National Park Service
U.S. Department of the Interior
Intermountain Region

Sylvan Pass Operational Risk Management Assessment
Secondary Review
Final Revision
August 10-12, 2010 Workshop
Mammoth Hot Springs, Wyoming
Yellowstone National Park

December, 2010

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II. Purpose, Participants & History

Introduction & Purpose

On August 10, 11 and 12, 2010, a panel of seven internal NPS and external avalanche control experts undertook a review of agency winter operations at Yellowstone National Park's, Sylvan Pass. This detailed systemic review was referred to as an Operational Risk Management Assessment (ORMA) and requested by the Yellowstone management team and served as a follow-up to the initial ORMA conducted in 2007. This new panel of experts evaluated the risks to employee and visitor safety as reflected by the operational profile that was initiated in 2007 as well as the potential gains (visitor access, agency cost, resource protection, and effectiveness of avalanche hazard mitigation) of several new and different potential avalanche hazard mitigation options and how Sylvan Pass operations had changed since the 2007 ORMA. The overall objective of operations at Sylvan Pass is to avoid negative avalanche-human contact. Figures 1 and 2 illustrate the location of Sylvan Pass and the avalanche paths.

The process was facilitated by Kim Slininger, Program Lead and ORMA facilitator at the Intermountain Region. The primary audience for this report is the Yellowstone National Park management team. The secondary audience for this report is the community of Cody, Wyoming, Park County, Wyoming, and the State of Wyoming due to their interest in maintaining access to the park for motorized over snow traffic (snowmobiles and snowcoaches) across Sylvan Pass in the winter season.

Figure 1: Location of Sylvan Pass, Yellowstone National Park.

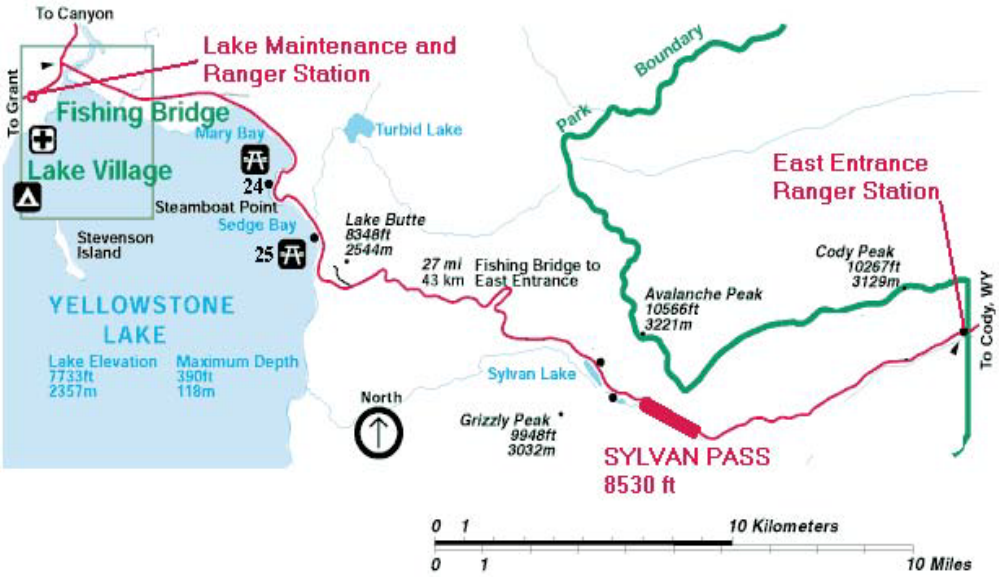
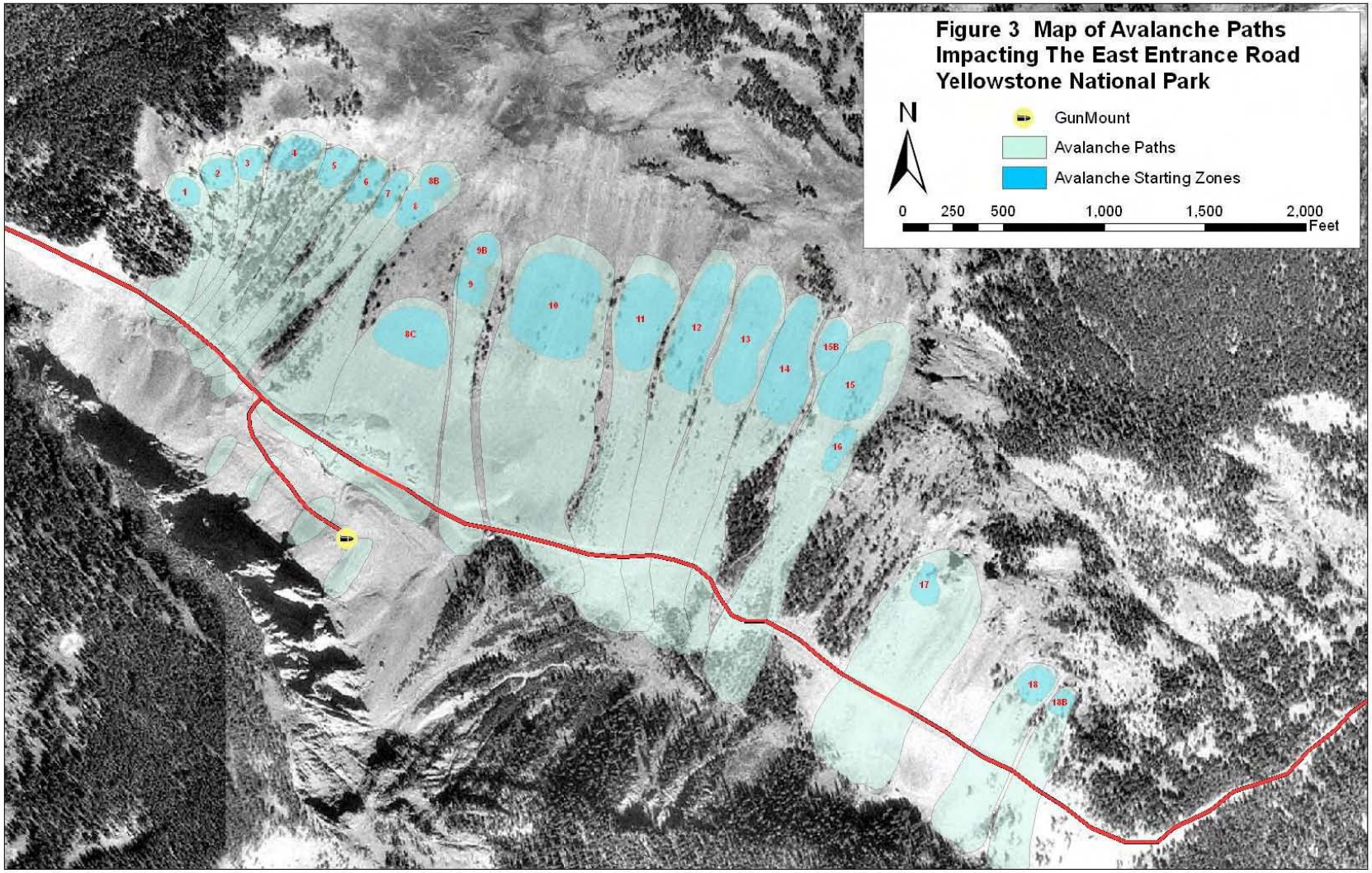


Figure 2: Avalanche paths at Sylvan Pass (taken from Comey 2007).



Who Was There and Why

The ORMA review occurred August 10, 11 and 12, 2010 at Park Headquarters in Mammoth Hot Springs, Wyoming. It was an open meeting with invitations sent by NPS to experts to serve as panelists and observers to watch the process. Attendees are listed in Table 1 below.

Table 1: ORMA Attendees

Attendee	*Organization*	*Contact Information*
Panelists		
Bob Comey	*Jackson Hole Mountain Resort*	*comey@wyom.net*
Ron Johnson	*US Forest Service, Jenny Lake Subdistrict, Grand Teton NP*	*Rjohnson.mt@gmail.com*
Maura Longden	*Yellowstone NP*	*Maura_longden@nps.gov*
Bruce Tremper	*Utah Avalanche Center*	*Bruce@utahavalanchecenter.org*
Jamie Yount	*Wyoming DOT*	*Jamie.Yount@dot.state.wy.us*
Richard Baerwald	*Yellowstone NP*	*Richard_baerwald@nps.gov*
Ken Meyer	*Yellowstone NP*	*Ken_meyer@nps.gov*
Facilitator/Contracting Staff		
Kim Slininger	*NPS-IMR*	*Kim_slininger@nps.gov*
John Sacklin	*Yellowstone NP*	*John_Sacklin@nps.gov*

Lori Fox	*The Louis Berger Group*	
Observers		
Tim Reid	*Yellowstone NP*	
Nick Herring	*Yellowstone NP*	
Brad Ross	*Yellowstone NP*	
Bruce Sefton	*Yellowstone NP*	
Tim French	*Park County, WY*	

Selected Context—Past and Present

Table 2 below chronologically highlights some of the past key events since 1932 that have helped shape the context for winter use decision-making in general and Sylvan Pass winter operations specifically.

This chronology was adapted from a more detailed version, Appendix B: History and Timeline, of the September 2007 Winter Use Plan Environmental Impact Statement for Yellowstone and Grand Teton Parks and John D. Rockefeller, Jr. Memorial Parkway.

Table 2: Winter Use Chronology

	In 1932, interested people in Cody request the NPS plow Yellowstone roads to allow year-round access. Park authorities' turndown the request, citing poor roads, severe winter conditions, non-winterized buildings, and lack of rotary plows. In 1938, NPS began plowing Mammoth to Cooke City year-round. Two years later, Cody asked again to look at feasibility of plowing Park roads year-round and the Park declined. Requests for Park plowing continued over the next decade from Cody and other local communities. With additional concerns about wildlife getting trapped in road corridors due to snow piled high on the roadsides, the NPS continued to turn down such requests, while soon accommodating a new form of winter tourism, oversnow motorized vehicles. In 1955, several West Yellowstone people began offering the first snowcoach tours of Yellowstone and several thousand people entered the park via snowcoaches the next several winters. In 1956, local communities again asked the agency to consider plowing park roads. In response, an NPS committee concluded it was feasible but not practical due to poor roads, severe weather, estimates of low traffic volumes, and cost of necessary developments and road improvements. In 1963, the first modern snowmobiles entered Yellowstone. In 1971, the park began packing snowroads to smooth them for oversnow vehicle travel and

	opened the first Snowlodge at Old Faithful (in a converted employee dormitory). In 1973, NPS began conducting avalanche control operations on Sylvan Pass to provide a safe travel corridor for visitors. By 1981, winter use had increased to 105,000 visitors annually (parkwide). In the 1980s the NPS closed Dunraven Pass in Yellowstone due to avalanche concerns; current management is backcountry use.
1989-1996	Winter use visitation continued to increase. Regarding Sylvan Pass operations during this period, Ranger Bob Mahn died in a 1994 accident while on patrol en route to Sylvan Pass to assess the avalanche danger.
1997-2005	See details in the EIS Appendix to review the succession of planning and lawsuits regarding winter use during this period. Regarding the Sylvan Pass aspects of the analyses, note that both the first EIS (2000) and Supplemental EIS (2003) examined avalanche control at Sylvan Pass, acknowledging that there was considerable risk in operating an avalanche control program. Also in 2001 and 2004 respectively, the Occupational Safety and Health Administration (*Sylvan Pass: Yellowstone National Park*) and the State of Montana Department of Military Affairs (*Potential Environmental and Safety Impacts Associated with the Use of Ordnance for Avalanche Control at Sylvan Pass, Yellowstone National Park, Wyoming*) identified hazards related to job tasks in the Sylvan Pass avalanche control program.
2004	The 2000 and 2003 winter plans were rejected by different Federal courts. To provide for winter oversnow vehicle access, the NPS completed a temporary plan. Sylvan Pass was analyzed and the decision was made to keep the pass open, but modify operations to emphasize use of helicopter dispensed explosives rather than the howitzer to minimize NPS employee safety issues.
2005-2007	NPS prepared a long-term winter plan to replace the 2004 temporary plan. Sylvan Pass was again analyzed, and the range of alternatives included the pass open and closed. As part of the impact analysis process, the NPS contracted with Robert Comey to produce the "Avalanche Hazard Assessment & Mitigation Report, Sylvan Pass, Yellowstone National Park." In addition, an ORMA was conducted in August 2007. The November 2007 Record of Decision called for managing the pass using forecasting only, without helicopter or howitzer dispensed explosives. The Record of Decision also called for the NPS to enter into discussions with the City of Cody, Park County, Wyoming, and the State of Wyoming regarding management of Sylvan Pass.
2007-2008	The Sylvan Pass Working Group was formed and included two representatives each from the park, Cody, Park County, the State of Wyoming, and Wyoming elected officials. The group met between December 2007 and May 2008 to exchange information and discuss the future of Sylvan Pass. The meetings resulted in the Sylvan Pass Agreement in early June 2008. The Sylvan Pass Study Group recommended to the Intermountain Regional Director of the National Park Service that the November 2007 Record of Decision on Winter Use in Yellowstone National Park be amended to keep Sylvan Pass open in future winter use seasons to motorized and non-motorized oversnow travel between December 22 and March 1. The group recommended continued use of a combination of avalanche mitigation techniques, including forecasting and helicopter and howitzer dispensed explosives. This recommendation to operate within a defined core season will reduce risk, improve safety, and maximize visitor access. The Sylvan Pass Study group reached agreement based on the following guiding principles: 1) Safety of visitors, guides and National Park Service employees is the first priority in any avalanche mitigation operation on Sylvan Pass. 2) Snowmobile and snowcoach motorized oversnow winter use access should be as regular and predictable as possible given weather constraints.

	3) Regular communications between Yellowstone National Park, the City of Cody, Park County, and the State of Wyoming is a key ingredient of any future winter operations on Sylvan Pass. The City of Cody, Park County, and the State of Wyoming agreed, in good faith, to work cooperatively to explore funding for safety and access improvements. The National Park Service agreed to make funding for safety and access improvements on Sylvan Pass a priority. The agreement was the basis for a July 2008 Record of Decision Amendment Members of the Sylvan Pass Study group agreed to establish consistent ongoing communications regarding Sylvan Pass winter use operations.
2008-2009	In September 2008, the U.S. District Court for the District of Columbia set aside the 2007 Winter Use Plan. The NPS prepared an interim winter plan and environmental assessment to guide winter use for a three-season period, while a new long-term winter plan was to be prepared. In November 2008, the U.S. Distirct Court for the District of Wyoming directed that the NPS implement the 2004 temporary plan provisions until it could be replaced by another winter use plan. The NPS honored the Sylvan Pass Agreement and implemented it during the winter of 2008-2009.
2009	The NPS completed the interim winter use plan and into effect for a two winter period, 2009-2010 and 2010-2011. The interim plan will expire in March 2011. The provisions of the Sylvan Pass Agreement were incorporated into the interim plan.
2009-2010	The NPS initiated a new long-term winter use plan and EIS to provide direction for winter use in the park. Scoping occurred January through March 2010, and a preliminary range of alternatives was made available in July 2010. Four of the five “action” alternatives call for keeping the pass open in accordance with the Sylvan Pass Agreement. One “action” alternative calls for closing the pass to oversnow vehicles. A draft environmental impact statement is slated for public release in spring 2011.
August 2010	The results of this second ORMA will be integrated into the avalanche control analysis of the Yellowstone Winter Use EIS and will help inform NPS decision makers. This second review is also intended to assist the Yellowstone Management Team in the assessment of the current avalanche control operations at Sylvan Pass. In addition it is expected to be helpful in determining if incorporating additional risk management techniques will lower the operational hazards of the existing procedures in place for the past three plus years.

Additional Historical Considerations of Visitor and Employee Safety

As noted above, Yellowstone began conducting avalanche control operations at Sylvan Pass in1973. Since this time, Park Staff have performed avalanche hazard mitigation to keep the pass open for oversnow vehicles and recreational use (not interstate commerce).

The East Entrance road crosses 20 avalanche paths through Sylvan Pass (see Figure 2). Until the past two winters, Rangers travelled through eight uncontrolled avalanche paths to reach the howitzer, which has been used historically for avalanche hazard reduction. In the past two winters, access to the howitzer has shifted to a somewhat safer route, in the runout zone of some of the eight avalanche paths. This shift has reduced, but not eliminated, exposure to these eight routes. In addition, sometimes the munitions used for

avalanche control do not explode, occasionally leaving hazardous unexploded ordnance on the slope. This ordnance can potentially reach the road corridor and pose a threat to the safety of visitors and employees. Also, park staff must contend with extreme conditions, including arctic cold temperatures and strong winds. The 2007 expert panelists knew of no other place where NPS rangers are doing this kind of avalanche hazard mitigation or where this type of work is performed for a transportation corridor that is primarily used by over-snow vehicles.

Trained, experienced NPS rangers operate the avalanche hazard mitigation program at Sylvan Pass. To date the program has been successful at preventing "negative avalanche-human contact,;[1] yet, because of the magnitude and complexity of Sylvan Pass, is understood as dangerous work. In 1994, Ranger Bob Mahn was killed in an accident while on patrol en route to Sylvan Pass to assess avalanche danger. Over the years there have been several instances when park employees or visitors had close calls or near misses during avalanche occurrences on the pass.

During historic use, the peak number of people who traveled through Sylvan Pass was less than 5,000 people (visitation there averaged about 4,500 per winter in the early 1990s). In 2004, the NPS implemented a managed winter use program in Yellowstone: all snowmobile groups and snowcoaches must be led by a commercial guide, snowmobiles must meet air and sound emission requirements, daily use levels have been in effect, and a nighttime (9:00 p.m. to 8:00 a.m.) closure has been in effect. Use from 2004 through 2008 ranged from 350 to 1200 people on snowmobiles and snowcoaches. In winter 2008-2009, snowmobile use totaled 92 people on 73 snowmobiles (no snowcoaches), and in 2009-2010 use totaled 85 people on 62 snowmobiles (again no snowcoaches).

III. ORMA Process

This section contains the ORM instructional materials and group work products from the three-day workshop (August 10-12, 2010) and are cataloged to provide a brief record of the steps the group followed and how they moved through each ORMA task. The material is divided into two main parts; foundations (for the work), and products (of the group). The subsections below roughly follow the order in which the group moved through each part.

Foundations

The group began with self-introductions and confirmed the substantive, procedural, and relational results they were seeking, as well as workshop objectives.

Substantive Outcomes Desired

1) Define Sylvan Pass avalanche control mission systematically and methodically; identify new hazards, assess risk, identify new options, and evaluate risk versus gain ratio.
2) Deliver Draft Operational Risk Management Report to the Yellowstone Management Team by end of October, 2010.

Procedural Outcomes Desired

[1] This was the short-hand phrase the expert panelists kept in mind as the goal as they conducted the ORMA.

3) Assist park managers toward informed risk decision(s) regarding avalanche control activities for Sylvan Pass.
4) Continue clarity and honesty about who has what kind of influence in the winter use decision, implementation steps, and schedule.
5) Post/share results with anyone interested.

Relational Outcomes Desired

6) Fully engage expert panelists as raters to get to the substantive results above.
7) Continue to invest in collaborative working relationships for the long term.

Workshop Objectives.

Demonstrate: A thorough understanding of the Operational Risk Management (ORM) process.

- Participants will efficiently be able to use the process and apply the principles in their role of providing objective expertise.
- Observers will understand the systematic and procedural methods involved in assessing risk profiles of avalanche control activities.

Do: Use the ORM process to complete a systematic and methodical review and assessment.

- Participants will gather meaningful data specific to Sylvan Pass without regard to subjective interferences.
- Participants will provide a detailed report of safety risks associated with avalanche control operation decisions on Sylvan Pass.

Background on ORM

Kim Slininger described how and where the National Park Service is making a priority to integrate ORM into NPS safety culture (where culture can be defined as "how we do things around here"). The Intermountain Region is implementing ORM in all aspects of their operations branch; doing so is influencing the way the agency functions from the inside out. A key feature is that ***Operational Risk Management does NOT tell you what to do, it gives you an accurate assessment of ALL risks and asks the question: "What is acceptable to you?"***

Four Core Principles

Four core principles of ORM exist that facilitate the critical thinking necessary to objectively complete this assessment:

1) Accept no unnecessary risk

2) Accept risk when benefits outweigh the cost

3) Anticipate and manage risk by planning

4) Make risk decisions at the right level.

Seven Key Steps of ORM

The group reviewed the seven key steps of ORM and understood that this workshop would only address steps 1-5:

1. Define mission
2. Identify hazards
3. Assess risks
4. Identify Options
5. Evaluate Risk vs. Gain
6. Execute Decisions
7. Supervise (watch for changes)

The group noted that they would have to develop a "mission" definition that could potentially apply to any avalanche control option conceived.

Green-Amber-Red—The "GAR" Model

Slininger instructed the group on use of the "GAR" Model, something called a "living, breathing animal." GAR is a dynamic, fluid tool, not a static exercise. This is the exact reasoning for requesting a secondary ORMA review to confirm assessments developed in 2007 and interject any new techniques or technology that will further reduce risk for the existing operations. Users can use it to continually adjust operations to minimize risk and maximize gains. GAR stands for Green, Amber, Red as depicted in the simple rating scale in Table 3 below. The GAR is a model and tool that is ideally used to evaluate an individual rotation of a field operation and is also used to assess operations programmatically (the typical conditions of a recurring operation). Numbers correlate with the colors to serve as a guideline measurement, and should not be considered a steadfast definition of risk or hazard. ORM recognizes that different organizations and workgroups within organizations have different levels of acceptable risk (i.e. the training division of an organization typically has a lower tolerance for risk than the operational division, the military typically has a higher tolerance of risk than a civilian organization, and/or the military has a higher tolerance of risk when at war than during peaceful periods). It is up to an organization's leadership to define what levels of risk are appropriate.

Table 3. GAR Scale. Numbers on the scale are derived from the Coast Guard scale as modified for NPS application. The numbers and colors are intended to serve as a qualitative and quantitative indication of risk. Charts 1 and 2 below apply this scale to the identified options for avalanche risk reduction at Sylvan Pass.

RED (High Risk)	**80**
AMBER (Caution)	**60**
GREEN (Low Risk)	**35**
	0

Risk Calculation Worksheets

Slininger further instructed the group in the use of the risk calculation worksheets they would use to rate activities or options for avalanche hazard mitigation at Sylvan Pass. An example of the worksheet is shown in Table 4 below. Expert panelists rate the avalanche hazard mitigation options on a scale of 1 to 10, with 10 being most risky. Panelists do this individually, but always check each other's assumptions and learn more through dialogue. For example, the question, "who put more than 6 on supervision?" could lead to a discussion in which participants may or may not reconsider their rating in light of more information from peers or other panelists.

Table 4. Risk Calculation Worksheet; operational components are defined and discussed in more detail below.

Operational Components	Rating
SUPERVISION	
PLANNING	
CONTINGENCY RESOURCES	
COMMUNICATION	
TEAM SELECTION	
TEAM FITNESS	
ENVIRONMENT	
INCIDENT COMPLEXITY	
TOTAL	

Working Definitions of GAR Elements

The working definitions of the eight operational components in the Risk Calculation Worksheet were important to review as a group so that all panelists were operating from the same framework. The group reviewed and discussed each in turn.

The experts were asked to look at different options with a variety of current park resources (and needed resources in reference to staffing levels and expertise) as they existed in the 2009-2010 winter. A turn-over of expertise in the staffing level of the operation for the winter of 2010-2011 is expected. For new options that do not exist (i.e. fixed gas), panelists were to assume that current resources would be augmented with the funding to implement and operate the option. If "current resources" change (for example, employee turnover brings more or less expertise), then the relevant scores might also change.

Supervision

Supervisory control should consider both how qualified the supervisor is and also whether supervision is actually taking place. Even if a team member is qualified to perform a task, supervision acts as a control to further minimize risk. This may simply be someone checking what is being done to ensure it is correct. The higher the risk, the more the supervisor needs to be focused on observing and checking. A supervisor who is actively involved in performing a task at hand rather than observing employee performance and

checking for safe compliance with procedures can be easily distracted and should not be considered an effective safety observer in moderate to high-risk situations.

Planning

Planning and preparation should consider how much information one has, how clear it is, and how much time one has to plan the incident or evaluate the situation. Planning includes the use of pre-defined plans and on-site incident plans.

Contingency Resources

Contingency resources should include those pre-defined resources that will be called upon in an overwhelming incident. Items to consider include:

Who is the team member going to call?

Can he or she make the call?

Are the contingency resources available and aware that they are such a resource?

What is their capability for the incident?

What is the response time for any given location?

Communications

Communications need to ensure the clear and accurate sending and acknowledging of information, instructions, and commands; and provision of useful feedback. Items to consider are not only interpersonal communications but also the physical communication equipment.

Team Selection

Team selection should consider the qualifications and experience level of the individuals used for the specific incident or operation. Individuals may need to be replaced during the incident or in the operation. The same concerns apply to the contingency resources. Also, teams should have an adequate number of members from which to choose for any single mission.

Team Fitness

Team fitness should consider the physical and mental state of the team. This is a function of the amount and quality of rest a team member has had. Quality of rest should consider sleeping conditions, potential sleep length, and any interruptions. Fatigue normally becomes a factor after 18 hours without rest; however, lack of quality sleep builds a deficit that worsens the effects of fatigue. Other factors to consider are physical preparedness and personal life factors that may impede the outcome of the operation.

Environment

Environment should consider factors affecting personnel performance and factors affecting the performance of equipment, vehicles, vessels, or aircraft. This includes, but is not limited to, time of day, wind exposure, temperature, humidity, precipitation, elevation, isolation, vertical exposure, proximity to aerial/navigational hazards and other exposures (e.g. oxygen deficiency, toxic chemicals, and/or injury from falls and sharp objects).

Incident Complexity

Incident complexity should consider both the required time and the situation. The longer exposed to a hazard, the greater the risks. Factors considered include how long the environmental conditions will remain stable and the complexity of the work.

The Severity, Probability and Exposure Model

The panel was also introduced to the Severity-Probability-Exposure (SPE) risk model, where a different measurement of risk is obtained from the formula: Risk = Severity x Probability x Exposure. This is a model used to take a closer look at specific operations and is helpful to consider when planning ongoing operations. In this ORM, the panel relied primarily upon the GAR model, but used the SPE model to illustrate the risks from three options, as discussed below.

The definitions of the SPE components are:

- **Severity:** the potential loss or consequences of a mishap (Risk Control such as protective devices, engineering controls, and personal protective equipment are used to control Severity.)
- **Probability:** the likelihood that given a certain exposure, the projected consequences will occur. (Risk Control--training, awareness, attitude change, etc.)
- **Exposure:** the amount of time, number of cycles, number of people involved, and/or amount of equipment involved (Risk Control--reducing the number of people involved, the number of events, cycles, evolutions, etc.).

To rate the Risk of an option under the SPE model, panelists would rate severity on a scale of 1 to 5 (5 being worst), probability on the same scale (5 being highest probability), and exposure on a scale of 1 to 4 (4 being worst) and then multiply the ratings to achieve an overall score. Table 5, below, illustrates how those multiples would be considered qualitatively.

Table 5. SPE Worksheet

Values*	Risk Level	Action
80-100	Very High	Discontinue
60-79	High	Immediate Correction
40-59	Substantial	Correction Required
20-39	Possible	Attention Needed
1-19	Slight	Possibly Acceptable

*These values are separate from and not related to the GAR values in Table 3.

To use the SPE model, the panel would compute the risk levels for each hazard identified. Then, those hazards can be rank ordered from the highest to the lowest risk, allowing such a panel to focus on the areas of most concern first under conditions of current resources.

Universal Risk Considerations

Finally, the group was exposed to the concept of "Universal Risk Considerations," broader factors that managers must consider when implementing an operation. For example, managers must consider impacts upon other facets of park operations when implementing a specific project. Some Universal Risk

Considerations include injury, occupational illness or death; equipment damage and fiscal resources; adverse or positive public impacts; reduced morale; adverse administrative and/or disciplinary actions. The group noted that many of these considerations will be applied to this process; however, the priority of this workgroup was to focus on the risk associated to employees and public. (Further discussion of universal risk considerations occurs in the Risk vs. (Factual) Gain section below).

Operational Risk Assessment

Upon completion of the ORM orientation the group conducted ORM steps 1-5 (see "Seven Key Steps of ORM" above) in the allotted time (3 days), but modified the order of the steps. The group took the foundations from the morning's orientation and began doing the assessment itself, as described below.

Mission: Keep Snow Off People

The group accepted the working description of the mission: "**keep snow off people**" or, more specifically, "**avoid negative avalanche-human contact**."

The group discussed that any option is potentially feasible to achieve that mission—an open mind is part of the process. Remaining open-minded keeps the steps honest and methodical, rather than value-laden and assuming at this stage. Also, the group agreed not to discuss financial costs of options until the very end of day 3 in order to evaluate all options objectively.

Options to Achieve the Mission

The basis of this review is to evaluate operational risk in Sylvan Pass avalanche forecasting and avalanche hazard mitigation options. The group was tasked with identifying avalanche hazard mitigation options that could be applied there.

The group began making a list of all the options they could think of to achieve the mission, stated as simply as possible "to keep snow off people" on Sylvan Pass. The options were named and re-named and defined a few times during the three days, but the end list of what the panel analyzed by the GAR method and what the group meant by each option is described below.

Background on Existing Operations

Maura Longden presented the existing avalanche hazard mitigation operations. Highlights of the program are:

- An Operational Profile exists that defines standards for communication, safe travel and all operations at Sylvan Pass.
- Avalanche awareness and rescue training occurs as well as networking with others in the region to keep up with the latest on avalanche mitigation.
- The pass (and East Entrance) are closed from 9 pm until 8 am or when determination is made if the pass is open or closed (typically 8-8:30 am but can take longer depending on current conditions). Since the last ORMA, this closure applies to park staff as well as visitors.
- The East Entrance (and the pass) opens for the winter season December 22 and closes for the season March 1. This is three weeks shorter than the balance of the park (December 15 to March 15).
- Once it is determined that the pass will be open, the information is broadcast to the communication center. The pass can close at any time due to changing conditions. When the pass is open, the NPS

sometimes makes contact with guides on-site at Sylvan Pass to inform them on changing conditions (education and outreach).

- When the pass is closed to visitor travel, it is also closed to park staff (except for avalanche-related travel).
- Park website has information on Sylvan Pass, but not daily updates.
- Staffing – 8 total staff (for forecasting) (Primarily located in the Lake administrative area with additional staff also at the East Entrance).
    - 3 forecasters and one trainee – Forecasters make the decision on when the road is opened or closed
    - 4 snow rangers
    - For Howitzer missions, 15 people are trained (includes groomers)
    - Groomers rebuild roads after missions or avalanches.
- Last couple of years the NPS has upgraded weather stations (Hoyt Peak and Sylvan Lake), now there is more accurate data available before they leave for the day enroute to Sylvan Pass.
- Morning condition assessment – starts at first light. Team members travel up the road corridor from Lake and make observations of snowpack and weather, looking for indications of instability. Observations specifics:
    - Representative slopes, signs of instability
    - Starting zones, cornices, old fracture lines
    - Road conditions, capability of over snow vehicles safe travel
    - Visibility
- Employees –November through spring plowing forecasting and working with the plow crew into May
- Conditions in Sylvan Pass can be very different than those in Cody
- Documentation – prepare an avalanche discussion every day to share info with all employees.

Access to the howitzer platform is an issue: Team must cross avalanche paths to access the Howitzer using either route. Access to the Howitzer can occur along two routes from the west (see Figure 2– the yellow dot is the howitzer platform). Both routes initially cross 8 avalanche paths (1-8 on the map). Then one route, used historically, uses the summer access road to reach the platform. In the winter, this road is groomed for snowmobile access to the platform. The road crosses an additional 4 chutes (not numbered on the map). In recent winters, in addition to using the summer access route, the gun crew has continued east on the East Entrance Road to a point directly north of the gun platform, where they leave their snowmobiles and proceed on foot to the platform. This alternate approach puts the crew on foot in deep snow, but avoids the three short avalanche paths on the side road and is in keeping with a recommendation by the Occupational Safety and Health Administration (OSHA). There are no other routes of access to the howitzer platform available; both of these routes entail traveling below uncontrolled avalanche chutes though the recent realignment of the East Entrance Road has created more distance between the road corridor and the base of the western-most avalanche paths.

- Howitzer and helicopter are two methods of avalanche hazard mitigation. The flight from Bozeman is problematic – last winter ran two helicopter missions. No operational control in the helicopter. Contractor chooses how to dispense the explosives, NPS just tells them they want it done. May do orientation flights in the beginning of the year.
- 2010 OSHA recommendations from recent program review
- Since the last ORMA:
    - The gun platform now has a structure with a propane heater to warm up.

- NPS has an agreement with the military for two-tracked over-snow vehicles for Sylvan Pass operations.
- Howitzer improved since last ORMA, increased size of deflection berm. Different gun (Korean Era, cold weather). Have a base plate under the axel of the gun to transfer energy, was able to remove back plates.

- Sylvan Pass is the only year round avalanche hazard mitigation program in the Park Service. Difficult to keep program going in terms of personnel training to meet operational profile. Recruitment and retention of employees is always an issue.
- Decisions on opening and closing the road rest solely with avalanche forecasters on the ground.
- The park updated the group on the recent visit from the Occupational Safety and Health Administration (OSHA).
- OSHA made several recommendations during this ATAR (Agency Technical Assistance Review) including,
- The NPS should put in writing scenarios where they will not do work at Sylvan – overview on the go/no-go situations.
- Bring in an outside contractor who specializes in decision logic, look at process and documentation on go/no-go process to make sure decisions are not skewed one way or another (stay in line with decisions)
- Snowmobiles – It is thought BATs, throttle blocks cause a significant reduction in power that creates concern when traveling through the avalanche zones. Group consensus also concluded removing the throttle blocks would provide capability to drive through powder snow and drifts. Pull rescue sleds, having enough power to take equipment and people during a rescue response. Recommendation to remove the throttle blocks has been made, change is yet to be approved.
- As personnel change, filling in behind them with experience, knowledge to keep program at the level that it is now is going to be a challenge. The NPS should not change the program to adapt to experience and knowledge of staff, but should keep the same program and make sure the staff match that experience and knowledge.
- Travel through paths 1-8, getting to the platform need to travel through avalanche zones so there is a level of risk there.
- Climbing up on the mountain side to conduct avalanche forecasting duties was identified as a risk.
- Tracked vehicles – One broke down last year, having a “buddy” system would be a safer alternative.
- UXO mitigation, not sure how many rounds there are on the slopes as records were not consistent in early years of the program. UXO have been found and the Air Force has been called in to detonate them in place. Continuing effort needs to be addressed. Dud rate with Howitzer 0.5%. 10 duds since 1997. 4-6 that have not been recovered. Comment: unconfirmed detonation doesn’t always equal UXO. Not sure what is up there before 1997. Have looked and not found much. Unstable footing, steep and loose rock movement. Last year four round were found and detonated.
- Discussion on how we will consider UXO mitigation – group felt we should look at this, even if it is separately, if time allowed. It was noted however, the primary focus of this assembled group was to assess the winter operations and risks associated with those tasks.

IV. Risk Model Findings

Options with GAR Analysis/Discussion

Option 1: Existing Operations

Discussion: Notes on existing operations:

- **Transportation** – Sylvan Pass team members all have assigned snowmobiles. Other employees share snowmobiles and do not have one per individual.
- **Worst case scenario –** how many people could be caught? 3-5. Mission, minimum 3 person crew on howitzer, would like to have a 4th. There are road guards on east and west side of Sylvan Pass. West side road guard is in the EMS vehicle with emergency supplies on board. Also have enclosed vehicle with emergency medical equipment on east side ready. A snow groomer is positioned on the west side ready to cut drifts, avalanche debris and re-build over snow road.
- **Daily general practices-** Check radio and transceiver before leaving and check again when zones have been reached. Team of two snowmobiles, check in with communications center, who will do status checks while operating in the avalanche zone. Only one moves at a time from safety zone to safety zone.
- **Resources-** Can call other resources such as maintenance staff that are trained in rescue. Resources are at a distance (22 mile to Lake, 6 miles to the East Entrance). At East Entrance the people available vary from 1-4, at Lake about 10 people, though this is not the number available on any given day. Everyone is equipped and trained. There is always a ranger ready for rescue and listening to coordinate and respond if needed.
- **Other resources-** Can go to other districts, but adding distance. For medical assistance, can get a helicopter in or use a sled to pull the person down the road to transfer to medical transport over-snow vehicle.
- **Daily forecasting-** When forecasting from east or west side, a forecaster and a snow ranger travel to the avalanche zone to conduct a morning assessment. If elevated avalanche hazard, procedures could have a person from either side of pass go up to be extra person based on the situation.
- **Forecasting duties-** daily morning evaluations, digging snow pits at study slope are done weekly. Looking at snowpack changes over time, making adjustments to pit profile locations throughout season.
- **Communications-** Reliable radio communications – no cell service. Like to use local radio communications, can be spotty at times with road guards but must always confirm communications are working before missions begin. Can use radio repeater for mission communications, more reliable – if communications go down, it is a no go for the mission.
- **Note:** Park County updated their system, wanted to know if the park could use their system if needed – both are digital. Possibility to link to Park County system.
- **Acquiring data and communicating that data –** computer capabilities, are the weather stations communicating? Connection to weather stations has improved, includes 15 minute data transmitted each hour.
- **Computer capabilities-** East is on a slow satellite connection, Lake is on a high speed connection. Problems can occur if there is a power outage. East has a generator but does not automatically cover the computer. Can talk on the phone between Lake and East (or other areas) if one site becomes disconnected. Weather station can go down, if damaged by winds or rime, but has improved.
- **Training-**Everyone on the crew goes through avalanche awareness training level 1 or 2 and avalanche education classes are offered to the crew that participates to some degree. Also crews are attending outside training every year (i.e. ISSW, wet snow seminar in Bozeman). On the job training is happening regularly. Try to focus on a full avalanche rescue scenario for training. Program is moving to try and have dogs, avalanche trained and certified in the future.
- **Road conditions –** Has changed a lot over time, newer groomers do a better job of keeping the road wide and new snow groomed down. Risk of getting stuck is part of decision to keep open or not.

- **Groomer operations –** Teams of two or more stay and spot the groomer while they are doing their work, after an avalanche hazard mitigation mission. Outside of a mission, it is by request or for a specific purpose. Communications center also tracks the groomer by checking status until they arrive back at Lake. No grooming in the avalanche zone after dark.

Additional notes-

- Sylvan Pass is closed to all nighttime travel. No nighttime travel allowed as of the 2009-2010 season.
- Public wants hours to be predictable. Public use period-East Entrance Road open from 8am to 9pm.
- Lots of moving parts – very complex program including avalanche forecasting, mitigation program and grooming operations.
- Environmental exposure in extreme weather, early morning and into the afternoon. May make more than one trip – 50% of the day is spent out. Some of the exposure is dependent on the hazard; more exposed to weather, poor road conditions and snowpack instability the greater the hazard.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

CURRENT CONDITIONS OPTION	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversight or guidance.	2	3	2	2	3	4	3	2.714
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	2	3	3	2.5	2	3	4	2.786
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	4	7	4,5	4	4	8	7	5.667
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	3	4	2.5	3	3	3	3	3.071
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	5	4	3	6	5	5	3	4.429
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	3	4	3.5	3.5	3	3	3	3.286
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	7	7	8	6	6	8	8	7.143
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	5	6	5	5	5	8	5	5.571
Total								34.67

Post Assessment Discussion

Following each group assessment the discussion focused on the evaluation and reasoning for scoring of individual elements by the expert panelists. Brief notes of the discussion follow each GAR assessment. Where no elements are mentioned there was no discussion regarding that specific element.

Supervision-

- Supervisors are an integral part of the daily operations, there is not a separate supervisor that is not part of management.
- Snow science is unique, what is replacement strategy for a supervisor with the right knowledge? This position has many functions in addition to avalanche control.
- UT Example – crowd sourcing for information is a valuable input.
- Ski resort practices – first people in (forecasters) make the recommendations, and then the mitigation team takes over. Division of tasks and more staff makes for ease of implementation.
- Should have a supervisor who is not in operations (noted this is the YELL model).

Planning-

- When higher exposure/risk is expected, more planning is done.
- Very structured and predictable operational profile. Staff works with it and trains by it.
- In the avalanche mitigation process, there are always things you cannot account for.

Contingency Resources-

- Operating in a remote environment ie: difficulty to get immediate response for a rescue. Have 15 minutes for reaction to an avalanche, this operation is about companion rescue. Staff is well trained.
- Companion rescue would be rated lower (3 or 4) but that is to locate victim and assess if there are injuries. Some details can be mitigated some cannot such as weather for aircraft support.
- Companion recue is good, but not a lot of companions out there.
- Resources coming from Lake and East Entrance are trained for these events and accepting of delay in travel time to get there.
- Compare contingency resources from a city or town and they are there within a few minutes. At Sylvan Pass they are 45 minutes away and care is even longer away.

Communications-

- Strong part is the communications internally. One panelist rated it at 4 because some of the computer issues. Radio communications really good and having dispatch track people is good.
- Communications tend to be short in windy, cold environments.
- Radio communications are good, concern about the dispatchers not realizing how important it is to be listening to staff in the field.

Team Selection-

- Good team assembled but depth of team is of concern
- Team is excellent. Have the no go option on mission if team leads don't feel they have experienced staff available.
- Variation in qualification and experience. Having an adequate number of people to choose from is optimal. Do not necessarily have that option now.
- Team selection beyond upper levels could be improved. It takes years to become proficient in aspects of snow science operations.
- Compared to Teton Pass (Wyoming Department of Transportation), Yellowstone operations have good personnel depth.

Team Fitness-

- There are operational distractions in the spring time that conflict with conducting forecasting and avalanche hazard mitigations.
- Need fit people who are efficient skiers.
- Avalanche forecasting is a full time job, causes fatigue over the season, difficult to take a break.
- Physical preparedness, ability on skis and to work through terrain without distraction, snowmobiles are used extensively.

Environment-

- Operating in a very harsh environment, probably the harshest in the lower 48. Doing a good job of mitigating the environment, that is why it is not a 10. Dealing with harsh conditions and dangerous travel. No night operations slightly lower risks. Warm areas help.
- Environment is harsh but a lot of mitigation measures in place to deal with it.
- Existing limitations on allowable cold, Park policy: cannot go out if it is 20 below zero.

Incident Complexity-

- Complex operation, long travel time, two crews from two areas, must pass avalanche areas but have tight mitigation measures
- Very complex, because of recent measures it has been made less complex.
- Complexity of logistics for the operation is huge, but installation of profile has made a logistically complex problem simpler. There is not a lot of diversity between avalanche paths, helps simplify things.
- Potentially taxing to current staffing levels. Concerns about preparedness psychologically to handle an avalanche incident.
- Multi-faceted different functions are taken on by individuals (grooming, forecasting, artillery, etc) possibly making operations difficult than they need to be.

Option 2: Existing Operations Plus Operational/Physical Enhancements

Discussion: What would make operations better at Sylvan Pass?

- NPS forecaster in helicopters during mission or during recon flight before.
- Use of Explosives-This would require exemption from Departmental Policy (NPS-65).
- Communication link with Park County.
- Air Bags.
- Use of snow-pit assessments on low angle slopes is recommended. Something YELL has already started doing.
- Moving Sylvan Pass road south (completed as of September 2010) is an improvement, but hazards still exist.
- 2008/2009: For all paths: 149 avalanches, 127 explosive-triggered avalanches with 35 reaching the roadway, 22 natural avalanches with 17 reaching the roadway.
- 2009-2010, 122 avalanches, 28 reached the road. 10 out of 28 hit old road in paths 1-8. None hit "new" groomed road. Really comes into play in the spring. Groomers could move enough snow to keep the swales open. In totality is an improvement – turnout at path 9 (active path) could be changed but may not plow this out till later.
- Engineer look at the most effective mound – already done? Can help use snow and debris to build up mounds.
- Moving road further? About as far south as they can be.
- Structures in avalanche starting zones? Hold this till later to discussion that looks at slope devices.
- Implement redundancy – have one wind and precipitation station now, more redundancy would give more confidence. Separate stations, gun mount? Precipitation meter is now at Sylvan Lake. Data collection improvements such as; web cams at the gun mount. Cold is a concern but new units that can handle the cold. This would give the public the current conditions/visibility at the pass.
- Discussion on future staff – can bring in someone with knowledge and expertise but takes time in this program due to individual aspect of this. Location in Lake is remote and could impact recruitment. Need to look at hiring a program, not a person. Forest Service, hires seasonal for the winter time. Maybe a new option? How you can improve with mechanical aspects vs. an attrition plan? The ANNUAC (Avalanche Artillery Users of North America Committee) is also struggling with this, people in the industry are starting to vacate positions and replacements are not coming, industry-wide issue. Continuity is key in the program's success. It is the event that happens once every 10 years that is the issue, need to know the area. Great procedures are in place that can be passed on. Examples – Glacier National Park have a U.S. Geological Survey forecaster for spring plowing operations (have a sister office in Bozeman). Can this be done though interagency agreements? Not sure how viable mentor program is due to quick turnover in the Park Service to other assignments.
- Fatalities in Yellowstone – in the 1990's, three researchers skiing in backcountry were killed in avalanches.
- For other alternatives – could use a contractor that could go in helicopters and use explosives, use external personnel for these activities. Explore options to make the helicopter operations more effective. This will require changing/amending the current contracting procedures.
- Augmenting cell service – cell phones boosters would increase coverage in the pass areas.

- Why have someone access from the east side? It is where part of team lives. Advantages of team members from both east and west sides see different things. East side also has some more problematic slides (17 and 18) best observed from that aspect. Biggest impact on the east side is not being able to go on as many missions. Historically, forecasting was done from the east.

Definition of option: Existing conditions with operational improvements (physical improvements)

- **Improved instrumentation – web cam is a specific, as well as redundant weather station**
- **Moving the road south with swales, berms, and mounds**
- **Air bags for staff**
- **Low angle work**
- **Communication link with Park County**
- **Cell phone boosters so there would be coverage in the pass**
- **Snowmobiles without a throttle block (full power)**
- **Engineered structures (earthworks) to reduce snow buildup at the gun mount (earthwork controls at the gun mount approach)**

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

CURRENT CONDITIONS OPTION – Enhanced	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversight or guidance.	2	3	1	2	2	4	3	2.429
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	1.5	2	2	2	2	3	3.5	2.286
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	3	6	4.5	4	4	8	6.5	5.143
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	2	2	2	2.5	2	2.5	2.143
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	5	4	2.5	6	5	5	3	4.357
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	2.5	4	3	3.5	3	3	3	3.143
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	6	6	7	6	5.5	7	7	6.357
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	5	5	3.5	5	5	6	5	4.929
Total								30.79

Post Assessment Discussion

Supervision-

- Moving the road – currently need a lot of supervision to see if decision to use road is right, with moved road less supervision needed. Same rational applies to planning.

Planning-

- Less than existing because of communication, more data.

Contingency Resources-

- Increase in communications, shared communications with Park County .

Communications-

- Added technology.

Team Fitness-

- Small decrease, one less worry.

Environment-

- Risk reduced because more options for testing, better snowmobiles – also moving the road.

Incident Complexity-

- Reduced but concern voiced about adding more things to the complexity. Severity may be declined a bit.

Safety Equipment-

- The park does not have avalanche air bags. Recommend that they have them. Have been used in Europe, have a 98.5% rate of survival (out of 240 incidents) compared to 90% without them. Backpack with compressed gas, in an avalanche inflates bags to "float" you to the top and try to keep you above the snow. A lot of programs in Europe have adopted these. 3 different kinds of bag - $350 to $800 can negotiate for large orders. All 3 have strengths and weaknesses. Question: do people accept a higher level of risk wearing these? A: yes has been seen.

August 11 Opening Discussion

Review of the GAR sheets from previous day. Existing condition with Operational Enhancements was revisited. Would a new enclosed snowcoach with two trained EMTs change either Environment or Contingency (both of which were rated high yesterday)? Is there anything else that would address contingency and environment?

- New vehicles would address the environment – ride up to the site in enclosed snowcoach and then transition to a snowmobile.
- Military OSV(Oversnow Vehicle) – useful during missions but move slowly, snowmobile can perform better. May not be able to drive up in a snowcoach in all situations.
- Right now, use East Ranger Station as a drop in point to escape the elements.

- Found that Mat-tracks conversions are rough on vehicles, now looking at snowcats for this winter's operation.
- Grooming cats are 10-14 mph, too slow to get work accomplished. Would need to shift time in the morning if the vehicles were slower.
- Possibility of leasing 1 or 2 snow cats this winter as a trial.
- Contingency Resources is the bigger issue is – upgrades at East Entrance could help the situation.

Recap of previous day's scoring – rating was 39 for existing conditions in the 2007 ORMA, now the rating is about 34. Risk is less than we thought it would be in part due to planning.

Options with GAR Analysis/discussion- (Continued Day Two)

Option 3: Existing Operations with Personnel Enhancements – Optimal Conditions (all staffing needed is available in terms of number and experience).

Discussion:

- Snow rangers – ideally looking for winter skills and ski ability, not trainee positions as occurred in the past.
- Options for staffing through other avenues than district personnel (look both within NPS ranks as well as other alternatives).
- Could avalanche work be done by contracting? Two different models:
    - All private contracting – this is done in Alaska. This option has flexibility – can ride in helicopters, use hand charges, have more freedom. Disadvantages is losing avalanche expertise within the NPS and developing the avalanche culture within the agency. To maintain these types of operations, NPS needs more avalanche culture/training.
    - Keep it within the government – what is typically done in the lower 48. Forecasters in U.S. Forest Service are GS-9, seasonal are GS-7 to 8. In Seattle they are GS-11/12 but they are meteorologists (more about weather than snowpack). This is what it is, not really what it should be. Within NPS, do we need to create a non-Law Enforcement position and create something more specific, or do we keep this within LE? Looking at separating workload. USFS has used winter seasonal to do this. Right now, resource pool is getting stressed at the transition seasons – would need to take these seasons into account when determining length of seasonal support, also want them to be there for the whole season for continuity. A permanent snow person and a seasonal snow person with only avalanche responsibilities would cover all of the bases.
- Right now program is in a place that has been working and the NPS is proud of. Need to look at possible scenarios to carry this forward and keep it a NPS controlled program. Possibly could blend and incorporate some contracting into this, with NPS control. Limitations, position requires someone to live in the interior of Yellowstone in the winter, not appealing to a large number of applicants.
- Can look at stationing people on the east side but concerns about safety crossing avalanche passes from the east to get to the gun mount. Need a forecaster in the west to enter the pass from the west.
- Risk lies in the availability of personnel to provide support to the rest of the park. To a large degree, staff is focused on Sylvan Pass and do not have a lot of extra time after these responsibilities.

- Jackson Hole – use two forecasters per day. Lead comes in first and does the forecast, second comes in to provide input. This is similar to what the park is doing now.
- 3-4 forecasters are the optimal level, consistent with what is done with highways throughout the country. Contracts in Alaska tend to use less (2), more for railroads, power lines, and other private section areas.
- Need to consider infrastructure support for staff (housing).

Definition of this option – looking at avalanche control:

- Existing operational profile: Program director, 3 forecasters (right now program director is one of the forecasters), 1 forecaster trainee, 4 snow rangers (9 positions total).
- Changes:
    - Take district ranger out of the operations. Have a district ranger that is removed from the forecasting, remain the avalanche program manager (there is a 12 month responsibility for this program). The program manager should be a highly knowledge subject expert. This does not really reduce time for the district ranger during the summer, maybe takes time away during the winter.
    - One of the forecasters could be a year-round winter use coordinator (part-time during the summer) to address year-round needs and take that off of the district ranger. Can have other duties during the summer but would keep the avalanche program going. Currently take Maura 2-3 days a week during the summer (contracting, ORMA, OSHA, other meetings).
    - 3 forecasters – lead forecaster/manger (new position, year-round), plus one dedicated ranger (like now) that has the skills to forecast (could be part-time or another ranger), and one seasonal.
- Permanent (subject to furlough) forecaster with a seasonal dedicated to avalanche control.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

CURRENT CONDITIONS OPTION - Enhanced Personnel	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversight or guidance.	1	2	1	1.5	1.5	3	2	1.714
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	1	2	2	1.5	1.5	2.5	2	1.786
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	2	5	4	2	4	3	6	3.714
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	2	2.5	2	2	2.5	3	2.286
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	2	3	2.5	4	4	4	2	3.071
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	2	3	2	3	2.5	3	2	2.5
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	6	6	8	5	5.5	8	8	6.643
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	4	5	4.5	4	5	7	5	4.929
Total								26.64

Post Assessment Discussion

Supervision-

- Risk reduced from other methods discussed so far. The program manger may or may not be there all the time overseeing operations, may be disconnected with the operations on the ground depending on where they are located. If missions are missed, there would be a reduction in supervision – it would depend on how the program manager position was developed.

Planning-

- More focused coordination, less task overload.

Contingency Resources-

- While it has decreased, you can't change how far the pass is from emergency response resources (can't move the pass, the hospital, etc). You can improve the situation, but the pass is still remote. May be able to enhance self-rescue with another person. Expertise of the staff is still an unknown variable.

Communications-

- You gain (reduce risk) by having more expertise.

Team Selection-

- A variable depending on who is on the staff. Some improved scores as this opens up to the avalanche professional field if it is not a LE position, specific snow position opens up the pool a little bit, but still risk involved as you will still have trainees but increases the pool at the senior forecaster level and may bring in outside perspectives.

Staffing levels

- Team size, teams of 3 or 4 are good for communication, greater than that can be an issue. In spring operations are stretched, as seasons overlap (not for spring opening operations) snow rangers may or may not have previous experience. Some people new to the snow environment and learn as the season goes, gaining experience and exposure to avalanche forecasting and mitigation operations. Dealing with variations in skill and knowledge, and the ability to get around in the snow (strength). Looking at transition of 3 out of 8 in the forecasting team this coming season – (note: if two of the three forecasters leave, and unable to replace, it is suggested to stop the program.) Some of the current team has been in place for a long time – concern would be depth of staff. If two people have flu at the same time, what do you do? Need to plan for attrition, job transfers, retirement - need to consider this when recruiting/hiring new staff for the program.

Team Fitness-

- Work/rest ratio would increase with another person. Program manager would be well versed, could be a back up if one of the three forecasters was unavailable. Would be an improvement in terms of morale, may be able to allow a forecaster to leave for trainings and other things if people were specifically dedicated. Also helps in the summer with the one person dealing with snow issues year-round (not worried about responding to LE incidents).

Environment-

- Many stayed the same from earlier scenarios. Staff working in the conditions rated lower because have worked in harsher conditions and are used to the conditions at Sylvan Pass. Crew is used to the conditions. Amount of exposure to steep avalanche terrain is less than in some other areas, even if the weather is not as harsh. More confined environment, not a huge area to forecast for like other places in the region.

- What if a patrol cabin was placed out in that area? Scores show that need to look at ways to address exposure and the environment which could include a vehicle, building to go to, etc. Having a building to go to may also enhance communication, difficult some times to take the time to stop and talk while you are in the elements. This occurs now to an extent at east. May also have an effect on contingency resources, another place to store equipment, address emergency issues, etc.

Option 4: Existing Operations with Personnel Turnover

Discussion: Certain staff changes will be occurring after this year. 1-2 forecasters are leaving, as well as two snow rangers.

There is an operational profile (Appendix) a drop below the profile dictates the operations cannot occur. With known staffing changes anticipated there is a need to fill the vacant positions. Need the core group of 8 people, or it is a no go. Currently, it is being operated at the required minimum staffing level. What is different is the expertise and experience. Shuffling top positions is different than the bottom positions.

Current work and planning will make transition easier for new staff. This model would change team selection and planning due to lack of on-the-ground experience. Last ORMA looked at this and noted high risk. In reality, new team built off of what old team put in place and this is not what happened. There are a lot of variables that are unknown. Risk could go up or down.

Looking at the wildland fire program as an example, anytime you lose key personnel, risk will go up but there is a temporal component, may just be a short period of time and over the long-run could lower risk as new ideas come in. There are good systems in place for replacement.

Definition of Option:

- **Existing operations (3 forecasters, 1 trainee, 4 snow rangers) with replacement personnel.**
- **Personnel would be qualified, but would lack on-the ground experience (lack of institutional knowledge).**

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Personnel Turnover Analysis	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	5	4	3	4	4	4	4	4
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	4	4	3.5	3	3	3	4	3.5
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	5	7	5	5	5	8	7	6
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	5	3	3	2.5	4	4	3.5	3.571
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	5	5	5	6	6	6	4	5.286
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	5	5	3.5	4.5	5	3	3.5	4.214
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	7	7	8	6	7	8	8	7.286
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	6	7	6	6	6	9	5	6.429
Total								40.29

Post Assessment Discussion

Supervision-

- There is a large unknown in this with respect to who comes in, what is the personnel turn- over, and the temporal changes (elevated initially, and as they get more experienced risk will go down). You could have the risk decrease from what new people bring to the situation. The person that comes in will need to know their limitations, be conservative and act accordingly.

Environment-

- Score rose (risk increased) because of the new personnel getting used to the cold. Also the environment impacts the snow pack and will be a new snowpack and conditions to learn. When looking at this option verses existing condition the risk increased.

Option 5: Employ a GazEx system (remote detonation)

Discussion: The following is a synopsis of the expert panelists' discussion around a Gazex system:

- A new generation of Gazex is available: it has been developed in the past three years.
- Currently about 2,000 units in the world.
- The newest version has a smaller footprint, a steel post the unit is mounted to for ease of removal for repair/off- season storage).
- The visual impacts are much less.
- There are three different diameters of radius of influence.
- Starting zones in Sylvan overlap would likely need less units then when last considered, resulting in less visual impacts
- General consensus concluded the risks would be lower from last ORMA.
- Installation of these units would need compliance (EA).
- New units would eliminate the need for gas plants (vs. old models). 6-1 oxygen to propane mixture.
- No duds, duds are just air.
- Need to be diligent about maintaining them in the summer.
- Proper placement (fixed location) will determine how effective it is. With big slide paths at Sylvan, easier to determine where Gazex should go.
- At Teton Pass, resupply the gas once per year, this will do 10-15 missions a season.
- Technology lets you address missions more quickly with less people than helicopter or howitzer operations.
- Increased safety (lower risk) due to remote detonation and ease of initiating multiple shots in a short amount of time.
- Installation problems: mountain side is unconsolidated. Questions came up about the installations shifting/movement. Company may also have engineering solutions – also consider new generation may have bugs in them.
- Need to look at initial costs, and then any reduction in annual costs (less helicopter and howitzer missions) and also reduction in risk.

- Not a substitution for forecasting, it a tool to mitigate hazards that forecaster see. Use of Gazex would remove howitzer, don't want to have exploders in howitzer shrapnel zone. WY has used helicopter bombing as needed even with Gazex. Annual costs, $200 for oxygen a year, plus helicopter. Howitzer can be up to $10,000 a year. Up front investment tends to be the issue, but may be able to partner with the State to assist with this. WY experience, built up with large exploders, found you don't need them that large. Location is critical: Installation should be assured the right area of influence.
- Testing the snowpack…existing program it takes a lot to do this logistically and need to determine if it is worth the logistics to test.
- Can use Gazex in certain situations to test the snowpack. Very useful for unanticipated events, maybe able to test less areas then do the mission. Idea is to hit it when the snow is not hitting the road so that it won't hit the road (a lot of little slides, rather than a big slide). It is easier to hit the button then to get the team together for the maintenance mission. Still need road guards, machinery, and forecasting.
- In the past, the status of the Sylvan Pass program was in question, and did not want permanent installations. For this discussion, not part of the risk to the operation.

Definition of Option:

- **Use of Gazex – other options have been dismissed. Remote controlled, exploder.**
- **Helicopter would be used as contingency, try to phase out if Gazex is effective.**
- **Forecasting staff would be at current levels and at current expertise.**

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Existing Operations with Gazex System	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversight or guidance.	2	3	1	2	2	3	2	2.143
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	2	2	1.5	3	2	3	2	2.214
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	3	6	3.5	4	4	6	5	4.5
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	5	2	2.5	2	3	3	2.786
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	2	4	2	4	4	3	3	3.143
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	2	4	2	3.5	2.5	2	2.5	2.643
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	4	6	4	4	4.5	4	5	4.5
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	3	6	3	4	4	5	6	4.429
Total								26.36

Post Assessment Discussion

Planning-

- Revision of the operational profile would be needed as well as more planning (Maura raised score because of this).

Contingency Resources-

- Risk lowered because system is timed better, potential to need contingency is decreased and potential for larger events is decreased. Others felt that following the definition, contingency has not changed – for the worst case- has not changed how the park responds. The need may be reduced but what you do has not changed. If you needed to evacuate someone off the east side, could do a blast quickly, clear that side and get someone out the east side easier, quicker.

Communications-

- System does not work if communications don't work (if radio link is out, system won't work), Need a computer and radio, wireless link is critical. This scenario has happened in Jackson, WY (antenna break, control unit goes bad). Weekly checks mandatory.
- There is some redundancy in the system, may have three different frequencies and will overlap in a redundant way. Some panelists thought this made communications easier, do not have to assemble a gun crew and transport over a long distance in harsh conditions.
- Some concern over need to learn new system and time needed to learn it. Also can increase planning and incident complexity.

Environment-

- Less exposure to the environment, less time exposed to the gun mount.

Incident Complexity-

- Risk went down due to the fact there are fewer moving parts in the communication link – less people to get ready to go for a mission. Some kept it the same, new tool you need to figure out, also need to make more frequent decisions.
- Potential issues include spare parts acquisition – components could be in France and take a long time to get.

Options 6 & 7 : Access to Sylvan Pass Operations with Existing Snowmobiles (Option 6) and With Enhanced/non Throttle Stop Snowmobiles (Option 7)

Discussion:

- Drive matt-tracks occasionally back and forth, difficult to handle (many people have put them in the ditch).
- Can cross significant snowdrifts from the Lake side, icing from the lake, and buffalo on the road.
- Cold temps and wind.
- Road is in good condition, can be "too fast".
- Have tipped machine going up to the platform.

- Riding groomer sleds in non-groomed conditions-however, newer Arctic Cats better.
- If conditions are too bad to ride, pass is likely closed.
- In past have had turbo bear cat intended for grooming and can go through rougher terrain.
- Throttle block – about torque and towing the rescue sled.
- Throttle block impacts contingency resources.
- Discussed that can be within BAT at lower speeds, only out of BAT when you need the extra power.
- Park has two-strokes that are used for patrols outside of the park.
- Sylvan and East operations are far removed from where monitoring occurs – some of the lowest sound levels are at Sylvan Lake in the winter.
- Last year was the first to transition to throttle block machines, can see difference in the number of injuries (# of times getting stuck).
- Feel it is straight forward that risk is lower with more power.
- Part of the no-go right now, if you cannot go up with a throttle block to the pass, the pass is closed. It did not happen last year, but has happened in the past.

Definition of Option 6:

- Accessing the pass from east or west on snowmobiles
- Morning evaluation – minimum of two people coming from the same direction (also for additional evaluation)
- After it is open to the public, can go one at a time
- Snow machines are ridden responsibly, within speed limits
- Sleds with throttle block -comes from winter use planning. Arctic Cat achieved BAT with a throttle block. Without throttle block, would exceed BAT. 98% Arctic Cats for administrative fleet right now. Yamaha and Bombardier make BAT snowmobiles as well. 2008 plan calls for 100% BAT for NPS by 2011/2012 season. As BAT is in place, air and sound have not improved to the extent thought because of non-admin BAT and snowcoaches.

Definition of Option 7

- Enhanced Snowmobiles that meet a higher power/performance level.

These options looked at access to Sylvan Pass only. No snow control operations were taken into consideration. The group discussion was centered on the Non-BAT snowmobiles and use by NPS personnel. It was pointed out the Yellowstone 2008 Winter Use Plan calls for 100% compliance of BAT snowmobiles. The conflicting issues of compliance and need for more powerful snowmobiles dominated this discussion. This issues was deemed to be a park policy, to move discussion along-decision was made to incorporate these two options into one assessment.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Snowmobile Access - Existing	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversight or guidance.					.5			2.643
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.								2.571
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.			.5					5.929
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.			.5					2.786
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).								3.714
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.								3.571
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.								6.857
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.								4.143
Total								32.21

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Snowmobile Access - Non-BAT Sleds	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	4	4	1	3	3	4	4	3.286
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	3	3	1	3	2	2	4	2.571
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	3	5	4	4	4	6	6	4.571
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	3	3	2.5	3	1.5	3	3	2.714
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	4	5	3	6	2	3	4	3.857
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	2	4	3	2.5	2	3	4	2.929
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	4	5	6	4	6	7	7	5.571
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	3	4	2	4	3	4	5	3.571
Total								29.07

Post Assessment Discussion

Supervision-

- Higher power sleds may result in an increase of supervision.

Contingency Resources-

- Scores improved for Non-BAT machines because more power available for rescue operations.

Team Selection-

- With the current machines, there is more training required. Someone new may go slower because they don't have the experience. Someone with a lot of experience may be able to access more areas because they are more comfortable. There is training – initial training for everyone who comes in (regardless of experience) with a refresher every year (classroom). Doing on-trail riding, but still someone who is newer gets stuck more than someone with experience. A higher powered sled may require more operator training.

Environment-

- Risk down on environment from existing. Different factors effecting performance of the equipment, out there less, not getting stuck as much, have enough power.

Incident Complexity-

- Probability of mishap is reduced, with more power won't get stuck but also with more power may have more accidents – does not change score for some as these balances out.

Option 8: Existing Operations, without the use of the Helicopter (but with Howitzer)

Discussion: Using the helicopter is a high risk operation that requires a lot of planning. Contingency resources, having the helicopter helps get people out.

Definition of Option:

- **Not going to contract for helicopter use**
- **Howitzer control only**

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Existing Operations - without helicopters	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	2	2	2	4	2	3	2.5	2.5
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	3	2	3	3	2	3	2	2.571
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	5	7	5	5	4	7	7	5.714
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	3	2.5	2	2	2	3	2.357
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	2	3	3	6	3	3	3	3.286
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	4	4	3.5	3.5	3	3	3	3.429
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	7	7	8	6	7	7	8	7.143
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	6	5	5	7	5	6	4	5.429
Total								32.43

Post Assessment Discussion

Supervision-

- Times when you can't get to the gun mount, and if not using the helicopter, need to be careful not to jump the gun.

Contingency Resources-

- Hand charges: hand charge routes are workable. Contingency resources are affected as well as team fitness and team selection all go up. Thoughts to contract to use hand charges on slide paths 1-8, to get to gun mount. If using hand charges, need to apply for an exemption from this Departmental Policy (NPS-65).
- Current policy requires a blasters license to use explosives. This would be part of team selection. New team members would need to be certified as blasters.
- No one on current team is certified as per NPS-65.
- Shock tube on a bomb tram – what is the goal, slide paths 1-8 to not expose people to greater risk, or to clean up after Howitzer. Can also be used for test shots.

Incident Complexity-

- Complexity could go up, without helicopter there are more hazards. Helicopters can bring everything down. Past peer reviews have talked about the need for redundant systems, more options is an advantage.
- Need to figure out how to make this tool more effective, how the tool can work better (such as a forecaster on board). There are pockets that cannot be hit with the gun, still good shot placement is essential.
- In the past helicopters have needed to turn around (weather) or didn't get as many slides as needed. But still the correct procedure because you cannot access the gun mount and this procedure still tested the snow. Helicopter gives access to east side shots the gun mount does not have access to (15, 17, 18 as examples).
- Can the contract be modified to allow more input into shot placement? No, cannot cross into operational control. It is a performance based contract. Doing a pre-flight adds complexity and cost. Might be able to do a re-con flight not during a mission but at a different time.

Option 9: Existing Operations (Helicopter and Howitzer) with the Addition of Hand Charges

Discussion: Note – how you use hand changes (when/where) influences the risk level.
Attached in Appendix- Portions of NPS-65 (National Park Service Blasting Policy) referring to prohibition of using hand charges and specific initiation devices.

This option could be used as feedback or to knock down slide paths 1-8, multiple options for use of hand charges.
Definition of Option:

- Hand charges are available to use, extent is not specified.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Existing Operations - with hand charges	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.								3.714
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.			.5					3.5
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.								5.571
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.			.5					2.786
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).			.5					5.071
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.			.5					4.214
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.								7.571
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.								5.714
Total								38.14

Post Assessment Discussion

Supervision-

- Goes up to get a clear understanding of how we employ this measure. Do you increase risk because now you can do things or you are doing them because you can, rather than because they are necessary.

Planning-

- Some felt planning easier because there is another tool. Some felt it would need more planning and with a good plan in place, some of the other risk numbers could go down.

Contingency Resources-

- Can use a hand charge to clear the way to make a rescue. Another tool to mitigate a potential concern.

Team Selection-

- Risk increased because of training needed to get someone comfortable with hand charges. Some considered this as a small specialized team, no trainees. Skier based activity, defines who can do this. If you don't have the right people, this is not an option – may be in the plan but not an option.

Environment-

- Steep, windy, and cold conditions at deployment zones.

Incident Complexity-

- Some didn't change complexity because it is another tool, but not running 3 things at the same time. More like trading one for another. Based on past experience, hand charge route is an easier tool to implement, intermediate feedback is available. Less risky if users are comfortable performing this task, but training up may be difficult. Some panelists increased the risk because this as adding another process that is currently not occurring.

Other Discussion on the scoring of this option:

Risk vs gain – this one may be high risk but needs to be weighed against the gain.
Proposal – change operational profile to say where hand charges can be used, take out the helicopter and then assess the risk.
Risk in this option is not from the explosive device; risk is more related to adding this program and going into the zones where you need to use the hand charges. Whole operation is more risky because there is more to do, but get more gains.
Program without helicopter and with hand charges – would just need to close road until you can get an assessment of the road hazard. Not carried forward by the group.

Just over 1.5 minutes for the groomer to get through 1-8 to the safe zone.

Option 9 cont.: Existing Operations (Howitzer) with the Addition of Hand Charges and Without a Helicopter

Discussion: State staff could use explosives, and fly in helicopters and would supplement program with required personnel.

Definition of Option:

- Hand charges are available to use, extent is not specified
- Use of Howitzer and Hand charges only (as described above under #11)
- All operations, with exception of the helicopter use, would remain the same.
- Assumption: have the waiver in place, and have qualified trained people who are going to deploy the hand charges.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Existing Operations-No Helo-With Hand Charges	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Randy Baum	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	4	2	2	3	3	2	3	3	2.75
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	3	2	3	3	3	2.5	2	2	2.563
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	2	6	5	5	5	4	7	6	5
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	3	3	2.5	2.5	3	2	1.5	3	2.563
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	5	5	3.5	2	3	3	3	4	3.563
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	4	4	3.5	5	4	3	3	3	3.688
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	5	7	8	8	6	5.5	6	7	6.563
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	5	5	5	5	5	4.5	5	4	4.813
Total									31.5

Post Assessment Discussion

Team Selection-

- Looking for a small specialized team, may or may not be able to fill this in a given year – team selection will be critical. Need to match the team to the tool to make this effective. If this is based on today's team, may be able to reduce the 7 given above but requires a blasting license and would need to bring someone in to do this. An exemption may occur but would still require the proper license and certification. Need one blaster – past operations blasters in training did the routes, while blaster was present. The park used to have a blaster in charge, with 7 blasters in training, certifications have not been kept up, a new program would need to be implemented. The 7 includes the sustainability of the program – with new assumptions, change the score to a 2.

Environment-

- One panelist questioned why was risk elevated high for this option? Statement was made "If we are taking avalanche risk into account, this process is lowering the risk." Some felt risk was lowered but it was still harsh weather conditions. Noted that the use of hand charges reduces the avalanche risk.

NOTE:
Overall, moved from 38.14 with a helicopter down to 31.5 without the helicopter, but adding hand charges.

Note: Joined by Randy Baum, Road Operations (other panel members same as previous days) for the following discussions.

Option 10: Spring Opening - Existing conditions (Sylvan Pass open all winter, avalanche forecasting all winter)

Discussion: Randy Baum briefed panelists on present snow removal operations.

Public use – since 1994, have had two control missions when they have been open to the public (last spring and 1997). Maybe should set this up with specific dates? Should not count in public use, has not been counted for other options explored. Do want to take into account admin travel, but if we do have public travel, there is an employee component to allow for this use.

Late season snowfall – has been measured at Jackson Hole, some years have very little snow and other seasons are more like this last with a lot of late season snow.

Spring hazards at the pass, two biggest are rock slides and avalanches. On the east side where it is steep, the rocks are releasing. Safety measures include always wearing helmets when moving rock from the road, part of the spring duties.

Comfort level: Exposure is a concern, in and out of slide paths. Do not recall near misses due to avalanches. Comfort level of the staff is high, but does not take away from the safety awareness

(view of Randy). Maura – comfort level varies throughout the pass, some paths hold more snow than others, and comfort level depends on where you are and what the conditions are.

Existing operations – staffing is thin but works because people have been working with the snow all season. If we took winter operations away, would have a different staffing need because could not use trainee, might need to contract or address it otherwise.

Definition of Option:

- Sylvan Pass operations during the winter season are at the existing level, forecasting has been occurring.
- Public OSV travel ends March 1 at Sylvan.
- After March 1, forecasting and mitigation continues will full staff till March 20th (1 forecaster drops out March 15), can go till March 20th with two forecaster, trainee, and snow rangers.
- As move into spring conditions, staffing reduces when staff is on annual leave and required annual training.
- Approach wet slide conditions, more difficult forecasting conditions.
- After March 20th, may not get to the pass every day or at least not at first light. From March 1 on, have

administrative travel going on. Have employees in Lake who have homes in Cody, administrative needs, etc. Pass is maintained for the safety of operations, are a lot more conservative of when they are open during this time and have closures to administrative use of OSV – this is caused by conditions but also when a forecaster is unavailable.

- For forecasting – during this time there is less time on the pass, more reliance on computer forecasting.

  Readjustment of program during this time. This goes on till end of March.
- Road crew moves into Lake and set up a road camp and avalanche awareness training is provided to the road crew (early April, first or second week). Communication and planning is good with the road crew. Process has been in play for the past five years.
- Road crew communicates with avalanche forecasters to let them know when work at Sylvan is anticipated to occur. Usually will do a mission before plowing goes into the pass. Due to staffing, during this time the forecaster trainee takes on a greater role, with oversight by senior staff, but maybe not directly on the scene.
- As plowing occurs, have a forecaster on site as well as EMT on site during operations. Will do a test mission before plowing occurs (day before). Mission could occur later in the day if there are wet slab concerns.
- No plowing work occurs at night – could occur but does not due to the risk of night plowing. Plowing may be reduced to ½ day if there are avalanche concerns.
- Rock fall concerns at the gun mount are higher during the spring than during the winter, but there is mitigation at that site. No evidence of rock hitting the mount since it was redesigned. Having hanging cornices out there, all spring rock fall is a concern at Sylvan Pass.
- Rain event – could cause a shutdown of plowing activities.

- After 1st of April, when plowing starts, stop OSV administrative travel. May 5th will open to public.
- Once opening is done, road maintenance is taken over by Lake, which includes clearing of pull out. Concern during this time that there are avalanche risks during this maintenance. Last year, tightened up the communication with the maintenance workers widening the road, may send a spotter up (these operations occur in May). Last year there were wet slides that closed the road after opening to the public, could be due to new snow that comes in or just because of the warm up (old snow sloughing off).
- Dunraven occurs about a month later. Wet slab activity not a constant over at Dunraven. Mostly wind loading releases here.
- Rock removal part of spring duties – staff required to wear helmets.
- Morning briefing – is there a designated hierarchy? A Designated supervisor? Yes, whoever is there from the ranger division (Maura or Brad) will be the one in charge. The road crew keeps their command structure, and the avalanche folks have a separate command. Role of avalanche folks is advisory to the road crew – let them know when and where they can operate (before and during the operations – in radio communication throughout the day). Have done a shut down (2-years ago) based on changing conditions (not because of activity, but expectation of instability).
- April 5 – May 5, open to wheeled vehicles, but admin only. Once the crew leaves, there is no plow equipment. During this time road can close due to snow because lack of equipment (can close with 2-3 inches of snow), if road is closed due to snow, reduced avalanche risk during this time. When it re-opens, how are avalanches considered? It is addressed but doing it with low numbers, might be one person who can make that call.
- Warm days with warm up wet slides that has been the main reason for spring closures.
- Snow movement activities
    - After safety issues have been addressed begin operations.
    - All operators wear transceivers.
    - Have spotters on site.
    - Crew will go in – dozer goes in first, rest of the crew does not go in and serve as spotters. Machines go in at intervals, no machine goes in together, maintain distance in between. Use experienced crews that know the zones and usually machines are not in the same zone.
    - Might work AM and pull everything out in PM due to weather.
    - Spotter in area if there is any equipment in the area.
    - If there is a storm in an area, forecasters are consulted.
    - Can do operations in 1-1.5 days. Hours of operations are 8:00-4:30 or 8-noon if there are weather concerns. In the last 12 years, have not taken over 2 days to complete. Have a week scheduled for the work.
    - Enclosed cabs with roll over protection for all equipment. Bull dozers and rotaries are used.
    - UXO – usually a visual search – not extensive. UXO can drop off and fall on the road, it has occurred in the past (tourist brought UXO to east). In the past the military has come in to look for UXO, this has mitigated down some but there are fragments up there. Could become more scientific about this part. Don't get a lot of duds now, very low number. The bigger risk is 75 round? Roadside sweep tends to be done after plowing (will be part of UXO discussion).
    - Path is pioneered and then cut down.

- Staff can be in avalanche path for up to an hour while pushing snow off the edge, dozer blade is pushing downhill.
- Supervisors are present.
- Four operators is usually the maximum of what is in the zone. Number of people outside the zone is less than those in the zone, but there are always people outside the zone. Generally 50/50 in and out of the zone. May have less people in the zone depending on what is in the zone. Morning meetings everyday determines what will occur in this area.
- Have not seen activity caused by the road cut (releasing the toe of the slope) – staff have not seen this before. The likelihood of this would increase if there was not forecasting all winter. Triggering of avalanches during the year reduces the risk of wet slides in the spring.
- Up to 12 people operating at any given time.

Two options for Spring Opening: One with forecasting and one without forecasting were rated together and panel discussion followed. It was noted that this operation should be looked at with a specific ORMA tailored to address risks of all spring operations inside Yellowstone not just Sylvan Pass.

Option 11: Spring Opening - Sylvan Pass closed all winter, no avalanche forecasting all winter

Discussion: Similar to what happens at Glacier and Yosemite, spring operation only, no control work; snow has not been studied all winter long. In these area have used consultants and USFS. Allow time to plan to have experts and forecasters on site. Can determine what team selection would look like. Environment becomes an issue. Possibility of using Wyoming Department of Transportation (WYDOT) agreement that has trained Howitzer teams currently in place

If looking at forecasting only, this option would need to look at a later opening and would be another alternative. Discussion that opening may be able to be delayed by a week, but probably not longer than that.

Definition of Option:

- Adequate trained personal, but may lack knowledge (in the forecaster position) of past experience. Existing staff may be able to cover this since they would not be forecasting the winter season. Assumption is there would be adequate staff.
- Road crew would need to come in later.
- Mitigation mission would occur in the spring before the road crew, after the road is plowed there would be forecasting.
- Missions would occur in the spring, with a trained crew (may be NPS, may have to bring in WYDOT or others).
- If there was no grooming, it would be softer than with groomed roads, would take less time to plow it out (snow is not as compacted). Time to open Sylvan Pass could possibly be reduced to ½ day total due to ease of opening unconsolidated snow roadway.

If you don't do the control in the winter, it is more dangerous in the spring.

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Spring Opening	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Randy Baum	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	3	2	3.5	1.5	2	2	2	2	2.25
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	3	2	3	1.5	2.5	2	3	2	2.375
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	2	3	4	3	5	3	5	4	3.625
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	3	2.5	2	4	2	2	2	2.438
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	4	3	4.5	4	3	3.5	3	3	3.5
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	3	3	3.5	3	4	3	3	3	3.188
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	4	4	7	3	6	5	4	4	4.625
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	3	4	6	3	4	6	4	3	4.125
Total									26.13

Operational/Mission Risk Assessment Worksheet

Risk rated 1-10 for each category. (Mitigations should be considered for any category rated higher than 5)

Overall Mission Risk

1-35	36-60	61-80
Green	*Amber*	*Red*

Spring Opening- Without Winter Forecasting	Bruce Tremper	Ron Johnson	Bob Comey	Maura Longden	Randy Baum	Richard Baerwald	Ken Meyer	Jamie Yount	PANEL AVERAGE
Visitor Management/Supervision. Presence, accessibility and effectiveness of oversite or guidence.	4	3	3.5	3.5	2	2	3	4	3.125
Planning. Level of planning applied to operation/option to mitigate overall risk to visitors and employees.	4	6	3.5	4	4	2	4	4	3.938
Contingency Resources. MOUs in place with participating cooperators. Planning accomplished with cooperators. Shared communications plan and frequencies.	3	4	4.5	5	4	3	5	5	4.188
Communication. Ability of employees and visitors to communicate with park staff or needed resources in a timely manner.	2	4	3	3	2	3	2	3	2.75
Team Selection. Level of experience, equipment, training, age, level of internal group supervision. Employee preparedness (training, experience, etc).	4	4	6	6	3	4	3	4	4.25
Team Fitness. Level of overall physical fitness and mental preparedness of visitor.	3	4	3	3	3	3	3	4	3.25
Environment. Extreme temperatures, elevation, difficulty of terrain, rock fall, trips/falls, exposure to height, etc.	5	6	10	8	8	7	7	9	7.5
Incident Complexity. Severity and probability of mishap. Potential for incident that would tax the current staffing levels.	5	6	8	8	3	6	7	8	6.375
Total									35.38

Post Assessment Discussion

Randy – type of operation where you are running a lot of machinery, takes a lot of communication. Operating on hillside and steep conditions, a lot of things can go wrong. You are ok working in the environment, but the things that go wrong in any given day, any given moment, can be high chance for incident. Others lowered their score because they are more comfortable dealing with wet avalanches. Focus of panelist is different, operational risk of the road crew is different from the operational risk of the avalanche forecasters.
Sylvan – considered a "tougher" area than some others, including Dunraven. It represents the largest safety/avalanche hazard. For example, Talus slope (on Yellowstone's South Entrance Road has a run out that is shallow, and the probability for slide taking out a big piece of equipment is minimal.

Sylvan is the largest thought process/planning effort – longest exposure to risk – in the view of the road crew. Others more worried about Dunraven and the push to do it earlier has escalated the risk. Forecasters have not worked with the snow, doing it earlier has raised the risk.

Planning-

- If not open all winter: Planning should consider how much information one has, coming in without a lot of information, starting behind the curve to build up the plan. Plan has to do with what is going on with the snowpack, you don't know what has been going on with the snowpack. Can get up to speed by digging pits, but won't be as good as if you were there all winter long. Others thought if you had all this time leading up to it, you have time to plan for the event and lowered their scores. Planning could also be more complicated trying to figure out staffing.

Team Selection-

- If not open all winter: A lot of uncertainty of who the team is going to be, what the selection criteria is going to be. If done by a contractor, are you going to get what you want? Some assumed a skilled team coming in, but even if they are coming in they may be coming from a different environment. Any staff that comes in will need to get fully briefed on what is going on since they have not been there all winter.

Environment-

- If open all winter: Some drops because believe the conditions are more favorable that the crews are working in. If there are bad conditions, they don't do the work. Also less exposure, in heated cabs, not riding a snowmobile for 20 miles.
- If not open all winter: 10 (from Bob C) – went to a 10 because of experience with wet snow avalanche experts, based on conversations with these experts forecasting and mitigation is poor (looked at how many days they said something would happen and how many days it actually happened, based on backcountry forecasting by the Swiss) – everything that existing program is for is for the dry snow condition. Well documented in highway mitigation for wet slab conditions that forecasting is not as accurate and also why complexity goes up. Jamie moved up for the same reasons, easy to get complacent with the wet snow. Long-period of time, early April till goes away, long time of exposure. Transition from dry to wet snow is the big area of concern.
- Experience in UT, wet snow is more predictable, especially with south-facing slopes and are more accurate than discussed. The situation may be different here.
- Park experience – when shot with the 75, naturally occurring avalanches were much bigger. Bob C report, shows bigger natural avalanches with less missions. Park currently changes tactics for forecasting as snow conditions change from dry to wet.

Options Discussed Without GAR Analysis (and Why)

Closure of the pass

The group discussed that this option was different from the others as they assumed the pass would be open. Overall, this option would include the pass being closed, including to administrative travel, with the area being treated as backcountry (if rescue was needed). It was noted that if the pass was closed, there would not be a Sylvan Pass program and the Operational Profile would not apply. After this discussion, it was determined that since there would be no program, that ORMA should not be conducted on this item.

Contract Out Entire Avalanche Control Program

Discussion: NPS holds the decision making authority for the closure. In Glacier National Park, The forecasting is contracted through USGS and the forecaster advised the park representative who makes the decision on allowing access to the avalanche zones. This takes the forecaster out of the political part of the decision. Contractor may not want to take on the level of liability associated with making a decision. Measurable product would be to provide a recommendation on a daily basis. Many variations on how contractor staff could be used were discussed. In the end, the group determined that is contractor staff were used, the risk would just be transferred, not reduced, and decided not to carry this forward for a GAR analysis. It was noted that the use of contracted staff should still be considered in the future (including the idea to create an agreement with the State of Wyoming to supply a forecaster and explosive expert though an interagency agreement), but was not relevant to the ORMA process.

UXO Removal

Discussion: UXO on the hillsides was discussed and potential ways to address this.
Some options for UXO removal included:

- Twice a year recon to look for UXO (spring and fall). Search in different times of day.
- Do a sweep along the road up a couple hundred feet about 300 feet (where people might go).
- Target known impact areas where there is not detonation.
- In house team: visual search by the avalanche team or people who are well supervised with a clear understanding in advance of what they are looking for. Need a certain level of athleticism. Do not need an avalanche expert, but do need a good leader who know the conditions and where you should or should not go.

It was decided that this discussion was helpful and indicated different techniques that could be used, but not a situation they want to score under GAR.

V. Risk vs Gain Findings

Risk vs. (Factual) Gain Analysis

Assessing risk vs. gain is an important part of risk management and one of the primary principles of the ORM process. Individual missions identify gain as a single mission objective, while programmatic gain (gain for the whole program of avalanche risk reduction, whatever that may be) is measured in several areas considered to be *Universal Risk Considerations*), of which only some are based in fact. The expertise contained in the working panel could only evaluate those potential gains related to the avalanche control options that were quantifiable (based on facts), as opposed to those potential gains based on organizational values (i.e. if the organization places a higher intrinsic value on fiscal resources, the "cost" component of measured gain would change the overall gain profile). The primary consideration for this assessment is the safety of personnel; therefore, the risk (measured and quantified by the GAR risk profile score—so a high score = high risk) should be compared to the overall gains. The factual gains assessed include:

- **Effectiveness**
- **Pass Access**
- **Natural Resource Avoidance**
- **Cost**

Discussion of Risk vs. Gain Ratios

The ideal ratio of risk to gain is a low risk/high gain model. Panelists had to look further inside each score to consider operational improvements.

- Effectiveness (high score = highly effective)
- Pass Access (high score = fewer closures)
- Natural Resource Avoidance (high score = low impact)
- Cost (high score = low cost) relative cost of each option, onetime costs, no maintenance or operations

- **After lunch, idea floated… add a gain, avalanche mitigation, and weight this higher than the rest because of its importance. Issue is about safety – "keep snow off people" makes sense to weight this element (X4). It was decided to be the effectiveness category and given a point value of up to 50. Discussed that the other three, while important, don't carry the same weight.**

Discussion on how to look at gains – suggested we verbalize and note it, rather than to put a number to it. Also noted by the panelists; Showing the gains was helpful to have in the report.

Consideration of cost – suggested not using a scale, more talking about costs in general. Should existing operations be a 5, and everything else is cheaper or more expensive?

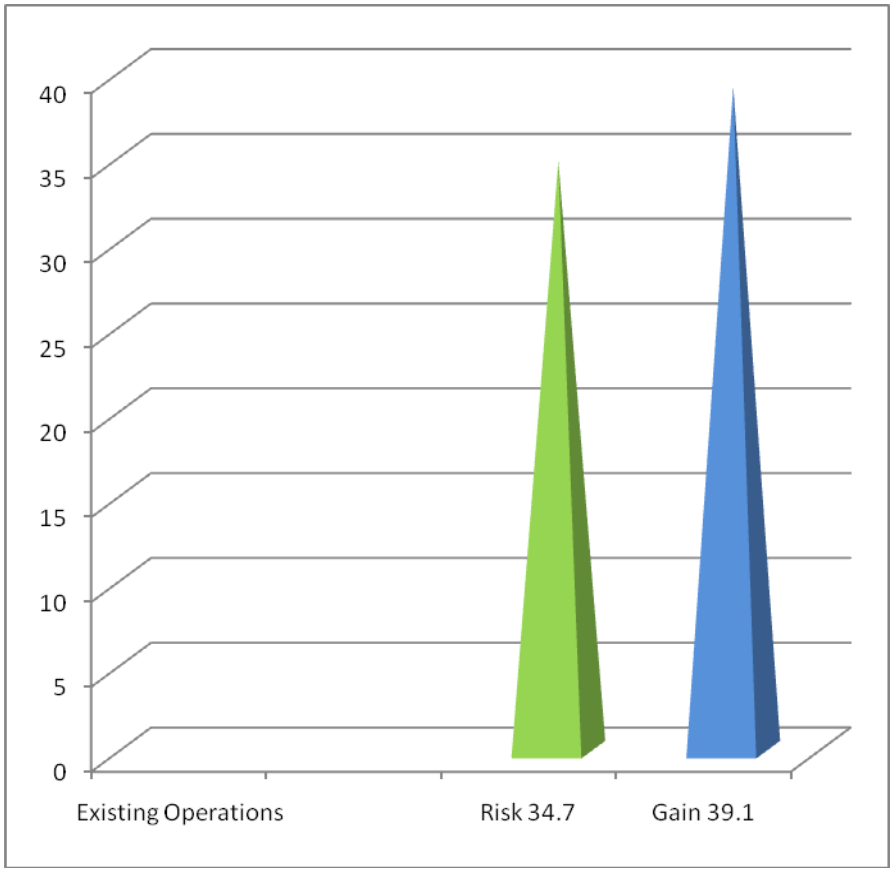
For all four categories, 5 is the baseline and everything else is relative to that.
Natural Resources indicator – how far out does this area go? The panel decided to look at impacts ridge to ridge

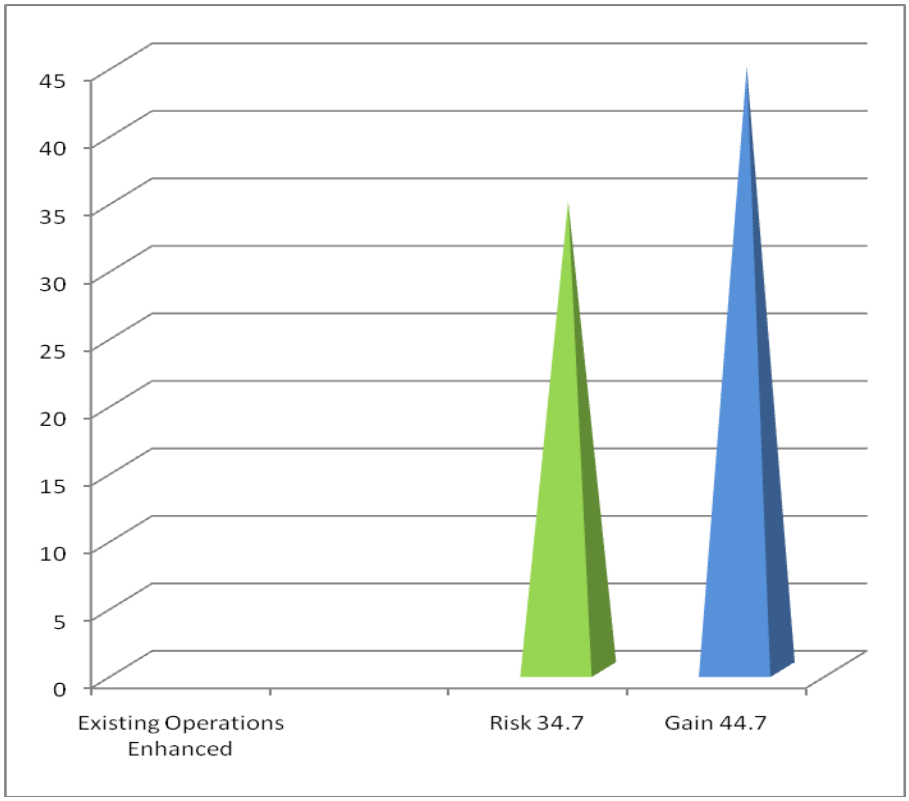
The group changed natural resources to look at the whole picture, not just wilderness.

Below are the analysis charts of Risk-verses-Gain for all twelve options Assessed:

The colors on the charts represent varying degrees of Risk verses Gain.

- Dark Green Risk and Blue Gain are optimal
- Light Green Risk and Blue Gain are considered acceptable, not optimal
- Yellow Risk and Green Gain are considered unacceptable
- Risk and Gain columns the same gray color are considered equal and thus unacceptable

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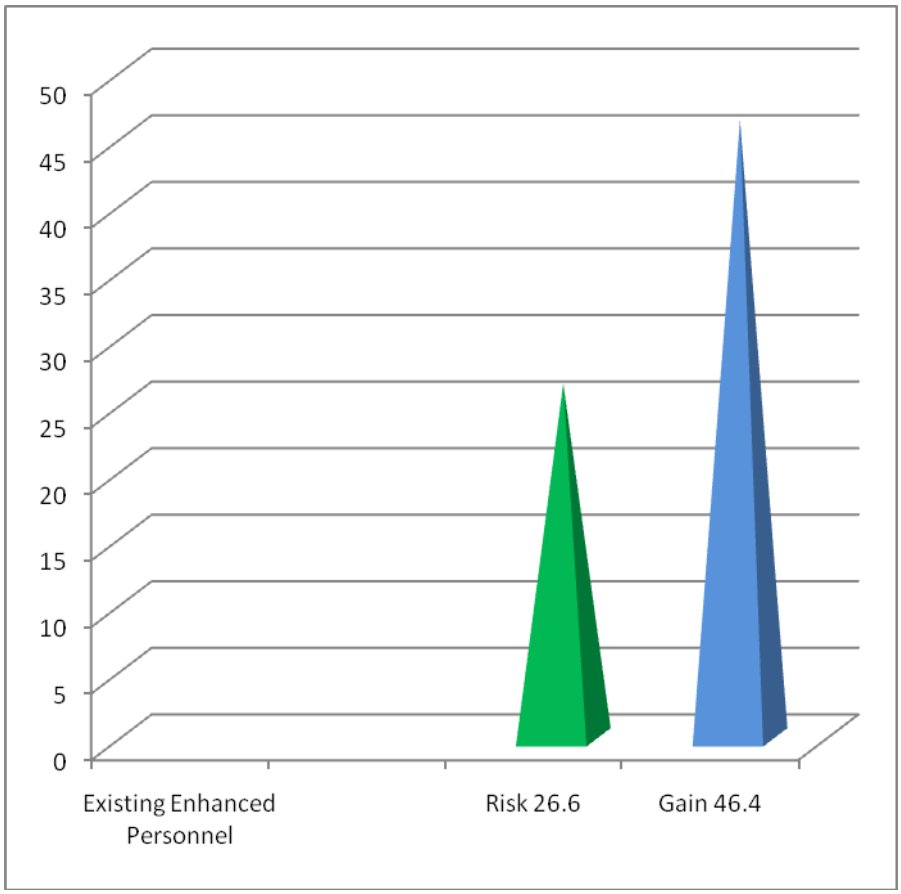
Existing Operations Enhanced
Risk 34.7
Gain 44.7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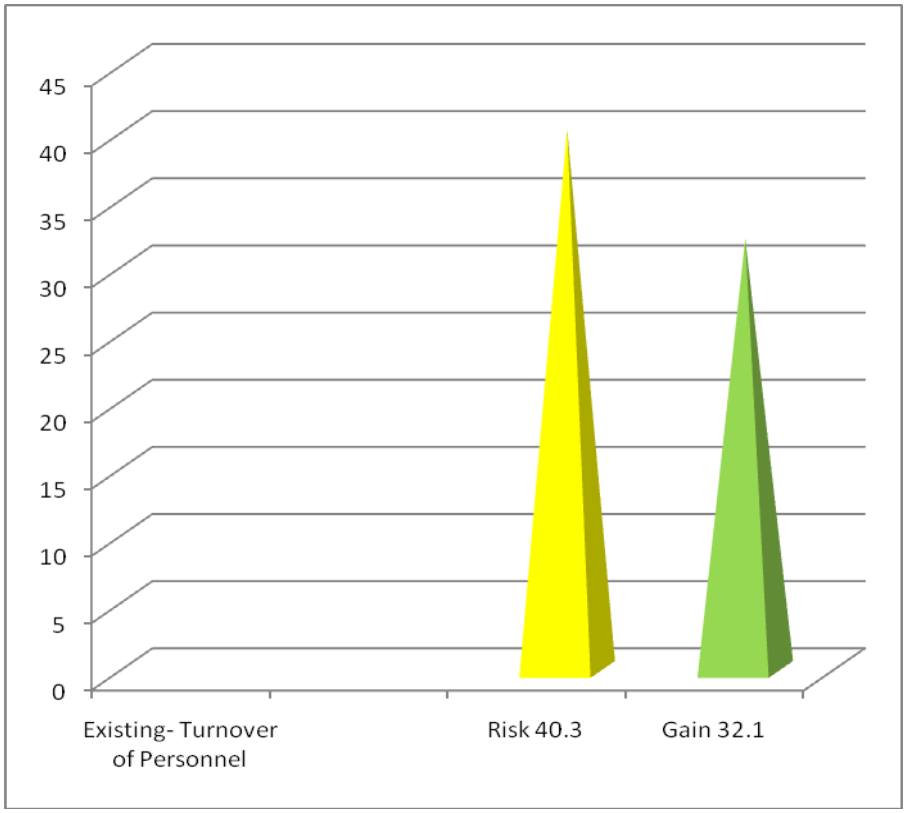
Existing Enhanced Personnel
Risk 26.6
Gain 46.4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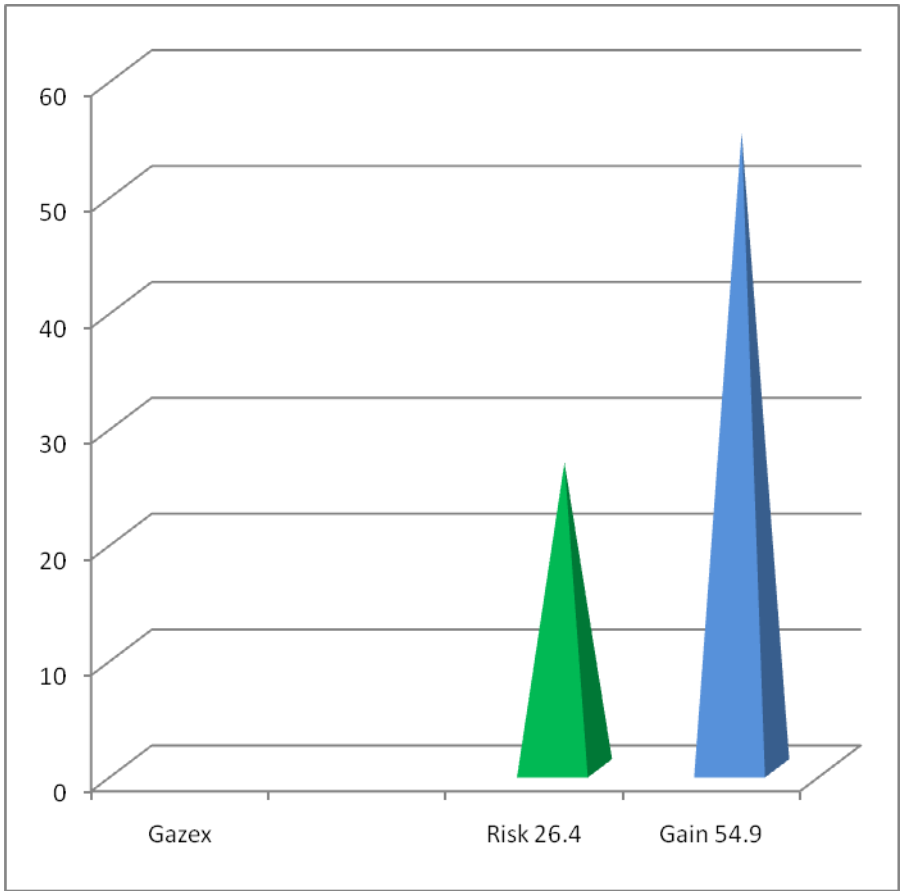
Existing- Turnover of Personnel
Risk 40.3
Gain 32.1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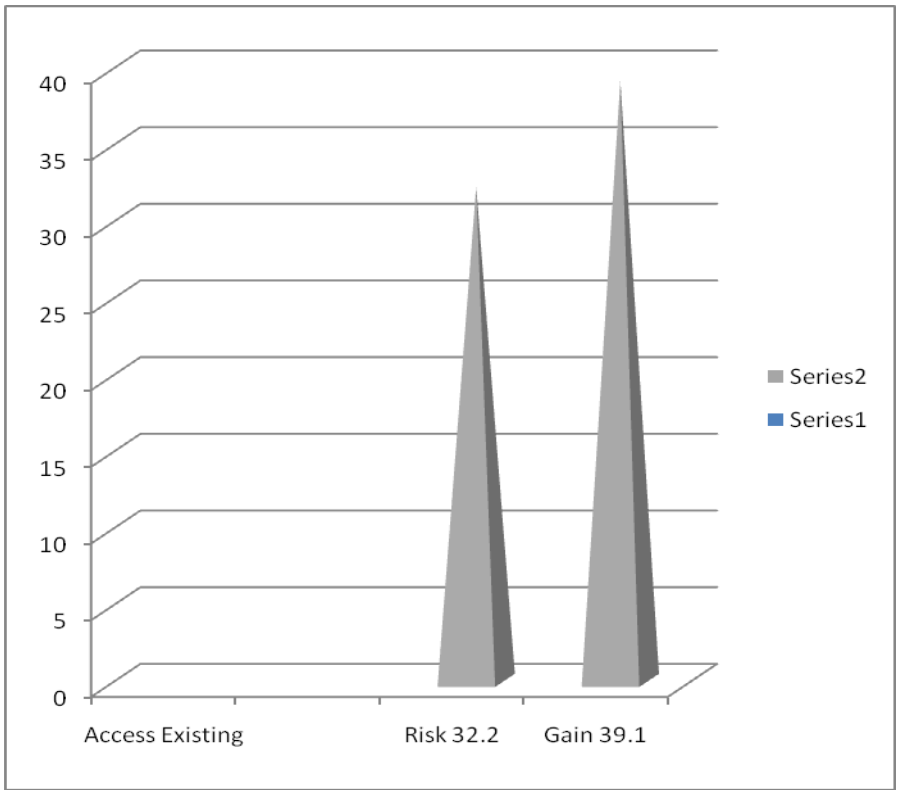
Gazex
Risk 26.4
Gain 54.9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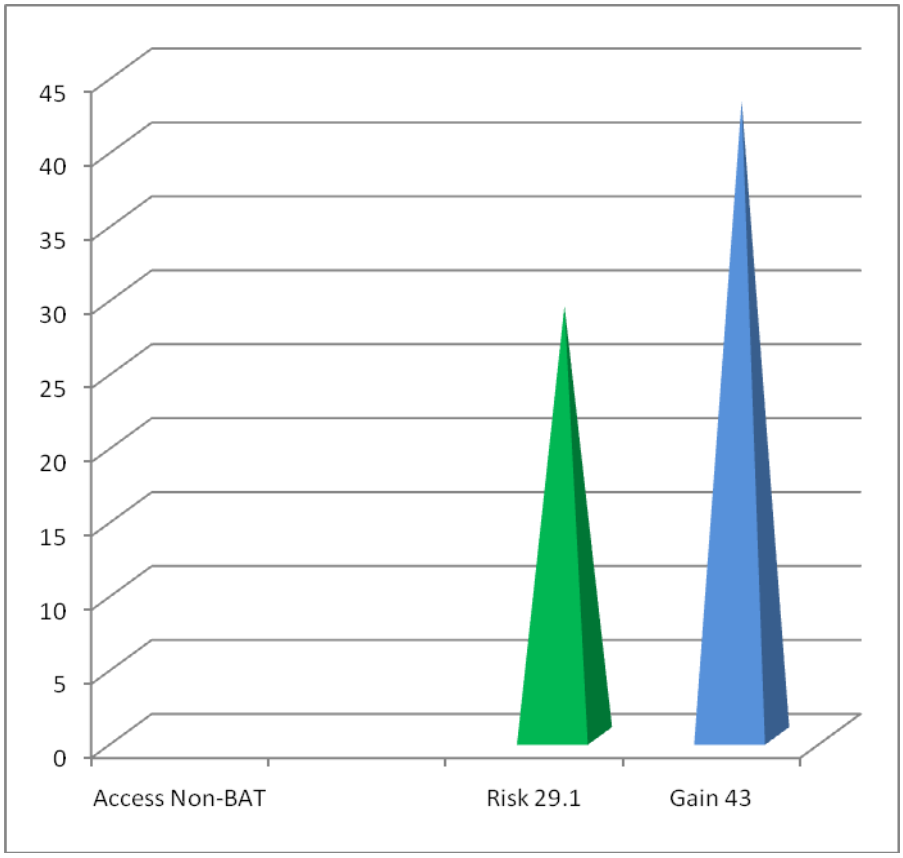
Access Existing
Risk 32.2
Gain 39.1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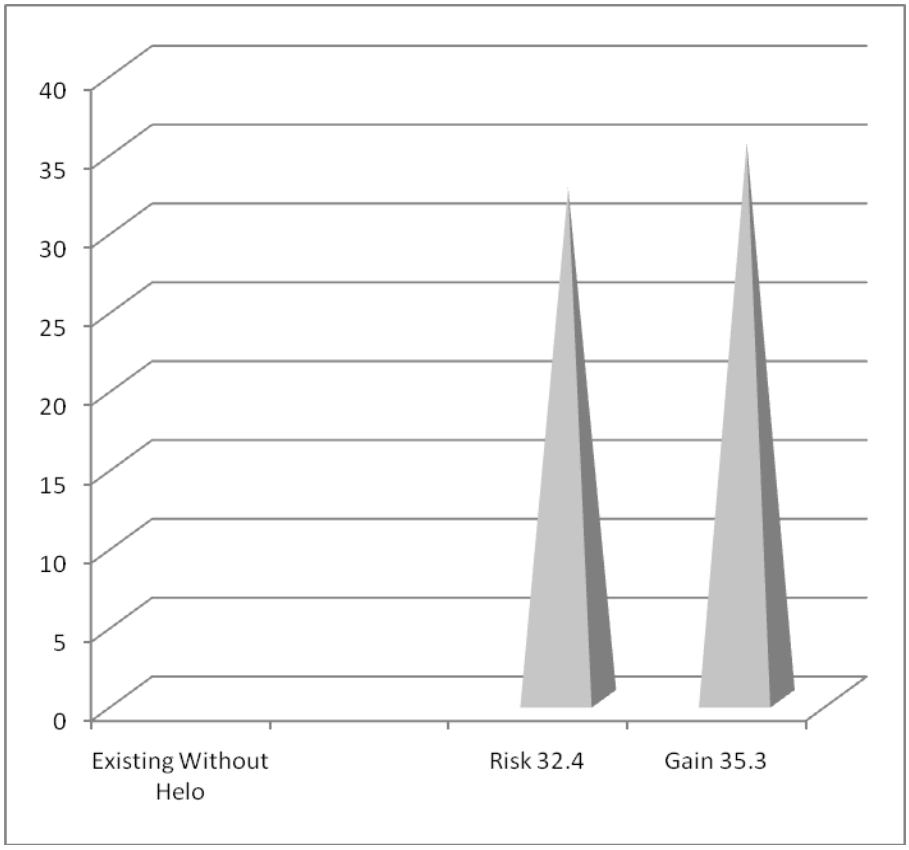
Access Non-BAT
Risk 29.1
Gain 43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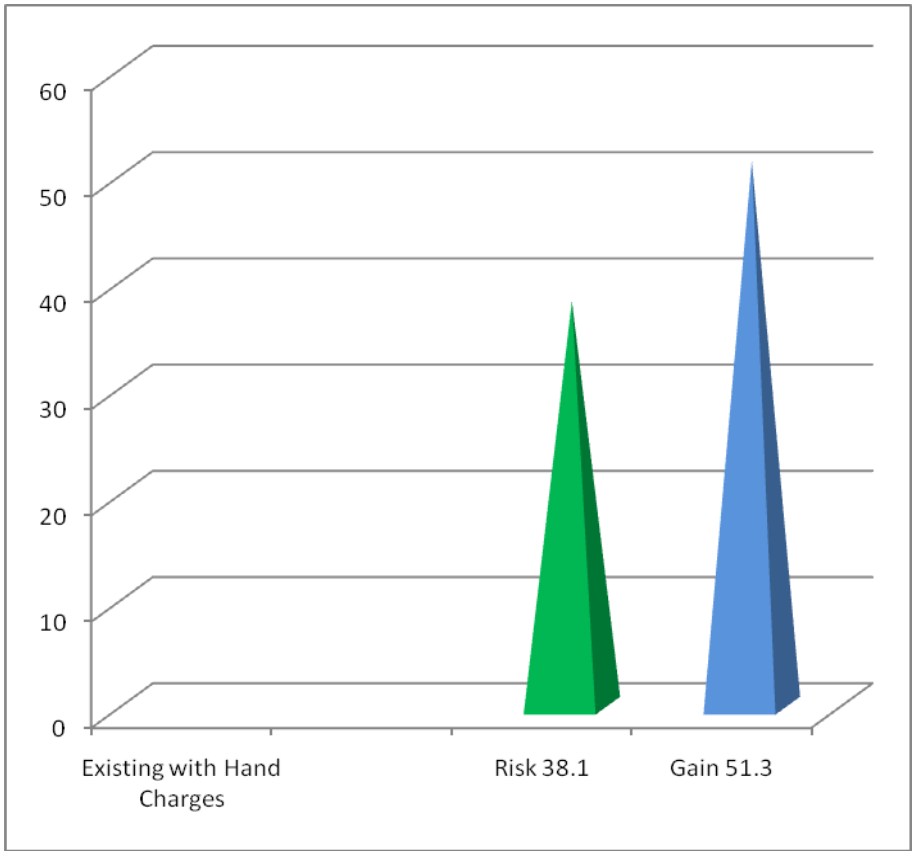
Existing Without Helo
Risk 32.4
Gain 35.3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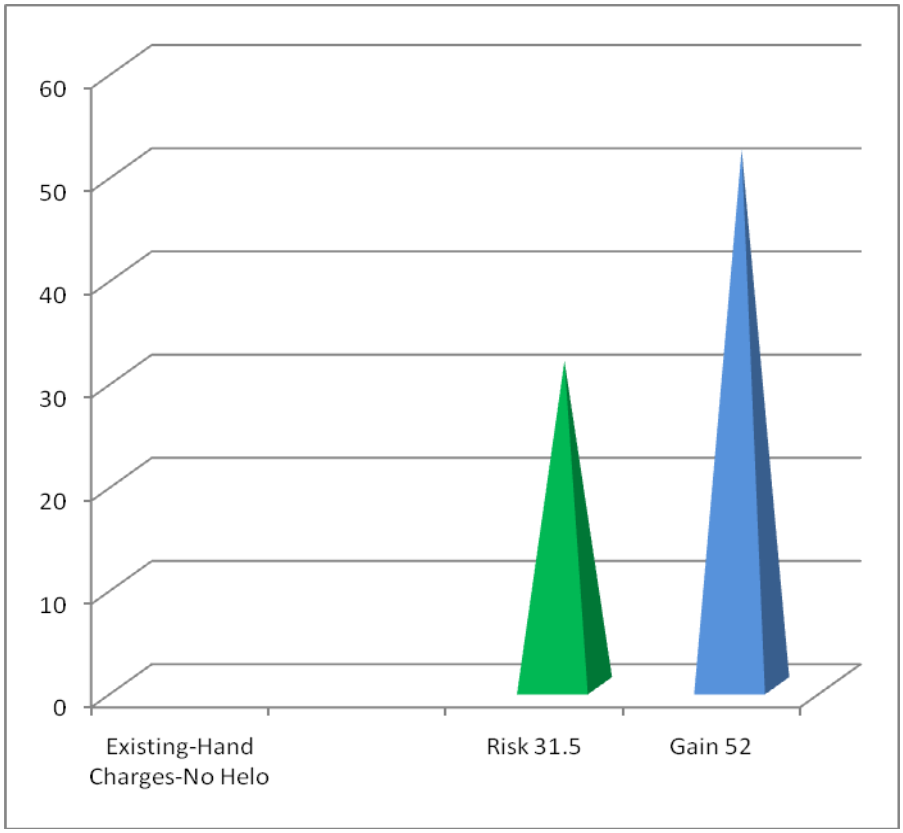
Existing with Hand Charges
Risk 38.1
Gain 51.3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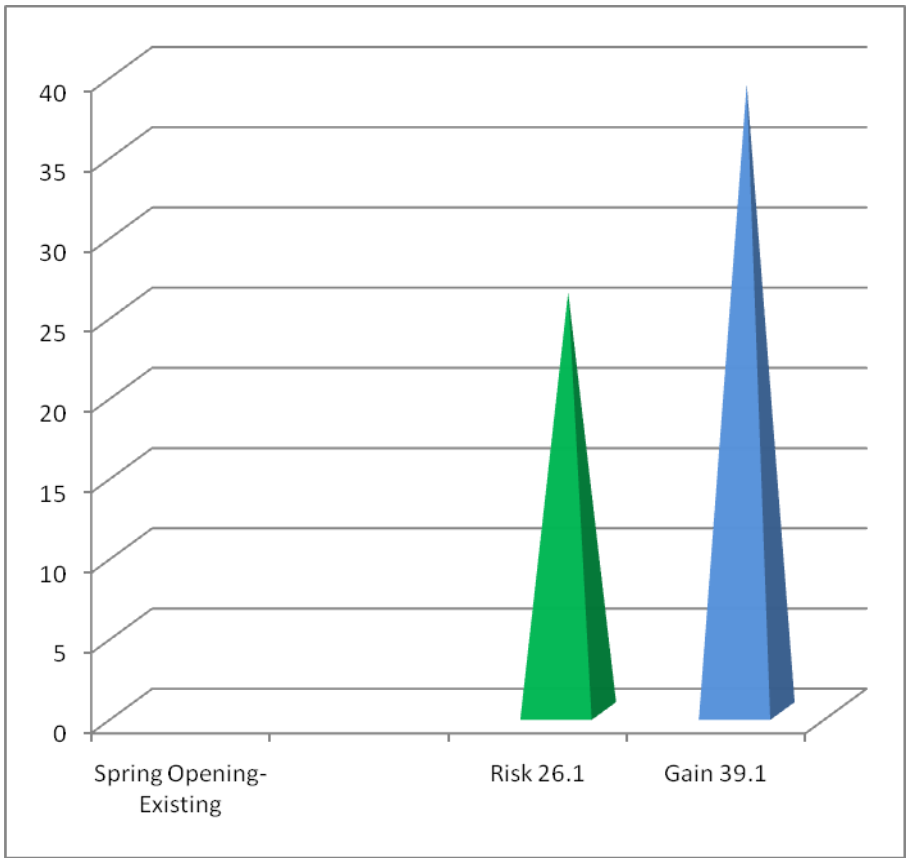
Existing-Hand Charges-No Helo
Risk 31.5
Gain 52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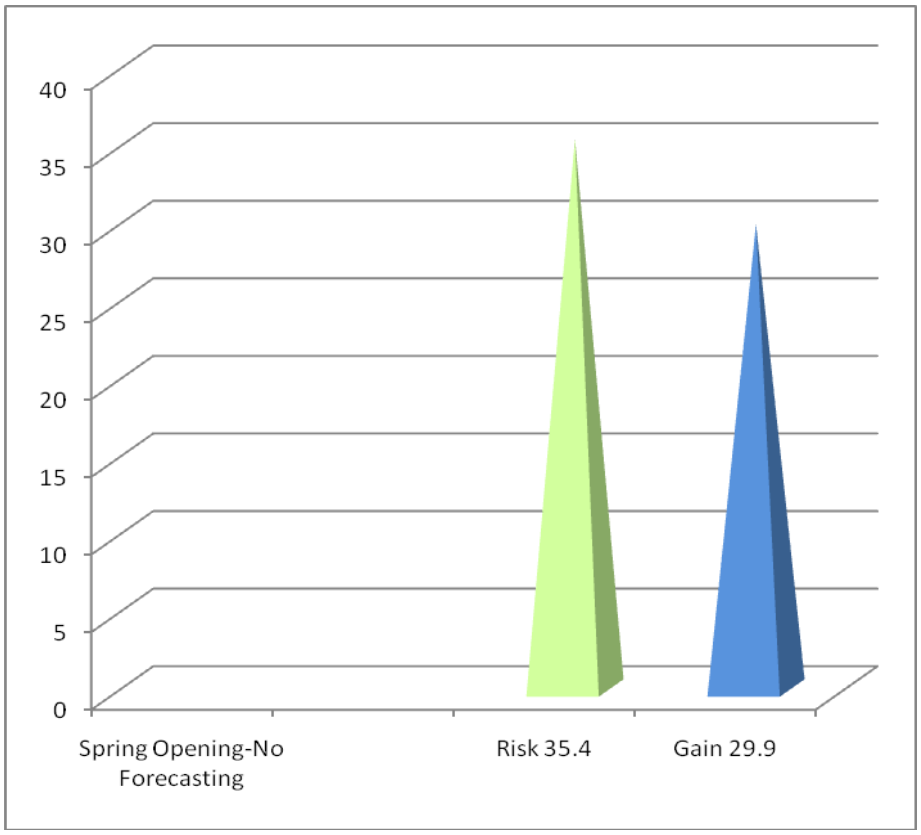
Spring Opening-Existing
Risk 26.1
Gain 39.1



Final Group Discussion

General discussion of ORMA Process

a. Feedback from the group was requested with the following responses:
   -Getting more at things we are evaluating this time around.
   - Defined what we are assessing better than we did last time
   - Appreciate the process and discussion, Also helpful in finding areas for improvement

b. A separate ORMA will be done for Spring opening, when this is conducted it was suggested that include forecasters. Forecasting and plowing is a defined period of time, Yosemite has a good program. Spring plowing and forecasting is a good one to look at to do by contract with the various responsibilities during that time. One alternative to look at, additional staff contracted for these operations. Look at three: spring operations (existing), Spring operations without a winter season, spring operations with enhancements.

c. Discussion: How does the GAR process capture avalanche risk?**.** Example is hand charges, higher GAR score but keeps you out of avalanche zone and reduces risk going to gun mount, those benefits need to be captured somehow. Reminder, not after the number, after the process. So even if the GAR number is higher, in totality the risk is being reduced. Concern was expressed that if the GAR score is the snapshot used by management for decisions, the report needs more than a note to show the contribution of reducing the risk of an avalanche. Conclusion: the report will note the avalanche risk and make clear how this relates to the ORMA that was completed.

d. How do you take into variability the change in panel from ORMA to ORMA – you can't, need to take it in totality. Concern this is an academic model with subjectivity. Would also like to weight the variables, another concern about the model. Would rather rate risk of the operation (i.e. driving to the site), and then the avalanche risk – noted that GAR was developed to capture the multiple aspects of an operation. Noted there is an acceptable level of risk to get a gain.

Spring Snow Conditions

Forecasting is more difficult with wet slabs (which occur mainly in spring conditions), altering the effectiveness of any option. This weakness is important when considering options that either do or do not include other active mitigation methods (i.e. artillery, fixed gas, etc.) or options that require clearing Sylvan Pass by a fixed date in the spring.

Weakening of a loaded snow slab is very poorly understood, even by the avalanche control community. The implications are significant and not intuitive when assessing risk in avalanche control activities. All active mitigation methods are much less effective in wet slab situations. Forecasting when wet snow conditions exist is more difficult, and hazards are more likely to change day to day and even hour to hour due to temperatures, exposure, moisture content, etc. Adding the difficulties of forecasting to the expected timelines of opening the pass compounds the chance of potential avalanche accidents.

The panel generally thought that opening and closing the pass with only forecasting as a tool was hazardous unless done extremely conservatively, in part due to the difficulty of predicting spring snow conditions. Those same conditions would also make repetitive openings and closings likely at that time of year.

Selected Parting Comments

Recap from the Panel Members – Objective views on the process (quality of program, suggestions to improve, overall impressions)

1. Bruce Tremper – Overall impression of program, doing a good job with the planning process and organization. Main threat to this program is the turnover, new staff needs to have necessary skills, if they don't have the necessary skills should not run down the program. It was clear that people were excited about Gasex, and think that this is where you should head. It is expensive but can look at ways to pay for it such as grants, State of Wyoming, etc.

2. Ron Johnson – Appreciate NPS doing a great job, how can that continue on? The ability to have a position that is focused on snow and the operation, take away the collateral duties during the winter and the spring. Need the people and expertise to use the tools. Gasex is a good option to look at, with the addition of the ability to use hand charges both as test of the snowpack and as an operation to clean up around the Gasex or facilitate getting to the gun mount. Enhancement of warming hut, better vehicles, etc can only help the operation.

3. Bob Comey – quality of the program, it is high compared to the rest of the industry. Discussion of other options such as hand charges is beneficial. The new road improvements should reduce avalanche mitigation risks; any future road construction should involve the expertise of an avalanche mitigation engineer. For industry standards, for the program you have you are spending a lot.

4. Jamie Yount – Impressed with the program and are keeping up with the industry standards. Improving the personnel stood out and Gasex is the direction a lot of programs should start looking into going. Could improve program by adding hand charging resource to paths 1-8. Artillery is a good tool, but would mitigate paths to protect team members. Timing issue, if hazard is high and need to wait for a helicopter, missing window. Bomb tram with detonation might fit within existing NPS protocol.

V. Continuing the Process: Considerations in Using this Assessment

The primary objective of this assessment is to provide an accurate and general measurement of the risk contained in both current and potential Sylvan Pass avalanche control operations. To meet this objective several models have been used to study the intrinsic risk. This report describes and illustrates:

- Those factors specific to Sylvan Pass that pose hazards and affect risk to personnel.
- Those hazards specific to all Sylvan Pass winter road corridor operations.
- Those operational components that affect risk to personnel in avalanche control activities.
- A measurement of personnel risk involved in past Sylvan Pass operations.
- A measurement of personnel risk involved in current Sylvan Pass operations.
- A measurement of risk to personnel involved in other potential avalanche control options.
- A comparison of risk measurements of combined avalanche control options.
- Risk trends in individual avalanche control options.
- Programmatic risk trends found in most control options.
- A measurement of factual gains directly related to each avalanche control option.
- A ratio measurement of risk vs. gain for each avalanche control option.

A weakness of this report is that it cannot provide an exact and precise assessment of any one single mission. All of the operational components can change from day to day, depending on which individuals are on duty, weather conditions that day, and many other dynamic factors. The principles and models used for this assessment can and should be used prior to personnel leaving their duty station en route to perform avalanche control on Sylvan Pass. It is only by doing so that a precise risk profile can be established for any one mission.

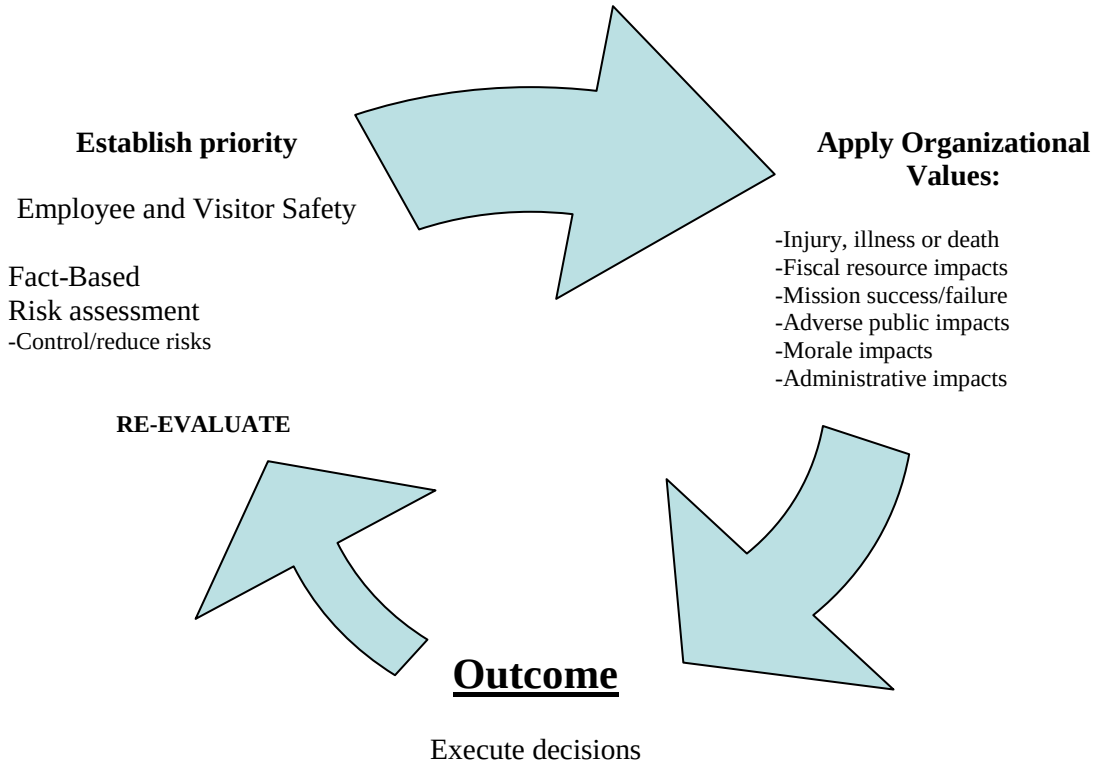
Another weakness of this report is that of evaluating potential operations in whose technical aspects the panel had expert knowledge but not experiential knowledge of how those aspects would specifically apply to Sylvan Pass and the work group that would conduct the operations. Some assumptions had to be made by the panel in quantifying those operational components.

This report also offers risk mitigation models as well as some suggestions that can apply to many of the avalanche control options. There are improvements that can be made to lower risk profiles for some of the options, improvements that will also affect risk vs. gain ratios. What the report leaves to the reader and ultimately the Sylvan Pass operational staff are the assessments of operational risk after (potential)

mitigations techniques have been implemented. As the decision to lower risk and by which mitigation techniques is an organizational one (based on value factors), this report and the panel that participated can only articulate that these options exist and should be considered. The assessments reported give an accurate representation of risk profiles for each control option and will accurately lead the reader to those options that can gain from operational changes.

Continued Process: Applying Values and Priorities

Limited opportunity exists to apply subjective reasoning when assessing operational components and applying numeric scores. As experts in avalanche control and Sylvan Pass operations, the panel was asked to base their assessments on what was realistic and based on fact. The next step in applying the operational risk management process is for management to apply organizational or agency values.



It should be common for an organization's priority to be its employees' safety but it is rare for it to be the *only* priority. Other considerations that also contain risk must be assessed, often times with values

attached. Financial risks, local and long-term repercussions to the organization's mission, external opinion and relationships, and internal staffing concerns all possess different ratios of risk and gain.

As an organization better understands what hazards and risks threaten an operation, new options become viable and other options become unacceptable. This decision tree, when used with the organization's other risk considerations and the associated values, are useful in designing durable operations and unassailable decisions. The final step is an ongoing commitment to re-assess and re-evaluate, always beginning first with those risks that affect personnel safety.

VI. Conclusions

None of the avalanche mitigation options identified in this workshop are without risk. Even those options with the lowest risk profile to personnel have significant impacts to NPS resources. Also, as with any field operation, the corollary requirements reach far into other park operations, affecting them in differing ways. Regardless of which option the NPS determines to be the best solution, there will be impacts, not evaluated in this report, to other work groups, including those responsible for snow grooming, road maintenance, facility management, emergency services, concessions, and park management.

As there appears to be no simple solution to significantly reduce avalanche risk at Sylvan Pass from the existing operations, it is extremely important to consider the common themes that this workshop and subsequent report have identified.

- **Sylvan Pass is unique.** Geographic, logistical, atmospheric, and managerial issues that are specific to Sylvan Pass significantly affect the risk profiles and overall effectiveness associated with mitigation options. These qualities must be considered when deliberating avalanche hazard mitigation options. Solutions to Sylvan Pass' avalanche hazards cannot be viewed in the same manner as they would be on other travel corridors**.**
- **There are elements in the NPS Sylvan Pass operation that positively and negatively affect the safety of our employees and visitors.** It is important to understand all of these elements as they relate to current operations and potential future operations rather than relying on common knowledge of what has worked in the past. Safety records do not speak for themselves and there are other factors specific to the NPS that are not evaluated in this report but that do affect personnel safety.
- **All risk involved in avalanche control on Sylvan Pass can be mitigated, but some mitigations may not be reasonable.** The options identified in this report, ranging from Gazex to hand charge deployment and an increase to seasoned, well trained staff, can reduce the avalanche hazards at Sylvan Pass. What this report does not assess is the feasibility of implementing these control options or mitigation techniques. Again, the exceptional nature of Sylvan Pass requires further research as well as management input to truly establish whether any of the identified options are achievable.
- **This assessment is a process.** If this assessment is of any value in making operational decisions, it is urged, even assumed, that this process, now that it has been continued, will remain on the path of risk assessment in the future and evolve as the avalanche control operations already have. This assessment has focused almost exclusively on facts related to safety.

VII. APPENDICES

- Director's Order #65: Explosives Use &Blasting Safety
- Sylvan Pass Avalanche Forecasting &Hazard Mitigation Operational Procedures

National Park Service

DIRECTOR'S ORDER #65: EXPLOSIVES USE AND BLASTING SAFETY

Approved: /s/ Denis P. Galvin (signed original on file)
for Director, National Park Service

Effective Date: May 25, 1999

Sunset Date: May 25, 2003

NPS Guideline 65 is superseded and replaced by this Director's Order.

I. Purpose and Scope

This Director's Order sets forth the policy and required procedures governing blasting operations within the National Park Service (NPS) to ensure a safe workplace and safe work practices.

As used herein, "blasting operations" includes the purchase, transportation, storage, handling, use and disposal of commercial explosive materials, blasting equipment and avalanche ammunition (artillery and recoilless rifle); it does not refer to military ordnance, historic black-powder weapons firing, or fireworks displays.

This Director's Order applies to all blasting operations conducted within the boundaries of the NPS, whether conducted by NPS or other Federal personnel, commercial contractors, or others (including utility companies).

II. Authorities

Authority to issue this Director's Order is contained in the NPS Organic Act (16 USC 1 through 4) and Part 245 of the Department of the Interior Manual (DM). NPS blasting operations are subject to the provisions of 18 USC 841 through 848 (Importation, Manufacture, Distribution and Storage of

Explosive Materials), 29 USC 668 (Occupational Safety and Health Act, Federal Agency Safety Programs), and 410 DM 114-60 and 485 DM 1.

III. Instructions/Requirements/Responsibilities

1. Explosives Use and Blasting Safety Requirements

1.1 All blasting operations will comply with this Director's Order, the NPS Handbook for the Storage, Transportation, and Use of Explosives (the Explosives Handbook), and all other applicable Federal, state and local laws and regulations.

1.2 NPS employees involved in blasting operations, including monitoring or inspecting, will be trained and certified prior to performance of such duties.

1.3 All blasters are required to have a state-issued commercial driver's license with hazardous materials endorsement, a Medical Examiner's Certificate issued by a licensed medical examiner, and carry a current standard first aid card.

1.4 Nitroglycerin materials, safety fuse and fuse caps will not be used. A material safety data sheet for each explosive material or avalanche ammunition must be available at the job site.

1.5 All blasting operations will be conducted by or under the direct supervision of a certified blaster.

1.6 A job safety analysis must be performed in the planning of all blasting operations.

1.7 When two or more blasters are working together, one will be designated as the blaster-in-charge by their supervisor(s) or, if need be, by the blasters themselves.

1.8 Any variance from the above requirements will be based solely on reasons of safety and will be approved by the appropriate Regional or Denver Service Center (DSC) Blasting Officer on a case-by-case basis, for a specified duration and/or situation.

1.9 Blasters employed under NPS contract, concessioner contract or special use permit must possess a valid state blaster's license (or documented training and experience commensurate with an NPS blaster). Blasters will comply with the standard explosives contract specifications contained in the Explosives Handbook, which must be included in all such contracts, agreements and permits.

1.10 All avalanche control and ordnance use and certification programs will be under the direct control and supervision of U.S. Army personnel. NPS employees will not attempt to dispose of ordnance which fails to detonate; their responsibility is to identify the location(s) of non-detonated rounds and inform the nearest Department of Defense team for disposal purposes.

1.11 Upon discovery of old, deteriorated or unstable commercial explosive materials, a site must be immediately secured to prevent human entry until disposal is accomplished, and the Regional Blasting Officer notified to assist the park in the disposal operation. Persons not licensed to perform the actual disposal will not attempt to handle or move deteriorated materials. Blasting caps and dynamite in particular can become extremely sensitive to any disturbance. Military ordnance disposal teams must be notified to dispose of military ordnance.

Disposal of old, deteriorated or unstable commercial explosive materials may be completed through the following sources (in priority order): (1) the explosives manufacturer, if known; (2) NPS personnel licensed for this specialty, a roster of whom will be maintained by the Service Blasting Officer; (3) military ordnance disposal teams; and (4) state, county or municipal bomb disposal teams. Ordnance and bomb-disposal personnel are seldom familiar with commercial explosives and detonators and should not be used without a written plan of disposal reviewed by an NPS employee licensed for disposal.

1.12 Accidents involving explosives will be immediately reported to the superintendent, park safety officer, chief park ranger and Chief Park Blaster. The Chief Park Blaster will promptly notify the Regional or DSC Blasting Officer, as appropriate, and regional safety manager. A Blasting Review Board hearing will be held within 3 working days of an accident with explosives.

Any theft or loss of explosives will be promptly reported to the superintendent, chief park ranger and Chief Park Blaster. Such theft or loss must also be reported within 24 hours to the local office of the Bureau of Alcohol, Tobacco and Firearms, the park safety officer, the Regional or DSC Blasting Officer, as appropriate, the regional safety manager or DSC safety engineer, as appropriate, and law enforcement specialist. A Blasting Review Board hearing will be held within 3 working days of any theft or loss of explosives. A Board of Survey must also be initiated within 30 days after discovering any loss or theft of explosives (see 410 DM 114-60).

YELLOWSTONE NATIONAL PARK

STANDARD OPERATING PROCEDURE DIVISION: **Resource & Visitor Protection & Maintenance**		EFFECTIVE DATE 2010 -2011 Winter Season valid until superseded
MANAGEMENT CATEGORY: **Safety**	AMENDS:	INDEX: **# Chap: 10-K**
TITLE SUBJECT: **Sylvan Pass Avalanche Forecasting & Hazard Mitigation Operational Procedures**	RESCINDS:	CROSS INDEX:
SUB ACTIVITY:	ATTACHMENTS/SUPPLEMENTS: **Appendix A-C**	DISTRIBUTION:
APPROVED: Steve Iobst Acting Deputy Superintendent		Date 12/6/2010

I. PURPOSE:

Establish Standard Operating Procedures for avalanche forecasting and avalanche hazard mitigation at Sylvan Pass.

II. OBJECTIVES:

I. Provide avalanche forecasting and avalanche hazard mitigation operations that meet generally accepted industry standards for highway, ski resort and railroad protection.
2. Establish access protocols that maximize employee safety for patrol, forecasting, grooming and mitigation.
3. Establish reporting and documentation requirements.
4. Utilize the following components for the purpose of avalanche hazard mitigation operations:
o Avalanche Forecasting
o Artillery Dispensed Explosives
o Helicopter Dispensed Explosives
o Road Grooming

III. POLICY:

Employee and visitor safety will take precedence over all other considerations concerning avalanche hazard mitigation and forecasting operations.

IV. GUIDELINES:

References utilized for hazard risk analysis and employee safety considerations include Mahn board of review 1994, Comey Avalanche Hazard Assessment & Mitigation Report March 2007, and Sylvan Pass Operational Risk Management Assessment, November 2007.

V. PROCEDURES:

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Chapter I

AVALANCHE FORECASTING & HAZARD MITIGATION OPERATIONAL CONSIDERATIONS

Employee and visitor safety takes precedence over all considerations associated with avalanche forecasting and avalanche hazard mitigation operations.

Snow conditions at Sylvan Pass are complex and are subject to rapid change due to environmental influences. Hazards may exist even after hazard mitigation missions are completed. Under certain conditions, natural avalanches may occur and may reach or cross the road when open to the public. The primary reasons for conducting explosives operations are to test the stability of the snow pack and to reduce the likelihood of large avalanches occurring. Despite avalanche forecasting and the use of artillery and aerial dispensed explosives to mitigate avalanche danger, winter travel through the Sylvan Pass avalanche zone presents some level of risk.

NPS forecasting staff will conduct a risk analysis when determining *go/no* go decisions for anticipated travel to and from Sylvan Pass, across Sylvan Pass, access to areas to conduct stability evaluations and travel to the gun mount site. Factors that will be considered include terrain, weather, visibility, snowpack stability, and staffing available at both East Entrance and Lake to meet minimum safety standards for backup, communications & emergency response. Personal preparedness and avalanche awareness are critical to safe travel and Sylvan Pass operations. Other human factors include each team member's health, alertness, attitude, judgment, communication, teamwork, and a healthy respect for the nature of the mission. All participating staff regardless of qualification and position, who are involved in forecasting and avalanche hazard mitigation, are authorized to stop an operation at any time for any reason they feel it is unsafe or violates policy or procedure. They will communicate their concern immediately to the lead forecaster and request a stand down until the situation is resolved and or mitigated.

The Sylvan Pass avalanche forecasters will advise other staff of current and predicted conditions. Forecasters will determine if avalanche hazard or hazardous weather or road conditions, warrants closing Sylvan Pass to over-snow travel. When a closure is in effect, Sylvan Pass is closed to all public and administrative travel, except for personnel directly involved in avalanche forecasting and mitigation operations. A decision to reopen the road will be made by an avalanche forecaster after the hazard has been mitigated and/or conditions have been reevaluated.

In addition to the integrated information utilized in avalanche forecasting, all staff should be observant of signs of snowpack instability, guiding a go-no-go travel decision at anytime.
Common factors include:

- Occurrences of natural avalanches
- Cornice blocks rolling down slopes
- Collapsing or cracking of the snowpack
- Heavy snow loading
- Wind loading
- Poor visibility or whiteout conditions
- Rain on snowpack
- Rapid warming or rapid melting
- Snow pinwheeling down slope

All observations or tests conducted at or while enroute to Sylvan Pass should be communicated to the forecasters.

SAFE TRAVEL PRACTICES

Communication, consultation, and coordination between all Lake District staff are critical components of the risk analysis and risk mitigation.

The travel standard for the road and avalanche zone evaluation from either East or Lake is a minimum of two avalanche rescue trained staff on separate machines, utilizing established safe travel practices for these operations. An alternate travel standard of one avalanche trained staff member traveling separately from both Lake and East and converging at either side of Sylvan Pass, may be utilized when the avalanche hazard rating is generally low and conditions are conducive to good visibility and reasonable road traveling conditions.

When evaluating the conditions on the East Entrance Road, all staff must be equipped with the following avalanche rescue equipment: avalanche transceiver (must be worn on person and turned on prior to beginning travel) avalanche probe and snow shovel. Snowmobiles must be equipped with standard emergency kit (consisting of first aid kit, fire-building kit, space blanket, extra gloves, flashlight, heat packs and or heat source, food/water, pocket knife and adjustable wrench) and any other appropriate personal protective equipment. Communications equipment will consist of a Park Radio with spare battery, at a minimum.

- Employees involved in work on Sylvan Pass should review information provided by the forecaster staff and evaluate existing weather and road conditions, prior to beginning travel to check conditions along the East Entrance Road
- Travel to and from Sylvan Pass will be conducted during daylight hours with reasonable lighting and visibility to support good visual evaluation of both the road surface and surrounding terrain
- Communications Center will be notified of beginning travel with destination and ETA
- Employees should remain observant of signs of snowpack instability while en route to Sylvan Pass

When traveling into the avalanche zone for the purpose of evaluating avalanche hazard and road conditions,

Confirm radio communication with other team member

- Notify the Communications Center when the team is entering the avalanche zone
- Cross avalanche paths one at a time, move quickly
- Leader communicates when it is safe for the next person to cross
- Keep visual contact with person crossing avalanche paths

  Plan your escape route
- Notify the Communications Center when team members are clear of the avalanche zone

- Persistent whiteout conditions and/or very poor road conditions (deep snow, considerable drifting) are considered high risk factors that will terminate any independent (single machine) travel to Sylvan Pass for the purpose of road evaluation

Chapter II.

FORECASTING

Avalanche forecasting considers many components including terrain, weather, current snowpack stability and predicted conditions. Forecasters integrate information from a variety of resources, observations and tests. A site specific forecast for Sylvan Pass will be used to determine the need for avalanche hazard mitigation operations and to determine when the East Entrance Road will be closed for public access and for administrative travel.

Avalanche Forecasting Staff -Staffing levels will support the capacity to meet daily operational and avalanche

mitigation mission requirements. General target staffing levels would be three qualified Avalanche Forecasters, one Forecaster trainee, and three Snow Rangers (one at East and two at Lake). Snow Rangers will support forecasting and avalanche hazard mitigation operations, and perform road condition evaluations. They will maintain skills in performing and leading winter emergency response, including avalanche rescue.

- **Avalanche Forecaster**

  Minimum completion of the National Avalanche School Phase I & II, or a Level I & Level II avalanche course, or equivalent experience. Annual avalanche awareness and rescue training

- Attendance at snow science related continuing education and/or professional conferences
- Attendance at International Snow Science Workshop (ISSW) every two years
- Formal training is complemented by on the job training and field work

- **Forecaster Trainee**
- Minimum completion of the National Avalanche School Phase I, or a Level I avalanche course, or equivalent experience.
- Annual avalanche awareness and rescue training
- Completion of a Level II avalanche course within first year as a trainee, and supervised field work with Forecasters
- One or two full seasons of supervised forecasting experience before conducting independent forecasting, per approval of the Lake District Ranger Avalanche Program Director.

- **Avalanche Support Staff**

  Additional avalanche support staff assisting with evaluations in the avalanche zone and/or avalanche hazard mitigation work must have completed annual avalanche awareness and rescue training. Annual completion of avalanche awareness and rescue training is required for any personnel observing or accompanying avalanche staff in the Sylvan Pass avalanche zone.

- **Avalanche Forecasting Operations**

- Avalanche forecasting activities are generally conducted between November 15th-May 1st
- Forecasters evaluate pertinent available avalanche forecasting data such as:
- Regional avalanche advisories for Gallatin. and Bridger-Teton National Forest
- Data from Sylvan Lake Snotel site & Hoyt Peak weather station including: wind speed and direction, temperature, precipitation, new snow, snow depth, etc.
- Weather forecasts, Regional and Western United States satellite images and prognostic charts
- Field observations of current weather conditions, temperature, snowfall amounts, water content, wind speed and direction on Sylvan Pass
- Data acquired from snow pits
- Forecasters will document all natural and explosives triggered avalanches
- Forecasters will document all helicopter and howitzer missions
- Forecasters will document all East Entrance Road Closures and Openings
- Forecasters will communicate conditions effecting access and operations to the Communications Center, Chief Rangers Office, Superintendant's Office, and, the Public Affairs Office.

- Avalanche Forecasters will prepare a daily weather and avalanche discussion for use by Sylvan Pass Avalanche Forecasting and Mitigation team members and other employees.
- Forecasters will communicate with regional avalanche forecast centers to share observations and reports of avalanche activity.

Weather Equipment

• Forecasters will utilize a variety of weather products and remote weather instrument stations including the Sylvan Lake Snotel and Hoyt Peak station, above Sylvan Pass

Forecasting Validation The Lake District Ranger / Avalanche Program Director and' other Forecasters will consult with other avalanche forecasting professionals and establish relationships and coordinate site visits for the purposes of independent review and feedback on the Avalanche Forecasting and Mitigation program. This peer review is considered vital to maintaining the programs integrity and in order to keep up with the continuing education and changing technologies associated with avalanche forecasting.

Chapter III

ARTILLERY DISPENSED EXPLOSIVES, M101 HOWITZER

The US Army has identified the MI0 I Howitzer as the "avalanche gun" and it is currently the most frequently used military weapon for avalanche control in the United States (for ski areas, highways and railroads). There has never been a malfunction/explosive accident with a MI0 I howitzer during avalanche control operations. This chapter is to be considered an addition to the MI0I-AI Howitzer Avalanche Control Firing Manual, which was produced by the Avalanche Artillery Users of North America Committee (AAUNAC). Required Training

- Frequency =Artillery training every three years, refresher required on between years.
- Training conducted in accordance with Avalanche Artillery Users of North America Committee (AAUNAC) recommendations. Contractor typically does every 3 year required; Howitzer Program Manager typically conducts between year refreshers.
- Hazardous Materials Training (operational level) -is narrow in scope and incorporated into artillery initial and 3 year recurring training and annual refreshers and is specific to the ammunition and explosives specific to M-IOJ howitzer.

Howitzer Team

• Key operational positions
- Howitzer Program Manager
- Gunner in Charge
- Gunner
- Loader

- Assistant Gunner. Attendance at artillery training (or equivalent) and a minimum of five missions are required to become an assistant gunner.
- Each position requires training, experience and demonstrated competency
- Depending on the number of missions it may take three to five years to advance from an Assistant Gunner to a Gunner position
- Two artillery trainings and a significant number of missions are required to reach the Gunner level.
- Continuing education and experience is critical to maintaining key operational positions
- The Gunner in Charge oversees the training and certification of personnel and is experienced with approved maintenance and servicing of the weapon
- Annual Avalanche Artillery Users of North America Committee (AAUNAC)meeting

o At least two team members attend each year, one of which is the Gunner in charge.

Operations

- A Crew is assembled from Lake and East Entrance, and other districts
- The Crew is trained to conduct in direct fire missions to pre-established targets (direct fire may be used to supplement indirect fire, when appropriate).
- Howitzer missions may be aborted at any time. Severe weather can affect the crews ability to perform the mission

Access to the Howitzer Platform

The avalanche hazard is assessed by an avalanche forecaster and is used to determine the potential effectiveness of using the howitzer and the ability to safely access the gun mount.

- Safe travel practices / plan for access to include:
- Transceiver checks
- Establish communications / rescue plan
- Travel one at a time
- Maintain visual on traveler

The Go/No Go decision may be based on the potential for avalanches to reach or cross the road along the west side of the avalanche zone. The decision to proceed is determined by the forecaster with consensus of the Howitzer crew. The method of accessing the gun mount will vary based on the evaluation of the avalanche hazard, conducted by the avalanche forecaster. Prior to the Howitzer mission, a briefing will be conducted outside of the avalanche zone and the route of access and other operational considerations will be reviewed with the Howitzer team.

o ***Option 1.*** *Snow pack and road conditions allow for reduced risk access to the gun platform. In this case, the groomer will gain access using both the main road and the platform access road. The groomer will be observed at all times by at least one trained avalanche rescue person. After the groomer has reached the platform, the gun crew will go up to the platform one at a time insuring that each member is observed by at least one trained avalanche rescue person. In this option, if the road is easily passable, one or more members of the crew could go ahead of the groomer to the staging point on the main road in front of the gun platform (this allows for better visibility of the groomer when it is re-establishing the platform access road}.*

o *Option 2. Snowpack conditions allow for reduced risk access to the top of the Pass, but not through the avalanche paths crossing the platform access road. In this case the groomer will gain access to the staging area at the top of the Pass if necessary to re-establish the main road. 1f the road is in an easily passable condition (low risk of getting stuck), the groomer will stage at the west side avalanche sign throughout the mission. The gun crew will go up to the staging area on the top of the Pass one at a time insuring that each member is obsel1led by at least one trained avalanche rescue person. The crew members will then travel up the "nose" of the platform directly in front of the gun to the platform.* ***The rock cornice catch basin behind the platform must be free of debris in order to use this option.***

• Under certain specific parameters /conditions, the avalanche forecaster may determine that given the totality of the risk analysis, avalanche trained staff may access the gun mount from the east side of Sylvan Pass, for the purpose of assisting with forecasting or hazard mitigation operations.

Operational Risk Considerations:

- Crew members cross the bottom of four avalanche run out zones en route to the platform
- Crew members cross two additional avalanche paths if they use the access road to the platform Crew members can walk up the "nose of the platform" to bypass these two paths Groomer (if needed) must drive up the access road to clean out the catch berm
- Catch berm is designed to catch rock or comice debris ifit falls from the cliffs behind the platform. Groomer crosses a total ofsix avalanche ron out zones if the catch berm is full of snow and needs to be cleaned out
- The platform has the potential to be affected by avalanche debris during "50 -100 year weather/avalanche cycles"

Risk Mitigation

- Team briefing and consensus for Go / No Go decision, all team members are authorized to stop a mission
- Determine appropriate access route
- Communications, consultation, and coordination between the East Entrance and Lake staff is considered a critical component of the risk mitigation
- Employ safe travel practices during all activities in and enroute to the avalanche zone
- Conduct daily avalanche hazard forecasting B Maintain operational readiness of all equipment
- All team members vigilant to situational awareness~
- All team members fit for duty (i.e. no distracting illness, injury, work rest guidelines met, zero tolerance for substance abuse, no alcohol consumption last 8 hours)

- Appropriate hazard reduction method and tools selected based on totality of the circumstances **Howitzer Ammunition**
- A magazine for howitzer rounds and another for fuses are stored at the platform
- Conduct and document ~TF mandated weekly inspections and monthly inventories
- Magazine meets *ATF* regulation of 300' (195 feet, if barricaded) from public highway
- 100 to 300 rounds and fuses are properly stored on site
- Unexploded Ordnance
- Any unexploded ordnance must be documented -Dud rate must be less than 1%
- Conduct annual search and disposal for unexploded ordnance according to mission profile
- Consider all intact projectiles "armed"
- Maintain signed closure of south/southeast facing slopes of avalanche zone
- Explosives
- Specifications ~AAUNAC Standard
- 1 05mm HE, Comp-B (Military designation for 105mm ammunition: HE ~ High Explosives, Comp-B ~type of explosive compound (INT is another type)

Equipment –M101 Howitzer

- Classified as a Loan Agreement with the US Military
- Military has the authority to remove the weapon from service at any time
- YNP pays an annual loan agreement administration fee to the Military
- NPS pays for maintenance
- Required bore/scope pullover inspections and recoil leak checks by Army approved personnel
- Major repairs if necessary
- Both the primary and backup Howitzers are stored at the La!):e Maintenance Area during the summer months and will be secured locked up, out of view and protected from the weather.

NPS Personnel -Minimum Required Minimum of five people who cover the following functions:

- Avalanche Forecaster on site (may also function in additional capacity in operations).
- East Road Guard
- West Road Guard
- Groomer and operator for debris clean-up (as needed and appropriate)
- Groomer operator and West Road Guard may function as one
- Howitzer Operations -minimum number of trained participants on the platform
- Gunner/Gunner in Charge
- Loader
- Assistant Gunner

Chapter IV.

AERIAL DISPENSED EXPLOSIVES (End Use **Contract)**

Aerial dispensed explosives (typically helicopters) are used in the avalanche hazard reduction to supplement a ground based artillery/explosives program and are not typically a stand-alone hazard mitigation tool.

Training

- A Contracting Officer Representative is required to monitor the contract with responsibilities that Include:
- Complete Initial forty-hour class with a forty-hour refresher every two years *a* Approve and submit payment of invoices
- Guidance and oversight of contract
- On site Contract Inspector
- Aviation Safety training (current B-3)
- Knowledge of terms of end use contract
- Expertise In avalanche hazard mitigation

Operation
- Communicate need for mission with pilot and Contracting Officer
- Commit pilot and aircraft to perform the mission within established timeframes
- Monitor weather at Sylvan Pass and along flight route from Bozeman. Advise pilot of current **and** expected conditions. Pilot still has the responsibility to get current weather for flight for his own evaluation.
- Post road guards (2) and establish landing zone for medical helicopter
- Conduct pilot briefing. Provide forecaster Information on snowpack observations and avalanche activity
- Maintain communications throughout mission, per request of the pilot.
- Document results of explosives work and pilot's observations
- Mission debrief with pilot
- Conduct post-mission evaluation of avalanche zone
- Report satisfactory completion of the mission to the Contracting Officer
- Flights will originate from the contractor's home base (currently Bozeman, MT).
- En-route flight time to Sylvan will vary between approximately 45 to 90 minutes depending on weather
- Transports unarmed explosives, examples Include:
- 20-25· 5 lb. boosters
- 50 blasting caps with 90 second fuses
- Personnel-blaster, controller and explosives permitee
- Certified Blaster
- Controller, certified blaster
- Explosives Permitee – ATF explosives credentials, certified blaster
- Explosives
- Explosives are purchased and stored by the vendor and are the sole responsibility of the vendor
- Contractor’s discretion on the type of explosives – typically 5 pound Trojan – 25 Booster, two blasting caps and 90 second fuse
- Each booster will have a RECCO chip attached
- Unexploded ordnance
- Dud rate is less than 1%
- Can be located using RECCO system
- Unexploded ordnance will be the responsibility of the contractor and shall not be handled by NPS staff
- Mitigation – avalanche control areas/slopes are presently closed to public access and posted appropriately

NPS Personnel-Minimum Required
- Minimum of two people who cover the following duties.
- Avalanche Forecaster on site.

- East Road Guard
- West Road Guard
- Project Inspector
- Groomer and operator for debris clean-up (Operator may also function as West Road Guard)
- Flight following will provided by YNP Fire Dispatch Center at the request of the pilot.

Chapter V

ROAD GROOMING OPERATIONS

Training

- Commercial driver's license required to operate the. groomer
- Annual Avalanche Hazard Awareness Training required with emphasis on transceiver and rescue operations and identification of observed potential avalanche hazards
- Operation of the groomer and implement and techniques of grooming, and road reconstruction over debris slides
- Groomer operators are generally cross trained for howitzer positions i.e. gunner, assistant gmmer and loader

Operations

- Groomer Operator consults with avalanche forecasters and has authority to decline a go decision for groomer to enter

Sylvan Pass during either routine grooming operations and or during hazard reduction operations

- Groomer operator equipped with avalanche rescue equipment such as prob. poles, snow shovel, avalanche transceiver, Avalanche transceivers must be worn and tuned on prior to beginning travel from Lake. Groomers must be equipped with standard emergency kit and any other appropriate personal protective equipment in the event the groomer malfunctions and the operator is required to operate a snowmobile.
- Groomers will not be operated in the Sylvan Pass avalanche zone after dark.
- Fishing Bridge Junction to Pahaska
- 29 miles
- 8 to 10 hours to groom
- 12+ hours when grooming coincides with an avalanche control mission
- depends on weather and avalanche debris clean-up
- 3 hours from. Fishing Bridge to Sylvan Pass
- Frequency
- As needed for quality of the road and/or drifting on Sylvan Pass
- Control Missions
- Helicopter avalanche control missions
- Groomer must clean up avalanche debris that crosses the road
- These operations requires west side road guard
- Howitzer avalanche control operations
- Groomer must clean up avalanche debris that crosses the road
- Groomer must clean out the "catch-berm" at the howitzer platform and around the howitzer
- West side road guard **Equipment consists of the**

following:

- Snow Grooming Equipment
- Owned by NPS
- This equipment must be able to accomplish the grooming needs associated with avalanche control

and clean-up **NPS Personnel-Minimum Required**

- Avalanche Forecaster on site (may also function in additional capacity in operations) during Avalanche reduction operations involving the groomer
- One individual to operate the equipment
- Staffing to provide seven day a week coverage
- Includes duties as a member of the howitzer team
- Independent spotter when hazards dictate or requested by groomer operator

APPENDIX A to Yellowstone Avalanche Forecasting and Hazard Mitigation

Winter 2010-2011 STAFFING & QUALIFICATIONS:

Brad Ross, Lake District Ranger/ Avalanche Program Director, Howitzer Program Manager, Forecaster

Rich Baerwald, Snow Science Coordinator, Lead Forecaster

Phil Strehle, Forecaster Trainee, Snow Ranger

Kevin Hammonds Forecaster, Snow Ranger

Michael Keator Forecaster, Snow Ranger

Eric Amundson Snow Ranger

Klint Powell Snow Ranger

Matt Harrison Snow Ranger

MIO I Howitzer Gun Crew attendance and 2010/2011 certification levels:

Brad Ross - Gunner / Howitzer Program Manager
Dave Whaley - Gunner
Rich Baerwald - Gunner
Boone Vandzura- Gunner (annual refresher pending as of 12/6/10)
Dave Hill - Assistant GunnerlLoader
Michael Keator - Assistant GunnerlLoader
Bruce Sefton - Assistant GunnerlLoader
Art Truman - Assistant GunnerlLoader
Phil Strehle - Assistant GunnerlLoader (annual refresher pending as of 12/6/10)
Ryan Bock -Trainee
Klint Powell -Trainee
Greg Bickings -Trainee
Burt Timmons - Trainee (annual refresher pending as of 12/6/10)
Eric Amundson-Explosives Handler

Aerial Dispenses Explosives (conducted under end use contract)

Contracting Officer -Andy Fox

Contracting Officer's Representative -Joe Krish, Wendy Hafer

Project Inspectors:

Rich Baerwald, Brad Ross, Phil Strehle, Michael Keator

Groomer Operators:
Dave Hill-Lead Operators, Phil Anderson -Lead Operator -Backup Operator

APPENDIX B to Yellowstone Avalanche Forecasting and Hazard Mitigation

Other Road Segments Employee and visitor safety will take precedence over all other considerations on all park roads. For all other park road segments, regional forecasting and site specific observations will guide determinations of potential avalanche hazard. If any road segment is determined to be unsafe to travel, that road segment will be closed to all public and administrative travel until the hazard is reduced. Aerial dispensed explosive may be used to reduce avalanche hazard at these locations when and if conditions allow for their use. Until that occurs (or conditions and/or natural releases indicates the hazard has subsided), the road segment will remain closed.

Documentation

A case incident report will be prepared when conditions warrant a road closure to public use or to administrative travel. The report will site reasons for the closure and a copy will be provided to the Chief Ranger's Office.

A case incident report will be prepared for all avalanche hazard reduction operations. Results of the operation and change in road status resulting from the operation will be included.

APPENDIX C to Yellowstone Avalanche Forecasting and Hazard Mitigation

GO / NO GO Safety Considerations Checklist for Sylvan Pass Field Activities

A GO / NO GO decision will be determined by a negative response to key critical minimum standards outlined throughout the SOP or a totality of the circumstances based on the field assessment. Key NO GO trigger denoted with ** below.

Factors

I) Consider road and weather conditions and time of day. **Is it safe to travel to the Sylvan Pass avalanche zone?

2) Consult forecasters on staff and consider weather and avalanche hazard. **Is it safe to travel through the Sylvan Pass avalanche zone?

3) Has avalanche control been conducted recently?

4) **Is minimum staffing available (per SOP) for the work to be performed?

5) ** Are personnel equipped and trained for the travel and assignment that they plan to conduct?

6) **Do staff involved have communications with each other?

7) ** Are emergency response personnel ready, available, and notified of work to be performed and response pre-plan identified and made known to all involved?

8) **Has the Communication Center been notified of travel plans and work to be conducted (during hours or conditions when the pass is closed to the public)?

9) Are there signs of snowpack instability both en route and on-site at Sylvan Pass?

10) Are weather conditions changing or are they different than anticipated?

II) **Are established SOP's being followed for avalanche hazard reduction and road grooming operations?

12) ** Are end use contract terms being followed?

13) Do all staff members assigned possess the attitude, awareness and judgment to safely accomplish the travel and work associated with Sylvan Pass?

14) **Are all identified hazards made known to participating personnel?

15) Should you stop the operation due to:

- Communications Loss
- Weather change
- Conflicting priorities
- Other priority operations elsewhere in the park
- When in doubt -stop and re-evaluate
- Are you deviating from the plan?
- Can you justify your actions?

16) Are you being driven to conduct these operations by a sense of urgency or pressure?

Situational Awareness Operational Considerations

Situational awareness refers to the operational crew's ability to;
- Maintain accurate perception of the external environment.
- Identify the source and nature of problems.
- Detect a situation requiring action.

Factors that reduce situational awareness:
- Insufficient communication
- Fatigue / Illness / stressful event in last 24 hours
- Task overload / under load
- Group Mindset
- "Press on regardless" philosophy
- Degraded operating conditions

Ways to prevent loss of situational awareness:
- Actively question and evaluate your mission
- Analyze your situation
- Update and revise your image of the mission profile

Use assertive behaviors when necessary;
- Make suggestions
- Provide relevant information without being asked.
- Ask questions as necessary
- Confront ambiguities
- State opinion on decisions / procedures

- Refuse unreasonable requests

It's OK to say no and stop the operation.