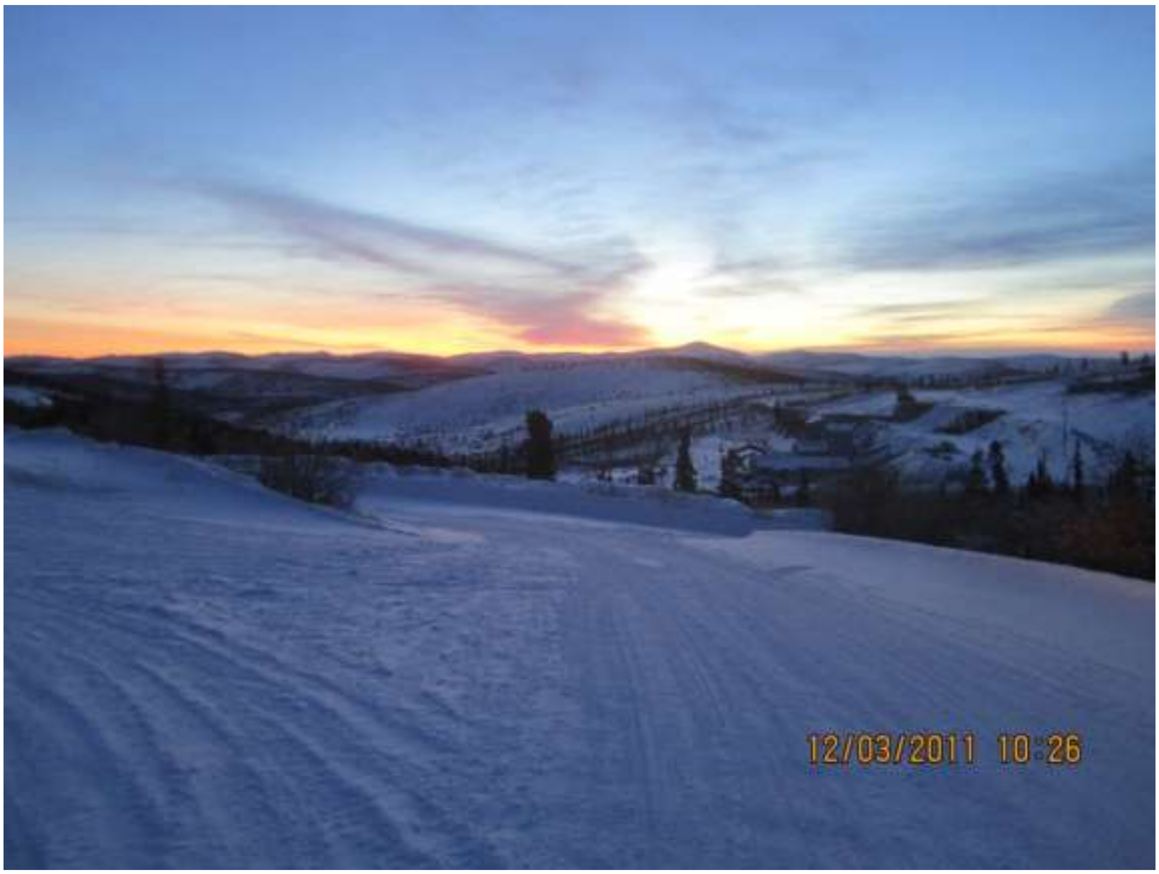
Government of Yukon
Energy Mines and Resources
Assessment and Abandoned Mines

Glaciation Assessment and Remediation

Of The Dome Creek Diversion Channel

At the Mount Nansen Site



December 12, 2011

E Nyland, P.Eng.

Synthesis

Glaciation of the Dome Creek Diversion Channel at the Mount Nansen Site could potentially result in excess water in the settling pond and damage to the existing bridge across the channel. Surface flows were caused by cold temperatures early in the year freezing the channel full depth. This document describes attempts to re-establish a subsurface flow to avoid repetitive excavation of ice.

Project Discussion

Yukon Government manages Care and Maintenance for the Mount Nansen abandoned mine site located approximately 64 km directly west of Carmacks Yukon. The site has been publicly managed since 1999 when the receiver for the bankrupt mining company abandoned the site to Canada.

In late November of 2011 the care and maintenance contractor at the site, Graceland Construction, contacted Yukon Government to advise of a potentially problematic glaciation along the Dome Creek diversion channel. The situation could become difficult if the level of the ice continues to rise and cause water to be released to the tailings pond and / or is allowed to come in contact with the bridge across the diversion channel. Yukon Government contacted Boreal Engineering for assistance with a solution to the problem.

Erik Nyland, P.Eng of Boreal Engineering arrived at the Mount Nansen site on Friday December 2 at approximately 10:30 AM. Already on site were Josee Perron and Jeff Moore from the Assessment and Abandoned Mines (AAM) branch of Energy Mines and Resources, Yukon Government.

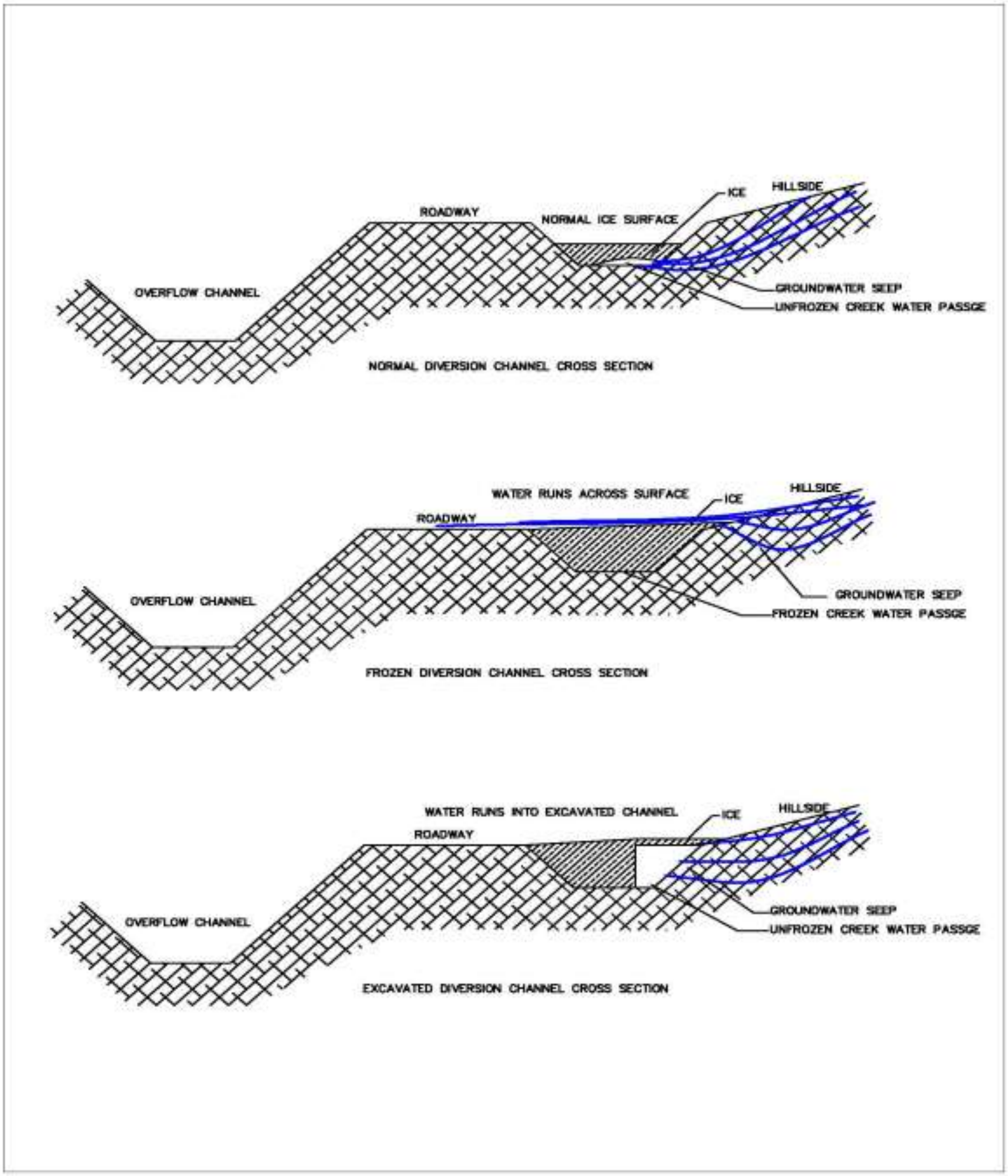
The issue was assessed to be a build-up of ice along the surface of the creek alignment. Some water had spilled over the diversion channel and was expanding along the road surface next to the channel and approaching the tailings pond. Ice had also built up to a level some 30 cm below the bottom of the bridge beams. If left unattended the situation would result in water and ice entering the tailings pond, resulting in extra water treatment and / or pumping costs. A second result would be that the ice could reach the level of the bridge, completely blocking the channel and resulting in significant effort and expense to remove the ice off of and out from under the bridge to allow an open channel in the spring.

It appeared that ground water was not able to travel through the normal creek channels due to the channel being frozen full depth, and thus the water was forced to be released along the surface of the existing ice. The Care and Maintenance contractor representative on site advised that this was an issue he had never seen in 12 years of his experience. His opinion was that early cold weather and minimal snow cover had resulted in a fully frozen channel.

The common solution for the problem is to completely excavate the ice from the channel to make room for more ice to form. This is a repetitive process depending on the amount of water being released, can be expensive over the course of the winter. The repeated excavations will almost certainly result in damage to the liner and banks of the diversion channel. Due to the time of year it was expected that the water would simply freeze in place rather than create a second free flowing path. A second consideration was that very little snow had fallen that would have otherwise provided some insulation for the channel.

An innovative solution is to excavate a narrow channel in the existing ice down to the bottom of the channel, or as close as is easily done, and allow the new channel to fill with water. It was expected that the new channel would form an insulating ice crust on the surface and maintain a flow path underneath for the water to travel. In this manner the existing ice would provide some measure of insulation and the flow would be restricted to the narrower channel resulting in higher velocity of water along the flow path and thus less freezing potential. The procedure is complicated by the slope of the channel, requiring the channel to be blocked at intervals to ensure a sufficient depth of water that allows an ice layer to form at the surface. Deeper water would result in thicker surficial ice layer in the new channel and would decrease the likelihood of freezing. A further complication is due to the groundwater currently flowing over the existing ice, which results in the necessity of excavating up to the uphill edge of the channel to allow the groundwater to develop new flow paths downwards into the newly excavated channel.

The first excavation was carried out downstream of the bridge to allow the water to escape while creating a channel under the bridge. In order to cut a channel under the bridge, several methods were considered including steam, cold water flow, drilling, heat trace, removal and replacement of bridge, and hand excavation using picks, shovels and a chainsaw. The hand excavation method was chosen which although labour intensive and uncomfortable due to water and cold temperatures, worked fairly well and was necessary due to lack of other available equipment. A 320 CAT size excavator as well as a D7G crawler operated by the Care and Maintenance Contractor excavated the narrow trench elsewhere in the diversion channel.


ROADWAY
NORMAL ICE SURFACE
ICE
HILLSIDE
OVERFLOW CHANNEL
GROUNDWATER SEEP
UNFROZEN CREEK WATER PASSGE
NORMAL DIVERSION CHANNEL CROSS SECTION
WATER RUNS ACROSS SURFACE
ICE
HILLSIDE
ROADWAY
OVERFLOW CHANNEL
GROUNDWATER SEEP
FROZEN CREEK WATER PASSGE
FROZEN DIVERSION CHANNEL CROSS SECTION
WATER RUNS INTO EXCAVATED CHANNEL
ICE
HILLSIDE
ROADWAY
OVERFLOW CHANNEL
GROUNDWATER SEEP
UNFROZEN CREEK WATER PASSGE
EXCAVATED DIVERSION CHANNEL CROSS SECTION

Excavation was completed in about 8 hours of work and resulted in a trench with a smallest depth of water of approximately 50 cm. At the end of the day an ice crust approximately 2.5 cm thick had formed in those areas which had been excavated first, and water was flowing continuously.

<u>Concerns and Resolutions:</u>

Directly below the bridge flow is exposed to the cold air due to the steep grade of the channel. If the flow is to freeze from the bottom, causing the water to flow on top of the ice, further glaciation will develop. If the flow is monitored and the build-up is excavated before backing up under the bridge it may redevelop a sub-surface channel.

Water depth is governed by the height of the snow dams constructed in three locations along the excavated channel. Water that is warm will erode the snow dams resulting in a loss of depth of flow. Once eroded it will be difficult to replace the dams with ice and a substitute will need to be found (gravel, plywood, tarp, etc). Reduction in water depth could result in formation of shell ice and a safety hazard. In this case the area should be delineated and warnings signs posted.

The diversion channel flow appears to consist of sub-surface exfiltration from the nearby hillside as well as some water from Dome Creek. Groundwater enters the channel at several locations along its length. Ice was excavated in these areas to allow the groundwater to re-enter the subsurface channel and form an insulating ice cover. If the groundwater flows into the channel at the surface further glaciation will develop, this should be excavated as soon as it becomes obvious. Due to the majority of the volume of water consisting of groundwater, if the volume of subsurface flow in the excavated channel is reduced the likelihood of the channel freezing is higher.

In those locations where the snow dam interrupts the flow, the water is exposed to the cold. If the weather was to turn very cold before an ice cover forms, these exposed areas may freeze and block the flow. This will force the subsurface flow to stop and the groundwater to flow over the ice resulting in further glaciation. This must be monitored and the snow dams removed immediately to allow subsurface flow to resume.

A period of warm weather may result in reduced surficial resistance to flow resulting in further surface flows. As the weather cools again the water flowing over the existing ice will freeze and cause further ice build-up. In this event the flow paths for the groundwater must be ensured to allow the groundwater to travel through the soil to access the channel under the ice. This may require further excavation.

<u>Results</u>

Further activity occurred at the site on December 8 with the onset of the predicted warm weather. The water resumed flow on the surface and began to cause further build-up on top of the previously deposited ice. Although this is not a danger upstream from the bridge as long as the level of the ice did not reach the top of the berm and allow water/ice into the settling pond, a build-up close to the bridge could cause damage to the bridge and abutments during freshet. The water had started flowing near the bridge and could potentially make contact with the bridge beams.

The ice was excavated (using the tracked excavator) immediately up stream of the bridge to allow surface water to flow into the previously excavated channel under the bridge. That channel appeared to have closed somewhat due to the reduced volume from water flowing over the surface. The channel under the bridge was re-excavated and deepened using a steamer and a heat trace was installed to maintain the channel.

Three further channels were excavated to the bank at the source of the surface flows to encourage the water to travel under the ice to the previously excavated diversion. These short channels appeared to work well in the previously developed areas; there just were not enough of them to handle all of the water source locations.

Warm weather was predicted for the next seven days so it was likely that the water would continue to flow over the surface and cause further glaciation. To prevent the water from causing a build-up near the bridge three snow dams were constructed across the surface of the ice in the diversion channel in order to prevent the water from travelling to the bridge. These dams will work if the weather is somewhat cold however in unseasonably warm weather the water will just flow around or through them.

Recommendations

The site should be monitored to ensure that:

- the ice build-up does not approach the bottom of the bridge beams;
- the heat trace remains in place under the bridge and keeps the channel open;
- the ice build-up does not reach the top of the berm of the diversion channel to allow water into the settling pond; and,
- the lower channel downstream of the bridge does not acquire a large enough ice build-up to cause a back flow or blockage of the channel resulting in further surface flow.

Warning signs should be posted to inform of thin or shell ice.

Weekly site visits are recommended until the situation stabilizes.

Erik Nyland, P.Eng.
Boreal Engineering Ltd

Update; December 15, 2011

Water quality and flow monitoring activities necessitating excavations through the ice caused further surface flow (estimated to be 3-4 L/s) due to the release of pressure under the ice layer. Water had been constrained by the sealing effect of the ice and restrictions to flow in the subsurface channel. If the surface flow were allowed to continue unabated there was a concern that subsurface flow would be reduced and significant surface build-up of ice would result. The area of the up-welling water was then excavated and connected to the spur trench through which the water had previously been passing. Excavation of the area resulted in a higher flow observed (estimated at 6 to 8 L/s). The trench was bermed to increase hydrostatic head on the subsurface water passage and potentially increase flow. Water flow did not appear to be slowing; however it was obvious that a portion of the water flowing from the recently excavated trench headwater was significantly less than that released as surface flow. It was concluded that a portion was dissipating through the subsurface passage.

Photo 1 - Surface Flow

Photo 2 - Increased flow from excavation activities

Photo 3 - Increased surface flow caused by trench excavated from upper left corner of picture

Further to release from the trench the water flowed on top of the ice to the next spur trench. In an attempt to reduce the flow and perhaps allow some water to be released under the ice, a hole was excavated into that spur trench. This resulted in a further release as the spur trench was under some hydrostatic pressure.

Several snow dams were placed across the ice on the diversion channel to intercept and slow water flow.

During the site visit it was observed that more water was entering the channel from the south east at the head of the channel near the confluence of two drainage ditches. While the volume of the water was not large it was travelling along the edge of a drainage channel at a higher elevation held in place by an ice build-up at the ice / snow interface, causing ice build-up on the road. Flows are very small and prevention of build-up may be difficult which will likely require machine excavation if it persists.

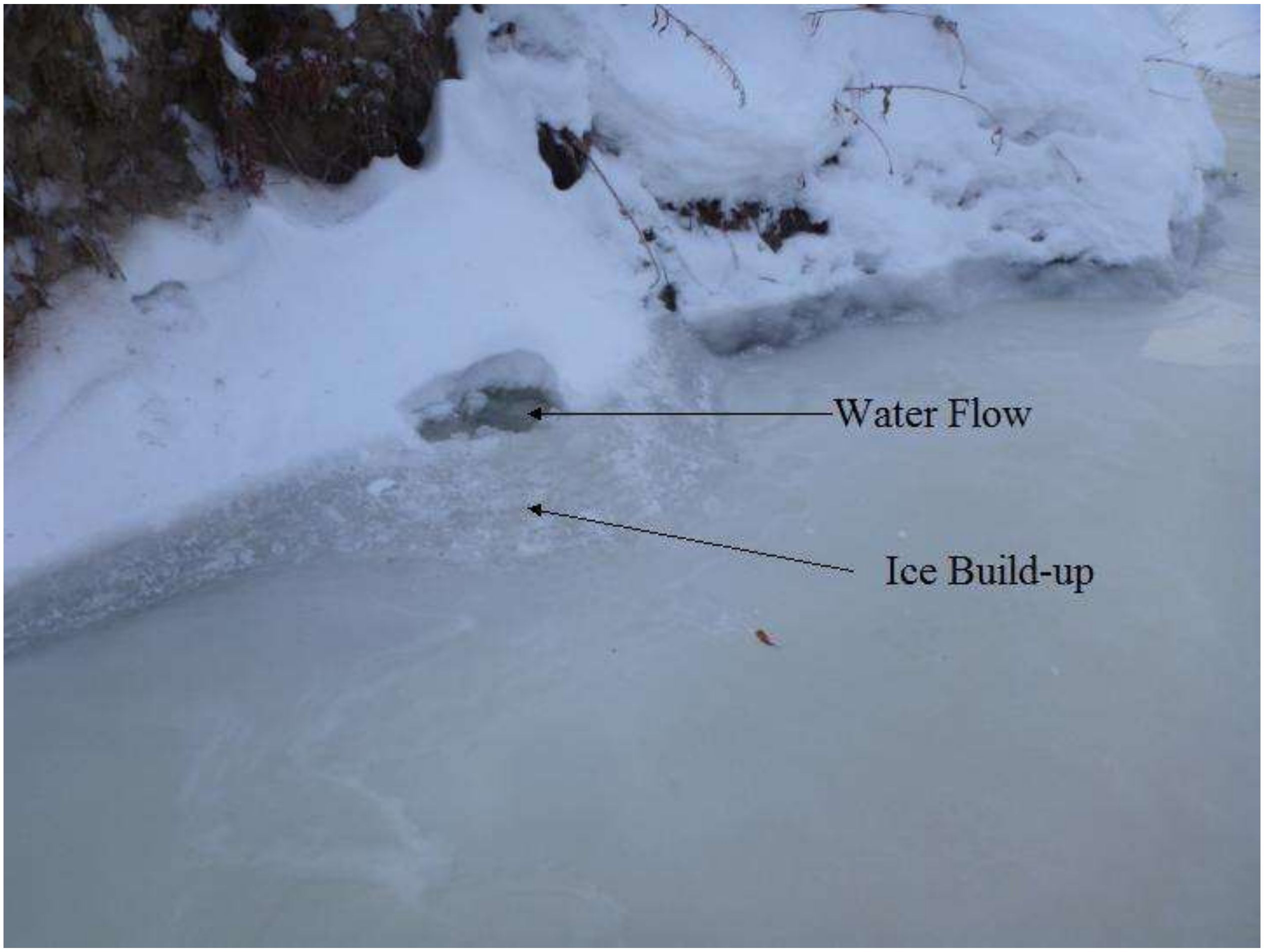


Photo 4 - Water flow along the edge of the drainage channel

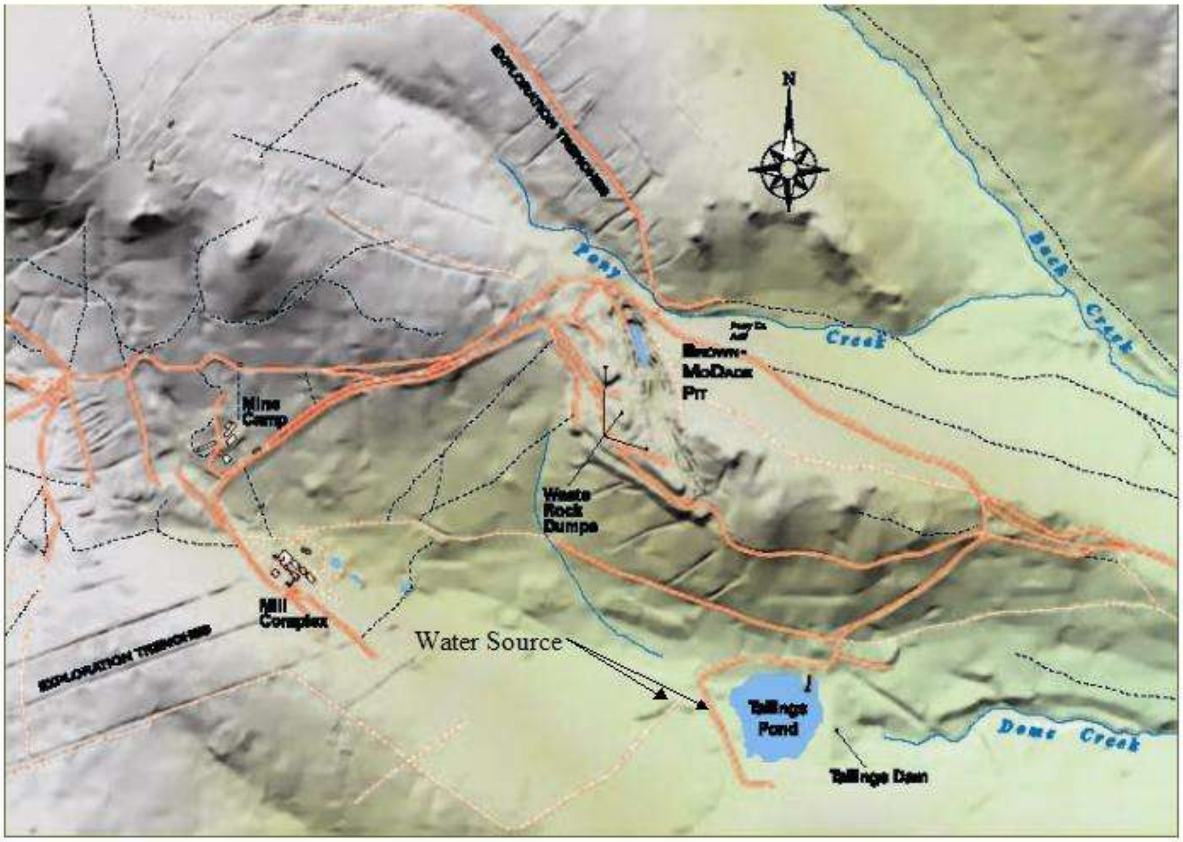


Photo 5 - Water source from drainage channel

A telephone conversation with the site operator the following day advised that the top of the recently released surface water had frozen and sealed off the flow. He felt that the situation had stabilized and unless the weather turned warm it would remain that way. The snow dams had blocked some of the flow and the water had not travelled to the bridge.

<u>On December 20</u> the situation appeared stable with a few noteworthy observations:

Flow was still apparent from the drainage channels along the south east edge of the diversion channel and had spread out onto the road somewhat further than previous as illustrated in photo 6.

Photo 6 - Ice on road near drainage channel. Note the height of the ice along the snow bank.

Although the inflow at Dome Creek had sealed with a frozen cover, a significant amount of water could be heard flowing under the ice. The noise was loud enough to believe that the flow had not abated in any appreciable amounts and may have actually increased. The flow could not be observed because it was occurring below the ice crust and if disturbed it may have resulted in further ice build-up on surface.

Several areas on the surface of the ice were observed that had been forced upwards, presumably by the subsurface hydrostatic pressure. The ice had developed a bulge and cracked radially from the center of the bulge as depicted by photos 7 and 8.

Photo 7 - Bulging ice showing radial tension cracks

Photo 8 - Bulging ice showing radial tension cracks

Water seemed to be flowing well under the bridge; however some outflow was occurring at the location where the heat trace descends through the ice. Pressure within the channel was higher than the upper level of the ice resulting in water moving through the hole melted by the heat trace. The Site Operator was asked to wrap some insulation around the heat trace to prevent it from thawing the ice in that location, or to excavate a trench in the ice and lay the heat trace and the extension cord in the trench so that only the power cord was penetrating the surface rather than the warm part of the heat trace. Should the water flow from the hole for an extended period further ice build-up under the bridge would result. In this case a steamer would be an efficient method of removal.

That portion of the channel directly below the bridge had seen extensive build-up where the water is released from the trench and evaporated to the atmosphere (Photo 9). A concern is that the ice will continue to build-up and prevent the water from escaping the trench to the diversion channel downstream. For this reason the Site Operator has been instructed to excavate that material from the channel to allow the water to flow. This will need to be done regularly over the winter.

Photo 9 - Ice build-up downstream of bridge. Note the large volume of excavated ice on the left.

<u>Recommendations</u>

Monitor daily the situation with those considerations previously indicated.

Update: December 27, 2011

Warm weather over the past week has caused some further surface flow originating from the north (uphill) bank, and approximately half way along the channel. This flow has migrated across the channel and surfaced on the road in the low spots which had previously been used to access the channel. Machinery had been crossing the snow bank to access the channel and as a result reduced the effectiveness of the snow bank as a barrier to flow. The front end loader on site was used to carry snow to these locations and build up the bank.

Photo 10 – Snow bank built up to reduce flow from channel onto road

Very little flow was observed from the uphill side of the channel, although when it does appear it is generally from a new location. This may be because the hydraulic gradient of the subsurface waters is decreasing due to restricted flows through the channel in the diversion.

Photo 11 – New flow from the uphill bank, minor volume.

The majority of the diversion channel is frozen on the surface at this time. Flow can be heard at the upper end and water is coming out of the lower end of the channel. The heat trace under the bridge appears to be working and keeping a channel open.

The lower end of the channel is experiencing significant ice build-up and will need to be excavated within the next week, particularly if the temperatures drop. If the ice is allowed to build up there is a chance that it will block the sub-surface flow and result in forcing the water to the surface. This has been discussed with the care and maintenance operator and he has agreed to monitor the build-up and remove the ice once it reaches an agreed upon thickness.

Update: January 2, 2012

Significant amounts of water had been released onto the surface of the channel over the last few days which resulted in a build-up of ice directly upstream of, and underneath, the bridge. Ice had built up to the point that the lower flange of the upstream side bridge beam was covered with ice. The ice by itself is not likely to damage the bridge however the indirect results of the ice could have drastic consequences for the structure. Of specific concern is the cause of the overflow, whether the channel under the ice had closed off to prevent the water from moving or for another reason.

Photo 12- Ice build-up to bridge beams

If the ice is allowed to remain in place and a second overflow event occurs, water passage will be blocked at the bridge. This will result in an ice build-up to the level of the deck of the bridge which will result in significant lateral forces during spring freshet and any melting event. Also another concern of importance will be the water movement during spring freshet, as the water will either run around the bridge causing erosion of the abutments or will find a passage over the diversion channel berm, which could erode the berm resulting in a loss of the diversion channel.

One potential reason for the assumed blockade was that the outlet from the channel had frozen to result in a backup of the water and an increase in channel hydraulic pressure near the bridge. The site Care and Maintenance Operator was asked to excavate the channel below the bridge starting from the outlet. The channel was found to be frozen throughout the area downstream of the bridge.

Photo 13 - Dry channel below bridge

The excavator then excavated a channel on the upstream side of the bridge. Approximately 100 m of channel was excavated, to the point where water began to flow again. This water was released from under the ice and contributed a significant flow to the excavated channel. Water travelled down the recently excavated channel to flow around and over the ice under the bridge. Sufficient room was available for the water to pass under. A further passage existed in the previous channel where the heat trace prevented freezing.

Due to the danger of the channel freezing again and the excessive build-up of ice under the bridge it was determined that all of the ice needed to be excavated from the entire channel as well as from under the bridge. This would prevent the channel from overtopping or damaging the bridge during freshet.

Update: January 7, 2012

Deadman Creek Enterprises through Boreal Engineering Ltd provided a D8N CAT Dozer and an EC290 LC Volvo Excavator to clean out the diversion channel. Both of the machines were transported to the Mount Nansen site on low-bed truck after the appropriate permits (wide-load permit and bridge crossing permit) were in place.

Photo 14 - D8N on low bed trailer crossing bridge

Conditions of the permits required that the machines be transported across the bailey bridge at km 30 on the Mount Nansen Road. The machines were hauled as far as Dome Creek (km 57) before the condition of the road due to icing was such that further transport by truck was not possible. The machines were unloaded at that point and the dozer was used to remove the ice along the road while the excavator was walked over to the diversion channel area for excavation. After cleaning the road to allow traffic to pass the dozer got stuck after breaking through the ice in the diversion channel and could not climb out up the steep sides. There was an estimated 2m of water in channel at that point.

EBA Engineering Consultants personnel Kisa Elmer was on site to monitor ice excavation. She is concerned about the rip rap in the channel but unsure of where the rip rap is located along the channel.

The Volvo excavator had no problem excavating the ice, whereas the care and maintenance operator's machine was not able to remove it without the CAT dozer ripping it first. That evening, the channel ice was removed upstream of the bridge as far as the pipes across the channel and effort was resumed again the next morning.

Photo 15 - Excavation of channel ice

Due to the size of the excavator it could not reach under the bridge and the ice was not removed other than to a straight up and down "wall" on either side of the bridge (Photo 16).

Denison Environmental Services arrived on site the morning of January 8 with four people and two vehicles. They immediately began steaming the ice from under the bridge and were able to create a small channel through the ice by that evening. They decided to stay overnight to allow the flow to subside, which would make ice removal easier in the morning.

Photo 16 - Ice removal to form a straight wall

During clearing operations, the dozer got stuck in the diversion channel and the blade and ripper were used to hold it up out of the water (Photo 17). After the water level subsided on the afternoon of January 8 the excavator broke the ice out from around the dozer and pushed enough under the machine to allow it to climb out of the channel. The machine lifted itself using its blade and ripper so that the excavator operator was able to push ice under the machine.

Excavation continued that afternoon until approximately 7:00 pm, when the machines were stopped due to nightfall and to allow the operators to return to Whitehorse for fuel and other consumables. A significant portion of the channel ice was removed and the project was completed on Tuesday, January 10.

Denison Environmental Services was unable to steam more than a small channel through the ice underneath the bridge. The crew worked in the morning on January 9 and had to return to Faro to attend other duties.

Photo 17 - Dozer stuck in channel with blade and ripper holding it up out of the water

Update: January 15, 2012

Boreal Engineering provided two people to remove ice from under the bridge. Three methods of ice removal were proposed, it was felt that at least one of them would prove satisfactory for the task.

- A small Kubota excavator was transported to site by pickup on a trailer. It was expected that the small excavator would be able to reach under the bridge to remove the ice.
- Two chainsaws were provided to cut the ice and remove it by hand. The small excavator would then be used to move the ice out of the channel and deposit on the bank nearby.

- A steamer trailer was brought to the site to melt a channel through the ice. Although this would be a slow and cold task it was felt that if other methods failed that removal of the ice could be accomplished using this method, although it may take several days.

The excavator proved to be a limited success as it could not reach in as far as halfway across the bridge. The ice on the upstream side of the bridge was too thin to support the machine and the water too deep causing it to get stuck in the channel, therefore making excavation from that side unlikely.

The chainsaws proved to be the most feasible method; although labour intensive it provided the most success in the shortest time. The ice was cut into blocks and broken using a heavy bar or a pick. The blocks would then be carried or rolled by hand out to where the small excavator could reach them. This procedure took place through the Friday afternoon and all of Saturday, January 14.

Photo 18 - Excavation complete with heat trace installed on bottom of the channel.

After the channel was excavated a new heat trace was installed on the bottom of the channel to ensure that a part of the channel would remain open. This had been done previously however the trace was hit by an excavator bucket rendering it useless.

It is expected that the channel will need regular excavation over the rest of the winter season. Timing will depend on the temperatures and amount of water draining through the channel.

All equipment is on site (excavator, dozer, steamer) for each excavation, with the operators ready to mobilize within 24 hours' notice.

Update: February 17, 2012

During the previous week the channel above the bridge and close to the location of the pipes crossing had frozen and caused a stoppage of flow. Randy Clarkson of New Era Engineering and Deadman Creek (DMC) Enterprises had excavated the ice from that location up to the curve near the entrance of Dome Creek. It was noticed that the level of the ice was at the same elevation of the road some 100m upstream of the entrance of Dome Creek, allowing surface water to flow over the road. This was a cause for concern because the water would eventually erode the surface and compromise the road / berm. The DMC crew attempted to excavate the ice from the channel in that area but had encountered significant amounts of water below the ice, resulting in the excavator getting stuck and requiring assistance. Another excavator was utilised to drain the water allowing the DMC machine to get unstuck. For further information refer to the February 14 Incident / Near Miss Investigation – Boreal Engineering Ltd.

On February 17 excavation of that section of the channel near the overflow area continued. Ice was removed to the location where the water had flowed across the road and beyond by approximately 25 m and was pushed to one side by the dozer. Excavation of the ice took some 6 hours using the EC 290 Volvo Excavator and the D8N Dozer to push the excavated ice away from the excavator. The ice was pushed toward the settling pond, which will eventually result in that amount of water entering the pond. Dean Hassard of Deadman Creek Enterprises advised that EBA Engineering Consultants personnel had authorized the placement.

Photo 19 - Excavation upstream of Diversion Channel

Following completion of the excavation, a channel was further cleared at the entrance to Dome Creek in an attempt to drain that section of the creek above the entry point. Some water was encountered however not as much as was expected. There was some concern on the part of the excavator operator that the ice would not support the machine so he did not excavate further.

Photo 20 - Excavation at the entrance to Dome Creek

The pipes crossing the channel were removed since there was some concern that the pipes were contributing to the channel freezing in that location sooner than other areas of the channel. During the removal of the pipes it became apparent that the wire crossing with the pipes was live, as indicated by the sparks when the cable broke. The sparks tripped a breaker in the nearby power control building rendering the line safe to handle. The breaker was then turned off. For further information refer to the February 17 Incident / Near Miss Investigation – Boreal Engineering Ltd.

Clearance under the bridge remains at a comfortable height with more than a meter clearance at this time. A portion of ice remains under the south end of the bridge, of which a part was removed this day using a chainsaw to cut the ice as well as a bar, pick and shovel to break it loose and remove it. Approximately 1.5 hours was spent on this work before other duties demanded attention.

There is a concern that subsurface water is building pressure within the wetlands of Dome Creek, resulting in storage of water volume. During freshet this volume of water may release slowly with no damage to channel or associated structures, however a disturbance to the channel may result in a sudden release and high flow for a short period.

Further site visits took place on February 22, February 26 and March 1, 2012. Significant amounts of free water have been flowing down the channel causing some build-up, particularly at the lower end near the outfall. Although sufficient room exists under the bridge, and freeboard to the road elevation, the ice should be excavated within the next 2 weeks. Spring weather with warm days could potentially cause a surge in water flow during the day and cooler temperatures at night which will result in ice build-up.

Photo 21 - Clearance between the ice and the beams of the bridge

At the March 1 site visit approximately 0.75 m clearance existed between the ice and the beams of the bridge. Warm daytime weather has been allowing water to leave the channel without freezing, slowing ice build-up.

Excavation of the ice should commence from the very lowest part of the outfall and continue to the bridge, and as close to the bridge as feasible without risking damage to the structure or deck. Excavation at the upstream side of the bridge should be restarted, again as close as reasonable without causing damage, excavating to the bottom of the channel continuing to the upper extents. After the ice is removed from the channel a significant block of ice will remain under the bridge. BEL will supply tarps and a "Master Heater" to thaw the ice. The tarps will be laid over the bridge and down both sides to keep the heat in, and place the heater so that it blows warm air directly under the bridge. This will thaw the ice and remove it in a much safer manner than a chainsaw and labour. It must be recognized however that the previous method was successful.

Photo 21 - March 1 Ice build-up at bridge

Update: March 11, 2012

Significant ice build-up both under the bridge and throughout the lower end of the channel required that the ice be removed. Excavation began on Saturday March 10 and continued through to March 11. The CAT 324D Excavator belonging to Boreal Engineering had no problems to excavate the ice with no CAT ripping assistance. The D6R dozer was to push the ice away from the excavation however a hose broke on the dozer while it was coming to the site and it was broken down until a new hose could be purchased, likely Monday. Ice was stacked alongside the excavation and will be pushed away to make room for the next time the ice is removed.

Photo 22 - Lower diversion channel with ice stacked on either side.

Depth of ice excavated was between 1.0 m to 2.5 m. The ice was removed down to original ground as far as the downstream side of the bridge and as close as possible to the bridge. The ice was then removed up to approximately 30 m upstream of the bridge. At that point water began to flow into the excavated channel so the machine work was stopped. The concern was that if too much water flowed into the channel it would fill the channel and possible overflow the ice under the bridge, making ice removal under the bridge very difficult. A small channel under the ice, created by the previously installed heat trace, was allowing the water to pass however flow was intermittent, possibly due to ice blockage of the passage.

Photo 23 - Upstream of bridge showing water in channel

Due to the amount of labour required to physically remove the ice under the bridge by manual methods, it was determined that master heaters to thaw the ice should be used instead. The bridge has been wrapped with a large tarpaulin and 2 heaters have been installed. A2x6 m plywood bridge was temporarily installed across the channel to support the heaters above the bottom of the stream bed. The concern is that if a large amount of water were to be released the heaters would remain above the flow. Initial results are encouraging as the heaters were able to melt a large volume in a fairly short time. Maintenance crews on site will refuel the heaters as required and monitor the progress until the ice is gone.

Photo 24 - Heater installation under the bridge

During excavation it was noted that the bed of the channel did not maintain a consistent grade or alignment. This results in pooling of water throughout the length of the excavated channel. If the channel was originally constructed to an engineered standard it can be speculated that this may be due to degradation of permafrost under the channel. To avoid icing issues in the future the channel should be graded for consistent drainage.

Update: March 20, 2012

Prior to ice removal the tarps, heaters and associated materials were removed from beneath the bridge. The concern is that in the event of a surge of water the materials and heaters could be damaged by the water. All items removed were placed along the bank of the channel in easy access locations for re use.

Ice was excavated out of the diversion channel to the confluence of Dome Creek. Significant ice build-up demanded extra work to remove it. Ice was placed on the uphill side in locations where practicable; otherwise ice was placed on the road and pushed to the edge of the settling pond with the dozer.

Water was flowing under the bridge through the thawed space left by the heat trace wires, which had been plugged during the ice thawing process. No large volumes of water were encountered during the excavation other than several small pockets of discoloured flow indicating that it had been resting in one location for a period of time. A channel was excavated up into the Dome Creek wetlands, however no large flows were encountered there either. It is expected that more trenches will be required in a different location to drain the backed up water.

Highways Maintenance personnel were at Dome Creek along the Mount Nansen Road on March 18 to steam the culvert. They were not able to locate the culvert and after several hours of searching they left the site and told the Boreal Engineering crew that they would return the next day. They returned on March 19 and were able to locate the culvert but were not able to clear it to allow water to flow.

Update: March 25, 2012

Priority for ice removal on March 23 was the lower end of the channel and some 50 m above the bridge. The intention was to ensure that the ice did not build further under the bridge causing more work to remove it. Significant ice growth had occurred during the previous two weeks when it was last excavated.

Photo 25 - Ice build-up in channel below bridge Mar 23

Ice was removed from the outfall of the creek to approximately 50 m upstream of the bridge. Water was flowing under the ice below the bridge, preventing build-up.

Excavation continued above the Dome Creek confluence on March 25 with the excavator placing ice on the berm / road in preparation to push it off toward the settling pond.

Highways Maintenance personnel were able to open the culvert at Dome Creek crossing on March 22, allowing the trapped water to flow. An exodus of water resulted in a settling of ice above the road by approximately 1 to 1.5 meters.

Photo 26 - Dome Creek at Mount Nansen Road showing relaxed ice March 23.

Update: April 23, 2012

During the period of March 23 to April 23 further effort has been made to ensure that the channel remains free of ice during the spring thaw period. The intention is to ensure that no opportunity exists for the water to backup and either allow overflow over the berm or to increase hydraulic head pressure which could assist any sub-surface that may occur.

Excavation of ice from the channel occurred on an ongoing basis during the period, with ice removal occurring as soon as any build-up was observed.

Previous ice melting efforts combined with the heat trace under the bridge ensured that a constant passage remained open.

At this time the channel is free of ice for the most part although the areas which are not exposed to the sun in early morning have ice along the edge.

Photo 27 - Channel is free flowing and generally free of ice at water level

At this time the water is flowing freely under the bridge and the channel remains open. Some ice does remain within the channel and under the bridge however it is not considered a problem. This ice will thaw and disappear over the next several weeks.

Photo 28 - Ice remaining under the bridge.

Due to the warming weather it is not expected that ice build-up will be a problem from this point on. It is recommended that once weather warms and freezing at night does not occur that the heat trace be removed from the channel along with the electrical supply cord.

Recommendations

Inconsistent grade and width of the channel bottom causes a variation in the velocity of the water flow which is one reason that the channel experiences icing problems. If the water were to be maintained at a constant velocity and in a very narrow channel the likelihood of freezing would be significantly reduced. A survey would provide information to allow an estimate of the work required to re-grade the channel. This may require a realignment of the channel through the upper portions of the diversion channel and near the confluence of Dome Creek.

During the cold weather it was observed through listening for water movement that some flow was occurring near the entrance point of Dome Creek into the channel, however there was no flow observed at the outfall. Several possibilities exist to explain this including subsurface flow within the channel alignment, a build-up of water within the catchment or a possibility of piping under the channel berm. There was no way to measure or even estimate the flow due to the ice cover, however the location suggested that the water was not being stored within the catchment. It is possible that the water was flowing subsurface however in that case the water could flow in any direction once below the seasonally active frost layer but more likely to flow down the phreatic surface gradient. This should be investigated further.

Further observation shows that the surface of the berm has settled in some locations, with the subsidence appearing to be extending into the channel. Settlement of this type within the area of disturbance and current activity could possibly be due to drainage of previously frozen soils. Sub surface ice lenses that are common within permafrost may melt and result in surficial settlement.

Photo 29 - Slide showing settlement area including the widened channel and slow moving water directly adjacent

A historical review of the channel through acquisition of as-built drawings should be undertaken to determine the physical shape when constructed. A current topographical survey would be useful to compare the existing condition of the berm with as-builts to determine the manner in which the berm and channel have changed since initial construction. In the event that the area is surveyed, the surveyor should be instructed to capture the area including the toe of the berm within the tailings pond to approximately 50m uphill from the channel. In this manner if reconstruction is done the survey will include all of the topographical information required for preliminary design.

The entire berm should be drilled to acquire soils information below the berm. Samples should be taken at approximately 1m depth intervals plus at any changes in soil conditions. Drilling should be completed at approximately 15m intervals and to a depth of a minimum of 10m. Particular care should be taken to ensure that the areas of settlement are investigated. Furthermore, some investigation of soils on the uphill side of the channel should be undertaken to gain an understanding of the permafrost and soils conditions in that area. This information will be important in the event of reconstruction.

Should the soils investigation determine that thawing of the permafrost has caused subsidence at the surface and is potentially resulting in subsurface flow, further investigation will become necessary. This is beyond the scope of this discussion and should be undertaken following the initial investigation. Piezometer data collected from the various test wells located near the tailings pond will also provide some insight into the changes in permafrost when analyzed over a period of time.

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