CHAPTER 3.0
DESIGN AND CONSTRUCTION
OF WINTER ICE ROADS
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3.1 Purpose of Design

The purpose of designing a winter road is to provide road parameters (thickness, width, etc.), which protect the terrain; and, aid equipment operators during construction by giving them a more concise idea of what they are trying to achieve in the field. Normally, all that is required is a few typical sketches, as shown opposite. In general, what is required on a winter road is 10 cm of compacted snow over the highest hummocks along the right-of-way. Drawings of typical snowfills, culverts installations and temporary bridge installations at creek crossings should also be provided.

3.2 Choosing the Right Winter Road for the Job

Of the numerous types of winter roads discussed earlier, the GNWT winter roads are generally tending towards compacted snow roads and winter trails. When mineral soil and organics are mixed with snow windrows at the side of the right-of-way, some unnecessary terrain disturbance is occurring. In low snowfall years this is to be expected, but when there is lots of snow pushed off to both sides in windrows, the snow should be used more effectively. More of the snow should be compacted on the right-of-way and this would better protect the terrain and eliminate the mineral soil and organics that are mixed with the snow. It is recognized that this is more easily said than done, because there is a fine line in compacting snow that will strengthen under traffic as compared to being destroyed by traffic. The following section hopefully will help you to understand why certain things must be done as well as when they should be done in order to achieve the best results.
There is a fine line in compacting snow that will strengthen under traffic as compared to being destroyed.
3.3 Tasks Involved in Constructing the Winter Road

On new rights-of-way, clearing of the right-of-way will be required. **Clearing activities should be Limited to winter after the ground is well frozen.** This ensures most trees will break off at ground level without uprooting and destroying the vegetative mat when hit with a blade about 1 m above the ground. **Slash should be pushed to the edge of the right-of-way leaving a break between it and the natural forest.** Breaks in the slash windrow should be placed every 50 m or so as wildlife crossings. Slash windrows should be tramped to reduce the volume. It is also important to ensure that slash materials are not left where they may enter into any watercourse.

Leaving the start of construction of winter roads too late into winter is not often the best thing to do. **Particularly in high snowfall years, providing ice covers are thick enough to get lightweight vehicles across, there are advantages in tramping the snow to bring down its insulating effect.** This ensures the ground will freeze to a good depth prior to heavier equipment being necessary to remove the snow for example. Another advantage of doing this is to provide a better base on which to build up the snow road. The ideal time to do this tramping is when the temperatures are above normal. The warmer the snow, the higher its moisture content, and the better compaction and freezing if compacted at higher temperature. If snow is compacted near the melting point, nearly solid ice will result after cold temperatures resume. If snow were compacted in place on the right-of-way there would be less of it to windrow later on. Another way of stating this is that a given machine effort would be much better utilized in compacting the snow in place on the right-of-way rather than in removing it later. Another disadvantage of not beginning earlier is that by January, temperatures are so low and persistently cold that there will be very little free moisture in the snow. This makes compaction very difficult, if not in some cases virtually impossible, as in the High Arctic and Arctic Islands.

Generally winter road construction should get under way when there is a minimum of 20 cm of snow. Tramping is effective even if there is only 5 to 10 cm. To achieve 10 cm of compacted snow over the highest hummocks, obviously more than 20 cm of snowfall would be required - at least 30 cm or more. In some areas, and in some years there may not be enough snow to do this.

In the cases where there is not enough snow, all you can do is try to make the best use of the little snow that is available. This generally means the road will be rough. In critical locations, water can be sprinkled or hosed onto the road to build up a smoother running surface. Also, chipped ice or ice aggregate can be used to produce a level surface. However, use of water or ice aggregate and water over long segments of road would become prohibitively costly under normal circumstances.
Tramping Early Snow With Light-Weight Tracked Vehicles Will Compact The Snow And Induce Frost Penetration.

Too Much Snow Can Be Winged Off The Winter Road By Grader To Be Brought Back On Later And Compacted.
When there is too much snow, snow can be pushed off the road forming windrows along each side. Once a solid base is achieved, snow can be bladed-in by grader from the side windrows and used to fill depressions with drags and/or graders.

Major construction such as installation of a permanent bridge and cutting the grades of the valley slope such as has been completed at Seagrams Creek is not normally associated with winter roads. In fact, the procedure used is much more similar to permanent road construction and because of this, environmental guidelines and erosion control measures should be similar to those for permanent trail or access road construction. The reader is referred to "Environmental Operating Guidelines: Access Roads and Trails" published by DIAND (1990) and Environmental Guidelines For Access Roads and Water Crossings, Ministry of Natural Resources, Ontario. Some of the guidelines contained therein are repeated as part of the following sections.

3.4 Environmental Implications and Mitigative Measures

Given that the initial planning has been completed diligently, there are very few environmental impacts resulting from winter road construction if construction is done properly. Although winter roads are an alternative to all-weather roads that may reduce environmental impacts, when they are being built over ice-rich soils it is important to use terrain-protective construction equipment. That is, low ground pressure vehicles with balloon tires or wide-track crawler tractors may be warranted. Also, it is more important here not to disturb the surface materials, remove or compress the organic insulating layer, and to ensure a minimum thickness of compacted snow covers the highest hummocks. Mushroom shoes on bladed vehicles can also be a protective measure for the terrain.

Winter roads can be considered an mitigative measure in themselves for protecting the terrain against the wear and tear caused by wheeled vehicles. To provide this protection with winter roads, the compacted snow over the highest hummocks should be at least 10 cm thick and the low portions filled sufficiently to provide an acceptable road surface with respect to smoothness. In low snowfall years, attaining such standards may be impossible. In such cases, the little snow that is available must be used to best advantage. Mitigative measures to be considered in low snowfall years are the use of water to spray or hose onto the roadway to build up a protective thickness of ice; the use of chipped ice or ice aggregate consolidated with water; and, collection of snow from snow collection areas or lakes and rivers.

Another means of mitigating the condition of low snowfall is to continually work toward upgrading the right-of-way so that a minimal amount of snow is required. For example, in Manitoba removal of boulders and rock outcrops has been undertaken for years. This reduces the amount of snow required on the right-of-way to build an acceptable winter road because the high points have been reduced by their removal. Likewise in severe
Too Little Snow Can Be Alleviated By The Use Of Ice Aggregate For Special Purposes.

Less Snow Is Required If High Spots Such As Small Rock Outcrops Are Removed By Blasting.
cases of rough terrain, there are cases where a permanent road grade has been built up so as to reduce or eliminate the need for snow as a fill material. However, if blasting is required for the removal of boulders and rock outcrops it should not be carried out within 15 metres of any water body that is not frozen to the bottom unless a Fisheries Authorization is obtained from DFO.

The environmental implications of building permanent bridges or culverts are many and more related to permanent road construction than normal winter road construction. Discussion on building permanent bridges or culverts follows under Design and Construction of River Crossings. In constructing cut back slopes at V-shaped valleys to improve grades, site lines and winter road construction, again the work is closer to permanent road construction than winter road construction. The greatest difference is that on winter road rights-of-way the work would normally be done in winter because access in summer would in most cases be impossible. However, because the environmental consequences of winter construction could be as serious in the following summer as summer construction, environmental guidelines of summer construction would be applicable. Two major problems could arise from cutting back slopes at V-shaped valleys: encountering ground ice; and, inducing erosion and sediment transport to the water body.

Any major work such as cutting back slopes and major excavation should be preceded by an extensive drilling program. A drilling program will identify what soils will be encountered during the work, so erosion potential can be determined prior to opening up the slope. More importantly, drilling will identify the likelihood of encountering ground ice and the possibility of initiating thermal erosion. If ground ice were encountered, one option would be to expose it, allow it to melt and drain the following summer, but under supervision and with mitigative measures in place to control sediment from reaching the river. By exposing it late in the winter, and completing the work early in the following winter road season, use of the right-of-way may not be lost.

During excavation of earth materials to flatten slopes in V-shaped valleys at the river and on the approaches, materials should be excavated uphill, or away from the river. For instance, at the river a backhoe should be used to pull material away from the river rather than having a bulldozer pushing material along and into the river or stream. Also, excavated materials should be pulled back up the hill as much as possible to keep loose material away from water. Grading of the slopes, installation of a herring bone pattern of drains to carry drainage water into the forest mat, and a revegetation program preferably with fast-root-taking local varieties as early as possible in the spring following construction should be undertaken. Otherwise, severe problems with erosion and sediment should be anticipated.

Eight principles of erosion and sediment control, which can be used as mitigative measures, have been identified (Ministry of Natural Resources, Ontario, 1988):
Major Work Such As Cutting Back Slopes At Creeks Should Be Proceeded By An Extensive Drilling Program.

Seeding With Fast-Root-Taking Local Varieties Early In The Spring Following Construction Should Be Undertaken To Achieve Successful Revegetation As Shown.
o Fit the road to the terrain. This means avoid erodible soil sites; follow the ground contours as much as possible; and, do not construct deeper fills and cuts than the road standard requires.

o Minimize the duration of soil exposure. Complete the grading operation and revegetate as soon as possible.

o Retain existing vegetation where feasible. Grub only where construction will take place. Re-establishment of comparable ground coverage after construction can take a long time.

o Grade disturbed soil to a stable slope. A slope, which is too steep to be stable, will be unable to satisfactorily establish a vegetative cover until it has eroded back to a stable slope.

o Encourage re-vegetation. Re-vegetation will occur naturally if the slope is stable, but can be encouraged by leaving some organic material mixed in the upper-most soil layer; and, by seed or fertilizer treatments.

o Divert runoff away from exposed soil. Runoff collected along the disturbed right-of-way should be diverted to an outlet or into the forest mat off the right-of-way. The frequency of outlets should be designed to fit the ground slope involved and often will result in a "herring bone" drainage pattern.

o Keep runoff velocities low to minimize the energy of flowing water. Keeping the ditch slopes mild can induce low velocities; lining erodible ditch bottoms with vegetation, riprap or brush; and, using check dams in ditch bottoms. Sizing the ditches to correspond with the area to be drained will tend to keep the ditch itself from eroding.

o Trap sediment before it can cause damage. Some erosion during construction is unavoidable, but it is desirable to trap sediment on land before it reaches the aquatic environment. Diverting flow onto the forest floor adjacent to the right-of-way is the most common method, where the sediment particles are filtered out through the surface vegetation and litter. Placement of a brush barrier made with slash debris on the lower slope area can also create a filter. Or, a silt fence made of geotextile fabric will pass the water through but retain the silt and sand. Sediment traps can also be made by excavating a depression downstream of the sediment source that will pond water so suspended soil can settle out. Granular material can also be used to fill gullies and slow erosion.

The reason it is so important to control erosion is that it leads to sedimentation, and possible destruction of fishery resources and habitat. In addition, it can decrease
Diverting Run-Off Away From Exposed Soil And Onto The Forest Mat Aids In Preventing Erosion And Sedimentation.

Excavating Sediment Tramps And Diverting The Effluent To The Forest Mat Is Even More Effective.
water quality through increased suspended solids and introduce other substances such as heavy metals, including mercury. Eroded soils carried into streams, rivers or lakes are often deposited on the bottom, which can cover and destroy fish eggs and spawning areas, or more generally degrade fish habitat.

3.5 **Summary of Environmental Guidelines for Design and Construction of Winter Roads**

- Clearing activities should be limited to winter after the ground is well frozen.
- Slash should be pushed to the edge of the right-of-way leaving a break between and the natural forest.
- Breaks in the slash windrow should be placed every 50 m or so as wildlife crossings.
- Slash windrows should tramped to reduce the volume.
- Provide design sketches to machine operators so as to give them a better idea of what they are trying to build.
- Consider starting winter road construction much earlier in the year by compacting the snow on the right-of-way soon after significant snowfalls, first with snowmobiles and later with lightweight wide-track vehicles. By building up this base of snow, drags and blades used later will tend to cut and fill compacted snow rather than the mineral soil or organics. It must be recognized starting earlier is only practical where ice thicknesses are sufficient to permit crossing of lakes, rivers or streams.
- Another advantage of starting construction earlier is that roads could be closed earlier in the spring when most environmental damage from winter roads occurs.
- Tramping the snow should begin as early as possible as soon as there is about 10 cm of snow on the right-of-way.
- In low snowfall years, a rough road may be inevitable, but options are to use water sprayed or hosed onto the roadway to build-up a protective thickness of ice; use chipped ice or ice aggregate consolidated with water to fill low spots; and, collect snow from snow collection areas or lakes and rivers to use as fill.

The environmental implications of cutting back slopes at V-shaped valleys are many and more related to permanent road construction than normal winter road construction.
Clearing Activities Limited To Winter, As This One Is, Are Best

Small Boulders Or Log Dams Will Act As Good Sediment Traps To Manage Surface Runoff Or Drainage Ditches.
However, because these construction activities have been incorporated into the winter road system in the NWT, some environmental guidelines that pertain are given below:

- An extensive drilling program should precede any major work similar to cutting back slopes at major creeks or rivers.

- During excavation of earth materials to flatten slopes in V-shaped valleys at the river and on the approaches, materials should be excavated uphill, or away from the river.

- Grading of the slopes, installation of a herringbone pattern of drains to carry drainage water into the forest mat, and a revegetation program preferably with fast-root-taking local varieties as early as possible in the spring following construction should be undertaken.

- Know the eight principles of erosion and sediment control:
  - Fit the road to the terrain;
  - Minimize the duration of soil exposure;
  - Retain existing vegetation where feasible;
  - Grade disturbed soil to a stable slope;
  - Encourage re-vegetation;
  - Divert runoff away from exposed soil;
  - Keep runoff velocities low; and,
  - Trap sediment before it can cause damage.