surface reclamation measures to reduce infiltration and percolation through the most likely source areas, as described above. After the road construction is complete and the surface reclamation plan has

been implemented, natural flushing of the remaining fine-grained sediment by storm flows will continue, but should diminish with time. Continuing the surface water monitoring program will hopefully demonstrate the effectiveness of those surface reclamation measures for reducing the sedimentation rates into MCS and downstream. Once the sedimentation rates into MCS have abated, it would be reasonable to consider other measures to remove the fine-grained sediment that has accumulated in the MCS and allow rejuvenation of the aquatic system in the pond.

Sincerely,

URS CORPORATION

John W. Thackston
Senior Hydrogeologist, CEG, RG, CPH

Appendix B

Chronology on East Entrance Road Project
and
Middle Creek Turbidity Investigations

1990

The Federal Highways (FHWA) *Preliminary Draft Material Source Study* identified potential and existing material sources within the park and on lands within 20 miles of park boundaries; potential source areas beyond this range were considered infeasible due to long haul distances with steep grades that would greatly increase transportation costs. The FHWA identified several in-park sites, including Sylvan Pass, as likely for generation of mineral aggregates and masonry sources under a preplanned program of reclamation and revegetation.

1991

12/16/91 Yellowstone National Park begins the process for the Parkwide Road Reconstruction Plan/Environmental Assessment (EA) to enter into a 20-year schedule of road reconstruction. The EA described the overall road rehabilitation needs; common borrow and mineral aggregate requirements; material sources needed for road reconstruction and maintenance over a 20-year period; and potential impacts.

1992

3/15/92 The Parkwide Road Reconstruction Plan and draft EA is available for a 30-day public review and comment period.

6/10/92 The Finding of No Significant Impact (FONSI) for Parkwide Road Improvement Plan/Environmental Assessment, which describes the overall parkwide road reconstruction program expected to continue over the next 20 years, is recommended for approval by Yellowstone National Park Acting Superintendent Joseph Alston. The FONSI is approved by Acting Regional Director Boyd Evison of the Rocky Mountain Region. A total of 10 comments were received; one comment from the Greater Yellowstone Coalition expressed concern over the development of material source sites.

6/25/92 A Categorical Exclusion is recommended by Yellowstone National Park's Supervisory Outdoor Recreation Planner and approved by Superintendent Robert Barbee to allow rock hauling on Sylvan Pass.

7/19/92 Rock hauling begins on Sylvan Pass. As many as 85 trucks per day haul raw materials from Sylvan Pass to the Norris Junction area for use in future road repair projects on the west side of the park.

8/04/92 The EA to reconstruct the East Entrance road is available for a 60-day public review and comment period. The preferred alternative calls for rock material to be excavated and removed from the sides of the slopes at Sylvan Pass and used as the paving aggregate and road base material.

8/28/92 Rock hauling on Sylvan Pass stops due to unanticipated problems found with the amount of ice and fine material contained in the rock. Each year as rock melts, it is pushed up into stockpiles. To take advantage of this seasonal melting of ice, the decision is made to quarry aggregate from Sylvan Pass throughout the course of projects.

1993

8/6/93 The East Entrance Road Segment B, 13(1) contract is awarded. This segment of road reconstruction is from Lake Butte Overlook to Sylvan Pass. The project uses 312,000 tons of aggregate and reconstructs 9.621 miles of road. The cost of the project is approximately $10,000,000. No washing of aggregate occurs.

1995

9/01/95 The East Entrance Road Segment A, 13(2) contract is awarded. This segment road reconstruction is from Indian Pont to Lake Butte Overlook. The project uses 166,500 tons of aggregate and reconstructs 5.538 miles of road. The cost of the project is approximately $9,134,000. No washing of aggregate occurs.

1998

8/28/98 The East Entrance Road Segment contract 13(7) and Grand Loop Road contract 10(8) are awarded. These contracts include road reconstruction for Arnica Creek, Lake Village, Fishing Bridge, and the East Entrance Road. The two projects use 158,000 tons of aggregate and reconstruct 11.6 miles of road. The cost for both projects is approximately $8,750,000. Light washing of aggregate, using water hauled from Sylvan Lake, occurs.

2001

3/14/01 The revised *Pollution Prevention Plan for Storm Water Discharges Associated with Industrial Activities Sylvan Pass Materials Source* issued by the State of Wyoming Department of Environmental Quality Water Quality Division states "Basic activities will consist of excavating talus material from the Sylvan Pass material source. This material will then be screened and washed at the material source prior to being hauled to the Grebe Lake stockpile location." The plan further notes that "Water used for washing will be contained at the material source and drawn from local waters."

4/04/01 Contract 13(8) is awarded to quarry, pre-crush, and haul 161,000 tons of talus from Sylvan Pass to Grebe Lake Pit. An additional 60,000 tons are added to the contract.

2003

8/04/03 The Dunraven Road Contract 10(12) and Hayden Valley Contract 10(14) are awarded. These projects use 154,000 tons of aggregate from portions stockpiled at Grebe Lake and aggregate from Sylvan Pass. Washing of aggregate, using water hauled from Sylvan Lake, occurs.

2004

3/25/04 A renewed National Pollutant Discharge Elimination System (NPDES) permit is issued to FHWA, effective until March 31, 2009. The permit authorizes an individual, industrial site at Sylvan Pass. The permit includes a storm water pollution prevention plan and applies to discharges composed entirely of storm water from industrial activities associated with mining or quarrying at the permitted facility. Process and wastewater discharges, including product wash water, are not included under the permit.

5/12/04 The contract for East Entrance Road Segment C 13(3) is awarded. This segment is from Sylvan Pass to the East Entrance. This project uses 83,000 tons of aggregate and reconstructs 5 miles of road. Washing of aggregate, using a different technique, occurs with approximately 250 gallons of water a minute piped from Sylvan Lake to Sylvan Pass.

6/14/04 An individual's photograph of Mammoth Crystal Springs shows white turbidity.

7/18/04 Heavy rains cause 30-thousand tons of mud, rock, and debris to cover a section of the road east of Sylvan Pass. More than 10-thousand tons of debris is removed, and the road reopens to the public on July 24, 2004.

7/20/04 In response to the intense rainfall and mudslides, Yellowstone Geologist, Dr. Hank Heasler, begins studies of the Sylvan Pass area to document the geologic and hydrologic response.

7/25/04 The first internal study, *Landslides Resulting from Intense Precipitation on 18 July, 2004, Yellowstone National Park*, by Cheryl Jaworowski and Hank Heasler, documents the geologic response to intense rainfall at Sylvan Pass. The report concludes that although the precipitation and debris flows from the mudslides did mobilize massive amounts of fine sediment, there is no indication that the turbidity in Mammoth Crystal Springs was caused by the mudslides, as indicated by the photograph taken on June 14, 2004.

8/3/04 The East Entrance Station reports white turbidity in Middle Creek. Middle Creek, bordering the East Entrance Road of Yellowstone National Park, is a tributary of the North Fork River, which flows into the Shoshone River. (*Note: Rivers outside the Yellowstone Boundary in the Shoshone National Forest are not designated as Class I watersheds.)*

8/17/04 Yellowstone National Park initiates an inspection to gather information on near-surface ground water flow in the area of Sylvan Pass and to investigate potential causes of the turbidity in Middle Creek.

The park receives phone calls from WY DEQ, regarding reports they (WY DEQ) have received of white turbidity in Middle Creek. The park explains to WY DEQ that an inspection has been initiated.

8/23/04 A second internal geologic and hydrologic study, *Geologic Reconnaissance of the Near-Surface Hydrology of the Sylvan Pass Area, Yellowstone National Park* by Hank Heasler and Cheryl Jaworowski describes near-surface ground water flow in the area of Sylvan Pass and investigated potential causes of increased turbidity reported in Middle Creek on August 3, 2004. The internal report concludes that gravel mining operations on Sylvan Pass was a likely cause of the degradation in water quality.

2005

4/25/05 A draft copy of a third internal report, *Reconnaissance of the Near-Surface Hydrology of the Sylvan Pass Area, Yellowstone National Park*, by Hank Heasler and Cheryl Jaworowski, is provided to park staff for an initial review.

5/12/05 A peer review by the U.S. Geological Survey of the third internal report, *Reconnaissance of the Near-Surface Hydrology of the Sylvan Pass Area, Yellowstone National Park,* by Dr. Henry Heasler and Dr. Cheryl Jaworowski, concurs with the conceptual hydrologic flow model proposed in the report and recommends additional work to lay out a comprehensive monitoring strategy.

5/16/05 Yellowstone National Park sends a letter to Mr. Howe Crockett of the Federal Highway Administration, outlining the analysis that has been done to date, summarizing the findings, and identifying potential concerns. The park agrees to allow the contractor to continue mining material and dry crushing aggregate, but that no washing of aggregate will occur until further studies are concluded. The park notes that they will continue monitoring activities of Mammoth Crystal Springs and Middle Creek.

5/18/05 The third internal report, *Reconnaissance of the Near-Surface Hydrology of the Sylvan Pass Area, Yellowstone National Park,* by Dr. Henry Heasler and Dr. Cheryl Jaworowski, is finalized. The report further documents the hydrology of the Sylvan Pass area. The third report contains a detailed analysis of temperature data, precipitation data, turbidity data, and ground water pumping procedures for the rock crushing operations of Sylvan Pass from August through September 2004. The conclusion of this internal report was that (1) groundwater flowed from the area near Eleanor Lake to Mammoth Crystal Springs and (2) mining operations in this flowpath were the likely source of the milky-white turbidity in Middle Creek.

6/2/05 Internal meeting with NPS staff regarding the third internal report findings.

6/8/05 Teleconference call with WY DEQ to discuss turbidity issue, permits, and other concerns. Park staff agrees to send WY DEQ a copy of the 5/18/05 internal report, *Reconnaissance of the Near-Surface Hydrology of the Sylvan Pass Area, Yellowstone National Park.*

6/21/05 A dye tracer test is conducted in the Sylvan Pass area.

6/22/05 A fourth internal report entitled, *Preliminary Results of a Dye Tracer Test on Sylvan Pass, June 21-22,* 2005, by Hank Heasler, described the results of a dye tracer test performed by U.S. Geological Survey hydrologists and the validation of the hydrologic model proposed in the third report. Findings of the test show that the dye traveled at an extremely fast rate (a distance of 1.4 miles between the dye injection site and Mammoth Crystal Springs in approximately 22.5 hours) for ground water flow, indicating an extremely porous and permeable aquifer. Such an aquifer could easily transfer rock fines associated with rock crushing operations and stockpiles of crushed materials.

7/01/05 Yellowstone National Park receives a letter from the FHWA, agreeing with the park's decision that dry crushing will be allowed, but no aggregate washing will be done in the Sylvan Pass area for the summer season of 2005.

7/6/05 NPS internal meeting to discuss Sylvan Pass concerns and operations.

7/7/05 Teleconference with FHWA and NPS about Sylvan Pass operations. It is agreed in a teleconference between FHWA and the park that a third party consultant will be hired to review all the internal reports, monitoring data, etc. and evaluate the geology, hydrology, and gravel mining operation in Sylvan Pass area.

7/13/05 In cooperation with the National Park Service (NPS) and the Western Federal Lands Highway Division (WFLHD), Cornforth Consultants are contracted to do an assessment. The scope of work includes the following:

- Evaluate the potential impacts associated with precipitation events and the increased turbidity in Mammoth Crystal Springs and Middle Creek.
- Evaluate the potential impacts associated with the gravel excavation and processing at Sylvan Pass and the increased turbidity in Mammoth Crystal Springs and Middle Creek. This evaluation should include: (i) gravel mining, including possible sub-surface ice layer disturbance; (ii) gravel crushing; (iii) discharge of water from gravel washing; (iv) gravel storage and stockpiles; and (v) reject material waste areas.
- Evaluate whether the gravel extraction and processing operations have affected or may affect the ground water regime at Sylvan Pass.
- Provide recommendations for mitigating turbidity in Mammoth Crystal Springs and Middle Creek that are attributed to gravel extraction activities.
- Provide recommendations (i.e., monitoring or testing) for determining the source of the turbidity in Mammoth Crystal Springs.
- The consultant will provide the National Park Service and Federal Highways Administration with a Report of Findings by October 21, 2005.
- Based on the information provided by the consultant, as well as studies and monitoring already conducted, the park will assess the risks of the current operation and future operations to park resources.

8/5/05 Teleconference with WY DEQ and park staff to share information on the dye test, monitoring data, and other concerns. A possible meeting for September is discussed.

8/8/05 One conclusion of the fifth internal draft report, *Results of turbidity and Discharge Measurements for the Mammoth Crystal Springs Hydrological System, Yellowstone National Park, May 9, 2005 to July 25, 2005,* by Dr. Henry Heasler, Dr. Cheryl Jaworowski, Melissa Brickl, and Ben Iobst, is that both surface and ground water quality continue to be degraded by gravel mining operation on Sylvan Pass, even with the dry crushing operation.

8/19/05 Internal meeting with park staff to discuss the findings of the fifth internal report, *Results of Turbidity and Discharge Measurements for the Mammoth Crystal Springs Hydrological System, Yellowstone National Park, May 9, 2005, to July 25, 2005.*

As a follow-up to the August 19, 2005, meeting, it was agreed that comments regarding monitoring and findings of the fifth internal draft report were to be submitted to Steve Iobst from NPS and FHWA by August 20, 2005, and distributed to all parties involved.

8/22/05 Park staff (Hank Heasler and Nancy Ward) and FHWA (Glenn Kutzera) met and were interviewed by Cornforth Consultants at Sylvan Pass. A tour was conducted at Sylvan Lake and from Eleanor Lake east through the material extraction operation to Mammoth Crystal Springs and its confluence with Middle Creek. The consultants have agreed to do the assessment on August 22 and 23, and provide a report to Yellowstone and FHWA on or about September 30.

9/21/05 Barb Shall, WY DEQ, met with FHWY (Glenn Kutzera and Jody Marshall) and park staff (Dale Reinhart, Eleanor Williams, Tom Olliff, Hank Heasler, and Chris Lehnertz) at the Sylvan Pass and Mammoth Crystal Springs site to discuss the turbidity issue, fuel storage, and future permitting concerns.

9/27/05 Cornforth Consultants provides a copy of their draft report, *Hydrogeologic Assessment, Sylvan Pass Road Material Extraction and Processing, Yellowstone National Park Wyoming, Task Order No. T-05-002, IDIQ Contract No. DTFH70-01-D-00001*, to park staff and FHWA for internal review.

10/19/05 The paper, *Use of Fluorescein Dye Tracing to Determine Ground-Water Flow in a Glaciated, Alpine Valley, Sylvan Pass, Yellowstone National Park, Wyoming*, by David D. Susong (U.S. Geological Survey), Lawrence E. Spangler, (U.S. Geological Survey), and Henry P. Heasler (National Park Service) is presented at the Geological Society of America's Annual meeting in Salt Lake City, Utah, by Mr. Susong. The paper discussed the results of the June 21, 2005, dye-tracer injection test conducted at Sylvan Pass which showed the injected Fluorescein dye moved at a very rapid rate, traveling a distance of 1.4 miles in approximately 22.5 hours, indicating surface disturbances could quickly affect water discharging from the springs.

10/21/05 NPS and FHWA staff met with Cornforth Consultants and Facilitator Nedra Chambers in Bozeman, Montana, to discuss Cornforth's research and findings and their final report, *Hydrogeologic Assessment, Sylvan Pass Road Material Extraction and Processing, Yellowstone National Park Wyoming, Task Order No. T-05-002, IDIQ Contract No. DTFH70-01-D-00001*. Comments and questions presented at the meeting are documented in the notes from the meeting. The report will be finalized by the consultant.

Following the Cornforth presentation, Yellowstone and FHWA met to discuss the report and possible mitigation measures. The group agreed that construction work needed to be completed on Sylvan Pass, but it's unclear whether Sylvan Pass will continue to be used as a material source or if another aggregate source will be used. The group agreed that further discussions need to continue, and NPS and WFHA staff plan to meet in Livingston on November 14 and 15 to explore alternatives and solutions. The group agreed to provide recommendations to Superintendent Lewis by December in order to meet her commitment to take the necessary steps to mitigate the problem in the near-term by December 24, 2005.

The following staff participated in the meeting:

Intermountain Regional Office: Mike Snyder, Acting Regional Director; Bob Moon, Associated Regional Director, Resource Stewardship and Research; Jayne Schaeffer, Acting Park Road Program Manager.

FHWA: Ricardo Suarez, Acting Division Engineer; Glenn Kutzera, Resident Engineer, Yellowstone; Howe Crockett, Construction Operations Engineer; Jody Marshall, Senior Environmental Specialist; Craig Dewey, Design Operations Engineer, Yellowstone; Terri Thomas, Environmental Manager; Bob Lale, Construction Branch Chief; Rafael Gastanon, Project Engineer, Yellowstone; Kerry Cook, Senior Geotechnical Engineer.

NPS: Bill Jackson, Acting Chief, NPS Water Resources Division.

Yellowstone National Park: Suzanne Lewis, Superintendent; Frank Walker, Deputy Superintendent; Cheryl Matthews, Chief of Public Affairs; Steve Iobst, Chief of Maintenance; Nancy Ward, Assistant Chief of Maintenance; Eleanor

Williams Clark, Chief of Planning, Compliance, and Landscape Architecture; Dale Reinhart, Landscape Architect East Entrance Project; John Varley, Director, Yellowstone Center for Resources; Tom Olliff, Chief of Natural Resources Branch, YCR; Hank Heasler, Park Geologist; Chris Lehnertz, SES Candidate Trainee, EPA.

11/15/05 NPS (Yellowstone, Intermountain Region, Water Resources Division) staff and WFHA staff met at Gallatin Gateway to discuss the future of the Sylvan Pass Road Material Source. The group reviewed options and alternatives developed at the October 21 meeting, updated the analysis and research done to date and what remains to be done, considered resource and financial impacts, and agreed on tasks that still need to be accomplished.

11/17/05 Yellowstone, Intermountain, and WFHA staff held an informal meeting at Mammoth to discuss hauling operations.

12/6/05 Letter and report from WFHA to Superintendent Lewis outlining options for the completion of Segment C of the East Entrance Road project, including other pertinent information related to the Sylvan Pass materials source.

12/6/05 Letter from Barbara L. Sahl, Wyoming Water Quality Division, to Terri Thomas, WFHA, regarding sediment discharges that have occurred at Mammoth Crystal Springs and the WY DEQ's position and understanding of the incident.

12/9/05 Conference call with Yellowstone and WFHA staff to discuss and work on the park's strategic approach to Sylvan Pass, and review and comment on the final Cornforth report.

12/15/05 Superintendent Lewis Meets with Sylvan Pass Team and presents the Draft Sylvan Pass Decision Framework.

SYLVAN PASS
DECISION FRAMEWORK
DECEMBER 15, 2005
DRAFT

Strategic	Tactical
• Dry Crushing Only of SPMS for Segment C, Option B and Reclamation of the Pass, including the short segment of roadway within the Pass (Future Contract)	• Hauling 11,000 washed metric tons • Hauling 3500 washed metric tons • Stampede Pit – Cody-commercial source preferred • YELL to assist w/Resource Assessments as needed
• Compliance NEPA WY DEQ Permit	• WFLHD Lead in conjunction with YELL/NPS conduct re-evaluation and detailed documentation
• Area 4 Mitigation	• WFLHD and Yell/NPS to jointly design including NPS Natural

	Water Resources Division
• Monitoring Program Preferred Option	• YELL/NPS Lead in conjunction with WFLHD
• Long-Term Material Sources for Park Roads Program • Budget/Funding	• WFLHD continue MS study with no comparison to Sylvan Pass • WFLHD and YELL/NPS re-evaluate overall road program strategy in light of material source needs/costs • FLHD and YELL/NPS prepare detail budget for implementation of decision framework and assess impact on current and future funding program
• Communication Plan Local Communities Media Stakeholder Groups USFS (Shoshone)	• YELL/NPS lead in consultation with WFLHD roll-out in early 2006
• Unacceptable Turbidity Levels in accordance with permit and resource monitoring	• Stop work procedures developed in conjunction with WFLHD and YELL/NPS in accordance with agreed upon criteria

2006

3/6/06 Proposed mitigation efforts for Sylvan Pass Construction Operations.

4/3/06 Yellowstone National Park, Superintendent Lewis, letter to Shoshone National Forest Supervisor, Becky Aus, informing her about Sylvan Pass turbidity and the proposed haul of material from Stampede Pit in Cody, Wyoming.

4/14/06 Shoshone National Forest Supervisor, Becky Aus, letter to Superintendent Lewis response of 4/3/2006 letter.

4/25/06	Contract Modification #15 - Contract Modification to 13(3) contract to address new material source at Stampede Pit in Cody, Wyoming, and the associated material haul. ($1,115,860.00)
4/25/06	Contract Modification #17 - Add option B to 13(3) contract. ($5,130,963.6+46 days)
5/10/06	U.S. Fish and Wildlife memo about changes of 13(3) contract that includes haul of material from Stampede Pit in Cody, Wyoming.
7/13/06	Contract Modification #18 - Add mitigation of area 4 to 13(3) contract. (76,300.00)
11/22/06	U.S. Army Corps of Engineers 404 Authorization (permit # 200140309) extension.
12/4/06	Wyoming Department of Environmental Quality **Revised** Storm Water Pollution Prevention Plan (permit # WY000004) for Industrial Activities at Sylvan Pass Material Source to April 1, 2004 – March 31, 2009.

2007

2/12/07	FHWA and YELL WYNPDES Permitting Program Agreement
4/17/07	The National Park Service - NEPA reevaluation of the East Entrance Road EA, Memo to the file #3, addressing changes of operation at Sylvan Pass Material Source, Turbidity at Mammoth Crystal Springs and Middle Creek and the haul of material from Stampede Pit in Cody, Wyoming.
4/18/07	The Federal Highway Administration - NEPA reevaluation of the East Entrance Road EA, Memo to the file #3, addressing changes of operation at Sylvan Pass Material Source, Turbidity at Mammoth Crystal Springs and Middle Creek and the haul of material from Stampede Pit in Cody, Wyoming.
7/21/07	USGS and WRD June 19 – 23, 2006, trip report to Sylvan Pass to install monitoring, to observe area 4 mitigation and to observe construction operations at Sylvan Pass.
10/11-12/07	Report and workshop: Sylvan Pass Area Hydrologic System Disturbance and Sediment Discharges to Ground Water and Surface Waters, Site Setting and Characterization Discussion to Support Evaluation of Mitigation and Restoration Workshop.
10/31/07	Final acceptance of completion of 13(3) contract, East Entrance Road Reconstruction project, Sylvan Pass to the East Entrance Gate.

NPS D-1265, August 2008

National Park Service
U.S. Department of the Interior

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