GEOLOGIC AND HYDROGEOLOGIC INTERPRETATIONS OF HAINES JUNCTION, DESTRUCTION BAY, BURWASH LANDING AND CHAMPAGNE, YUKON TERRITORIES

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1.0 EXECUTIVE SUMMARY

Suitability maps at a scale of 1:20,000 for terrain in the immediate vicinities of Haines Junction, Destruction Bay, Burwash Landing and Champagne for road construction, building construction and installation of underground utilities, sewage lagoons and sanitary landfills, septic systems, and construction materials including granular materials are presented herein. In addition, unique Quaternary geologic features, potential for lake-side recreational development, and the ground water potential including quality, quantity, recharge and direction of ground water flow are briefly evaluated.

Five classifications are established to evaluate the suitability of terrain for a variety of purposes. These classifications are a comment upon the relative amount of terrain modification required to adapt terrain to a specific use or facility, upon the relative amount of effort required to maintain a use or facility, upon the amount of effort required to prevent physical disturbance and deterioration of the immediate environs from a specific use or facility, and upon the amount of preliminary investigations that might be required before a facility or use should be considered or completed. Terrain factors were established that allow any undisturbed terrain type's suitability to be classified in a northern environment frequently characterized by permafrost and periglacial processes. These factors included slope; drainage; flood hazard; permafrost and ice contents; hazards due to mass wastage, fault activity, glacier advance, etc.; bedrock depth; material composition and stoniness.

The suitability maps are to be used only as a guide to planning and development in that they outline the major problems and degrees of problems for specific utilization within an area. Site assessment may determine that a site may be more or less suitable for a specific purpose than is defined on the suitability maps for a complete area because of variability of the properties of terrain types, and limitations of accuracy of the terrain typing, terrain type characterization and suitability evaluation. Accuracy of the suitability maps is limited by the accuracy of the base data or terrain typing and the accuracy of characterizing terrain factors within terrain types.

The suitability for the purposes listed above and the ground water potential is controlled by the terrain types and surficial materials present at each community. Haines Junction lies in an area of discontinuous permafrost,and compact dense till overlain by a blanket of lacustrine silt and clay of variable thickness; areas of gravelly and sandy outwash are present to the north and alluvium is present along the Dezadeash River to the south.

Destruction Bay and Burwash Landing are in areas where streams originating in the Kluane Ranges have deposited alluvium in the form of alluvial-fans. The alluvium, which is primarily gravel at Burwash Landing and which is a mixture of clayey silt, sand, and gravel at Destruction Bay, overlies and abuts against till and outwash. Permafrost is present at both communities with taliks under water bodies and within certain alluvial landforms.

Champagne lies in a large glacial lake basin filled with varved clays and silts and bedded silty sands. This sequence is interupted by a ridge of gravel and sand and the Dezadeash River alluvium and pond deposits at Champagne. Sand dunes are also a common phenomena at Champagne.

2.0 OBJECTIVES

The objectives of this study are to prepare suitability maps at a scale of 1:20,000 of terrain in the immediate vicinities of Haines Junction, Destruction Bay, Burwash Landing and Champagne for road construction, building construction and installation of underground utilities, sewage lagoons and sanitary landfills, septic systems, and construction materials including granular materials; to indicate areas of unique Quaternary geologic features; and to indicate the ground water potential including quality, quantity, recharge and discharge areas, and direction of ground water flow within the communities.

The suitability maps are to be based on evaluations and interpretations of investigations of the surficial geology and landforms; discussions of ground water potential are to be based on an assessment of available and collected data.

The suitability maps and the hydrogeologic assessment are to be such that they can be used for urban and rural planning and development. This includes planning for provision of infrastructures for services and recreational facilities.

3.0 METHODOLOGY

3.1 Field Investigations

During the summer of 1979, field investigations were undertaken in the vicinities of the settlements to upgrade the knowledge of the surficial geology in their vicinity. The various properties of the terrain types present, i.e. slope, topography, bedrock depths, material grain-size distribution, compaction and permeability, permafrost and ground ice distribution, active layer thicknesses, water tables and drainage, peat thicknesses, presence of hazards, processes and features such as flooding, recent fault scarps, and liquefaction were noted where possible. Special emphasis was placed on identifying potential sources of granular materials, including an estimate of the quantity and quality of the sand and gravel in these sources. Samples of a number of typical materials and potential aggregates were collected for grain size analysis in order to assess their potential for a number of purposes.

At each community, interviews were carried out with a number of residents to help determine the number, depth, yield and water quality of abandoned and existing water wells. Eighteen ground water samples and six surface water samples were collected for chemical analysis (bicarbonate, sulphate and chloride anions; calcium, magnesium, sodium and potassium cations; nutrient and trace element concentrations).

3.2 Office Studies

Office studies involved the preparation of maps of the surficial geology of communities, and the preparation of suitability maps for road construction, building construction, sewage lagoons and sanitary landfills, and septic systems. This involved establishing five classifications for terrain suitability, defining the different states of seven critical terrain factors that affect the suitability of terrain for a specific purpose, and evaluating the suitability of terrain types for a purpose based on the defined guidelines.

All available data concerning the hydrology and granular materials for each community were collected and collated from government files, and together with data collected during this investigation were analyzed. Maps and a section of this report were then prepared to define and discuss the hydrology and ground water potential, and quantity and quality of granular materials for each community. Unique Quaternary features were identified and located at each community.

3.3 Suitability Maps

3.3.1 Classification

Five classifications have been established to evaluate the suitability of terrain types or areas for a variety of purposes. The classifications are GOOD, FAIRLY GOOD, FAIR (MARGINAL), POOR and UNSUITABLE (VERY POOR). These classifications are a comment upon the relative amount of terrain modification required to adapt terrain to a specific use or facility, upon the relative amount of effort required to maintain a use or facility, upon the amount of effort required to prevent physical disturbance and deterioration of the immediate environs from a specific use or facility, and upon the amount of preliminary investigations that might be required before a facility or use should be considered or completed. In essence, the costs required to successfully adapt an area to a specific purpose are relatively low for an area classified as GOOD, and progressively increases to a maximum cost for an area classified as UNSUITABLE (VERY POOR).

It should be noted that terrain factors such as material composition and characteristics, slopes, drainage, permafrost and ground ice distribution have some degree of variability in any terrain type. A suitability classification for a terrain type has to take into consideration and integrate the variability of the terrain factors. For example, an area classified as FAIR (MARGINAL) may have a terrain factor that makes the terrain type universally marginal for a specific purpose, or it may be that some of the terrain type could be classified as relatively GOOD for that purpose, but significant parts could only be classified as FAIR (MARGINAL) or POOR for that purpose.

A classification of GOOD indicates relative ease in adapting an area or terrain type to a specific use or in construction and maintenance of a specific facility. For example, road construction and maintenance on a gently-sloping well-drained unfrozen gravel outwash surface would require minimal costs and efforts relative to road construction on other terrain types.

A classification of FAIRLY GOOD indicates a minor problem or limitation that will slightly increase the effort and cost in adapting an area or terrain type to a specific use or facility. For example road construction and maintenance on a gently-sloping well-drained unfrozen bouldery gravel would require slightly more effort and cost, however minor, than on a gravel without boulders because of the necessity of removing the boulders.

A classification of FAIR (MARGINAL) indicates limitations are present within an area or terrain type that will require significant effort and cost in adapting the area or terrain type to a specific use or facility. For example, some preliminary investigations and special design, and extra efforts and costs will be required for road construction in an area of till underlain by permafrost with possible scattered areas having up to 0.5 m of high ice content.

A classification of POOR indicates limitations are present within an area or terrain type that will require much effort and cost in adapting the area or terrain type to the specific use or facility. For example, road construction in an area of flat till overlain by a blanket of peat will probably involve the expense of removing the peat from below the roadbed or some other mitigative measures.

A classification of UNSUITABLE (VERY POOR) indicates very severe limitations are present within an area or terrain type that are insurmountable or will require extraordinary effort and expense to adapt the area or terrain type to a specific use or facility. For example, road construction in an area where a thin veneer of peat overlies more than 5 m of clay having very high ice contents would require special design and expensive construction techniques to prevent deterioration of the permafrost from beneath the road bed and associated ditches. Continuous monitoring and maintenance would be required to prevent deterioration of the road and its surrounding environment.

In general, areas having a suitability classification of POOR or UNSUITABLE (VERY POOR) for a specific purpose should be avoided for that purpose where possible. Only where absolutely necessary, should the expensive required mitigative measures to allow adaption of the area probably be considered. However, neither classification excludes use of the terrain. Even the classification of UNSUITABLE or VERY POOR is only meant to imply that a particular purpose is impractical in a certain area or extraordinary effort and cost is required if the area is to be used for such a purpose.

3.3.2 Suitability Limitations - Terrain Factors

Terrain factors were established that allow any undisturbed terrain type's suitability to be classified in a northern environment frequently characterized by permafrost and periglacial processes. These factors included slope; drainage; flood hazard; permafrost and ice contents; hazards due to mass wastage, fault activity, glacier advance, etc.; bedrock depth; material composition and stoniness.

Guidelines were established to give the particular state of any individual terrain factor that would define a certain degree of suitability for a specific purpose. For example, in Table 4.3.3 slopes of less than 1.5 degrees are required for some areas within a terrain type for the slopes to be considered as

GOOD for sewage lagoons and sanitary landfills, and slopes of greater than 15 degrees throughout a terrain type indicate slopes that are UNSUITABLE (VERY POOR) for sewage lagoons and sanitary landfills. Intermediate distributions of slopes define intermediate suitabilities.

For evaluating the state of slope that dictates degree of suitability, degrees of slope were defined. However, the frequency and pattern of these slopes were also considered in terrain type classifications. For example, a flat area with a small discontinuous scarp within it would still be classified as GOOD on the basis of slope if flatness was required for a certain purpose.

Drainage was evaluated partly on the position of the water table throughout the year in unfrozen terrain, but mainly on the state of drainage of the ground surface and near-surface, (i.e. an evaluation of the amount of terrain where free water was present on the ground surface or in the near-surface; and/or of the amount of time during the year that free water was present on the ground surface or in the near-surface). This is particularly important in areas of permafrost as the water table, in the usual sense of the term, often lies below the base of the permafrost and is unrelated to the ground surface drainage.

Flood hazard was evaluated on the basis of estimated frequency of flooding of a terrain type. Some consideration was given to the severity of a flood within an area, e.g. water depths, scour, etc. in the final evaluation.

Permafrost was evaluated on its areal distribution within a terrain type. However some consideration was given to its depth and the thickness of the active layer that characterized a terrain type. Ice contents within the upper 2 to 4 m were considered as most critical in defining degree of suitability; however some consideration was given to ground ice distribution at greater depths.

In evaluating hazards, the following things were considered:

> the presence, occurrence or likely occurrence of such catastrophic mass wastage features as landslides, slope failures and rock falls; the occurrence or likely occurrence of geologic phenomena such as surface ruptures and earthquakes resulting from faulting, glacier advances and overriding, liquefaction of sediments caused by seismic activity, wind deflation and movement of silty and sandy sediment; periglacial phenomena such as frost creep, solifluction and nivation.

Flooding and phenomena directly related to permafrost and ground ice such as thermokarst and thaw-induced slope failures were not considered as they were evaluated in the flooding and permafrost ground ice factors.

Bedrock depth was evaluated on the actual depth to bedrock. Some consideration was given to the variability of the depth to bedrock or the ruggedness of its surface.

Material composition and stoniness was evaluated as a terrain factor on the basis that grain size distribution, compaction, organic content, and boulder and cobble content defined such parameters as permeability, workability, bearing capacity and susceptibility to frost penetration and heave; all characteristics considered important in the utilization of a terrain type for most purposes considered in this report.

3.3.3 Terrain Type Suitabilities

In constructing the suitability maps, the suitability of terrain types on the map of the surficial geology of the communities were evaluated (c.f. Appendix A).

In defining the terrain type suitability, all terrain factors are considered. The suitability of the terrain type is then defined by the terrain factor or factors having the relatively lowest degree of suitability. For example, if all terrain factors within a terrain type were GOOD or FAIRLY GOOD, except for drainage and flood hazard, which were POOR, the terrain type would have a suitability of POOR with drainage and flood hazard being the limiting factors.

3.3.4 Suitability Maps - Usage and Accuracy

The suitability maps, which show the suitability classification as defined in Section 3.3.1 and the limiting factors as defined in Section 3.3.2, have been derived by transposing the suitability and limiting factors of terrain types to areas mapped as those terrain types.

The suitability maps are to be used only as a guide to planning and development in that they outline the major problems and degrees of problems for specific utilization within an area. Site assessment may determine that a site may be more or less suitable for a specific purpose than is defined on the suitability maps for a complete area because of variability of the properties of terrain types, and limitations of accuracy of the terrain typing, terrain type characterization and suitability evaluation. However, the limiting factors do define problems that might be avoided by careful site selection or that could be relieved by mitigative measures that would allow development within reasonable effort and cost (the latter being defined by the necessity and return provided by the utility or use). For example, a main highway across an area classified as P - pf, mt (poor suitability due to permafrost and material composition) or U - pf, mt (unsuitable due to permafrost and material composition) would probably be undertaken after investigations determined where the most favourable geotechnical conditions were present in spite of costs, whereas a road to a cottage in a similar area would probably be considered impractical and too costly. The suitability maps do not negate the requirement for individual site investigations prior to utilization for many purposes. For example, investigations of materials, drainage, etc. would still be required for the installation of a sewage lagoon, even in an area classified as GOOD for that purpose.

The accuracy of the suitability maps is limited by the accuracy of the terrain typing, the accuracy of the chacterization of the terrain types and the degree to which the characterization applies to unique areas and sites within terrain types. The terrain typing was completed by air ground checking combined with air photo analysis and errors are inherent. However, even if the terrain typing is in error, the fact that the air photo patterns were similar enough to cause incorrect terrain typing indicates that some similarity in properties may be present and the suitability classification may be partly applicable.

The evaluations of suitability are subjective. Some errors in the degree of limitation imposed by a terrain factor on the suitability of a terrain type for a specific purpose is probable; but it is also probable that the error will only be relative. For example, imperfect drainage may define an area as being POOR for road building on maps in this report, whereas authorities in road construction may consider terrain marked by imperfect drainage as being FAIR (MARGINAL) or UNSUITABLE (VERY POOR) for road construction, but not probably GOOD or VERY GOOD. It is also probable that similar suitability classifications with different terrain limiting factors do not have equal environmental or economic implications. For example, terrain classified as FAIR because of permafrost and ground ice may be as difficult for road construction as terrain classified as FAIR because of shallow bedrock. The maps can still be used with the realization that the limiting factors are real, but the suitability is in error to a degree that can be redefined. However, it is beyond the scope of this report to make a cost analysis of all limiting factors for all specific uses.

4.0 HAINES JUNCTION

4.1 Geologic Setting

Haines Junction is located at the juncture of two large valleys; the Shakwak Trench, which runs parallel to the Alaska Highway northwest of Haines Junction and parallel to the Haines Road southeast of Haines Junction; and the Takhini Valley, which runs east toward Whitehorse. The geology and physiography of the sharp-crested Kluane Ranges southwest of the Shakwak Trench differ significantly from the dissected rolling upland surface of the Ruby and Dezadeash Ranges north and east of the Shakwak Trench. The valley bottom at Haines Junction is gently rolling with elevations between 590 m and 700 m. The valley bottom rises rapidly to over 750 m to the northwest and south. The Takhini Valley east of Haines Junction is gently rolling to flat and the axis is well below 700 m, even though the Dezadeash River, which drains this section, flows from the east and drains southwest through a gap in the Kluane Ranges.

At Haines Junction thick unconsolidated deposits are the result of deposition during several Pleistocene glacial and interglacial periods, and include till, outwash, glaciolacustrine silt and clay, and alluvial silt, sand and gravel. Most of the surface materials shown on Map 4.1 were deposited during the Kluane (Macauley) glaciation. During this glaciation large valley glaciers flowing northeast along the Shakwak Trench coalesced with a glacier flowing through the gap in the Kluane Ranges occupied by the Dezadeash River; this glacier then flowed northwest along the Shakwak Trench. East of Haines Junction this large glacier encountered another flowing west along the Takhini River; it is difficult to determine in which direction the net flow was, but some glacier flow was diverted north into the headwaters of Marshall Creek. As deglaciation proceeded from the northwest to southeast, drainage from the Kluane Ranges directly west of Haines

Junction was diverted along the northwest flank of the waning glacier and resulted in outwash being deposited north of Bear Creek and near Pine Lake. After further deglaciation a large lake, Glacial Lake Champagne, which formed because of the continued blockage of the Dezadeash River by glaciers to the south and blockage of other present-day drainage patterns to the east covered much of the Haines Junction area; its maximum elevation was between 748 m (2450 ft) and 762 m (2500 ft) as evidenced by beaches within this range of elevations. Following deglaciation of areas to the south, the Dezadeash River established its present drainage course and the present drainage system was established.

During Neoglacial time, the Alsek River into which the Dezadeash River flows has been periodically damed by a surging glacier to the south. Early advances between 3000 and 1000 years ago caused at least two, if not more lakes, to form in the area; the largest lake reached elevations of around 667 m (2200 ft). Between 350 and 500 years, a couple of lakes were formed whose maximum elevations were near 640 m (2100 ft). Around 250 years ago a lake was formed with a maximum elevation of 623 m (2040 ft) and between 75 and 150 years ago a lake with a maximum elevation of 595 m (1955 ft). The maximum elevations of these lakes are marked by beaches, wave-cut benches, and in the case of younger ones, strandlines composed of driftwood. In intervals during which these lakes were not present, the Dezadeash River continued to flow near its present level.

Periodically, since the Macauley glaciation parts of the Haines Junction area have been bare of vegetation because of deglaciation and submergence. During these intervals, the strong south winds blowing out of the Dezadeash River gap in the Kluane Ranges has deposited loess north of Bear Creek. Wind scour has also occurred on scarps having a southern aspect and has resulted in cliff-top dunes being formed. Marl in the Pine Lake basin

Table 4.1 Descriptive Legend of Terrain Types at Haines Junction

Terrain Type	Geomorphology, Slopes Drainage	Nature of Materials and Thickness	Permafrost, Ground Ice, Active Layer	Stability and Miscellaneous Engineering Characteristics	Potential Hazard
Rp, Rn	Glacially scoured bedrock; slopes vary from less than 5 degrees (Rp) to between 5 and 20 degrees with isolated steep scarps (Rn); well drained.	Pockets of thin drift and frost-heaved bedrock rubble present on bedrock.	Scattered pockets of permafrost may be present; ground ice contents low in drift; active layer 0.5-1.2 m.	Rock forms stable foundation; thawed drift generally good foundation material.	
Rs	Steep bedrock slopes and bedrock cliffs; slopes to greater than 60 degrees; well drained.	Isolated pockets of rubbly and blocky colluvium on bedrock.	Generally unfrozen with negligible ground ice content.		Rock falls.
aDv/Rn	Drift-veneered glacially scoured bedrock; slopes generally between 5 and 20 degrees; well drained.	Between 0.5 to 2.0 m of undifferentiated coarse-textured outwash and till; boulders common component.	Scattered pockets of permafrost with low ground ice contents; active layer 0.5-1.2 m.	Thawed sediment may be unstable foundation material if medium ground ice contents present.	
Db/Rn	Drift-blanketed glacially scoured bedrock; slopes generally less than 8 degrees; well drained.	Between 1.5 and 3 m of till and outwash; former probably dominant.	Permafrost unlikely.	Stable foundation material; till susceptible to frost heave.	
tMp; tMm	Morainic plain and undulating moraine; flat to gently sloping with few slopes to 10 degrees; well drained; few depressions imperfectly drained.	Between 3 and 10 m of till overlying interbedded clay, silt sand, gravel and till (the latter three dominant).	Generally unfrozen; nil to low ground ice contents.	Stable foundation material; till susceptible to frost heave.	
xLv/tMp ; xLv/tMm	Lacustrine-veneered morainic plain and undulating moraine; flat to gently sloping with few slopes to 10 degrees; well drained; few depressions imperfectly drained.	Between 0 and 1 m of undifferentiated clay, silt, sand, and gravel (rarely to 2.5 m) over 2 to 5 m of till over interbedded clay, silt, sand, gravel and till (sand dominant).	Permafrost unlikely.	Stable foundation material; fine textured sediments, especially silty clay, susceptible to frost heave; isolated small volumes of aggregate present.	

Table 4.1 Descriptive Legend of Terrain Types at Haines Junction (Cont'd)

f/mLb / tMm ; a/fLb / tMm	Lacustrine-blanketed undulating moraine including beaches and strandlines; flat to gently sloping with few slopes to 10 degrees; well drained; few depressions imperfectly drained.	Between 0 and 1 m of gravel and sand over 0 to 1 m of silty sand (a/f Lb) over till; or between 0 and 1 m of silt and silty sand over 0.5 to 2.0 m of clayey silt (f/m Lb) over till.	Permafrost generally absent except possibly in a few imperfectly drained areas; ground ice contents medium to high where permafrost present.	Stable foundation materials except clayey lacustrine sediments only fair; clayey silt highly susceptible to frost heave; isolated small volumes of aggregate present in coarser facies (a/fLb).	
xLb / tMn	Lacustrine-blanketed morainic plain; gently to moderately sloping with slopes to 12 degrees; moderately well to well drained.	Between 0.5 and 2.0 m of undifferentiated clay, silt, sand and gravel (clay and silt probably most dominant) over 2 to 5 m of till.	Permafrost present, but distribution and thickness not known. Ground ice contents generally low, but medium to high in clayey silt if frozen; active layer, 0.5-1.2 m.	Stable foundation materials except clayey lacustrine materials only fair, poor upon thawing; clayey silt highly susceptible to frost heave.	
aLv / tMb	Lacustrine-veneered moraine blanket; gentle to moderate slopes to 15 degrees; moderately well to well drained; few low areas imperfectly drained.	Between 0 and 2 m of sand and gravel over 1 to 4 m of till over bedrock.	Permafrost likely present on north-facing slopes and in low-lying imperfectly drained areas.	Generally stable foundation material; till susceptible to frost heave.	
aGm	Undulating outwash; gentle to moderate slopes to 12 degrees; well drained; few low areas moderately well to imperfectly drained.	More than 3 m of gravel and sand over interbedded clay, silt, sand and gravel.	Generally unfrozen; negligible ground ice contents.	Stable foundation material; source of aggregate.	
fEv / gGp	Outwash plain capped by wind-blown sand and silt; flat to gently sloping, few slopes to 10 degrees; well drained.	Between 0 and 0.5 m of silty sand over 5 m plus of gravel and sand; along clifftops fine sand and silt thicken to 4 m plus.	No permafrost.	Stable foundation material; outwash is source of aggregate.	Eolian deposits subject to deflation if disturbed.
xLv / aGp	Lacustrine-veneered outwash plain; flat to very gently sloping; well drained.	Between 0 and 0.5 m of silt, sand and fine gravel over 3 m plus of gravel and sand.	No permafrost.	Stable foundation material; outwash and lacustrine veneer are source of aggregate.	
aLv / aGb	Lacustrine-veneered outwash blanket; flat to very gently sloping; well drained.	Between 0.5 and 2 m of sand and gravel over 3 m plus of till; sand and gravel may be discontinuous.	No permafrost.	Stable foundation material; till susceptible to frost heave; possible source of aggregate.	

Table 4.1 Descriptive Legend of Terrain Types at Haines Junction (cont'd)

$\frac{aLb}{aGp}$	Lacustrine beaches eroded in scarp composed of outwash (lacustrine blanket on outwash); variable slopes from 0 to 30 degrees; well drained.	More than 10 m of sand and gravel present.	No permafrost.	Stable foundation material; source of aggregate.	
f/mLp, f/mLn, f/cLp, f/cLp	Lacustrine plain; flat to very gently sloping (f/cLp, f/mLp) to moderately sloping (f/mLn); occasionally modified by thermokarst (f/cLp); flatter areas imperfectly to moderately well drained; sloping areas moderately well drained.	Between 2 and 5 m of clay (c) and clayey silt (m) over interbedded till and gravel; upper part of silty clay contains interbeds of silt and silty sand (f).	Permafrost common in unit to depths of 10 m plus; ground ice contents frequently medium to high in upper 5 m; active layer 0.3 to 1.2 m.	Upon thawing silty clay poor foundation material; silty clay and till susceptible to frost heaving.	Subject to thermokarst subsidence if thermally modified.
f,oLp	Lacustrine plain; flat; imperfectly to moderately well drained.	Between 2 and 5 m of clay silt and fine sand (f) and marl (o) over interbedded till and gravel.	Permafrost continuous to 10 m plus except near Pine Lake; ground ice contents generally medium to high in upper 5 m; active layer 0.3 to 1.2 m.	Poor foundation material upon thawing; thawed sediment susceptible to frost heaving.	Subject to thermokarst subsidence if thermally modified.
$\frac{pOv}{fLb}$	Organic-veneered lacustrine blanket; flat to very gently sloping; imperfectly to poorly drained.	Between 0 and 1 m of peat and organic silt over 0.5 to 2 m of silt, clay and fine sand over till.	Irregular distribution of permafrost; medium to high ground ice contents possible in upper 2 m.	Poor foundation material; susceptible to frost heaving.	Minor thermokarst subsidence.
gAf, xAf	Alluvial-fan; gently sloping; moderately well to well drained.	More than 5 m of gravel (gAf) or interbedded silt, sand and gravel (xAf); occasionally having up to 0.5 m of silt and fine sand on surface.	Permafrost unlikely.	Good foundation material.	Some risk of flooding and stream avulsion.
fAf	Alluvial fan; gently sloping imperfectly drained.	More than 3 m of interbedded organic silt, silt and silty sand over sand and gravel.	Thin patches of permafrost possibly present; medium to high ground ice contents possible.	Poor foundation material; susceptible to frost heaving.	Risk of flooding.
$\frac{fLv}{gAf}$, $\frac{sLv}{gAf}$	Lacustrine-veneered alluvial fan; gently sloping; imperfectly to moderately well drained.	Between 0 and 1 m of sand or silty sand ($\frac{sLv}{gAf}$); or sand, silt and clay ($\frac{fLv}{gAf}$) over gravel	Permafrost unlikely.	Good foundation material; source of aggregate.	Some risk of flooding and stream avulsion.

Table 4.1 Descriptive Legend of Terrain Types at Haines Junction (con'd)

f/aAt	Stream terrace; flat; imperfectly to moderately well drained with few areas, poorly drained.	Between 0.5 and 1.5 m of silt and sandy silt over 3 m plus of sand and gravel.	Permafrost generally absent, but few patches of thin permafrost present with low to medium ground ice contents.	Fine grained sediments subject to frost heave; possible source of aggregate.	Rare flooding possible.
cLv/aAp, mLv/aAp	Lacustrine-veneered alluvial plain; flat (cLv/aAp) to gently or moderately sloping (Mlv/aAp); flat areas imperfectly to poorly drained; sloping areas moderately well to well drained.	Between 0.5 and 1.0 m of clay (c) and silt and sandy silt (m) over 3 m plus of sand gravel; few thin beds of peat in clay silt and silty sand; few gravelly beds.	Permafrost generally absent, but few patches of thin permafrost possible with low to medium ground ice contents.	Fine ground sediments subject to frost heave; improbable source of aggregate.	Very rare flooding possible.
cLb/aAp	Lacustrine-blanketed alluvial plain; flat to gently sloping; few areas moderately sloping; flat areas imperfectly to moderately well drained; sloping areas moderately well to well drained.	Between 0.5 and 2.0 m of clay and silty clay over 3 m plus of sand and gravel; few thin beds of peat in clay and silty clays; rare thin gravelly beds.	Permafrost generally absent, but few patches of thin permafrost possible with low to medium ground ice content.	Fine-grained sediment, poor foundation material and subject to frost heave.	Very rare flooding in low areas possible.
xAp	Alluvial plain; flat with few channels; moderately well drained; channels poorly drained.	Between 1 and 2 m plus of silty sand, sand and sandy gravel; boulders lag present under thin veneer of silt and clay in channels.	Permafrost unlikely.	Fair to good foundation material; finer-grained facies subject to frost heave.	Channels subject to flooding.
pOv/fAp	Peat-veneered alluvial plain; flat; poorly to imperfectly drained.	Between 0 and 1.0 m of peat over 0.5 to 3 m of clay, silt and sand.	Permafrost generally absent, but isolated patches of thin permafrost possible.	Fine-grained sediments poor foundation material and subject to frost heave.	
f/aAp-A f/gAp-A gAp-A	Floodplain; flat to gently sloping with few minor scarps; imperfectly to moderately well drained (f/aAp, f/gAp) to well drained (gAp).	Between 0 and 1.5 m of silt and silty sand over 3 m plus of sand and gravel.	No permafrost.	Possible source of aggregate.	Very frequent flooding.
aCa	Talus apron; moderate to steep slopes; well drained.	Between 0.5 and 5 m plus of rubble and blocks over unconsolidated sediments and bedrock.	Permafrost with low ground ice contents probable on north-facing slopes only.	Unstable foundation due to looseness of material and slopes; possible source of crushed aggregate.	Rock falls.

Table 4.1 Descriptive Legend of Terrain Types at Haines Junction (con'd)

xCm	Landslide; gentle to moderate slopes to 12 degrees; moderately well drained.	Five metres plus of mixed clay, silt, sand, gravel and till.	Permafrost, generally with low ground ice contents; active layer 0.5 to 1.2 m.	Thawed fine-grained sediments subject to frost heave.

and peat in other poorly drained areas has also accumulated in the time interval since the Macauley glaciation.

Haines Junction lies in the zone of discontinuous permafrost. At Haines Junction permafrost is discontinuous and generally very thin; the active layer is relatively thick except on poorly drained benches having thin veneers of peat along the Dezadeash River. Permafrost is widespread in the poorly drained lacustrine plain west of Pine Lake and on north-facing slopes south of the Dezadeash River. Organic materials and fine-grained lacustrine deposits, especially near Pine Lake, are characterized by medium to high ice contents.

4.2 Terrain Types and Their Characterization

Map 4.1 shows the distribution of terrain types in the Haines Junction area. The geomorphology, slope distribution, drainage, nature and thickness of materials, permafrost distribution, ground ice contents, active layer thicknesses, ground stability, engineering characteristics and potential hazards for each mapped terrain are given in Table 4.2. Details of grain size analysis are given in Appendix B.

4.3 Suitability Maps

Suitability maps for road construction, building construction and underground utility installation, sewage lagoons and sanitary landfills, septic systems, and construction materials including granular materials are presented (Maps 4.3.1 and 4.3.5). These suitability maps were derived following the techniques outlined in Section 3.3 of this report.

4.3.1 Suitability for Road Construction

The suitability map for road construction (Map 4.3.1) assumes that roads for year-round use are to be constructed and

Table 4.3.1 Terrain Property Guidelines for Assessing Suitability for Highways and Roads

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of all-weather highway and roads (without asphalt surface).

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Less than 8 degrees	Less than 12 degrees	Slopes between 12 and 16 degrees	Greater than 16 degrees
Drainage (wt)[1]	Rapid to well; greater than 1 m to water table	Well to moderately well; greater than 0.75 m to water table	Moderately well to imperfect; water table generally 0.50 to 0.75 m	Imperfect to poor; water table less than 0.5 m	Poor, water table continuously near-surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 to 100 years	Annual flooding	Flooding more than once a year
Permafrost and[2] ice contents (pf)	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep; isolated rock fall; evidence of faulting within last 10,000 years	Slight chance of glacier readvance or sediment liquefaction; possibility of fault-induced surface rupture within next 100 years; rock falls common	Possibility of landslide, sediment liquification within next 100 years; rapid solifluction, nivation or surface creep
Bedrock depth (br)	Greater than 2 m	Greater than 1.0 m	Between 0.5 m and 1.0 m	Less than 0.5 m	Generally near surface
Material composition and stoniness[4,5] (mt)	Gravel and sand, sandy till; stones less than 5 percent	Clayey till, silty sand, silty gravel; stones less than 10 percent	Clayey silt, sandy silt; stones less than 25 percent	Clay, organic silt, peat up to 2 m thick; stones 25 to 50 percent	Thick peat; stones greater than 50 percent

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low (<10%; medium 10-20%; high > 20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Due to frost heaving, terrain units having significant contents of silt and clay in areas of imperfect and poor drainage should be altered to one less degree of suitability if material is the limiting factor; where the highway is to be surfaced by asphalt the suitability should be more severely altered.

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

maintained on undisturbed terrain. For the purposes of drainage it is assumed the roads are graded, and ditches are present where required. The subgrade is to consist of materials underlying the roadway and the base material is to be locally obtained where possible. No provision is made on the suitability map for the source of surfacing material, which is assumed to be stabilized crushed gravel, till or rock.

The terrain factors were evaluated on the basis of how they affect the initial construction and how they affect load capacities and maintenance. Slope, drainage, permafrost, bedrock depth, and material primarily affect initial construction, whereas flood hazard, ice contents, and miscellaneous hazards primarily affect maintenance. The terrain property guidelines for assessing suitability for highway and road construction and maintenance are defined in Table 4.3.1.

4.3.2 Suitability for Building Construction and Utility Installation

The suitability map for building construction and utility installation (Map 4.3.2) assume that buildings are to have basements and utilities are buried in the ground. It is assumed that standard construction procedures are used except that special insulative procedures are used in areas of permafrost. It is also assumed that ground conditions are such that some mobility is viable in the vicinity of the buildings, and that utility and ground surface maintenance is minimal.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and how they affect the continued stability and maintenance of the building, building site and utility. Slope, permafrost, bedrock depth, material composition and stoniness primarily affect construction and excavation, whereas drainage, flood hazard, ice contents, and hazards due to

Table 4.3.2 Terrain Property Guidelines for Assessing Suitability for Building Construction and Utility Installation

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction or installation and maintenance of buildings and underground utilities.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 12 degrees	Slopes between 12 and 20 degrees	Greater than 20 degrees
Drainage (wt)[1,2]	Rapid to well; greater than 2.5 metres to water table	Well to moderately well drained; greater than 1.5 metres to water table	Moderately well to imperfect drainage; 0.5 - 1.0 metres to water table	Imperfectly or poorly drained; <.5 m to water table	Poor drainage; water table continuously near surface
Flood Hazard (fl)	None	None	Very rare; subject to once in 100 years or less	Occassional; subject to once in 10 to 100 years	Annual flooding
Permafrost and ice contents (pf)[2,3]	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<1.0 metres) sediment with medium to high ice contents	Permafrost with up to 1 metre of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 metre
Hazards due to[4] mass wastage, fault activity, (glacier advance, etc.)(hz)	No hazards	No hazards	Slow near-surface soil creep; within 1 km of post glacial active fault	Slight chance of glacier advance or sediment liquefaction; rock fall present; evidence of faulting within last 10,000 years	Possibility of landslides, fault-induced surface rupture, sediment liquefaction or glacier advance within next 100 years; rapid solifluction, nivation or soil creep
Bedrock depth (br)	Always greater than 2.5 m	Usually greater than 2 m	1 - 2 metres	Less than 1 metre	Generally at surface
Material composition and stoniness (mc)	Gravel and sand; sandy till; stones less than 5%	Clayey till; clayey silt and silty sand less than 1 m thick; stones less than 15%	Thick silty sand, silt, silty clay, stones 15 to 25%	Thick clay; organics to 2 m in depth, stones 25 to 50%	Organics greater than 50%; stones greater than 50%

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).
2. In cases of buildings without basements and where the limiting factors are drainage, permafrost and ice contents or bedrock depth, the degree of suitability should be altered to a more favorable rating because of less interaction between the undisturbed terrain type and the buildings in this mode of construction.
3. Ice contents given in percent volume excess ice: low <-10%; medium 10-20%; high >20%.
4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and Ice Contents (pf).
5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

mass wastage, glacier advances, faulting, liquefaction primarily affect stability and maintenance. The terrain property guidelines for assessing suitability for building construction and utility installation are defined in Table 4.3.2.

4.3.3 Suitability and Optimum Locations for Sewage Lagoons and Sanitary Landfills

The suitability map for sewage lagoons and sanitary landfills assumes that the sewage lagoons and sanitary landfills are to be constructed through shallow excavations or through the construction of berms on the undisturbed ground surface. The prevention of pollution through the movement of surface or ground water to terrain surrounding the facilities was considered to be of prime importance in their location. Minimal maintenance of berms and other confinements to the movement of pollutants was also considered paramount.

The guidelines for sanitary landfills are generally less severe than for sewage lagoons as no fluid pollutants are initially introduced. Thus the suitability maps give a more conservative evaluation of terrain for use of sanitary landfills than sewage lagoons; in many cases the suitability classification for sanitary landfills can be adjusted to the next higher suitability classification to that which is shown on the suitability maps for sewage lagoons and sanitary landfills.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and berm emplacement and how they affect continued berm stability and prevention of pollution. Slope, flood hazard, permafrost, hazards due to mass wastage, glacier advance, faulting, liquefaction, bedrock depth and material composition were considered primarily for their influence on pollutant confinement.

Locations where grain size analysis have been completed are plotted on Map 4.3.3 and show the basis on which the material compositions and permeabilities have been related. Grain size distributions for typical materials collected during the field investigations and located on map 4.3.3 are shown in Appendix B.

In addition to drainage and material stoniness, many of the above terrain factors would also affect lagoon and landfill construction and maintenance. The terrain property guidelines for assessing suitability for sewage lagoons and sanitary landfills are defined in Table 4.3.3.

Areas containing possible optimum locations for sewage lagoons are indicated on map 4.3.3 by patterns. The area analyzed for optimum locations is restricted to a 15 sq. km area where maps with contour intervals of 1.5 m (5 ft) are available. These optimum locations are restricted by a terrain suitability classification of G or FG and slopes of less than 1.5 degrees. It is our opinion that the Neoglacial lacustrine terrace immediately southwest of BM1956.0 at Haines Junction is the most suitable and practical location for a sewage lagoon because of the impermeable layer of clay on this bench, its relatively good drainage, the absence of permafrost, its elevation above the probable maximum flood level of the Dezadeash River and its location below the existing sewage lagoon. It lies outside the boundaries of Kluane National Park and could be easily screened by tree cover from Haines Junction and the Alaska Highway.

Ideal sanitary landfill sites abound in the Haines Junction area, but are probably best located in areas classified as FG and well away from stream and drainage courses such as most of the area adjacent to Haines Junction in a northeasterly direction.

Table 4.3.3 Terrain Property Guidelines for Assessing Suitability for Sewage Lagoons and Sanitary Landfills

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to impound water, sewage, and leachate to be evaluated.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)[1]	Less than 1.5 degrees	Less than 3 degrees	Less than 8 degrees	Less than 15 degrees	Greater than 15 degrees
Drainage (wt)[2]	Rapid to well drained; water table 1.5 m plus	Moderately well drained; water table generally 1.0 m plus	Imperfectly drained; water table generally 0.5 to 1.0 m	Poorly drained; water table generally less than 0.5 m	Permanently wet; water table continuously near surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Rare; subject to once in 50 years to 100 years	Occasional; subject to once in 5 to 50 years	Frequent; subject to at least once a year
Permafrost and[3] ice contents (pf)	No permafrost	Scattered permafrost with low ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediments with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep	Slight chance of glacier advance; evidence of faulting within last 10,000 years; some rock fall	Rapid soil creep or solifluction prevail; possibility of landslide, fault induced surface rupture, sediment liquification, or glacier advance within next 100 years
Bedrock depth (br)	Greater than 1.5 metres (blanket)	Greater than 1.0 metres (blanket)	Between 0.5 and 1.0 metres (veneer)	Less than 0.5 metres (veneer)	Generally at surface
Material composition and stoniness[5] (mt)	Silty clay; less than 3 percent stones	Clayey silt and silt; clayey till and compact till; 3 to 10 percent stones	Silt with some organic content; sandy or gravelly silt or clay; loose till; 10-25 per cent stones	Silty sand and silty gravel; less 25-50 per cent stone	Sand and gravel; greater than 50 percent stones peat

1. Slopes are a more limiting factor to the construction of viable sewage lagoons than sanitary landfills. Thus terrain unit suitability for sanitary landfills should be altered to one less severe degree of suitability if slope is the limiting terrain factor.

2. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

3. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high > 20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

4.3.4 Suitability for Septic Systems

The suitability map for septic systems (Map 4.3.4) assumes that the effluent from a septic tank is to be distributed in the natural surficial material by means of a sub-surface or raised tile bed. It was assumed that it would be required that water bodies and water supplies within 60 metres and surface water are not to be polluted by the septic system. It is also assumed that the systems are to be emplaced by standard procedures and that ground surface maintenance following emplacement is to be minimal.

The permeability of surficial materials within a terrain type was considered extremely important in evaluating terrain types for septic field suitability because the absorption of effluent without the pollution of water supplies or water bodies greater than 60 metres from the septic field is of prime importance. Grain size distributions for typical materials collected during the field investigations and located on map 4.3.4 are shown in Appendix B.

The terrain factors were evaluated on how they affect initial sewage system emplacement and maintenance and how they affect absorbtion of effluent and pollution prevention. The material composition, mainly its permeability, was considered of prime importance in evaluating terrain types for septic field suitability. Other terrain factors such as slope, drainage, permafrost, flood hazards, hazards due to mass wastage, glacier advances, liquefaction and faulting, and bedrock depth primarily affect the continued prevention of pollution of adjacent surface water, water bodies and water supplies; and to a lesser degree the emplacement and maintenance of the septic systems. The terrain property guidelines for assessing suitability for septic systems are defined in Table 4.3.4.

Table 4.3.4 Terrain Property Guidelines for Assessing Suitability for Septic Systems

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of septic systems.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 8 degrees	Between 8 and 15 degrees	Greater than 15 degrees
Drainage (wt)[1]	Well drained; water tables deeper than 1.5 m	Moderately well drained; water tables occasionally rise to levels above 1.5 m	Moderately well to imperfectly drained; water tables usually 0.5 m below surface	Imperfectly to poorly drained; seasonal surface ponding of water	Poorly drained; surface ponding common
Flood Hazard (fl)	None	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 years or less	Occasional; subject to once in 5 years or less	Annual flooding
Permafrost and ice contents (pf)[2]	None	Rare permafrost; generally no ground ice	Discontinuous permafrost	Permafrost present with rare areas having shallow (0.5 m) sediment with medium to high ice contents	Continuous permafrost with many areas having shallow sediment with medium to high ground ice contents
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	None	None	Minor soil creep	Some rock fall; slight chance of glacier advance; evidence of faulting within last 10,000 years	Rapid soil creep, solifluction and nivation; active landslide activity at site or on adjacent slope; possibility of glacier advance or liquifaction within next 100 years
Bedrock depth (br)	Greater than 1.5 m	1 to 1.5 m	0.5 to 1 m	Less than .5 m, uneven thickness (veneer)	Generally less than 0.5 m
Material composition and stoniness[4] (mt)	Fine to coarse sand; loose sandy till; less than 5 percent silt, clay and stones	Sand and loose sandy till; 5 to 20 percent component of silt, clay and stones	Sand, gravelly sand, sandy till; 20 to 50 percent component of silt, clay and stones	Gravel, silt and clay content greater than 70 percent of unit; clayey till	Gravel, clay, silt, stone content greater than 50 percent; peat

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

4.3.5 Suitability and Availability of Construction Materials

The suitability map (Map 4.3.5) assumes that the construction materials are to be used as aggregate or fill. The suitability of the different terrain types are evaluated according to the quality and quantity of the surficial materials within it, and the workability and ease of extraction of those materials. Materials that are required to be impermeable such as dikes are excluded from consideration; the suitability for sewage lagoons and sanitary landfills give a partial assessment of suitability for impermeable materials. The suitability of bedrock as a construction material has not been evaluated. Terrain types containing gravel and sand with potential as aggregate are given the highest suitability classification as they can easily be adapted to most construction purposes. Other terrain types are evaluated on the basis of the compressibility, compactibility, susceptibility to frost action and surface trafficability of the surficial materials within them.

The terrain factors were evaluated on the basis of how they affect the usefulness and versatility of the contained materials as a construction material, the ease or difficulty of extraction, and the volumes that could be extracted from a unit area. Material composition and stoniness primarily affects usefulness as a construction material, whereas slope, drainage, permafrost, flood hazard, miscellaneous hazards, and bedrock depth affect the extractable volumes per unit area and the ease or difficulty of extraction. The terrain property guidelines are defined in Table 4.3.5.

A number of sources of aggregate have been outlined on map 4.3.5. The gravel:sand:fines ratios (based on grain size distribution obtained during this and earlier investigations) and the cu. metres per hectare of deposits (based on our estimate of minimal extraction thicknesses) are indicated for each viable

Table 4.3.5 Terrain Property Guidelines for Assessing Suitability for Construction Materials Including Workability and Usefulness as General Fill and Sources of Gravel and Sand

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated as a potential source of construction materials, including sand and gravel.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Between 5 and 12 degrees	Between 12 and 20 degrees	Between 20 and 30 degrees	Greater than 30 degrees
Drainage (wt)[1,2]	Rapid to well; water table >2 m	Well to moderately well; water table 1.0 to 2 m	Imperfect to moderately well; water table 0.5 to 1.0 m	Imperfect to poor; water table less than 0.5 m	Permanently wet; water table near surface
Flood Hazard (fl)	None	Very rare; subject once in 100 years or less	Occasional to rare; subject to once in 5 to 100 years	Frequent; subject to annual flood	Very frequent; flooded more than once per year
Permafrost and[3] ice contents (pf)	None	Scattered permafrost with low ground ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	Flow near-surface soil creep	Rapid soil creep or solifluction; evidence of faulting within last 10,000 years; chance of glacier advance	Possibility of landslide, surface rupture or sediment liquification within next 100 years	Imminent possibility of landslide and sediment liquification
Bedrock depth (br)	Greater than 2 m	Between 1.5 and 2 m	Greater than 1.0 m (blanket)	Between 0.5 and 1.0 m (veneer)	Less than 0.5 m
Material composition and stoniness[5] (mc)	Gravel and sand; stones less than 3 percent	Silty sand, silty gravel, sandy till; thin cover (veneer) over sand or gravel; stones less than 10 percent	Till, silty fine sand; stones less than 25 percent	Silt, clay, clayey silt; thick cover (blanket) over sand and gravel; 25 to 50 percent stones	Peat, organic silts; greater than 50 percent stones

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).
2. Ice contents given in percent volume excess ice: low <10%; medium 10-20%; high >20%.
3. Water tables are considered only where permafrost is absent as a perched water table is generally present where permafrost is present. However, only a limited and easily controlled amount of water would be introduced from most excavations from this perched water table.
4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).
5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

source. Further test pitting is required to determine quantities more accurately. No attempt has been made to assess the sources as potential concrete aggregate.

Adequate supplies of gravel and sand appear to be present in the Haines Junction area for future development. However, since transportation costs are critical, the community might consider estimating the volumes required for future development and reserving a portion of the closest deposits for this purpose.

4.3.6 Recreation and Cottage Areas - Pine Lake

Pine Lake is the focus of some recreational and cottage activity for the residents of Haines Junction. Such recreational activity usually involves some lake access and increased foot and vehicle travel. Cottages involve buildings, generally without basements and with some sewage disposal, preferably a septic system.

Map 4.3.2, which gives the suitability for building construction and utility installation, and map 4.3.4, which gives the suitability for septic systems, are a guide to areas most suitable for recreational and cottage development. Individual assessment of potential sites is still required. Basically, the southwestern shoreline of Pine Lake seems most suitable (FG - mt, wt, map 4.3.2; F - mt, map 4.3.4) because of limitations imposed by permafrost, materials and bedrock along other shorelines. Individual sites may not be suitable for development because of improper lake access due to steep slopes or a narrow fringe of swampy ground. Isolated areas may be present along the northern shoreline (F - sl, br, wt and P - br, mt, map 4.3.2; F - sl, pf, P - br, mt, sl, U - br, mt, sl, map 4.3.4) that are suitable for campgrounds or individual cottages; each site would require a separate assessment. Also raised tile beds may be acceptable in some areas of relatively shallow bedrock.

The present campground and boat launching facility would appear to be undesirable in that continued maintenance, fill and aggregate will be required to counteract thermokarst caused by permafrost degradation and ground ice melting where the ground's thermal regime has been altered by tree and brush clearing or road construction.

4.4 Unique Features

Particularily unique and interesting Quaternary features are shown on map 4.1.

Most features relate to the Neoglacial lakes that once submerged much of the Haines Junction area. At (1) the highest levels achieved by Neoglacial Lake Alsek are recorded by wave-cut benches and a spit that dams a ravine eroded during the post-glacial. At localities noted by (4), pits have been dug that expose multiple buried soil sequences in Neoglacial silt and sand. Particularily good beaches and driftwood strand lines are present at localities marked (5); trim lines in the trees are present at localities noted at (6). At (13), a good example of floodplain alluvium buried under multiple layers of Neoglacial lake clay and soils is present.

At locality (3), beaches are present that record high levels of Glacial Lake Champagne. Similarily, strandlines at (9) cut in a talus apron were formed by this lake.

During postglacial time marl has been deposited in the Pine Lake basin. It can be seen in the shallow waters of Pine Lake and may still be forming (10). At (11) marl is exposed in banks being undermined by thermokarst.

Excellent examples of thermokarst are present at (11) where thawing is being accelerated by an adjacent water body and recent road construction activity and at (12) where thawing has been promoted by the presence of an old road bed.

At (14) gravel and sand are exposed that predate late Wisconsin till and glaciolacustrine deposits; and at (15) land-slide is present. Cliff-top dunes, in part still active, are present at locality (2). At (8), glacially scoured steep slopes are present.

Most features relating to Neoglacial Lake Alsek can be found at other localities within and beyond the limits of map 4.1. However, the beaches at locality (1) are a type locality and should be preserved. The present pit should be only expanded to the east of its present locality and should be regraded to a more aesthetically acceptable form. The marl at Pine Lake is unique for areas this far west of Whitehorse, but are not confined to one locality at Pine Lake. Other features, although of particular interest, are well distributed beyond the limits of map 4.1 in the Yukon.

4.5 Hydrogeology

The hydrogeology of Haines Junction is summarized under the headings of well survey, water chemistry, test drilling results, groundwater flow regime, and water supply potential.

4.5.1 Well Survey

A well survey of Haines Junction revealed 42 wells (located on Fig4.5.1) in the community; at least 8 were dug wells and the remainder were drilled (Table4.5.1). Some of this presentation is based on discussions with a local retired well driller who estimated that a total of 50 to 60 wells had been constructed in the village (the wells not identified by this study are primarily dug wells which are apparently not in use at the present time).

Seven wells in Haines Junction were sampled to provide water quality information about aquifers in the community. In addition, a grab sample of Dezdeash River water was analyzed. Water chemistry data are summarized as Table 4.5.2 of this report.

4.5.2 Water Chemistry

Two wells are used to furnish the Haines Junction communal water supply, a shallow well (14 m deep) and a deep well (134 m deep). Samples of both wells were taken at the well head. A second sample of the shallow communal wellwater which was supplying the village during the summer of 1979 was taken at the Gateway Motel. The shallow well samples showed almost identical chemical compositions.

Water from the shallow town well is moderately soft (69.1 mg/l hardness) and is not highly mineralized (total dissolved solids about 140 mg/l). The water is an alkali earth

Table 4.5.1 Haines Junction Well Survey

Description	Depth	Static Level	Use	Yield	Log and Remarks
Brewsters Hotel	156 m	-	Hotel	-	-
R.C.M.P. shallow well	<30 m	9.3 m	garden + lawn	-	-
Stardust Motel	60 m	-	Motel	-	-
Watsons Garage	27 m	-	commercial	-	none
Parks Canada deep well	158 m	-	Park headquarters	-	log reproduced in text
Public Health Clinic	7 m	2.4 m	not in use	-	-
Pine Lake Campsite	-	-	campground	-	-
Community wells: No. 1	13.7 m	-	-	-	log reproduced in text
Community well: No. 2	-	-	-	-	see text
Two wells near Stardust Hotel	23 m no data on one well		domestic	-	-
Two wells at Blue Mountain garage	no data		abandoned	-	-
Two wells at school	no data	-	abandoned	-	-
Domestic residence across from church on Alaska Highway	24 m	-	-	high yield 7100 l/min	completed into gravel
Dalton and Cairnes St.	30 m	-	not in use	-	-

Table 4.5.1 (cont'd)

Klondike Inn 10 wells (dug and drilled)	drilled wells 27 m to 137 m	-	hotel	-	27 m aquifer very hard, deeper aquifers much softer
Ogilvie Road (one drilled well + four dug wells)	14 m	-	not in use	-	-
Domestic residence on Black St.	dug well	-	not in use	-	-
Residence behind Gateway Hotel	13 m	-	-	-	-
Residence 1 south of Ogilvie St.	drilled 24 m	-	not in use	high yield 7100 l/min	-
Residence 2 south of Ogilvie St.	18 m	-	not in use	7100 l/sec	-
Residence 3 south of Ogilvie St.	-	-	not in use	130 l/sec	silt in water if pumped harder
Community Center	14 m	-	not in use	-	-
House behind Community Center	9 m	-	not in use	-	-
House north side of Community Center	dug	-	not in use	-	-
Yukon Electric	drilled well	-	not in use	-	-
Yukon Government Yard	drilled well	-	not in use	-	-

Table 4.5.1 (cont'd)

Refinery well	-	-	abandoned	-	-
Airport	over 150 m	-	domestic	low, less than 50 l/min	no data

Table 4.5.2 WATER CHEMISTRY DATA (Champagne - Haines Junction)
(in mg/l unless indicated)

Sample	HCo_3^-	uMHos Cond.	Ca^{++}	Mg^{++}	Na^+	K^+	Fe^{-2}	Mn^{-2}	No_3^-	Cl^-	$So_4^=$	mg/l $Po_4^{\equiv}$	Surface Water or Aquifer	Approx TDS	Hardness	(PPM $CaCo_3$)
Town Well 2 (at well head)	86	215	5.6	2.3	32.5	1.7	.05	-	-	-	13	214	Deep aquifer	150	23.4	very soft
Town water supply well #1 (Gateway Hotel)	89	200	20.1	4.6	2.6	.75	-	-	.53	-	8.6	-	Shallow aquifer	140	69.1	mod. soft
Town well #1 (at pump station)	87	200	20.1	4.5	2.5	.75	.1	-	.22	3.5	18	-	Shallow aquifer	140	69.0	mod. soft
Parks Canada Headquarters	156	360	5.5	2.6	62.5	1.0	.05	-	1.86	7.0	19	459	Deep aquifer	252	24.4	very soft
Brewsters Motel	100	250	4.9	1.4	32.5	0.37	.11	-	.22	-	19	61	Deep aquifer	175	17.9	very soft
R.C.M.P. well (in garage)	79	215	20.0	4.7	2.75	0.75	.02	-	.35	3.5	12	-	Dug well	150	69.3	mod. soft
Stardust Motel	114	405	10.3	8.7	50.0	1.87	-	-	-	5.3	72	30	Deep aquifer	283	61.4	mod. soft
Kusawa Lake	14	66	2.5	.6	.5	.25	0.05	-	-	-	-	-	Lake sample	46	8.7	very soft
Dezdeash River (Champagne)	48	128	9.7	2.7	1.75	.47	.05	-	-	-	3.7	-	River sample	89	35.3	soft
Dezdeash River (Haines Junction)	70	170	16.3	4.6	2.25	.5	.13	-	-	-	9.8	31	River sample	119	59.6	soft

(calcium with minor magnesium) bicarbonate sulphate water type. The deep well water is very soft (23.4 mg/l hardness) but is slightly more highly mineralized than the shallow communal well. This water is also an alkali earth bicarbonate sulphate water but sodium is the predominant cation and minor element concentrations are dissimilar to the shallower aquifer.

The Parks Canada headquarters' well, (158m deep), the Stardust Motel well (60 m deep) and the Brewsters Hotel well (156 m deep) all have alkali earth (sodium rich) bicarbonate sulphate waters. Significant variation is evident in the chemical data between these wells however which indicates that they are not interconnected or associated. The aquifer elevations (435 m, 534 and 446 metres respectively) and the large distances between these three wells supports this conclusion.

All of these deep aquifers have moderately to very soft water and are only moderately mineralized (total dissolved solids range from 175-283 mg/l).

One shallow drilled well located at the R.C.M.P. residence was also sampled. The water of this well is almost identical to communal well No. 1 and Dezdeash River water. (Moderately soft calcium, minor magnesium-bicarbonate, minor sulphate water.)

In general, water from all the wells sampled is chemically potable and is considered to be of good quality for human consumption.

4.5.3 Test Drilling Results

Detailed well log and hydraulic data are available for three wells in Haines Junction; the Parks Canada headquarters'

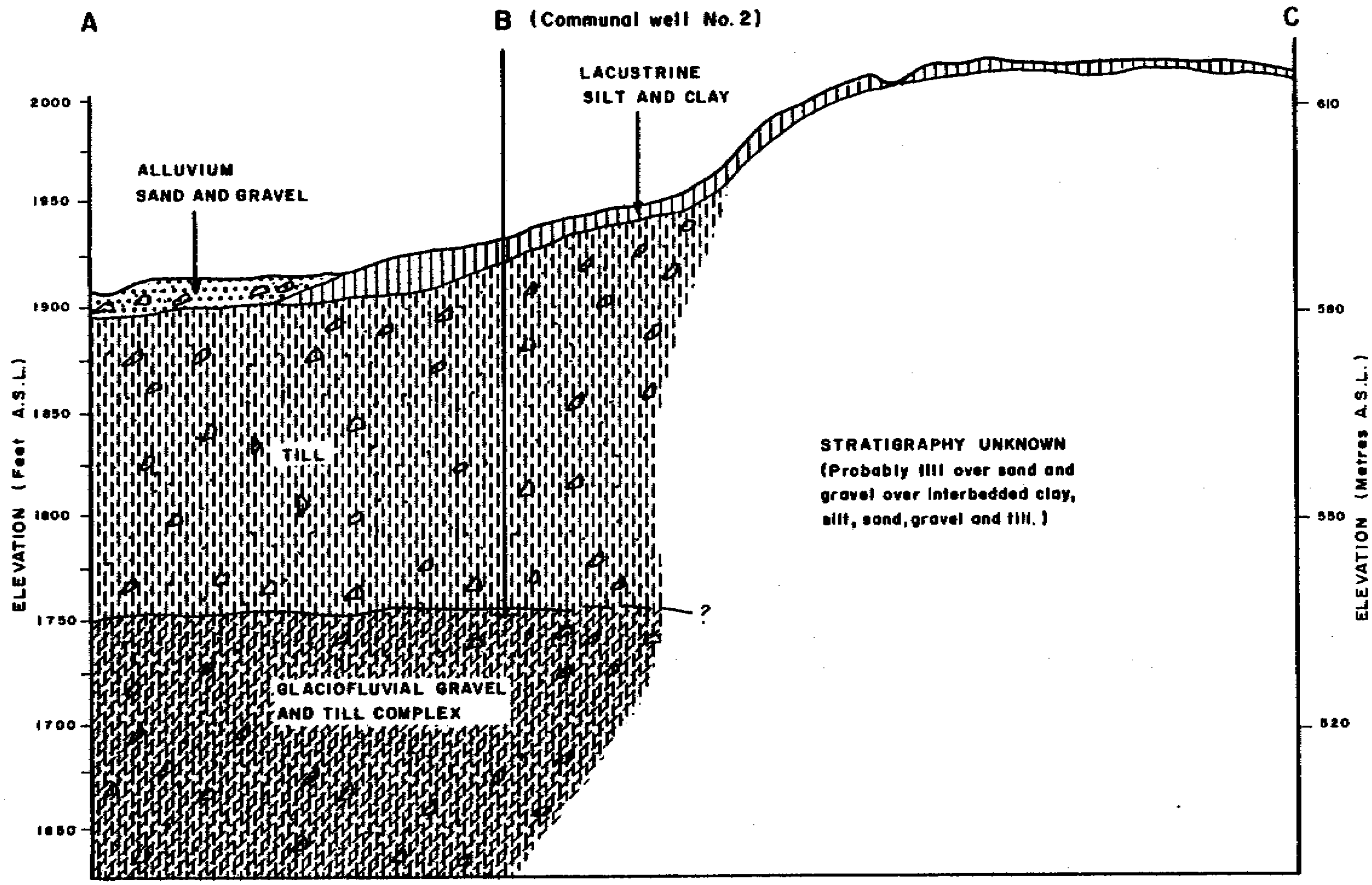


FIGURE 4.5.3

GEOLOGICAL CROSS-SECTION

HAINES JUNCTION

(See Map 4.3.7. for locations.)

well drilled in 1973 and completed in 1977, community well No. 1 drilled in 1974 and community well No. 2 drilled in 1978. A summary follows:

Parks Canada Well

The drillers stratigraphic log is included as Table 4.5.3 a. In 1973 the well was drilled 143 m into boulders and the casing was dynamited to act as a well screen. A 2.2 l/minute yield was obtained. In 1977 the well was deepened to 174 m, screened and developed. An artesian well which flows at a rate of 68 litres/minute was developed.

Testing during July 1977 revealed that the well water contained large concentrations of suspended sediment even though Park personnel permitted the well to flow freely for a 6 month period after drilling. Pumping at rates in excess of the 68 litres/minute artesian flow still cause high silt concentration problems at the present time.

Community Well No. 1

The stratigraphic log of this well is included as Table 4.5.3 b of this report. The well is located within 10 metres of the Dezdeash River. It penetrates a sequence of lacustrine and alluvial sediments and is completed with slotted casing into a thin glaciofluvial gravel stratum at a depth of 13.7 metres. This aquifer which is only .9 m thick was pumped at 227 l/minute for 6 hours without drawdown. Direct recharge from the river is evidently occuring as indicated by the chemical similarity of each water type and the fact that a slight northward gradient has been established in this aquifer by piezometric level surveying (Hydrogeological Consultants Ltd. 1974).

A transmissivity of 9.4×10^4 ig/day foot and a storativity of 2.8×10^{-2} has been calculated for this aquifer.

Table: 4.5.3a

Stratigraphic Log
of Parks Canada Well
Haines Junction

Depth (metres)	Drillers Lithological Description	Probable Terrain Unit
0-10.9	hardpan + boulders	
10.9 - 13.4	silty sand	
13.4 - 17.6	hardpan with boulders	M+G
17.6 - 21.3	hardpan with clay	
21.3 - 23.2	sandy gravel	
23.2 - 32.6	sand, silt, some gravel	
32.6 - 39.6	clay	L or A
39.6 - 45.7	fine sand + silt	
45.7 - 57.9	hardpan	M
57.9 - 59.4	silty clay	
59.4 - 67.9	black silt	L or A
67.9 - 81.7	fine sand/silt	
81.7 - 90.8	clay	
90.8 - 96.3	hardpan	
96.3 - 97.2	sand + fine gravel	
97.2 - 99.6	fine sand	
99.6 - 100.5	hardpan	
100.5 - 101.5	fine sand + gravel	
101.5 - 106.4	hardpan	G + M
106.4 - 106.9	silt, sand	
106.9 - 138.3	hardpan	
138.3 - 138.9	silt, sand	
138.9 - 140.2	hardpan	
140.2 - 141.7	boulders	
141.7 - 143.6	bedrock	
143.6 - 174 m	no log kept when well deepened	

Table: 4.5.3b(cont'd)

Stratigraphy
Community Well No. 1
Haines Junction

Depth (m)	Drillers Log	Terrain Unit
0 to 1.3	sandy silt	L or A
1.3 to 5.2	sandy gravel to silt	A
5.2 to 5.5	fine black sand	
5.5 to 7.0	grey till	M
7.0 to 7.6	gravel	G
7.6 to 13.7	till	M

Table: 4.5.3c(cont'd)

Stratigraphy of
Community Well No. 2
Haines Junction

Depth (m)	Driller's Log	Terrain Unit
0 - .3	gravel	A
.3 - 3.4	clay	L
3.4 - 4.3	gravel	
4.3 - 8.5	gravel + clay	
8.5 - 21.0	till with gravel	M
21.0 - 39.3	clay till with some gravel	
39.3 - 64.0	clay silt with gravel	
64.0 - 109.4	clay till with gravel	
109.4 - 113.9	silt with gravel	
113.9 - 118.3	till, gravel	
118.3 - 121.6	sandy silt	M + G
121.6 - 133.2	gravelly till	
133.2 - 134.4	gravel	

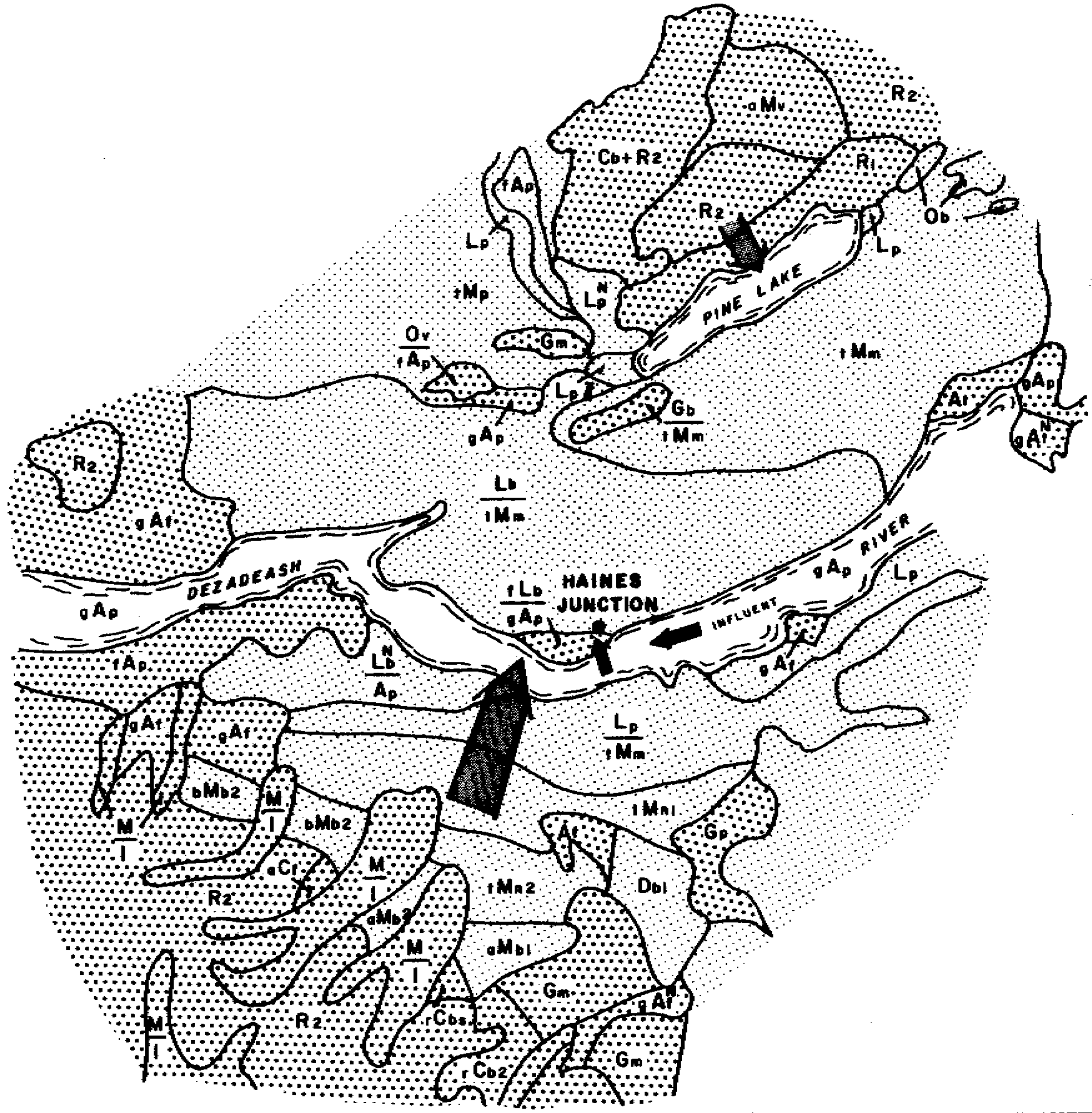


FIGURE 4.5.4

GROUNDWATER FLOW

HAINES JUNCTION

LEGEND

- PROBABLE LOCAL GROUNDWATER FLOW DIRECTIONS
- PROBABLE REGIONAL GROUNDWATER FLOW DIRECTIONS
- AREAS WITH HIGH RECHARGE POTENTIAL
- AREAS WITH LOW RECHARGE POTENTIAL

0 1 2 4 km

Community Well No. 2

This well was drilled in 1977 in an attempt to alleviate cold water freezing problems encountered during utilization of the shallow river connected aquifer described above. The total depth of the well is 134 metres with three aquifers identified during drilling, a shallow gravel (3.3 to 4.2 m depth), a deep till (76.5 - 78.3 m) and a deep gravel (133 - 135 m) (Table 4.5.3c and Fig. 4.5.3). This well was completed into the middle aquifer and is capable of producing a sustained yield of 900 litres/minute (200 ipgm). A high suspended sediment (silt) problem has existed in this well since it was completed, although the water is soft, only slightly mineralized and is usually 6^{o} Celcius during winter months.

4.5.4 Groundwater Flow

Existing published reports on the hydrogeology of the Haines Junction area do not address the subject of groundwater flow due to the lack of piezometric elevation data in the village. The following information about flow regimes is based on the topographic and geological information presented in this report.

The till and glaciolacustrine clay/silt terrain units in the study area are impermeable (Table 4.5.4: $K=10^{-5}$ cm/sec or less) and do not permit any groundwater recharge (Figure 4.5.4). No relationship between topography and recharge or groundwater flow directions are likely throughout the village. Permeable units are restricted to the alluvial fan, colluvium/rock and openwork glaciofluvial gravel units on the mountain slopes south and north (Canyon Mountain) of the village. The fact that the three deep wells mentioned in the previous section of this report are flowing wells indicates that a hydraulic connection is present between these recharge areas and deeper aquifers under the village. As mentioned, aquifers at the Park office, Brewsters Hotel and

Table: 4.5.4 Haines Junction
Grain Size and Hydraulic Conductivity Measurements

Sample No.	Location	Description	Hydraulic Conductivity (cm/sec)
SY 6	Haines Junction	Lacustrine (Lb) silt	less than 9×10^{-6}
SY 8	Haines Junction	Till (Mm)	less than 9×10^{-6}
SY 2	Pine Lake	Marl	1.23×10^{-5}
89 PY	Haines Junction	Gravel	3.73×10^{-2}
SP 1	Haines Junction	Gravel	2.5×10^{-1}
123 PY	Marshall Creek	Gravel	2.07×10^{-2}

Community Well No. 2 are not well interconnected as evidenced by elevation and water chemistry variations between them. These aquifers probably are thin glaciofluvial gravel units interstratified with thick silty till sequences (c.f. Figure 4.5.3). As such, they are apparently only several metres in maximum thickness and are likely to have a channel, not blanket morphology. Yields from these zones are restricted by the size of the aquifer (i.e. boundary conditions exist) and high silt/turbidity problems when pumped at high volumes. Interference between deep wells in these units is a distinct possibility. A northerly regional flow direction (figure 4.5.4) is estimated through these glaciofluvial aquifers.

Communal well 1 recharges from the Dezdeash River and a northerly local flow is indicated from piezometric measurements in this area. (Hydrogeological Consultants Ltd. 1974). It is possible that the river is influent along its bed both up and downstream from the village with older alluvial sand/gravel strata feeding some neighbouring shallow or even moderately deep wells in the village.

Local southerly flow and recharge to Pine Lake from permeable units on Canyon Mountain is possible. However, the extent of movement from this recharge area towards Haines Junction cannot be evaluated on existing data.

4.5.5 Water Supply Potential

Two sources of future groundwater supplies for Haines Junction are evident

1) An additional shallow well tapping near surface alluvial material near the Dezadeash River floodplain. The surficial materials act as a filter gallery to reduce the high turbidity of the Dezadeash River to acceptable levels. This type of supply will provide high yields but the necessity to heat cold water ($0^{\circ}C$ in

winter) is a major economic constraint to this type of supply development.

2) An additional deep well into one of glaciofluvial lenses which underlie the village. Uncertain and low yields, high silt/turbidity concentrations and high drilling and construction costs are major constraints to utilization of deep aquifers. However, water temperatures of up to 4°C can be expected in winter from these aquifers and heating costs will be reduced significantly as a consequence.

Stanley and Associates Ltd. (1979) estimate that an additional 2.6 l/s (35 igpm) is needed to augment existing groundwater yields at present. However, at present neither the Parks well or the Community well No. 2 provide this yield without becoming unfit for drinking due to high silt concentrations. In addition a recently constructed (summer 1979) well at the airport was drilled to a depth of over 150 metres and obtained a water supply which was barely adequate for a single domestic residence (TNTA Ltd., Personal Communication). It is felt that new deep wells are a questionable potential source of high water-volumes as a consequence. The decision to drill a new deep well or shallow well in the village should be based on a careful evaluation of existing hydrogeological data as well as a recent cost/benefit analysis. The water quality from all sources is chemically potable for human consumption however.

5.0 DESTRUCTION BAY

5.1 Setting

Destruction Bay is located on the southwest shore of Kluane Lake in the Shakwak Trench, which is the physiographic expression of a large fault system that transects both Alaska and Yukon Territory, and that has been active during the late Tertiary and Pleistocene. At Destruction Bay, the ground surface rises gradually from about 780 metres at Kluane Lake to about 1120 metres at the edge of the Shakwak Trench, where a 800 metre escarpment forms the sharp boundary between the Shakwak Trench and Kluane Ranges. At Destruction Bay, itself, the terrain is gently sloping or undulating except for some small scarps of 10-15 metres formed by stream dissection and wave erosion near Kluane Lake.

At Destruction Bay, thick unconsolidated deposits are the results of deposition during several Pleistocene glacial and interglacial periods, and include till, outwash, glaciolacustrine silt and clay, and alluvial silt, sand and gravel. Most of the surface materials shown on map 5.1, and figures 5.5.1a, b were deposited during or after the Macauley glaciation. During this glaciation a large trunk valley glacier flowed northwest along the Shakwak Trench. At Destruction Bay undulating moraine (tMm), outwash (aGp, f/aGp, aGv), and during its later phases, loess (mEv) were deposited during this glaciation (Table 5.1).

During the waning stages of the Macauley glaciation, Kluane Lake drained to the northwest. However, during the hypsithermal, the Kaskawulsh Glacier at the head of the Slims River retreated far up its valley and allowed Kluane Lake to drain to the Alsek River and to be lowered by over 40 metres. Although rapid formation and aggradation of the alluvial-fans flanking the Kluane Ranges occurred following deglaciation of the Shakwak

Trench some stream incision probably occurred near the present edge of Kluane Lake as the streams graded to the lower level of Kluane Lake.

During Neoglacial time, the Kaskawulsh Glacier re-advanced, blocked the drainage of Kluane Lake to the Alsek River, and caused Kluane Lake to rise to an elevation 10 to 12 metres above its present elevation. A new outlet (the present Kluane River) was re-established to the northwest and Kluane Lake quickly returned to near its present level. This new level of Kluane probably caused further aggradation and a deterioration of drainage on the alluvial-fans. The alluvium deposited by streams crossing the alluvial-fans ranges from clayey silt and silty sand (fAb, fAf) to sand and gravel (aAf) to interbedded mixtures of both types (xAf). Peat (pOv) has begun to accumulate on parts of the inactive fans whose surface is underlain by fine-grained sediments.

The Neoglacial rise in the level of Kluane Lake has resulted in some areas below elevations of about 792 metres having a capping of wave-washed material (aLb). Fine-grained lacustrine sediments (cLv, xLp) have been deposited in sheltered bays. Modern wave action continues to modify beach ridges and beaches (aLr) at lake level. Shoreline erosion appears to be moderate at Destruction Bay.

Destruction Bay lies in an area where permafrost is near continuous. Only those units, eg. alluvial-fans, that are frequented by surface streams (parts of xAf, fAf, f/aAf) and floodplains or low terraces lacking a significant capping of fine-grained sediment and peat (gAp, gAf) are free of permafrost. Even those portions of alluvial-fans having permafrost at their surface often have taliks throughout their total thickness because of ground water percolating through them to Kluane Lake. Kluane Lake itself may also cause the thickness of permafrost to be relatively thin near it. The total thickness of permafrost at Destruction

Table 5.1 Descriptive Legend of Surficial Materials at Destruction Bay

Terrain Type	Geomorphology; Slopes; Drainage	Nature of Materials and Thickness	Permafrost; Ground Ice; Active Layer Thickness	Miscellaneous Engineering Characteristics	Potential Hazards
mEv/tMm	Loess Veneer over undulating moraine; slope vary between 0 and 10 degrees; moderately well to well drained.	Between 0 and 1 m of sandy silt over 1 to 10 m of compact silty sandy till over interbedded clay, sand, gravel and till.	Continuous permafrost with active layer of 0.5 to 1.0 metres; ground ice content nil to low except medium to high occasionally in loess.	Stable foundation material; susceptible to frost heave if unfrozen.	
mEv/Dm	Loess veneer over undulating drift; slopes vary between 0 and 10 degrees; moderately well drained.	Between 0 and 1 m of sandy silt over silty sand till or glaciofluvial gravel and sand.	Continuous permafrost with active layer of 0.5 to 1.0 metres; ground ice content nil to low except medium to high occasionally in loess.	Stable foundation material; till susceptible to frost heave if unfrozen.	
aGv/tMm	Outwash veneer over undulating drift; slopes vary between 0 and 10 degrees; moderately well drained.	Between 0 and 2 m of gravel or pebbly sand over 1 to 10 m of compact silty sandy till.	Continuous permafrost with active layer of 0.5 to 1.0 metres; ground ice content nil to low.	Stable foundation material; till susceptible to frost heave if unfrozen.	
f/aGp	Outwash plain; flat to gently sloping; variable drainage - good to imperfect.	Between 0 and 1 m of silt and silty sand over 2 m plus of sand and gravel.	Continuous permafrost with active layer of 0.3 to 1.0 metres; ground ice content generally low to medium.	Stable foundation material except where high ground ice contents present.	
gAp	Floodplain including braided channel; well drained.	Thick gravel and sand.	Generally unfrozen.	Stable foundation material.	Risk of flooding.
gAf	Alluvial fan; very gently sloping with few small scarps; well drained.	Thick gravel and sand.	Probably contains isolated patches of permafrost with negligible ground ice contents; active layer of 0.7 to 1.5 metres.	Stable foundation material.	High risk of stream avulsion
f/aAf	Alluvial fan; very gently sloping with few shallow channels; drainage variable from imperfect to moderately well.	Between 0.5 and 2 m of silt and fine sand, frequently organic, over gravel and sand.	Permafrost with many taliks due to surface and groundwater flow; ground ice contents frequently medium to high in fines; low to nil in gravel and sand; active layer 0.5 to 1.5 m plus.	Thawed fines poor foundation material.	Risk of flooding and stream avulsion.

Table 5.1 Descriptive Legend of Surficial Materials at Destruction Bay (cont'd)

xAf	Alluvial fan; very gently sloping with few shallow channels; drainage generally moderately well to imperfect, but channels poorly drained.	Between 5 to 10 m plus of interbedded silt, sand, gravel with peaty layers.	Permafrost with many taliks due to surface and groundwater flow; ground ice contents frequently medium to high in fines; low to nil in gravel and sand; active layer 0.5 to 1.5 m plus.	Thawed fines poor foundation material.	Risk of stream avulsion.
fAf	Alluvial fan; very gently sloping with few shallow channels; drainage generally moderately well to imperfect; channels poorly drained.	Between 5 and 10 m plus of clayey silt, silt, silty sand with few gravel and peat layers.	Permafrost with many taliks due to surface and groundwater flow; ground ice contents frequently medium to high; active layer 0.3 to 1.0 m.	Thawed fines poor foundation material.	Risk of stream avulsion.
pOv/fAf	Alluvial fan capped with peat veneer; very gently sloping with few shallow channels; drainage imperfect.	Between 0.5 and 1.5 m of peat over clayey silt, silt, silty sand with few gravel and peat layers.	Continuous permafrost with some subsurface taliks due to groundwater flow; ground ice contents frequently medium to high; active layers 0.2 to 0.7 metres.	Thawed peat and fines poor foundation material.	
fAb/aGp	Alluvial blanket over outwash; flat to gently sloping; drainage moderately well; few areas imperfectly drained.	Between 0.5 and 2.5 m of clayey silt, silt, silty sand over gravel and sand.	Continuous permafrost; ground ice content frequently medium to high in fines; low in gravel and sand; active layers 0.3 to 1.0 m.	Thawed fines poor foundation material.	
cLv/xAf	Alluvial fan capped with lacustrine clay; flat to very gently sloping; imperfect to moderately well drained.	Between 0.3 and 1.0 m of clay and silty clay with peat layers over interbedded gravel sand and silt.	Permafrost generally continuous, but with taliks and shallow; ground ice contents generally low to medium active layer 0.5 to 1.0 m plus.	Stable foundation material, except where excessive thickness of fines present.	Some risk of stream avulsion.
aLb/xAf	Alluvial fan blanketed by lacustrine sand and gravel gently sloping, but few small ridges; moderately well to well drained.	Between 0.5 and 2.0 m of gravel and sand over interbedded gravel, sand and silt.	Permafrost with many taliks; ground ice generally low to nil in sand and gravel; frequently medium to high in fines; active layer 0.5 to 1.5 m plus.	Stable foundation material except where excessive thickness of frozen fines present.	Some risk of stream avulsion.
aLb/tMm	Undulating moraine blanketed by lacustrine sand and gravel; slopes vary up to 5 degrees; well drained.	Between 0.5 and 2.0m of gravel and sand over compact silty sandy till.	Permafrost continuous, but probably relatively thin; ground ice contents low to nil; active layer 0.5 to 1.5 m plus.	Stable foundation material.	

Table 5.1 Descriptive Legend of Survidial Materials at Destruction Bay (cont'd)

xLp	Lacustrine plain; flat to very gently sloping; imperfect to poor drainage.	Interbedded clay, silt, sand and gravel; probably exceeding 1 m in thickness.	Unfrozen.	Fines poor foundation material.	Liquefaction and flooding.
aLr	Beach ridges; well drained.	One metre plus of gravel and sand (individual beach ridges indicated as symbols may only be 0.5 m thick and are underlain by a variety of materials).	Generally unfrozen.	Good foundation materials generally present.	Ridges at lake level subject to flooding and wave erosion.

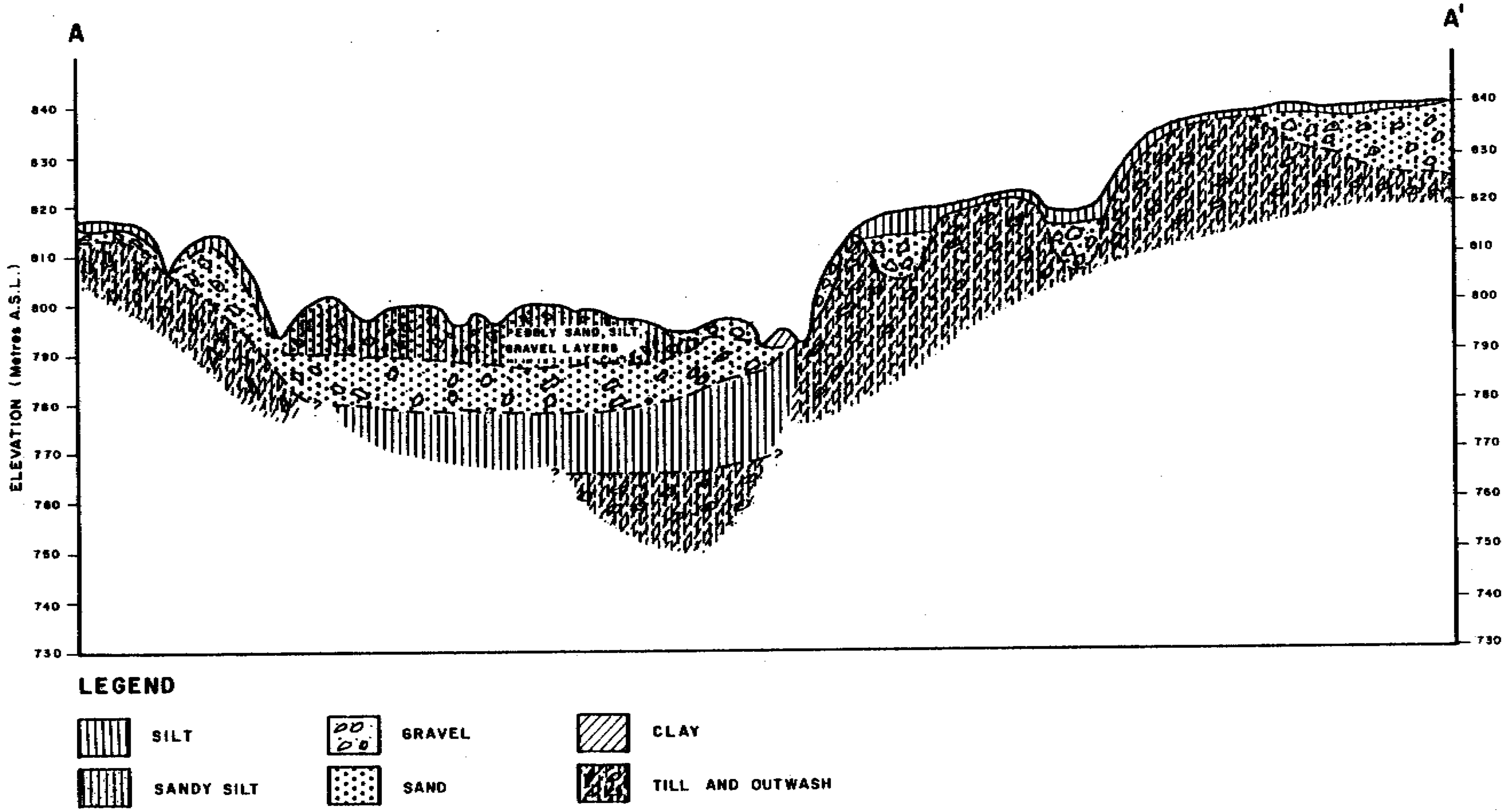


FIGURE 5.5.1 A.

GEOLOGICAL CROSS-SECTION

DESTRUCTION BAY

(See Map 5.5.1 for location.)

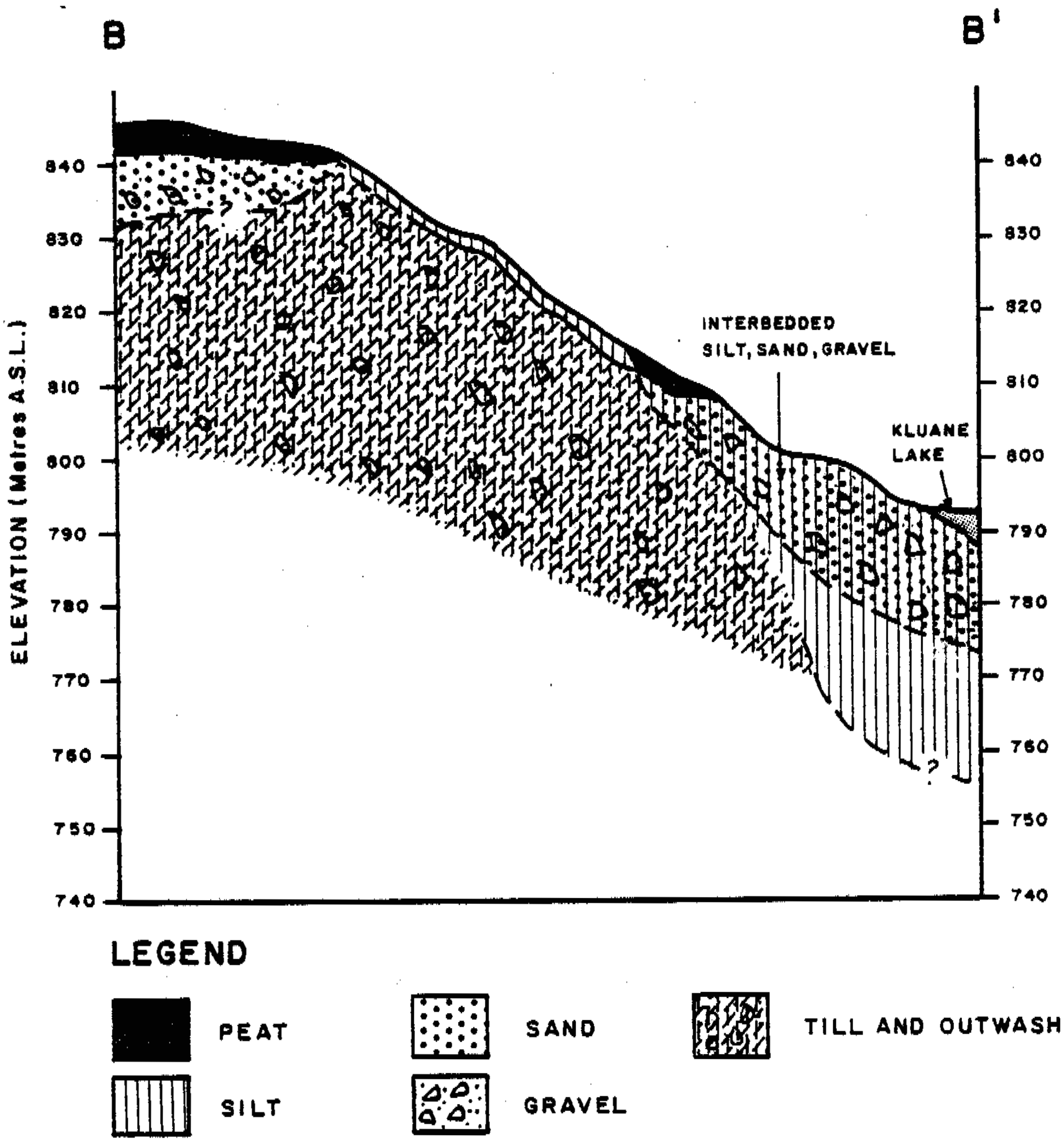


FIGURE 5.5.1. B

GEOLOGICAL CROSS SECTION

DESTRUCTION BAY

(See Map 5.5.1 for location.)

Bay is unknown, but Foothills Pipe Lines (South Yukon) Ltd. has drilled many holes to depths between 10 and 15 metres that have failed to reach the base of permafrost in the vicinity of Destruction Bay.

Destruction Bay is within 10 km of a line of features indicating recent fault activity about 10,000 years ago and tends to be affected by earthquakes due to its proximity to this fault and a zone of high seismic activity in the St. Elias Mountains to the south. A slight risk of a large block detaching itself from the glacially oversteepened face of the Kluane Ranges and moving across the valley to cover Destruction Bay is also present. However, this hazard is probably negligible as the last landslide in this area appears to be of great antiquity, and no signs of imminent slope instability is present along the mountain front.

5.2 Terrain Types and Their Characteristics

Map 5.1 and figures 5.5.1a,b shows the distribution of terrain types at Destruction Bay. The geomorphology, slope distribution, drainage, nature and thickness of materials, permafrost distribution, ground ice contents, active layer thicknesses, ground stability, engineering characteristics and potential hazards for each mapped terrain type are given in Table 5.2 . Detailed grain size analysis for typical surficial materials are given in Appendix B.

5.3 Suitability Maps

Suitability maps for road construction, building construction and underground utility installation, sewage lagoons and sanitary landfills, septic systems and construction materials including granular materials are presented (Maps 5.3.1 - 5.3.5). These suitability maps are derived following the techniques outlined in Section 3.3 of this report.

5.3.1 Suitability for Road Construction

The suitability map for road construction (Map 5.3.1) assumes that roads for year-round use are to be constructed and maintained on undisturbed terrain. For the purposes of drainage it is assumed the roads are graded, and ditches are present where required. The subgrade is to consist of materials underlying the roadway and the base material is to be locally obtained where possible. No provision is made on the suitability map for the source of surfacing material, which is assumed to be stabilized crushed gravel, till or rock.

The terrain factors were evaluated on the basis of how they affect the initial construction and how they affect load capacities and maintenance. Slope, drainage, permafrost, bedrock depth, and material primarily affect initial construction, whereas flood hazard, ice contents, and miscellaneous hazards primarily affect maintenance. The terrain property guidelines for assessing suitability for highway and road construction and maintenance are defined in Table 5.3.1.

5.3.2 Suitability for Building Construction and Utility Installation

The suitability map for building construction and utility installation (Map 5.3.2) assume that buildings are to have basements and utilities are buried in the ground. It is assumed that standard construction procedures are used except that special insulative procedures are used in areas of permafrost. It is also assumed that ground conditions are such that some mobility is viable in the vicinity of the buildings, and that utility and ground surface maintenance is minimal.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and how they affect the continued stability and maintenance of the building, building

Table 5.3.1 Terrain Property Guidelines for Assessing Suitability for Highways and Roads

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of all-weather highway and roads (without asphalt surface).

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Less than 8 degrees	Less than 12 degrees	Slopes between 12 and 18 degrees	Greater than 18 degrees
Drainage (wt)[1]	Rapid to well; greater than 1 m to water table	Well to moderately well; greater than 0.75 m to water table	Moderately well to imperfect; water table generally 0.50 to 0.75 m	Imperfect to poor; water table less than 0.5 m	Poor, water table continuously near-surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 to 100 years	Annual flooding	Flooding more than once a year
Permafrost and[2] ice contents (pf)	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep; isolated rock fall; evidence of faulting within last 10,000 years	Slight chance of glacier readvance or sediment liquefaction; possibility of fault-induced surface rupture within next 100 years; rock falls common	Possibility of landslide, sediment liquification within next 100 years; rapid solifluction, nivation or surface creep
Bedrock depth (br)	Greater than 2 m	Greater than 1.0 m	Between 0.5 m and 1.0 m	Less than 0.5 m	Generally near surface
Material composition and stoniness[4,5] (mt)	Gravel and sand, sandy till; stones less than 5 percent	Clayey till, silty sand, silty gravel; stones less than 10 percent	Clayey silt, sandy silt; stones less than 25 percent	Clay, organic silt, peat up to 2 m thick; stones 25 to 50 percent	Thick peat; stones greater than 50 percent

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).
2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.
3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).
4. Due to frost heaving, terrain units having significant contents of silt and clay in areas of imperfect and poor drainage should be altered to one less degree of suitability if material is the limiting factor; where the highway is to be surfaced by asphalt the suitability should be more severely altered.
5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

Table 5.3.2 Terrain Property Guidelines for Assessing Suitability for Building Construction and Utility Installation

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction or installation and maintenance of buildings and underground utilities.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 12 degrees	Slopes between 12 and 20 degrees	Greater than 20 degrees
Drainage (wt)[1,2]	Rapid to well; greater than 2.5 metres to water table	Well to moderately well drained; greater than 1.5 metres to water table	Moderately well to imperfect drainage; 0.5 - 1.0 metres to water table	Imperfectly or poorly drained; <.5 m to water table	Poor drainage; water table continuously near surface
Flood Hazard (fl)	None	None	Very rare; subject to once in 100 years or less	Occassional; subject to once in 10 to 100 years	Annual flooding
Permafrost and ice contents[2,3] (pf)	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<1.0 metres) sediment with medium to high ice contents	Permafrost with up to 1 metre of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 metre
Hazards due to[4] mass wastage, fault activity, (glacier advance, etc.)(hz)	No hazards	No hazards	Slow near-surface soil creep; within 1 km of post glacial active fault	Slight chance of glacier advance or sediment liquefaction; rock fall present; evidence of faulting within last 10,000 years	Possibility of landslides, fault-induced surface rupture, sediment liquefaction or glacier advance within next 100 years; rapid solifluction, nivation or soil creep
Bedrock depth (br)	Always greater than 2.5 m	Usually greater than 2 m	1 - 2 metres	Less than 1 metre	Generally at surface
Material composition and stoniness (mt)	Gravel and sand; sandy till; stones less than 5%	Clayey till; clayey silt and silty sand less than 1 m thick; stones less than 15%	Thick silty sand, silt, silty clay, stones 15 to 25%	Thick clay; organics to 2 m in depth, stones 25 to 50%	Organics greater than 50%; stones greater than 50%

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. In cases of buildings without basements and where the limiting factors are drainage, permafrost and ice contents or bedrock depth, the degree of suitability should be altered to a more favorable rating because of less interaction between the undisturbed terrain type and the buildings in this mode of construction.

3. Ice contents given in percent volume excess ice: low <-10%; medium 10-20%; high >20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and Ice Contents (pf).

5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

site and utility. Slope, permafrost, bedrock depth, material composition and stoniness primarily affect construction and excavation whereas drainage, flood hazard, ice contents, and hazards due to mass wastage, glacier advances, faulting, liquefaction primarily affect stability and maintenance. The terrain property guidelines for assessing suitability for building construction and utility installation are defined in Table 5.3.2.

5.3.3 Suitability and Optimum Locations for Sewage Lagoons and Sanitary Landfills

The suitability map for sewage lagoons and sanitary landfills assumes that the sewage lagoons and sanitary landfills are to be constructed through shallow excavations or through the construction of berms on the undisturbed ground surface. The prevention of pollution through the movement of surface or ground water to terrain surrounding the facilities was considered to be of prime importance in their location. Minimal maintenance of berms and other confinements to the movement of pollutants was also considered paramount.

The guidelines for sanitary landfills are generally less severe than for sewage lagoons as no fluid pollutants are initially introduced. Thus the suitability maps give a more conservative evaluation of terrain for use of sanitary landfills than sewage lagoons; in many cases the suitability classification for sanitary landfills can be adjusted to the next higher suitability classification to that which is shown on the suitability maps for sewage lagoons and sanitary landfills.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and berm emplacement and how they affect continued berm stability and prevention of pollution. Slope, flood hazard, permafrost, hazards due to mass wastage, glacier advance, faulting, liquefaction, bedrock depth and material composition were considered primarily for their influence on pollutant confinement.

Locations where grain size analysis have been completed are plotted on Map 5.3.3 and show the basis on which the material compositions and permeabilities have been related. Grain size distributions for typical materials collected during the field investigations and located on Map 5.3.3 are shown in Appendix B.

In addition to drainage and material stoniness, many of the above terrain factors would also affect lagoon and landfill construction and maintenance. The terrain property guidelines for assessing suitability for sewage lagoons and sanitary landfills are defined in Table 5.3.3.

Areas containing possible optimum locations for sewage lagoons and sanitary landfills are contained within those areas classified as FAIR on the suitability map.

Table 5.3.3 Terrain Property Guidelines for Assessing Suitability for Sewage Lagoons and Sanitary Landfills

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to impound water, sewage, and leachate to be evaluated.

Terrain Factor (symbol)	Degree of Terrain Suitability Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)[1]	Less than 1.5 degrees	Less than 3 degrees	Less than 8 degrees	Less than 15 degrees	Greater than 15 degrees
Drainage (wt)[2]	Rapid to well drained; water table 1.5 m plus	Moderately well drained; water table generally 1.0 m plus	Imperfectly drained; water table generally 0.5 to 1.0 m	Poorly drained; water table generally less than 0.5 m	Permanently wet; water table continuously near surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Rare; subject to once in 50 years to 100 years	Occasional; subject to once in 5 to 50 years	Frequent; subject to at least once a year
Permafrost and ice contents[3] (pf)	No permafrost	Scattered permafrost with low ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediments with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep	Slight chance of glacier advance; evidence of faulting within last 10,000 years; some rock fall	Rapid soil creep or solifluction prevail; possibility of landslide, fault induced surface rupture, sediment liquification, or glacier advance within next 100 years
Bedrock depth (br)	Greater than 1.5 metres (blanket)	Greater than 1.0 metres (blanket)	Between 0.5 and 1.0 metres (veneer)	Less than 0.5 metres (veneer)	Generally at surface
Material composition and stoniness[5] (mt)	Silty clay; less than 3 percent stones	Clayey silt and silt; clayey till and compact till; 3 to 10 percent stones	Silt with some organic content; sandy or gravelly silt or clay; loose till; 10-25 per cent stones	Silty sand and silty gravel; less 25-50 per cent stone	Sand and gravel; greater than 50 percent stones peat

1. Slopes are a more limiting factor to the construction of viable sewage lagoons than sanitary landfills. Thus terrain unit suitability for sanitary landfills should be altered to one less severe degree of suitability if slope is the limiting terrain factor.

2. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

3. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high > 20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

5.3.4 Suitability for Septic Systems

The suitability map for septic systems (Map 5.3.4) assumes that the effluent from a septic tank is to be distributed in the natural surficial material by means of a sub-surface or raised tile. It was assumed that it would be required that water bodies and water supplies within 60 metres and surface water are not to be polluted by the septic system. It is also assumed that the systems are to be emplaced by standard procedures and that ground surface maintenance following emplacement is to be minimal.

The permeability of surficial materials with a terrain type was considered extremely important in evaluating terrain types for septic field suitability because the absorption of effluent without the pollution of water supplies or water bodies greater than 60 metres from the septic field is of prime importance. Grain size distributions for typical materials collected during the field investigations and located on Map 5.3.4 are shown in Appendix B.

The terrain factors were evaluated on how they affect initial sewage systems emplacement and maintenance and how they affect absorbtion of effluent and pollution prevention. The material composition, mainly its permeability, was considered of prime importance in evaluating terrain types for septic field suitability. Other terrain factors such as slope, drainage, permafrost, flood hazards, hazards due to mass wastage, glacier advances, liquefaction and faulting, and bedrock depth primarily affect the continued prevention of pollution of adjacent surface water, water bodies and water supplies; and to a lesser degree the emplacement and maintenance of the septic systems. The terrain property guidelines for assessing suitability for septic systems are defined in Table 5.3.4.

Table 5.3.4 Terrain Property Guidelines for Assessing Suitability for Septic Systems

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of septic systems.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 8 degrees	Between 8 and 15 degrees	Greater than 15 degrees
Drainage (wt)[1]	Well drained; water tables deeper than 1.5 m	Moderately well drained; water tables occasionally rise to levels above 1.5 m	Moderately well to imperfectly drained; water tables usually 0.5 m below surface	Imperfectly to poorly drained; seasonal surface ponding of water	Poorly drained; surface ponding common
Flood Hazard (fl)	None	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 years or less	Occasional; subject to once in 5 years or less	Annual flooding
Permafrost and[2] ice contents (pf)	None	Rare permafrost; generally no ground ice	Discontinuous permafrost	Permafrost present with rare areas having shallow (0.5 m) sediment with medium to high ice contents	Continuous permafrost with many areas having shallow sediment with medium to high ground ice contents
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	None	None	Minor soil creep	Some rock fall; slight chance of glacier advance; evidence of faulting within last 10,000 years	Rapid soil creep, solifluction and nivation; active landslide activity at site or on adjacent slope; possibility of glacier advance or liquifaction within next 100 years
Bedrock depth (br)	Greater than 1.5 m	1 to 1.5 m	0.5 to 1 m	Less than .5 m, uneven thickness (veneer)	Generally less than 0.5 m
Material composition and stoniness[4] (mc)	Fine to coarse sand; loose sandy till; less than 5 percent silt, clay and stones	Sand and loose sandy till; 5 to 20 percent component of silt, clay and stones	Sand, gravelly sand, sandy till; 20 to 50 percent component of silt, clay and stones	Gravel, silt and clay content greater than 70 percent of unit; clayey till	Gravel, clay, silt, stone content greater than 50 percent; peat

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

5.3.5 Suitability and Availability of Construction Materials

The suitability map (Map 5.3.5) assumes that the construction materials are to be used as aggregate or fill. The suitability of the different terrain types are evaluated according to the quality and quantity of the surficial materials within it, and the workability and ease of extraction of those materials. Materials that are required to be impermeable such as dikes are excluded from consideration; the suitability for sewage lagoons and sanitary landfills give a partial assessment of suitability for impermeable materials. The suitability of bedrock as a construction material has not been evaluated. Terrain types containing gravel and sand with potential as aggregate are given the highest suitability classification as they can easily be adapted to most construction purposes. Other terrain types are evaluated on the basis of the compressibility, compactibility, susceptibility to frost action and surface trafficability of the surficial materials within them.

The terrain factors were evaluated on the basis how they affect the usefulness and versatility of the contained materials as a construction material, the ease or difficulty of extraction, and the volumes that could be extracted from a unit area. Material composition and stoniness primarily affects usefulness as a construction material, whereas slope, drainage, permafrost, flood hazard, miscellaneous hazards, and bedrock depth affect the extractable volumes per unit area and the ease or difficulty of extraction. The terrain property guidelines are defined in Table 5.3.5.

A number of sources of aggregate have been outlined on map 5.3.5. The gravel:sand:fines ratios (based on grain size distribution obtained during this and earlier investigations), and the cu. metres per hectare of deposits (based on our estimate of minimal extraction thicknesses) are indicated for each source.

Table 5.3.5 Terrain Property Guidelines for Assessing Suitability for Construction Materials Including Workability and Usefulness as General Fill and Sources of Gravel and Sand

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated as a potential source of construction materials, including sand and gravel.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Between 5 and 12 degrees	Between 12 and 20 degrees	Between 20 and 30 degrees	Greater than 30 degrees
Drainage (wt)[1,2]	Rapid to well; water table >2 m	Well to moderately well; water table 1.0 to 2 m	Imperfect to moderately well; water table 0.5 to 1.0 m	Imperfect to poor; water table less than 0.5 m	Permanently wet; water table near surface
Flood Hazard (fl)	None	Very rare; subject once in 100 years or less	Occasional to rare; subject to once in 5 to 100 years	Frequent; subject to annual flood	Very frequent; flooded more than once per year
Permafrost and[3] ice contents (pf)	None	Scattered permafrost with low ground ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	Flow near-surface soil creep	Rapid soil creep or solifluction; evidence of faulting within last 10,000 years; chance of glacier advance	Possibility of landslide, surface rupture or sediment liquification within next 100 years	Imminent possibility of landslide and sediment liquification
Bedrock depth (br)	Greater than 2 m	Between 1.5 and 2 m	Greater than 1.0 m (blanket)	Between 0.5 and 1.0 m (veneer)	Less than 0.5 m
Material composition and stoniness[5] (mt)	Gravel and sand; stones less than 3 percent	Silty sand, silty gravel, sandy till; thin cover (veneer) over sand or gravel; stones less than 10 percent	Till, silty fine sand; stones less than 25 percent	Silt, clay, clayey silt, thick cover (blanket) over sand and gravel; 25 to 50 percent stones	Peat, organic silts; greater than 50 percent stones

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in percent volume excess ice: low <10%; medium 10-20%; high >20%.

3. Water tables are considered only where permafrost is absent as a perched water table is generally present where permafrost is present. However, only a limited and easily controlled amount of water would be introduced from most excavations from this perched water table.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

The area in which 73PY is located on map 5.3.5 probably contains the largest source of near-surface gravel and sand closest to Destruction Bay; although much of this area may be limited by medium depths of overburden, imperfect drainage and flood hazard, further investigations would certainly establish easily extractable reserves of gravel and sand that total beyond the foreseeable requirements of Destruction Bay.

Patches of gravel and sand are present on the surface of most units east of Destruction Bay along the Alaska Highway, and gravel and sand are generally present under the till forming the surface. However, these sources involve either disturbing large areas or costly stripping of overburden. Gravel and sand is also common along the scarps along the edge of Kluane Lake northwest of Destruction Bay, but again are covered by thick overburden. Large volumes of gravel are present in alluvial-fans east of the Destruction Bay study area. However, this would involve large haul distances and extra cost.

Till for fill and road binding purposes is available immediately east of Destruction Bay in all areas marked as F - pf, mt on map 5.3.5.

5.3.6 Recreation and Cottage Areas

Some areas of excellent potential for recreation and cottage development are present within the Destruction Bay study area. These areas allow for increased access, foot and vehicle travel and cottages with some type of sewage disposal, preferably a septic system.

Map 5.3.2, which gives the suitability for building construction and utility installation, and map 5.3.4, which gives the suitability for septic systems, are a guide to areas most suitable for recreational and cottage development. The areas southeast of Destruction Bay and north of the Alaska Highway that are mapped as FG - pf, mt and F - pf on map 5.3.2 and as F - pf and P - pf, mt on map 5.3.4 appear to be best suited for recreation and cottage development. That area mapped as FG - pf, mt on map 5.3.2 having a gradual slope to lake levels appears to be extremely favourable.

5.4 Unique Features

Few particular and unique features are present at Destruction Bay. At (1), (2), and (3) on map 5.5.1 features are present that relate to the high Neoglacial lake level of Kluane Lake. At (1) some indistinct sands and gravel raised beach ridges are present; at (2) submerged tree stumps are visible in the lake; and at (3) fine-grained Neoglacial lake sediments bury a soil layer overlying alluvium. With the exception of unique feature (3) all are better illustrated at other sites around Kluane Lake.

5.5 Hydrogeolgy

The hydrogeology of Destruction Bay is described under the headings of well survey, water quality, groundwater flow regime and water supply potential.

5.5.1 Well Survey

A well survey of the community of Destruction Bay identified 6 wells that are presently in use and include a communal well which services the village core; and an additional 8 wells which are not operative at present. These wells are located on Map 5.5.1 and the available hydrogeological information about them is summarized on Table 5.5.1 of this report. Well depths vary significantly from 15-20 m deep to 161 m. All wells are drilled and no dug wells or surface water sources are used for water supply in the community.

Table 5.5.1 Hydrogeological Data, Destruction Bay

Well No.	Description	Depth	Static Level	Use	Yield	Log
DB8 (1963)	Talbot Arms Hotel	20.7 m	flowing	hotel -not in use	sufficient for large lodge	no log, water highly corrosive
DB1 (1973)	Talbot Arms Hotel	87 m	<5 m	hotel	sufficient for large hotel and restaurant	no log, soft water
DB2 (1955)	Destruction Bay Lodge Ltd.	28 m	flowing	abandoned	used for small lodge	no log
DB3	Yukon Territorial Government yard	shallow estimated 15 to 20 m	near surface	yard uses	low volume	no log
DB14	Boat rental building	56 m	flowing	not in use	unknown	continually froze shut at 30 m depth
DB8	Dept. of Public Works	unknown	2.3 m	not in use	unknown	no log
DB6	Yukon Electric (Eikland household)	75 m	<5m	domestic	very low yield, 1200 l storage tank used	no log, well runs out of water on occasion
DB9	Canadian National Telecommunications	30 m	close to surface	not in use	unknown	no log

Table 5.5.1 (cont'd)

Well No.	Description	Depth	Static Level	Use	Yield	Log
DB10,11	Test wells in new subdivision east of Destruction Bay	no data	not flowing	domestic use intended	no data available	completed by Midnight Sun Drilling Ltd.
	Community Wells					
DB12 (1940's)	#1	30 m	unknown	village water supply	45 l/min	silt problem
DB13 (1940's)	#2	24 m	unknown	as above	not known	silt problem
DB5	#3	161 m	near surface	village water supply		see text
DB4	Parks Canada Residence	88 m	2.7 m	domestic residence	180 l/min	

Three of the sampled wells (30m, 24m and 161 metres deep), which are adjacent to the lake, presently furnish the communal groundwater supply for the village. The deep well is the only one in the village with a stratigraphic log (Hydrogeological Consultants Ltd. 1978). Other data was obtained from local residents and Parks Canada and Department of Transport files.

5.5.2 Water Quality

The water chemistry of the 6 wells sampled in Destruction Bay is outlined as Table 5.5.2a. An analysis of raw Kluane Lake water was included to examine the possibility of recharge of wells from the lake.

Bicarbonate is the major anion in the wells at Destruction Bay lodge, at the Yukon Territorial Government yard and at the Parks Canada residence. These wells all have very hard water although the first two are a bicarbonate (minor sulphate) - magnesium (minor calcium) type and the last is a bicarbonate (minor sulphate) - calcium (minor magnesium) type. These wells have a low chloride content, a characteristic which is typical of the region. The concentrations of 373.1, 321.8 and 244.5 ppm total dissolved solids and variations in minor and trace element chemistry show that different aquifers are being utilized in each case.

The Talbot Arms Hotel, Town Water Supply and Yukon Electric wells are all sulphate (minor bicarbonate) - alkali earth cation waters. Sodium predominates in the first, magnesium in the second and equal amounts of each cation are found in the third.

There is no geochemical evidence to suggest that any well is recharging from Kluane Lake waters which is a slightly mineralized sulphate (minor bicarbonate) - calcium (minor magnesium) type.

Table 5.5.2 a

WATER CHEMISTRY DATA (Destruction Bay)

(in mg/l unless indicated)

Sample	HCo_3^-	uMlios Cond.	Ca^{++}	Mg^{++}	Na^+	K^+	Fe^{+2}	Mn^{+2}	No_3^-	Cl^-	$So_4^=$	mg/l $Po_4^{\equiv}$	Surface Water or Aquifer	Approx TDS	Hardness	(mg/l $CaCo_3$)
Talbot Arms Hotel	109	560	25	36.2	37.5	1.75	-	-	3.0	N.D	184	31		392	210.9	very hard
Destruction Bay Lodge	374	820	43.7	91	15	3.1	.2	.12	-	3.5	115	31		574	373.1	very hard
Yukon T. Government Yard	231	660	41.8	53	22.5	2.37	.1	.11	.44	-	142	2142		462	321.8	very hard
Parks Canada Residence	238	520	65	20	4.25	.6	.05	-	1.5	-	41	-		364	244.5	very hard
Town Water Supply	150	600	22.5	50	22.5	2.5	.1	-	1.72	3.5	162	-		420	261.3	very hard
Yukon Electric (Eikland Home)	87	580	21.3	37.5	37.5	1.5	.1	-	1.86	-	207	-		406	207.0	very hard
Kluane Lake (waterfront)	86	380	27.5	16.3	4.25	.25	.05	-	-	-	91	-	Lake Sample	266	135.6	hard
Lewis Creek	75	260	20.0	7.5	1.75	1.12	.05	-	.13	-	37	31	Surface water	182	80.7	moderately soft
Congden Creek	281	660	62.5	35.0	5.5	1.0	.8	.32	-	-	68	-	Surface water	462	299.8	very hard

All samples are considered to be chemically potable except the Yukon Territorial Government well which is very high in phosphate (2142 mg/ml). This well may be contaminated from the truck and equipment washing facilities which are in close proximity to the well. It is understood that the well only furnishes water for this purpose in any case and is not used for human consumption.

5.5.3 Groundwater Flow Regime

Existing test drilling results and groundwater flow information are summarized in the following sections of this report. Two cross sections have been included to show the stratigraphy of the Destruction Bay area based on available water-well and bore hole logs (Figures 5.5.1a, b). The stratigraphy at depth beneath the village is shown on Table 5.5.2b (after Hydrogeological Consultants Ltd. 1978) from data obtained during drilling of the community well in the village.

A) Test Drilling Results

A test well was drilled in 1978 to a 161 metre depth beside the existing communal wells at the village water front. It penetrated an 11.5 m (38 foot) thick alluvial fan complex. This unit overlies a 9.4 m (31 foot) glaciolacustrine silt/clay stratum, a thick 92.9 sequence of cobbley, sandy and dense hard glacial till, another lacustrine unit 19.2 m thick and a 24.9 m cobbley till stratum. This entire geological section is underlain by a brown silty unit of unknown origin and total thickness. Bedrock was not reached in this well.

Potential water bearing zones were identified at the 74.0 to 75.3 m, 44.8 to 46.3 m and 33.2 to 34.4 m depths in the well. No major water bearing zones were found in any of the glaciolacustrine, alluvial or morainal terrain units described above. The 32.2 m to 34.4 m zone which might be interpreted as thin

Table: 5.5.2b

Stratigraphy of Destruction Bay
Community Well
(After Hydrogeological Consultants Ltd. 1978)

Depth (m)	Lithology	Terrain Unit
0	Gravel with some silt	xAf
	Clay	L
30.5	Till; soft	
	Till; with sand layers	
61	Till; hard	M
	Till; with one layer of coarse gravel	
91.5	Till; cobbled	
	Silt; black	
	Clay; grey	
	Silt; dark grey	
122		
	Clay; hard grey silty	L
	Clay; silty	
152.5	Till; cobbled	M
	Silt; brown	Unknown
167	To bottom of hole	

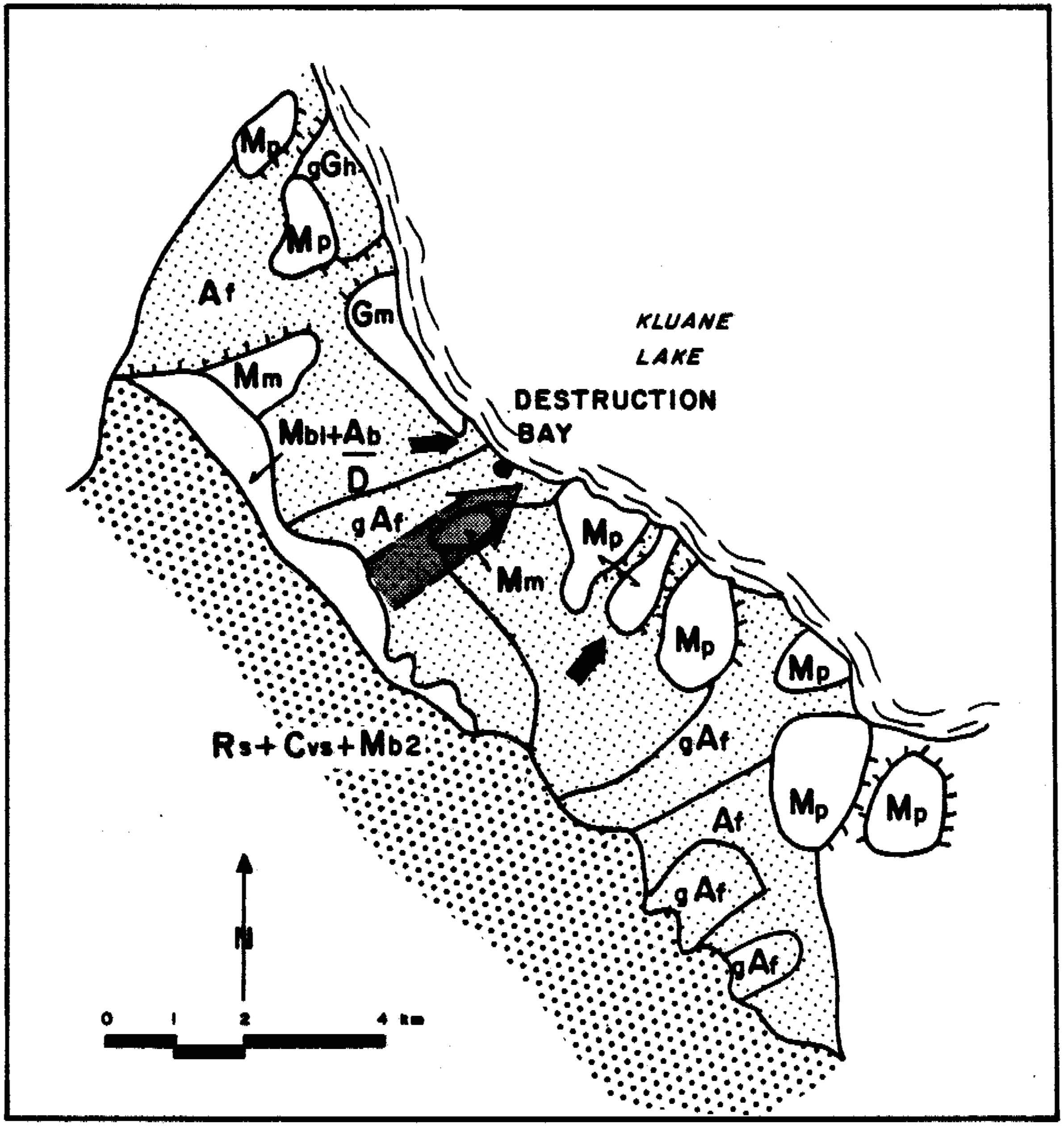
glaciofluvial sand/gravel unit found within the major till sequence proved to be water bearing. A 94.5 litre/minute flow was blown from the well during development after installation of a well screen in this zone. The effective transmissivity of the aquifer is 6 x 10^2 ipd/ft.

B) <u>Groundwater Flow Directions</u>

Table 5.5.1 indicates the depths of aquifers which are being utilized in each well in Destruction Bay. A wide variation (627 to 779 m A.S.L.) is evident even between wells which are in very close proximity which suggests that aquifers are thin and discontinuous laterally.

All wells have been drilled to a depth of at least 15 metres below the ground surface and are considered to be utilizing confined aquifers in the till and gravel units, which underlie much of the Destruction Bay area. No dug or drilled wells in the Alluvial Fan sequences have been constructed in this settlement. The potential of this terrain unit to provide adequate quantities of good quality water should be reasonable, but freezing problems are a major constraint of wells in shallow unconfined aquifers however.

Surficial terrain units and probable groundwater flow directions are summarized on Figure 5.5.3. Both the predominant regional and local groundwater flow directions are to the northeast towards Kluane Lake. Unconfined permeable alluvial fan and glaciofluvial materials which are exposed at the surface, cover a large area of the region. These units generally overlie a thick low-permeability till sequence and recharge from surface precipitation. The fact that three flowing wells are present in the village suggest that deeper aquifers are recharging from higher elevation rock, colluvium and sloping alluvial fan units southwest of the study area, especially in the area where the Shakwak Trench



LEGEND

LOCAL GROUNDWATER RECHARGE WHERE PERMAFROST NOT AT SURFACE

PRINCIPAL RECHARGE AREA FOR DESTRUCTION BAY WELLS (High sensitivity to contamination.)

POSSIBLE GROUNDWATER FLOW DIRECTIONS;

REGIONAL GROUNDWATER FLOW

NEAR SURFACE (Local) GROUNDWATER FLOW

FIGURE 5.5.3.

GROUNDWATER FLOW

DESTRUCTION BAY

(the broad valley in which Kluane Lake lies) adjoins the Kluane Range. Probably some hydraulic connections are also present throughout glaciofluvial deposits and till sequence. The possibility exists that vertical movement of water from the surface is occuring through the surficial complex to generate these artesian pressures. This recharge source cannot be verified with existing data however, and is considered unlikely if till units are continuous because of the till observed where morainal units are exposed at the surface generally has low permeability. Permafrost in parts of the alluvial-fan complex would also inhibit local recharge where permafrost was present.

5.5.4 Water Supply Potential

The following conclusions can be made about the water supply potential of the Destruction Bay area.

A) Most geological materials buried at depth beneath Destruction Bay are of glaciolacustrine and morainal origin and are not waterbearing. The potential for the development of major aquifers as water supplies is very limited in these strata. For example, the aquifer developed during the drilling of communal well no. 3 is a thin stratum of permeable sand and gravel, perhaps of glaciofluvial origin. The safe yield and transmissivity of this aquifer is low and the potential exists to service only 3 or 4 domestic residences from this one source. High turbidity problems are often associated with this type of aquifer.

B) High yields of potable water may be present in unconfined near-surface alluvial-fan and glaciofluvial sand/gravel deposits. However, freezing problems are likely to preclude use of these aquifers for future development. Due to the high permeability of this type of terrain the contamination risk of shallow wells from any pollutant source (sewage, hydrocarbon spills, etc.) is high.

C) Future development in Destruction Bay will likely require the construction of well fields consisting of several 20 - 100 m deep properly screened low volume wells supplying a communal distribution system.

6.0 BURWASH LANDING

6.1 Setting

Burwash Landing is located near the western end of Kluane Lake in the Shakwak Trench, which is the physiographic expression of a large fault system that transects both Alaska and Yukon Territory, and that has been active during the late Tertiary and Pleistocene. At Burwash Landing, the ground surface rises gradually from about 780 metres at Kluane Lake to about 1120 metres at the edge of the Shakwak Trench. Near Kluane Lake, the terrain is gently sloping or undulating except for some small scarps of 10-15 metres formed by wave erosion near Kluane Lake.

At Burwash Landing, thick unconsolidated deposits are the result of deposition during several Pleistocene glacial and interglacial periods, and include till, outwash, glaciolacustrine silt and clay, and alluvial silt, sand and gravel. Most of the surface materials shown on map 6.1, and figure 6.1 were deposited during or after the Macauley glaciation. During this glaciation a large trunk valley glacier flowed northwest along the Shakwak Trench. At Burwash Landing undulating and flat moraine (tMm, tMp), outwash (aGp), and during its later phases, loess (mEv) were deposited during this glaciation. Peat (Ob) has begun to accumulate in swales in morainic areas.

During the waning stages of the Macauley glaciation, Kluane Lake drained to the northwest. However, during the hypsithermal, the Kaskawulsh Glacier at the head of the Slims River retreated far up its valley and allowed Kluane Lake to drain to the Alsek River and to be lowered by over 40 metres. Rapid formation and aggradation of the alluvial-fans flanking the Kluane Ranges that occurred following deglaciation of the Shakwak probably continued near Burwash Landing, as material was not being removed from the base of the alluvial-fans by the Kluane River.

During Neoglacial time, the Kaskawulsh Glacier re-advanced, blocked the drainage of Kluane Lake to the Alsek River, and caused Kluane Lake to rise to an elevation 10 to 12 metres above its present elevation. A new outlet (the present Kluane River) was re-established to the northwest and Kluane Lake quickly returned to near its present level. This new level of Kluane Lake probably caused some erosion on the Duke River alluvial-fan. Alluvium deposited by the Duke River is mainly gravel near Burwash Landing (gAf).

The Neoglacial rise in the level of Kluane Lake has resulted in some areas below elevations of about 792 metres having a capping of wave-washed material (aLv, sLb). Modern wave action continues to modify beach ridges and beaches at lake level. Shoreline erosion appears to be moderate at Burwash Landing.

Burwash Landing lies in an area where permafrost is near continuous. Only those units, eg. alluvial-fans, that are frequented by surface streams or that lack a significant capping of fine-grained sediment and peat (gAf) are free of permafrost. Even those portions of alluvial-fans having permafrost at their surface often have taliks throughout their total thickness because of groundwater percolating through them to Kluane Lake. Kluane Lake itself may also cause the thickness of permafrost to be relatively thin near it. The total thickness of permafrost at Burwash Landing is unknown, but Foothills Pipe Lines (South Yukon) Ltd. has drilled many holes to depths between 10 and 15 metres that have failed to reach the base of permafrost in the vicinity of Burwash Landing.

Burwash Landing is within 10 km of a line of features indicating recent fault activity about 10,000 years ago and tends to be affected by earthquakes due to its proximity to this fault and a zone of high seismic activity in the St. Elias Mountains to the south.

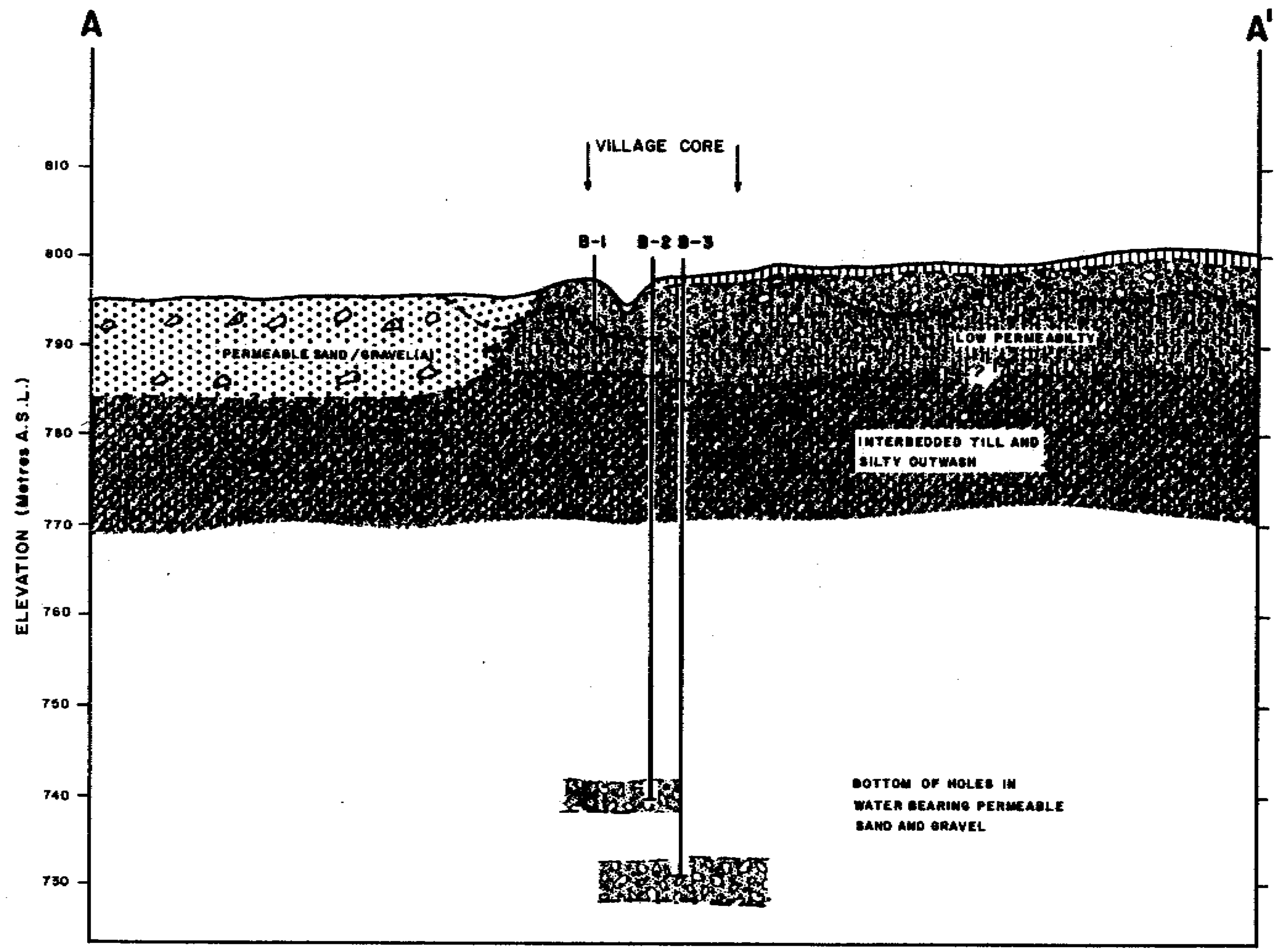


FIGURE 6.1
GEOLOGICAL CROSS SECTION
BURWASH LANDING

LEGEND

- SAND (L)
- SILT (E)
- GRAVEL (G)
- TILL (M)

B-2 WELL

A A' LOCATED ON MAP 6.5.1

6.2 Terrain Types and Their Characteristics

Map 6.1 and figure 6.1 show the distribution of terrain types at Burwash Landing. The geomorphology, slope distribution, drainage, nature and thickness of materials, permafrost distribution, ground ice contents, active layer thicknesses, ground stability, engineering characteristics and potential hazards for each mapped terrain type are given in Table 6.1. Detailed grain size analysis for typical surficial materials are given in Appendix B.

6.3 Suitability Maps

Suitability maps for road construction, building construction and underground utility installation, sewage lagoons and sanitary landfills, septic systems and construction materials including granular materials are presented (Maps 6.3.1 - 6.3.5). These suitability maps are derived following the techniques outlined in Section 3.3 of this report.

6.3.1 Suitability for Road Construction

The suitability map for road construction (Map 6.3.1) assumes that roads for year-round use are to be constructed and maintained on undisturbed terrain. For the purposes of drainage it is assumed the roads are graded, and ditches are present where required. The subgrade is to consist of materials underlying the roadway and the base material is to be locally obtained where possible. No provision is made in the suitability map for the source of surfacing material, which is assumed to be stabilized crushed gravel, till or rock.

The terrain factors were evaluated on the basis of how they affect the initial construction and how they affect load capacities and maintenance. Slope, drainage, permafrost, Table: 6.1 Descriptive Legend of Surficial Materials at Burwash Landing

Terrain Type	Geomorphology, Slopes, Drainage	Nature of Materials and Thickness	Permafrost, Ground ice, Active Layer	Miscellaneous Engineering Characteristics
$\frac{{}_{m}E_{v}}{{}_{t}M_{m}}$	Loess veneer over undulating moraine; slopes vary between 0 and 10 degrees; moderately well to well drained; low areas imperfectly drained.	Between 0 and 1 m of sandy silt over 1 to 10 m of compact silty sandy till over interbedded clay, sand, gravel and till.	Continuous permafrost with active layer of 0.3 to 1.0 metres; ground ice content nil to low except occasionally medium to high in loess.	Stable foundation material; susceptible to frost heave if unfrozen.
$\frac{{}_{m}E_{v}}{{}_{t}M_{p}}$	Loess veneer over morainic plain; slopes flat to very gentle, moderately well to well drained.	Between 0 and 1 m of sandy silt over 1 to 10 m of compact silty sandy till over interbedded clay, sand, gravel and till.	Permafrost continuous, but may be relatively thin near Kluane Lake; ground ice content nil to low except occasionally medium to high in loess; active layer of 0.5 to 1.0 metres.	Stable foundation material; susceptible to frost heave if unfrozen.
$\frac{{}_{m}E_{v}}{({}_{a}G_{ft}M)_{p}}$	Loess veneer over outwash and till plain; slopes flat to very gentle; well to moderately well drained.	Between 0 and 1 m of sandy silt over 10 metres plus of interbedded sand, gravel and till.	Permafrost continuous, but may be relatively thin near Kluane Lake with active layer of 0.5 to 1.0 metres; ground ice content nil to low except occasionally medium to high in loess.	Stable foundation material; loess and till susceptible to frost heave if unfrozen.
$\frac{O_{b}}{D_{p}}$	Organic blanket over undifferentiated undulating to flat till and outwash; all slopes nearly flat; imperfect to poor drainage.	Between 0.5 and 2.5 m of peat and organic silt over 0.5 to 1.0 m of interbedded clay, silt, sand over till, sand and gravel.	Generally continuous permafrost, although some taliks possibly due to water movement; medium to high ice contents in peat and fine-grained sediments; low ice contents in till and outwash; active layer 0.3 to 0.7 metres.	Thawed peat and fines are poor foundation material.

Table: 6.1 (cont'd)

${}_{g}A_{f}$	Alluvial fan; gently sloping; well drained.	Between 0 and 0.5 m of sand and silt over 5 m plus of gravel.	Discontinuous permafrost; active layer 0.6 to 1.2 metres plus; negligible ice contents.	Stable foundation material.
$\frac{{}_{a}L_{v}}{{}_{g}A_{f}}$	Wave washed alluvial fan; gently sloping; well drained.	Between 0 and 1.0 m of loose sand and gravel over 5 m plus of gravel.	Permafrost unlikely.	Stable foundation material.
$\frac{{}_{s}L_{b}}{{}_{g}A_{f}}$	Lacustrine blanket over alluvial fan; flat to gently sloping; imperfectly drained.	Between 0.5 and 1.5 m of silty sand over 5 m plus of gravel; patches of thin peat (<0.3 m) over sand.	Thin patches of permafrost with medium ice contents in the sand.	Thawed sand may be poor foundation materials.

Table 6.3.1 Terrain Property Guidelines for Assessing Suitability for Highways and Roads

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of all-weather highway and roads (without asphalt surface).

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Less than 8 degrees	Less than 12 degrees	Slopes between 12 and 18 degrees	Greater than 18 degrees
Drainage (wt)[1]	Rapid to well; greater than 1 m to water table	Well to moderately well; greater than 0.75 m to water table	Moderately well to imperfect; water table generally 0.50 to 0.75 m	Imperfect to poor; water table less than 0.5 m	Poor, water table continuously near-surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 to 100 years	Annual flooding	Flooding more than once a year
Permafrost and[2] ice contents (pf)	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep; isolated rock fall; evidence of faulting within last 10,000 years	Slight chance of glacier readvance or sediment liquefaction; possibility of fault-induced surface rupture within next 100 years; rock falls common	Possibility of landslide, sediment liquification within next 100 years; rapid solifluction, nivation or surface creep
Bedrock depth (br)	Greater than 2 m	Greater than 1.0 m	Between 0.5 m and 1.0 m	Less than 0.5 m	Generally near surface
Material composition and stoniness [4,5] (mt)	Gravel and sand, sandy till; stones less than 5 percent	Clayey till, silty sand, silty gravel; stones less than 10 percent	Clayey silt, sandy silt; stones less than 25 percent	Clay, organic silt, peat up to 2 m thick; stones 25 to 50 percent	Thick peat; stones greater than 50 percent

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Due to frost heaving, terrain units having significant contents of silt and clay in areas of imperfect and poor drainage should be altered to one less degree of suitability if material is the limiting factor; where the highway is to be surfaced by asphalt the suitability should be more severely altered.

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

bedrock depth, and material primarily affect initial construction, whereas flood hazard, ice contents, and miscellaneous hazards primarily affect maintenance. The terrain property guidelines for assessing suitability for highway and road construction and maintenance are defined in Table 6.3.1.

6.3.2 Suitability for Building Construction and Utility Installation

The suitability map for building construction and utility installation (Map 6.3.2) assume that buildings are to have basements and utilities are buried in the ground. It is assumed that standard construction procedures are used except that special insulative procedures are used in areas of permafrost. It is also assumed that ground conditions are such that some mobility is viable in the vicinity of the buildings, and that utility and ground surface maintenance is minimal.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and how they affect the continued stability and maintenance of the building, building site and utility. Slope, permafrost, bedrock depth, material composition and stoniness primarily affect construction and excavation whereas drainage, flood hazard, ice contents, and hazards due to mass wastage, glacier advances, faulting, liquefaction primarily affect stability and maintenance. The terrain property guidelines for assessing suitability for building construction and utility installation are defined in Table 6.3.2.

6.3.3 Suitability and Optimum Locations for Sewage Lagoons and Sanitary Landfills

The suitability map for sewage lagoons and sanitary landfills assumes that the sewage lagoons and sanitary landfills are to be constructed through shallow excavations or through the construction of berms on the undisturbed ground

Table 6.3.2 Terrain Property Guidelines for Assessing Suitability for Building Construction and Utility Installation

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction or installation and maintenance of buildings and underground utilities.

Terrain Factor (symbol)	Degree of Terrain Suitability Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 12 degrees	Slopes between 12 and 20 degrees	Greater than 20 degrees
Drainage (wt)[1,2]	Rapid to well; greater than 2.5 metres to water table	Well to moderately well drained; greater than 1.5 metres to water table	Moderately well to imperfect drainage; 0.5 - 1.0 metres to water table	Imperfectly or poorly drained; <.5 m to water table	Poor drainage; water table continuously near surface
Flood Hazard (fl)	None	None	Very rare; subject to once in 100 years or less	Occassional; subject to once in 10 to 100 years	Annual flooding
Permafrost and ice contents (pf)[2,3]	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<1.0 metres) sediment with medium to high ice contents	Permafrost with up to 1 metre of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 metre
Hazards due to[4] mass wastage, fault activity, (glacier advance, etc.)(hz)	No hazards	No hazards	Slow near-surface soil creep; within 1 km of post glacial active fault	Slight chance of glacier advance or sediment liquefaction; rock fall present; evidence of faulting within last 10,000 years	Possibility of landslides, fault-induced surface rupture, sediment liquefaction or glacier advance within next 100 years; rapid solifluction, nivation or soil creep
Bedrock depth (br)	Always greater than 2.5 m	Usually greater than 2 m	1 - 2 metres	Less than 1 metre	Generally at surface
Material composition and stoniness (mt)	Gravel and sand; sandy till; stones less than 5%	Clayey till; clayey silt and silty sand less than 1 m thick; stones less than 15%	Thick silty sand, silt, silty clay, stones 15 to 25%	Thick clay; organics to 2 m in depth, stones 25 to 50%	Organics greater than 50%; stones greater than 50%

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).
2. In cases of buildings without basements and where the limiting factors are drainage, permafrost and ice contents or bedrock depth, the degree of suitability should be altered to a more favorable rating because of less interaction between the undisturbed terrain type and the buildings in this mode of construction.
3. Ice contents given in percent volume excess ice: low <-10%; medium 10-20%; high >20%.
4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and Ice Contents (pf).
5. Stones are defined as clastshaving a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

Table 6.3.3 Terrain Property Guidelines for Assessing Suitability for Sewage Lagoons and Sanitary Landfills

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to impound water, sewage, and leachate to be evaluated.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)[1]	Less than 1.5 degrees	Less than 3 degrees	Less than 8 degrees	Less than 15 degrees	Greater than 15 degrees
Drainage (wt)[2]	Rapid to well drained; water table 1.5 m plus	Moderately well drained; water table generally 1.0 m plus	Imperfectly drained; water table generally 0.5 to 1.0 m	Poorly drained; water table generally less than 0.5 m	Permanently wet; water table continuously near surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Rare; subject to once in 50 years to 100 years	Occasional; subject to once in 5 to 50 years	Frequent; subject to at least once a year
Permafrost and[3] ice contents (pf)	No permafrost	Scattered permafrost with low ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediments with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep	Slight chance of glacier advance; evidence of faulting within last 10,000 years; some rock fall	Rapid soil creep or solifluction prevail; possibility of landslide, fault induced surface rupture,, sediment liquification, or glacier advance within next 100 years
Bedrock depth (br)	Greater than 1.5 metres (blanket)	Greater than 1.0 metres (blanket)	Between 0.5 and 1.0 metres (veneer)	Less than 0.5 metres (veneer)	Generally at surface
Material composition and stoniness[5] (mt)	Silty clay; less than 3 percent stones	Clayey silt and silt; clayey till and compact till; 3 to 10 percent stones	Silt with some organic content; sandy or gravelly silt or clay; loose till; 10-25 per cent stones	Silty sand and silty gravel; less 25-50 per cent stone	Sand and gravel; greater than 50 percent stones peat

1. Slopes are a more limiting factor to the construction of viable sewage lagoons than sanitary landfills. Thus terrain unit suitability for sanitary landfills should be altered to one less severe degree of suitability if slope is the limiting terrain factor.

2. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

3. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high > 20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

surface. The prevention of pollution through the movement of surface or ground water to terrain surrounding the facilities was considered to be of prime importance in their location. Minimal maintenance of berms and other confinements to the movement of pollutants was also considered paramount.

The guidelines for sanitary landfills are generally less severe than for sewage lagoons as no fluid pollutants are initially introduced. Thus the suitability maps give a more conservative evaluation of terrain for use of sanitary landfills than sewage lagoons; in many cases the suitability classification for sanitary landfills can be adjusted to the next higher suitability classification to that which is shown on the suitability maps for sewage lagoons and sanitary landfills.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and berm emplacement and how they affect continued berm stability and prevention of pollution. Slope, flood hazard, permafrost, hazards due to mass wastage, glacier advance, faulting, liquefaction, bedrock depth and material composition were considered primarily for their influence on pollutant confinement.

Locations where grain size analysis have been completed are plotted on Map 6.3.3 and show the basis on which the material compositions and permeabilities have been related. Grain size distributions for typical materials collected during the field investigations and located on Map 6.3.3 are shown in Appendix B.

In addition to drainage and material stoniness, many of the above terrain factors would also affect lagoon and landfill construction and maintenance. The terrain property guidelines for assessing suitability for sewage lagoons and sanitary landfills are defined in Table 6.3.3.

Areas containing possible optimum locations for sewage lagoons and sanitary landfills are contained within those areas classified as FAIRLY GOOD on the suitability map. Other possible locations are present in areas classified as FAIR and east of Burwash Landing in the area classified as POOR. In the latter area sites would be required where compact till with low ice contents was present near the surface.

6.3.4 Suitability for Septic Systems

The suitability map for septic systems (Map 6.3.4) assumes that the effluent from a septic tank is to be distributed in the natural surficial material by means of a sub-surface or raised tile beds. It was assumed that it would be required that water bodies and water supplies within 60 metres and surface water are not to be polluted by the septic system. It is also assumed that the systems are to be emplaced by standard procedures and that ground surface maintenance following emplacement is to be minimal.

The permeability of surficial materials with a terrain type was considered extremely important in evaluating terrain types for septic field suitability because of the absorption of effluent without the pollution of water supplies or water bodies greater than 60 metres from the septic field is of prime importance. Grain size distributions for typical materials collected during field investigations and located on Map 6.3.4 are shown in Appendix B.

The terrain factors were evaluated on how they affect initial sewage systems emplacement and maintenance and how they affect absorption of effluent and pollution prevention. The material composition, mainly its permeability, was considered of prime importance in evaluating terrain types for septic field suitability. Other terrain factors such as slope, drainage, permafrost, flood hazards, hazards due to mass wastage, glacier advances,

Table 6.3.4 Terrain Property Guidelines for Assessing Suitability for Septic Systems

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of septic systems.

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 8 degrees	Between 8 and 15 degrees	Greater than 15 degrees
Drainage (wt)[1]	Well drained; water tables deeper than 1.5 m	Moderately well drained; water tables occasionally rise to levels above 1.5 m	Moderately well to imperfectly drained; water tables usually 0.5 m below surface	Imperfectly to poorly drained; seasonal surface ponding of water	Poorly drained; surface ponding common
Flood Hazard (fl)	None	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 years or less	Occasional; subject to once in 5 years or less	Annual flooding
Permafrost and ice contents (pf)[2]	None	Rare permafrost; generally no ground ice	Discontinuous permafrost	Permafrost present with rare areas having shallow (0.5 m) sediment with medium to high ice contents	Continuous permafrost with many areas having shallow sediment with medium to high ground ice contents
Hazards due to mass wastage, fault activity, glacier advance, etc. (hz)[3]	None	None	Minor soil creep	Some rock fall; slight chance of glacier advance; evidence of faulting within last 10,000 years	Rapid soil creep, solifluction and nivation; active landslide activity at site or on adjacent slope; possibility of glacier advance or liquifaction within next 100 years
Bedrock depth (br)	Greater than 1.5 m	1 to 1.5 m	0.5 to 1 m	Less than .5 m, uneven thickness (veneer)	Generally less than 0.5 m
Material composition and stoniness[4] (mc)	Fine to coarse sand; loose sandy till; less than 5 percent silt, clay and stones	Sand and loose sandy till; 5 to 20 percent component of silt, clay and stones	Sand, gravelly sand, sandy till; 20 to 50 percent component of silt, clay and stones	Gravel, silt and clay content greater than 70 percent of unit; clayey till	Gravel, clay, silt, stone content greater than 50 percent; peat

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).
2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.
3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).
4. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

liquefaction and faulting, and bedrock depth primarily affect the continued prevention of pollution of adjacent surface water, water bodies and water supplies; and to a lesser degree the emplacement and maintenance of the septic systems. The terrain property guidelines for assessing suitability for septic systems are defined in Table 6.3.4.

6.3.5 Suitability and Availability of Construction Materials

The suitability map (Map 6.3.5) assumes that the construction materials are to be used as aggregate or fill. The suitability of the different terrain types are evaluated according to the quality and quantity of the surficial materials within it, and the workability and ease of extraction of those materials. Materials that are required to be impermeable such as dikes are excluded from consideration; the suitability for sewage lagoons and sanitary landfills give a partial assessment of suitability for impermeable materials. The suitability of bedrock as a construction material has not been evaluated. Terrain types containing gravel and sand with potential as aggregate are given the highest suitability classification as they can easily be adapted to most construction purposes. Other terrain types are evaluated on the basis of the compressibility, compactibility, susceptibility to frost action and surface trafficability of the surficial materials within them.

The terrain factors were evaluated on the basis of how they affect usefulness and versatility of the contained materials as a construction material, the ease or difficulty of extraction, and the volumes that could be extracted from a unit area. Material composition and stoniness primarily affects usefulness as a construction material, whereas slope, drainage, permafrost, flood hazard, miscellaneous hazards, and bedrock depth affect the extractable volumes per unit area and the ease or difficulty of extraction. The terrain property guidelines are defined in Table 6.3.5.

Table 6.3.5 Terrain Property Guidelines for Assessing Suitability for Construction Materials Including Workability and Usefulness as General Fill and Sources of Gravel and Sand

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated as a potential source of construction materials, including sand and gravel.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Between 5 and 12 degrees	Between 12 and 20 degrees	Between 20 and 30 degrees	Greater than 30 degrees
Drainage (wt)[1,2]	Rapid to well; water table >2 m	Well to moderately well; water table 1.0 to 2 m	Imperfect to moderately well; water table 0.5 to 1.0 m	Imperfect to poor; water table less than 0.5 m	Permanently wet; water table near surface
Flood Hazard (fl)	None	Very rare; subject once in 100 years or less	Occasional to rare; subject to once in 5 to 100 years	Frequent; subject to annual flood	Very frequent; flooded more than once per year
Permafrost and[3] ice contents (pf)	None	Scattered permafrost with low ground ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	Flow near-surface soil creep	Rapid soil creep or solifluction; evidence of faulting within last 10,000 years; chance of glacier advance	Possibility of landslide, surface rupture or sediment liquification within next 100 years	Imminent possibility of landslide and sediment liquification
Bedrock depth (br)	Greater than 2 m	Between 1.5 and 2 m	Greater than 1.0 m (blanket)	Between 0.5 and 1.0 m (veneer)	Less than 0.5 m
Material composition and stoniness[5] (mt)	Gravel and sand; stones less than 3 percent	Silty sand, silty gravel, sandy till; thin cover (veneer) over sand or gravel; stones less than 10 percent	Till, silty fine sand; stones less than 25 percent	Silt, clay, clayey silt, thick cover (blanket) over sand and gravel; 25 to 50 percent stones	Peat, organic silts; greater than 50 percent stones

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in percent volume excess ice: low <-10%; medium 10-20%; high >20%.

3. Water tables are considered only where permafrost is absent as a perched water table is generally present where permafrost is present. However, only a limited and easily controlled amount of water would be introduced from most excavations from this perched water table.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

A large source of aggregate have been outlined on map 6.3.5. The gravel:sand:fines ratios (based on grain size distribution obtained during this and earlier investigations), and the cu. metres per hectare of deposits (based on our estimate of minimal extraction thicknesses) are indicated for it. Other potential sources are available and have been utilized in areas classified as F - pf and F - pf, mt. Gravel and sand is plentiful in the area classified as F - pf as indicated in scarps along Kluane Lake, but requires delineation. In the area classified F - pf, mt, till generally overlies gravel, but the till often is utilized as fill or road binder in pit development.

Plentiful supplies of gravel and sand are available within the confines of map 6.3.5 and immediately west and east of it.

6.4 Unique Features

No particularily unique geologic features are present at Burwash Landing, although both the alluvial-fan surface (map 6.1) and beach ridges on its surface and east of Burwash Landing relate to drainage and elevation changes of Kluane Lake. Submerged stumps are also visible in shallow water. However, better examples of these phenomena are present at many other localities around Kluane Lake.

6.5 Hydrogeology

The hydrogeology of Burwash Landing is described under the headings of Well Survey, Water Quality, Groundwater Flow Regime and Water Supply Potential.

6.5.1 Well Survey

Four water wells are presently in use in the community of Burwash Landing. These wells are located on Map 6.5.1 and available hydrogeological data are summarized in Table 6.5.1.

Table: 6.5.1 HYDROGEOLOGICAL DATA AT BURWASH LANDING

Well No.	Description	Depth	Static Level	Use	Yield	Log
B1.	Burwash Airport	8.2 m	6.4 m	drinking and toilet	2700 l/hr	alluvial-fan gravels
B2.	Burwash Lodge Well No. 1	5 m	near surface	hotel	enough for large lodge and restaurant	no data
B2a.	Well No. 2	48 m	flowing	abandoned	100 l/min	gravel aquifer
B3.	Priest's Home	56 m	3 m	domestic	not known	no data
B4.	Indian Village Wash House	72 m	near surface	drinking water	potable water for 40 people	no data

Well B1 at the Burwash airport is a shallow well completed into well washed alluvial-fan gravels. The static level (i.e. watertable) in this unconfined aquifer is 6.4 m from the ground surface and penetration of 1.8 m section of the gravels with 15 cm casing furnishes a 2700 l/hr water yield.

Stratigraphic logs were not kept during the drilling of wells at Burwash Lodge, the priest's residence or the Indian village wash house. Brandon (1965) reported a 100 l/minute flowing well had been constructed into a gravel aquifer at the Burwash Lodge prior to 1965. Apparently this well was abandoned due to freezing and/or silt problems and a shallow well is presently being used. The type of aquifers which are being utilized in the Indian village and at the priest's residence are not known, and high water yields have not been demanded from these wells. Depth elevations show that water is being drawn from different stratigraphic horizons in each well, and suggests that aquifers are both thin and discontinuous laterally.

6.5.2 Water Quality

Previous comments about the physical separation of water bearing horizons are confirmed by the water chemistry of the groundwater in each well (see table 6.5.2).

Airport well: Calcium (minor magnesium)-Bicarbonate (minor sulphate) type

Burwash Lodge well: Calcium (minor magnesium)-Bicarbonate (minor chloride) type

Priest's Residence well: Calcium (minor sodium)-Bicarbonate (minor sulphate) type

Indian Village well: Sodium-Bicarbonate type

None of the water analyses corresponds closely with the chemistry of Kluane Lake, which is an alkali earth (i.e.

TABLE: 6.5.2 WATER CHEMISTRY OF BURWASH LANDING WELLS

(in mg/l unless indicated)

Sample	HCo_3^-	uMHos Cond.	Ca^{++}	Mg^{++}	Na^+	K^+	Fe^{+2}	Mn^{+2}	No_3^-	Cl^-	mg/l $So_4^=$	$Po_4^=$	Surface Water or Aquifer	Approx. TDS	Hardness	(mg/l $CaCo_3$)
B1: Airport	228	710	82.5	32.5	5.0	3.0	.15	-	14.6	38	89	-	Alluvial-fan surficial aquifer	497	339.5	very hard
B2: Burwash Inn	153	360	33.1	12.5	3.5	0.75	.44	-	.35	35	8.6	-	Shallow aquifer	252	134	hard
B3: Priest's house	120	350	31.7	13.7	31.2	1.5	-	-	.22	N.D	43	31	Deep confined aquifer	245	135.4	hard
B4: Indian Village well	172	430	17.5	20.6	40	2.12	.05	-	-	-	41	153	Deep confined aquifer	301	128.2	hard
Kluane Lake (at Destruction Bay for comparison)	86	380	27.5	16.3	4.25	.25	.05	-	-	-	91	-	Lake sample	266	135.6	hard

calcium with lesser magnesium) sulphate (minor bicarbonate) water type. It is possible however, that the Burwash Lodge well is recharging from the lake as the depth to water is approximately at lake level and the well is in close proximity to the lake. Water exchange reactions between lake water and clay minerals in the surficial materials are one explanation for the observed variations in chemistry.

In general, all samples revealed that groundwater is hard or very hard in the Burwash Landing area. Values of 128 - 135 mg/l were found in deep wells in the village while the airport well has very hard water. Surprisingly, this alluvial-fan aquifer is also the most highly mineralized water in the area with a conductivity of 710 umhos/cm and total dissolved solids content of about 497 mg/l.

All water samples are considered to be chemically potable except the airport well. A nitrate value of 14.6 mg/l found in this analysis exceeds the 10 mg/l Canadian Public Health standard and may be indicative of septic tank effluent contamination of this water supply. The Burwash Lodge sample slightly exceeded the .30 mg/l iron standard but is a negligible health risk and water from this aquifer would not require treatment.

6.5.3 Groundwater Flow Regime

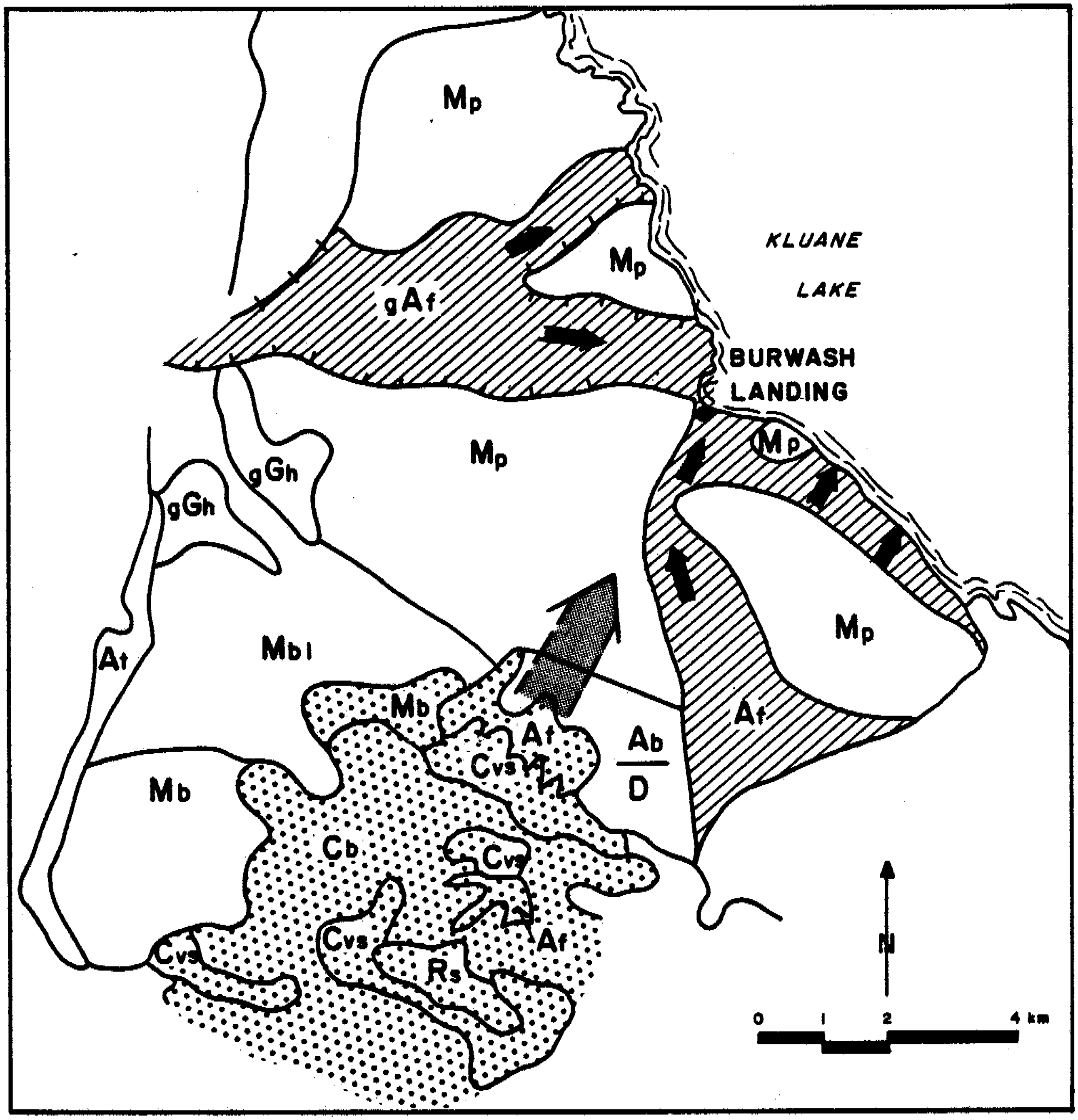
The lack of detailed stratigraphic data at depths below 20 m from the ground surface in the Burwash area restricts flow interpretation severely. However, existing flow information is depicted on Figure 6.5.3 based on the geological information shown in cross section as Figure 6.1. Hydraulic conductivity data are summarized for various terrain units in Table 6.5.3. A summary of known aquifer characteristics follows.

West of the village a large alluvial-fan complex overlies till or interbedded till and silty outwash material. Recharge to this unit is occuring from the direct infiltration of

TABLE: 6.5.3

HYDRAULIC CONDUCTIVITY OF GEOLOGIC MATERIALS AT BURWASH LANDING

Sample No.	Location	Terrain Unit	Description	Hydraulic Conductivity (cm/second)
SY 39	Shoreline cut	E (loess)	clayey sandy silt	2.5×10^{-5}
SY 40	Highway cut	M (till matrix)	clayey silty sand	2.25×10^{-4}
PY 60	Gravel pit	G	sandy gravel	5.04×10^{-1}
PY 57	Gravel pit	G	gravelly sand	4.41×10^{-2}



LEGEND

TERRAIN UNITS WITH HIGH RECHARGE POTENTIAL

TERRAIN UNITS WITH HIGH GROUNDWATER POTENIAL

POSSIBLE GROUNDWATER FLOW DIRECTIONS;

DEEP REGIONAL FLOW

LOCAL FLOW

FIGURE 6.5.3.

GROUNDWATER FLOW

BURWASH LANDING

precipitation through the openwork permeable gravel of which it is composed and by lateral water flow through the fan complex from the Duke River system. Horizontal movement with minimal vertical hydraulic gradients are expected. Little downward movement of water into the less permeable strata which underlie the fan is likely to be occuring. This unconfined aquifer has an excellent potential to yield high quantities of groundwater and large diameter wells could be constructed in this material with yields of greater than 250 litres/second expected. Peripheral and distal areas of the fan typically have finer grained strata with abundant organic horizons and may have poor yields and water quality than more central areas. Two constraints are evident if this aquifer is to be used as a water source. First, it has a high potential to become contaminated if wells are situated near sewage disposal, hydrocarbon storage or other potential pollution sources. Secondly, freezing problems would severely hamper well use during winter months.

In places, as is apparently the case in the shallow well (B2) at Burwash Lodge, a discontinuous layer of outwash sand (aG) and gravel underlies a thin loess veneer (mEv) and overlies a till unit (tMp) of unknown thickness. This unit may be water bearing and may possibly be recharging from Kluane Lake in places very near the lake. Farther away from the lake a northerly flow of water in the gravels above the till sheet is likely with very local recharge from surface precipitation. Wells in this aquifer are subject to the two constraints mentioned in the previous paragraph.

Deep wells B2 and B3 have been drilled into an interbedded till and silty outwash deposit which is at least 72 m thick under Burwash Landing. Aquifers in this strata probably consist of outwash gravel lenses which are probably moderately permeable, of limited lateral and vertical extent, and of variable thickness. The geochemical evidence previously mentioned indicates that wells B2, B3 and B4 bottom in different, probably unconnected aquifers. The yields of these outwash channel aquifers are unknown but are likely to be low. A 100 l/minute flow reported from a 48 m deep abandoned well at the Burwash Lodge is the only yield figure available. This well flowed after construction indicating a recharge elevation above 797 m (2615 ft) asl. The source of this water is unknown as hydraulic connections may exist with either the alluvial-fan complexes east or west of the village or with mountains south of Burwash Landing. Neither well B1 or B2 flows however, indicating local recharge conditions in these aquifers.

The terrain immediately south of Burwash Landing is a zone of continuous permafrost over 20 m in depth (till and outwash units), typified by occasional ice lenses. Taliks may exist within the till and silty gravel unit which could alter flow directions and characteristics significantly. No drilling and hydraulic observations have been made however, and the effects of permafrost on the flow regime is unknown.

6.5.4 Water Supply Potential

Deep drilled wells into glaciofluvial deposits which underlie Burwash Landing will provide the best water supply for future development in this area. These wells should provide water with a temperature above freezing in winter, will be of acceptable water quality for human consumption and will remain free of contamination if properly constructed. This conclusion is based on the premise that high yields (i.e. greater than 100 l/minute) will not be required for most future development in this village. It is likely that single drilled wells could be used to supply a cluster of 2-5 residential homes if required, thereby reducing costs significantly.

7.0 CHAMPAGNE

7.1 Geologic Setting

Champagne is located in the middle of the broad Takhini Valley on the Dezadeash River. Here the Dezadeash River bends sharply from northeastward course out of a narrow valley in the Dezadeash Ranges to a westward course along the Takhini Valley. Except for local relief due to the ridge of glaciofluvial material east of Champagne, sand dunes and stream incission, the valley floor at Champagne is flat; elevations range between 700 and 710 metres.

At Champagne thick unconsolidated deposits are the result of deposition during Pleistocene glacial and interglacial periods. The upper sequence of sediment however is mainly due to deposition of clayey silt and sandy silt in a large glacial lake, Glacial Lake Champagne.

During the last glaciation of this area ice flowed down the Dezadeash River valley to coalesce in the Takhini Valley with ice from other north-south oriented valleys. This ice then flowed north through gaps in the north side of the Takhini Valley such as the Mendenhall River valley. During the initial stages of deglaciation an esker appears to have developed in an interlobate subglacial environment at Champagne. Following further deglaciation, but before development of present drainage, Glacial Lake Champagne formed and covered the Takhini Valley - silt deposited near the calving ice margin was generally sandier than that at some distance.

Immediately following drainage of Glacial Lake Champagne, wind deflation of sandy lacustrine materials began and dune fields became established; some of these dune fields migrated north up valley walls into alpine passes. The Dezadeash River also began

Table: 7.1 Descriptive Legend of Surficial Materials of Champagne

Terrain Type	Geomorphology, Slopes, Drainage	Nature of Materials and Thickness	Permafrost, Ground Ice, Active Layer	Stability and Miscellaneous Engineering Characteristics	Potential Hazard
${}_{s}E_{n}$	Sand dunes; slopes up to 12 degrees; well drained.	Between 2 and 10 m of sand over clay, sand and gravel.	Unfrozen.	Loose sand only fair foundation material.	Sand subject to deflation and blow-outs.
$\frac{{}_{f}E_{v}}{{}_{c}L_{p}}$	Eolian veneer on lacustrine plain; flat; moderately well drained.	Between 0 and 1.0 m of fine silty sand and silt over 20 m plus of clay.	Generally unfrozen; few patches of permafrost possible with low to medium ground ice content.	Fair to poor foundation material.	Slight possibility of liquefaction.
$\frac{{}_{s}E_{v}}{{}_{u}G_{n}}$	Eolian veneer on esker-like ridge; slopes up to 20 degrees on flanks; well drained.	Between 0 and 1.0 m of sand over 0-0.5 m of clay over 20 m plus of gravel and sand.	Unfrozen.	Loose sand only fair foundation material; spoil source of aggregate and fill.	
$\frac{{}_{s}E_{b}}{{}_{c}L_{p}}$	Eolian blanket on lacustrine plain; flat to gently sloping; well drained.	Between 1 and 3 m of sand over 20 m plus of clay.	Generally unfrozen.	Materials only fair to poor foundation material.	Sand subject to deflation and blow-outs.
$\frac{{}_{s}E_{v}}{{}_{f}L_{p}}$	Eolian veneer on lacustrine plain; flat to very gently sloping; moderately well to well drained.	Between 0 and 1.0 m of sand over 3 m plus of interbedded marl, clay silt and sand.	Generally unfrozen; few patches of permafrost possible with low to medium ground ice content.	Fair to poor foundation material.	Some beds possibly susceptible to liquefaction.

Table: 7.1 (cont'd)

$\frac{{}_{s}E_{b}}{{}_{f}L_{p}}$	Eolian blanket on lacustrine plain; flat to gently sloping; well drained.	Between 1 and 3 m of sand over 3 m plus of interbedded marl, clay, silt and sand.	Unfrozen.	Fair to poor foundation material.	Some beds possibly susceptible to liquefaction.
$\frac{{}_{s}E_{b}}{{}_{s}U_{p}}$	Eolian blanket over flat-lying sand; flat to gently sloping; moderately well to well drained.	Between 1 and 3 m of sand over 3 m plus of pebbly sand.	Unfrozen.	Loose sand only fair foundation material.	Sand subject to deflation.
$\frac{{}_{s}L_{v}}{{}_{s}U_{p}}$	Lacustrine veneer over flat-lying sand; moderately well drained.	More than 3 metres of sand with pebbly layers toward base.	Unfrozen.		
${}_{f}L_{p}$	Lacustrine plain; flat, poorly drained.	Interbedded clay, silt and fine sand of unknown depth.	Few patches of thin permafrost; ground ice content expected to be low to medium where frozen; active layer 0.3-1.0 m plus.	Poor foundation material.	Slight possibility of liquefaction.
${}_{f}A_{p}$	Floodplain; flat, but with few small scarps; drainage variable from poor through moderately well.	Between 1 and 3 m plus of interbedded silt, clay and fine sand.	Generally unfrozen.	Poor foundation material.	Subject to frequent flooding.

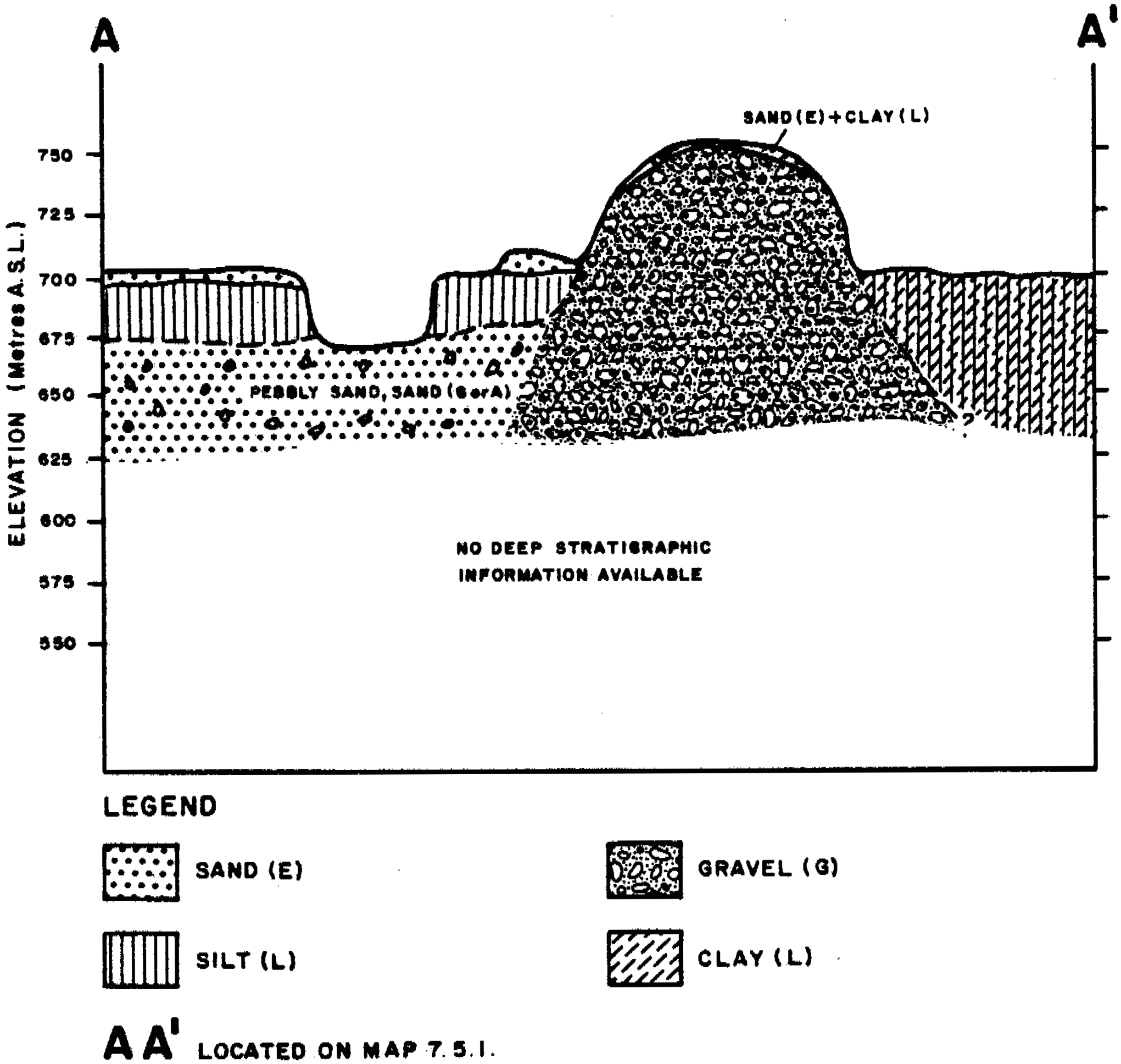


FIGURE 7.1

GEOLOGICAL CROSS-SECTION

CHAMPAGNE

to erode to its present level at this time. Broad terraces probably formed because its downward erosion may have been inhibited by clogging of its course with wind-blown sand and slow down-cutting of its course west of Champagne. In fact, during the hypsithermal its lower course may have been blocked causing a shallow lake in which marly sediments were deposited to form in the vicinity of Champagne.

Presently, the meandering Dezadeash River is undercutting some banks and expanding its meander plain (cf. map 7.1). Small active blow-outs are also present in the sand dunes.

7.2 Terrain Types and Their Characteristics

Map 7.1 and figure 7.1 show the distribution of terrain types at Champagne. The geomorphology, slope distribution, drainage, nature and thickness of materials, permafrost distribution, ground ice contents, active layer thicknesses, ground stability, engineering characteristics and potential hazards for each mapped terrain type are given in Table 7.1. Detailed grain size analysis for typical surficial materials are given in Appendix B.

7.3 Suitability Maps

Suitability maps for road construction, building construction and underground utility installation, sewage lagoons and sanitary landfills, septic systems and construction materials including granular materials are presented (Maps 7.3.1 - 7.3.5). These suitability maps are derived following the techniques outlined in Section 3.3 of this report.

7.3.1 Suitability for Road Construction

The suitability map for road construction (Map 7.3.1) assumes that roads for year-round use are to be

Table 7.3.1 Terrain Property Guidelines for Assessing Suitability for Highways and Roads

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of all-weather highway and roads (without asphalt surface).

Terrain Factor (symbol)	Degree of Terrain Suitability: Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Less than 8 degrees	Less than 12 degrees	Slopes between 12 and 18 degrees	Greater than 18 degrees
Drainage (wt)[1]	Rapid to well; greater than 1 m to water table	Well to moderately well; greater than 0.75 m to water table	Moderately well to imperfect; water table generally 0.50 to 0.75 m	Imperfect to poor; water table less than 0.5 m	Poor, water table continuously near-surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 to 100 years	Annual flooding	Flooding more than once a year
Permafrost and[2] ice contents (pf)	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep; isolated rock fall; evidence of faulting within last 10,000 years	Slight chance of glacier readvance or sediment liquefaction; possibility of fault-induced surface rupture within next 100 years; rock falls common	Possibility of landslide, sediment liquification within next 100 years; rapid solifluction, nivation or surface creep
Bedrock depth (br)	Greater than 2 m	Greater than 1.0 m	Between 0.5 m and 1.0 m	Less than 0.5 m	Generally near surface
Material composition and stoniness[4,5] (mc)	Gravel and sand, sandy till; stones less than 5 percent	Clayey till, silty sand, silty gravel; stones less than 10 percent	Clayey silt, sandy silt; stones less than 25 percent	Clay, organic silt, peat up to 2 m thick; stones 25 to 50 percent	Thick peat; stones greater than 50 percent

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low <10%; medium 10-20%; high > 20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Due to frost heaving, terrain units having significant contents of silt and clay in areas of imperfect and poor drainage should be altered to one less degree of suitability if material is the limiting factor; where the highway is to be surfaced by asphalt the suitability should be more severely altered.

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

constructed and maintained on undisturbed terrain. For the purposes of drainage it is assumed the roads are graded, and ditches are present where required. The subgrade is to consist of materials underlying the roadway and the base material is to be locally obtained where possible. No provision is made in the suitability map for the source of surfacing material, which is assumed to be stabilized crushed gravel, till or rock.

The terrain factors were evaluated on the basis of how they affect the initial construction and how they affect load capacities and maintenance. Slope, drainage, permafrost, bedrock depth, and material primarily affect initial construction, whereas flood hazard, ice contents, and miscellaneous hazards primarily affect maintenance. The terrain property guidelines for assessing suitability for highway and road construction and maintenance are defined in Table 7.3.1.

7.3.2 Suitability for Building Construction and Utility Installation

The suitability map for building construction and utility installation (Map 7.3.2) assume that buildings are to have basements and utilities are buried in the ground. It is assumed that standard construction procedures are used except that special insulative procedures are used in areas of permafrost. It is also assumed that ground conditions are such that some mobility is viable in the vicinity of the buildings, and that utility and ground surface maintenance is minimal.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and how they affect the continued stability and maintenance of the building, building site and utility. Slope, permafrost, bedrock depth, material composition and stoniness primarily affect construction and excavation whereas drainage, flood hazard, ice contents, and hazards due to mass wastage, glacier advances, faulting, liquefaction primarily

Table 7.3.2 Terrain Property Guidelines for Assessing Suitability for Building Construction and Utility Installation

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction or installation and maintenance of buildings and underground utilities.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 12 degrees	Slopes between 12 and 20 degrees	Greater than 20 degrees
Drainage (wt)[1,2]	Rapid to well; greater than 2.5 metres to water table	Well to moderately well drained; greater than 1.5 metres to water table	Moderately well to imperfect drainage; 0.5 - 1.0 metres to water table	Imperfectly or poorly drained; <.5 m to water table	Poor drainage; water table continuously near surface
Flood Hazard (fl)	None	None	Very rare; subject to once in 100 years or less	Occassional; subject to once in 10 to 100 years	Annual flooding
Permafrost and ice contents (pf)[2,3]	No permafrost	Scattered permafrost but generally no ground ice	Permafrost generally present, but only rare areas having shallow (<1.0 metres) sediment with medium to high ice contents	Permafrost with up to 1 metre of near-surface sediment having medium to high ice contents; isolated sediment at depth with high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 metre
Hazards due to[4] mass wastage, fault activity, (glacier advance, etc.)(hz)	No hazards	No hazards	Slow near-surface soil creep; within 1 km of post glacial active fault	Slight chance of glacier advance or sediment liquefaction; rock fell present; evidence of faulting within last 10,000 years	Possibility of landslides, fault-induced surface rupture, sediment liquefaction or glacier advance within next 100 years; rapid solifluction, nivation or soil creep
Bedrock depth (br)	Always greater than 2.5 m	Usually greater than 2 m	1 - 2 metres	Less than 1 metre	Generally at surface
Material composition and stoniness (mt)	Gravel and sand; sandy till; stones less than 5%	Clayey till; clayey silt and silty sand less than 1 m thick; stones less than 15%	Thick silty sand, silt, silty clay, stones 15 to 25%	Thick clay; organics to 2 m in depth, stones 25 to 50%	Organics greater than 50%; stones greater than 50%

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. In cases of buildings without basements and where the limiting factors are drainage, permafrost and ice contents or bedrock depth, the degree of suitability should be altered to a more favorable rating because of less interaction between the undisturbed terrain type and the buildings in this mode of construction.

3. Ice contents given in percent volume excess ice: low <-10%; medium 10-20%; high >20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and Ice Contents (pf).

5. Stones are defined as clastshaving a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

affect stability and maintenance. The terrain property guidelines for assessing suitability for building construction and utility installation are defined in Table 7.3.2.

7.3.3 Suitability and Optimum Locations for Sewage Lagoons and Sanitary Landfills

The suitability map for sewage lagoons and sanitary landfills assumes that the sewage lagoons and sanitary landfills are to be constructed through shallow excavations or through the construction of berms on the undisturbed ground surface. The prevention of pollution through the movement of surface or ground water to terrain surrounding the facilities was considered to be of prime importance in their location. Minimal maintenance of berms and other confinements to the movement of pollutants was also considered paramount.

The guidelines for sanitary landfills are generally less severe than for sewage lagoons as no fluid pollutants are initially introduced. Thus the suitability maps give a more conservative evaluation of terrain for use of sanitary landfills than sewage lagoons; in many cases the suitability classification for sanitary landfills can be adjusted to the next higher suitability classification to that which is shown on the suitability maps for sewage lagoons and sanitary landfills.

The terrain factors were evaluated on how they affect initial construction, mainly excavation and berm emplacement and how they affect continued berm stability and prevention of pollution. Slope, flood hazard, permafrost, hazards due to mass wastage, glacier advance, faulting, liquefaction, bedrock depth and material composition were considered primarily for their influence on pollutant confinement.

Table 7.3.3 Terrain Property Guidelines for Assessing Suitability for Sewage Lagoons and Sanitary Landfills

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to impound water, sewage, and leachate to be evaluated.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)[1]	Less than 1.5 degrees	Less than 3 degrees	Less than 8 degrees	Less than 15 degrees	Greater than 15 degrees
Drainage (wt)[2]	Rapid to well drained; water table 1.5 m plus	Moderately well drained; water table generally 1.0 m plus	Imperfectly drained; water table generally 0.5 to 1.0 m	Poorly drained; water table generally less than 0.5 m	Permanently wet; water table continuously near surface
Flood Hazard (fl)	No flooding	Very rare; subject to once in 100 years or less	Rare; subject to once in 50 years to 100 years	Occasional; subject to once in 5 to 50 years	Frequent; subject to at least once a year
Permafrost and[3] ice contents (pf)	No permafrost	Scattered permafrost with low ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediments with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity glacier advance, etc. (hz)	No hazards	No hazards	Slow near surface soil creep	Slight chance of glacier advance; evidence of faulting within last 10,000 years; some rock fall	Rapid soil creep or solifluction prevail; possibility of landslide, fault induced surface rupture, sediment liquification, or glacier advance within next 100 years
Bedrock depth (br)	Greater than 1.5 metres (blanket)	Greater than 1.0 metres (blanket)	Between 0.5 and 1.0 metres (veneer)	Less than 0.5 metres (veneer)	Generally at surface
Material composition and stoniness[5] (mt)	Silty clay; less than 3 percent stones	Clayey silt and silt; clayey till and compact till; 3 to 10 percent stones	Silt with some organic content; sandy or gravelly silt or clay; loose till; 10-25 per cent stones	Silty sand and silty gravel; less 25-50 per cent stone	Sand and gravel; greater than 50 percent stones peat

1. Slopes are a more limiting factor to the construction of viable sewage lagoons than sanitary landfills. Thus terrain unit suitability for sanitary landfills should be altered to one less severe degree of suitability if slope is the limiting terrain factor.

2. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

3. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high > 20%.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6cm, i.e., cobbles, coarse rubble, boulders, blocks.

Locations where grain size analysis have been completed are plotted on Map 7.3.3 and show the basis on which the material compositions and permeabilities have been related. Grain size distributions for typical materials collected during the field investigations and located on Map 7.3.3 are shown in Appendix B.

In addition to drainage and material stoniness, many of the above terrain factors would also affect lagoon and landfill construction and maintenance. The terrain property guidelines for assessing suitability for sewage lagoons and sanitary landfills are defined in Table 7.3.3.

Areas containing optimum locations for sewage lagoons and sanitary landfills are contained in the areas classified as FAIRLY on the suitability map near 210PY. Some optimum locations may be present in the area classified as F - mt at Champagne, but site assessment of materials will be required.

7.3.4 Suitability for Septic Systems

The suitability map for septic systems (Map 7.3.4) assumes that the effluent from a septic tank is to be distributed in the natural surficial material by means of a sub-surface or raised tile beds. It was assumed that it would be required that water bodies and water supplies within 60 metres and surface water are not to be polluted by the septic system. It is also assumed that the systems are to be emplaced by standard procedures and that ground surface maintenance following emplacement is to be minimal.

The permeability of surficial materials with a terrain type was considered extremely important in evaluating terrain types for septic field suitability because the absorption of effluent without the pollution of water supplies or water

Table 7.3.4 Terrain Property Guidelines for Assessing Suitability for Septic Systems

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated for construction and maintenance of septic systems.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 3 degrees	Less than 5 degrees	Less than 8 degrees	Between 8 and 15 degrees	Greater than 15 degrees
Drainage (wt)[1]	Well drained; water tables deeper than 1.5 m	Moderately well drained; water tables occasionally rise to levels above 1.5 m	Moderately well to imperfectly drained; water tables usually 0.5 m below surface	Imperfectly to poorly drained; seasonal surface ponding of water	Poorly drained; surface ponding common
Flood Hazard (fl)	None	Very rare; subject to once in 100 years or less	Occasional; subject to once in 10 years or less	Occasional; subject to once in 5 years or less	Annual flooding
Permafrost and[2] ice contents (pf)	None	Rare permafrost; generally no ground ice	Discontinuous permafrost	Permafrost present with rare areas having shallow (0.5 m) sediment with medium to high ice contents,	Continuous permafrost with many areas having shallow sediment with medium to high ground ice contents
Hazards due to[3] mass wastage, fault activity, glacier advance, etc. (hz)	None	None	Minor soil creep	Some rock fall; slight chance of glacier advance; evidence of faulting within last 10,000 years	Rapid soil creep, solifluction and nivation; active landslide activity at site or on adjacent slope; possibility of glacier advance or liquifaction within next 100 years
Bedrock depth (br)	Greater than 1.5 m	1 to 1.5 m	0.5 to 1 m	Less than .5 m, uneven thickness (veneer)	Generally less than 0.5 m
Material composition and stoniness[4] (mt)	Fine to coarse sand; loose sandy till; less than 5 percent silt, clay and stones	Sand and loose sandy till; 5 to 20 percent component of silt, clay and stones	Sand, gravelly sand, sandy till; 20 to 50 percent component of silt, clay and stones	Gravel, silt and clay content greater than 70 percent of unit; clayey till	Gravel, clay, silt, stone content greater than 50 percent; peat

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in per cent volume excess ice: low <-10%; medium 10-20%; high >20%.

3. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

4. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

bodies greater than 60 metres from the septic field is of prime importance. Grain size distributions for typical materials collected during the field investigations and located on Map 7.3.4 are shown in Appendix B.

The terrain factors were evaluated on how they affect initial sewage systems emplacement and maintenance and how they affect absorption of effluent and pollution prevention. The material composition, mainly its permeability, was considered of prime importance in evaluating terrain types for septic field suitability. Other terrain factors such as slope, drainage, permafrost, flood hazards, hazards due to mass wastage, glacier advances, liquefaction and faulting, and bedrock depth primarily affect the continued prevention of pollution of adjacent surface water, water bodies and water supplies; and to a lesser degree the emplacement and maintenance of the septic systems. The terrain property guidelines for assessing suitability for septic systems are defined in Table 7.3.4.

7.3.5 Suitability and Availability of Construction Materials

The suitability map (Map 7.3.5) assumes that the construction materials are to be used as aggregate or fill. The suitability of the different terrain types are evaluated according to the quality and quantity of the surficial materials within it, and the workability and ease of extraction of those materials. Materials that are required to be impermeable such as dikes are excluded from consideration; the suitability for sewage lagoons and sanitary landfills give a partial assessment of suitability for impermeable materials. The suitability of bedrock as a construction material has not been evaluated. Terrain types containing gravel and sand with potential as aggregate are given the highest suitability classification as they can easily be adapted to most construction purposes. Other terrain types are

Table 7.3.5 Terrain Property Guidelines for Assessing Suitability for Construction Materials Including Workability and Usefulness as General Fill and Sources of Gravel and Sand

Different states of individual terrain factors are established that allow the suitability of the undisturbed terrain type to be evaluated as a potential source of construction materials, including sand and gravel.

Terrain Factor (symbol)	Degree of Terrain Suitability				
	Good - G	Fairly Good - FG	Fair (Marginal) - F	Poor - P	Unsuitable - U (very poor)
Slope (sl)	Less than 5 degrees	Between 5 and 12 degrees	Between 12 and 20 degrees	Between 20 and 30 degrees	Greater than 30 degrees
Drainage (wt)[1,2]	Rapid to well; water table >2 m	Well to moderately well; water table 1.0 to 2 m	Imperfect to moderately well; water table 0.5 to 1.0 m	Imperfect to poor; water table less than 0.5 m	Permanently wet; water table near surface
Flood Hazard (fl)	None	Very rare; subject once in 100 years or less	Occasional to rare; subject to once in 5 to 100 years	Frequent; subject to annual flood	Very frequent; flooded more than once per year
Permafrost and[3] ice contents (pf)	None	Scattered permafrost with low ground ice contents	Permafrost generally present, but only rare areas having shallow (<0.5 m) sediment with medium to high ice contents	Permafrost with up to 1 m of near-surface sediment having medium to high ice contents	Continuous permafrost with sediments having high ground ice contents to depths greater than 1 m
Hazards due to[4] mass wastage, fault activity, glacier advance, etc. (hz)	No hazards	Flow near-surface soil creep	Rapid soil creep or solifluction; evidence of faulting within last 10,000 years; chance of glacier advance	Possibility of landslide, surface rupture or sediment liquification within next 100 years	Imminent possibility of landslide and sediment liquification
Bedrock depth (br)	Greater than 2 m	Between 1.5 and 2 m	Greater than 1.0 m (blanket)	Between 0.5 and 1.0 m (veneer)	Less than 0.5 m
Material composition and stoniness[5] (mt)	Gravel and sand; stones less than 3 percent	Silty sand, silty gravel, sandy till; thin cover (veneer) over sand or gravel; stones less than 10 percent	Till, silty fine sand; stones less than 25 percent	Silt, clay, clayey silt, thick cover (blanket) over sand and gravel; 25 to 50 percent stones	Peat, organic silts; greater than 50 percent stones

1. For drainage characterization see Canada Soil Information System (Canada Soil Survey Committee, 1978).

2. Ice contents given in percent volume excess ice: low <10%; medium 10-20%; high >20%.

3. Water tables are considered only where permafrost is absent as a perched water table is generally present where permafrost is present. However, only a limited and easily controlled amount of water would be introduced from most excavations from this perched water table.

4. Hazards such as flooding and failures due to man-induced thawing of permafrost are considered in Flood Hazard (fl) and Permafrost and ice contents (pf).

5. Stones are defined as clasts having a diameter greater than 6 cm, i.e., cobbles, coarse rubble, boulders, blocks.

evaluated on the basis of the compressibility, compactibility, susceptibility to frost action and surface trafficability of the surficial materials within them.

The terrain factors were evaluated on the basis of how they affect usefulness and versatility of the contained materials as a construction material, the ease or difficulty of extraction, and the volumes that could be extracted from a unit area. Material composition and stoniness primarily affects usefulness as a construction material, whereas slope, drainage, permafrost, flood hazard, miscellaneous hazards, and bedrock depth affect the extractable volumes per unit area and the ease or difficulty of extraction. The terrain property guidelines are defined in Table 7.3.5.

A major source of aggregate has been outlined on Map 7.3.5. The gravel:sand:fines ratios (based on grain size distribution obtained during this and earlier investigations), and the cu. metres per hectare of deposits (based on our estimate of minimal extraction thicknesses) are indicated for this source. This large source has more than adequate volumes for future needs in the Champagne area.

7.4 Unique Features

Although good examples of sand dunes and blow-outs are present in the vicinity, no unique features are present. Stratigraphy exposed along the banks of the Dezadeash River west of Champagne is particularly interesting in that the sediments appear to have been deposited in a number of environments (fluvial, lacustrine, eolian) and under variable climatic conditions. Paleo-environmental studies of this sequence might be particularily interesting.

7.5 Hydrogeology

The hydrogeology of Champagne is described under the headings of Well Survey, Water Quality, Groundwater Flow Regime and Water Supply Potential.

7.5.1 Well Survey

A survey of existing residences in the community of Champagne revealed that no wells are presently being utilized for domestic water supplies. Several dug wells have been constructed in the village to a depth of 10 to 12 metres but are unreliable water sources. Champagne residents are hauling water from the Dezadeash River in winter and pump water to several storage tanks in summer.

7.5.2 Water Quality

The Dezadeash River was sampled (Table 7.5.2) and analyzed. Results indicate that water is dilute with total dissolved of 89 mg/l and is soft with a 35.3 mg/l total hardness. The river contains alkali earth (calcium with minor magnesium) water with a bicarbonate (minor sulphate) anionic composition which is typical of Yukon surface waters. The Dezadeash River tends to be excessively turbid due to erosion of glaciolacustrine silts, which forms its banks and channel in this area. A considerable length of settling time would be required to remedy this problem due to the fine grain size of suspended sedimentary material. High turbidity is a nuisance, not a health hazard, and the raw river water apparently is chemically potable.

7.5.3 Groundwater Flow Regime

It is reported that one water well was drilled to a 24 m depth in Champagne but went dry, "probably because of

TABLE: 7.5.2

WATER CHEMISTRY AT CHAMPAGNE

(in mg/l unless indicated)

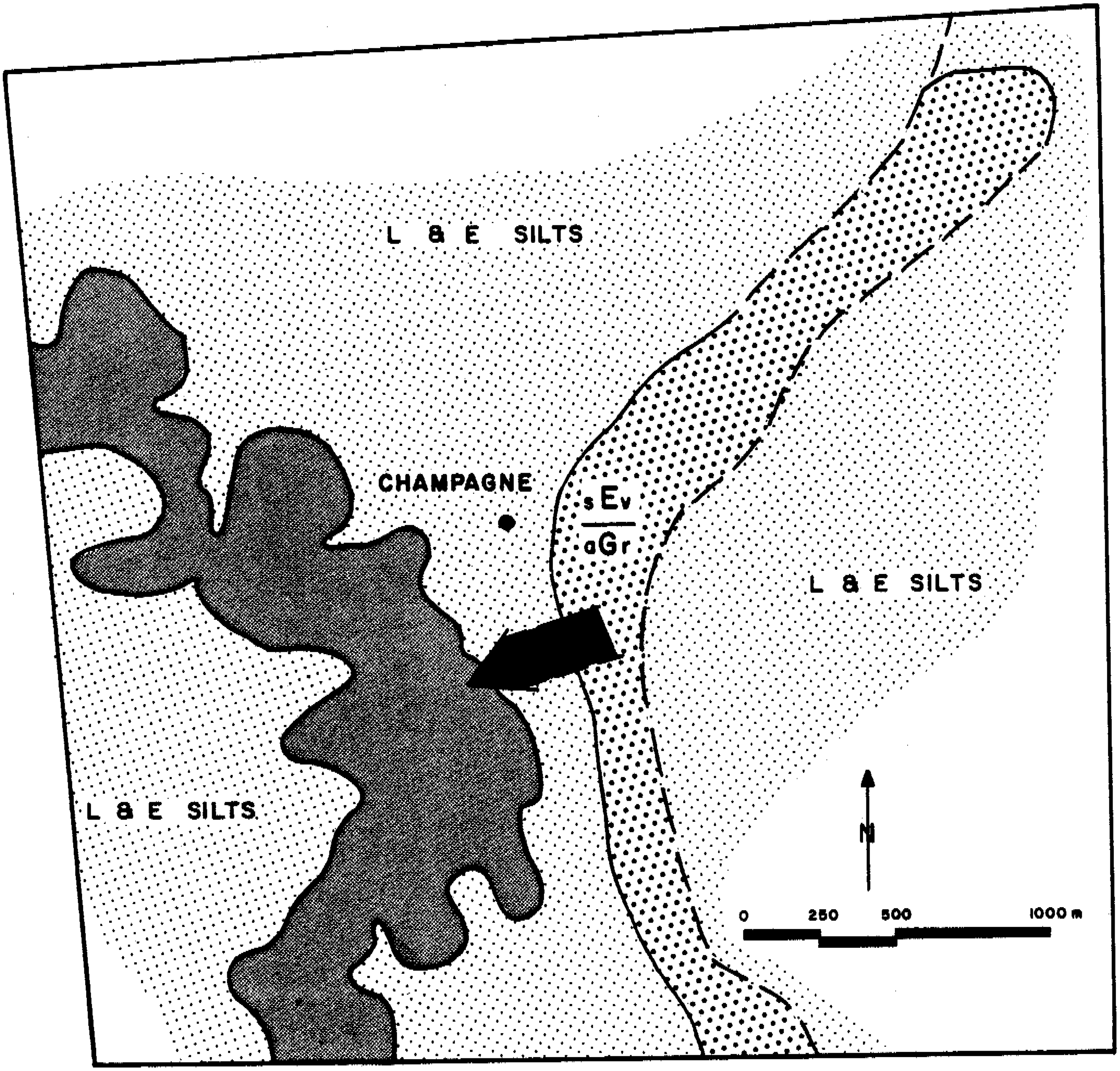
Sample	HCo_3^-	uMHos Cond.	Ca^{++}	Mg^{++}	Na^+	K^+	Fe^{-2}	Mn^{-2}	No_3^-	Cl^-	$So_4^=$	$Po_4^{\equiv}$	Surface Water or Aquifer	Depth	Approximate Total Dissolved Solids	Hard-ness (PPm $CaCo_3$)
Dezadeash River (Champagne)	48	128	9.7	2.7	1.75	.47	.05	-	-	-	3.7	-	River sample	Surface grab	89	35.3 soft

poor construction and corrosion" (intera environmental consultants 1975). Without drill hole data, groundwater observations must be based only on surficial geological mapping. Much of the terrain surrounding Champagne is relatively flat with thick lacustrine silt deposits overlain by a fine grained veneer of aeolian sediment. These units have a very low permeability (estimated to be less than 1 x 10^{-6} cm/sec) and infiltration of water into these materials is negligible. Precipitation moves to the river by overland flow.

East of Champagne a broad ridge of glaciofluvial sand and gravel runs north-south and roughly parallel to the river channel. Although covered by a veneer of aeolian sand and lacustrine silts, some minimal amount of precipitation may infiltrate this more permeable landform and allow groundwater movement to the west towards the Dezadeash River (Figure 7.5.3). This flow regime would be weak at best considering the aridity of the climate and is unverified at present. Sand and gravel is exposed in basal sections of the Dezadeash River banks as shown in cross section (Figure 7.5.1). It is possible that wells into more permeable and coarser grained strata of this terrain unit could draw water from the river either by direct recharge (i.e. the hydraulic gradient slopes eastward) or by reversing weak westerly gradients.

7.5.4 Water Supply Potential

Lacustrine units are thick and barren of water, and drilled and properly screened wells in the more permeable and coarser sand and gravel deposits that underlie the silts are the only potential water supply source in the Champagne area. It is possible that locations nearer the river could have a higher chance of yielding adequate water supplies than more distant sites. No information is available on potential well yields.



LEGEND

NO RECHARGE, MINOR OVERLAND FLOW TO RIVER

SOME INFILTRATION WHERE COARSE-GRAINED MATERIAL EXPOSED AT SURFACE

DEZADEASH RIVER FLOODPLAIN

POSSIBILITY OF SOME GROUNDWATER MOVEMENT TOWARDS RIVER

FIGURE 7.5.3

GROUNDWATER FLOW

CHAMPAGNE

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9.0 GLOSSARY OF GEOTECHNICAL TERMS

Active layer:	the top layer of ground in areas underlain by permafrost that thaws each summer and refreezes each fall.
Aggregate:	hard, inert construction materials such as sand, gravel or crushed stone.
Beaded outwash:	outwash in the form of a number of small knolls that trend along a relatively straight line.
Bearing capacity:	the load per unit area which the ground can safely support without excessive yeild.
Berm:	narrow, man-made embankment.
Braided drainage pattern:	pattern having interlacing or tangled network of several, small branching and reuniting shallow channels separated by islands and bars.
Colluvium:	loose soil and rock fragments deposited chiefly by mass wasting on and at the base of slopes.
Compactibility:	property of material that allows it to decrease in volume or thickness under pressure.
Deglaciation:	the uncovering of land from beneath a glacier by the withdrawal of ice due to shrinkage by melting.
Effluent:	liquid waste which will render groundwater or surface water supplies unsuitable for human consumption.
Esker:	long, narrow, senuous ridge composed of sand and gravel that was deposited by water in a subglacial or englacial environment.
Faulting:	fracturing and displacement of rock along a surface or zone.
Fluted moraine:	moraine characterized by parallel, smooth, broad furrows.
Frost creep:	soil slowly creeping downslope because of annual freezing and thawing.
Frost heave:	the uneven upward movement of surface soil, rock, vegetation or structures resulting from the subsurface freezing of water and growth of ice masses.

Frost shattering:	mechanical disintegration of rock due to pressure exerted by freezing of water in cracks and pores.
Frost sorting:	sorting of unconsolidated material through ice movement as caused by freezing and thawing.
Frost-susceptible soil:	soil in which significant detrimental ice forms when the requisite moisture and freezing conditions are present.
Geology:	the study of the planet Earth; its composing materials; its morphology; its history; and the forces that are acting upon it.
Glacially over-steepened:	a valley wall whose slopes have been steepened due to erosive force of a glacier.
Glaciation:	(a) the covering of land by glaciers; (b) a part of geologic time during which glaciers were more extensive than at present.
Glaciolacustrine:	pertaining to or deposited in glacial lakes.
Ground ice:	ice in pores and other openings in soil or rock.
Hydrogeology:	scientific study of the chemistry, supply potential and flow characteristics of water in surficial geological materials and near-surface bedrock.
Ice-cored moraines:	moraines underlain by solid glacier ice cores.
Interglacial:	pertaining to or formed during the time interval between two glaciations.
Lacustrine (deposit):	deposited in a lake.
Liquefaction:	the sudden large decrease of the shearing resistance of a cohesionless soil caused by a shock or strain and associated with sudden, temporary increases in pore fluid pressure.
Loess:	windblown, homogeneous, commonly nonstratified, unconsolidated silt and fine sand.
Marl:	a mixture of soft, loose fine-grained soil and calcium carbonate deposited in water.

Mass wastage:	the process by which the dislodgement and down-slope transport of soil and rock occurs through gravitational stresses primarily.
Moraine:	mound, ridge or distinct accumulation of unsorted unstratified material (till) deposited directly by a glacier.
Neoglaciation (Neoglacial):	the readvance of glacier ice and time period (approximately the last 3000 years) during which these readvances occurred.
Nivation:	erosion of soil and rock beneath a snowbank and around its margin, caused mainly by frost action and meltwater transport.
Nivation terraces:	a bench or terrace formed by the process of nivation.
Nunatak:	an isolated hill or mountain that projects prominantly above the surface of a glacier (past or present).
Organics:	material composed of peat or finely decomposed plant and animal remains (muck).
Outwash:	stratified sand and gravel deposited near the front of a glacier by meltwater streams.
Peat:	unconsolidated, compressible soil consisting of partially decomposed semi-carbonized remains of plants, some animal residues and minor mineral soil.
Peatland:	extensive areas underlain by peat.
Periglacial processes:	processes occuring in cold regions due to frost action.
Permafrost:	the thermal condition in soil or rock having temperatures below 0°C persist over two or more years.
Permafrost discontinuous:	permafrost occuring in some areas beneath the ground surface throughout a regional zone where other areas are free of permafrost.
Permeability:	the ability of a porous or fractured medium to transmit water.
Physiography:	description of the surface features of the Earth such as water and land bodies.

Pleistocene:	the part of the Quaternary when glaciers repetitively expanded much beyond their present limits (covering most of Canada) and retracted to near their present positions.
Pollutants:	any dissolved chemical or suspended contaminant which degrades the potability of a water supply.
Polygonal ground:	patterned ground marked by polygon-like arrangements of rock fragments, soil, vegetation or ice-wedge network.
Postglacial:	pertaining to the time interval since the last major glaciation of the Pleistocene (approximately the last 10,000 years).
Quaternary:	the period of time encompassing the last two or three million years.
Rock glacier:	a mass of rock fragments and soil cemented by ice and/or underlain by ice that moves slowly downslope in a manner similar to glacier flow.
Seismic activity:	the peneomena of Earth movements including earth quakes.
Solifluction:	slow, viscous downslope movement of waterlogged surficial material underlain by frozen ground.
Strandline:	a former level at which a body of water meets the land.
Stratigraphy:	the arrangement of sedimentary units within the earth.
Subgrade:	the surface immediately below a structure that is levelled off to receive the foundation of an engineering structure.
Terrain type:	a landscape or terrain unit characterized by a unique morphology and underlain by a defined surficial material.
Trafficability:	the quality or suitability of a soil or a terrain to permit and support moving vehicles.
Thermokarst:	the process of differential thaw settlement because of the melting of ground ice in an area of permafrost.

Thermokarst depressions:	depressions in the land surface formed by thermokarst.
Thermokarst lakes:	lakes within depressions in the land surface formed by thermokarst.,
(Late) Wisconsinan:	the time interval during which the last great Pleistocene glaciation occurred, approximately between 30,000 and 10,000 years ago.

APPENDIX A

Suitability Evaluations
of
Terrain Typing

Table A.4.3.1 Evaluation of Terrain Type Suitability for Roads in Haines Junction Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor, U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
Rp	G	G	G	G	G	P	P	P	br,mt
Rn	F-P	FG	G	G	G	U	P	U	br,mt
Rs	U	G	G	G	F-P-rock fall	U	P	U	br,sl,mt
sDv/Rn	F-P	FG	G	F-FG	G	P	P-F	P	br,mt
Dm/Rm	FG-F	F	G	F-FG	G	FG	FG	F	pf,sl
sMp	G	FG	G	G	G	G	FG	FG	wt,mt
sMm	FG	G	G	G	G	G	FG	FG	mt,sl
sLv/sMp	G	G	G	G	G	G	FG	FG	mt
vLv/sMm	FG	G	G	G	G	G	FG	FG	mt,sl
fm Lb/s Mm	FG	FG	G	G	G	G	FG-F	FG	mt,wt,sl
a/f Lb/sMm	FG	G	G	G	G	G	FG	FG	mt,sl
sLb/sMn	F	G-FG	G	F	G	G	FG-F	F	pf,sl
sLv/sMs	F	FG-F	G	F-FG	G	G	FG	F	pf,sl
sGm	F-FG	FG-G	G	G	G	G	G	FG	sl,wt
sEv/gGp	G	G	G	G	FG-deflation	G	G	FG	hz
sLv/sGp	G	G	G	G	G	G	G	G	
sLv/sGb	G	G	G	G	G	G	G	G	
sLb/sGp	P-FG	G	G	G	G	G	G	P	sl
f/m Lp	G	P-F	G	P	FG-liquefaction	G	F	P	pf,wt
f/m Ln	G	P-FG	G	F	G	G	F	F	pf,mt,wt
f/c Lp	G	P-FG	G	P-U	FG-liquefaction	G	P	P	pf,wt,mt
f/c Lp-R	FG	P-F	G	U	FG-liquefaction	G	P	U	pf,wt,mt
fs Lp	G	F-P	G	P-U	FG-liquefaction	G	P	P	pf,mt,wt
pOv/fLb	G	P	G	FG	FG-liquefaction	G	P	P	wt,mt
gAf	G	G	FG	G	G	G	FG	FG	fl,mt
sAf	FG	G	F	G	G	G	FG-F	F	fl,mt
fAf	G	P-U	F	F-P	FG-liquefaction	G	P	P	wt,mt,pf
fLv/gAf	G	P-F	F	FG	G	G	FG	P	wt,fl
sLv/gAf	G	F-P	F	G	G	G	FG	F	wt,fl
f/m Ae	G	F-P	F	FG	G	G	FG	F-P	wt,fl
sLv/sAp	G	P-F	FG	FG	G	G	FG-P	P-F	wt,mt
aLv/sAp	G	F-FG	FG	FG	G	G	FG-P	F	wt,mt
sLb/sAp	G	F-FG	G-FG	FG	G	G	F-FG	F	wt,mt
sAp	G	P	FG-F	G	G	G	FG-P	P	wt,mt,fl
pOv/fAp	G	U	FG	FG	FG-liquefaction	G	P	U	wt,mt
aCa	U	G	G	FG	P-rock falls	G	U	U	sl,hz,mt
sCm	P-F	F	G	F-FG	FG-landslide	G	F	P	sl,pf,wt
f/m Ap-A	G	P-U	P-U	G	G	G	FG	P-U	wt,fl
f/s Ap-A	G	P	P-U	G	G	G	FG	P	wt,fl
gAp-A	G	P-P	U	G	G	G	FG	U	fl,wt

Table A.4.3.2 Evaluation of Terrain Type Suitability for Buildings in Haines Junction Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
R_p	G	G	G	FG	G	P	P	P	br,mt
R_n	F-P	G	G	FG	G	P	P	P	br,mt
R_s	U	G	G	G	U-rock falls	U	P	U	sl,hz,br
aOv/R_n	F-P	FG	G	FG	G	F-P	FG-F	F	sl,br
b/R_n	FG-F	FG	G	FG	G	FG	FG	F	sl
M_p	G	G-FG	G	G	G	G	FG	FG	mt,wt
M_m	G	G-FG	G	G	G	G	FG	FG	mt,wt
sLv/M_p	G	G-FG	G	G	G	G	G-FG	FG	mt,wt
sLv/M_m	G	G-FG	G	G	G	G	G-FG	FG	mt,wt
$f/aLb/M_m$	G	FG	G	G	G	G	FG	FG	mt,wt
$a/fLb/M_m$	G	FG	G	G	G	G	FG	FG	mt,wt
sLb/M_n	P	FG	G	F	G	G	F-FG	F	sl,pf,mt
aLv/M_b	F-P	FG	G	"G	G	G	FG-F	F	sl,mt
aG_m	FG	G	G	G	G	G	G	FG	sl
$fEslgG_p$	G	G	G	G	FG-deflation	G	FG	FG	hz,mt
sLv/aG_p	G	G	G	G	G	G	G	G	
aLv/aG_b	G	G	G	G	G	G	G	G	
aLb/aG_p	F-P	G	G	G	G	G	G	P	sl
$f/m L_p$	G	F	G	P	FG-liquefaction	G	F-P	P	pf,mt
$f/m L_n$	F-P	FG	G	F	G	G	F-P	F	pf,sl,mt
$f/a L_p$	G	F	G	P-U	FG-liquefaction	G	F-P	U	pf,mt,wt
$f/c L_p$ - *	FG	P	G	U	FG-liquefaction	G	F-P	U	pf,mt,wt
$f.o L_p$	G	F	G	P-U	FG-liquefaction	G	P	U	pf,mt,wt
pOv/fL_b	G	P	G	FG	FG-liquefaction	G	P	P	wt,mt
gA_f	FG	FG	FG	G	G	G	G	FG	sl,wt,fl
A_f	FG	FG	F	G	G	G	G	F	fl
A_f	FG	P	F	F-FG	FG-liquefaction	G	F-P	P	wt,mt,fl
fLv/gA_f	FG	F	F	FG	G	G	FG	P	wt,fl
sLv/gA_f	FG	F	F	G	G	G	G-FG	F	wt,fl
$f/a A_b$	G	F-P	F	FG	G	G	G-FG	F	wt,fl
aLv/aA_p	G	F-P	FG	FG-F	G	G	FG-F	F	wt,mt,pf
mLv/aA_p	FG	F-P	FG	FG-F	G	G	FG-F	F	wt,mt
cLb/aA_p	FG-F	FG-F	G-FG	FG	G	G	F-FG	F	wt,mt
A_p	G	F-P	FG-F	G-FG	G	G	FG-F	F	wt
pOv/fA_p	G	U	FG	F-FG	FG-liquefaction	G	F-P	U	wt,mt
aC_a	P-U	G	G	FG	P-rock fall	G	P	U	sl,hz,mt
sC_m	F-P	F	G	F	FG-landslide	G	FG-F	F	sl,pf,wt
$f/a A_p$ -A	G	P-U	P-U	G	G	G	FG	U	fl,wt
$f/g A_p$ -A	G	P	P-U	G	G	G	FG	U	fl,wt
gA_p -A	G	F-P	U	G	G	G	G	U	fl,wt

Table A.4.3.3 Evaluation of Terrain Type Suitability for Sewage Lagoons and Sanitary Landfills in Haines Junction Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor, U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
R_p	FG-F	G	G	FG	G	P	U	U	mt,br
R_n	F-P	G	G	FG	G	P	U	U	mt,br
R_s	U	G	G	G	P-U-rock falls	U	U	U	sl,br,mt
${}_{a}O_{v}/R_{n}$	F-P	G	G	FG	G	G-FG	P-U	P	mt,sl
O_{b}/R_{n}	F	G	G	G	G	G	F-P	F	mt,sl
${}_{t}M_{p}$	G	G	G	G-FG	G	G	G-FG	FG	mt
${}_{t}M_{m}$	FG	G	G	G-FG	G	G	G-FG	G	pf,mt
${}_{x}L_{v}/{}_{t}M_{p}$	G	G	G	G	G	G	FG-F	FG	mt
${}_{x}L_{v}/{}_{t}M_{m}$	FG	G	G	G	G	G	FG-F	FG	mt
${}_{f/m}L_{b}/{}_{t}M_{m}$	FG	G	G	G-FG	G	G	FG-F	FG	mt
${}_{a/f}L_{b}/{}_{t}M_{m}$	G	G	G	G-FG	G	G	F	F	mt
${}_{x}L_{b}/{}_{t}M_{n}$	F	FG	G	F	G	G	FG-F	F	pf,sl
${}_{a}L_{v}/{}_{t}M_{b}$	F	G-FG	G	FG	G	G	F	F	mt,sl
${}_{a}G_{m}$	FG	G	G	G	G	G	P	P	mt
${}_{f}E_{v}/{}_{g}G_{p}$	G	G	G	G	F-deflation	G	P-U	P	mt
${}_{x}L_{v}/{}_{a}G_{p}$	G	G	G	G	G	G	F	F	mt
${}_{a}L_{v}/{}_{a}G_{b}$	G	G	G	G	G	G	F-P	P	mt
${}_{a}L_{b}/{}_{a}G_{p}$	P-U	G	G	G	G	G	P-U	P	mt,sl
${}_{f/m}L_{p}$	G	FG-F	G	F-P	FG-liquefaction	G	G-FG	P	pf
${}_{f/m}L_{n}$	F-P	FG-F	G	F-P	G	G	G-FG	P	pf,sl
${}_{f/c}L_{p}$	FG	F	G	P	FG-liquefaction	G	G-FG	P	pf,wt
${}_{f/c}L_{p}$-K	FG	F	G	P	FG-liquefaction	G	G-FG	P	pf,wt
${}_{f\cdot o}L_{p}$	G	FG-F	G	U	FG-liquefaction	G	FG	U	pf
${}_{p}O_{v}/{}_{f}L_{b}$	G	F-P	G	FG-F	FG-liquefaction	G	FG-F	P	wt
${}_{g}A_{f}$	FG	G-FG	FP	G	G	G	P	P	mt,fl
${}_{x}A_{f}$	FG	G-FG	F-P	G	G	G	F-P	P	fl,mt
${}_{f}A_{f}$	FG	F	F-P	FG-F	FG-liquefaction	G	F	F	fl,mt
${}_{f}L_{v}/{}_{g}A_{f}$	FG	FG-F	P-P	G	G	G	F-P	P	fl,mt
${}_{s}L_{v}/{}_{g}A_{f}$	FG	FG-F	P-P	G	G	G	F-P	P	fl,mt
${}_{f/a}A_{t}$	G	FG-F	F	FG	G	G	F-P	F	mt
${}_{c}L_{v}/{}_{a}A_{p}$	FG	F-P	FG	FG	G	G	FG	F	wt
${}_{m}L_{v}/{}_{a}A_{p}$	FG	F-P	FG	FG	G	G	P	P	mt
${}_{c}L_{b}/{}_{a}A_{p}$	G-FG	FG-F	FG	FG	G	G	G-FG	FG	wt,mt
${}_{x}A_{p}$	G	FG	P	G	G	G-FG	P	P	wt,mt
${}_{p}O_{v}/{}_{f}A_{p}$	G	P	G	FG	FG-liquefaction	G	F	P	wt
${}_{a}C_{a}$	P-U	G	G	FG	P-U-rock fall	G	U	U	sl,hz,mt
${}_{x}C_{m}$	F-P	FG	G	FG	G	G	P	P	mt,sl
${}_{f/a}A_{p}$-A	FG	FG	U	G	G	G	F-P	U	fl,mt
${}_{f/g}A_{p}$-A	FG	FG	U	G	G	G	F-P	U	fl,mt
${}_{s}A_{p}$-A	FG	G	U	G	G	G	F-P	U	fl,mt

Table A.4.3.4 Evaluation of Terrain Type Suitability for Septic Systems in Haines Junction Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor,
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
R_p	FG	G	G	FG	G	P	U	U	mt,br
R_n	F-P	G	G	FG	G	P	U	U	mt,br,sl
R_s	U	F	G	G	P-U-rock fall	U	U	U	sl,br,mt
$_aD_v/R_n$	F-P	G	G	F	G	P-F	F-P	P	br,mt,sl
O_b/R_n	F	G	G	FG-F	G	FG	FG-F	F	sl,pf
$_tM_p$	G	G	G	G-FG	G	G	P	P	mt
$_tM_m$	G-FG	G	G	G-FG	G	G	P	P	mt
$_sL_v/_tM_p$	G	G	G	G	G	G	F	F	mt
$_sL_v/_tM_m$	G	G	G	G	G	G	F	F	mt
$_{f/m}L_b/_tM_m$	G	G	G	G-FG	G	G	P-F	P	mt
$_{a/f}L_b/_tM_m$	G	G	G	G-FG	G	G	F	F	mt
$_aL_b/_tM_m$	F-FG	FG	G	P-F	G	G	F	P	pf
$_aL_v/_tM_b$	F-FG	G-FG	G	FG	G	FG	F-FG	F	mt,sl
$_aG_m$	F-FG	G-FG	G	G	G	G	F-P	F	mt,sl
$_fE_v/_gG_p$	G	G	G	G	F-deflation	G	F	F	mt,hz
$_sL_v/_aG_p$	G	G	G	G	G	G	F-P	F	mt
$_aL_v/_aG_b$	G	G	G	G	G	G	P-F	P	mt
$_aL_b/_aG_p$	U-P	G	G	G	G	G	P-F	U	sl,mt
$_{f/m}L_p$	G	F-P	G	P	FG-liquefaction	G	F-P	P	pf,mt
$_{f/m}L_n$	F-P	FG-F	G	P	G	G	F-P	P	pf,sl
$_{f/c}L_p$	G-FG	F	G	P-U	FG-liquefaction	G	P	P	pf,mt
$_{f/c}L_p-\bar{K}$	G-FG	F	G	P-U	FG	G	P	P	pf,mt
$_{f,o}L_p$	G	F-FG	G	U	FG	G	P	U	pf,mt
$_pO_v/_fL_b$	G	F-P	G	FG-F	FG	G	U	U	mt
$_gA_f$	G-FG	G-FG	F-P	G	G	G	P	P	fl,mt
$_xA_f$	G-FG	G-FG	F-P	G	G	G	F-P	P	fl,mt
$_fA_f$	G-FG	P-F	F-P	FG-F	FG	G	F-P	P	wt,fl,mt
$_fL_v/_gA_f$	G-FG	FG-F	F-P	G	G	G	F-P	F	fl,mt
$_sL_v/_gA_f$	G-FG	FG-P	F-P	G	G	G	F-P	F	fl,mt
$_{s/a}A_t$	G	FG-F	FG-F	G	G	G	F-FG	F	mt,fl
$_sL_v/_{fa}A_p$	G-FG	F-P	FG	FG-F	G	G	P-U	P	mt,wt
$_mL_v/_aA_p$	G-FG	F-P	FG	FG	G	G	F-P	F	wt,mt
$_cL_b/_aA_p$	G	FG-F	FG	FG	G	G	P-U	P	mt
$_xA_p$	G	FG	F-P	FG	G	G-FG	FG-F	F	fl,mt
$_pO_v/_fA_p$	G	P	G	FG	FG-liquefaction	G	U	U	mt,wt
$_aC_a$	P-U	G	G	FG	P-U-rock fall	G	U	U	sl,hz,mt
$_xC_m$	F-P	FG	G	F-FG	G	G	FG-F	F	sl,mt
$_{f/a}A_p-A$	G-FG	FG	U	G	G	G	P	U	fl,mt
$_{f/g}A_p-A$	G-FG	FG	U	G	G	G	P	U	fl,mt
$_gA_p-A$	G-FG	G	U	G	G	G	U	U	fl,mt

Table A.4.3.5 Evaluation of Terrain Type Suitability for Construction Materials in Haines Junction Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor,
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
R_p	G	G	G	G	G	P	U	U	mt, br
R_n	FG	G	G	G	G	P-F	U	U	mt, br
R_a	U-P	G	G	G	F-landslide rockfall	U-P	U	U	mt, br, sl
${}_{a}D_{v}/R_{n}$	FG-F	FG-F	G	FG	G	P-F	P	P	mt, br
D_{b}/R_{n}	FG-F	G	G	G	G	F	P-F	P	mt
${}_{t}M_{p}$	G	G-FG	G	G	G	G	F	F	mt
${}_{t}M_{m}$	G-FG	G-FG	G	G	G	G	F	F	mt
${}_{x}L_{v}/{}_{t}M_{p}$	G	FG-G	G	G-FG	G	G	F	F	mt
${}_{x}L_{v}/{}_{t}M_{m}$	G-FG	FG-G	G	G	G	G	F	F	mt
${}_{f/m}L_{b}/{}_{t}M_{m}$	G	FG-G	G	G	G	G	F-P	F	mt
${}_{a/f}L_{b}/{}_{t}M_{m}$	G-FG	G	G	G	G	G	FG-F	FG	mt
${}_{x}L_{b}/{}_{t}M_{m}$	FG-F	FG	G	F	G	G	F-P	F	pf mt
${}_{a}L_{v}/{}_{t}M_{b}$	FG-F	FG-F	G	FG	G	G	F	F	mt, wt
${}_{a}G_{m}$	FG-F	G-FG	G	G	G	G	FG	FG	mt, sl
${}_{f}E_{v}/{}_{g}G_{p}$	G	G	G	G	G	G	FG	FG	mt
${}_{x}L_{v}/{}_{a}G_{p}$	G	G-FG	G	G	G	G	FG-G	FG	mt
${}_{a}L_{v}/{}_{a}G_{b}$	G	G	G	G	G	G	FG-F	FG	mt
${}_{a}L_{b}/{}_{g}G_{p}$	F-P	G	G	G	G	G	G-FG	F	sl
${}_{f/m}L_{p}$	G	F-P	G	P	G	G	P	P	pf mt wt
${}_{f/m}L_{n}$	G	FG	G	F-P	G	G	P	P	mt pf
${}_{f/c}L_{p}$	G	P-F	G	P-U	G	G	P	P	pf mt wt
${}_{f/c}L_{p}$-K	G	P	G	U	G	G	P	U	pf mt wt
${}_{f.o}L_{p}$	G	F	G	U-P	G	G	U	U	pf mt
${}_{p}O_{v}/{}_{f}L_{b}$	G	P	G	FG	G	G	U-P	U	mt wt
${}_{g}A_{f}$	G	FG	F-FG	G	G	G	G-FG	F	fl
${}_{x}A_{f}$	G	FG	F-FG	G	G	G	FG-F	F	fl mt
${}_{f}A_{f}$	G	P	F	FG-F	F-liquefaction	G	P	P	wt mt fl
${}_{f}L_{v}/{}_{g}A_{f}$	G	F-P	F	G	G	G	FG-F	P	wt fl
${}_{a}L_{v}/{}_{g}A_{f}$	G	FG-F	F	G	G	G	FG-G	F	fl wt
${}_{f/a}A_{t}$	G	F	F-FG	G	G	G	F-FG	F	wt fl mt
${}_{c}L_{v}/{}_{a}A_{p}$	G	F-P	FG	FG	G	G	F	F	mt wt
${}_{m}L_{v}/{}_{a}A_{p}$	G	FG	G	G	G	G	F	F	mt
${}_{c}L_{b}/{}_{a}A_{p}$	G	FG-F	G	G	G	G	P-F	P	mt
${}_{x}A_{p}$	G	F	FG	FG-G	G	G	F-P	F	mt wt
${}_{p}O_{v}/{}_{f}A_{p}$	G	U	FG	FG	G	G	P-U	U	wt mt
${}_{a}C_{a}$	P	G	FG	FG	FG-rockfall	G	P	P	sl mt
${}_{x}C_{m}$	G	FG	G	F-FG	FG-landslide	G	F-P	F	pf mt
${}_{f/a}A_{p}$-A	G	P	P-U	G	G	G	FG	P	fl wt
${}_{f/g}A_{p}$-A	G	F	P-U	G	G	G	FG	P	fl wt
${}_{g}A_{p}$-A	G	FG	P-U	G	G	G	G-FG	P	fl

Table A.5.3.1 Evaluation of Terrain Type Suitability for Roads in Destruction Bay Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{tM_m}$	FG	FG	G	F	G	G	FG	F	pf
$\frac{nE_v}{O_m}$	FG	FG	G	F	G	G	FG	F	pf
$\frac{aG_v}{tM_m}$	FG	FG	G	F-FG	G	G	FG-G	F	pf
f/aG_p	G	F	FG	F	G	G	FG	F	wt,pf
gA_f	G	G	P-U	G	G	G	FG	U	fl
gA_f	G	G	F-FG	FG	G	G	FG-G	F	fl
f/aA_f	G	F	F-FG	FG	G	G	FG	F	fl,wt
xA_f	G	F-P	F-FG	P	G	G	F-P	P	pf,wt,mt
fA_f	G	F-P	F-FG	P-U	G	G	U-P	U	pf,wt,mt
$\frac{fO_u}{fA_f}$	G	P-F	FG	P-U	G	G	U-P	U	pf,mt,wt
$\frac{fA_b}{aG_p}$	G	F	G	P-F	G	G	P	P	mt,pf
$\frac{cL_u}{xA_f}$	G	F-P	F-FG	F-P	G	G	F	F	wt,pf,mt
$\frac{aL_b}{xA_f}$	G	FG	FG-F	F-FG	G	G	FG-F	F	pf,mt,fl
$\frac{aL_b}{tM_m}$	G	G	G	F-FG	G	G	FG	F	pf
xL_p	G	P	P-U	G	P-liquefaction	G	U-P	U	mt,fl,hz
aL_n	FG	G	P-U	G-FG	G	G	FG	P	fl

Table A.5.3.2 Evaluation of Terrain Type Suitability for Buildings in Destruction Bay Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor, U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{tM_m}$	FG	FG	G	F	G	G	FG	F	pf
$\frac{mE_v}{D_m}$	FG	FG	G	F	G	G	FG	F	pf
$\frac{aG_v}{tM_m}$	FG	FG	G	FG-F	G	G	G-GF	FG	pf
$fa\,G_p$	G	F	G-FG	F	G	G	FG	F	wt,pf
gA_p	G	G	P-U	G	G-FG	G	G-FG	U	fl
gA_f	G	G	FG-F	G-FG	G-FG	G	G-FG	F	fl
$f/a\,A_f$	G	F	F	FG-F	G-FG	G	FG	F	mt,fl,pf
xA_f	G	F-P	F	F-P	G	G	F-P	P	mt,pf,wt
fA_f	G	F-P	F	P-U	G	G	P	P	wt,pf,mt
$\frac{pO_v}{fA_f}$	G	F-P	FG	P-U	G	G	P-U	U	pf,mt,wt
$\frac{fA_b}{aC_p}$	G	FG-F	G	F-P	G	G	P-F	P	pf,mt
$\frac{cL_v}{fA_f}$	G	F	F-FG	F-P	G	G	F-P	P	pf,mt
$\frac{aL_b}{fA_f}$	G	FG	FG-F	FG-F	G	G	FG-F	FG	fl,pf,mt
$\frac{aL_b}{tM_m}$	G-FG	G	G	FG-F	G	G	FG	FG	pf,mt
xL_p	G	P	P-U	G	P-liquefaction	G	P-U	U	fl,mt,wt,hz
aL_n	FG	G	P-U	G-FG	G	G	FG	P	fl

Table A.5.3.3 Evaluation of Terrain Type Suitability for Sewage Lagoons and Sanitary Landfills in Destruction Bay Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
mEv/tMm	FG-F	G-FG	G	F	G	G	FG	F	pf
mEv/Dm	FG-F	FG	G	F	G	G	FG-F	F	pf,mt
aGv/tMm	FG-F	FG	G	F	G	G	F-FG	F	pf,mt
f/a Gp	G-FG	FG-F	G	F	G	G	F-P	F	wt,pf,mt
gAp	G	G	U	G	G	G	P-U	U	fl,mt
gAf	G	G	F-P	FG	G	G	P-U	U	mt,fl
f/a Af	G	FG-F	F	P-U	G	G	F-P	P	pf,mt
xAf	G	FG-F	F	P-U	G	G	F-P	P	pf,mt,fl
fAf	G	FG-F	F	P-U	G	G	FG	P	pf,fl
pOu/fAf	G	F	G-FG	P-U	G	G	F-P	P	pf,mt,wt
fAb/aGp	G	FG	G	F-P	G	G	FG-G	F	pf
cLv/xAf	G	FG-F	F-FG	F	G	G	FG-F	F	pf,fl,mt
aLb/xAf	FG	G-FG	FG	FG-F	G	G	P	P	mt
aLb/tMm	G-FG	G	G	FG	G	G	P-F	P	mt
xLp	G	F-P	P-U	G	P-liquefaction	G	F-P	U	fl,hz,mt
aLv	FG-F	G	P	G	G	G	P	P	fl,mt

Table A.5.3.4 Evaluation of Terrain Type Suitability for Septic Systems in Destruction Bay Area

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{tM_m}$	FG-F	G-FG	G	P	G	G	F-P	P	pf,mt
$\frac{mE_v}{D_m}$	FG-F	FG	G	P	G	G	F-P	P	pf,mt
$\frac{sG_v}{tM_m}$	FG-F	FG	G	P-F	G	G	FG-F	P	pf
f/aG_f	G-FG	FG-F	G	P-F	G	G	FG-F	P	pf
gA_p	G	G	P-U	G	G	G	P-F	P	fl,mt
gA_f	G	G	F	FG	G	G	P-F	P	mt,fl
f/aA_f	G	F	F	F-P	G	G	F-P	P	pf,fl,mt
xA_f	G	F	F-FG	U	G	G	P-F	U	pf,mt
fA_f	G	F	F-FG	U	G	G	F-FG	U	pf
$\frac{pO_u}{fA_f}$	G	F-P	G-FG	U	G	G	F-P	U	pf,wt,mt
$\frac{fA_b}{aG_p}$	G	FG	G	P-U	G	G	F-P	P	pf,mt
$\frac{cL_v}{xA_f}$	G	F	FG	P-F	G	G	P	P	pf,mt
$\frac{aL_b}{xA_f}$	FG	G-FG	G-FG	F-P	G	G	F-P	F	pf,mt
$\frac{aL_b}{tM_m}$	G-FG	G	G	F-P	G	G	FG-P	F	pf
xL_p	G	P	P-U	G	P-liquefaction	G	F-P	U	fl,wt,hz
aL_r	G-FG	G	P	FG	G	G	P-F	P	fl,mt

Table A.5.3.5 Evaluation of Terrain Type Suitability for Construction Materials in Destruction Bay Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor, U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{{}_{m}E_{v}}{{}_{t}M_{m}}$	G	FG	G	F	G	G	F	F	pf mt
$\frac{{}_{m}E_{v}}{D_{m}}$	G	FG	G	F	G	G	F	F	pf mt
$\frac{{}_{u}G_{v}}{{}_{t}M_{m}}$	G	FG-G	G	F	G	G	F-FG	F	pf mt
$f/{}_{a}G_{p}$	G	F	G	F	G	G	FG-F	F	pf wt mt
${}_{g}A_{p}$	G	G	P	G	G	G	FG	P	fl
${}_{g}A_{f}$	G	G	F	F	G	G	FG	F	fl
$f/{}_{a}A_{f}$	G	F	F	FG	G	G	FG-F	F	fl wt mt
${}_{x}A_{f}$	G	P-F	FG-F	P-U	G	G	U	U	mt pf wt
${}_{f}A_{f}$	G	P-F	FG-F	P-U	G	G	U	U	mt pf wt
$\frac{{}_{p}O_{v}}{{}_{f}A_{f}}$	G	P	G	U-P	G	G	U	U	mt pf wt
$\frac{{}_{f}A_{b}}{{}_{a}G_{p}}$	G	F-FG	G	P	G	G	P-U	P	mt pf
$\frac{{}_{c}L_{v}}{{}_{x}A_{f}}$	G	F-P	FG-F	F	G	G	F-P	F	mt wt pf
$\frac{{}_{a}L_{b}}{{}_{x}A_{f}}$	G	G	FG-F	F-FG	G	G	F-FG	F	mt pf fl
$\frac{{}_{a}L_{b}}{{}_{t}M_{m}}$	G	G	G	FG-F	G	G	F-FG	F	mt pf
${}_{x}L_{p}$	G	P	U-P	G	F-liquefaction	G	P	U	fl mt wt
${}_{a}L_{A}$	G	G	F	G	G	G	FG-G	P	fl

TableA.6.3.1 Evaluation of terrain type suitability for Roads in Burwash Landing Area

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor. U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{+M_m}$	FG-G	FG-F	F	F	G	G	FG	F	pf,wt
$\frac{mE_v}{+M_p}$	G	FG	G	F	G	G	FG	F	pf
$\frac{mE_v}{(aG + +M)_p}$	G	FG	G	F	G	G	G-FG	F	pf
$\frac{O_b}{O_p}$	G	P	FG-F	P-F	G	G	P	P	mt,wt,pf
gA_f	G	G	G	FG	G	G	G	FG	pf
$\frac{aL_v}{gA_f}$	G	G	G	G	G	G	G	G	
$\frac{sL_b}{gA_f}$	G	F	G	FG	G	G	FG-F	F	wt,mt

Table A.6.3.2 Evaluation of terrain type suitability for Buildings in Burwash Landing Area

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{+M_m}$	FG-G	FG-F	G	F	G	G	FG	F	pf,wt
$\frac{mE_v}{+M_p}$	G	FG	G	F	G	G	FG	F	pf
$\frac{mE_v}{(aG+tM)_p}$	G	FG	G	F	G	G	G-FG	F	pf
$\frac{O_b}{O_p}$	G	P	FG-F	P-F	G	G	P	P	wt,mt,pf
gA_f	G	G	G	FG	G	G	G	FG	pf
$\frac{aL_v}{gA_f}$	G	G	G	G	G	G	G	G	
$\frac{sL_b}{gA_f}$	G	F	G	FG-F	G	G	G-FG	F	wt

Evaluation of terrain type suitability for Sewage Lagoons and Sanitary Landfills in Burwash Landing Area

Table A.6.3.3

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{tM_m}$	FG-F	FG	G	F-FG	G	G	FG	F	pf,sl
$\frac{mE_v}{tM_p}$	G	FG	G	FG-F	G	G	FG	FG	pf,wt,mt
$\frac{mE_v}{(aG+tM)_p}$	G	FG	G	F-FG	G	G	F-P	P	mt,pf
$\frac{O_b}{O_p}$	G	P	FG-F	P-F	G	G	P-U	P	mt,pf,wt
gA_f	G	G	G	G-FG	G	G	P	P	mt
$\frac{aL_v}{gA_f}$	G	G	G	G	G	G	U	U	mt
$\frac{sL_b}{gA_f}$	G	F	G	FG-F	G	G	P	P	mt,pf

Table A.6.3.4 Evaluation of terrain type suitability for Septic Systems in Burwash Landing Area

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{+M_m}$	FG-F	FG	G	P	G	G	F-P	P	pf,mt
$\frac{mE_v}{+M_p}$	G	FG	G	P	G	G	F-P	P	pf,mt
$\frac{mE_v}{(aG + +M)_p}$	G	FG	G	P-F	G	G	F-FG	P	pf
$\frac{O_b}{O_p}$	G	P	FG-F	P-F	G	G	P	U	mt,wt,pf
gA_f	G	G	G	F-FG	G	G	P-F	P	mt
$\frac{aL_v}{gA_f}$	G	G	G	FG	G	G	P-F	P	mt
$\frac{sL_b}{gA_f}$	G	F	FG	P-F	G	G	F-P	P	pf,wt,mt

Table A.6.3.5 Evaluation of terrain type suitability for Construction Materials in Burwash Landing Area

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
$\frac{mE_v}{tM_m}$	G	F-FG	G	F	G	G	F	F	pf,mt
$\frac{mE_v}{tM_p}$	G	FG	G	F	G	G	F	F	pf,mt
$\frac{mE_v}{(aG+tM)_p}$	G	FG	G	F	G	G	FG-F	F	pf
$\frac{O_b}{O_p}$	G	U	F	P	G	G	U	U	wt,mt,pf
gA_f	G	G	G-FG	FG	G	G	G	FG	pf
$\frac{aL_v}{gA_f}$	G	G	G	FG	G	G	G	FG	pf
$\frac{sL_b}{gA_f}$	G	F-P	F-FG	P-F	G	G	F-P	P	pf,wt,mt

Table A.7.3.1 Evaluation of Terrain Type Suitability for Roads in Champagne Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
${}_{s}E_{N}$	FG-F	G	G	G	F-deflation blow-outs	G	FG-F	F	hz sl mt
$\frac{{}_{f}E_{v}}{{}_{c}L_{p}}$	G	FG	G	FG	FG-liquefaction	G	F	F	mt
$\frac{{}_{s}E_{v}}{{}_{a}G_{N}}$	F-P	G	G	G	FG-deflation	G	FG	F	sl hz
$\frac{{}_{s}E_{b}}{{}_{c}L_{p}}$	G-FG	G	G	FG	FG-deflation blow-outs	G	F-FG	F	mt
$\frac{{}_{s}E_{v}}{{}_{f}L_{p}}$	G-FG	FG	G	FG-F	FG-liquefaction	G	F	F	mt pf
$\frac{{}_{s}E_{b}}{{}_{f}L_{p}}$	G-FG	G	G	FG	FG-liquefaction	G	F-FG	F	wt
$\frac{{}_{s}E_{b}}{{}_{s}U_{p}}$	G-FG	FG	G	G	F-deflation	G	FG-G	F	hz
$\frac{{}_{s}L_{v}}{{}_{s}U_{p}}$	G	FG	G	G	G	G	FG-G	FG	mt wt
${}_{f}L_{p}$	G	P	FG	FG-F	F-liquefaction	G	F-P	P	wt mt
${}_{f}A_{p}$	G	P-F	P-U	G-FG	F-liquefaction	G	F	U	fl wt

Table A.7.3.2 Evaluation of Terrain Type Suitability for Buildings in Champagne Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor, U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
${}_sE_v$	FG-F	G	G	G	F-deflation blow-outs	G	FG-F	F	sl hz
$\frac{{}_fE_v}{{}_cL_p}$	G	FG	G	FG	FG-liquefaction	G	FG-F	FG	mt wt
$\frac{{}_sE_v}{{}_aG_v}$	F-P	G	G	G	FG-deflation	G	G	F	sl
$\frac{{}_sE_b}{{}_cL_p}$	G-FG	G	G	FG	F-deflation blow-outs	G	FG-G	F	hz mt
$\frac{{}_sE_v}{{}_fL_p}$	G-FG	FG	G	FG-F	FG-liquefaction	G	FG-F	FG	mt wt
$\frac{{}_sE_b}{{}_fL_p}$	G-FG	G	G	G	FG-liquefaction	G	FG	FG	hz mt
$\frac{{}_sE_b}{{}_sU_p}$	G-FG	FG	G	G	F-deflation	G	FG-G	F	hz mt
$\frac{{}_sL_v}{{}_sU_p}$	G	FG	G	G	G	G	FG	FG	mt wt
${}_fL_p$	G	P	G	FG-F	F-liquefaction	G	F-P	P	wt mt
${}_fA_p$	G	F-P	U	G	F-liquefaction	G	F	U	fl wt

Table A.7.3.3 Evaluation of Terrain Type Suitability for Sewage Lagoons and Sanitary Landfills in Champagne Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
${}_{s}E_{N}$	F	G	G	G	F-deflation blow-outs	G	F-P	P	mt
$\frac{{}_{f}E_{v}}{{}_{c}L_{p}}$	G	FG	G	FG	FG-liquefaction	G	FG	FG	wt pf mt
$\frac{{}_{s}E_{v}}{{}_{a}G_{n}}$	P-U	G	G	G	FG-deflation	G	P-F	P	sl mt
$\frac{{}_{s}E_{b}}{{}_{c}L_{p}}$	G-FG	G	G	FG	FG-deflation blow-outs	G	F-P	F	mt
$\frac{{}_{s}E_{v}}{{}_{f}L_{p}}$	G-FG	FG	G	FG-F	FG-liquefaction	G	F	F	mt
$\frac{{}_{s}E_{b}}{{}_{f}L_{p}}$	G-FG	G	G	G	FG-liquefaction	G	F-P	P	mt
$\frac{{}_{s}E_{b}}{{}_{s}U_{p}}$	G-FG	FG	G	G	FG-deflation	G	P-F	P	mt
$\frac{{}_{s}L_{v}}{{}_{s}U_{p}}$	G	FG	G	G	G	G	P-F	P	mt
${}_{f}L_{p}$	G	P	G	FG-F	FG-liquefaction	G	F	P	wt mt
${}_{f}A_{p}$	G	F-P	U	G	FG-liquefaction	G	F	U	fl wt mt

Table A.7.3.4 Evaluation of Terrain Type Suitability for Septic Systems in Champagne Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor,
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
${}_sE_v$	F	G	G	G	FG-deflation blow-outs	G	FG	F	sl
$\frac{{}_fE_v}{{}_dL_p}$	G	FG	G	F	FG-liquefaction	G	P-F	P	hz mt pf
$\frac{{}_sE_v}{{}_aG_n}$	P-U	G	G	G	G	G	F-FG	P	sl mt
$\frac{{}_sE_b}{{}_cL_p}$	G-FG	G	G	G	FG-deflation blow-outs	G	FG	FG	hz mt
$\frac{{}_sE_v}{{}_fL_p}$	G-FG	G-FG	G	F	FG-liquefaction	G	F-FG	F	mt
$\frac{{}_sE_b}{{}_fL_p}$	G-FG	G	G	G	FG-liquefaction	G	FG	FG	hz mt
$\frac{{}_sE_b}{{}_sU_p}$	G-FG	G-FG	G	G	FG-deflation	G	FG	FG	hz mt
$\frac{{}_sL_v}{{}_sU_p}$	G	FG	G	G	G	G	FG-F	FG	hz wt
${}_fL_p$	G	P	G	F-P	FG-liquefaction	G	P-F	P	wt mt pf
${}_fA_p$	G	F-P	U	G	FG-liquefaction	G	F-P	U	fl wt mt

Table A.7.3.5 Evaluation of Terrain Type Suitability for Construction Materials in Champagne Area.

Terrain Factors: G - Good, FG - Fairly Good, F - Fair (marginal), P - Poor.
U - Unsuitable (very poor), I.A. - Individual Assessment preferrable.

Terrain Unit Symbol and Special Conditions	Slope (sl)	Drainage (wt)	Flood Hazard (fl)	Permafrost and Ice (pf)	Hazards (hz)	Bedrock Depth (br)	Materials; Stoniness (mt)	Terrain Unit Rating	Limiting Factors
${}_{s}E_{r}$	FG	G	G	G	F-deflation	G	F	F	mt
${}_{f}E_{v}/{}_{c}L_{p}$	G	FG	G	FG	FG-liquefaction	G	P	P	mt
${}_{s}E_{v}/{}_{s}G_{r}$	F-FG	G	G	G	G	G	G	FG	sl
${}_{s}E_{b}/{}_{c}L_{p}$	G	G	G	FG	FG-deflation	G	F-P	F	mt
${}_{s}E_{v}/{}_{f}L_{p}$	G	G	G	G	FG-liquefaction	G	P	P	mt
${}_{s}E_{b}/{}_{s}L_{p}$	G	G	G	FG	FG-liquefaction	G	F-P	F	mt
${}_{s}E_{b}/{}_{s}U_{p}$	G	G	G	G	FG-liquefaction	G	F	F	mt
${}_{s}L_{v}/{}_{s}U_{p}$	G	FG	G	G	G	G	F	F	mt
${}_{c}L_{p}$	G	U	G	FG	FG-liquefaction	G	U-P	U	mt wt
${}_{f}A_{p}$	G	P	P-F	G	FG-liquefaction	G	P	P	mt wt fl

APPENDIX B

Grain Size Analysis

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT	CLIENT	DATE RECORDED
'Yukon'	Terrain Analysis & Mapping	Oct./79

JRP FILE:	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO.	LAB NO.
Y-1898				SY 7	31

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	99.2		.055	100	.004	67.6
1½		20	98.9		.039	97.9		
1		40	98.5		.028	96.8		
3/4		100	98.0		.020	96.5		
1/2	100	200	97.6		.014	96.0		
3/8	99.5				.010	94.5		
4	99.4				.007	90.6		
					.005	81.2		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Sandy Silty Clay					

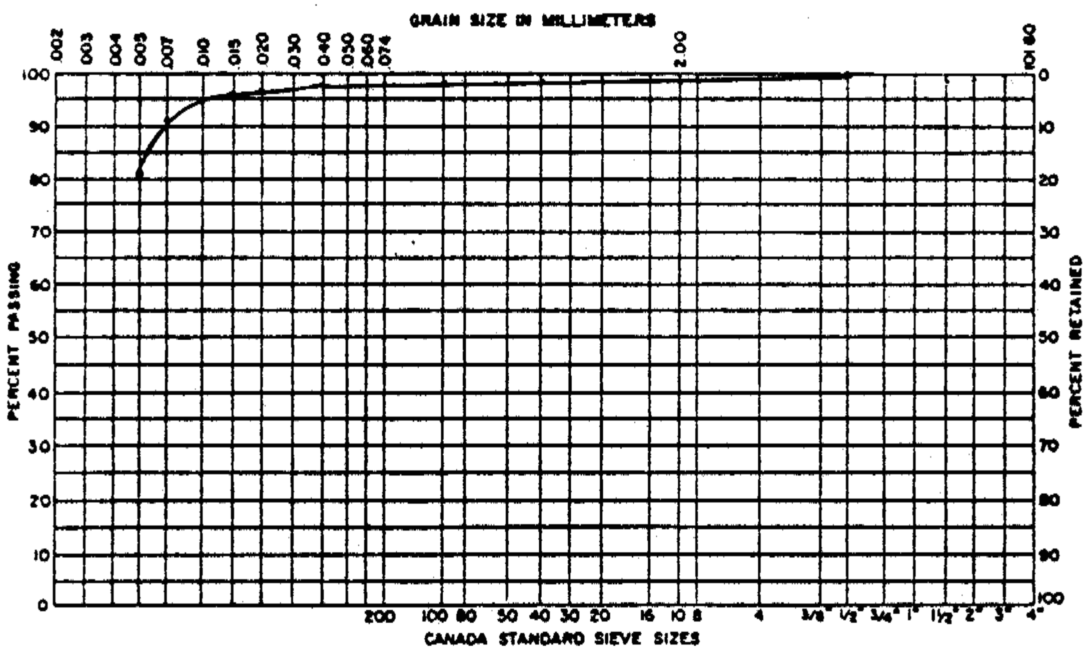
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
- Washed Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY 84	LAB NO. #25

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	99.8	.057	67.9	.005	16.9
1½		20	99.5	.042	60.9		
1		40	98.0	.031	54.7		
3/4		100	89.8	.022	47.8		
1/2		200	77.9	.016	41.6		
3/8				.012	35.5		
4	100			.009	20.7		
				.006	20.3		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H2O	S.G.
	Clayey Sandy Silt					

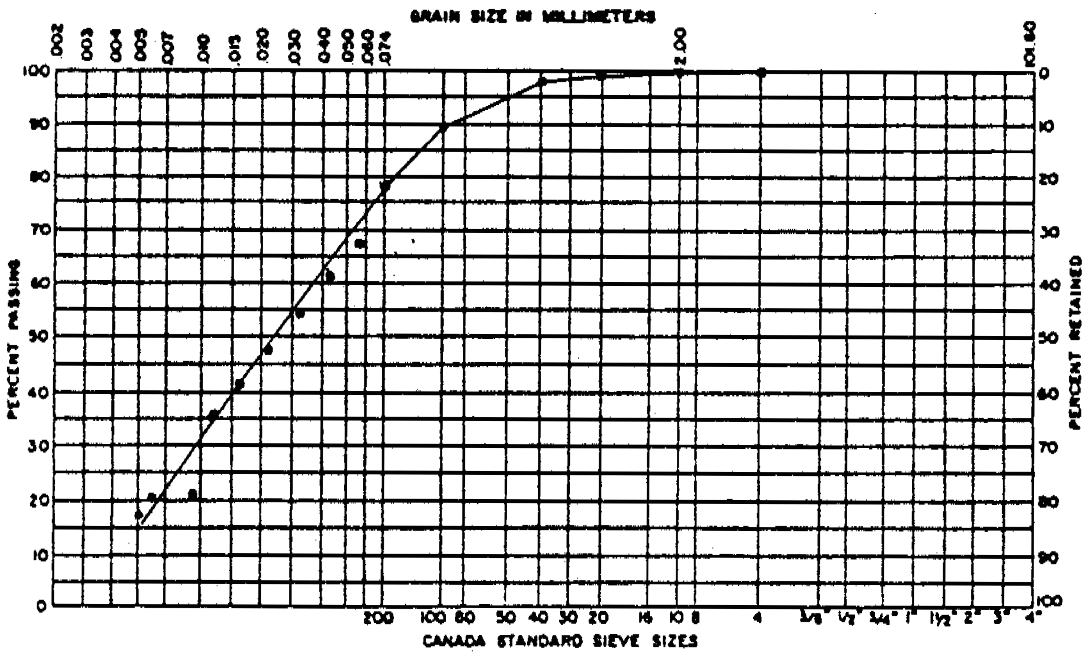
CRUSH COUNT ________ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
- Washed Sieve.

DATE SAMPLED ________
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'		CLIENT Terrain Analysis & Mapping	DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 123 PY	LAB NO. #8

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	43.7				
1½	100	20	33.9				
1	98.1	40	24.5				
3/4	95.6	100	8.9				
1/2	86.4	200	4.6				
3/8	79.1						
4	59.9						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H2O	S.G.
	Gravelly Sand					

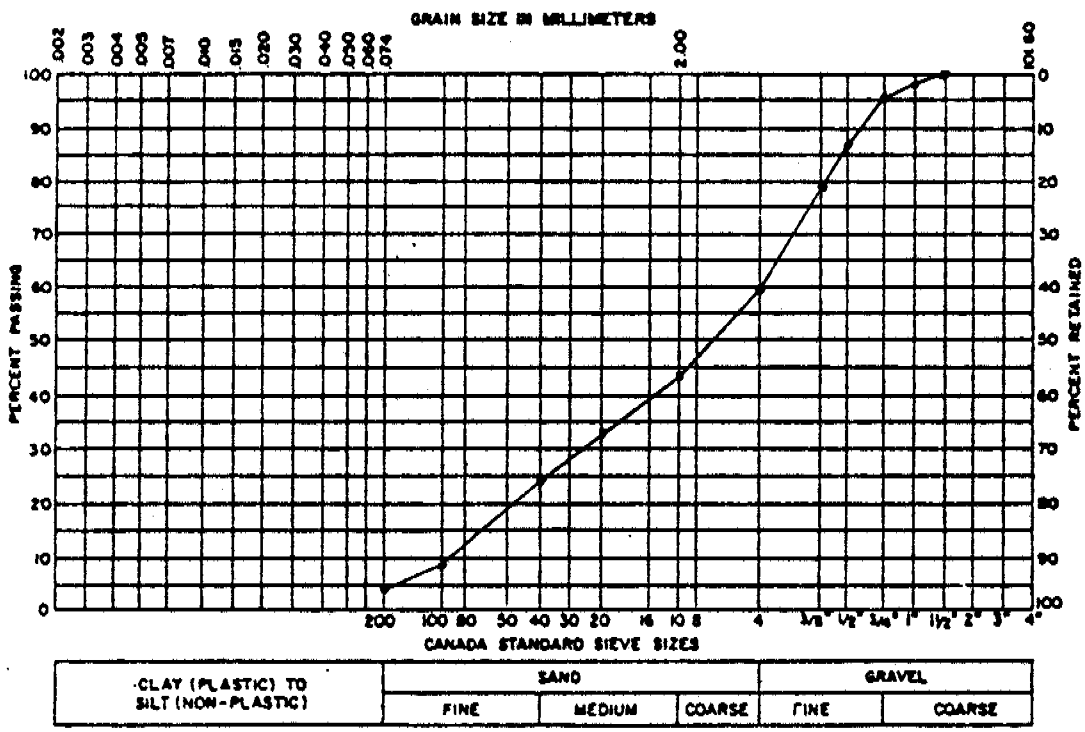
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY2	LAB NO. 26

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	100	.059	63.1	.005	15.3
1½		20	99.6	.044	55.8		
1		40	96.9	.032	48.3		
3/4		100	88.7	.023	39.8		
1/2		200	73.7	.017	34.9		
3/8				.013	29.8		
4				.009	24.7		
				.007	19.9		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H2O	S.G.
	Organic Clayey Sandy Silt					

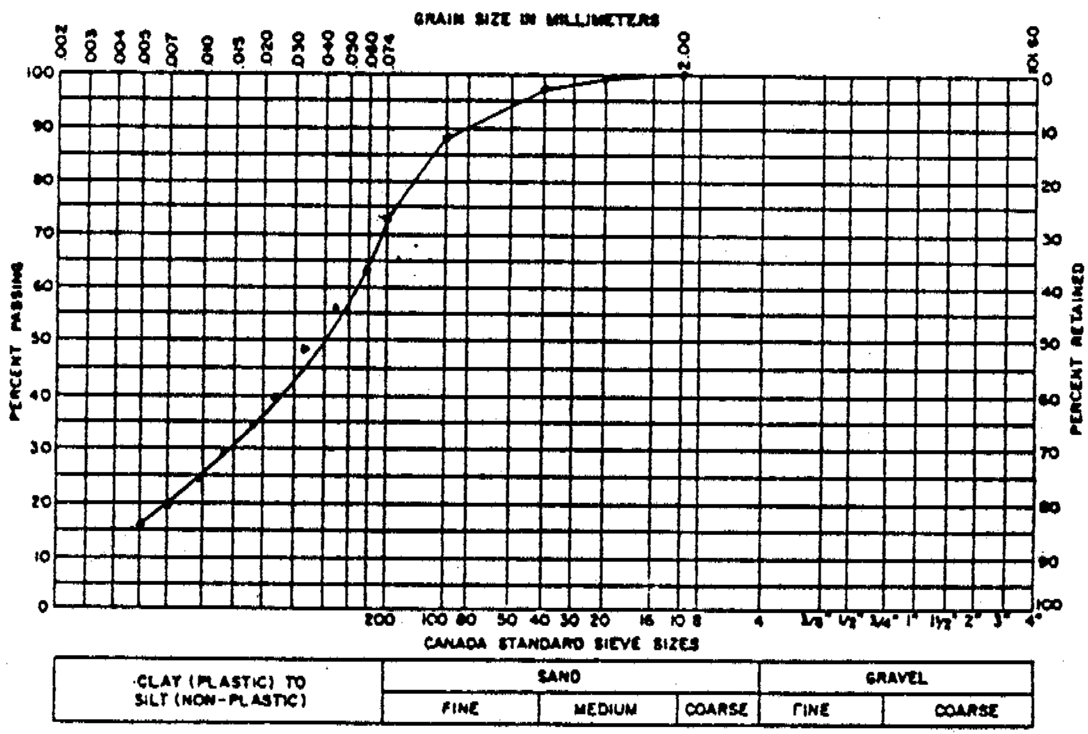
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Washed Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY 6	LAB NO. 34

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	100	.058	85.2	.005	23.6
1½		20	99.7	.042	78.8		
1		40	99.2	.031	68.6		
3/4		100	96.3	.023	57.6		
1/2		200	92.0	.017	50.2		
3/8				.012	43.0		
4				.009	34.0		
				.006	27.6		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Sandy Clayey Silt					

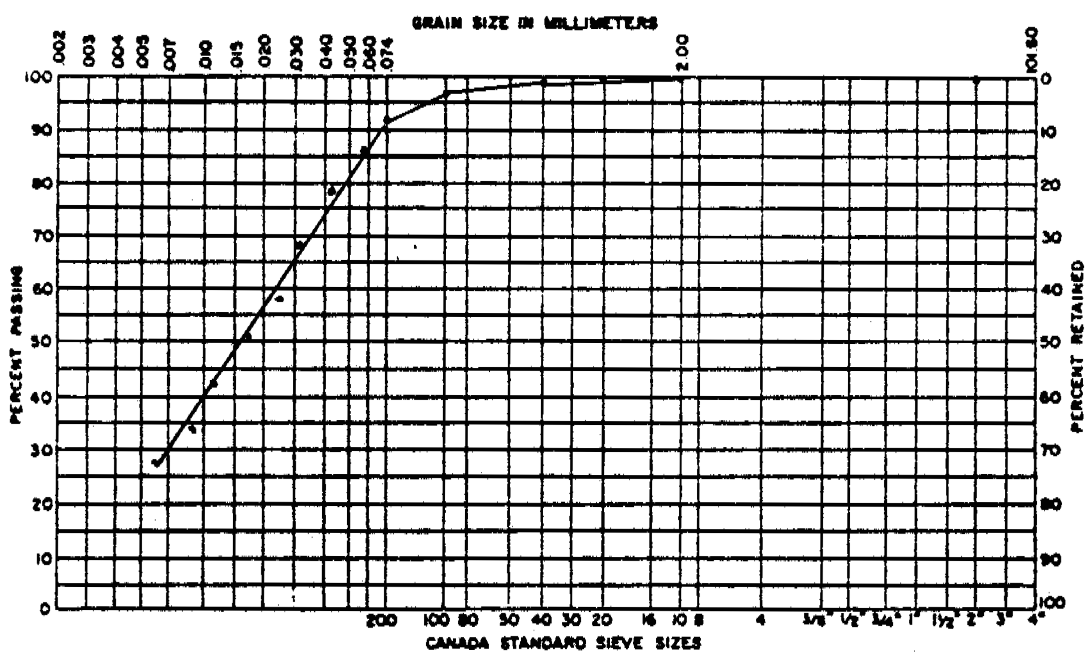
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS — WashedSieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.

CONSULTING AND TESTING ENGINEERS

PROJECT	CLIENT	DATE RECORDED
'Yukon'	Terrain Analysis & Mapping	Oct./79

JRP FILE:	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO.	LAB NO.
Y-1898				SY 8	28

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	91.9	.060	68.2	.005	27.2
1½		20	86.4	.044	63.8		
1		40	82.0	.032	60.1		
3/4		100	74.7	.023	56.4		
1/2	100	200	67.1	.016	54.6		
3/8	98.9			.012	49.5		
4	95.4			.009	41.9		
				.006	33.6		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H₂O	S.G.
	Clayey Sandy Silt					

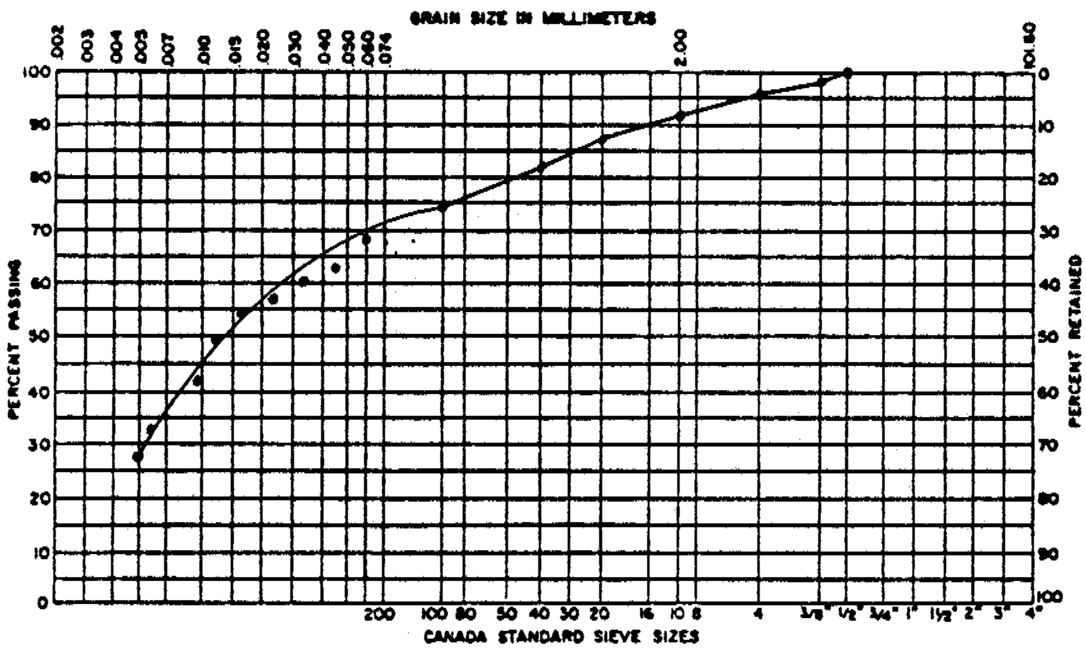
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
- Washed Sieve

DATE SAMPLED
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'	CLIENT Terrain Analysis & Mapping	DATE RECORDED Oct./79

JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SP 1	LAB NO. #16

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	33.1				
1½	100	20	15.6				
1	98.4	40	6.8				
3/4	97.7	100	1.0				
1/2	92.8	200	.4				
3/8	88.5						
4	70.4						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand					

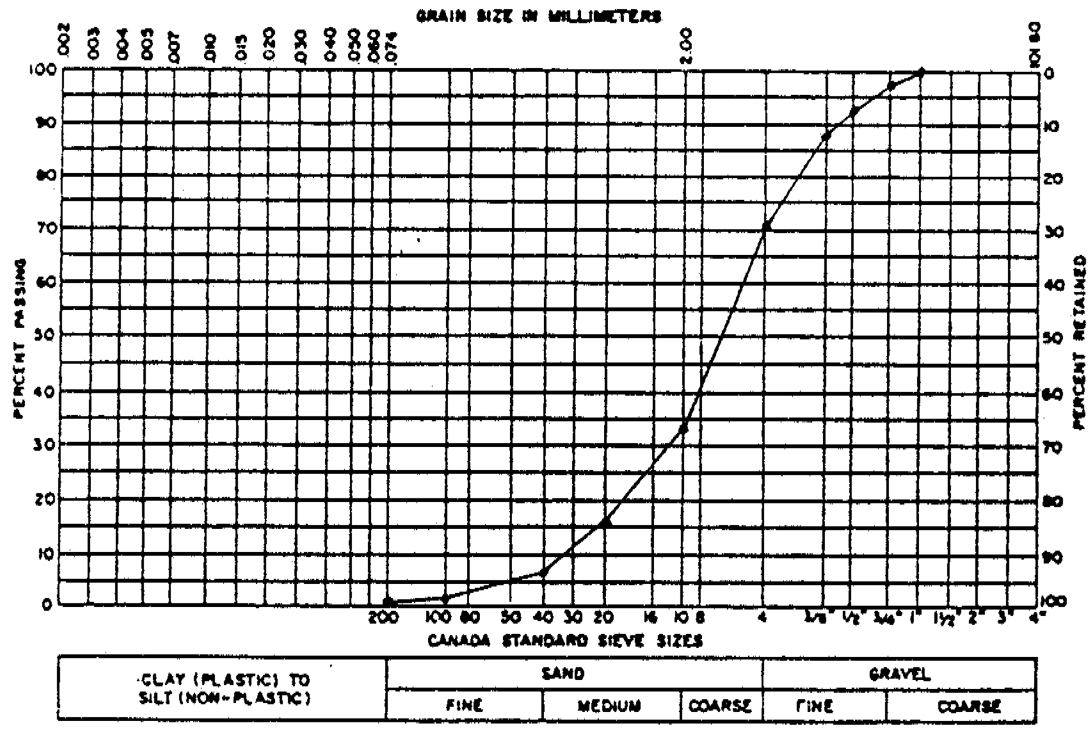
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'		CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 89 PY	LAB NO. #15

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	54.7				
1½		20	42.0				
1	100	40	17.0				
3/4	98.6	100	1.5				
1/2	89.8	200	.4				
3/8	82.9						
4	68.4						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand					

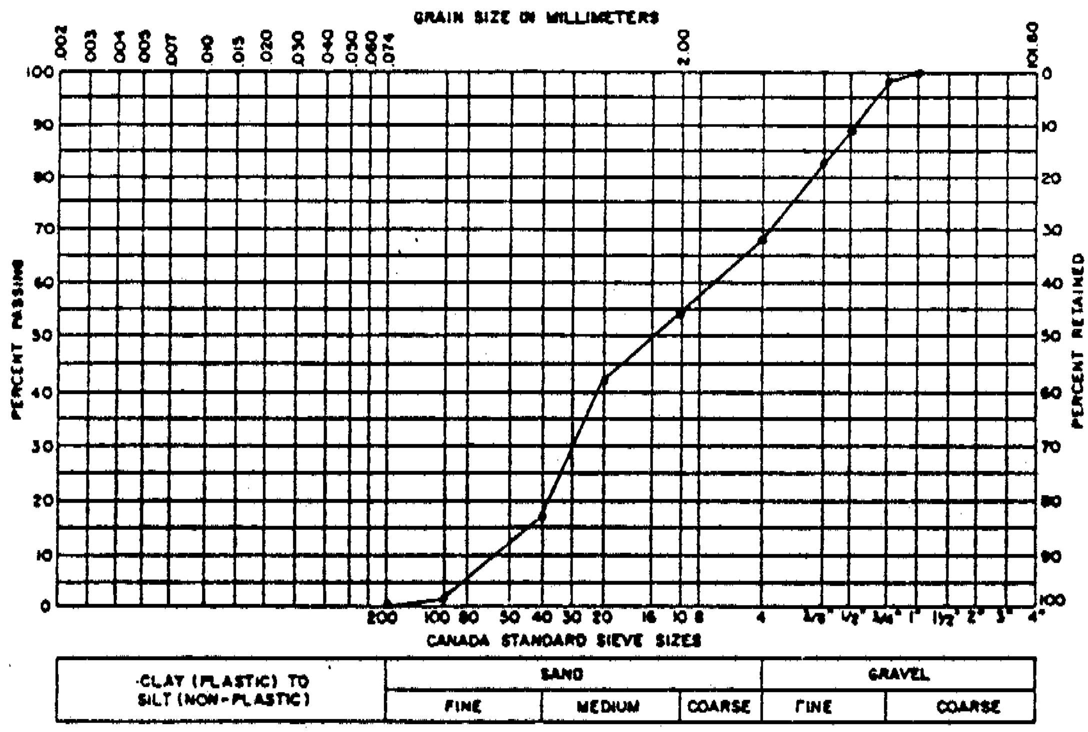
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT	CLIENT	DATE RECORDED
'Yukon'	Terrain Analysis & Mapping	Oct./79

JRP FILE:	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO.	LAB NO.
Y-1898				SY 78	#3

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	70.2				
1½		20	49.1				
1		40	17.2				
3/4	100	100	2.2				
1/2	98.5	200	1.1				
3/8	95.8						
4	86.0						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand					

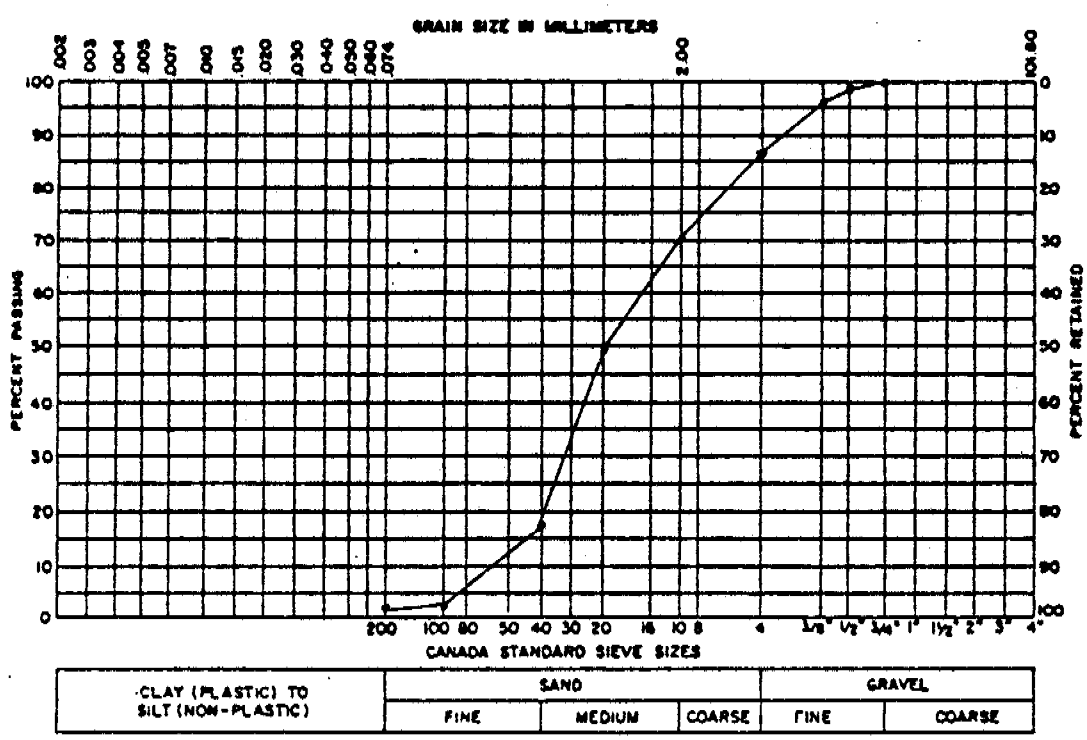
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY 95	LAB NO. #2

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
3"	100						
2"	91.7	10	67.3				
1½	88.0	20	62.7				
1	82.7	40	52.3				
3/4	79.3	100	13.7				
1/2	76.7	200	4.7				
3/8	74.6						
4	71.3						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand					

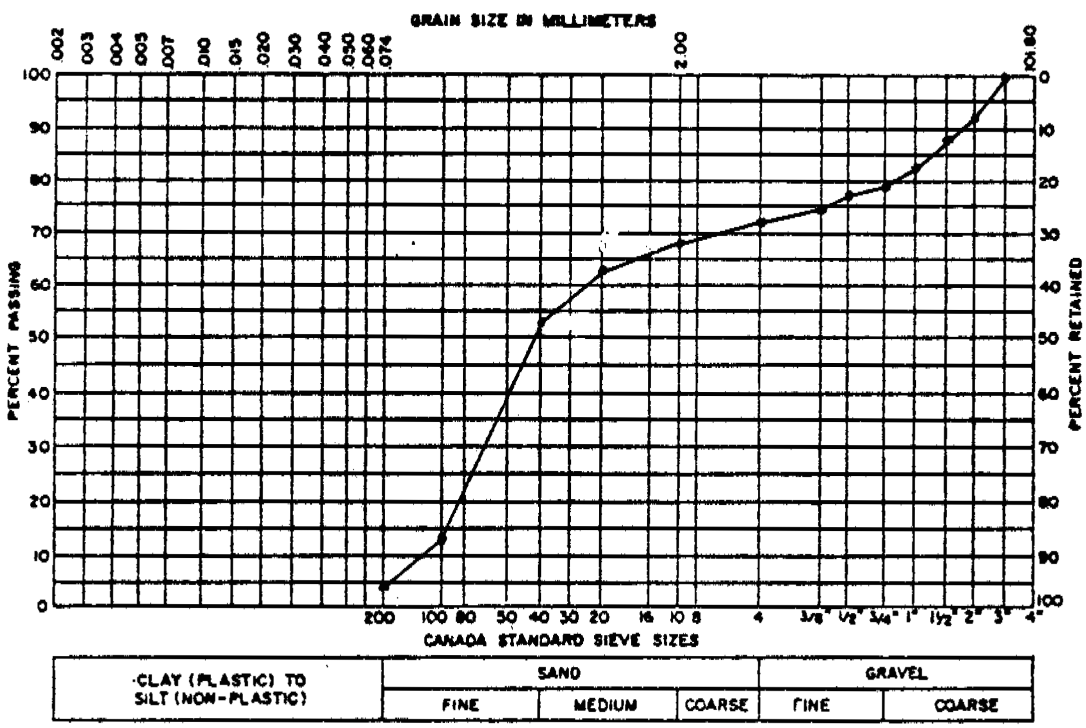
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 73 PY	LAB NO. #17

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	52.7					
1½		20	32.9					
1	100	40	18.6					
3/4	96.0	100	7.9					
1/2	90.8	200	6.0					
3/8	85.8							
4	71.8							

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand.					

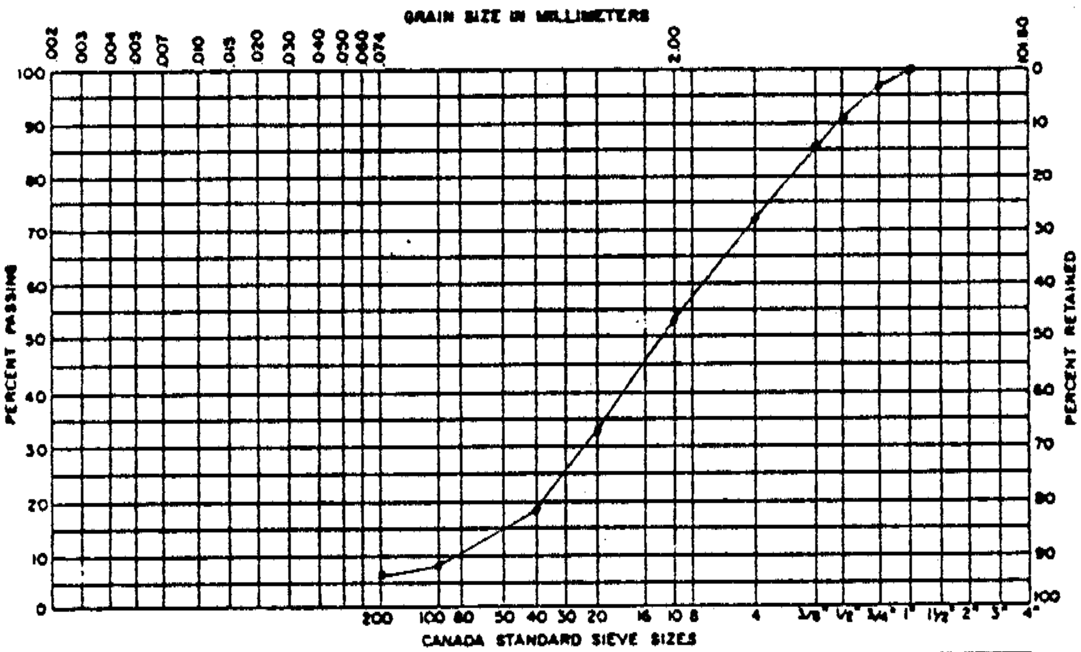
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
– Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'	CLIENT Terrain Analysis & Mapping	DATE RECORDED Oct./79

JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. ISS RY	LAB NO. #6

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	89.3					
1½		20	64.7					
1	100	40	30.7					
3/4	99.4	100	1.0					
1/2	98.8	200	.6					
3/8	97.8							
4	95.6							

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Sand					

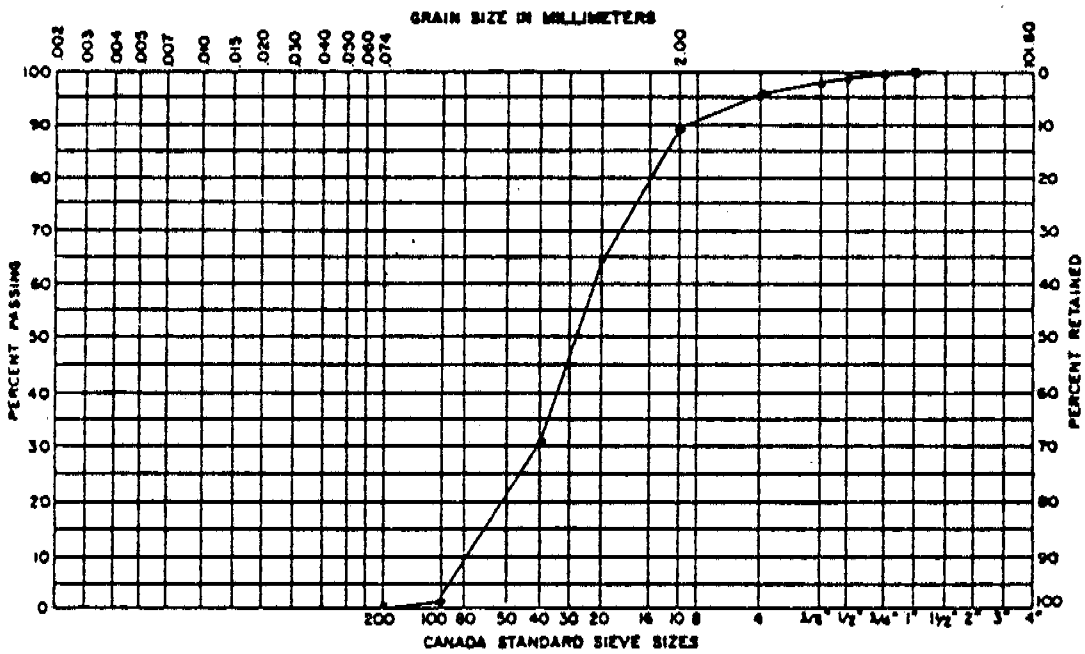
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
PLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'			CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 57 PY	LAB NO. #23

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	42.2					
1½		20	27.7					
1	100	40	15.5					
3/4	94.3	100	5.5					
1/2	76.8	200	2.7					
3/8	70.0							
4	56.5							

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H2O	S.G.
	Gravelly Sand					

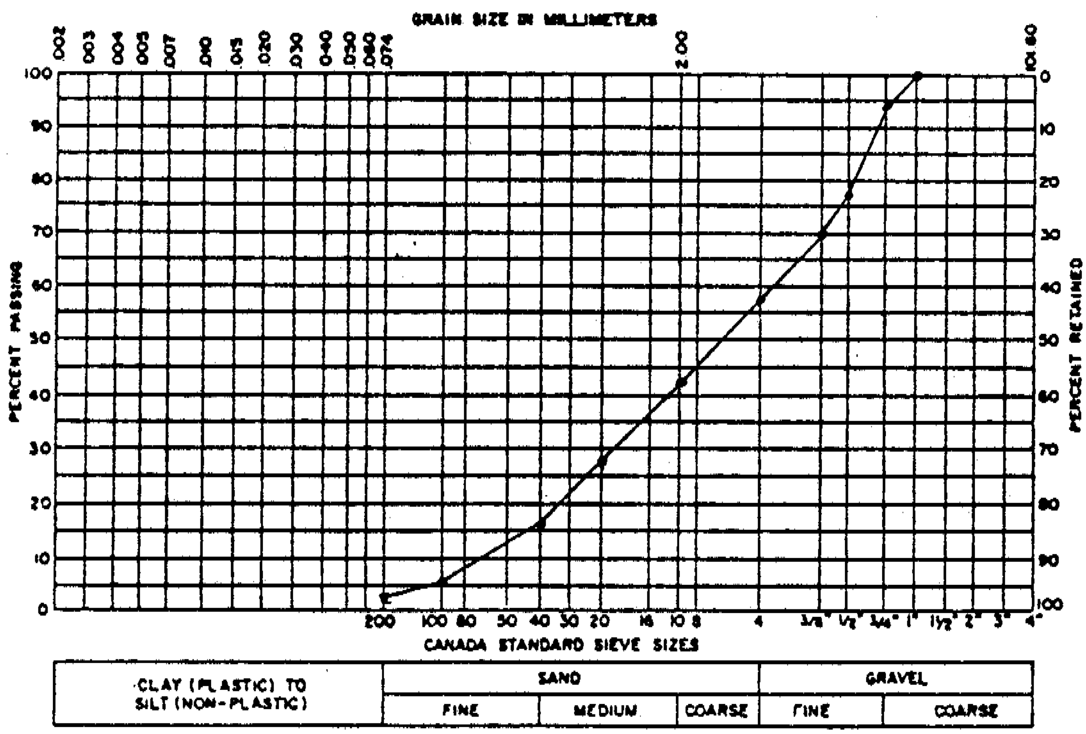
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS - Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT				CLIENT	DATE RECORDED
'Yukon'				Terrain Analysis & Mapping	Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY 39	LAB NO. 29

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	79.2		.060	60.4	.005	9.0
1½		20	73.0		.044	53.5		
1	100	40	69.2		.033	44.7		
3/4	96.1	100	66.0		.024	33.9		
1/2	90.5	200	61.2		.018	26.0		
3/8	88.5				.013	20.1		
4	83.4				.009	14.9		
					.007	11.2		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Clayey Sandy Silt					

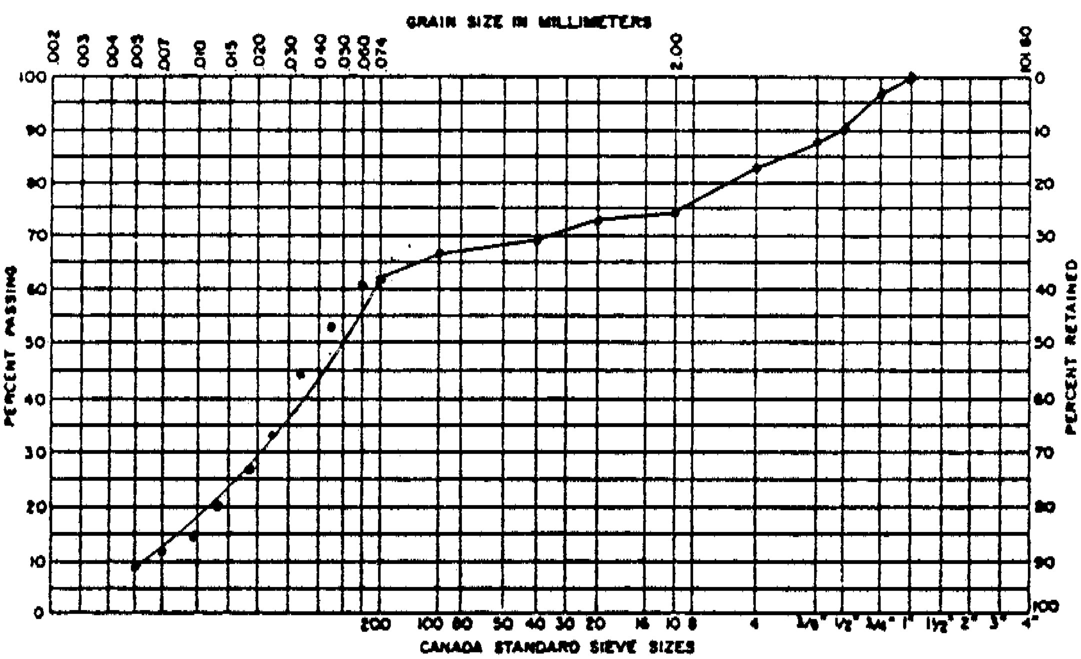
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS ______
- Washed Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'		CLIENT Terrain Analysis & Mapping		DATE RECORDED Oct./79
JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. SY 40	LAB NO. 27

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	54.5	.068	24.3	.005	4.4
1½	100	20	41.7	.049	19.4		
1	90.7	40	33.9	.036	15.0		
3/4	90.7	100	26.2	.026	13.5		
1/2	83.1	200	20.8	.018	10.8		
3/8	79.5			.013	8.6		
4	68.5			.009	7.5		
				.007	5.5		

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Clayey Silty Sand					

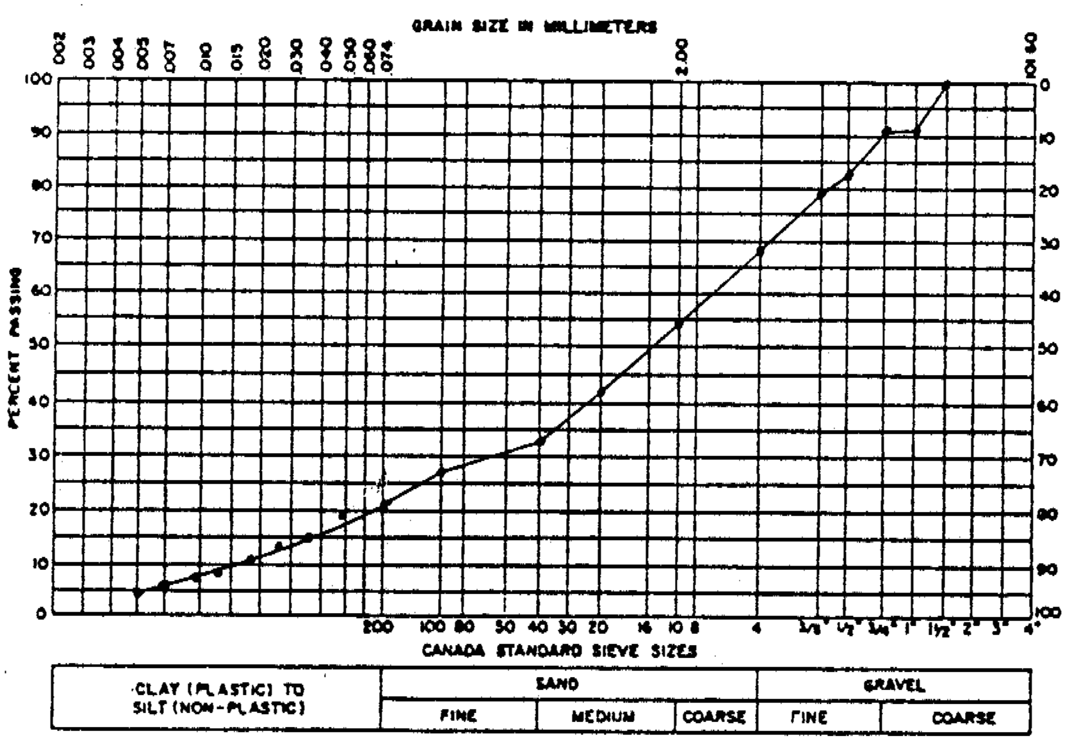
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS
- Washed Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'	CLIENT Terrain Analysis & Mapping	DATE RECORDED Oct./79

JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 60 PY	LAB NO. #21

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT		Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	27.6					
1½	100	20	11.9					
1	98.0	40	4.3					
3/4	93.1	100	1.3					
1/2	82.5	200	.7					
3/8	74.2							
4	50.6							

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	SandyGravel					

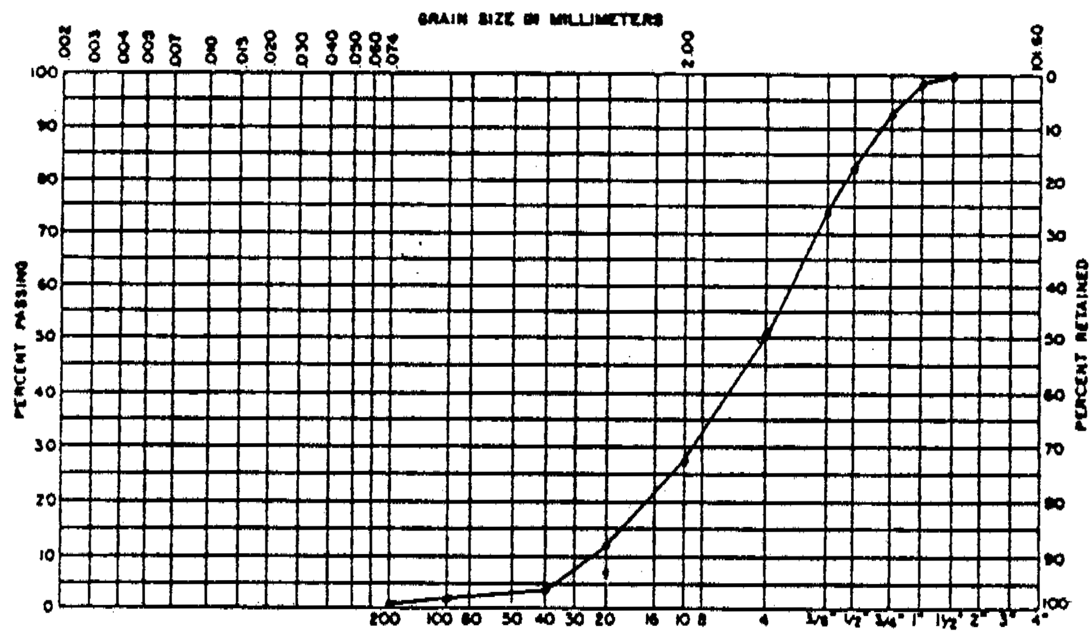
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



CLAY (PLASTIC) TO SILT (NON-PLASTIC)	SAND			GRAVEL	
	FINE	MEDIUM	COARSE	FINE	COARSE

LABORATORY'S REMARKS
- Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

J. R. Paine & Associates Ltd.
CONSULTING AND TESTING ENGINEERS

PROJECT 'Yukon'	CLIENT Terrain Analysis & Mapping	DATE RECORDED Oct./79

JRP FILE: Y-1898	SAMPLE TYPE	DEPTH	HOLE NO.	FIELD NO. 100 PY	LAB NO. #19

LABORATORY TESTING REPORT

GRAIN SIZE ANALYSIS

SIEVE SIZE	% FINER BY WEIGHT	SIEVE SIZE	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT	Dia. mm	% FINER BY WEIGHT
2"		10	59.3				
1½		20	39.8				
1		40	14.7				
3/4	100	100	2.1				
1/2	89.1	200	0.4				
3/8	82.9						
4	71.7						

SAMPLE NO.	UNIFIED CLASSIFICATION	L.L.	P.L.	P.I.	NATURAL % H_2O	S.G.
	Gravelly Sand					

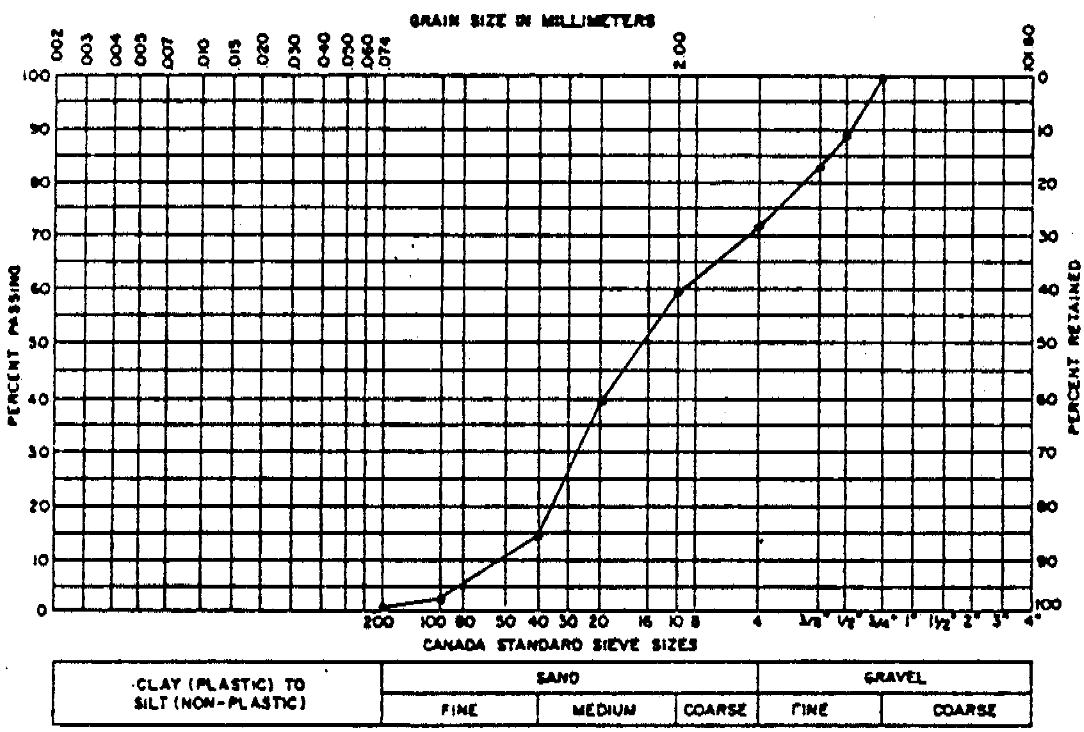
CRUSH COUNT ______ %

PETROGRAPHIC ANALYSIS

MATERIAL TYPE	% OF TOTAL SAMPLE

PARTICLE SHAPE ANALYSIS

ROUND	
SUB-ROUND	
ANGULAR	
SUB-ANGULAR	
FLATS	
NEEDLES	



LABORATORY'S REMARKS - Dry Sieve.

DATE SAMPLED ______
DATE RECEIVED Aug./79
TECHNICIAN(S) ls & ls
CHECKED BY [signature]

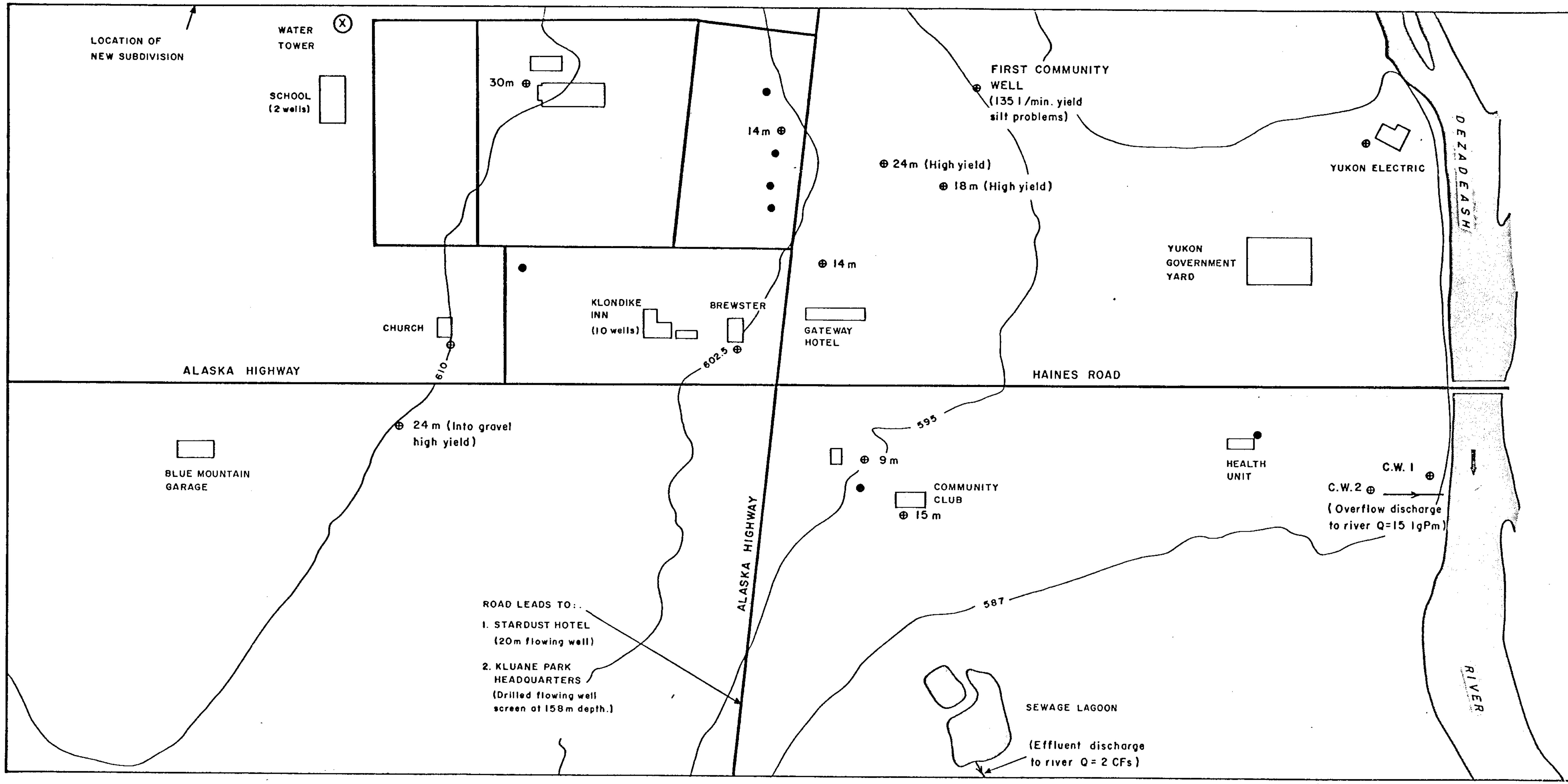


FIGURE 4.5.1.

WELL LOCATIONS

HAINES JUNCTION

LEGEND

⊕ DRILLED WELL

● DUG WELL

C.W.1 COMMUNAL WELL

HIGH YIELD 725 IgPm ESTIMATE (110 l/min.)

18m DEPTH OF WELL (In metres)

→ RIVER FLOW DIRECTION

-610- CONTOURS (In metres)