ALASKA DIVISION OF GEOLOGICAL &
GEOPHYSICAL SURVEYS

INTERPRETED GEOLOGICAL CONSTRAINTS CHART

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SHEET 1 OF 25

CONSTRAINT: PERMAFROST, THERMOKARST SUBSIDENCE AND FROST ACTION

DESCRIPTION OF HAZARD

Permafrost is frozen ground that does not completely thaw each year. In permafrost areas, the layer of ground that freezes each winter and thaws each summer, called the active layer, varies in thickness according to moisture content. Generally the thickness is from $\frac{1}{2}$ to 1 foot in wet organic sediments and up to 6 to 9 feet in well drained gravels. The ice content of the permafrost and thickness of the active layer has the most important effect on land use.

The most ubiquitous and unique geologic hazard in NWRMPA results from the thawing of ice-rich permafrost. This thawing promotes a loss of bearing strength, high mositure content and subsidence of the ground. Removal of the insulating vegetation blanket by forest fire or man allows the ground to absorb more solar heat, and as the ground ice melts, the ground surface settles or caves. Thermokarst subsidence requires the presence of large ground ice masses (ice-rich permafrost) near the ground surface. Subsidence seldom occurs where ground ice is present only as a cement between sediment grains. On gentle slopes, groundwater circulation thaws ice and hydraulically enlarges cavities. Surface water is often diverted underground where it contributes to thawing and subterranean erosion. Evidence for this is seen in beaded drainages which consist of a series of small pools connected by short waterways. On horizontal surfaces this water forms shallow ponds and thaw lakes in depressions. The banks of these ponds and lakes continue to thaw from fluctuating water levels and waves, and hence the ponds grow in size until they drain. Thawing of ground ice occurs in the upper 15 feet. Construction of roads on ice-rich permafrost is a serious problem in Alaska. The best defense against this geologic hazard is location of roads to non-frozen areas of sand and gravel containing minimal ground ice. If these alternatives are not practical or economical, then placement of insulation between the gravel overlay and subgrade may reduce the problem. With few exceptions, all building and road construction in permafrost areas of the NWRMPA should include installation of a pad or gravel fill before consturction. Gravel is a good conductor of heat, and if thick enough (about 6 feet) will help contain seasonal freezing and thawing of the ground.

Frost action is also a serious hazard in NWRMPA. Thick organic silt deposits, long periods of freezing and poor drainage provide ideal conditions for frost action. In areas of permafrost on lower hillslopes and in creek valley bottoms where drainage is poor, frost action is intense in near surface silts. A major problem is frost heaving of structures supported by piles. When piles are used to prevent melting of the permafrost, it is often difficult to keep piles in place because of seasonal freezing of the ground. If piles are heaved, displacement may cause damage to the structure they support. Heaving increases as the seasonal frost layer thickens. Most heaving occurs during late winter. If the pile penetrates the underlying permafrost, the strong grip of the permafrost acts to hold it in place. Roads are subject to intense seasonal frost action particularly when the fill or subgrades contains a high percentage of silt. The best way to prevent frost action induced losses is to avoid construction on poorly drained, fine grained sediments. If construction on fine grained sediments is necessary, then improvements in surface and subsurface drainage and installation of a insulation blanket between the subgrade and fill will reduce the frost action problem. As for piles, they should be placed into permafrost to twice the depth of the seasonal frost layer.

Thermokarst due to melting of the permafrost and seasonal frost action in the active layer or silt laden areas are the two most critical hazards affecting construction engineering in the MWRMPA. A thorough and detailed study of permafrost, seasonal frost, and soil lithologies should be included in the planning of any engineering project in the NWRMPA.

TERRAIN UNITS AFFECTED BY HAZARD

Permafrost is prevalent almost everywhere in the NWRMPA, and all terrain units contain permafrost to varying degrees. Thermokarst subsidence results in the formation of Thaw Lake and Thaw Basin deposits (Ttl) and Beaded Drainage deposits (Tbd). Intense frost action results in the formation of Patterned Ground deposits (Ppg) and Pingo deposits (Pp).

CONSTRAINT: MASS-WASTING

DESCRIPTION OF HAZARD

Mass-wasting is the movement of regolith downslope by gravity. Several types of mass-wasting occur in the NWRMPA. Gelisolifluction is is the primary mass-wasting process occurring in NWRMPA. This process involves water-logged soil and other unsorted and saturated surficial material ranging in size from silt to gravel that is slowly flowing from higher to lower ground. Permafrost is critical to the gelisolifluction process. The permafrost table prevents downward movement of moisture and thereby promotes saturation of the overlying materials. Melting snow, rain, and thawing of seasonally frozen ground (active layer) provides the moisture. Gelisolifluction is strongly influenced by grain size, and thus where the process is occurring, inference to grain size can be made. The high porosity and permeability of good gravel and sand promote good drainage, and do no favor saturated flow. Silt, on the other hand, tends to remain wet longer, requires less moisture and is subject to flow because it lacks cohesion. If silt is lacking, gelisolifluction will not occur. The gelisolifluction process results in sheet, lobe, and benchlike landforms. Lobe and bench deposits can be as much as 15 feet thick. The average thickness is probably 3 - 5 feet. Gelisolifluction movement can vary from a fraction of an inch per year to as much as 1 - 2 feet per year. The average movement is 1 - 2 inches per year. The upper 1 - 2 feet of gelisolifluction deposits move the most. Although the gelisolifluction process is slow, development on these deposits can be hazardous. Building foundation engineering is more expensive and difficult in areas where this process is active. Roads frequently cut and sometimes overly these deposits in the NWRMPA. These roads require more maintenance in areas where this process is active.

Avalanches are another mass-wasting process present in NWRMPA. Avalanches are rapid movement of snow and/or rock debris down a slope. Avalanches are an alpine phenomena characteristic of steep slopes. Before development occurs in an alpine area, a detailed evaluation of avalanche prone slopes and areas should be done.

Rapid mechanical erosion and deposition in alpine environments is another mass-wasting process found in NWRMPA. Talus deposits and rock glaciers consist of coarse angular pebbles, cobbles, and boulders. A hazard associated with these deposits is they are subject to continued depositional growth and slow movement. As with avalanches, before development occurs in an alpine area, a detailed evaluation of talus covered slopes should be done.

TERRAIN UNITS AFFECTED BY HAZARD

Gelisolifluction deposits (Cgs) discussed above are the direct result of this gelisolifluction mass-wasting process. Talus deposits (Ct) and Rock Glacier deposits (Crg) result from alpine mechanical erosion and deposition. These three deposits are unstable, slowing moving, and hazardous to most development.

CONSTRAINT: ICING

DESCRIPTION OF HAZARD

In the winter, water reaching the ground surface from a river, spring, or well may freeze in successive irregular sheets, mounds, or encrustations until the ice is several feet thick and covers a large area along slopes and in valleys. Icings usually parallel the underlying ground surface, and unlike glacier ice, it is rarely deformed. Most icings melt in the summer and form again the following winter. Seepage icings form where ground water moves downslope, especially above the permafrost table. Icings are enhanced by cold air temperatures, thin early winter snow cover, seasonally frozen ground, and thick late winter snow cover. Stream icings form on floodplains where a shallow river breaks through its ice cover during freeze up. When freezing approaches the river bed, and there is a continual flow of water, hydrostatic pressure results in the river flowing on top of its ice cover.

Ground water seeps in the winter may be natural phenomenon or result from human activity such as in intercepting the groundwater table in roadcuts, or influencing the rate and depth of seasonal frost penetration by building and road construction. Ground water moving downslope under hydrostatic pressure is trapped between the thickening seasonal frost layer and underlying permafrost table. Unfrozen ground beneath a building or road provides an exit for the water as it seeps out and up through this unfrozen ground. Almost all seepages along roads are artificially induced as roadcuts intercept springs and seepages. In winter, frost penetration is more rapid beneath roads where snow is removed than beneath adjacent undisturbed areas where the vegetation and snow has not been removed. When seasonal frost moves downward and contacts the permafrost table, an ice dam is created. This dam can stop ground water moving downslope, thus causing it to crack the frozen ground and seep out at the surface due to hydrostatic pressure.

Stream icings occur where a stream or river freezes to the bottom and upstream water is backed up and breaks through ice fissures forming thin ice sheets downstream over the existing ice. On wide streams, icings may occur over thousands of acres. In the spring, icings are last to melt, and if snow melt increases streamflow during breakup, then some streams are diverted around the icings beyond the normal floodplain causing erosion of adjacent sediments, roads, buildings, etc.

Icings are a serious geologic hazard that must be dealt with annually. The cost of maintenance and property damage can be reduced in some areas where there is careful understanding of icings. Detailed development planning should involve persons familiar with this winter hazard.

TERRAIN UNITS AFFECTED BY HAZARD

All terrain units are affected by this hazard. See DGGS Report of Investigations 84-16 for 1:250,000 scale Icing maps of NWRMPA.

CONSTRAINT: SEISMICITY

DESCRIPTION OF HAZARD

NWRMPA is in the Central Alaska seismic zone. Approximately 10 percent of all Alaska earthquakes occur in this zone. Shallow earthquakes with a magnitude less than 6.0 primarily occur in this zone.

Earthquakes are one of our most damaging geologic hazards. Earthquakes result from the release of tremendous stresses which accumulates in rock most commonly from opposing crustal plate tectonic movements, or molten rock (magma) movement such as beneath a volcano. Most earthquakes result from rock rupture along pre-existing opposing fault planes. The sudden slip of rock along faults releases energy in the form of seismic waves which cause moving and shaking of the earth's crust near the fault.

Earthquakes are measured by physical parameters such as ground acceleration and velocity, duration of shaking, and interval between seismic waves. These parameters reflect the earthquake's intensity or magnitude. The direct or indirect effects caused by an earthquake are referred to as seismic effects and include ground displacements due to faulting, damage from ground shaking, ground failure due to lurching or movement, soil liquefaction, differential settlement, landsliding, and abnormal wave action in lakes or the ocean.

Potential for damage from an earthquake in any given area is dependent upon the actual energy released (magnitude and length of shaking), distance to source of energy release (hypocenter), local rock and soil characteristics for area, and vulnerability of man-made property to earthquake intensity. Most earthquake-induced damage to buildings, road, airfields, etc occurs on unconsolidated sediments. Foundation sediments fail easily and if water saturated, then differential subsidence caused by liquefaction can occur.

TERRAIN UNITS AFFECTED BY HAZARD

The faults shown on the 1:250,000 scale terrain unit maps were taken from existing data. It is unknown by this author as to whether the existing data is accurate in regards to the type of fault and exact location. Some of the faults may not have moved for hundreds of thousands of years, and would be considered seismically inactive and less of a hazard in generating an earthquake. Some undiscovered and unmapped faults that may have been seismically active within the last 100,000 years probably also occur in the NWRMPA. Fault traces or scapps occurring in any of the terrain units except bedrock (Bx and Bx-w) indicate geologically recent seismicity. This determination has to be made in the field, however, because faults shown on the terrain unit maps were mapped during previous bedrock geologic mapping programs, and even though faults are shown crossing terrain units other than bedrock, this does not mean they actually rupture the younger terrain units.

CONSTRAINT: FLOODING

DESCRIPTION OF HAZARD

Floods are natural and recurrent events. Streams periodically overflow their banks and inundate their natural floodplains. Floods become a problem and are costly when development occurs on a floodplain. Floodplains are usually accessible and profitable for development, so they become inhabited.

Flodoing occurs when the volume of water entering the stream channel exceeds the channel's carrying capacity. A typcial stream will overflow its banks and flood low areas of its floodplain about every 2 - 3 years. Greater floods occur at less frequent intervals, but generally affect greater areas. Spring breakup floods usually contain ice. Flooding can also occur in the spring in connection with icing dams (see Icings).

TERRAIN UNITS AFFECTED BY HAZARD

Most of the fluvial terrain units would be subject to this hazard. Those terrain units that will be frequently flooded are Floodplain deposits (Fp), Meander Floodplain deposits (Fpm), Meander Floodplain-Cover deposits (Fpm-c), Braided Floodplain deposits (Fpb), and Braided Floodplain-Cover deposits (Fpb-c). Those fluvial terrain units that are likely to be flooded are Abandoned Floodplain deposits (Fpa) and Alluvial Fan deposits (Ff). Fluvial terrain units that are least likely to be flooded are Fluvial Terrace deposits (Ft) and Old Fluvial Terrace deposits (Fto).

CONSTRAINT: STORM WAVES, TSUNAMIS AND SEA ICE

DESCRIPTION OF HAZARD

When storms approach land they usually produce large waves. The storm's size, path, speed, and configuration of the sea bottom and coastline determine how big the waves become. When waves strike shore, run-up and surge heights can be tremendous. These waves can result in flooding and pounding of natural beach deposits, artificial fill, and other man-made developments.

Tsunamis, or seismic sea waves are large ocean waves caused by earthquakes, submarine volcanic eruptions, or large submarine landslides. The waves form in groups having great length (100 miles or more) from crest-to-crest and long periods. As a Tsunami wave enters shallow water near coastal areas, the wave velocity diminishes and height increases. When the waves strike land they are measured in terms of run-up elevation above sea level. Wave crest heights can be over 100 feet as they begin to run up on land. The forces associated with Tsunamis are often so great that the only positive means of protection is to avoid areas subject to Tsunami impact.

Ice shove ridges are beach sediments and debris that become ploughed up by sea ice. These ridges tend to be located on unprotected low-lying capes exposed to strong currents and drifting sea ice. Sea ice may be pushed tens or hundreds of feet inland. Sea ice near Pt. Barrow was pushed 200 feet inland and nearly destroyed buildings. The forces associated with ploughing sea ice, like Tsunamis, is so great that the only positive means of protection is to avoid areas subject to ice shove impact.

TERRAIN UNITS AFFECTED BY HAZARD

Beach deposits (Mb) and Emerged Beach deposits (Mbe) are subject to the above hazards. Coastal Plain deposits (Mp) could also be subject to the above hazards.

NORTHWEST PROJECT

K. Krause 1986