DAMALANCHE: AVALANCHE DAMMED RIVER

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ABSTRACT: January 2014 brought an unseasonably warm and prolonged low-pressure system to Alaska. Heavy precipitation associated with above freezing temperatures created an eighteen-day avalanche cycle. Large avalanches dammed and flooded the Lowe River. The Richardson Highway, bridges through Keystone Canyon and residential areas were threatened by the possibility of outburst flooding.

KEYWORDS: avalanche dam, wet snow avalanche, entrainment, outburst flooding

1. BACKGROUND AND INTRODUCTION

The term, ‘avalanche dam’, often refers to avalanche control structures built in run-out zones to deflect or catch avalanche debris. During the winter of 2014 Valdez, Alaska had a different kind of avalanche dam – a dam of wet entrainment avalanche debris that blocked the Lowe River and temporarily formed a new lake. The townspeople of Valdez dubbed it the ‘Damalanche’ (Fig.1).

In recent history, avalanche dams have been known to block other rivers such as the Illecillewaet River near Roger’s Pass, British Columbia and the Middle Fork of the Flathead River, Montana. Avalanche dam events have been reported and studied in the European Alps, the Torlesse Range of New Zealand, the Andes and the Himalaya Mountains (Butler, 1989). Avalanche dams are usually associated with wet snow avalanche debris. Avalanche dams are a concern when flooding occurs upstream of the blockage. Problems include erosion of highways and, should catastrophic failure of the dam occur, the valley downstream is in danger.

The threat from avalanche dams can be likened to an outburst flood from glacier meltwater, or jökulhlaup event where serious damage and loss of life is possible.

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The objective of this paper is to describe the January 2014 Damalanche and associated avalanche cycle.

Fig. 1: Damalanche. Avalanche dammed lake flooding Richardson Highway.

2. LOCATION

The Damalanche was a series of avalanches that filled Snowslide Gulch and the Lowe River valley below. The valley at this site narrows as the river enters Keystone Canyon (Fig. 2). The avalanche path runs to the valley floor annually, sometimes several times a winter.

Five start zone areas feed Snowslide Gulch. The upper start zones are alpine bowls on and between three sub-peaks of a massif locally named ‘Hogback’. Some of the upper start zones are glaciated. The upper fracture lines from this event were above 5500 feet (1675m) with debris running down into the valley at 430 feet (130m). The tracks are 30-45 degree open slopes with very little vegetation. The Richardson Highway connects the sea Port of Valdez and Fairbanks. It runs along the opposite side of the river 150 feet (45m) from the bottom of Snowslide Gulch. Snowslide Gulch faces east-southeast; most of the avalanche slopes funneling into it have a south-southeast aspect.

Snowslide Gulch is the site of two avalanche fatalities in 1914. Flooding in October of 2006 deposited a lot of rock and gravel into the bottom of the avalanche track, reducing what little avalanche catchment area existed previously. Avalanche debris has blocked the river more than ten times in the last thirty years.

The Alaska Department of Transportation (AKDOT) Valdez District has one portable 105mm Howitzer artillery that is used for hazard mitigation. Avalanches large enough to place debris on the highway occur every two to three years, sometimes multiple times a season.

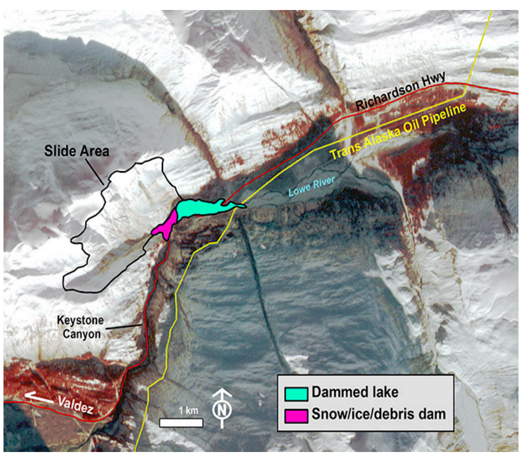

Fig. 2: ASTER image of Snowslide Gulch debris and lake (Leonard and Abrams).

2.1 <u>Snow Climate Zones</u>

Located at 61 degrees north latitude and roughly sixteen miles (25km) from the waters of northern Prince William Sound, the snow climate zone is sub-arctic maritime.

Crossing the Chugach Mountains from the Port of Valdez, the Richardson Highway passes through three climate zones over 70 miles (113km) of avalanche terrain. Based on weather and the effects of that weather on the snowpack, the snow climate zones are:

- Maritime (coastal) - from the sea Port of Valdez to Thompson Pass at Milepost 26, elevation 2678 feet (816m)
- Inter-mountain (transitional) - from Thompson Pass to the Milepost 46, Rendezvous Lodge at Serendipity, elevation 1150 feet (350m)
- Continental (interior) - from Mileposts 46 to 64, elevation 1800 feet (550m)

2.2 <u>Elevation designations for forecasting</u>

Multiple avalanche problems due to the snowpack structure, air temperature and precipitation were experienced during the avalanche cycle that produced the Damalanche. Elevation played a large role in how the weather affected the snow.

Three elevation bands are designated for forecasting:

- Lower elevation - between sea level and 1500 feet (450m)
- Mid-elevation - between 1500 feet and 3000 feet (450-900m)
- Upper elevation - above 3000 feet (900m)

3. SNOWPACK AND WEATHER HISTORY

The progression and timing of this avalanche cycle was challenging due to the extended duration (eighteen days), limited reliable weather data and that rain-on-snow events over a large forecast area are difficult to monitor. Questions asked:

- After the initial avalanches, how much rain would the snowpack absorb before it avalanched again? (Timing)
- How much entrainment would occur and how far would the wet snow slide? (Extent)

During this cycle there were several entrainment avalanches that ran previously unforeseen distances. Rain-soaked wet slab avalanches released from slopes less than 20 degrees. One ran almost a mile (1.6km) dropping only 750 feet (230m). Also, numerous times new avalanche activity would get previous deposits to again start moving downslope. A notable instance was January 30th at Milepost 39 after the old deposit had formed a substantial crust from overnight freezing.

3.1 Data Collection

Collecting snowpack data was difficult during the period. The avalanche danger for the backcountry rose to High by January 15 and remained High or Considerable throughout the rest of the month.

The weather data resources are:

- The National Weather Service office (NWS) in Valdez stopped collecting climate data March 16, 2014 and is now closed after forty one years in America's snowiest city.
- The 12 Mile automated Road Weather Information System (RWIS) at 341ft elevation (104m)
- The 19 Mile RWIS at 676 feet elevation (206m)
- The 26 Mile Mile RWIS at 2736 feet elevation (834m)
- The Sugarloaf Snotel hydrology monitoring station at 551 feet elevation (168m)
- The Tsaina River Snotel at 1750 feet elevation (533m)

Although the 26 Mile RWIS at Thompson Pass is the highest elevation weather station, it is still 2000 feet (600m) below the avalanche start zones. This site showed above freezing temperatures January 21st-25th. Temperatures spiked into the 40'sF (5+C) and did not drop below freezing until the afternoon of January 28th when the post-storm temperature inversion finally dissipated and the freezing level began to drop.

Starting in April 2014, the University of Fairbanks and State of Alaska Climate and Cryosphere Hazards Program has posted temperature data from a temporary weather station at 6600 feet (2000m) above the Valdez Glacier to monitor flooding that would isolate Valdez.

Precipitation was steady from January 13th-22nd and then increased in intensity through the 25th. Manual snowfall and snow water equivalent measurements at Thompson Pass measured twenty-three inches (600mm) of precipitation added to the snowpack from January 13th-25th. The 19 Mile RWIS station recorded twelve inches of (300mm) of precipitation during the twenty-four hours from 2pm January 22nd-23rd. The 12 Mile RWIS station reported more than twenty-one inches (530mm) of precipitation from January 21st 2pm-January 24th. Various observers and the National Weather Service office anecdotally verified these amazing quantities. The Valdez NWS reported more than three inches (80mm) of rain during twenty-four hours of January 23rd-24th (Fig. 3).

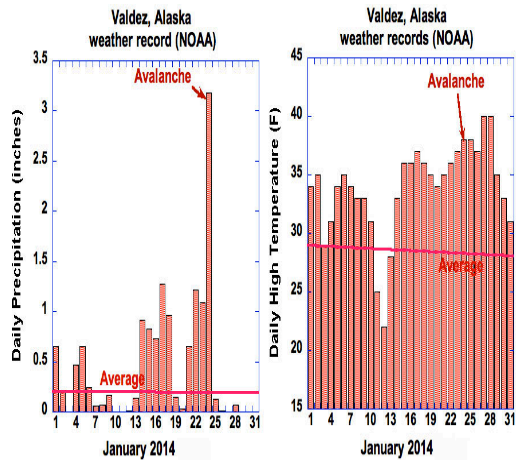

Fig. 3: Precipitation and Temperature record (NWS Valdez, NOAA).

3.2 Snowpack

Going into January, Thompson Pass had a rather weak two-meter snowpack with facets at the ground. Great quantities of snow accumulated in the upper elevations January 13th-17th and rapidly overwhelmed the weak snowpack structure. Storm snow and wind slab avalanches were prevalent in the mid-upper elevations throughout the last two weeks of January.

The snowpack below 2000' (600m) became rain saturated and isothermal across all three climate zones creating wet snow avalanches. Many paths had avalanches that started as dry slab releases and then stepped to ground entraining moist and wet snow as they descended.

3.3 Weather and Avalanche Activity

In January eighty inches (203cm), one third of the winter's total snowfall of 250 inches (635cm), accumulated at Thompson Pass.

A low-pressure system moved into south-central Alaska on January 13th. The "stuck" jet stream and resultant strong meridional flow was fed by significant moisture pumped north from the tropics. Heavy snowfall to sea level in Valdez and a prolonged forecast of unseasonably high temperatures challenged the highway avalanche program. Temperatures rose until rain began falling January 21st. The first rain on cold snow triggered avalanches to destructive scale size 3 at all elevations. Avalanches initiated at both storm interfaces and the basal facets.

Widespread avalanche activity began as the freezing level rose and rain fell in the upper elevations. Avalanches were gouging into the old snow by January 22nd. Persistent warm air triggered avalanches from ever-higher elevations. As those avalanches travelled down into the mid-elevation, many stepped down releasing the entire snowpack to ground. One observer noted the smell of dirt. Residents in town heard what sounded like a repeated barrage of jet planes or thunder.

The freezing level rose above 5000 feet (1525m) on January 23rd and rose to 8000 feet (2430m) the next day.

4. AVALANCHE DAM: DAMALANCHE

The Damalanche was not a single avalanche but the accumulation of many avalanches between January 14th and 30th. AKDOT shot and bombed Snowslide Gulch January 14th, 16th, 25th, 26th, 29th and 30th.

Both natural avalanches and avalanches to size 3 triggered by artillery released January 14th into Snowslide Gulch. The Lowe River was briefly blocked, but flow continued almost immediately. Two days later on January 16th both natural and artificially triggered avalanches again ran into Snowslide Gulch and out to the valley bottom. The Lowe River was briefly blocked for a second time.

A large avalanche off Snowslide blocked the Lowe River January 23rd briefly affecting the highway with surface water running off the deposit onto the road until the bridge deck drain holes were cleared while the river water simultaneously found a route under the deposit. Both the highway and river were completely blocked at 6:00 AM January 24th by yet another natural avalanche at Snowslide Gulch.

The largest of the successive avalanches was a size 4.5 triggered January 25th by AKDOT helicopter bombing. It began as a dry, storm slab avalanche near 5300 feet (1615m). It stepped down to deeper weak layers, including full depth to glacier ice twenty feet (7m) beneath the snow surface. It entrained rain-saturated snow as it gained speed. The powder cloud could be seen billowing away while the leading edge bulldozed debris piles from previous avalanches. When it finally came to rest, some of the deposit had flowed upstream, diverted by the many channels of wet debris.

A pilot that was in the air above the avalanche said he watched the debris "reverse the course of the river; I've never seen a river run backward."

2000 feet (600m) of road was buried with wet debris over 140 feet (40m) deep. The entire deposit of multiple avalanches piled on top of one another in the river valley was estimated to *average* 2000 feet long by 500 feet wide by 75 feet deep (600m X 150m X 23m = 2,070,000 m3) equaling 75 million cubic feet of snow (more than 2 million cubic meters) with debris weighing 500 kg/m^3.

After triggering successive enormous

avalanches, heli-bombing was halted on the 25th until the floodwaters subsided sufficiently to restart measures to ensure the safety of the workers clearing debris. The reasons for ceasing the mission on the 25th was to prevent creating a deeper deposit elevating the threat of flooding, as well as to stop increasing the mammoth task of clearing the highway.

Fig. 4: AKDOT crew surveying Damalanche and buried highway.

Further AKDOT avalanche mitigation work in the region January 26th, 29th and 30th produced numerous large avalanches from all three snow climate zones. The precipitation ceased, but lingering cloud and fog below 2500 feet (760m) and a temperature inversion in the upper elevations did not allow the snowpack to freeze. It wasn't until January 30th that both the air temperatures and the lake level dropped before crews could safely begin clearing the highway.

Working around the clock for 139 hours (5.8 days), twenty-four workers using a Hitachi 450 excavator, four bulldozers including a Cat D8, four front-end loaders and three rock trucks removed 100,000 tons of snow from the highway (Fig. 4). The highway closure lasted more than 12 days.

5. THREAT TO PEOPLE AND PROPERTY

Both the Damalanche discovered at the AKDOT crew shift change at 6:00 AM January 24th and a fuel tanker trapped between two avalanche deposits at Milepost 39.5 predicated the closure of the highway. The river began backing up and by that afternoon public officials prepared for a flash-flood rapid breech of the avalanche dam.

The Snowslide Gulch avalanche path is five miles (8km) upstream of the Alpine Woods subdivision and two miles (3km) downstream of the Heiden View subdivision. The Lowe River constricts through Keystone Canyon for three miles (5km), flowing under three bridges, then fanning out into a braided glacier riverbed floodplain on which the Alpine Woods subdivision is built.

After aerial surveillance, Valdez disaster managers began notifying downstream residents that a voluntary evacuation was in affect and the City opened an emergency shelter for those who decided to leave their homes.

With police knocking on each door on three successive evenings from January 24th-26th informing people of the situation and voluntary evacuation, many residents felt panicked and were concerned for the well being of their families and property. With the flood of October 2006 a fresh memory, many feared a breach of the avalanche dam could swiftly flood the valley. The City installed a camera and 24-hour surveillance to monitor the flow.

Fig. 5: Old highway tunnel allowing drainage

Fortunately, the water found a hydraulic pathway in the old highway tunnel. The tunnel had not been used since the 1970's when bridges replaced it as the road was upgraded for the construction of the 800-

mile (1300km) oil pipeline (Fig. 5). The upstream tunnel entrance had been buried by decades of mass wasting. It was also deeply buried by Damalanche debris.

After the water level behind the avalanche dam began dropping January 27th, flow input roughly equaled flow output. The flash flood advisory was canceled January 30th, seven days after the initial threat of flooding was perceived.

The melting of the snowpack caused by both rain and the unseasonably elevated freezing levels exacerbated the runoff that backed up behind the Damalanche. At it's maximum, the impounded lake flooded 139 acres (56 ha) with almost a thousand million gallons of floodwaters (850,000,000 gal) or 2,628 acre-feet (3,250,000 m3) (Fig. 6: Quantum Spatial, 2014). Using peak and maximum discharge equations one could compare the potential for outburst flooding with the actual flooding that occurred during the '100 year event' in October 2006. These comparative studies are future projects.

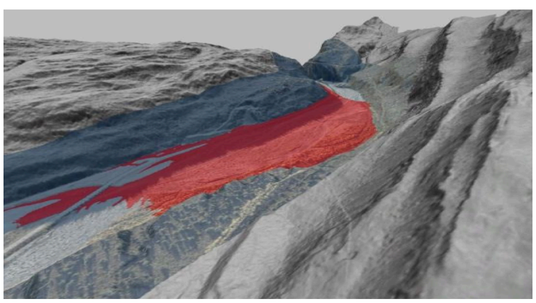

Fig. 6: LiDAR estimations of lake impounded behind the Damalanche (Quantum Spatial).

While the threat of flooding had ceased, the town of Valdez was still isolated due to the highway blockage. No traffic passed in or out for almost two weeks. The town of 4000 residents missed truck deliveries to the only grocery store. Concerned residents stockpiled many consumables in fear that the closure could cause a food shortage.

Even while some media reports portrayed Valdez as a stranded community in dire need, these concerns were alleviated by the addition of increased air flight and ferry service to the community. The City implemented action-plans that facilitated normal community operations and ensured safety to residents. After initial scenes of hoarding and fear, the grocery store re-stocked shelves by barge. The highway re-opened February 5.

5.1 Highway closure complications

Closing a highway is no small undertaking. Once the decision is made to close a section of highway for avalanche concerns, crews must sweep the corridor making sure members of the public are clear of the closed section. As with any mountain road in winter, driving conditions usually deteriorate as avalanche danger increases. Clearing stuck semi-trucks and private vehicles can take precious time. Having two communities and a number of lodges and heli-ski operations within the avalanche area also complicates Thompson Pass closures. Using four road closure gates at Mileposts 12, 16, 19 and 46, highways maintenance crews managed closures according to which avalanche paths were threatening the highway.

After the road was closed, a strange story unfolded the next day while AKDOT avalanche mitigation was underway:
A man and woman with a sick cat removed the highway closure gates and, when stopped by a deposit, attempted to hike the cat to a veterinarian in Valdez forty-six miles away. They were spotted crossing over avalanche debris piles, subsequently halting artillery and helicopter avalanche work. They were flown to Valdez where they were arrested and spent a night incarcerated, inflaming public opinion beyond Alaska.

6. SUMMARY

When the skies cleared February 1st, the Chugach Mountains surrounding Valdez and Prince William Sound looked like a war zone. The vistas included numerous fracture lines thousands of feet long. Large avalanches gouged to bare ground, leaving brown streaks down many of the mountains. The wet debris piles licked the valley floors like frozen dragon tongues stretching far and wide. Large amounts of forest were broken and cleared by moving snow and dirt. With prolonged above-freezing temperatures more indicative of spring, and unprecedented amounts of precipitation falling on a winter snowpack, this January avalanche cycle was a unique historical event.

This event influenced snow stability for the remainder of the season. The crust that froze and remained in the snowpack acted as a bed surface and facet farm. Many avalanches, human triggered and natural, peeled down to this significant crust/facet combination well into April.

The Damalanche became a summer attraction for tourist and locals alike. Avalanche debris remained in the valley floor throughout the summer (Fig. 7).

Fig. 7: Remains of the Damalanche August 4, 2014.

7. ACKNOWLEDGEMENTS

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