# Chinook Pass: 25 Years On

John Stimberis*, *Washington State Department of Transportation*,
Snoqualmie Pass, Washington, USA

ABSTRACT: Washington State Route 410 over Chinook Pass (1656 m) is generally closed from late November through late May each year due to heavy snow loads and avalanche hazards. By early April each year, the Washington State Department of Transportation (WSDOT) begins clearing the highway. The clearing project exposes highway workers to over 100 avalanche paths as they make their way toward the summit of Chinook Pass. This process has been repeated each year since 1935.

In 1983 the WSDOT Avalanche Forecasting and Control Program was called upon to provide assistance with the spring opening. This marked the beginning of a unique backcountry avalanche program where travel to avalanche paths is limited to ski touring, and the avalanche forecasters have the opportunity to work closely with the snowpack as it transitions from a fine-grain, layered snow pack to a homogenous, well-drained snow pack.

At the 1986 International Snow Science Workshop, Craig Wilbour presented an overview of this newly created program. This paper and corresponding presentation will provide an update of the Chinook Pass Avalanche Forecasting and Control Program, some 25 years after its inception.

KEYWORDS: Forecasting, Avalanche Control, Highways

## 1. INTRODUCTION

Chinook Pass (1656 m) is located in the Central Cascade Mountains of Washington State (46° 52.33 N 121° 30.94 W). The Mather Memorial Highway, state route 410, begins in Sumner, WA and crosses Chinook Pass before ending at the junction with US 12 near Naches, WA. The section of SR 410 that crosses the Cascade Mountains is a secondary, non-commercial highway, providing access to Mount Rainier National Park and the Wenatchee National Forest. The Washington State Department of Transportation (WSDOT) manages and maintains the highway. Mountainous terrain, a maritime snow climate and numerous avalanche paths force the closure of a 27 km section of SR 410 each year from approximately late November through the end of May. Snow removal efforts usually start at the beginning of April.

Construction of SR 410 was completed in the early 1930's, with snow removal records dating back to 1935. Avalanches have always been a concern, but the WSDOT lacked any avalanche personnel. During the 1960's and 70's avalanche concerns were increasing on other Washington State highways and the first avalanche forecasting and control programs were established on Stevens and Snoqualmie Passes. In 1980, WSDOT maintenance personnel called upon the Snoqualmie Pass Avalanche Forecasting and Control Program to assess the avalanche hazard along SR 410. In March of 1983, WSDOT Maintenance crews again contacted the Snoqualmie Pass avalanche program and asked for their assistance with avalanche forecasting and control along SR 410. This time around, the avalanche forecasting and control program would be included on a regular basis during the spring opening project.

### 1.1 *Weather and Climate*

The Cascade Mountains of Washington State are classified as a maritime snow climate (McClung and Schaerer, 2006). Chinook Pass is located in the Central Cascade Mountains, an area that defines the classification of maritime snow climate. Annual snowfall exceeds 2000 cm with rain-on-snow events common throughout the snow season. It is common for Chinook Pass to exceed 500 cm snow height during snowpack maximum, on par with locations such as Paradise (1692 m) on Mt. Rainier and Mt. Baker Ski Area (1280 m). Both of these locations have been, or

*Corresponding author address: John Stimberis 1005 D St Ellensburg, WA, USA 98926; tel: 509.929.1647; email: stimbej@wsdot.wa.gov

currently are, holders of world records for annual snowfall.

Although the Chinook Pass region near and west of the Cascade Crest receives heavy snowfall, the climate dries quickly east of the crest. Conditions become drier to the north as well due to the rain-shadow effect of Mt. Rainier. Local SNOTEL sites demonstrate this phenomenon. Over the October through May period (2007-2008 winter) the Paradise, WA SNOTEL station (1561 m) recorded 3172.5 mm of precipitation, and a maximum height of total snow (HTS) of 559 cm on 8-April-2008. Chinook Pass precipitation data was unavailable, though the weather site at Chinook Pass (1656 m) recorded a maximum HTS of 540 cm on 8-April-2008. In contrast, the Morse Creek SNOTEL site (1646 m), located 4.5 km east of Chinook Pass, received 1988.2 mm of precipitation and a maximum HTS of 405 cm on 9-February-2008.

### 1.2 *Terrain*

The geography of the Chinook Pass area places SR 410 in numerous avalanche paths to the east of the summit. This section of the highway follows the Rainier Fork of the American River, a glacially carved valley that maintains the classic “U” shape, with the highway situated about mid-slope on a south to southeast aspect. Avalanches paths tend to have average starting zones exceeding 35 ° with slope angles exceeding 30° at highway elevation. Average vertical fall to the highway is 300 m from the ridges with an additional 200 m below the highway to the valley bottom (Wilbour, 1986). WSDOT does not attempt to maintain SR 410 during the winter months due to the excessive snowfall, numerous avalanche paths, and terrain hazards.

Figure 1 shows the area east of Chinook Pass. The Morse Creek gate is located 9 km east of the summit. The avalanche paths are infrequent along the first 2-3 km of road above Morse Creek (Wilbour, 1986). Avalanche debris is encountered, though it is usually from mid-winter avalanche cycles. This section of road is characterized by large old-growth timber and dense stands of younger forest where avalanche paths are confined to gullies.

Moving west along SR 410 towards the summit there are a few transitions to note. The edge of the large timber is encountered about 3 km above the Morse Creek gate. By this point, the terrain has less large vegetation, and is prone to more frequent avalanches, though they are still generally contained to established and definable paths. After an additional kilometer, there is a transition where the avalanche paths, though still distinct, become more frequent and crowded. The paths begin to have multiple starting zones that feed into singular paths creating additional forecasting and control challenges. This area, known as Knob 3/Picnic Point is where the avalanche crew usually begins to have forecasting and control concerns (see figure 1). The maintenance crews also begin to spend more time exposed to the paths as the snow gets deeper and clearing efforts take longer.

The Crusher Site is reached 6 km above the gate. This location is significant in that it provides a safe location for crews and equipment and it is a staging point for avalanche crews to reach both the Knob 2 and Knob 3 paths. The next two kilometers beyond the crusher provide little safety from avalanches. Avalanche paths through this area become more frequent. Multiple starting zones feed into larger paths and a number of small, contiguous paths affect the highway. These small paths are less than 150 m above the road, and exceed 30° steepness (Wilbour, 1986). In addition to exposure from above, the Maintenance crews are also increasing their exposure below as they are now 200 m above the valley bottom.

The area beneath Knob 1 contains numerous avalanche paths with multiple starting zones. Vegetative anchors are few and the snowpack is significantly deeper than the paths on Knobs 2 and 3. Starting zones range from 30° to over 40°. Wind loading contributes to cornice formation and additional new snow hazards during spring snowstorms. Maintenance crews often spend a considerable amount of time working in these paths. This area has the greatest potential to be an avalanche hazard after the highway has opened to the public.

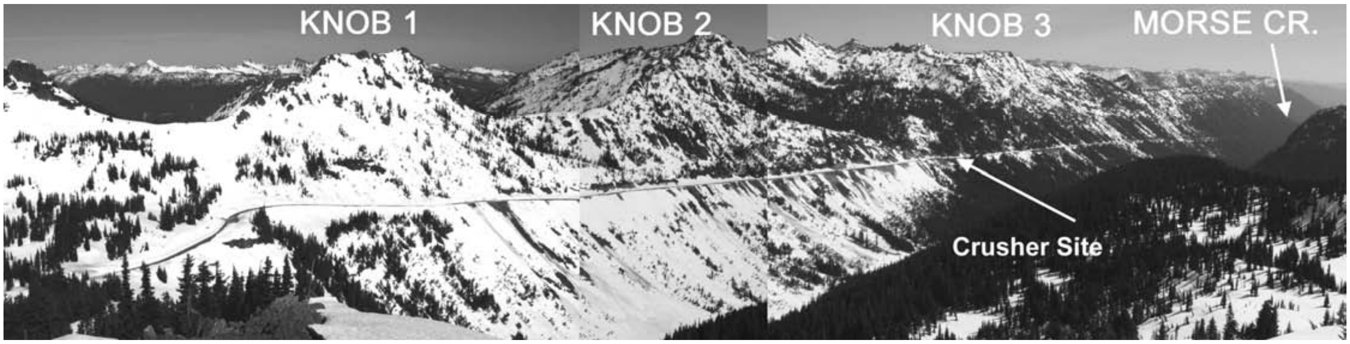


Figure 1: SR 410 East of Chinook Pass, WA

2. METHODS

Spring snow removal and the subsequent need for avalanche forecasting and control typically begins by mid-April, with the project lasting 6-8 weeks. Over the history of the project, the latest opening has been July 12, 1974 and the earliest was April 5, 1973 (Wilbour, 1986). During the past 25 years, the latest opening was July 1, 1999 and the earliest has been April 28, 2005. The 25-year average opening date is May 22. Prior to the introduction of the avalanche crew, the average opening date was May 27.

The project follows a similar pattern each year with avalanche personnel making a reconnaissance tour in late March to assess the overall snow coverage. Separate WSDOT Maintenance crews then begin clearing the highway from both east and west seasonal closures. The Westside crew begins in March and clears SR 410 to the summit of Cayuse Pass (1425 m) and the junction with SR 123. They encounter little avalanche hazard over this stretch of highway. The Westside crew then continues south on SR 123 before returning to SR 410. Avalanche hazard assessment and occasional avalanche control are needed along SR 123. Meanwhile, by early April, the Eastside crew begins clearing the highway at the Morse Creek gate 9 km east of Chinook Pass. WSDOT Avalanche crews are usually on-site though the remainder of the project, advising maintenance crews about weather and snow conditions, performing avalanche control, and additional blasting when needed.

2.1 *Forecasting*

Daily avalanche and weather forecasting differs from wintertime operations in two distinct ways: The crew does not have access to the Internet, and although the traffic volume on the affected portion of road is minimal, the exposure is near constant; maintenance personnel often spend the entire day exposed to a single avalanche path as they clear snow. This requires the avalanche crew to be well informed about the structure of the snowpack and the expected weather conditions for the day.

The avalanche crew is housed in a remote location where internet and cellular services are non-existent. Weather forecasts and some mountain weather data are available from the Northwest Weather and Avalanche Center (NWAC). The crew is able to receive information via telephone in the mornings, prior to meeting with the maintenance crew. Weather data typically consists of a few select sites in the general region. Communication problems have interrupted data retrieval from the Chinook Pass site. NWAC Forecasters also provide a mountain weather forecast. WSDOT Avalanche crews provide NWAC with local snow and weather data. The information given to the NWAC is usually the only field data that they receive during the Spring.

Snowpits, both test and full-profile, are dug early in the project. They are not commonly used for daily avalanche forecasting as the instability is usually limited to the surface, or near-surface. Deep instabilities and persistent weak layers are uncommon or isolated to certain slopes at this time of year and in this particular region. Chinook Pass has provided forecasters with a unique setting to study wet-snow avalanches. Conway, Breyfogle and Wilbour have all conducted or collaborated with wet snow research in the 1980's to early 1990's (Wilbour, 1986) (Conway *et al*, 1988)

2.2 *Travel*

Terrain dictates access to the starting zones. Access to the ridges is gained on skis with alpine touring bindings and climbing skins. Helicopters are used to transport explosives to ridge top storage magazines, weather permitting. Helicopter use is usually limited to one time per season. Day to day operations rely on ski travel, both to the ridges and back, as well as during avalanche control. Employees use the latest alpine touring gear and alpine touring boots. Each of the main sites, or knobs, has well-established routes that provide safe access. In some cases, cornices affect the access and crewmembers work to remove the hazard early in the project. Safe travel techniques are employed at all times.

2.3 *Avalanche Control*

Avalanche control is performed when necessary and where possible. Crews do not always limit themselves to the immediate concern, the slopes above the maintenance crews. Instead, they look to affect slopes ahead of the clearing operation whenever possible. This provides two advantages: it reduces the hazard ahead of the crews allowing work to continue uninterrupted, and if a large avalanche releases it easily passes the highway, reducing the amount of snow to be removed. Avalanche control above sections of cleared highway results in additional snow removal for the maintenance crews.

When avalanche control is performed, the crews rely on two primary methods. Explosives are used in the larger avalanche paths and starting zones, and ski cutting is used throughout the area. Ski cutting tends to be very effective when dealing with surface instability.

Avalanche control using explosives is confined to larger starting zones, and in areas that have proven to be effective. The primary explosive used is ANFO with cast primers packaged in 6.5 and 13 kg bags. Avalanche personnel bury the shots and connect the shot holes with detonating cord for remote triggering. Rigging is done early in the day when stability is good. Depth of placement is dependent upon layering in the snowpack and total snow cover; at least 1 meter of snow is maintained as a buffer to the ground below. After the rigging is completed, the avalanche personnel retreat to safe ground and wait for the air temperature to increase, or snow stability to decrease. The advantages of buried explosives are two-fold: if a deep instability exists, it is usually triggered by the large amount of explosives, and the large mass of snow released by the explosives helps gouge the track, removing additional snow cover.

Ski cutting is another widely used technique. While burying large amounts of explosives has a profound effect on one area, ski cutting allows the avalanche worker to access many different slopes. Wide varieties of instabilities exist over a slope. Variations in slope angle, aspect, elevation and snow cover have an effect on stability. Spring conditions at Chinook Pass usually favor surface instability. This type of wet-snow instability does not always respond well to explosives. Skis can cover a large amount of starting zones in a short time, producing some favorable results.

Throughout the project, the avalanche crew is also called upon to provide assistance with other roadside hazards. Large rocks, hazard trees and “tip-ins” (large snow banks that collapse onto the highway) may need attention. Many of these hazards are mitigated with the use of explosives.

3. DISCUSSION

For the past 25 years, the WSDOT has managed a unique backcountry avalanche program where travel to avalanche paths is limited to ski touring, and the avalanche forecasters have the opportunity to work closely with the snowpack as it transitions from a fine-grain, layered snow pack to a homogenous, well-drained snow pack. This transformation is considered to mark the end of avalanching (Conway *et al*, 1988). Quantification of wet-snow avalanche conditions has been conducted on the slopes above Chinook Pass utilizing a variety of devices (Wilbour, 1986). Modifications to travel routes, techniques and equipment have improved both safety and efficiency for Avalanche and Maintenance personnel alike. Avalanche control techniques, particularly concerning the use of explosives, have evolved. Assistance and coordination with the Maintenance operations have increased as well. What follows is a review of some of the changes and consistencies over the past 25 years.

3.1 *Avalanche Control*

Avalanche control has likely seen some of the biggest changes during the past 25 years. Techniques, products used, timing and location have all been modified. Originally much of the avalanche control with explosives was done with hand charges, placed or thrown on the snow surface. This evolved to elevating the shot placement, either on sticks or with cable trams. Over the years it has been found to be more effective to bury the shots, particularly for the long-term benefits of removing snow from the starting zones and encouraging snow melt. This change in approach was accompanied by the use of larger shots, particularly the inclusion of ANFO. Increasing the amount of explosives used was found to have a greater and potentially deeper effect upon the snowpack. Nitro-based explosives were discontinued due to the potential for an adverse reaction (headaches/nausea). This change has been seen elsewhere in the avalanche control business.

One aspect that remains the same is ski cutting. Ski cutting remains a very effective tool for triggering wet-loose avalanches. This method allows the skier to cover a wide variety of terrain in a short time. The results are often impressive. The WSDOT has also put additional effort into reducing roadside snow hazards. Large snow banks have a tendency to collapse into the road creating a hazard for motorists. Removing these snow banks, using explosives, has become an additional task for the avalanche crew.

3.2 _Travel_

Travel techniques have been modified a bit over the years, though most of the routes used nowadays are the same routes pioneered by the first avalanche controllers at Chinook Pass. Terrain often dictates, or limits, what can used as a safe or convenient route. Equipment has improved, particularly the advent of alpine touring bindings and boots. The original crews did far more boot packing than is done today. Craig Wilbour, in a personal correspondence, reports that the time it took to get to the ridges has not changed much, though travel must be more efficient with today's equipment. Protecting certain ascent routes by controlling cornices has increased as a priority.

3.3 _Safety_

Safety has also seen improvements. The WSDOT places a premium on worker safety. All crews are equipped with avalanche transceivers, probe poles and shovels. Avalanche personnel train the maintenance staff on the proper use and handing of transceivers. When the avalanche crew first became involved with Chinook Pass, they used transceivers and shovels and carried equipment that would be considered appropriate for backcountry travel. Maintenance personnel were not so equipped or as willing to utilize the proper safety equipment. Daily safety discussions, in the form of a Pre-Activity Safety Plan, are now required. Communication is emphasized between the maintenance and avalanche crews.

A project such as this one could easily lead to complacency through familiarity. Rob Gibson, in a personal correspondence, summed it up this way: "Analyze something for what it truly is, not how it fits into your experience." Continued discussion and analysis of this project should help maintain a culture of safety.

3.4 _Forecasting_

Forecasting has undergone changes as well. The techniques used to assess the conditions have improved since the 1980's. According to Craig Wilbour, "(The) understanding of wet snow avalanches has improved considerably since 1980." Conway, Breyfogle and Wilbour collaborated on wet-snow and rain-on-snow studies, utilizing such devices as the "sling centrifuge" and "crust-o-meter" (Wilbour, 1986) (Conway *et al*, 1988). The emphasis on quantification has changed since the days when Conway *et al* were studying the effects of temperature, rain and melt water on snow stability. These days, the crews tend towards qualification rather than quantification of snow avalanche hazards; less time is spent in the snow pit and more time is spent investigating the variability of the diverse terrain.

Some aspects have not changed much. Computers and the Internet have not reached the Chinook Pass project, at least not on a daily basis or as part of the daily forecasting routine. Weather information is still gathered once a day by talking to the NWAC Forecaster. Local weather does not always follow the script and conditions change. Snowpack assessment and stability forecasting are still accomplished by getting out there to see and feel what the snow is doing.

## 4. ACKNOWLEDGEMENTS

I wish to thank Craig Wilbour and Rob Gibson for their assistance and those that I have had a chance to work with on Chinook Pass over the past 10 years.

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