



PEMCAN SERVICES

COPY #34

DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

FORT SIMPSON, N.W.T.
COMMUNITY STUDY AREA



TABLE OF CONTENTS

	Page
Preface	i
METHODOLOGY - EVALUATION	
Investigation Procedure	1
Geomorphology	3
Terrain Photographs	6
Environment	7
SUMMARY	
Recommendations and Conclusions	11
Figure 1 - Surficial Geology	
Figure 2 - Tabulated Summary, Site Locations and Wildlife Areas	
SITE DESCRIPTION	
Site Descriptions - Fort Simpson Study Area	
GLOSSARY - BIBLIOGRAPHY	

PREFACE

The Government of Canada anticipated the potential need for extensive volumes of granular material for proposed major construction projects in the area of the Mackenzie River Valley and initiated an investigation of granular materials in this region during 1972 and 1973.

In September, 1972 the Department of Indian Affairs and Northern Development engaged PEMCAN Services "72" to conduct Stage 1 of the Territorial Granular Materials Inventory. Stage 1 is defined as the area from Fort Simpson to Fort Good Hope, N.W.T.

The objectives of this investigation were specified as:

- Part 1: An investigation of the availability of granular material deposits within a ten mile radius of the communities of Fort Simpson, Wrigley, Fort Norman, Norman Wells and Fort Good Hope.
- Part 2: An investigation of the availability of granular material deposits in the intermediate areas between the respective communities.

Part 1 of the investigation for the granular materials has been carried out by PEMCAN Services "72" in accordance with the Terms of Reference as specified by the Department of Indian Affairs and Northern Development. The results of the investigation pertaining to Part 1 are submitted in five separate reports which cover the respective communities within the Study Area. Part 2 of the investigation includes four separate inter-community area reports and a summary section.

The Terms of Reference specified the following definitions and procedures:

1. "Granular Material" is defined as all naturally occurring unconsolidated material, and bedrock which can be processed for suitable engineering construction.
2. Compilation and evaluation of the Geological Survey of Canada's surficial geology and granular material maps and all other relevant information prior to the undertaking of the field investigation.
3. Location, testing and classification of all granular and potential bedrock quarry materials within the specified search area and recommendations for their best use.

The data compiled for each site will include:

- a) The quantity and quality of usable material available, and recommendations as to its suitability as a construction material. Recommendations shall be substantiated by including results of tests on applicable material samples; these tests include:

Grain size distribution

Petrographic analysis

Moisture content

Ice content

Organic content

Hardness test

(In addition to the above tests, PEMCAN Services "72" recommended the use of Los Angeles Abrasion tests on samples from potentially high priority granular material and bedrock quarry sites).

- b) The location of borrow pits, and recommendations for development.

- c) Recommendations on the most efficient sequence of development where several pits can be developed in the same general area.
 - d) Evaluate the best access routes from prospective sites to the center of each community or to existing or proposed utilities.
 - e) Recommendations for development, exploitation, disposal of overburden and waste, and restoration of proposed borrow pits in such a manner to minimize terrain disturbance.
- 4. Development of a method of mapping, rating and reporting the deposits within the Study Area.
 - 5. Identification on the plan of granular deposits exposed in, or along banks of streams and rivers adjacent to the communities but exclusion of such deposits in the material availability for the community unless no other sources of granular materials are available.
 - 6. If satisfactory granular materials are not available within the designated Study Area around the communities, then recommendations pertaining to either alternate sources outside of these areas, or bedrock quarry development will be required.

The successful completion of this study was enhanced by the cooperation and contributions of the respective Territorial Land Use Agents and other Federal and Territorial Government personnel including the Federal Department of Public Works and their respective consultants. In particular, we wish to acknowledge the assistance, guidance and liaison provided by Mr. H.D. Dekker, Chairman, and other members of the Granular Materials Working Group.



INVESTIGATION PROCEDURE

Pertinent geological information was compiled from the study and from correlation of previous reports of investigations conducted within the Study Area. These included Geological Survey of Canada reports and open files; pipeline route investigations, previous PEMCAN studies and field investigations, and personal communication with noted authorities of the region. The surficial geology map shown in Figure 1 has been derived from both the aforementioned information and field observation data.

Airphoto interpretation of prospective sites was undertaken prior to the field work with J.D. Mollard and Associates Ltd. Recent airphotos, scaled at 1":3,000', provided by The Department of Indian Affairs and Northern Development, were utilized to outline sites, estimate the areal extent of sources and note locations of test hole and required access roads. Pertinent parts of these airphotos have been reproduced and used as location plans for catalogued sites. Air mosaics showing revised route locations for the Mackenzie Highway were provided by The Federal Department of Public Works or their respective engineering consultants.

The preliminary field work, carried out in September and October, 1972, commenced with aerial reconnaissance in order to assess prospective sites. Selected sites were then investigated by means of test pits which were excavated manually, logged and sampled to depths of seven feet below the ground surface. On the basis of the airphoto interpretation and preliminary field reconnaissance, four sites were designated for drilling during the winter program.

Material samples secured from outcrops, test pits and drill holes were shipped to Calgary for laboratory analyses which included grain size distribution, petrographic analysis moisture content determination and hardness tests. In specific cases the samples or combined samples were tested for resistance to mechanical abrasion.

The potential quantities of available granular materials, availability of existing access roads, drainage conditions, wildlife implications and the distance from the community were con-



sidered for selecting sites for more detailed investigations. Smaller or more marginal deposits were assessed but were not studied in detail because of remoteness from the community or planned utilities. These sites are identified in Figure 2 by the suffix "X" behind the site number.

A total of thirteen sites were catalogued in the ten mile radius of Fort Simpson (Figure 2). Of these, eight sites were investigated to a greater detail by means of test pits and four sites by means of drill holes. Three additional sites were investigated by Geological Survey of Canada personnel and partial information from their studies is incorporated in this report.

Results of the investigation are summarized in this report and detailed information of the studied sites is compiled in the section on Site Description. The areal extent of the individual deposits are based on airphoto interpretation, field reconnaissance and field drilling records. Except on sites where drill holes penetrated the total depth of the granular deposit, the average thickness of individual deposits was generally estimated from morphological and geological features or with respect to thickness indicated by natural outcrops. However, the estimated volumes should be conservative since adjustments were made for variables such as drainage conditions and sloping ground along the outer limits of the deposit.

Test pit logs, drill hole logs, outcrop descriptions and laboratory test results are attached to the individual Site Descriptions. Symbols, terminology and classification systems used are explained in the glossary.



GEOMORPHOLOGY

The Fort Simpson Study Area lies within the western part of the Great Slave physiographic region. The terrain, in general, has a very low relief and forms the lowlands along the Liard and Mackenzie Rivers. In the Study Area, river channels and relatively infrequent erosional gullies are the only major features which disturb the generally flat character of the land surface.

The bedrock, predominantly greenish grey shales and siltstones of the Upper Devonian, Simpson formation, is covered with morainal, glaciofluvial and glaciolacustrine deposits. Following the final retreat of the glaciers, the development of drainage patterns resulted in localized re-exposures of older deposits such as glacial tills and glaciofluvial sediments along major stream channels. Rivers have eroded their beds deeply through unconsolidated deposits into the underlying bedrock, and have reworked the eroded material into terrace and alluvial plain deposits. Wind action has reworked surficial layers of former lake basins and redeposited fine grained materials into numerous dunes. The main landforms and geological features are illustrated by Figure 1.

The Study Area is primarily covered by glaciolacustrine deposits, consisting mainly of fine grained sand and silt which contains buried beach ridges and glaciofluvial gravels. In most cases these coarse granular deposits are too deep to be identified. With the exception of relatively narrow strips along deeply incised water courses, the glaciolacustrine plain is poorly drained. This inadequate drainage usually results in high water tables, dense organic covers and generally, moderate amounts of ground ice.

Glaciolacustrine material has been blown by wind into dunes and duned ridges. These deposits are interspread within the southern section of the Study Area where they rise to maximum heights of sixty feet above the flat plain. Eolian deposits generally consist of poorly graded, medium to fine grained, dry sands, with little or no ground ice.



Morainal deposits, consisting of till, which is a heterogeneous mixture of silt, sand and clay with scattered pebbles and cobbles is exposed or covered with a relatively thin veneer of glaciofluvial and glaciolacustrine sediments on the northern side of the Mackenzie River. Glacial tills at other locations are deeply buried under more recent deposits.

Alluvial deposits consist of silts and sands with localized gravel beds, usually, at greater depths. Alluvial flood plains border present water courses while terraces are well above recent channels.

Bedrock in the Study Area is usually covered by thick surficial deposits. The only outcrops are at a few locations in the steep, deeply cut outer banks of the Liard and Mackenzie Rivers. The bedrock consists of soft shales and siltstones which are generally incompetent as manufactured aggregates for construction purposes.

In the Study Area there are four main geomorphologic forms in which natural granular materials occur:

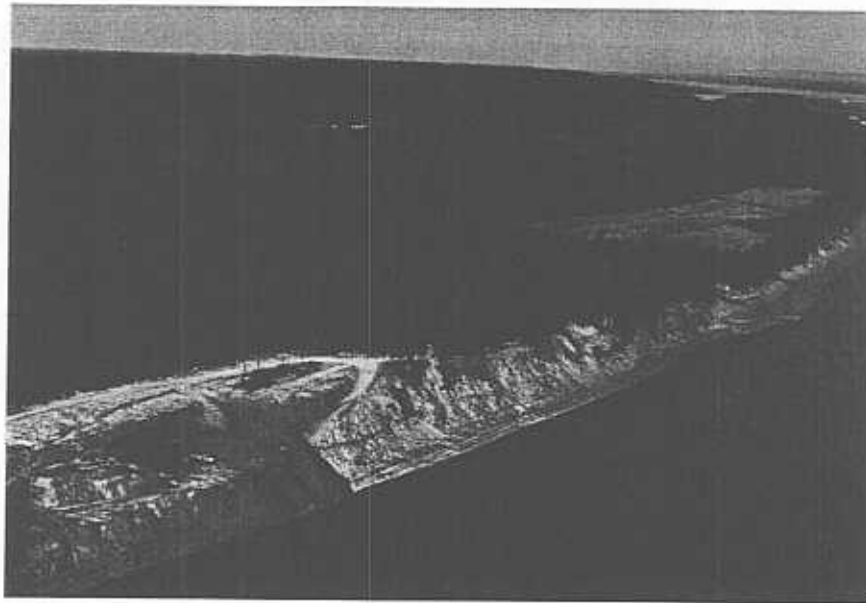
- Dunes and duned ridges, containing poorly graded, fine grained sands. These deposits are widespread south and southwest from Fort Simpson.
- Alluvial terraces along the Liard River, containing mostly silts and sands with gravel beds at depth.
- Remnants of a glaciolacustrine beach exposed on the west side of the Liard River, and consisting of sand with gravel layers and lenses.



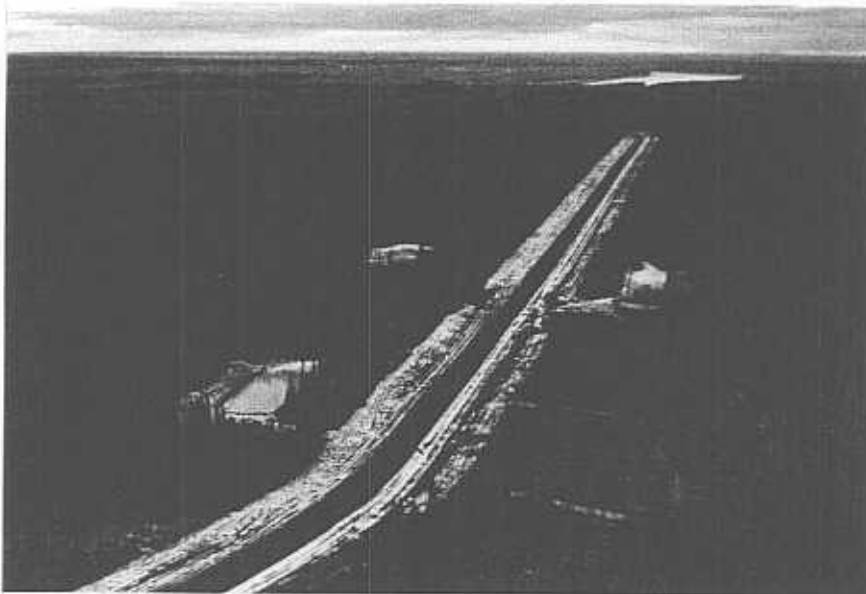
- Glaciofluvial outwash, containing silty sand and gravel with silt and clay pockets, locally exposed within the northern Mackenzie River Bank, west of the Harris River.

The Study Area lies within the discontinuous permafrost zone and the occurrence of frozen soils is sporadic. Excess ice, usually less than fifty percent, is generally encountered in fine grained, poorly drained soils topped with thicker organic soil layers. No or very little excess ice exists in the well drained materials which were investigated during the study. The depth of the seasonal freezing and thawing usually varies from 1.5 to 6 feet, depending upon localized conditions such as type of material and thickness of vegetation cover.

TERRAIN PHOTOGRAPHS



Alluvial terrace three miles southeast of Fort Simpson on the west bank of the Liard River. Note active borrow pit operations (Ref. Site FS 1).



All weather Mackenzie Highway approximately thirty miles south of Fort Simpson. Note abandoned borrow pits.



ENVIRONMENT

The ten mile radius of the Study Area is encompassed within the fifteen mile radius of the Fort Simpson "Development Area" as enacted by the Commissioner of the Northwest Territories. Within the "Development Area" the Territorial Government, in the interests of the public, regulates and controls orderly domestic and industrial development. All of the area in the "Development Control Zone" around Fort Simpson is included within the boundaries of the Study Area as shown in Figure 2. Management of lands within this zone have been transferred from Federal to Territorial Government control. Federal projects, such as buildings, highways, and airports, are excluded from this transfer.

The Fort Simpson Study Area is geographically located in an area that offers considerable use and development of both water and land environments. The eastern segment of the Study Area in the Mackenzie and Liard River Valleys is especially enhanced by natural attributes such as vegetation and water components.

Terrain sensitivity and reaction to modification is less pronounced in the Fort Simpson Study Area than in regions further to the north. In general, the occurrence of permafrost is more discontinuous and at greater depths.

The relatively flat, low-profiled and generally fine grained terrain types such as silt-clay plains, beaches, river deposits and organic terrain generally contain minimal ground ice content. Therefore, disturbance because of low strength and high compressibility values is generally less than in similar terrain types at higher latitudes. However, vegetated sites are still susceptible to subsidence, slumping and gullying if the vegetation is removed or highly compressed and disturbed. Thermokarst subsidence, undercutting and channel shifting can also be expected, especially in fine river deposit terrain.



Hummocky and rolling terrain as characterized by the till plains in the area generally contain moderate ground ice content. Localized contrasts in material type and ice content is oftentimes evident between well drained slopes and low depressions. This terrain in general exhibits minor to moderate susceptibility to thermokarst, ground ice slumping and gullying. Usefulness of till material as fill is usually limited by its ice content.

In general, the favourable granular material sites in the Fort Simpson Study Area tend to be located on fairly well drained geomorphic features that contain relatively low amounts of ground ice. Therefore, properly managed development procedures should minimize the detrimental terrain reaction to acceptable levels. In many cases, the access routes to these sites will traverse areas of low wet terrain that generally will contain higher ice contents and will therefore be more susceptible to adverse reaction when disturbed. In these cases, sound development procedures such as the incorporation of protective measures for retainment of vegetation ground-insulation layers and the establishment of adequate fill materials for access roads will limit detrimental terrain reaction to satisfactory levels.

Vegetation

In the Upper Mackenzie Valley, the Boreal forest region of Canada is restricted to a narrow band that extends along the Inner Mackenzie Valley. The Fort Simpson Study Area lies within the southernmost reaches of this Boreal forest zone.

In the Community Study Area the dominant tree species are black and white spruce, tamarack, poplar, birch, willows, alder and occasional pine. The ground cover is predominantly mosses, lichens, sedges, herbs and shrubs. The vegetation ranges from commercial growths on river islands and alluvial flats to shrubby growth and treeless muskeg.



Poorly drained alluvial sites commonly support growths of black spruce, tamarack, willow and alder. Muskeg areas generally support black spruce, tamarack and occasionally, birch; relatively shallow permafrost areas may support white spruce, especially if the permafrost acts as a media to maintain relatively high surficial moisture contents. Well drained sites commonly support white spruce and poplar, with lesser growths of birch and pine.

Benchland areas that are underlain by fine-grained materials with discontinuous permafrost generally support growths of spruce, with occasional tamarack, willow and alder. Well drained benchland areas are characterized by growths of poplar, with lesser pine and spruce.

In the Fort Simpson Study Area, natural regrowth of vegetation on existing trails and cutlines indicates that in general, regeneration of disturbed areas will occur, especially if the nutrient levels within the topsoil layer are left undisturbed. However, in areas where permafrost acts as a favourable moisture retention media for vegetation that normally would not grow because of lack of moisture, disturbances such as clearing, may sufficiently alter moisture conditions to a point where timber growth is inhibited.

Wildlife

Wildlife species that are predominantly characteristic of the Boreal forest utilize the Fort Simpson Study Area and adjacent regions. For the most part, the utilization of this area by wildlife, waterfowl and fishery resources is based upon seasonal migration patterns that generally follow the Mackenzie River Valley. Although various wildlife species inhabit the Study Area, and in some cases serve as a means of livelihood for local residents, there are no known wildlife habitats within the Study Area that are classified as either important or critical by the Canadian Wildlife Service.

In the Study Area, wildlife resources are hunted and trapped along both banks of the



Mackenzie and Liard Rivers, and in the southeastern portion of the area south of the Mackenzie River (Figure 2). Both river bank areas are hunted year-round for moose, with occasional trapping for beaver and mink during the winter. The southeastern section of the Study Area is trapped for beaver, mink, lynx and marten by residents of Fort Simpson.

Fishery resources in the Fort Simpson Study Area are predominantly those found in the Mackenzie and Liard Rivers and their respective tributaries, and include both resident species and those that seasonally migrate through the river systems. Many of the water-courses in the Study Area are believed to support spawning runs of various species, including grayling, pike, pickerel and sucker. Two streams that are particularly noted for their potential spawning sections are Martin River at the extreme northwest end of the Study Area and Harris River, which flows into the Mackenzie at a point directly north of Fort Simpson townsite. The waters of the Mackenzie River in the vicinity of the townsite are noted as a domestic fishing area for local residents (Figure 2). The Mackenzie River is also noted as an upstream fall migration route for various fish species, including whitefish, cisco and inconnu.

An archeological site is recorded and located southeast of the central airstrip near the townsite.



RECOMMENDATIONS AND CONCLUSIONS

The recommendations and conclusions, which are presented herewith, have been based on airphoto interpretation, office literature studies, preliminary field reconnaissance work and detailed field drilling data.

The approximate quantities of granular materials required for Fort Simpson, as specified in the Terms of Reference received from the Department of Indian Affairs and Northern Development, are outlined as follows.

Fine grained aggregates (Sand)	60,000 cubic yards.
Coarse grained aggregates (Gravel).....	90,000 cubic yards.
Material suitable for building pads, roads, airstrips, etc.	1,500,000 cubic yards.

The results of the completed study indicate that the availability of quality granular materials in the Fort Simpson Community Study Area is relatively limited, especially on the southside of the Mackenzie River where the Fort Simpson townsite is located. The following sites are recommended for the granular material requirements of Fort Simpson.

Site FS 13: Located approximately $2\frac{1}{2}$ miles north of Fort Simpson and one-half mile inland from the north bank of the Mackenzie River, Site FS 13 is a large glacial till deposit which contains an isolated pocket of gravel. This gravel pocket encompasses an area approximately 4000 feet in length and 2000 feet in width and varies in thickness from five feet to in excess of fifteen feet with an average overburden depth of three feet.

The large pocket of gravel is estimated to contain 1,500,000 cubic yards of medium grained, poor to well graded gravels which are considered suitable for building pads, road bases, airstrips, and base course aggregates. Production of concrete aggregates from this source can be considered if



proper crushing, screening and washing operations are employed.

Development of the gravel pocket within Site FS 13 for granular materials for the Fort Simpson community will entail a crossing of the Mackenzie River which will restrict the transportation of material to the winter and summer months. Such procedures will necessitate barge hauling during the summer and truck haul utilizing an ice bridge during the winter season. Therefore, holding stockpiles for various aggregate types will be required to ensure a continual supply of material during the spring break-up and winter freeze-up periods.

The existing winter road which provides direct access to the southern perimeter of the site area should be upgraded to an all weather status to provide year round access to the north shore of the Mackenzie River. Because of a high water table within the gravel deposit, the borrow pit development should be commenced at the south end of the site area with progressive extensions northward in order to facilitate drainage of the site area into the Mackenzie River.

It is considered likely that other isolated deposits of gravel are present within the outlined limits of Site FS 13. Therefore, a detailed subsurface investigation by systematically gridding the site area with drill holes or hand dug test pits would be required to search, locate and delineate the extent of any additional gravel pockets.

The detailed assessments and recommendations for the proposed development and exploitation of granular materials from Site FS 13 are outlined in the Site Description section of the report.



Site FS 1: Located approximately three miles southeast of Fort Simpson, Site FS 1 consists of two alluvial terrace segments on the west bank of the Liard River. A sizeable pocket or bed of well graded sands and gravels are located at a depth within the northwestern segment of the alluvial terrace. This site has an estimated quantity of 500,000 cubic yards of sands and gravels, which are primarily suited for general fill requirements in the construction of road bases and backfill and embankment material. In addition, some quality surface course aggregates may be secured from this source by the selective harvesting of the coarser grained gravel strata, however, some screening of the pit run gravel and blending of other gravels may be necessary to produce aggregates for specified construction requirements.

The depth of overburden at this site, which can be in excess of thirty feet, presents considerable difficulty in the exploitation of granular materials. In addition, the immediate proximity of the Liard River channel restricts equitable and economical disposal of the overburden material.

An existing borrow pit is currently being operated on the northeastern portion of the site on the west bank of the Liard River. The detailed assessments and recommendations for the continued development of Site FS 1 are outlined in the Site Description section of this report.

Site FS 12: Located approximately 2 miles north of Fort Simpson immediately adjacent and parallel to the south bank of the Mackenzie River, Site FS 12 consists of discontinuous glaciofluvial outwash materials which are layered between fine grained fluvial sediments and morainal till.

Although detailed airphoto interpretations, preliminary field reconnaissance and evaluation of existing Geological Survey of Canada data indicated very promising potential for granular materials, the results of the winter



drilling program showed a predominance of stratified gravelly sands, silts and clays exhibiting a "washed till-like" texture. One drill hole located in the northwestern extremities of Site FS 12 encountered thin layers of gravel.

However, it is considered that the presence of large isolated pockets of fair quality granular materials within the outlined limits of Site FS 12, similar to the large gravel pocket established at Site FS 13, is relatively high. Therefore, a detailed sub-surface investigation by systematically gridding the site area with drill holes or hand dug test pits would be required to search, locate and delineate the extent of these isolated gravel pockets before Site FS 12 can be considered for exploitation of granular materials.

Sites FS 3,

FS 8 & FS 10: These sites, which contain virtually unlimited quantities of fine grained, eolian sand, can be considered as potential sources of very marginal fill material for use in the construction of road bases, building pads and other marginal backfill operations. Material from these sources is not recommended for augmenting the granular material requirements of the Fort Simpson community.

Site locations and physical and environmental data on each site within the Fort Simpson Study Area are tabulated and presented in map form on Figures 1 and 2 respectively. A synopsized tabulation of pertinent information for each site is tabulated and noted on Figure 2.

The table in Figure 2 presents a tabulation of pertinent data relative to the sites investigated within the Study Area. Each potential site is evaluated in terms of material type, suitability of material, estimated volume, recoverable depth, overburden characteristics, ground ice content, drainage, method of extraction, haul distance, environmental considerations and



assessment.

ESTIMATED VOLUME is calculated by means of various parameters including drill hole and test pit data, airphoto interpretation and geomorphology. Adjustments have been made for irregular topography and stream dissection.

RECOVERABLE DEPTH is determined by various methods including drill hole and test pit data, geomorphology and in the case of bedrock, projected stratigraphic thickness.

GROUND ICE CONTENT is reported as high, medium or low by visual inspection of both samples and test pit walls.

METHOD OF EXTRACTION refers to the type of equipment required for development and exploitation of granular materials. "Conventional" as used, indicates the utilization of standard excavation equipment such as bulldozers, overhead loaders, backhoes and light rippers.

HAUL DISTANCE is the distance along existing and/or proposed access from the site to the community centre.

ENVIRONMENTAL CONSIDERATIONS include any salient factors related to wildlife, waterfowl and fishery resources, archeological sites and potential terrain sensitivity of the site and adjacent areas including proposed access routes. If any environmental implications are considered to exist at a particular site they are synopsized in this column. Further comments on the importance of these conditions as related to potential development are made within the text of the respective sites in the Site Description section of the report.

ASSESSMENT OF SITE relates to the evaluation of each site in terms of recommendations for development, nondevelopment or possible future development of potentially recoverable granular materials at each site investigated in the Study Area.

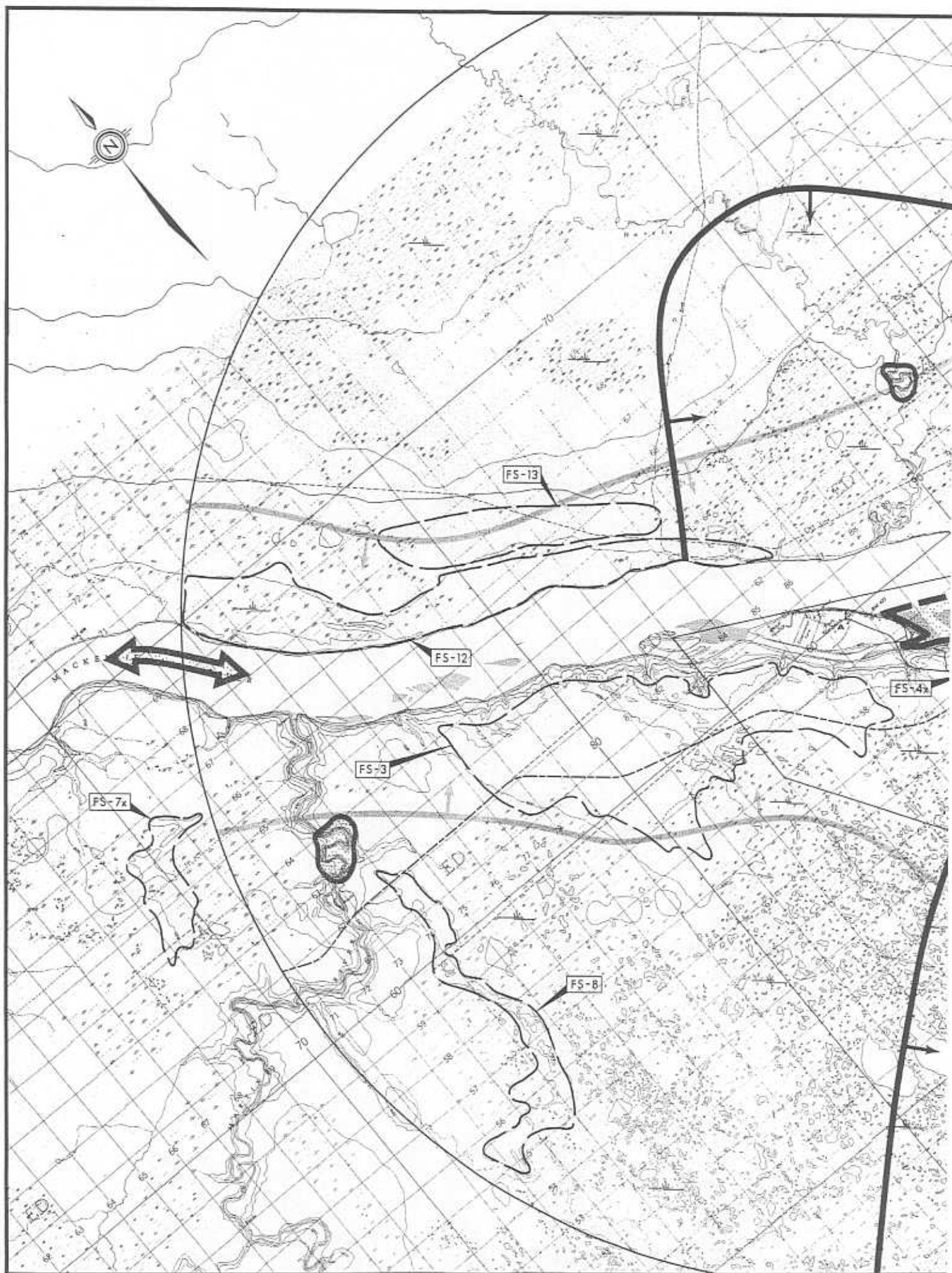


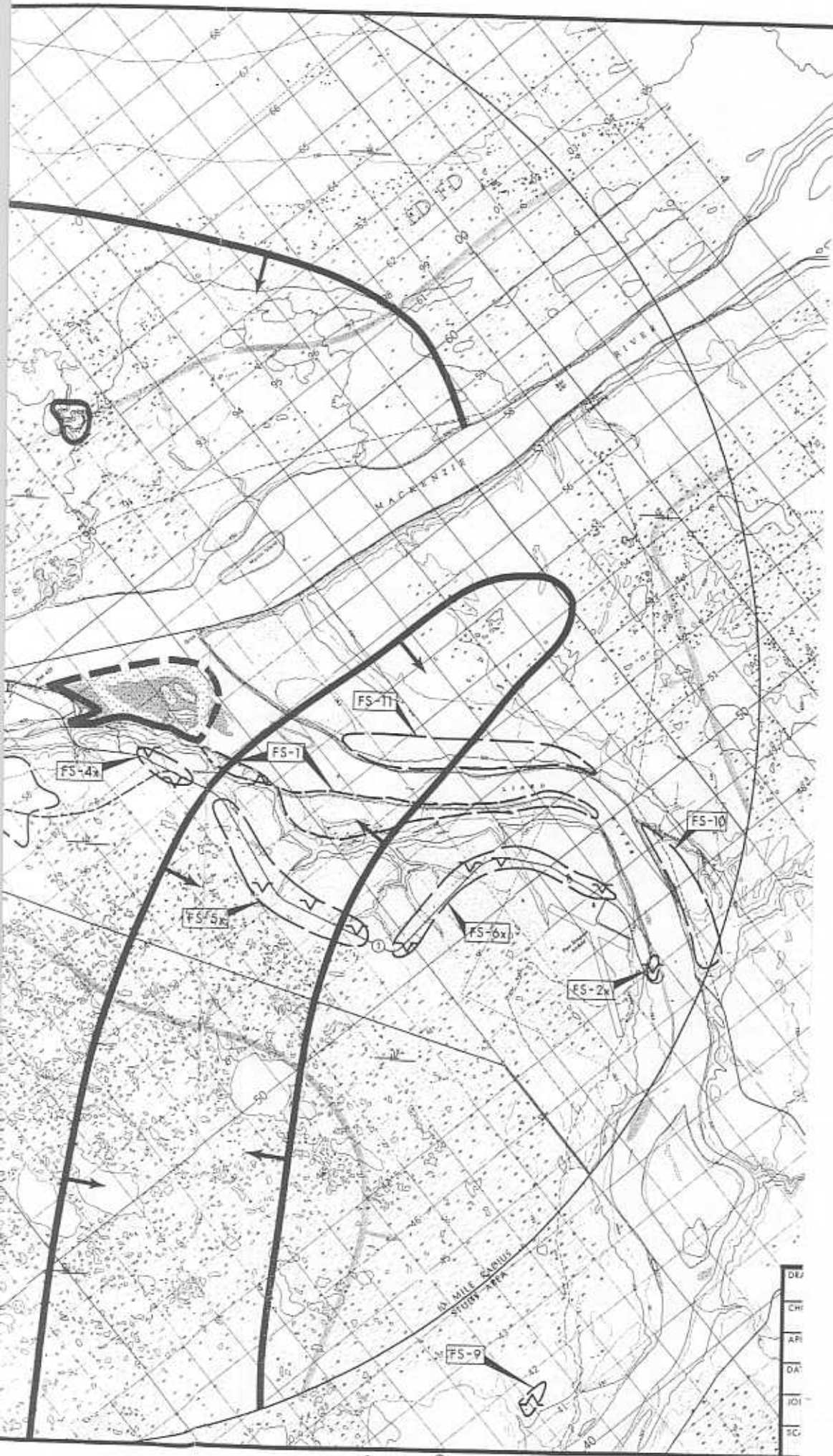
These recommendations are based upon an assessment of all known data on each respective site including location, access, physical characteristics, environmental considerations, development procedures and quantity, quality and suitability of material as related to projected granular material requirements for the community.

SITE NO.	MATERIAL TYPE		SUITABILITY OF MATERIAL	ESTIMATED VOLUME (cu. yds.)	ESTD. RECOV. DEPTH (feet)	OVERBURDEN			GROUND ICE (Content)	DRAINAGE	METHOD OF EXTRACTION	HAUL DIST. (miles)	ENVIRONMENTAL CONSIDERATIONS	ASSESSMENT OF SITE
	DESCRIPTION	SYM.				TYPE	DEPTH (feet)	DISPOSAL						
FS 1	Sand & Gravel	SW-GW	General Fill	500,000	+15	Topsoil & Silt	+30	Strip & Waste	Low	Good to Southeast	Conventional	3	Adjacent to River; Fishing Area for Local Residents	Active; Continue Development
FS 2X	Silt; clayey	MH	Not Suitable	N/A	—	Topsoil	1	—	—	Good to East	—	9	Adjacent to River	Not Recommended
FS 3	Sand; fine	SP	Marginal General Fill	Unlimited	+5	Topsoil	1	Strip & Stockpile	N.D.	Well Drained	Conventional	1½	No Critical Wildlife Areas Sensitive Terrain	Possible Future Development
FS 4X	Sand; fine	SP	Marginal General Fill	—	—	—	—	—	N.D.	Well Drained	—	½	Adjacent to River; Area of New Town Development	Not Recommended
FS 5X	Sand; silty	SP-SM	Very Marginal General Fill	—	—	Topsoil	+1	—	N.D.	Well Drained	—	2	No Critical Wildlife Areas	Not Recommended
FS 6X	Silt; sandy	ML	Not Suitable	—	—	Topsoil	2½	—	N.D.	Fair to West	—	6½	Adjacent to Airport	Not Recommended
FS 7X	Sand; fine	SP	Very Marginal General Fill	2,000,000	30	Topsoil	1	Strip & Stockpile	N.D.	Well Drained	Conventional	11	No Critical Wildlife Areas Sensitive Terrain	Not Recommended
FS 8	Sand; fine	SP	Very Marginal General Fill	15,000,000	+40	Topsoil	1½	Strip & Stockpile	N.D.	Well Drained	Conventional	8	No Critical Wildlife Areas Sensitive Terrain	Possible Future Development
FS 9	Sand & Gravel	SW-GW	Base; Surface Courses; General Fill	600,000	+5	Topsoil & Silt	+1	Strip, Waste & Stockpile	N.D.	Well Drained to East	Conventional	16	No Critical Wildlife Areas; Some Hunting and Trapping	Active; Continue Development & Exploitation
FS 10	Sand & Silt; gravel pockets	SM-ML	Very Marginal General Fill	—	—	Topsoil	1	—	None	Fair to West	Conventional	10	Adjacent to River; Some Hunting and Trapping	Possible Future Development
FS 11	Sand & Silt	SM-ML	Very Marginal General Fill	—	—	Topsoil	2	Strip & Stockpile	N.D.	Fair to South	Conventional	14	Adjacent to River; Some Hunting and Trapping	Possible Future Development
FS 12	Sand & Gravel Pockets	SW-GW	Base; Surface Courses; General Fill	N.D.	10	Topsoil & Silt	+6	Strip, Waste & Stockpile	Low	Good to South	Conventional	+2	Adjacent to River; Hunting Along North Bank	Possible Future Development
FS 13	Gravel; Discontinuous	GW-GM	All Construction Aggregates	1,500,000	+10	Topsoil, Peat & Silt	+3	Strip, Waste & Stockpile	Low to None	Fair to South	Conventional	2½	No Critical Wildlife Areas; High ground-water table	Recommended for Development

Notes:




















- ESTIMATED VOLUME (N/A): Not Applicable because the site does not contain materials of granular quality.
- GROUND ICE (content): Rating and depth figures inferred from test pits or drill holes.
- DRAINAGE: Rating as shown generally refers to drainage conditions within the site.
- METHOD OF EXTRACTION: "Conventional" indicates use of standard excavation equipment such as dozers, overhead loaders, backhoes, light rippers.
- HAUL DISTANCE: Is distance from site to the community along existing or required access.
- ENVIRONMENTAL CONSIDERATIONS: Sensitive Terrain refers to thermal and/or erosional sensitivity at or adjacent to the site (Ref. Text).
- SITE ASSESSMENT: "Active" indicates site is currently or periodically being used.
- N.D.: Not determined.





A ← B → C

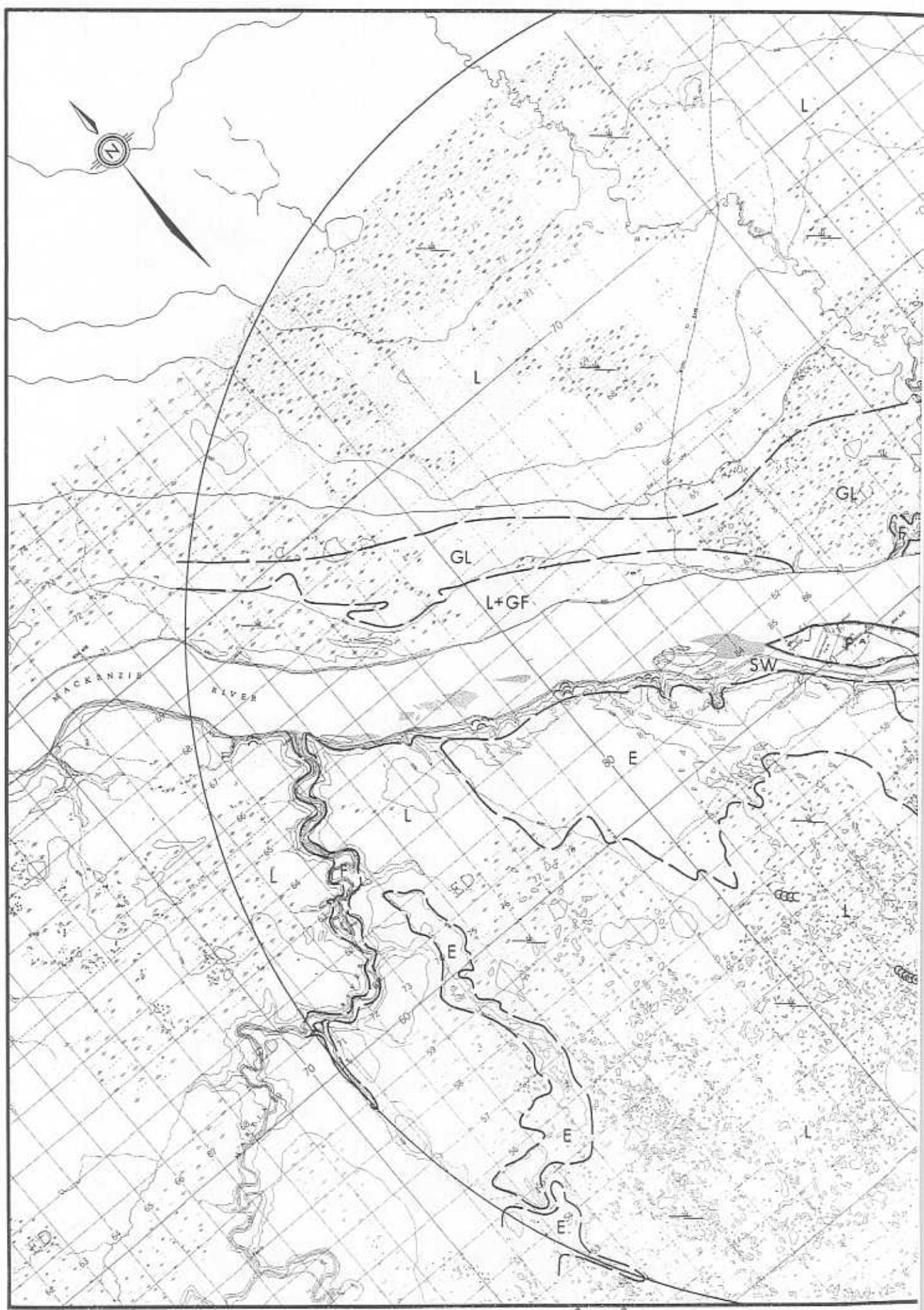
LEGEND

-  Bedrock escarpment
-  Escarpment in unconsolidated material
-  Cone or fan
-  Esker
- (a)  (b)  Borrow pit (a) in operation (b) abandoned
-  Archeological site
-  Dune
-  Muskeg
-  Slump
-  Existing trails and cutlines
-  Fishery resources
-  Hunting areas
-  Trapping areas
-  Development control zone
-  Site location (granular material)
-  Proposed Mackenzie Highway
-  Defined boundary
-  Approximate boundary

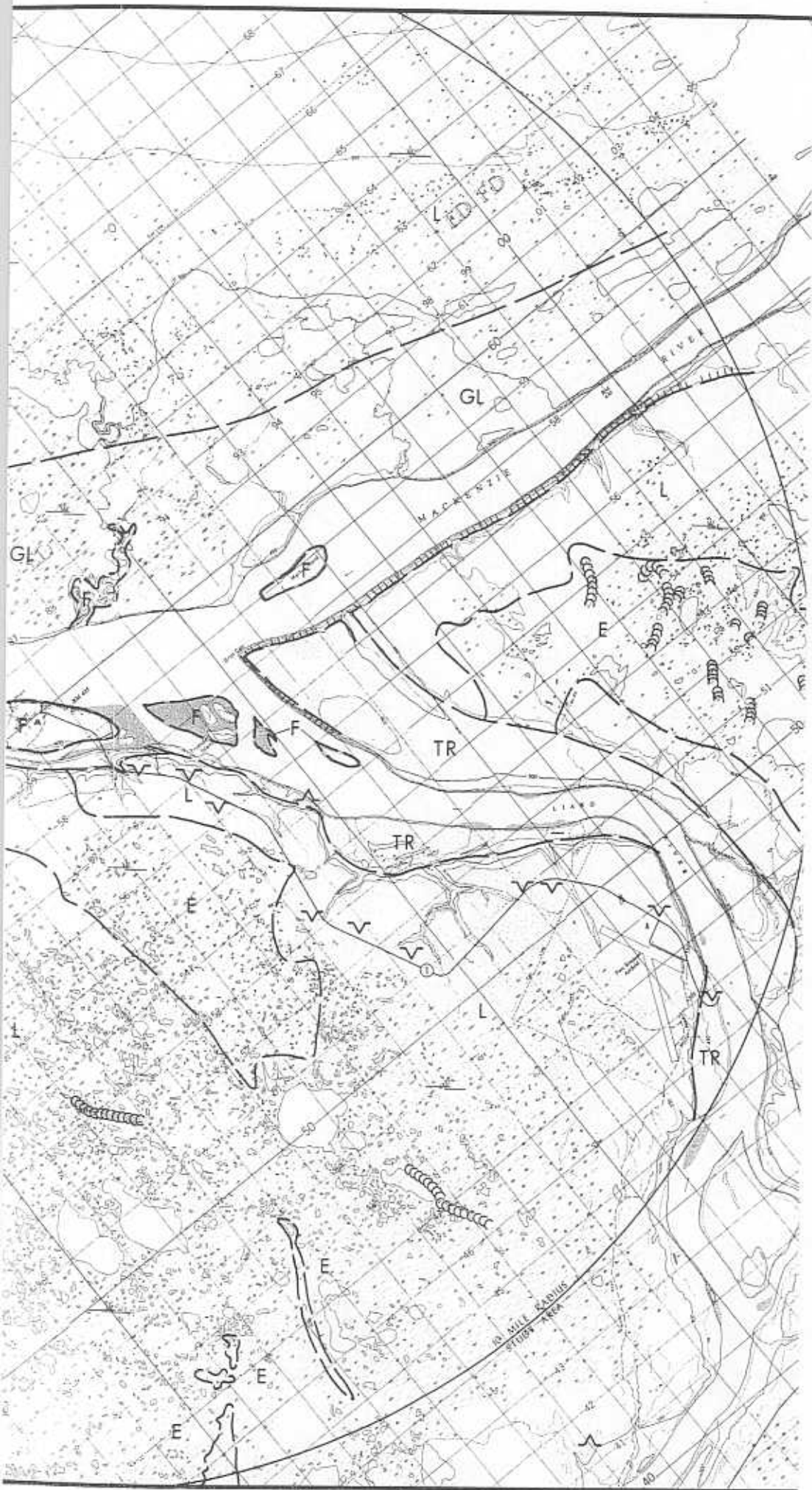


DRAWN	M.J. Haas	GOVERNMENT OF CANADA	
CHECKED		DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	
APPROVED		GRANULAR MATERIALS INVENTORY	
DATE	JAN. 1973	FORT SIMPSON COMMUNITY	
JOB No.	P72-502	SITE LOCATIONS AND WILDLIFE AREAS	
SCALE	As Shown	PEMCAN SERVICES "72"	
FILE No.		FIGURE	2
REVISION			

B < C















A → B



A ← B → C

LEGEND

-  Bedrock Escarpment
-  Escarpment in unconsolidated materials
-  Cone or fan
-  Talus
-  Esker
-  Borrow pit (a) in operation (b) abandoned
-  Archeological site
-  Dune
-  Muskeg
-  Slump
-  Defined boundary
-  Approximate boundary
- R** Bedrock (predominantly limestone)
- R'** Shallow soil overlying bedrock
- T** Talus (mixed, usually coarse material on steep slopes)
- F** Fluvial deposits (either fine or coarse material)
- L** Lacustrine deposits (fine textured soil, flat ground)
- E** Eolian sediments (fine windblown sand)
- GL** Glacial deposits (mixed silt, sand, clay material)
- TR** Terrace deposits (mainly sand and silts with some gravelly beds)
- GF** Glaciofluvial deposits (mainly gravel and sand with silt and clay inclusions)
- SW** Slopewash



DRAWN M.J. Haas	GOVERNMENT OF CANADA	
CHECKED	DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	
APPROVED	GRANULAR MATERIALS INVENTORY	
DATE JAN. 1973	FORT SIMPSON COMMUNITY	
JOB No. P72-502	SURFICIAL GEOLOGY	
SCALE As Shown	PEMCAN SERVICES "72"	
FILE No.	FIGURE 1	REVISION

B ← C



PEMCAN SERVICES

SITE DESCRIPTIONS - FORT SIMPSON STUDY AREA



<u>SITE NUMBER</u>	<u>PAGE</u>
FS 1	1 - 1
FS 2 X	2 - 1
FS 3	3 - 1
FS 4 X	4 - 1
FS 5 X	5 - 1
FS 6 X	6 - 1
FS 7 X	7 - 1
FS 8	8 - 1
FS 9	9 - 1
FS 10	10 - 1
FS 11	11 - 1
FS 12	12 - 1
FS 13	13 - 1

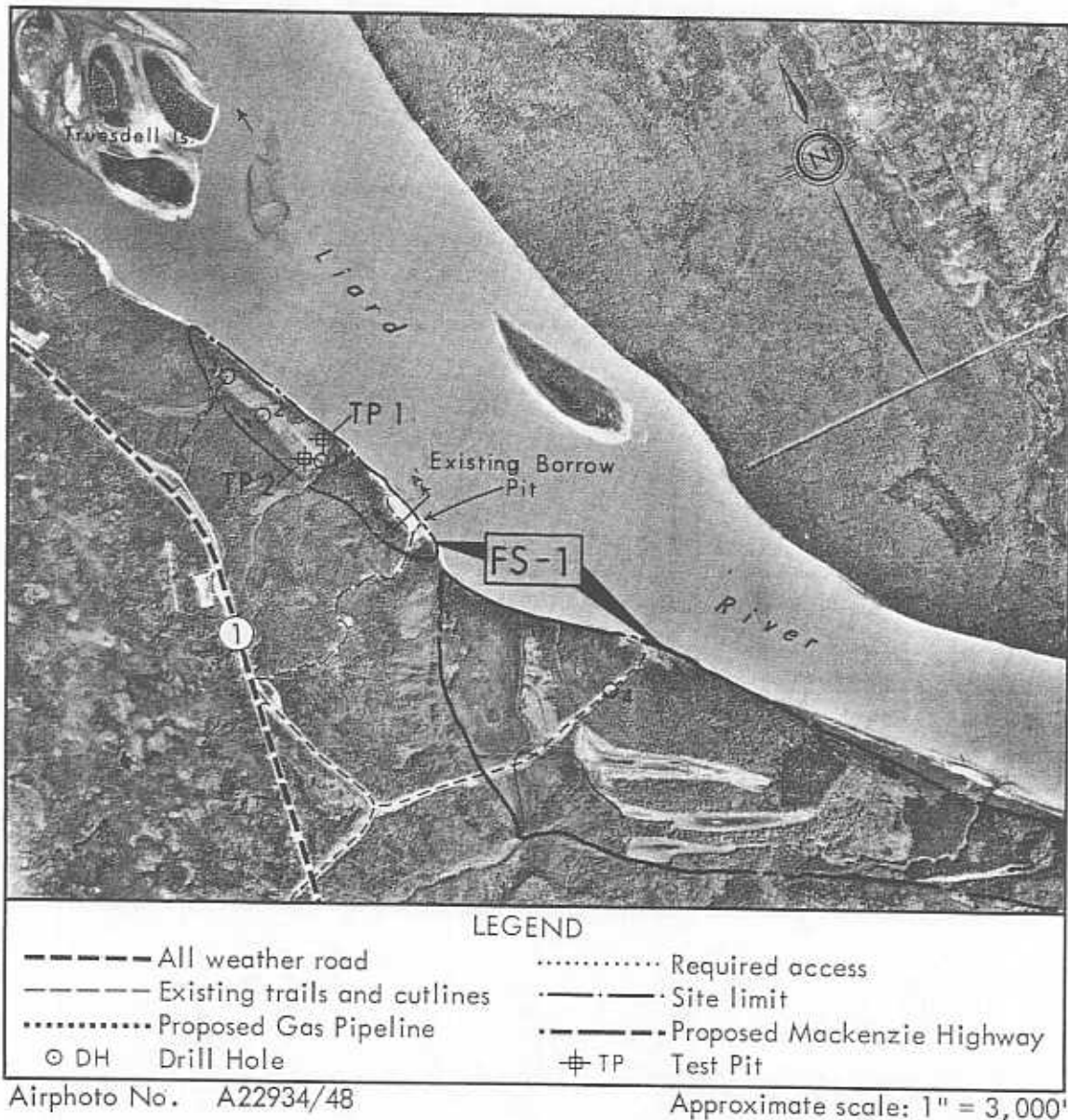
SITE NO. FS 1

Located approximately 3 miles southeast of Fort Simpson, Site FS 1 consists of two alluvial terrace segments on the west bank of the Liard River. An existing borrow pit is currently in operation in the southeastern portion of the downstream terrace.

Type of Material: Gravel; some sand, medium grained.

Estimated Volume: 500,000 cubic yards.

Assessment: Good quality material suitable for base course, surface course and general fill requirements. This site is recommended for continued exploitation of granular materials; however, the extensive thickness of overburden may limit development of this site.





ENVIRONMENT

Site FS 1 is located approximately 3 miles southeast of Fort Simpson and consists of two alluvial terrace segments on the west bank of the Liard River. The site is about 5 miles upstream from the mouth of the Liard River. The upstream segment of this terrace is 1500 to 3000 feet wide and more than 3 miles long while the downstream portion is approximately 5000 feet in length and 700 feet in width. The Liard River forms the eastern boundary of the site and small, deeply incised stream channels traverse the terrace segments.

The upper part of the alluvial terrace is comprised of irregularly stratified silt and sand layers with well graded sand and gravel beds at depth. The gravel stratum is exposed in the existing borrow pit where the overburden thickness is in excess of 25 feet has been observed in the headwall. Outside of the existing borrow area an overburden thickness in excess of 30 feet is indicated. The relatively shallow topsoil layer supports moderate to dense growths of spruce and poplar.

There are no known critical wildlife areas in the immediate vicinity of the site. However, the area about 3 miles downstream from the site near the mouth of the Liard River is noted as a domestic fishing locale for the residents of Fort Simpson (Figure 2).

The eastern perimeter of the site drops steeply into the Liard River while the western portion of the site rises gradually onto a glaciolacustrine plateau. The surficial drainage of the site area is eastward into the Liard River. The downstream terrace segment is well drained while the upstream terrace contains a few abandoned river segments which collect surficial runoff water. An existing borrow pit is located on the southeastern portion of the downstream terrace segment and is currently being exploited for granular materials.

An existing haul road provides access from the operating borrow pit area to the all weather road which flanks the western extremity of the site area at a distance of approximately $\frac{1}{4}$ of a mile.

DEVELOPMENT

Site FS 1 is recommended for continued development and the existing borrow pit in its present location can be operated to augment the granular material requirements for the community. The exploratory drill holes which were extended to a maximum depth of 29 feet during the winter drilling program showed stratified sands and silts. Therefore, the depth of overburden is quite considerable and may increase outside of the existing borrow pit. This can adversely affect the economics of the borrowing and therefore only a south-eastern part of the downstream terrace was considered for estimating the available volume of granular materials.

The following development guidelines should be considered during the continued extraction of material from this site.

- In order to decrease downstream siltation, dozing of the sandy silt overburden over the west bank of the Liard River should be restricted.



- Relative to granular deposits in the site immediately adjacent to the Liard River, consideration should be given to the development of new borrow pit areas further removed from the watercourse. A vegetation buffer zone of adequate dimensions should be maintained between the river and the working area of the borrow pit. The excessive depth of overburden material may restrict the continued lateral expansion of the existing borrow pit area.
- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.
- The organic topsoil layer should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.
- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain to the Liard River. The silty and sandy overburden removed from the borrow pit area should be wasted above the high water mark.
- Stands of natural growth should be retained between borrow pit areas in order to promote natural regeneration after abandonment.
- Generally, dozers, overhead loaders and standard ripping equipment should be adequate for the removal of material from this site. The selection of equipment required may be governed by ground ice content at deeper extremities of this source.
- The exploitation of quality surface course and general fill aggregates is considered possible by utilization of the granular materials from this site. However, a screening and crushing operation will have to be considered to produce aggregates that meet specific construction requirements.
- The extensive depth of overburden material which has to be removed and wasted, will limit the extensive removal of the granular materials from this site.

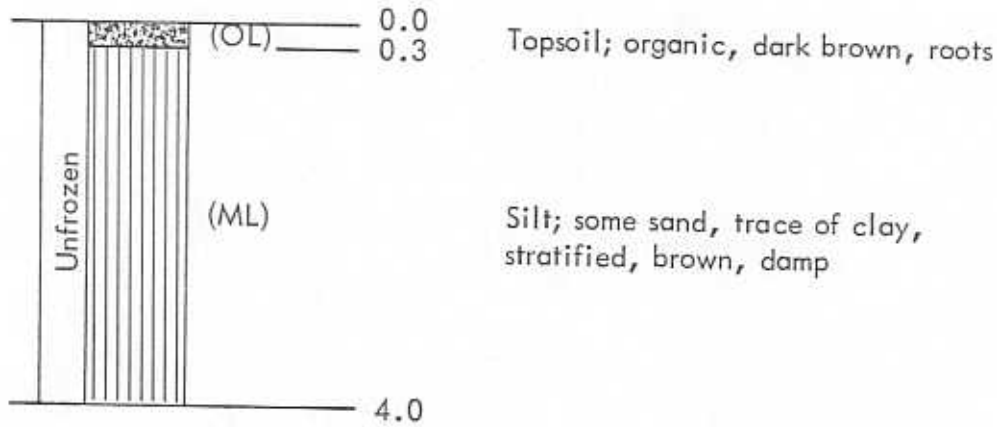
ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

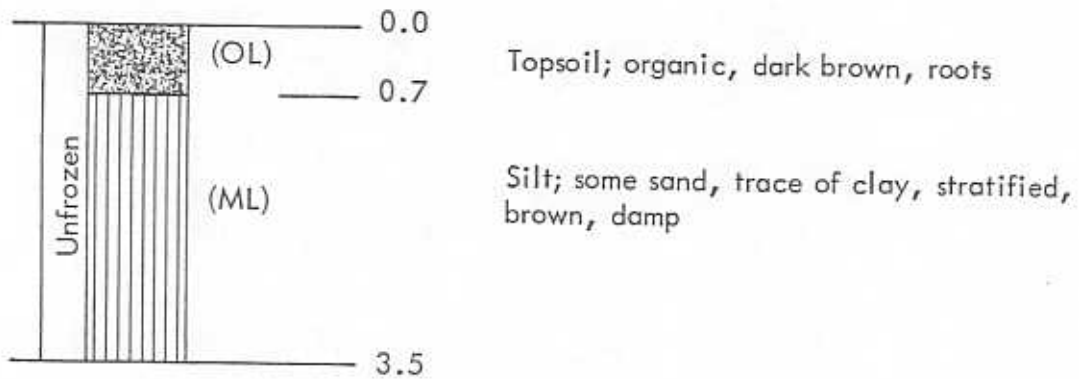
- Recontouring of the pit areas to provide general drainage that is compatible with the natural drainage of the adjacent terrain.
- Replacing stockpiled surficial waste material and organic topsoil on the abandoned recontoured pit areas.
- Reseeding of the recontoured pit areas should be considered in areas that may pose erosional problems. At these locations, the artificial reseeded of annuals and perennials will result in a semi-permanent cover growth prior to reestablishment of native species.

DETAILED TEST PIT LOG

FS 1/TP 1

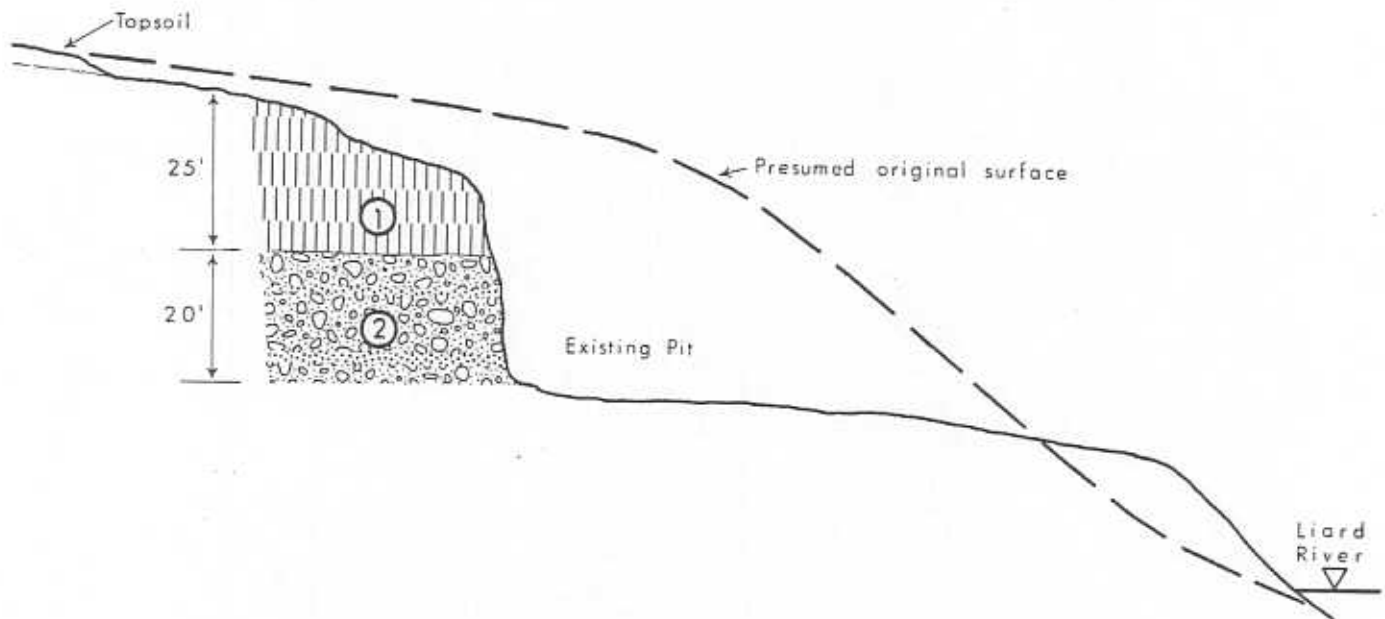


FS 1/TP 2



SECTION A-A'

NOT TO SCALE



Description of the Pit Wall:

1. Silt; some sand, trace of clay, infrequent pebbles, grey, horizontally stratified.
2. Gravel; some sand, well graded, brown, interspersed with layers of sand with some gravel.

DETAILED DRILL HOLE LOG



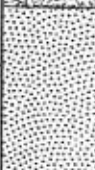


SITE NO. FS 1

HOLE NO. DH-1

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	1.5 TOPSOIL: some silt, trace sand, little organic, roots, light to medium brown		Nf	VL		0
3		SP	SAND: trace silt, fine grained, poorly graded, dry					3
6			- becoming damp from 7.0'				MC	6
9								9
12		MH	11.0 SILT: some clay, trace sand, medium plastic, frequent pebbles, damp, brown	UF				12
15								15
18					Vx	M		18
21								21
24								24
27			27.0 TOTAL DEPTH 27.0'		Vs	M		27
30								30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY






PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 1

HOLE NO. DH-2

DATE: FEB. 19, 1973 LOGGED BY: ☒ PEMCAN ☐
 DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	1.0 TOPSOIL: some silt, little organic, brown					0
2			SILT: trace sand, greyish brown		Vx	M		2
4								4
6								6
8								8
10		ML	- occasional clay layers 2" thick from 9.0'	UF				10
12								12
14								14
16								16
18			18.0 TOTAL DEPTH 18.0'					18
20								20

GOVERNMENT OF CANADA
 DEPARTMENT OF INDIAN AFFAIRS
 AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 1

HOLE NO. DH-3

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR ☐ AIR REVERSE ☐ CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	TOPSOIL: some silt, little organic, roots, dry					0
3		ML	SILT: little sand, light to medium brown, dry		Nf	VL		3
6		SM-SP	SAND: trace silt, fine grained, poorly graded, greyish brown					6
9								9
12				UF				12
15		ML	SILT: little clay, grey, wet					15
18								18
21								21
24					Vx	M		24
27			TOTAL DEPTH 26.0'					27
30								30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG










SITE NO. FS 1

HOLE NO. DH-4

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	2.0 TOPSOIL: some silt, organic, roots, dark brown		Vs	M		0
3		ML	SILT: little clay, dark grey		Nbn	L		3
6								6
9			- becoming wet at 9.0'	UF				9
12					Nbn	L		12
15								15
18		SP-SM	17.0 SAND: little silt, poorly graded, fine to medium grained, grey		VxVs	L-M		18
21			- trace of silt from 20.0' to 23.0'					21
24								24
27		ML	26.0 SILT: little sand, dark grey		Vs	L		27
30			29.0 TOTAL DEPTH 29.0'					30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

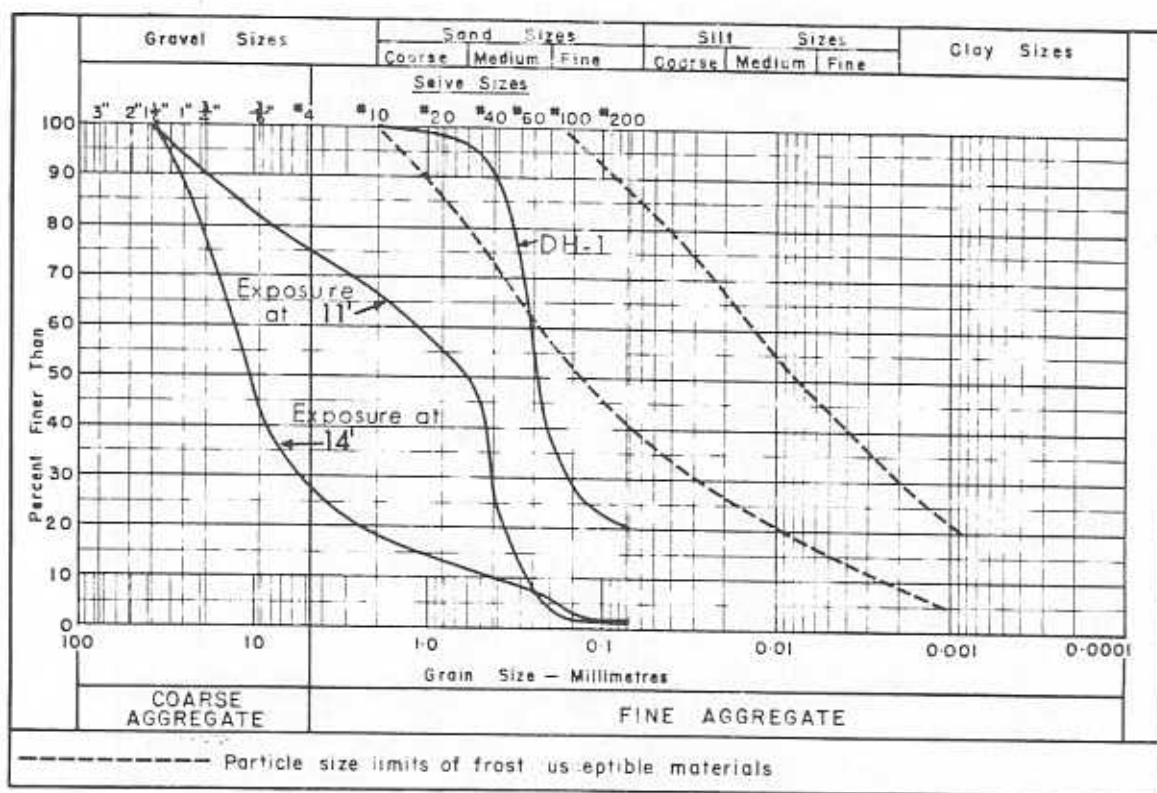


PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 1 (Exposure)	FS 1 (Exposure)	FS 1/DH-1
Sample Depth (Feet):	11.0	14.0	9-10
Moisture Content (%):	1.3	1.3	5.3
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

Limestone and dolomite	43.6 %
Igneous rocks	34.7 %
Quartzites	12.9 %
Cherts	2.9 %
Siltstone, sandstone	5.9 %

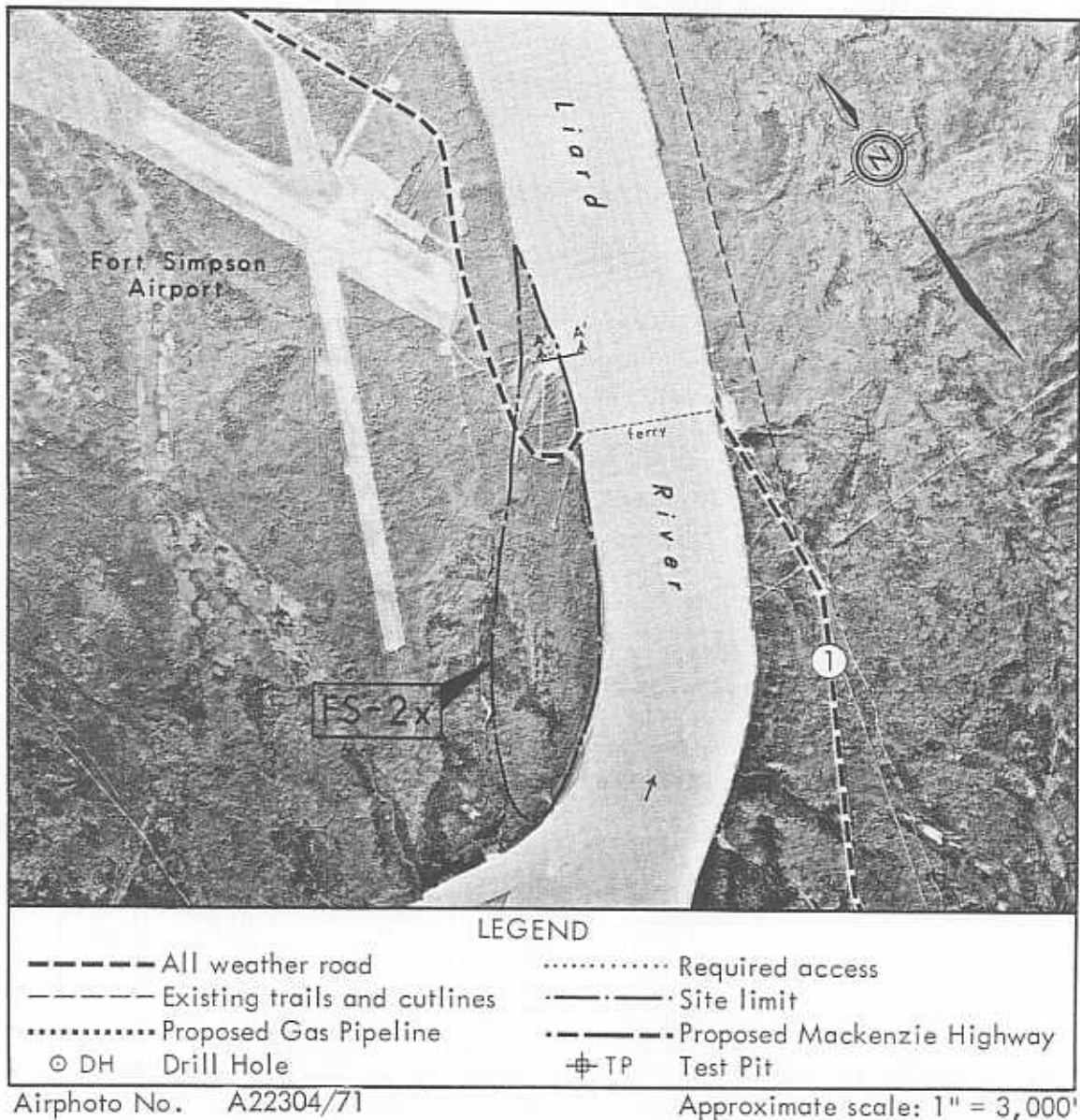
SITE NO. FS 2X

Located approximately 9 miles southeast of Fort Simpson, Site FS 2X encompasses an alluvial flood plain on the west bank of the Liard River. An abandoned borrow pit is located at the northern tip of this site.

Type of Material: Silt; some clay with little gravel.

Estimated Volume: Not established.

Assessment: This site is not recommended for development because granular materials were not encountered at this site. The in situ material may be considered for utilization in embankment construction.





ENVIRONMENT

Site FS 2X is located approximately 9 miles southeast of Fort Simpson on the west bank of the Liard River and immediately adjacent to the east side of the airstrip. This site encompasses an area approximately 3000 feet in length and 1200 feet in width and consists of a flat, alluvial terrace. This terrace was an erosional characteristic and the thickness of alluvial deposits is shallow.

The material at Site FS 2X is primarily a clayey silt interspersed with occasional cobbles and boulders. These alluvial deposits are, generally, horizontally stratified and are considered to overlie glacial till deposits. The organic topsoil layer is approximately one foot thick, and supports dense growths of spruce, birch and poplar ranging in height from 10 to 50 feet and in trunk diameter from 2 to 12 inches. The understory growth consists primarily of moss and sedge.

There are no known critical wildlife areas in the immediate vicinity of the site.

The surficial drainage of the site is, generally, easterly into the Liard River channel.

The all weather highway with its attendant ferry facilities is located at the extreme north end of the site area.

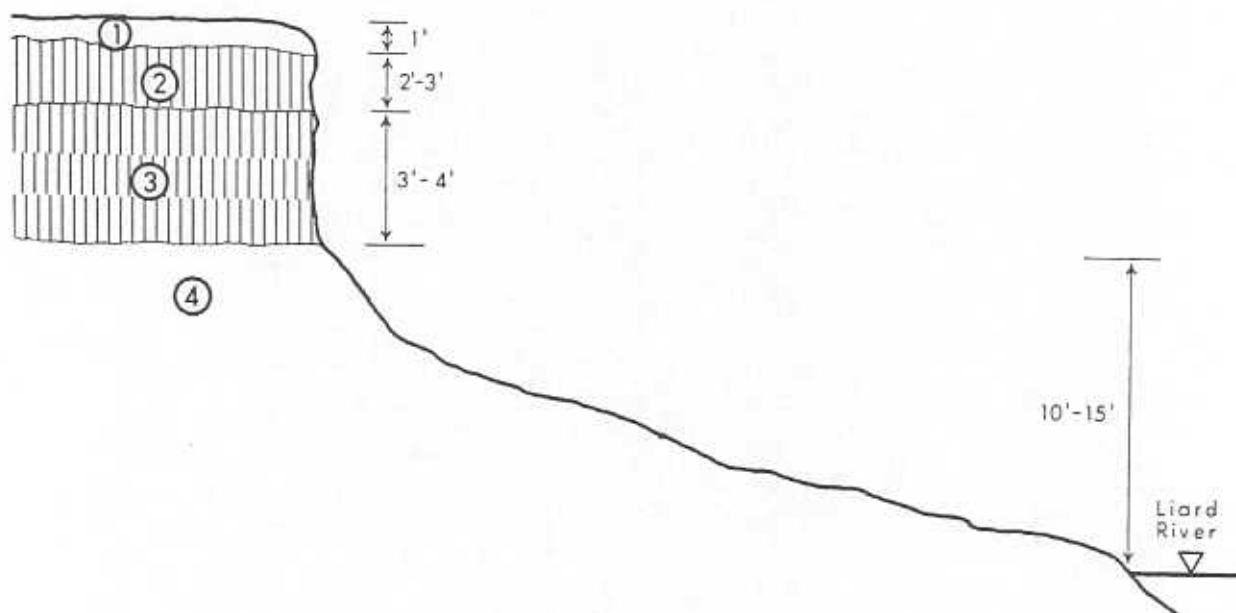
DEVELOPMENT

Site FS 2X is not recommended for development because the materials encountered to depths investigated do not constitute a granular type material.

However, the material in the alluvial terrace may be considered for utilization in the construction of road embankments. Such exploitation should be undertaken in the southern part of the site where there is greater likelihood of encountering isolated gravel pockets.

SECTION A-A'

NOT TO SCALE



Description of the Exposure:

1. Topsoil; organic.
2. Silt; trace of clay, scattered boulders to 2 feet in diameter.
3. Silt; trace of clay, scattered pebbles and boulders, horizontally stratified.
4. Morainal Till; silt, sand and clay mixture with pebbles, cobbles and boulders.

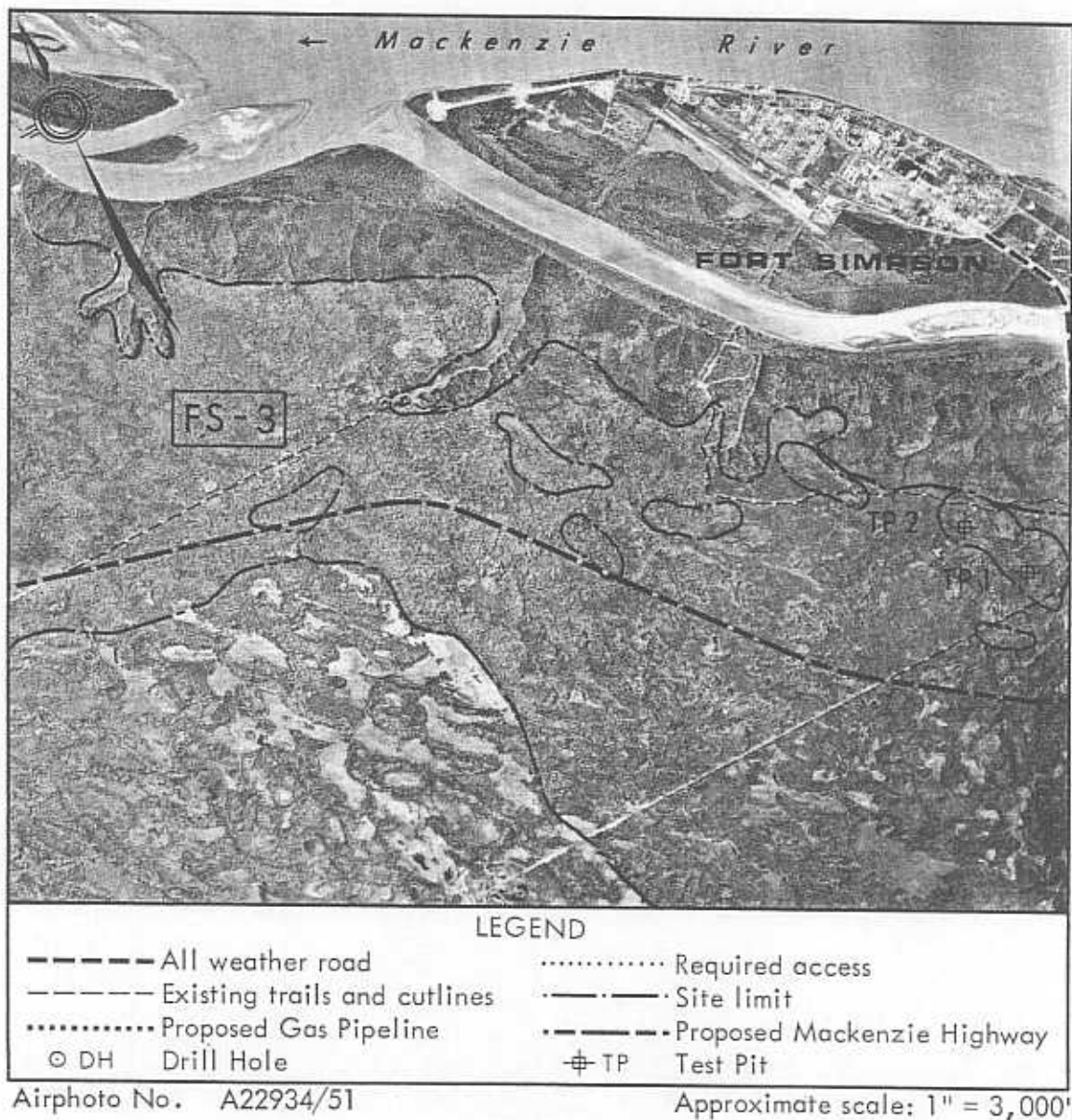
SITE NO. FS 3

Located approximately $1\frac{1}{2}$ miles southwest of Fort Simpson, Site FS 3 consists of a flat, glaciolacustrine plain which has been reworked by wind action. Numerous small sand dunes are prevalent over the site area.

Type of Material: Sand; very fine, little silt.

Estimated Volume: Unlimited for requirements of Fort Simpson.

Assessment: Poor quality material suitable only for marginal general fill requirements. Site FS 3 is only recommended for development to supply the requirements in the construction of local utilities.





ENVIRONMENT

Site FS 3 is located approximately $1\frac{1}{2}$ miles southwest of Fort Simpson on the flat, glacio-lacustrine plain the surface of which has been reworked by wind action. Numerous small sand dunes are prevalent over the site area. Some of the more prominent dunes are schematically outlined on the airphoto shown on the previous page. The overall site area is approximately 7 miles in length and averages $1\frac{1}{2}$ miles in width.

The materials encountered at Site FS 3 consist of very fine eolian sands with a little silt and are suitable only for marginal general fill requirements. A thin veneer of topsoil, 6 to 12 inches in depth, overlies the entire site area and supports dense growths of poplar, spruce and birch.

There are no known critical wildlife areas in the vicinity of the site. However, both the Mackenzie River to the north and the Martin River to the west are noted as migration and spawning areas for fishery resources (Figure 2).

The surficial drainage along the northern periphery of the site is good and drains northward into the Mackenzie River. Numerous erosional gullies are noted along the northern perimeter of Site FS 3. The adjacent terrain to the south is poorly drained and is inundated with numerous ponds.

The cleared right-of-way of the proposed Mackenzie Highway traverses the entire length of the site area. In addition numerous seismic cutlines are evident throughout Site FS 3.

DEVELOPMENT

Site FS 3 is recommended for development because of the acute shortage of granular materials in the Fort Simpson area. The available material at this site is of very poor quality and is suitable only for marginal general fill requirements and should be restricted in use for the construction of local utilities.

The following operational guidelines should be considered if borrow pits are to be developed in Site FS 3.

- The development of borrow pit areas should be restricted to the more pronounced and well developed sand dunes. These areas are noted on the site airphoto (page 3-1).
- Vertical excavation opposed to horizontal excavation should be considered to minimize erosion by wind or water action.
- The shallow organic topsoil should be carefully stripped and stockpiled along the lower slopes of the dune for future utilization in the restoration of the borrow pit areas.



- Vegetation buffer zones should be maintained between work areas to minimize erosion and instability of the dune area.

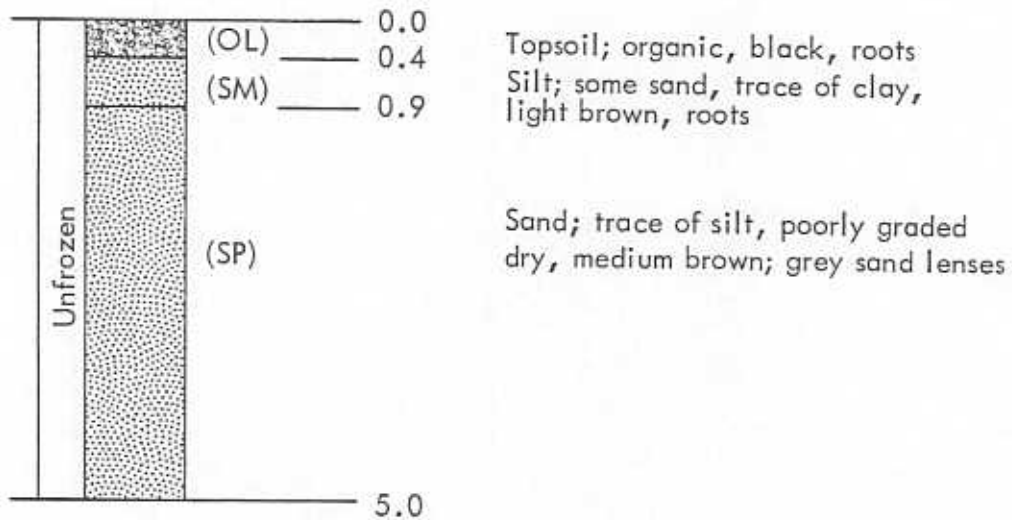
ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following for the development of borrow pits in Site FS 3:

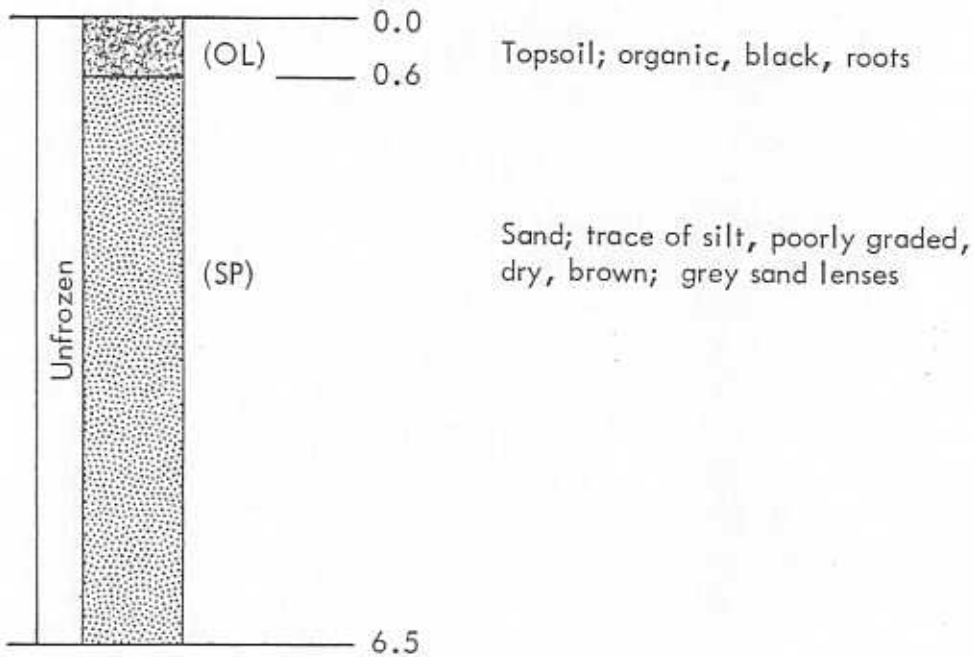
- Recontouring of borrow pit area to maintain good drainage to the adjacent terrain.
- Replacement and spreading of organic topsoil from pre-production stockpiles on to the recontoured exposed borrow pit areas.
- Revegetation of the restored pits in areas where erosion may be severe.

DETAILED TEST PIT LOG

FS 3/TP 1



FS 3/TP 2



SUMMARY OF LABORATORY TEST DATA

Sample Location: FS 3/TP 2

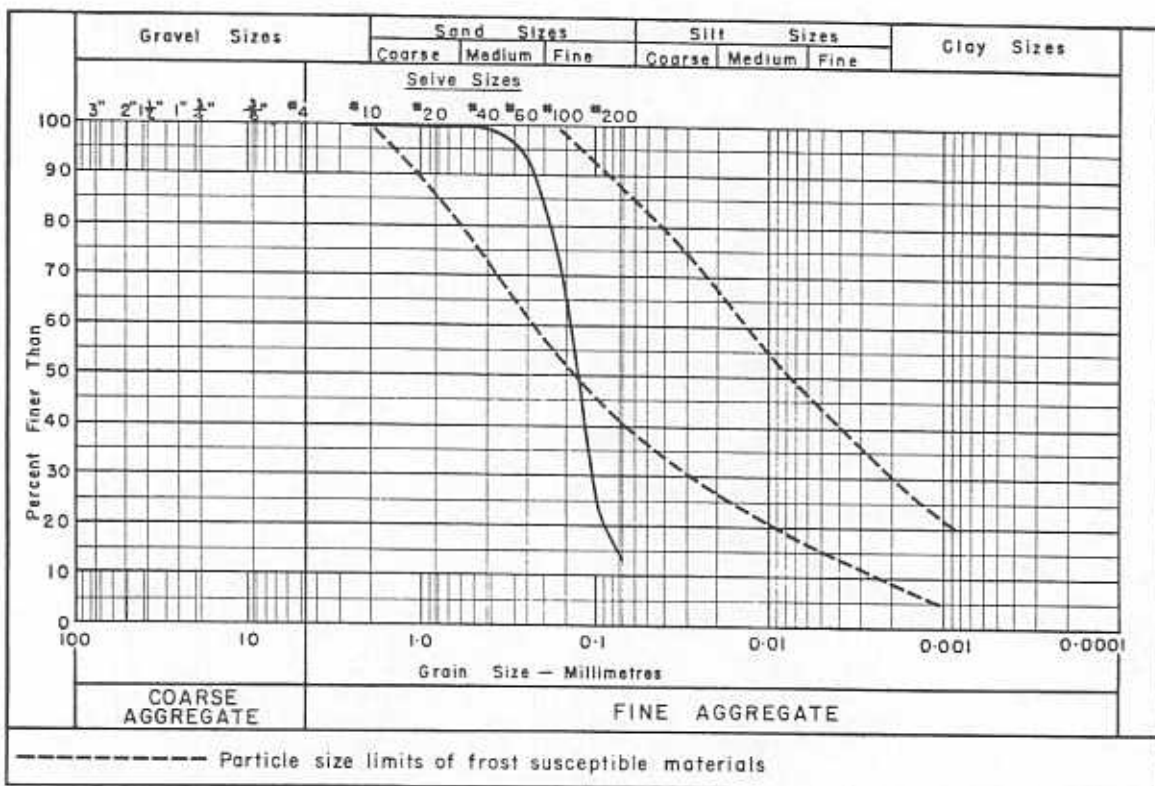
Sample Depth (Feet): 5.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SITE NO. FS 4X

Located approximately $\frac{1}{2}$ mile southeast of Fort Simpson along the west bank of the Liard River, Site FS 4X encompasses a narrow strip of glaciolacustrine silts and sands. Three abandoned borrow pits were noted along the east side of the highway which passes through the site area.

Type of Material: Sand; fine, some silt.

Estimated Volume: Not established.

Assessment: Very poor quality material, suitable only for marginal general fill requirements. This site is not recommended for development.





ENVIRONMENT

Site FS 4X is located approximately $\frac{1}{2}$ mile southeast of Fort Simpson along the west bank of the Liard River at the confluence of the Mackenzie River. The site represents the northeastern tip of the glaciolacustrine plain and encompasses a narrow area, approximately 2 miles in length and $\frac{1}{4}$ mile in width. The all weather highway to the Fort Simpson airport traverses the entire length of the site area and several trailer parks have been developed along the east side of the highway immediately south of the Fort Simpson townsite.

The material in the site area consists of silty sands that are only suitable for marginal general fill requirements. The organic topsoil layer is approximately $\frac{1}{2}$ to 2 feet thick and supports dense growths of spruce, birch and poplar ranging in height to 70 feet and in trunk diameter to 15 inches. The understory growth consists of moss, sedge and small brush.

There are no known critical wildlife areas in the immediate vicinity of the site. The area around the mouth of the Liard River is, however, noted as a domestic fishing locale for the residents of Fort Simpson (Figure 2).

The surficial drainage of the site area is relatively good and drains eastward into the Liard River.

Three borrow pits designated as "a", "b", and "c" on the site airphoto (page 4-1) have been developed in this part of the glaciolacustrine plain during the construction of the existing highway. These borrow pits have been excavated to a depth of 10 to 25 feet below existing ground surface and the exposed borrow pit walls have been sloped at 2.0 to 2.5:1, horizontal to vertical respectively. These exposed pit walls are experiencing localized sloughing and surficial erosion.

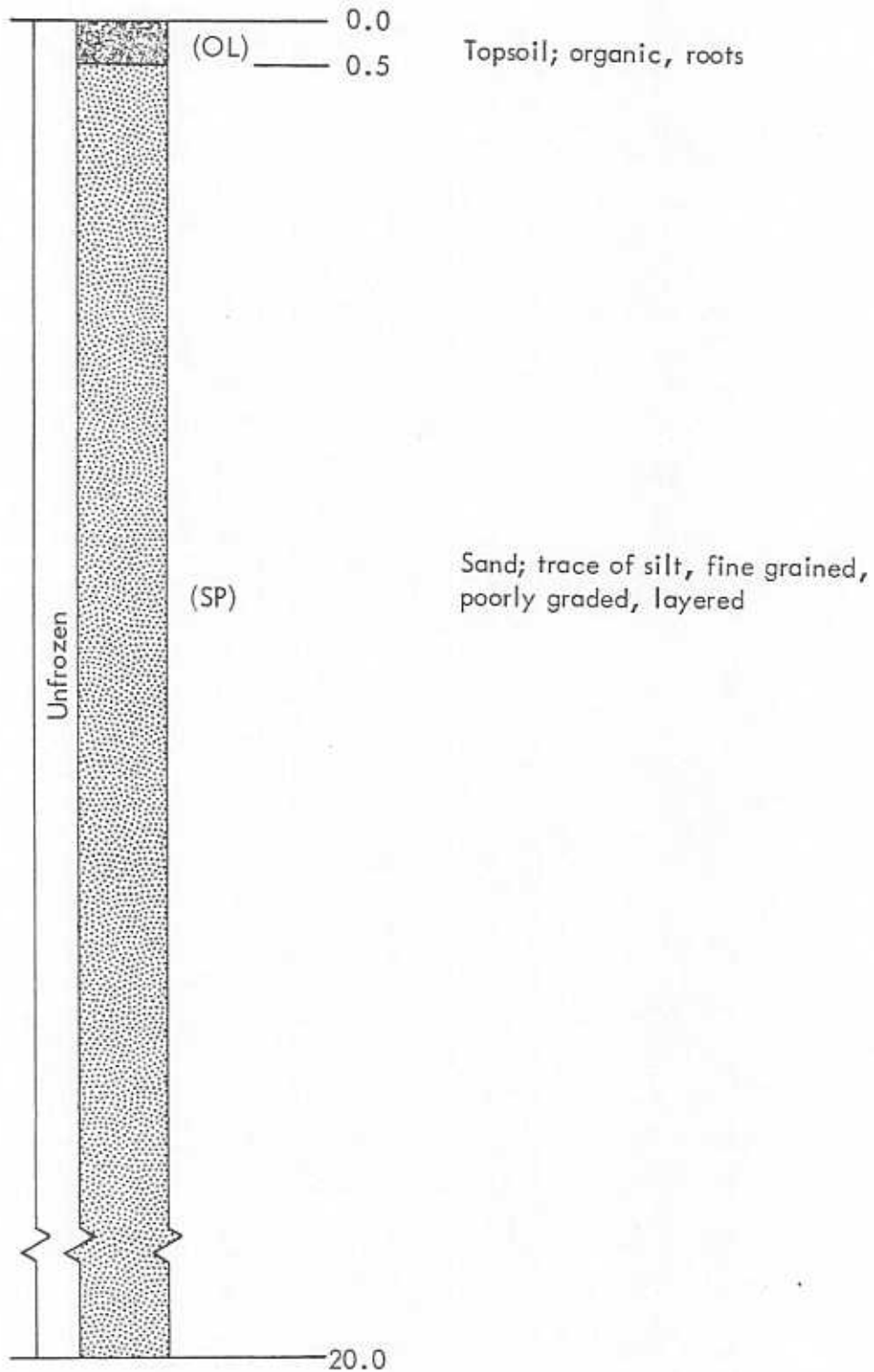
DEVELOPMENT

Site FS 4X is not recommended for development because of the following reasons:

- The available material is a fine, silty sand which is, generally, susceptible to frost action and not normally considered as a granular type material.
- The exposed in situ material at this site, as noted in the existing borrow pit areas, is very susceptible to surficial erosion and is relatively unstable when exposed.
- The current development of trailer park facilities, generally, negates further development of borrow pits since it would appear that this site area is being designated for future expansion of the Fort Simpson townsite.

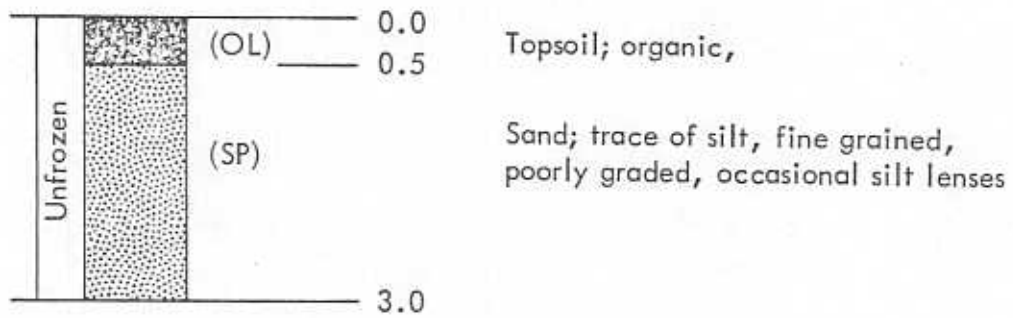
DETAILED TEST PIT LOG

FS 4X/TP 1



DETAILED TEST PIT LOG

FS 4X/TP 2



SUMMARY OF LABORATORY TEST DATA

Sample Location: FS 4X/TP 1

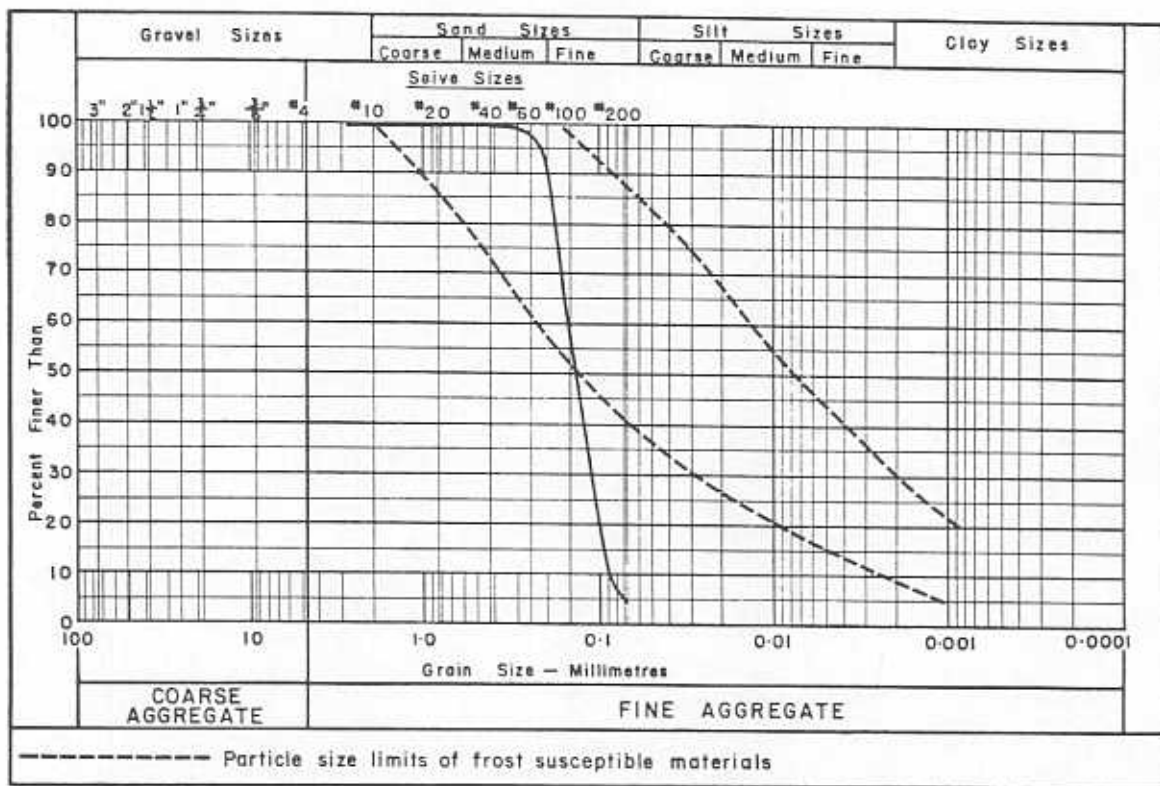
Sample Depth (Feet): 6.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

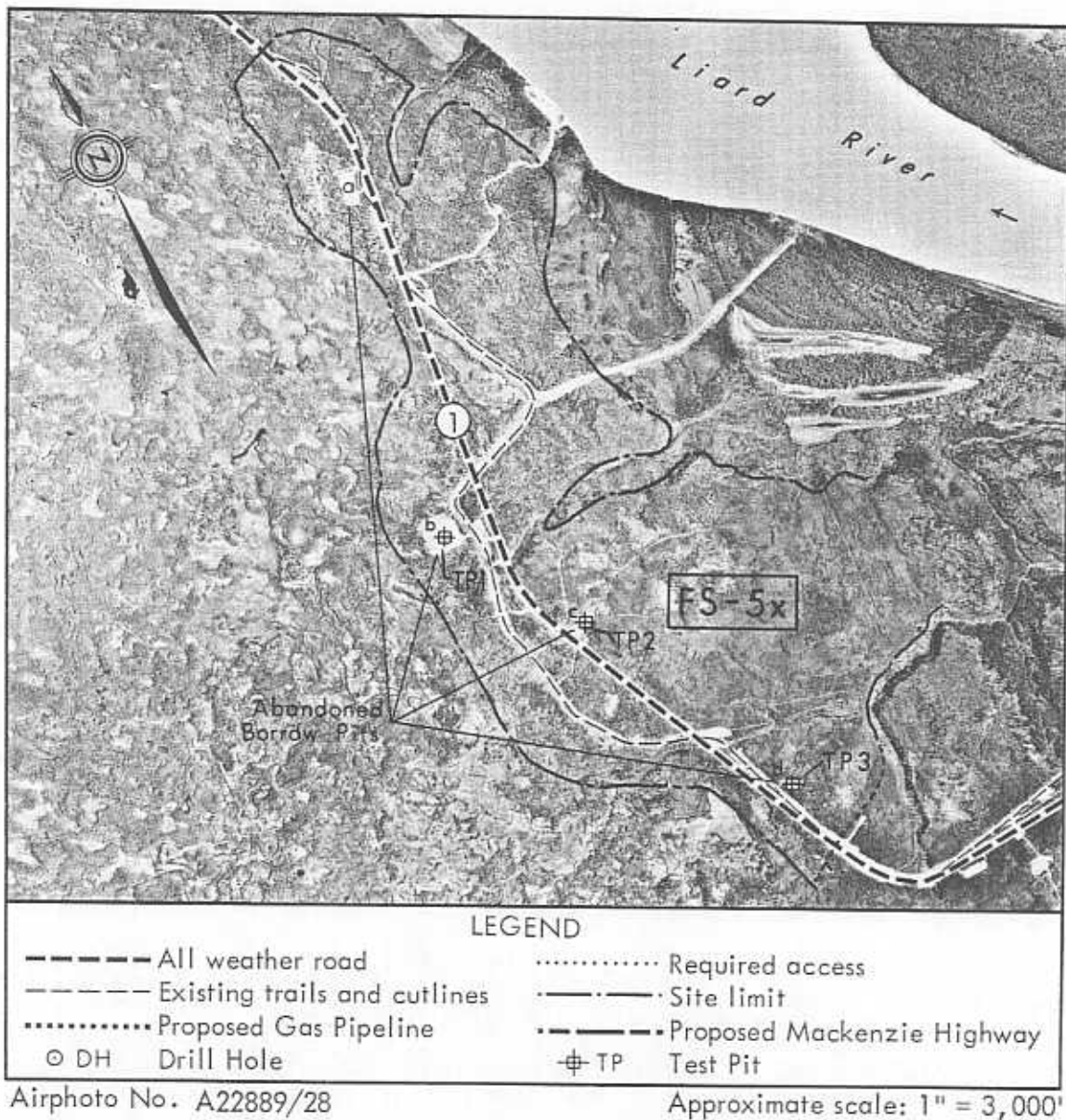
SITE NO. FS 5X

Located approximately 2 miles south of Fort Simpson along the west bank of the Liard River, Site FS 5X consists of the glaciolacustrine plain extending south from Site FS 4X.

Type of Material: Sand; fine, some silt.

Estimated Volume: Not established.

Assessment: Very poor quality material suitable only for marginal general fill requirements. This site is not recommended for development.





ENVIRONMENT

Site FS 5X is located approximately 2 to 5 miles south of Fort Simpson along the west bank of the Liard River and basically represents an extension of the glaciolacustrine plain from the southern extremity of Site FS 4X. The site encompasses an area 3 miles in length and varies from $\frac{1}{2}$ to 1 mile in width.

The glaciolacustrine plain consists of very fine grained, silty sands which are susceptible to frost action and are not considered suitable for granular material requirements. A shallow organic topsoil layer, 6 to 18 inches in depth, overlies the entire site area and supports a dense growth of spruce, birch and poplar ranging in height to 70 feet and in trunk diameter to 15 inches.

There are no known critical wildlife areas in the immediate vicinity of the site.

The general surficial drainage of the site area is towards the east into the Liard River. The eastern periphery of the site area is incised with several erosion gullies.

The all weather highway to the Fort Simpson airport passes through the western extremity of Site FS 5X. Four abandoned borrow pits designated as "a", "b", "c", and "d" on the airphoto plate (page 5-1) have been developed along the east and west sides of the highway during construction.

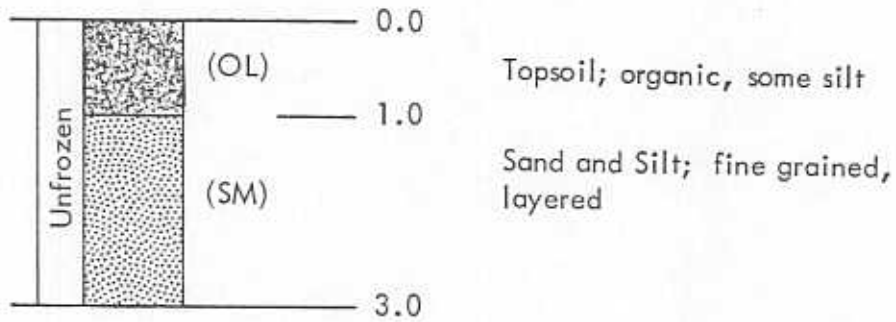
DEVELOPMENT

Site FS 5X is not recommended for development because of the following reasons:

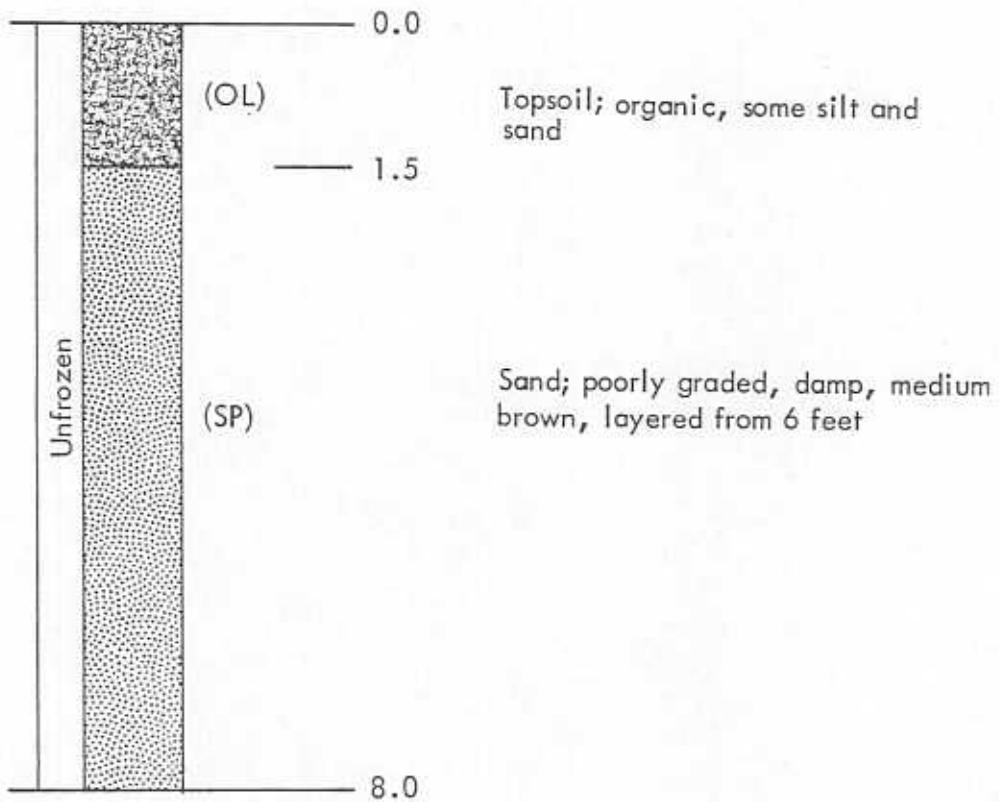
- The available material is a fine, silty sand which is, generally, susceptible to frost action and is not normally considered as a granular type material.
- The exposed in situ material at this site, as noted in the existing borrow pit areas, is very susceptible to surficial erosion and is relatively unstable when exposed.

DETAILED TEST PIT LOG

FS 5X/TP 1

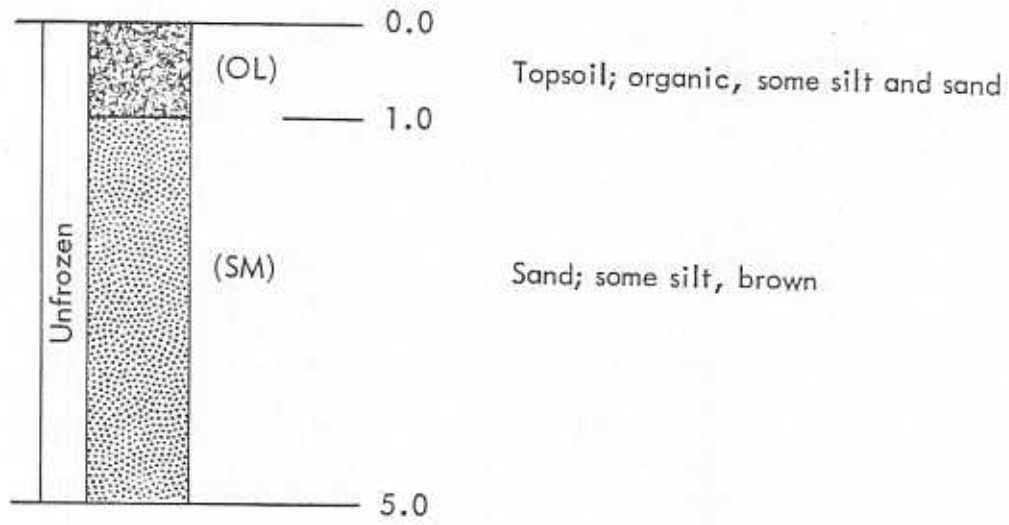


FS 5X/TP 2



DETAILED TEST PIT LOG

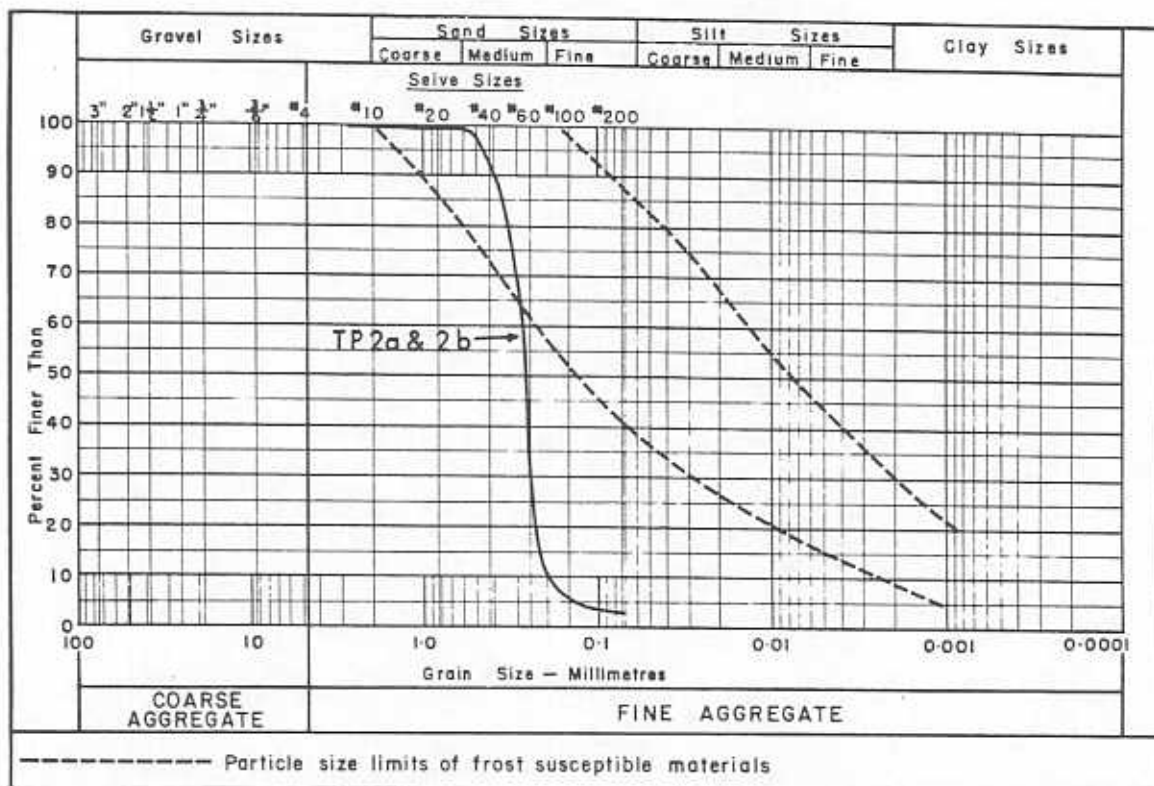
FS 5X/TP 3



SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 5X/TP 2a	FS 5X/TP 2b	FS 5X/TP 1
Sample Depth (Feet):	4.0	9.0	10.0
Moisture Content (%):	-	-	30.1
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



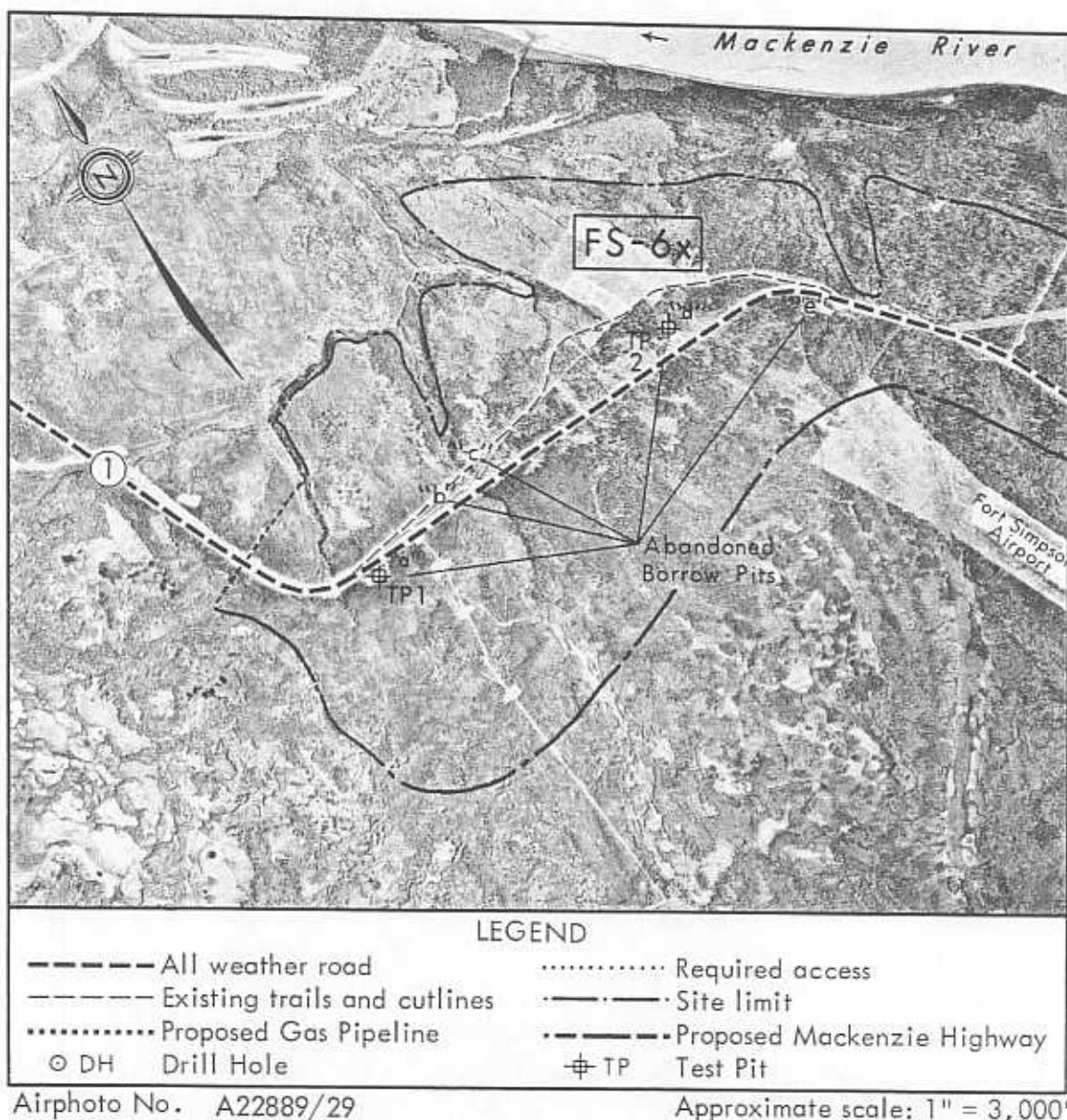
SITE NO. FS 6X

Located approximately $6\frac{1}{2}$ miles southeast of Fort Simpson, Site FS 6X consists of the southern portion of the glaciolacustrine plain which borders on the west bank of the Liard River. The Fort Simpson airport is located immediately adjacent to the southern extremity of the site area.

Type of Material: Sand; fine, some silt, clay lenses.

Estimated Volume: Not established.

Assessment: Very poor quality material, possibly suitable for very marginal fill requirements. This site is not recommended for development.





ENVIRONMENT

Site FS 6X is located approximately $6\frac{1}{2}$ miles southeast of Fort Simpson along the top of the west bank of the Liard River and basically represents an extension of the glaciolacustrine plain from the southern extremity of Site FS 5X. The site encompasses a better drained crescent shaped segment of the plain, some 3 miles in length and $\frac{1}{2}$ mile in breadth. The Fort Simpson airport is located adjacent to the southern extremity of Site FS 6X.

The glaciolacustrine plain consists of very fine grained, silty sands which are susceptible to frost action and are not considered suitable for granular material requirements. Occasional clay layers were encountered in the sand stratum. A shallow organic topsoil layer, 6 to 18 inches in depth, overlies the entire site area and supports a dense growth of spruce, birch and poplar ranging in height to 70 feet and in trunk diameter to 15 inches.

There are no known critical wildlife areas in the immediate vicinity of the site.

The general surficial drainage of the site area is fair and orientated towards the north and east into the Liard River. The northern periphery of the site area is incised with erosional gullies.

The all weather highway to the Fort Simpson airport passes through the middle of Site FS 6X. Five abandoned borrow pits, designated as "a", "b", "c", "d", and "e", have been developed adjacent to the highway during its construction.

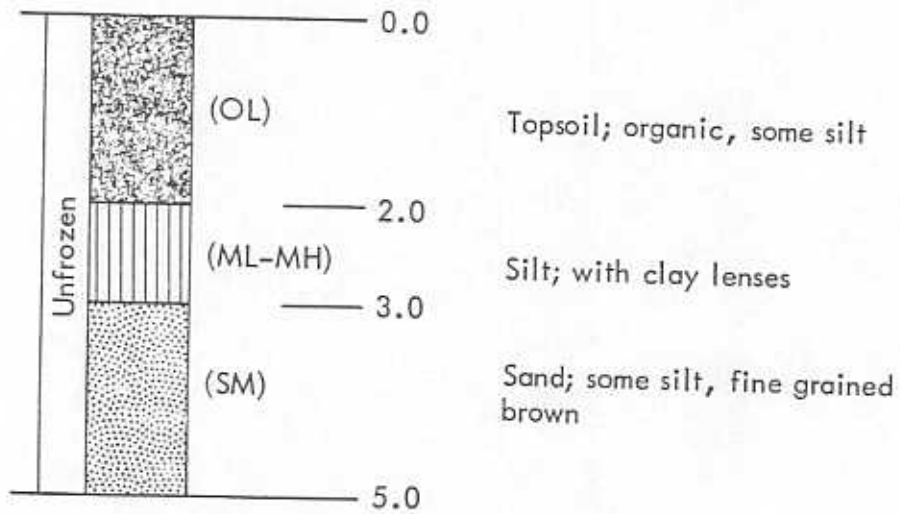
DEVELOPMENT

Site FS 6X is not recommended for development because of the following reasons:

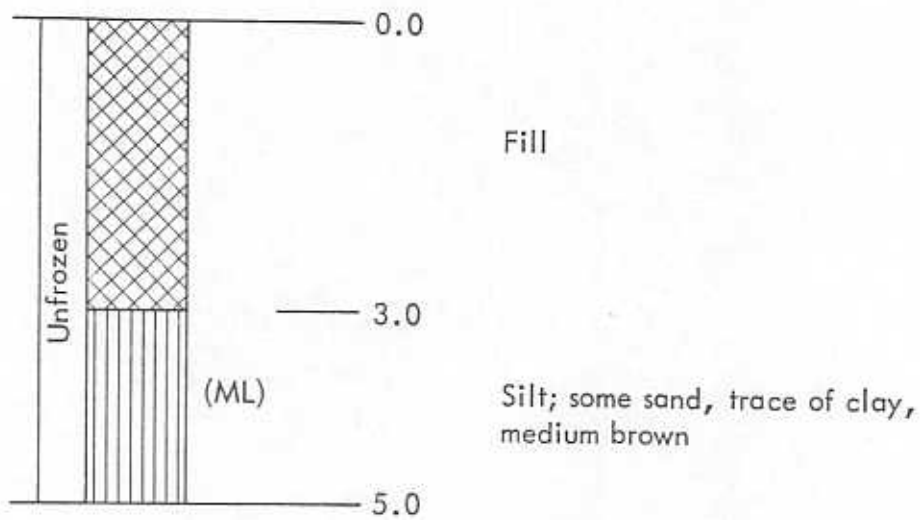
- The available material is a fine, silty sand which is, generally, susceptible to frost action and is not normally considered as a granular type material.
- The exposed in situ material at this site, as noted in the existing borrow pit areas, is very susceptible to surficial erosion and is relatively unstable when exposed.
- The proximity of the Fort Simpson airport at the southern extremity of Site FS 6X further negates any borrow pit development in that portion of the site.

DETAILED TEST PIT LOG

FS 6X/TP 1



FS 6X/TP 2



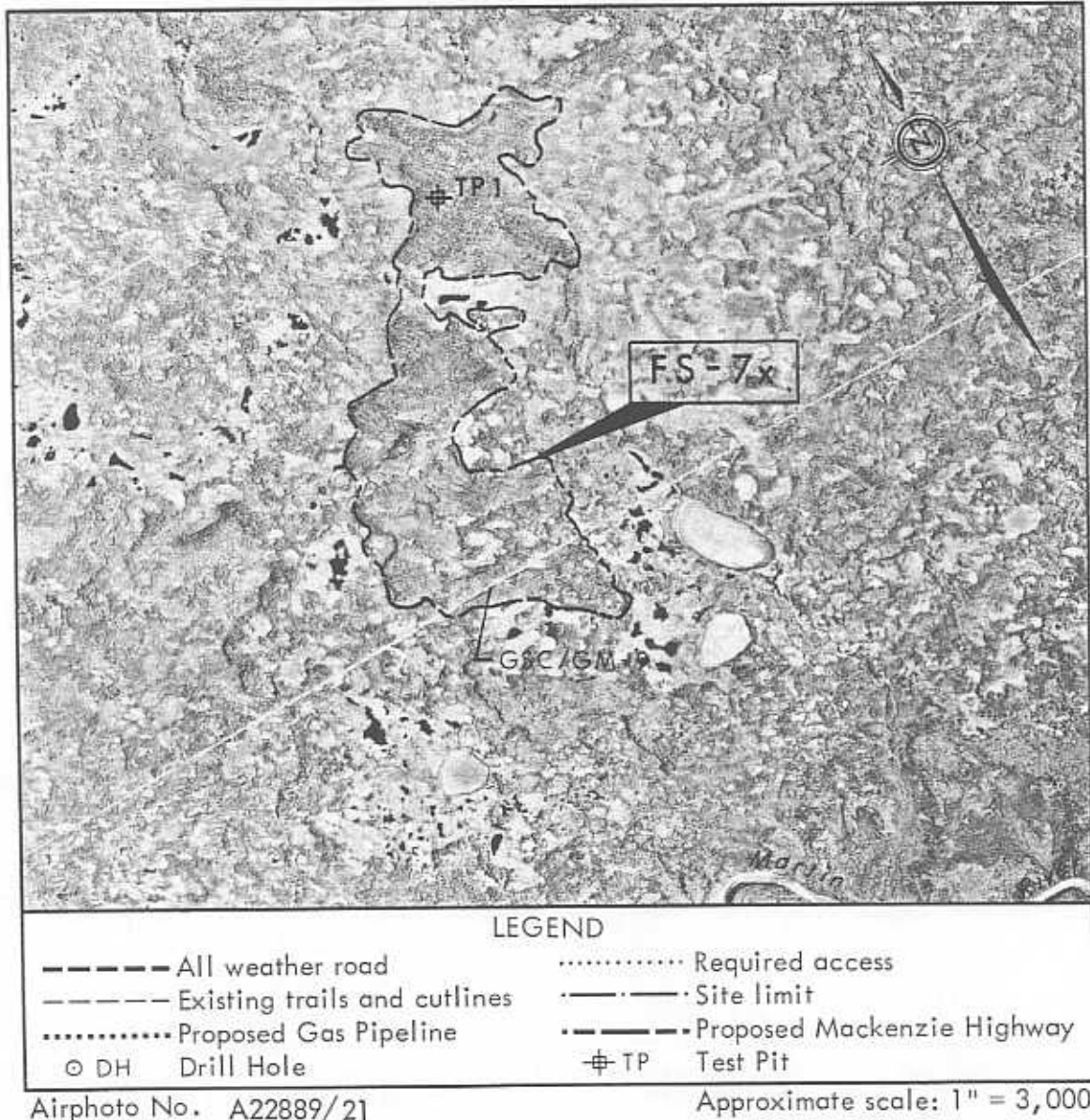
SITE NO. FS 7X

Located approximately 11 miles west of Fort Simpson, between the proposed highway route and the southern bank of the Mackenzie River, Site FS 7X consists of a large group of windblown sand dunes.

Type of Material: Sand; fine, trace of silt.

Estimated Volume: 2,000,000 cubic yards.

Assessment: Very low quality material suitable for very marginal general fill only. The site is not recommended for development because of remoteness and because similar quality material is available at sites more accessible to Fort Simpson.





ENVIRONMENT

Site FS 7X is located approximately 10 miles west of Fort Simpson and consists of numerous interconnected sand dunes which rise 10 to 40 feet above the adjacent terrain. The site encompasses an area approximately $1\frac{1}{2}$ miles in length and $\frac{1}{2}$ mile in width.

The dunes, unfrozen to depths investigated, contain very fine, eolean sand with a trace of silt.

The dune slopes are covered with a shallow layer of organic topsoil, 6 inches in depth and support growths of poplar, birch and spruce. The understory growth consists of moss, sedge and small bushes. The adjacent terrain is relatively flat, poorly drained and contains numerous muskeg bogs. The sand dune formations are well drained into the adjacent terrain.

There are no known critical wildlife areas in the immediate vicinity of the site.

The cleared right-of-way of the proposed Mackenzie Highway is located at the southern extremity of the site area.

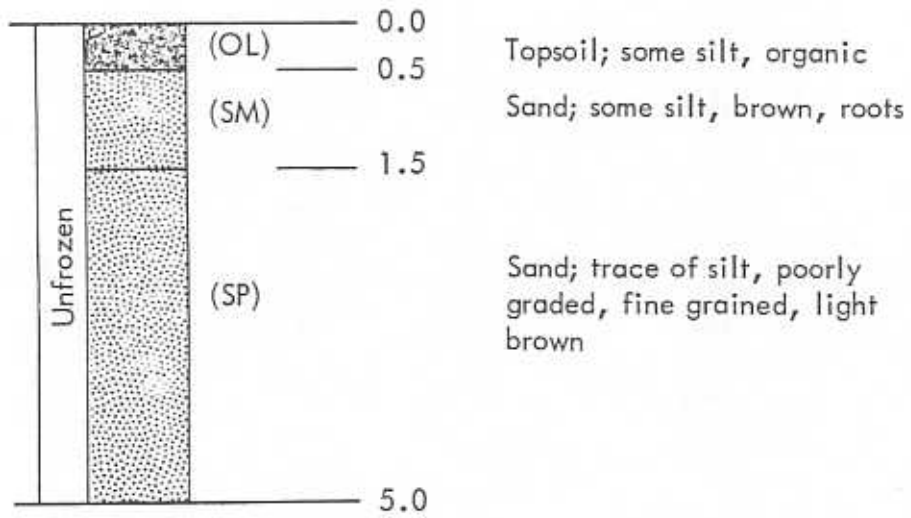
DEVELOPMENT

Site FS 7X is not recommended for development because of the following reasons:

- The available material is of very poor quality and is only suitable for very marginal general fill requirements.
- Similar quality material in extensive quantities is available at sites more accessible to Fort Simpson.
- The borrow pits developed in these dune complexes would be very sensitive to wind and water erosion.

DETAILED TEST PIT LOG

FS 7X/TP 1



SUMMARY OF LABORATORY TEST DATA

Sample Location: FS 7X/TP 1

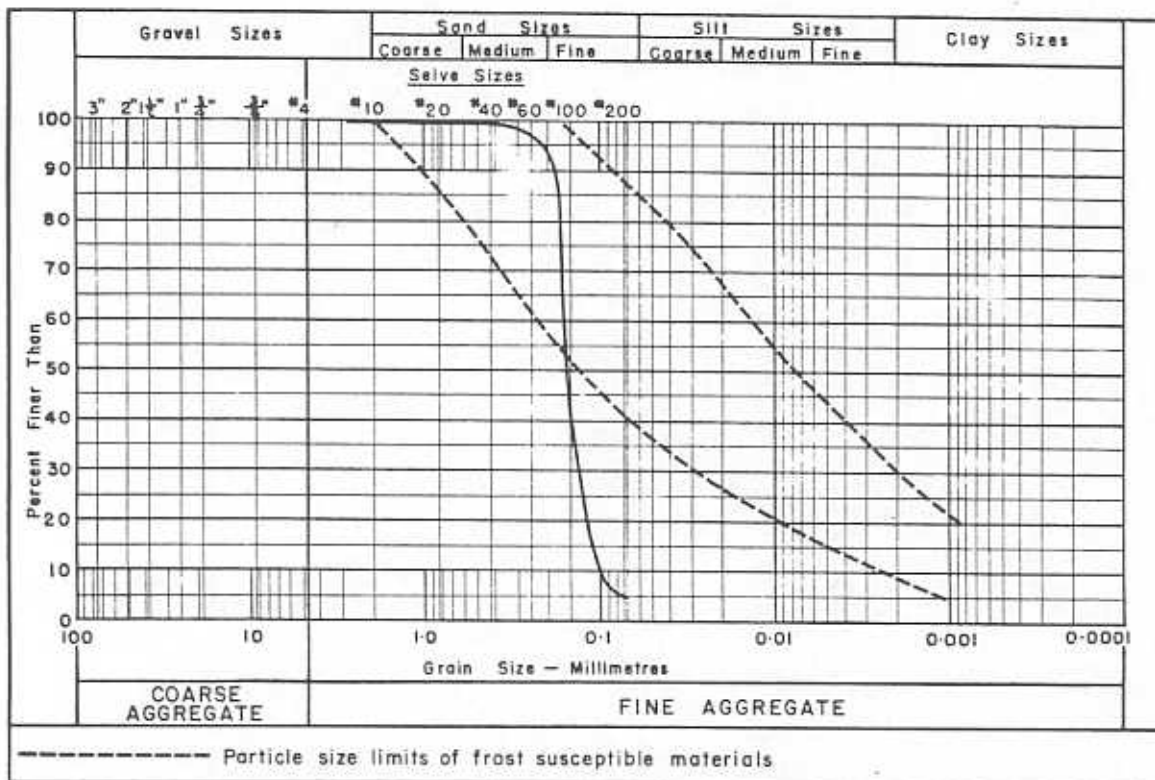
Sample Depth (Feet): 2.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

SUMMARY OF LABORATORY TEST DATA

Sample Location: GSC #GM-9

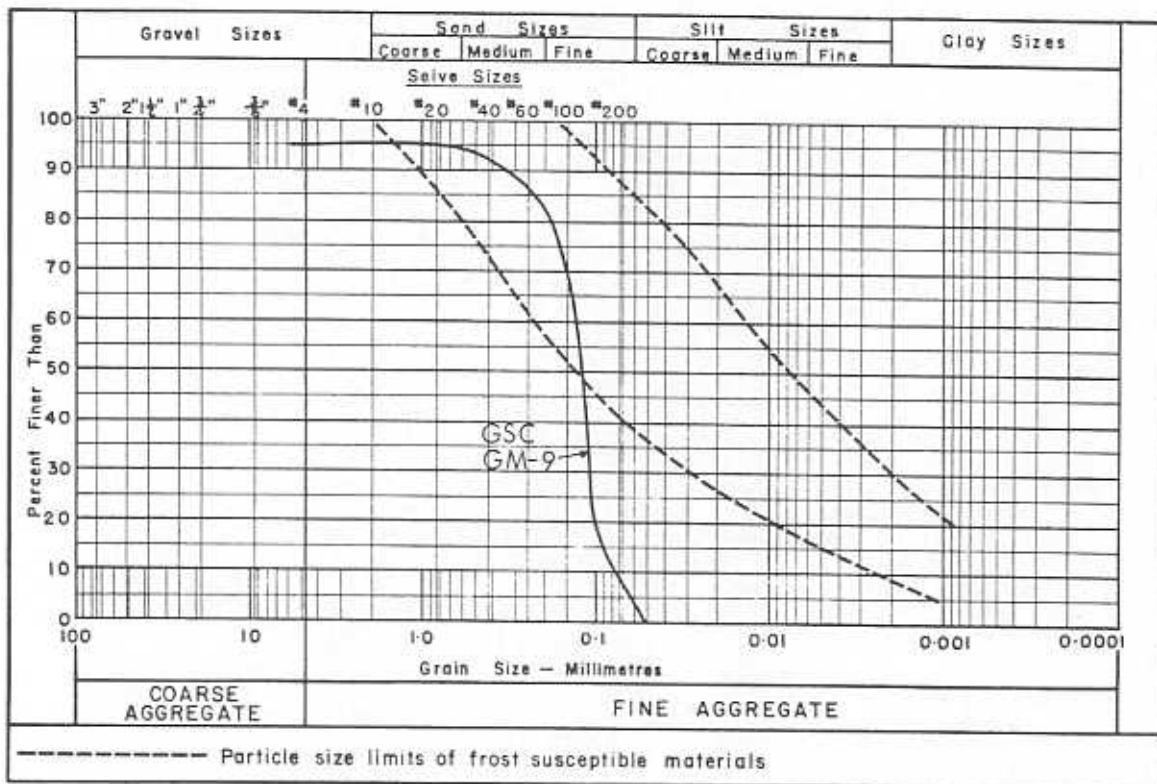
Sample Depth (Feet): -

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): -

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

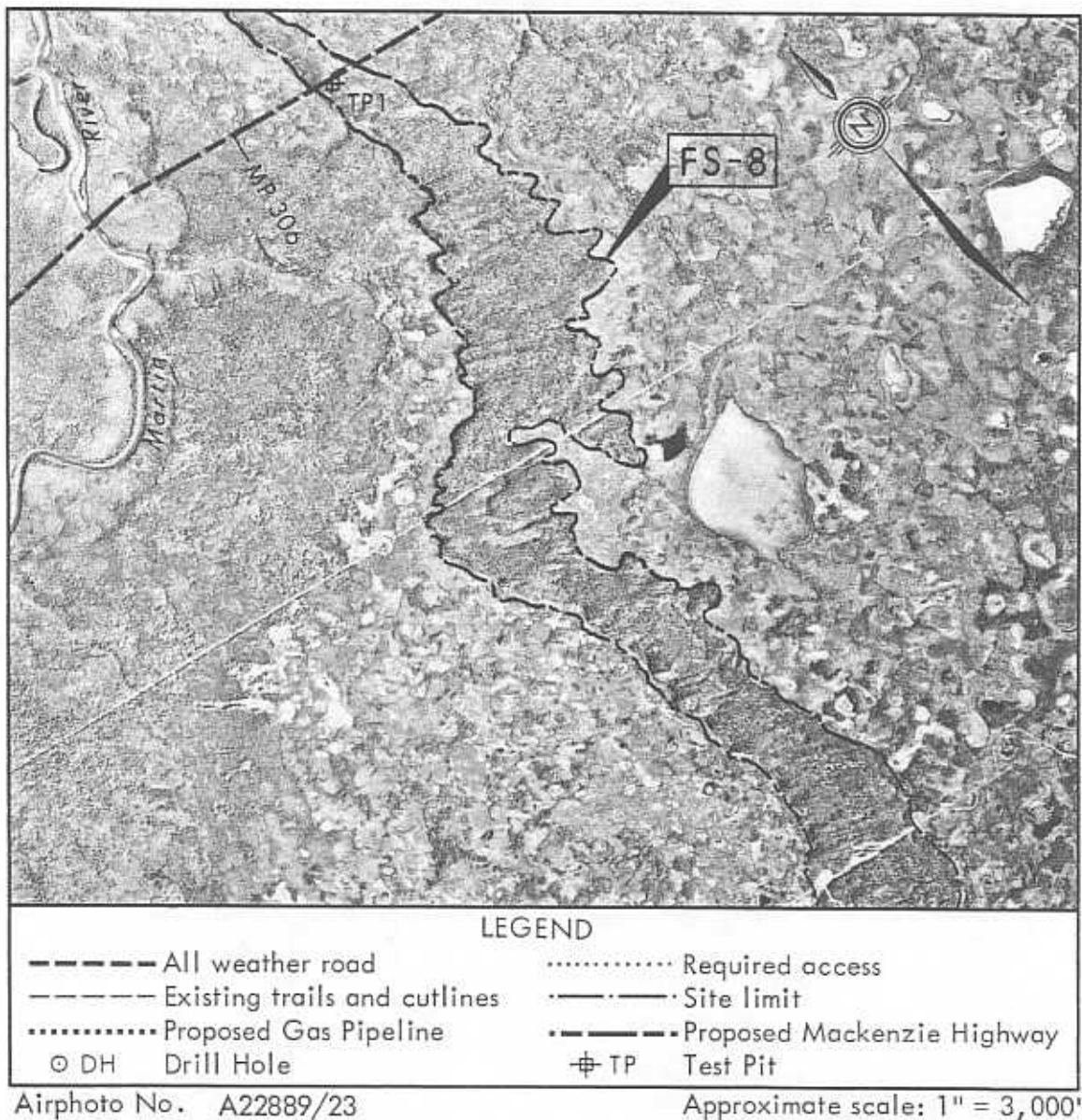
SITE NO. FS 8

Located 8 miles west of Fort Simpson, Site FS 8 consists of a large complex of sand dunes which covers about two square miles of the terrain paralleling the Martin River.

Type of Material: Sand; fine.

Estimated Volume: 15,000,000 cubic yards.

Assessment: Very low quality material suitable for general fill only. This site is not recommended for immediate development but could be considered for construction of local utilities.





ENVIRONMENT

Site FS 8 is located approximately 8 miles west of Fort Simpson and consists of a large complex of sand dunes which encompasses about two square miles of the terrain paralleling Martin River. The site area is in excess of 5 miles in length and 1000 to 2000 feet in width. The dune ridges are generally interconnected and rise 30 to 60 feet above the flat glaciolacustrine plain.

The sand dunes are relatively well drained and contain fine grained, poorly graded, eolian sand. The dune slopes are covered with a relatively shallow layer of organic topsoil, generally 6 inches in depth, and support dense growths of spruce and poplar with some birch. The adjacent terrain is relatively flat and poorly drained and exhibits some thermokarst features which may be an indication of higher ground ice content.

There are no known critical wildlife areas in the immediate vicinity of the site. However, Martin River is noted for its potential spawning areas near the north end of the site.

The cleared right-of-way of the proposed Mackenzie Highway traverses the northern extremity of the site area.

DEVELOPMENT

Site FS 8 is not recommended for immediate development but may be considered as a possible source for marginal general fill requirements in the construction requirements of local utilities.

The following development guidelines should be considered in the operation of any borrow pits at Site FS 8:

- The shallow organic topsoil should be carefully stripped and stockpiled along the lower slopes of the dunes for future utilization in the restoration of the borrow pit areas.
- The clearing of existing tree and understory growth on the dune slopes should be carried out in accordance with applicable land use guidelines.
- Vertical excavation opposed to horizontal excavation should be considered to minimize the erosion of the exposed borrow area by wind and rain action.
- The material should be adequately extracted with the use of standard excavation equipment such as dozers, overhead loaders and backhoes.



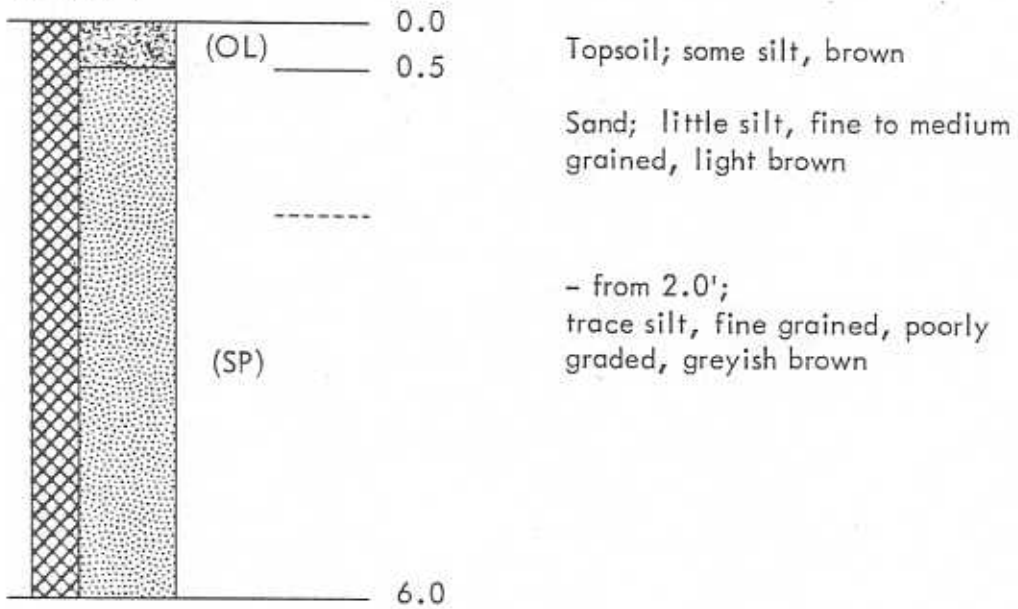
ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site FS 8 is exploited as a source of granular materials at a future date:

- Recontouring of borrow pit areas to maintain good drainage to the adjacent terrain.
- Replacement and spreading of organic topsoil from pre-production stockpiles on to the recontoured pit areas.
- Revegetation of the restored borrow pit areas should be considered, especially in areas where exposed and abandoned pits may be susceptible to rapid gullyng by water or blow outs by wind.

DETAILED TEST PIT LOG

FS 8/TP 1



SUMMARY OF LABORATORY TEST DATA

Sample Location: FS 8/TP 1

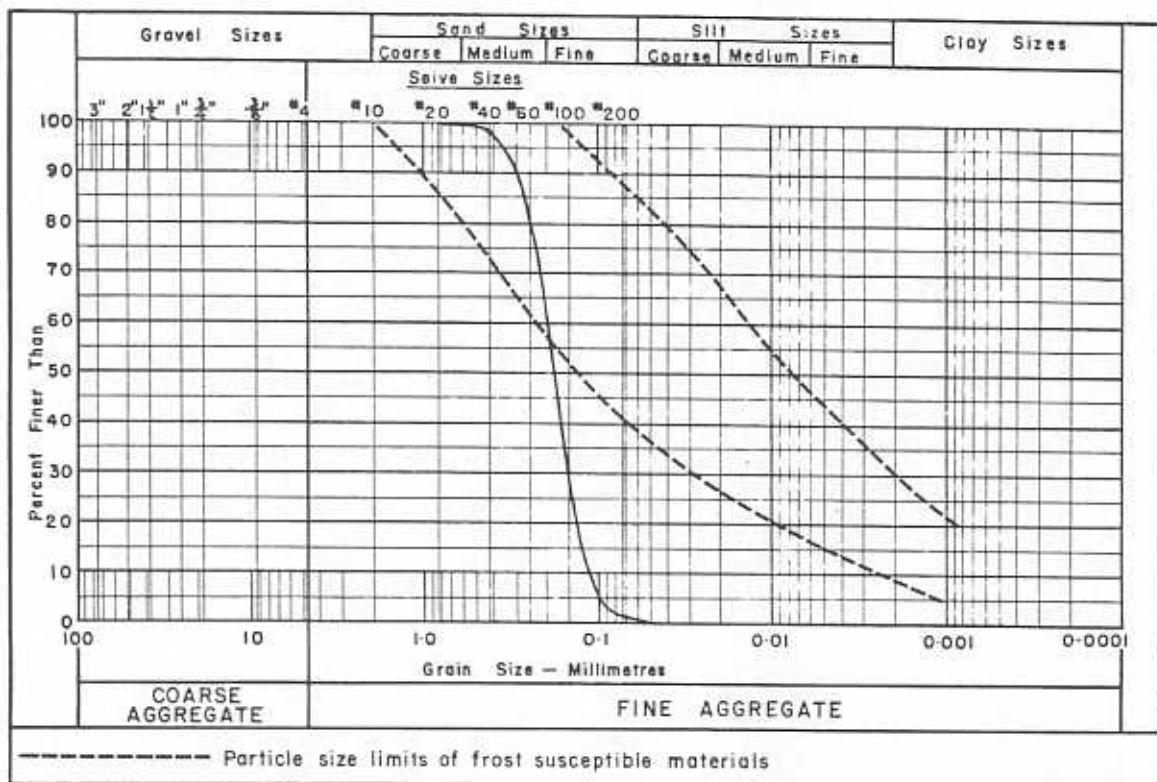
Sample Depth (Feet): 5.0

Moisture Content (%): -

Ice Content (%): -

Organic Content (%): 1.9

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

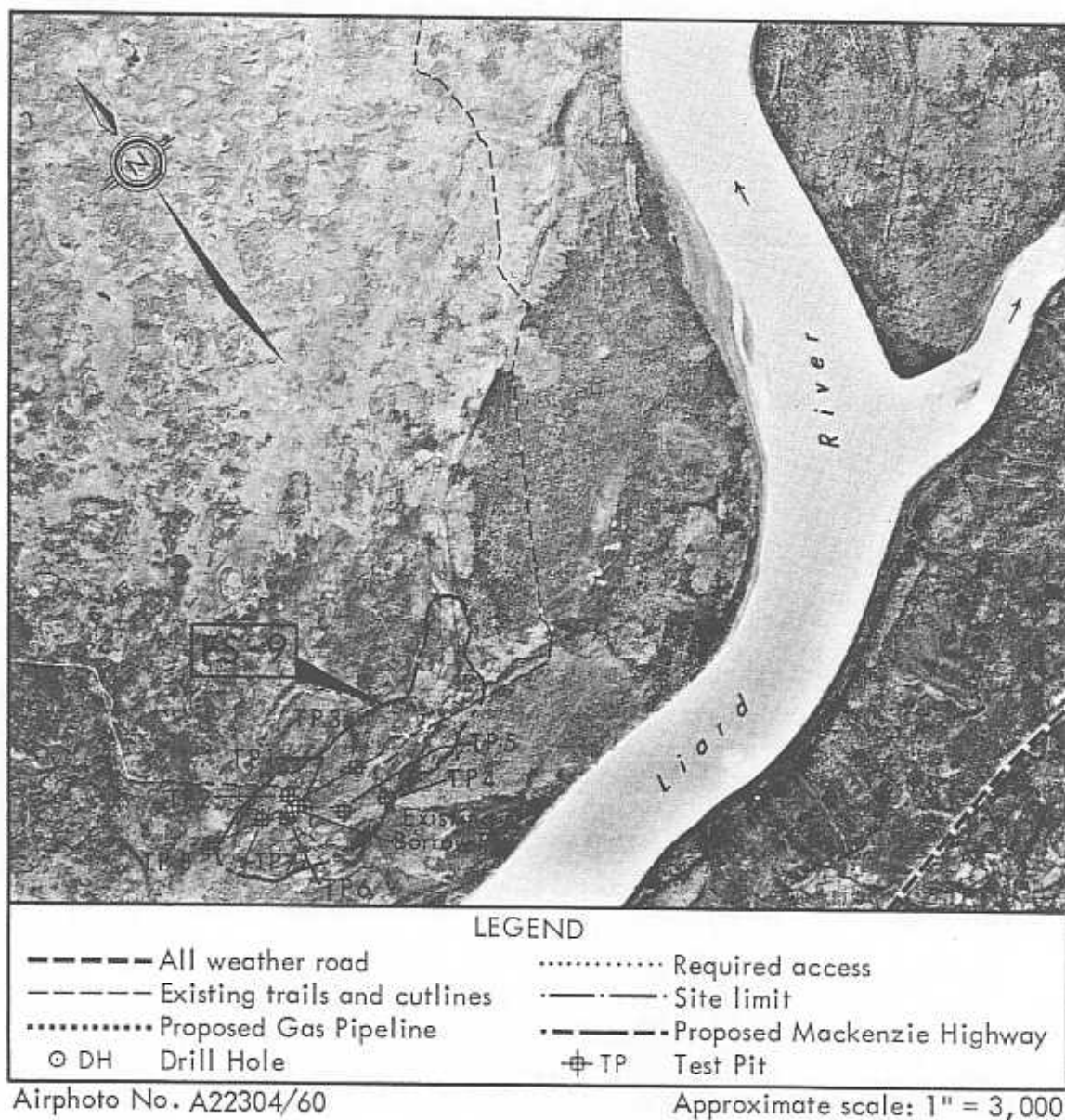
SITE NO. FS 9

Located approximately 11 miles directly south of Fort Simpson, Site FS 9 consists of a crescent shaped beach ridge on the edge of a flat glaciolacustrine plain on the west bank of the Liard River. An existing borrow pit is currently being exploited at this site and the existing access road provides direct access to Fort Simpson, although the total haul distance is approximately 16 miles.

Type of Material: Sand; medium to fine grained, large gravel pockets.

Estimated Volume: 500,000 cubic yards.

Assessment: Good quality granular material is available in localized pockets. However, this site is not recommended at this time for the granular requirements of the community because of its remoteness, but it may be utilized for the granular material requirements in the construction of local utilities.





ENVIRONMENT

Site FS 9 is located approximately 11 miles directly south of Fort Simpson and consists of a crescent shaped edge of a flat glaciolacustrine plain, sloping gently to the crest line of the steep west bank of the Liard River. An erosional gully parallels the western extremity of the site area. The site area, approximately 3000 feet in length and 500 feet in width, is a glaciolacustrine beach ridge that is partly eroded along the Liard River valley wall.

The material in the beach ridge consists predominantly of medium to fine grained sand with a little silt. Occasional pockets and layers of well graded, medium grained gravels are interspersed throughout the ridge. The silty organic topsoil layer varies from 1 to 3 feet in depth and supports a moderately dense growth of poplar with the occasional spruce ranging in height to 50 feet and in trunk diameter to 8 inches.

There are no known critical wildlife areas in the immediate vicinity of the site.

The site area and the adjacent terrain is well drained towards the east into the watershed of the Liard River.

An existing pit is currently located in a localized and relatively large gravel pocket. An existing road from Fort Simpson provides direct access to this site area although the total haul distance is approximately 16 miles along existing roads.

DEVELOPMENT

In view of the long haul distance the use of granular materials from this site for the requirements of the community is not recommended at this time. However, Site FS 9 is recommended for continued development to augment the granular material requirements in the construction of local utilities.

The following development guidelines should be considered in the operation of borrow pits in this area:

- Exploitation of additional granular materials may be undertaken by expanding the development of the existing borrow pit. Test pits excavated in the site area indicate that similar quality granular materials are available in the immediate proximity of the existing pit area.
- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.
- The organic topsoil layer should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.



- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain to the Liard River channel.
- The location of topsoil and waste disposal areas should be selected to minimize the drainage of waste material into the watershed of the Liard River.
- Generally, dozers, overhead loaders and standard ripping equipment should be adequate for the removal of material from this site.
- Vegetation buffer zones should be maintained between work areas to minimize erosion and instability of the dune area.

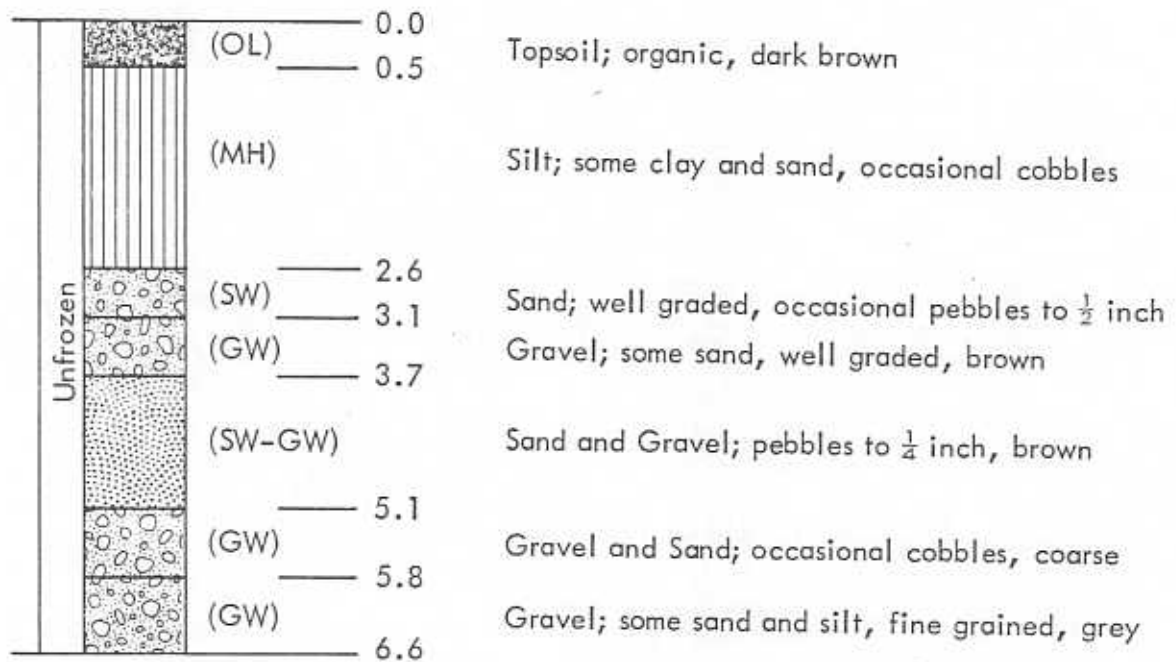
ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation guidelines should include the following if Site FS 9 is developed as a borrow pit:

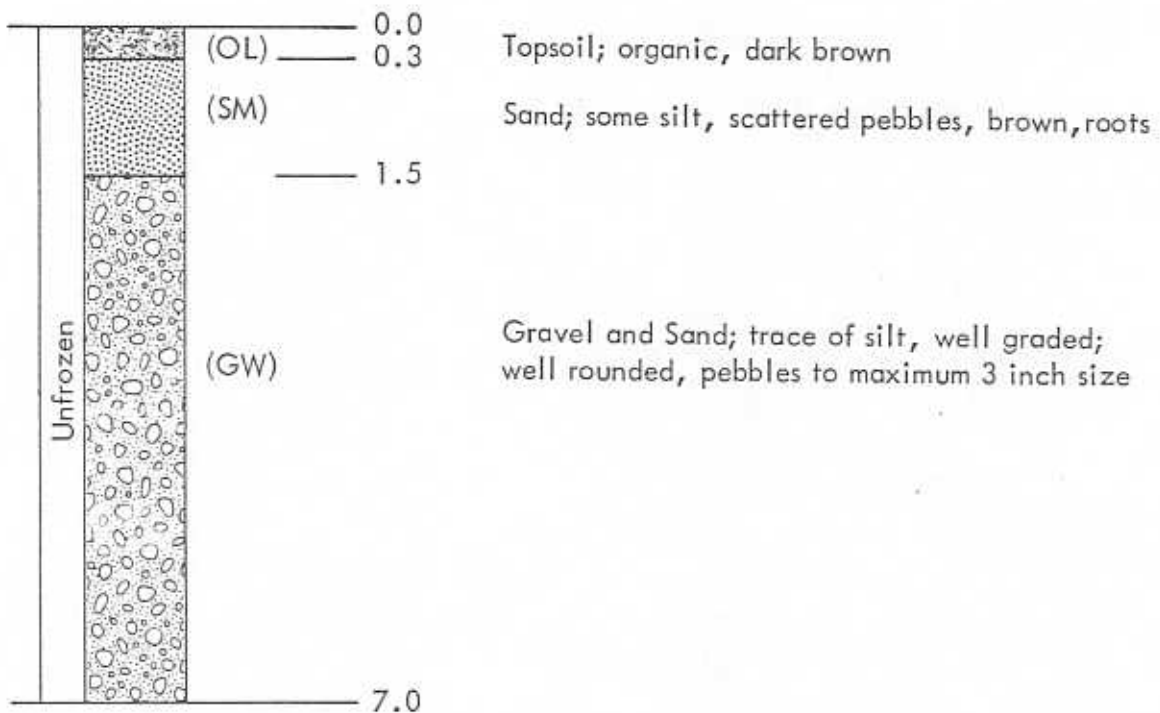
- Recontouring of borrow pit area to maintain good drainage to the adjacent terrain.
- Replacement and spreading of organic topsoil from pre-production stockpiles on to the recontoured exposed borrow pit areas.
- Revegetation of the restored borrow pits in areas where erosion may be severe.

DETAILED TEST PIT LOG

FS 9/TP 1

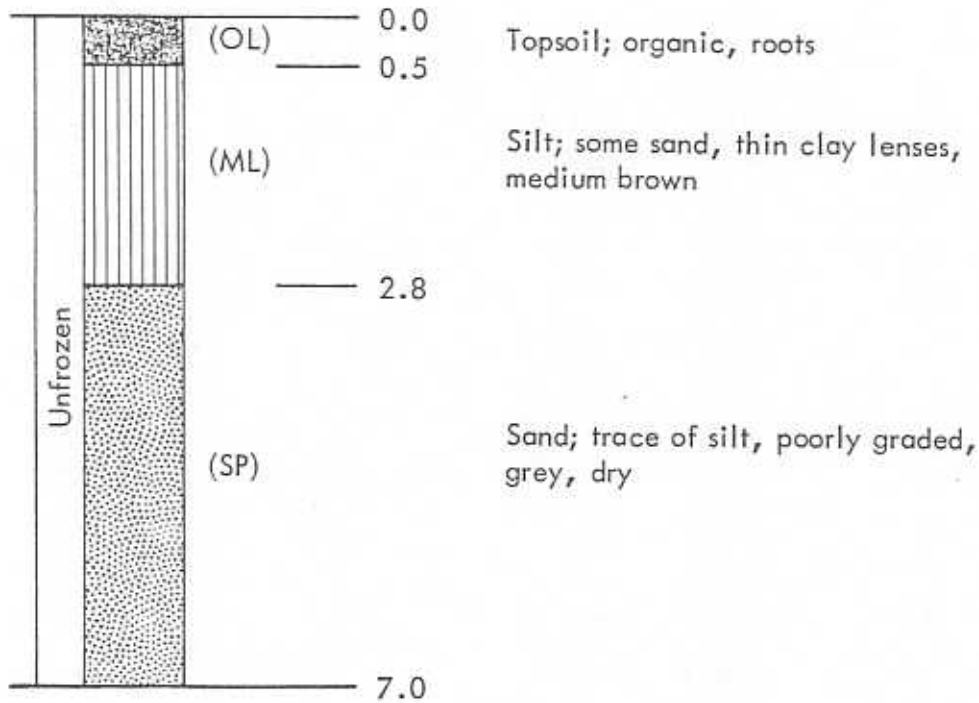


FS 9/TP 2

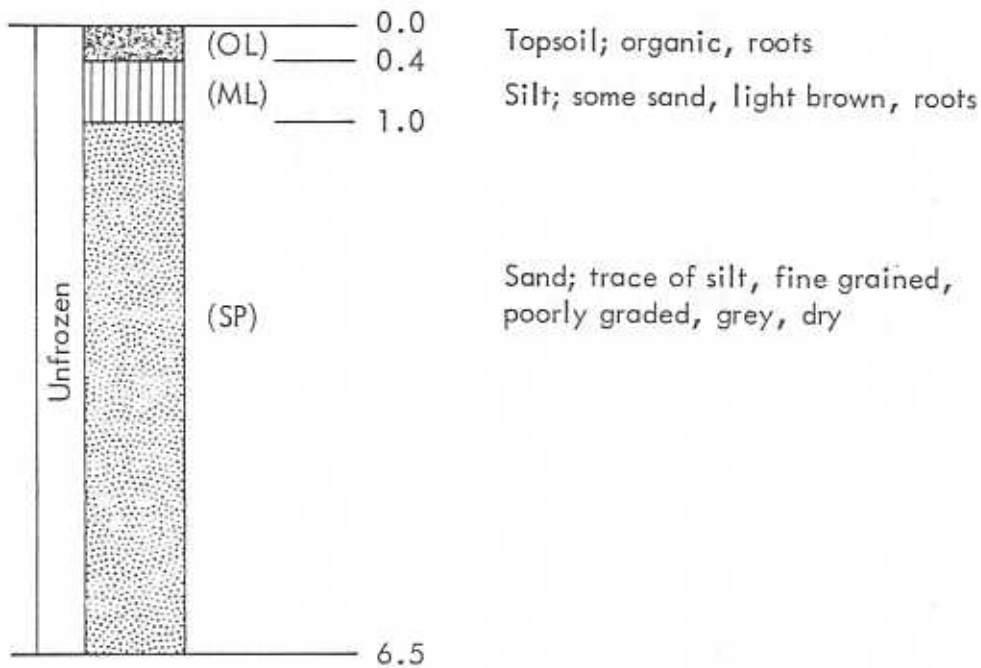


DETAILED TEST PIT LOG

FS 9/TP 3

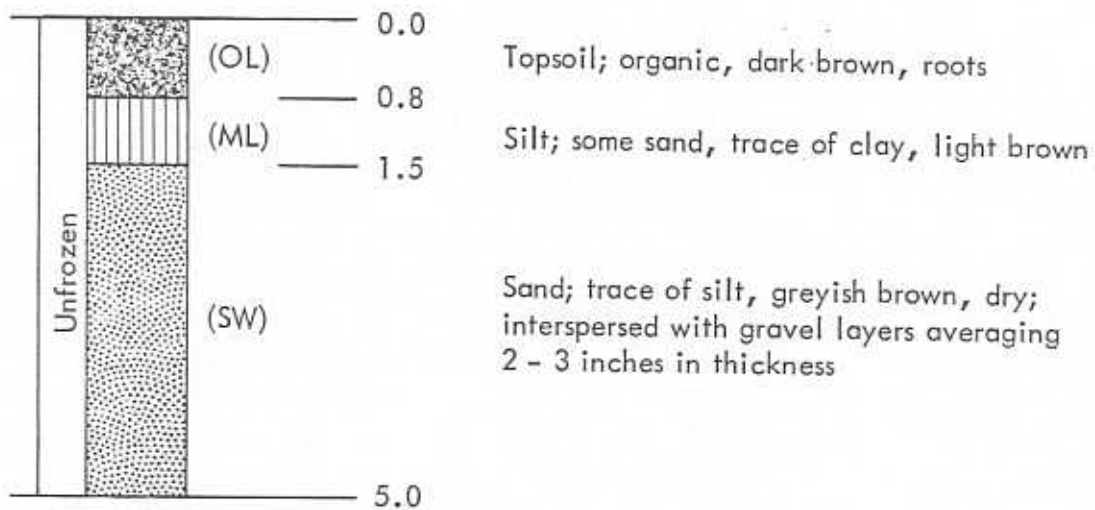


FS 9/TP 4

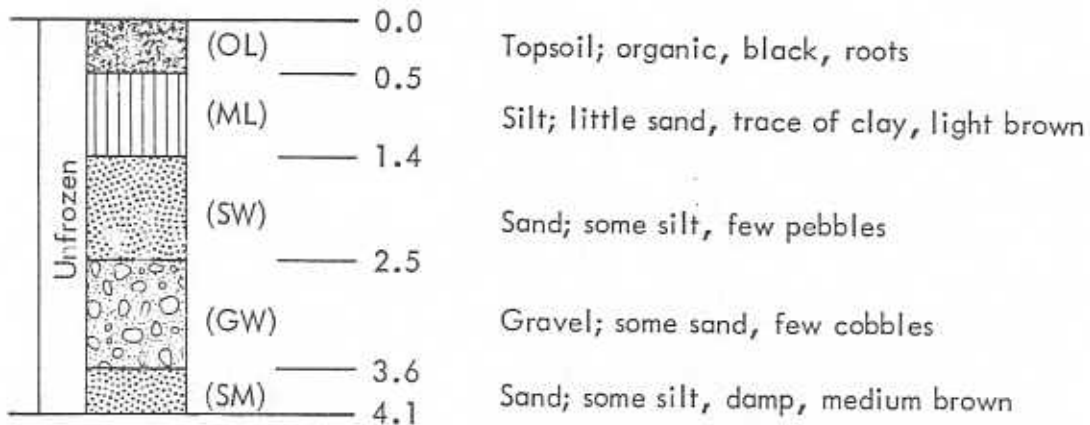


DETAILED TEST PIT LOG

FS 9/TP 5

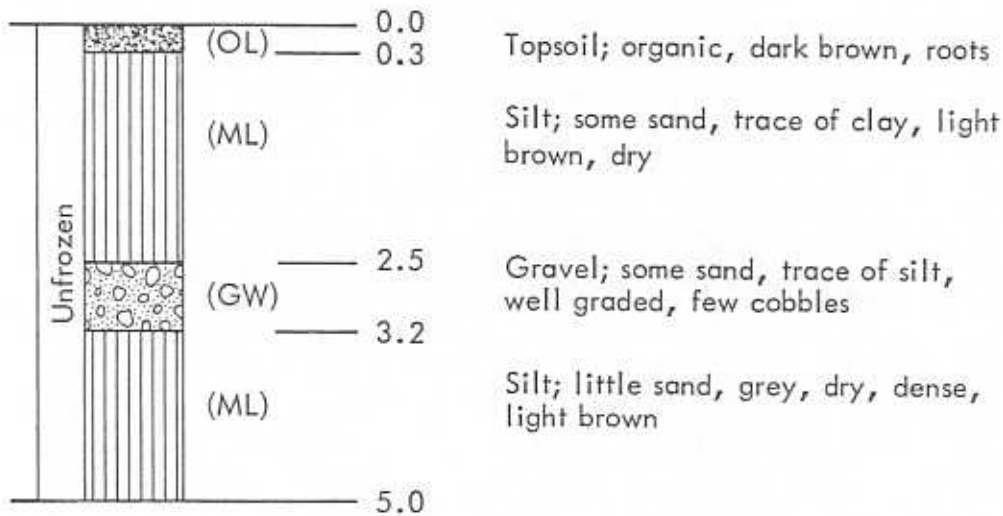


FS 9/TP 6

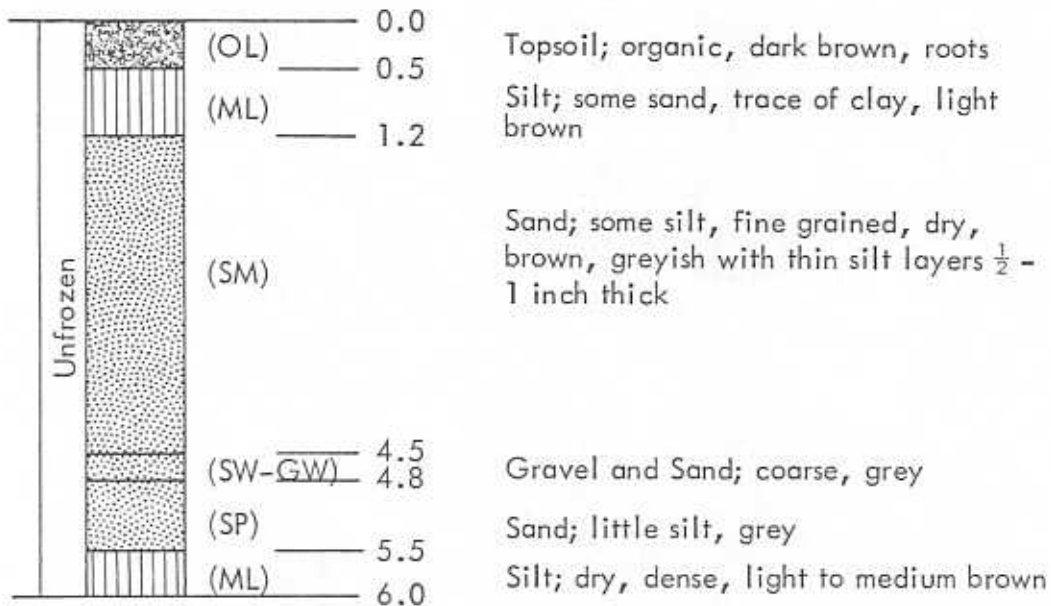


DETAILED TEST PIT LOG

FS 9/TP 7



FS 9/TP 8



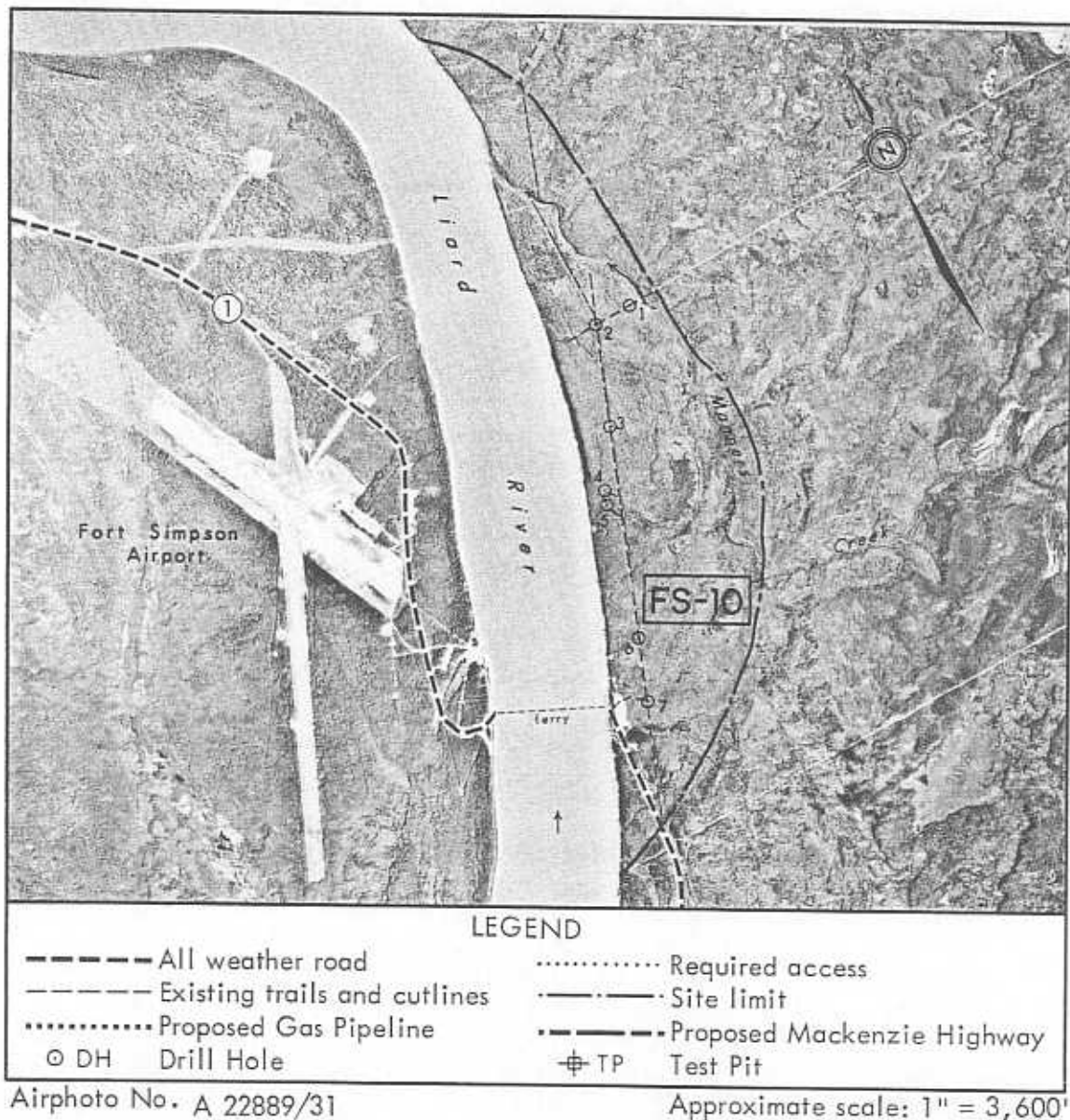
SITE NO. FS 10

Located approximately 10 miles southeast of Fort Simpson on the east side of the Liard River, Site FS 10 consists of an alluvial river terrace.

Type of Material: Silt; some sand, pockets of gravel at depths.

Estimated Volume: Not established.

Assessment: The silts and sands are of very poor quality suitable only for very marginal general fill, while the gravel deposits at depth are of fair to good quality.





ENVIRONMENT

Site FS 10 is located approximately 10 miles southeast of Fort Simpson on the east bank of the Liard River and consists of a long, narrow alluvial river terrace. The site area is approximately 3 miles in length and $\frac{1}{4}$ to $\frac{1}{2}$ mile in width. The top of the terrace is approximately 40 feet above the Liard River water level. The river banks at this site area are very steep and are periodically eroded by the river. The adjacent terrain, in general, slopes gently towards the river valley walls. Manners Creek flows along the eastern periphery and across the northern tip of the terrace. The relatively flat terrain is etched with numerous shallow stream channels.

The terrain consists primarily of very fine sands and silts with localized pockets and layers of gravel at depth. This silt and sand stratum may be in excess of 40 feet in depth and, in view of slope washing, a thicker depth of fine sediments is anticipated in areas adjacent to the valley walls.

The topsoil and organic surficial silt layer varies considerably throughout the site area ranging from one foot to five feet. This organic silt and topsoil layer supports growths of very dense bush and clustered stands of tall spruce, birch and poplar.

There are no known critical wildlife areas in the immediate vicinity of the site.

The surficial drainage of the site and adjacent terrain is generally westward into the watershed of the Liard River.

The access to the site area involves a crossing of the Liard River by ferry. The all weather highway to Fort Simpson traverses through the northern half of the site area.

DEVELOPMENT

Exploratory drill holes extended to maximum depths of 30 feet, recovered stratified sands and silts of very frost susceptible characteristics. A small isolated pocket of fine gravel and sand was noted in drill hole DH-4 at a depth of 28 feet below the existing ground surface. Infrequent small gravel pockets were also noted in cuts in the northern tip of the site.

Site FS 10 is not recommended for development for the requirements of Fort Simpson; however, this site may be considered for the exploitation of very marginal granular fill requirements in the construction of local utilities.

The following operational guidelines should be considered for the development of borrow pit areas at Site FS 10.

- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.
- The organic topsoil layer should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.



- Operating procedures during borrow pit development should be maintained whereby surficial waste materials do not drain to the Liard River.
- Relative to development of borrow pit areas immediately adjacent to the Liard River, the development procedures should be commenced at the site area farthest removed from the water course. A vegetation buffer zone should be maintained between the stream and the final limits of the borrow pit.
- Stands of natural growth should be retained between borrow pit areas in order to promote natural regeneration after abandonment.
- Generally, dozers, overhead loaders and standard ripping equipment should be adequate for the removal of material from this site.

ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

- Recontouring of the pit areas to provide general drainage that is compatible with the natural drainage of the adjacent terrain.
- Replacing stockpiled surficial waste material and organic topsoil on the abandoned recontoured pit areas.
- Reseeding of the recontoured pit areas should be considered in areas that may pose erosional problems. At these locations, the artificial reseeding of annuals and perennials will result in a semi-permanent cover growth prior to reestablishment of native species.

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-1

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0								0
3		OL	1.0 TOPSOIL: some silt, trace sand, light brown					3
6			----- SAND AND SILT: fine grained, poorly graded, brown - becoming siltier at 4.0'		Nf	VL		6
9		SP-SM						9
12								12
15								15
18			18.0					18
21		SM	SILT AND SAND: greyish brown	UF				21
24								24
27		SM-SW	25.0 SAND: little silt, occasional pebbles, fine to medium grained, well graded, greyish brown					27
30			30.0 TOTAL DEPTH 30.0'					30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



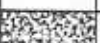


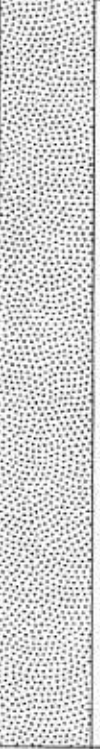
PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-2

DATE: FEB. 19, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE CONT.		
0		OL	TOPSOIL: some silt, little sand and organic, roots, dry, light brown					0
3		ML	SILT: little sand, dry, brown		Nf	VL		3
6		SM-SP	SAND: some silt, fine grained, poorly graded, brown					6
9				UF				9
12								12
15			- little silt, greyish brown from 15.0'					15
18								18
21			TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-3

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE CONT.		
0		OL	TOPSOIL: some silt, little sand, trace organic, roots, dry, brown			VL		0
4		ML	SILT: little sand, dry		Nf	VL		4
8		SM-SP	SAND: some silt, fine grained, poorly graded, brown, from 6.0' moist	UF			MC O	8
12								12
16								16
20								20
24								24
28								28
32			TOTAL DEPTH 31.0'					32

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-4

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒

AIR
CONVENTIONAL

☐ AIR REVERSE
CIRCULATION

☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0								0
3		OL	TOPSOIL: some silt, little sand and organic, light brown					3
6		SM-SP	SILT AND SAND: fine grained, poorly graded, dusty, dry, brown		Nf	VL		6
9		SP-SM	SAND: some silt, fine grained, poorly graded, brown					9
12				UF				12
15								15
18								18
21								21
24								24
27			SAND: little gravel and silt, fine to coarse grained, well graded, 3/4" maximum, occasional cobbles rounded to subangular, greyish brown				MC GS	27
30			TOTAL DEPTH 30.0'					30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-5

DATE: FEB. 19, 1973

LOGGED BY: ☒ PEMCAN ☐





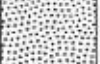
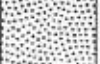
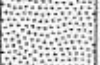

DRILLING METHOD: ☒

CONVENTIONAL

☐ AIR

☐ AIR REVERSE CIRCULATION

☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	1.0 TOPSOIL: some silt, little sand, some organic, roots, brown		Vx	M		0
2		SM-SP	SILT AND SAND: fine grained, poorly graded, dry, brown		Nf	VL		2
4								4
6								6
8		SP-SM	SAND: fine grained, poorly graded, damp, brown	UF				8
10								10
12			11.0 TOTAL DEPTH 11.0'					12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG





SITE NO. FS 10

HOLE NO. DH-6

DATE: FEB. 19, 1973


LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR ☐ AIR REVERSE ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	1.5 TOPSOIL: some silt, trace sand, little organic, brown					0
3		ML	5.0 SILT: little sand, brown		Vx	M		3
6		SP-SM	SAND: some silt, fine grained, poorly graded, greyish brown					6
9				UF				9
12								12
15								15
18								18
21			21.0 TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

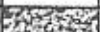

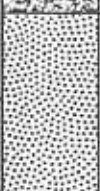

DETAILED DRILL HOLE LOG

SITE NO. FS 10

HOLE NO. DH-7

DATE: FEB. 19, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	TOPSOIL: some silt, trace sand, little organic, dark grey					0
3		SM-SP	SAND AND SILT: fine grained, poorly graded, greyish brown, damp from 5.0'		Vx	M		3
6			- little silt, brown from 8.0'					6
9				UF				9
12								12
15		ML	SILT: some sand, damp, greyish brown					15
18								18
21			TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

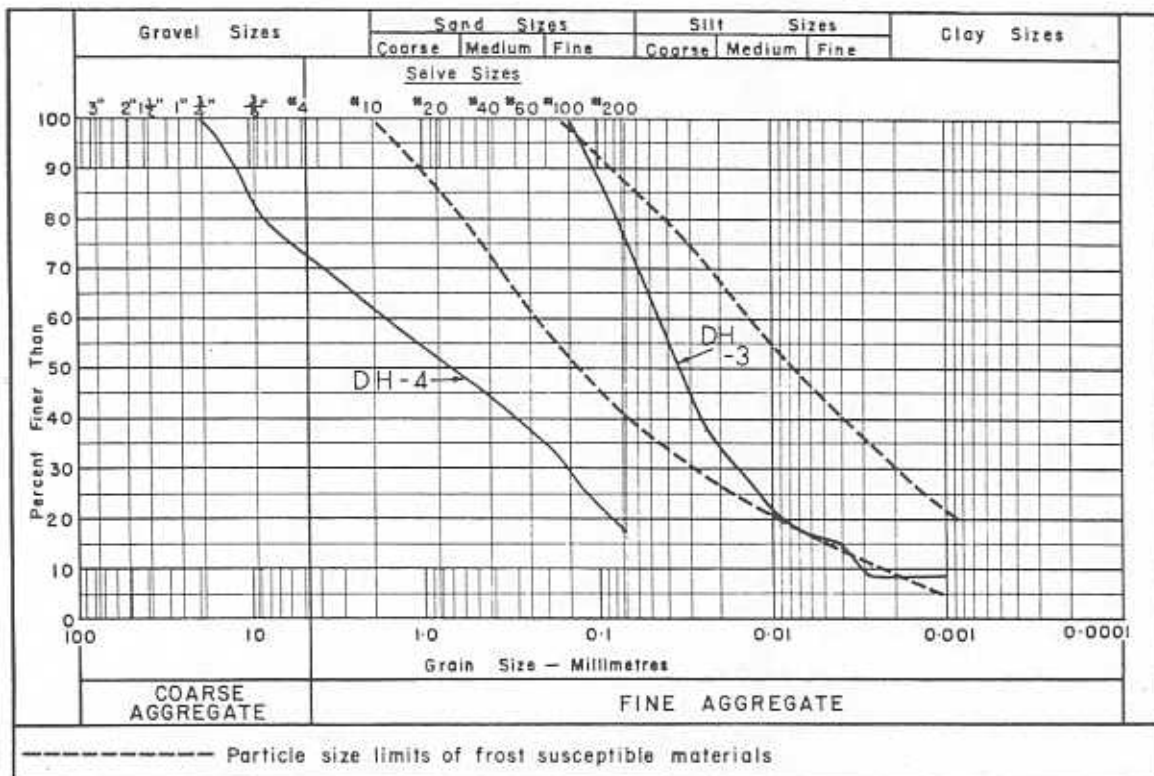


PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 10/DH 4	FS 10/DH 3	FS 10/DH 3
Sample Depth (Feet):	28.0	16.0	15.0
Moisture Content (%):	4.6	15.4	-
Ice Content (%):	-	-	-
Organic Content (%):	-	3.5	4.6

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

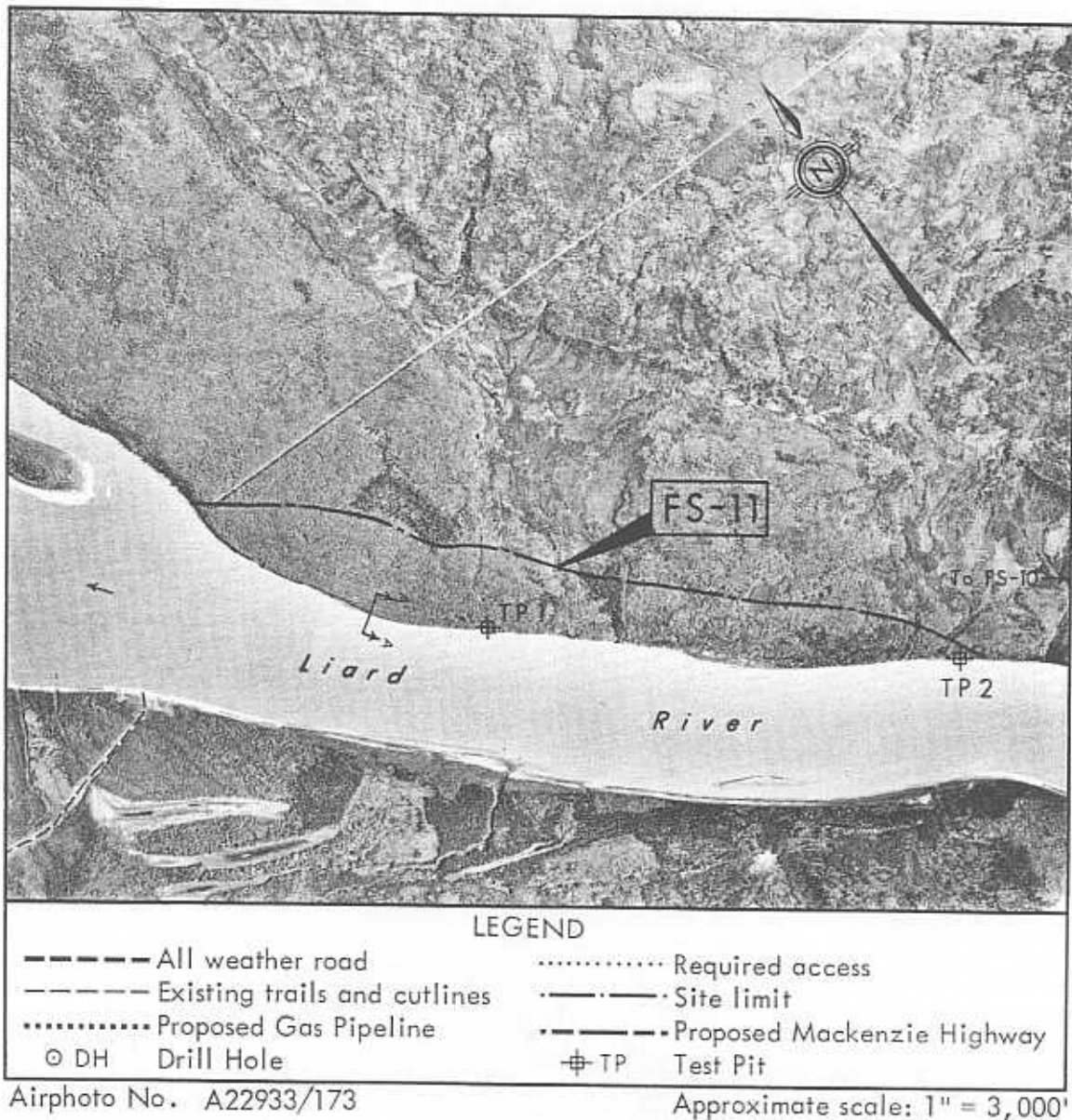
SITE NO. FS 11

Located approximately 5 miles southeast of Fort Simpson on the east bank of the Liard River, Site FS 11 consists of a large alluvial terrace formed between the Mackenzie and Liard Rivers. The total haul distance is approximately 14 miles.

Type of Material: Sand & Silt; fine, some pockets of gravel.

Estimated Volume: Not established.

Assessment: Very poor quality material suitable only for very marginal general fill. This site is not recommended for development because of very difficult access and marginal quality material.





ENVIRONMENT

Site FS 11 is located approximately 5 miles southeast of Fort Simpson on the east bank of the Liard River and consists of a large alluvial terrace formed between the Mackenzie and Liard Rivers. The site is approximately 2 miles in length and 1000 feet in width and the top of the terrace rises about 50 feet above the Liard River water level. The river bank is quite steep as it is being periodically undermined by stream erosion.

The terrace consists primarily of horizontally stratified silts and sands with localized small pockets and layers of gravel. The surficial topsoil and organic silt layer is a relatively shallow 1 to 2 feet in depth and supports a dense growth of birch and poplar with occasional spruce. The surficial drainage of the site area and adjacent terrain is good, in a westward direction into the watershed of the Liard River.

There are no known critical wildlife areas in the immediate vicinity of the site. However, the downstream area at the mouth of the Liard River is noted as a domestic fishing locale for the residents of Fort Simpson.

The existing access to Site FS 11 is very poor involving the development of new haul roads along existing cutlines from the north end of Site FS 10, a ferry crossing of the Liard River and one small stream crossing. The total haul distance to Fort Simpson townsite is about 14 miles.

DEVELOPMENT

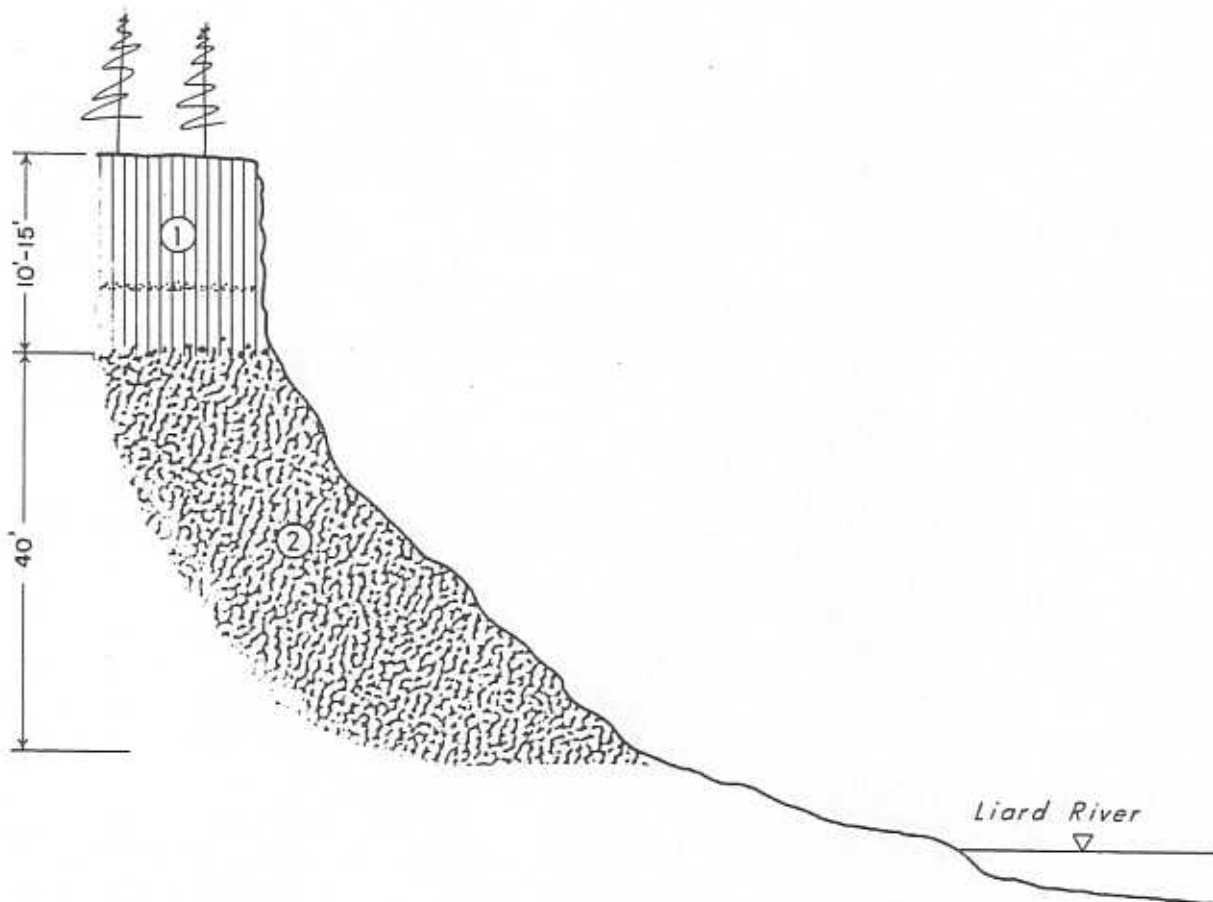
Site FS 11 is not recommended for development for the following reasons:

- Access to the site is very difficult and relatively lengthy.
- The available materials at this site are of very poor quality and similar marginal quality material is available at other sites more accessible and nearer to the community.
- If Site FS 11 is developed at a future date, then restoration procedures that are compatible with the development and legislative land use requirements that are current at that time should be developed. These might include procedures such as redistribution of stockpiled surficial materials, recontouring and reseedling of critical areas.

FS 11

SECTION: A-A'

(Not to Scale)

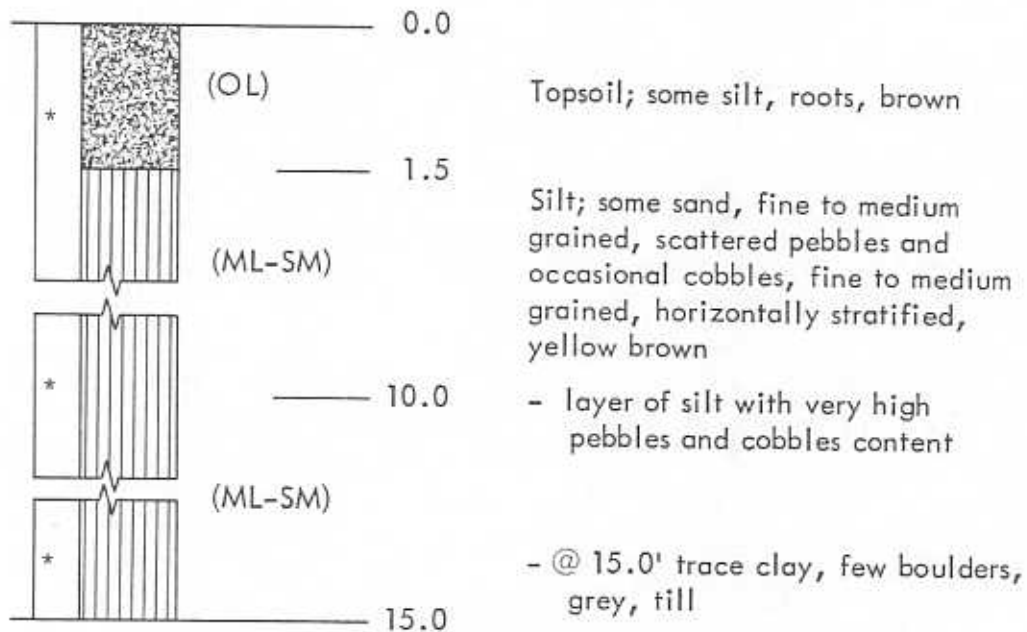


Description of the Exposure

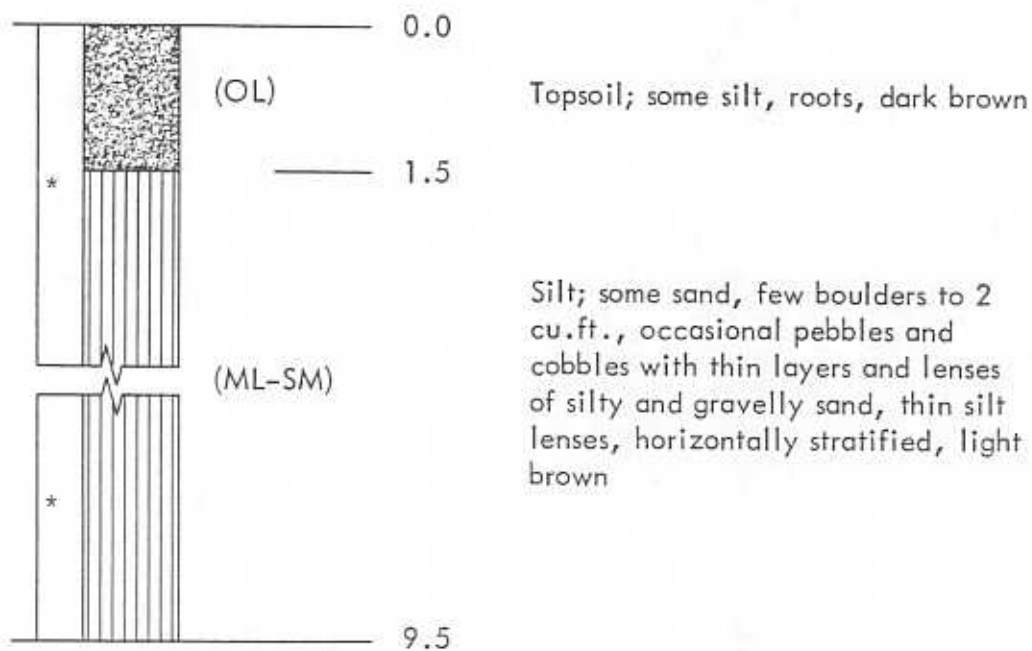
1. Silts and Sands; stratified, very fine grained.
2. Silt, Sand, Clay Mixture; scattered pebbles and cobbles, grey. (TILL).

DETAILED TEST PIT LOG

FS 11/TP 1



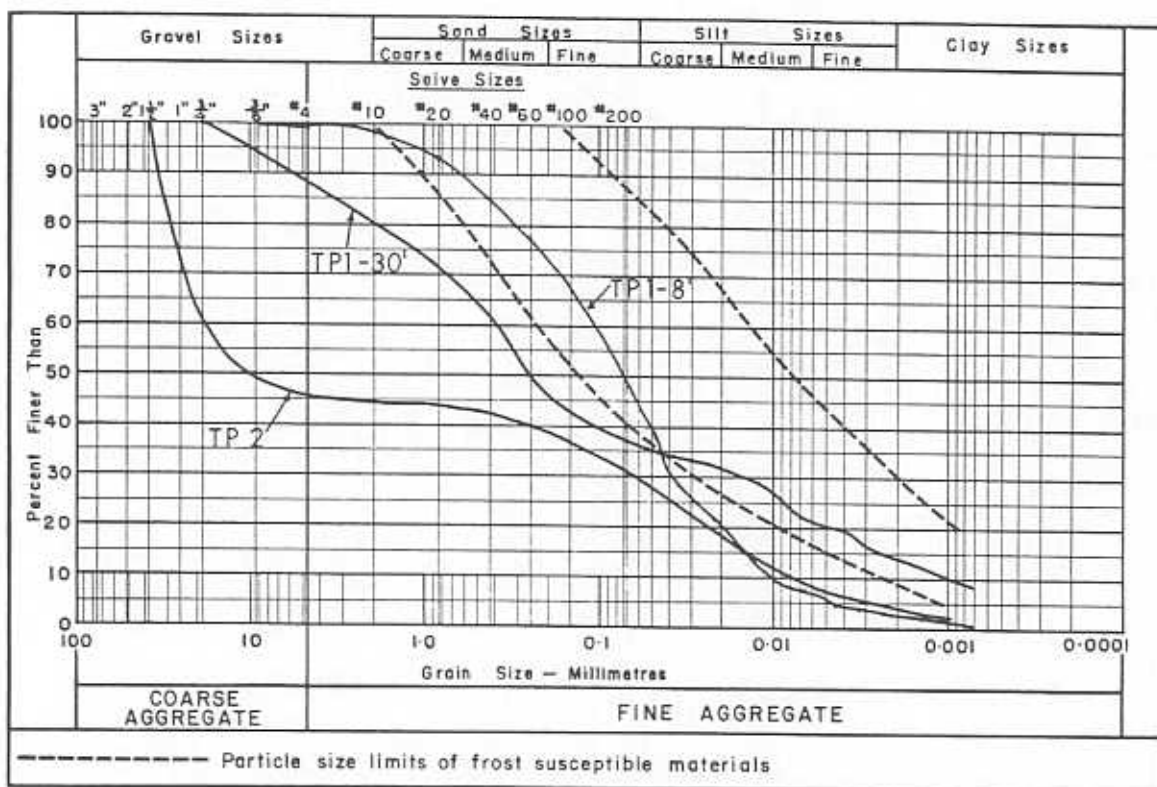
FS 11/TP 2



SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 11/TP 1	FS 11/TP 1	FS 11/TP 2
Sample Depth (Feet):	8.0	30.0	8.0
Moisture Content (%):	-	-	-
Ice Content (%):	-	-	-
Organic Content (%):	3.8	-	4.9

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:

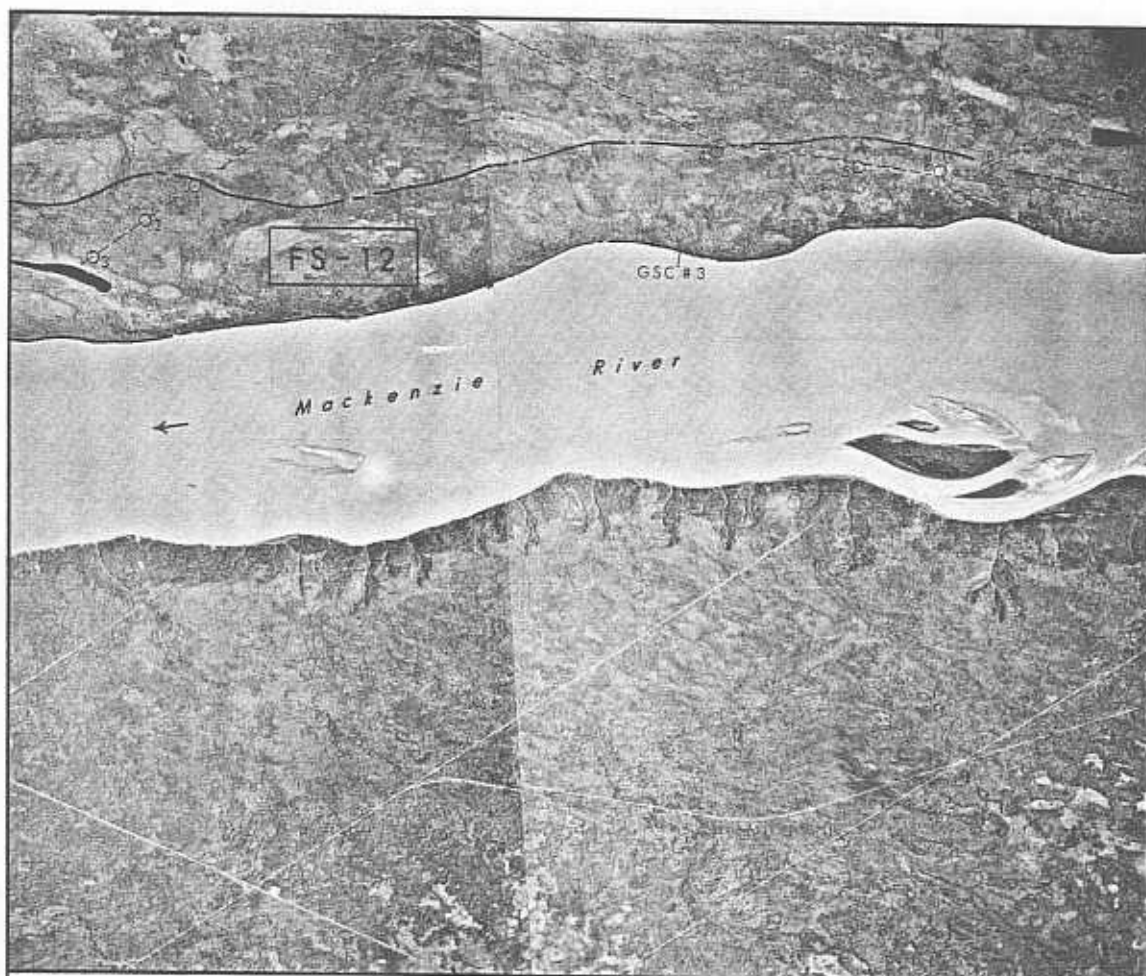
SITE NO. FS 12

Located approximately 2 miles north of Fort Simpson along the north bank of the Mackenzie River, Site FS 12 consists of glaciofluvial outwash material.

Type of Material: Gravel; coarse sand.

Estimated Volume: Not established.

Assessment: Isolated larger pockets of sandy, coarse gravel suitable for fair to good quality general fill material are irregularly scattered throughout the site and may be selectively exploited. Possible future development of such pockets requires additional field investigation.



LEGEND

- | | |
|------------------------------------|--------------------------------|
| ----- All weather road | Required access |
| ----- Existing trails and cutlines | --- Site limit |
| Proposed Gas Pipeline | --- Proposed Mackenzie Highway |
| ⊙ DH Drill Hole | ⊕ TP Test Pit |

Airphoto No. A22934/52 & 53

Approximate scale: 1" = 3,600'



ENVIRONMENT

Site FS 12 is located approximately 2 miles north of Fort Simpson along the north bank of the Mackenzie River and consists of discontinuous glaciofluvial outwash material sandwiched between fine grained fluvial sediments and morainal till. The site area extends in a westerly direction beyond the limits of the 10 mile radius of the Fort Simpson Study Area. The width of Site FS 12 ranges from 1000 to 4000 feet. The terrain, which is pitted with numerous muskeg bogs is rolling to hummocky, and rises some 40 to 60 feet above the Mackenzie River water level.

The material at Site FS 12 consists of coarse glaciofluvial gravels with sand, silt and occasional clay layers. These deposits are mantled by a surficial layer of fluvial sand and silt with a thickness ranging from 6 feet to in excess of 10 feet. Granular deposits apparently represent erosional remnants of glaciofluvial outwash plain or channel filling up the depressions within the underlying glacial till sheet. The site area is generally, densely wooded with stands of spruce, birch and poplar. The poorly drained muskeg bog areas are characterized by sparse growths of tamarack.

There are no known critical wildlife areas in the immediate vicinity of the site although the area is occasionally hunted and trapped by residents of Fort Simpson.

Surficial drainage is relatively good along the Mackenzie River bank while the northern boundary of the site area as well as the depressional portions of the terrain exhibit poor drainage.

There is no direct existing access to the site area although the CNT pole line is located along the eastern periphery of the site. Any future development of this site will entail a crossing of the Mackenzie River.

DEVELOPMENT

Although detailed airphoto interpretation, preliminary field reconnaissance and evaluation of existing Geological Survey of Canada data indicated very promising potential for granular materials, the results of the winter drilling program carried out on Site FS 12 showed a predominance of stratified gravelly sands, silts and clays exhibiting a "washed till-like" texture. Only drill hole DH-1, located at the northwestern extremity of Site FS 12, encountered thin layers of gravel. A larger pocket, some 500 feet long and about 4 feet thick, of well graded, coarse gravel is exposed in the steep river bank at the point marked as GSC 3 on the airphoto. As noted on the preceding Site Description airphoto (ref. page 12-1), the drill holes were conducted on reasonably accessible existing trails and seismic cutlines which traverse a relatively widespread area of Site FS 12.

Therefore, based on the results and assessment of the investigations conducted to date, the immediate development of Site FS 12 is not recommended.

However, it is considered that the likelihood of large isolated pockets of fair quality granular materials within the outlined limits of Site FS 12 is relatively high. Since the

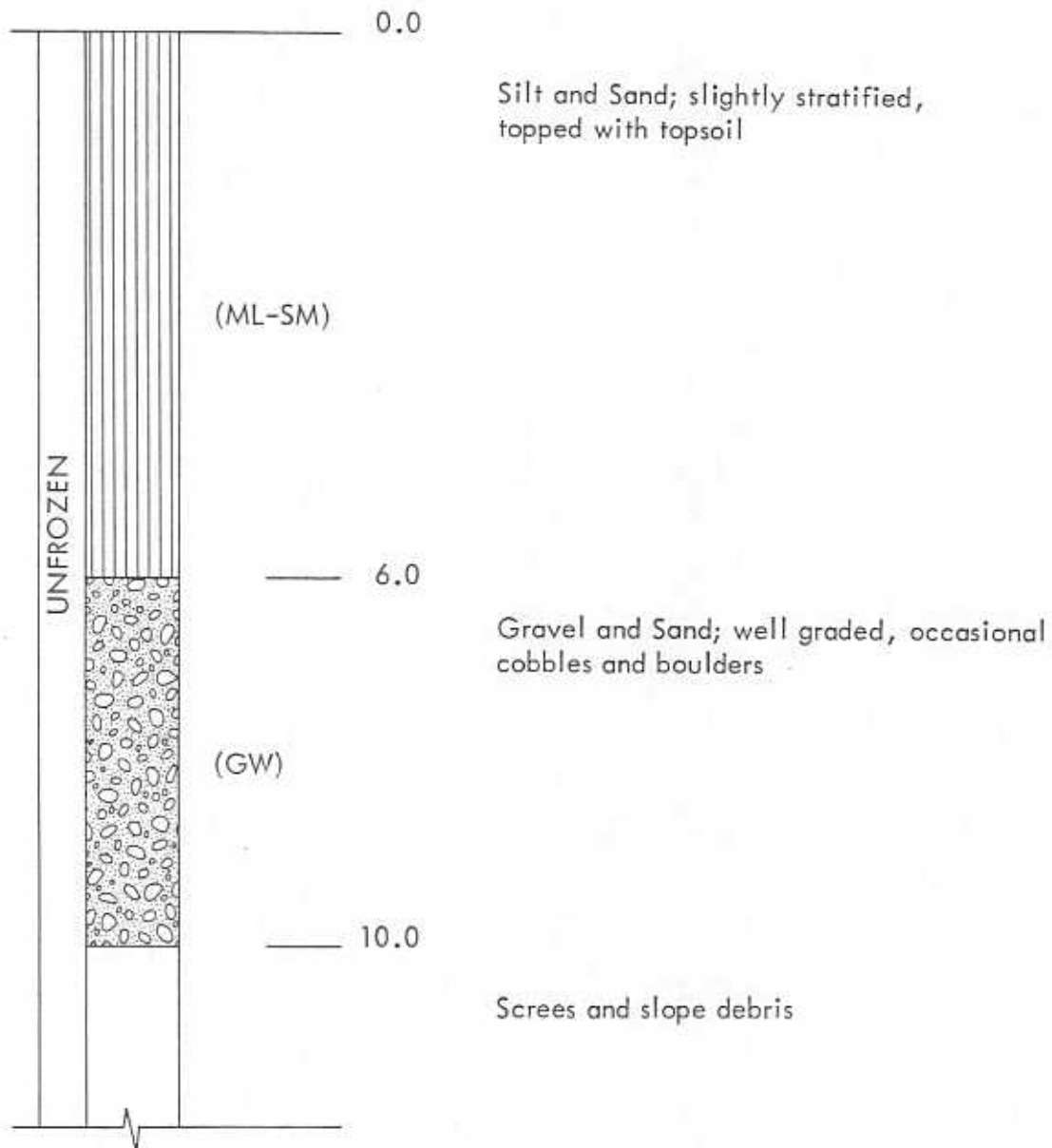


surficial texture of the site area is well masked by heavy tree and understory growth, a detailed sub-surface investigation consisting of systematically gridding the site area by drill holes or hand dug test pits would be required to search, locate and delineate the extent of these gravel pockets.

If Site FS 12 is considered for development of granular materials, subject to the findings of a more detailed site investigation program, then operating procedures which would be compatible with existing land use regulations would have to be employed in the development of borrow pit areas.

DETAILED TEST PIT LOG

FS 12/GSC-#3






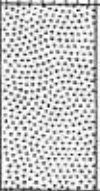


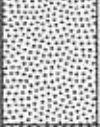


Note: Description of outcrop showing upper portions of the soil profile, located on the northern bank of the Mackenzie River. (ref. Site airphoto, page 11-1). Reported by G. Minning of the Geological Surveys of Canada.

DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-1

DATE: FEB. 18, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL <input type="checkbox"/> AIR <input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:			

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	1.5 TOPSOIL: some silt, little sand, organic, brown		Vx	M		0
2		ML-SM	SILT: some sand, occasional pebbles, brown					2
4								4
6								6
8		SM-GM	7.0 SAND AND SILT: some gravel, frequent silt pockets, predominantly subangular from 1/16" to 3/4", greyish brown (TILL)		Nf	L		8
10		GM-GW	10.0 SAND AND GRAVEL: little silt pockets, trace clay, coarse to fine grained, well graded, maximum 3/4", greyish brown, damp					10
12								12
14		SM	13.0 SILT AND SAND: occasional pebbles, grey				M GS P	14
16			15.0 BEDROCK: shale, weathered, grey					16
18								18
20			20.0 TOTAL DEPTH 20.0'					20

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"





DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-2

DATE: FEB. 18, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR ☐ AIR REVERSE ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	TOPSOIL: organic, little silt, roots, fibrous, dark brown		Vs	M		0
1		ML-SM	SILT: little sand, trace clay, occasional pebbles, greyish brown		Vx	M		1
2								2
3								3
4								4
5								5
6								6
7								7
8								8
9								9
10				UF				10
			10.0 TOTAL DEPTH 10.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG




SITE NO. FS 12

HOLE NO. DH-3

DATE: FEB. 18, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR ☐ AIR REVERSE ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS		ICE EST'D CONT.	SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS			
0		OL	1.0 TOPSOIL: organic, little silt, roots, fibrous, dark brown		Vs	M		0
2		ML						2
4			SILT: some sand, occasional pebbles to 1" size, brown		Vs	M		4
6								6
8								8
10			- few coal specks at 10.0'	UF			MC	10
11.0			TOTAL DEPTH 11.0'					11.0
12								12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY






PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-4

DATE: FEB. 18, 1973 LOGGED BY: ☒ PEMCAN ☐
 DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	PEAT: organic, fibrous, muskeg					0
2		ML	SILT: some sand, trace clay, light brown		Nbn	L		2
4								4
6								6
8		ML-CL	SILT, CLAY, SAND MIXTURE: rust and coal specks, frequent pebbles to 1" size, occasional boulders (TILL)		Nf	L		8
10								10
12								12
13.0			TOTAL DEPTH 13.0'					14

GOVERNMENT OF CANADA
 DEPARTMENT OF INDIAN AFFAIRS
 AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-5

DATE: FEB. 18, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒

AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER: ☐

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			ICE CONT.	SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D			
0									0
3		ML-SM	SILT: some sand and clay with gravel pockets and thin layers, few pebbles, occasional cobbles and boulders, medium brown		Nbn	L-M			3
6			5.0						6
9									9
12			11.0	UF					12
15		SM-SW	SAND, SILT, GRAVEL MIXTURE: trace clay, pebbles to 1½", occasional boulders, medium brown, very wet (TILL)						15
18								GS P	18
21									21
24			22.0						24
27			TOTAL DEPTH 22.0'						27
30									30

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-6

DATE:		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>					
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR <input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:					

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	PEAT: organic, fibrous, muskeg		Nbn	L		0
3		ML-SM	SILT: some sand and clay, with gravel in pockets and thin layers, few pebbles to 1" size, occasional cobbles and boulders, brown - becoming medium grey at 7.0'		Nf	L		3
6								6
9								9
12								12
15								15
18								18
21								21
24								24
			TOTAL DEPTH 23.0'					




GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	


DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-7

DATE: FEB. 18, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	PEAT: organic, fibrous, muskeg		Nbn	L		0
3		ML	SILT: some sand and clay, sand lenses, few pebbles, medium brown - becoming medium grey at 9.0'		Vx	L		3
6				6				
9				9				
12								12
15								15
18								18
21								21
22.0			TOTAL DEPTH 22.0'					22.0
24								24

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	 PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	

DETAILED DRILL HOLE LOG



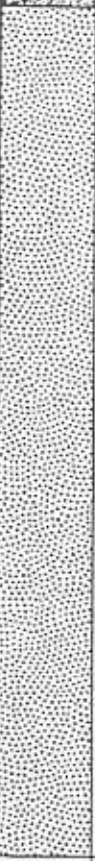

SITE NO. FS 12

HOLE NO. DH-8

DATE: FEB. 18, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	1.5 TOPSOIL: some silt and organic, frequent pebbles, brown		Nbn	L		0
3		SM-SW	SAND: some silt and clay, little gravel, fine to coarse grained, occasional pebbles and cobbles to 1/2", medium brown		Nbn	L		3
6								6
9								9
12								12
15				UF			GS MC	15
18								18
21								21
22.0			TOTAL DEPTH 22.0'					22.0
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"





DETAILED DRILL HOLE LOG

SITE NO. FS 12

HOLE NO. DH-9

DATE: FEB. 18, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		Pt	1.5 PEAT: organic, fibrous, muskeg, dark brown		Vs	M		0
3		ML-SM	SILT: some sand and clay, gravel in pockets and thin layers, few pebbles (3/4") and cobbles, occasional boulders, medium grey		Vx	L		3
6								6
9								9
12								12
15				UF				15
18								18
21								21
22.0			TOTAL DEPTH 22.0'					22.0
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

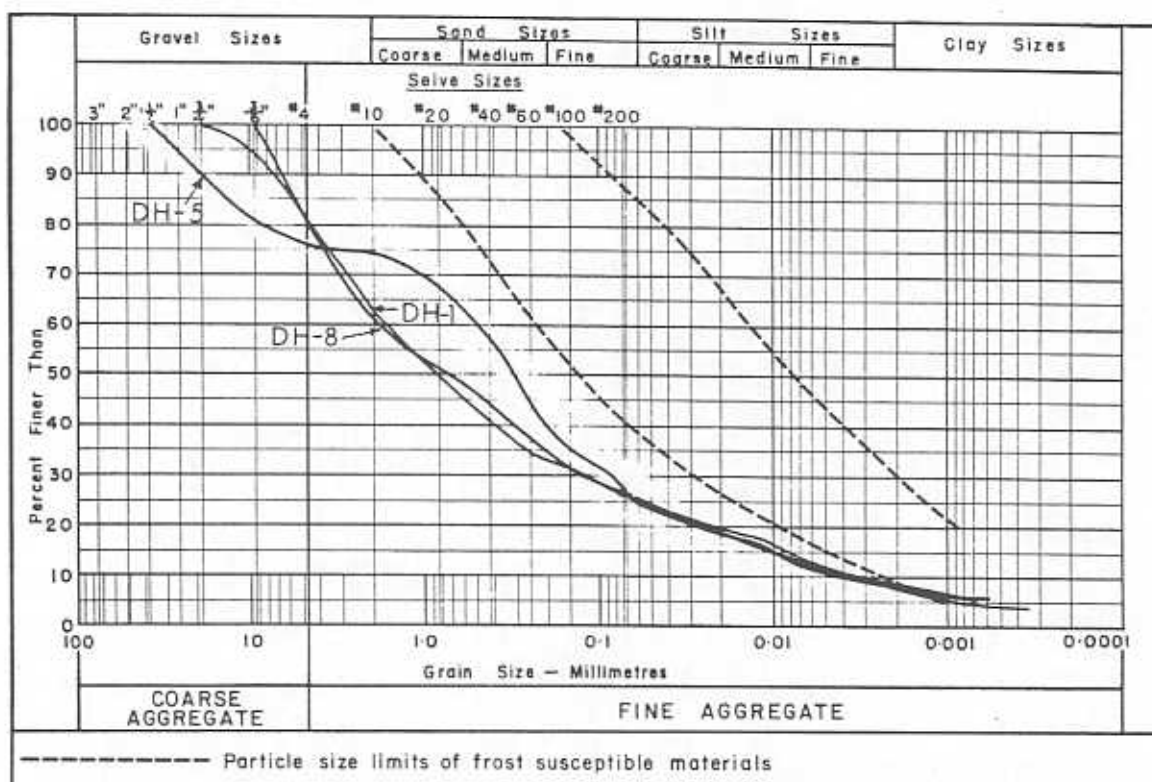


PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 12/DH 1	FS 12/DH 5	FS 12/DH 8
Sample Depth (Feet):	12.0	17.0	19.0-20.0
Moisture Content (%):	5.7	-	6.3
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



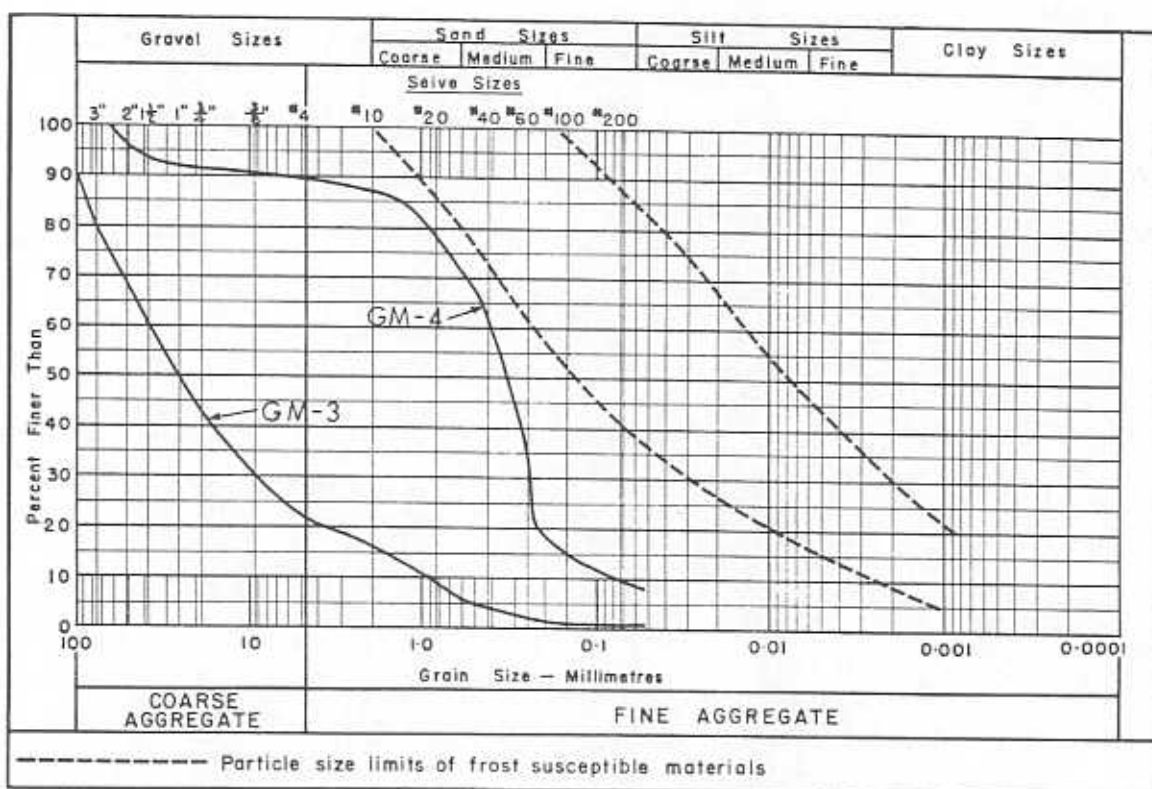
PETROGRAPHIC ANALYSIS: (FS 12/DH 5 at 17.0')

Limestone and dolomite (sound)	45.8%
Quartzite	40.1%
Igneous	11.5%
Deleterious slate and ferruginous sandstone	2.6%

SUMMARY OF LABORATORY TEST DATA

Sample Location:	GSC #GM-3	GSC #GM-4	FS 12/DH-3
Sample Depth (Feet):	-	-	10.0
Moisture Content (%):	-	-	9.3
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS: (FS 12/DH 5 at 12.0')

Quartzite	28.4%
Limestone and dolomite (sound)	26.8%
Igneous	11.5%
Deleterious slate, siltstone and clay lumps	33.3%

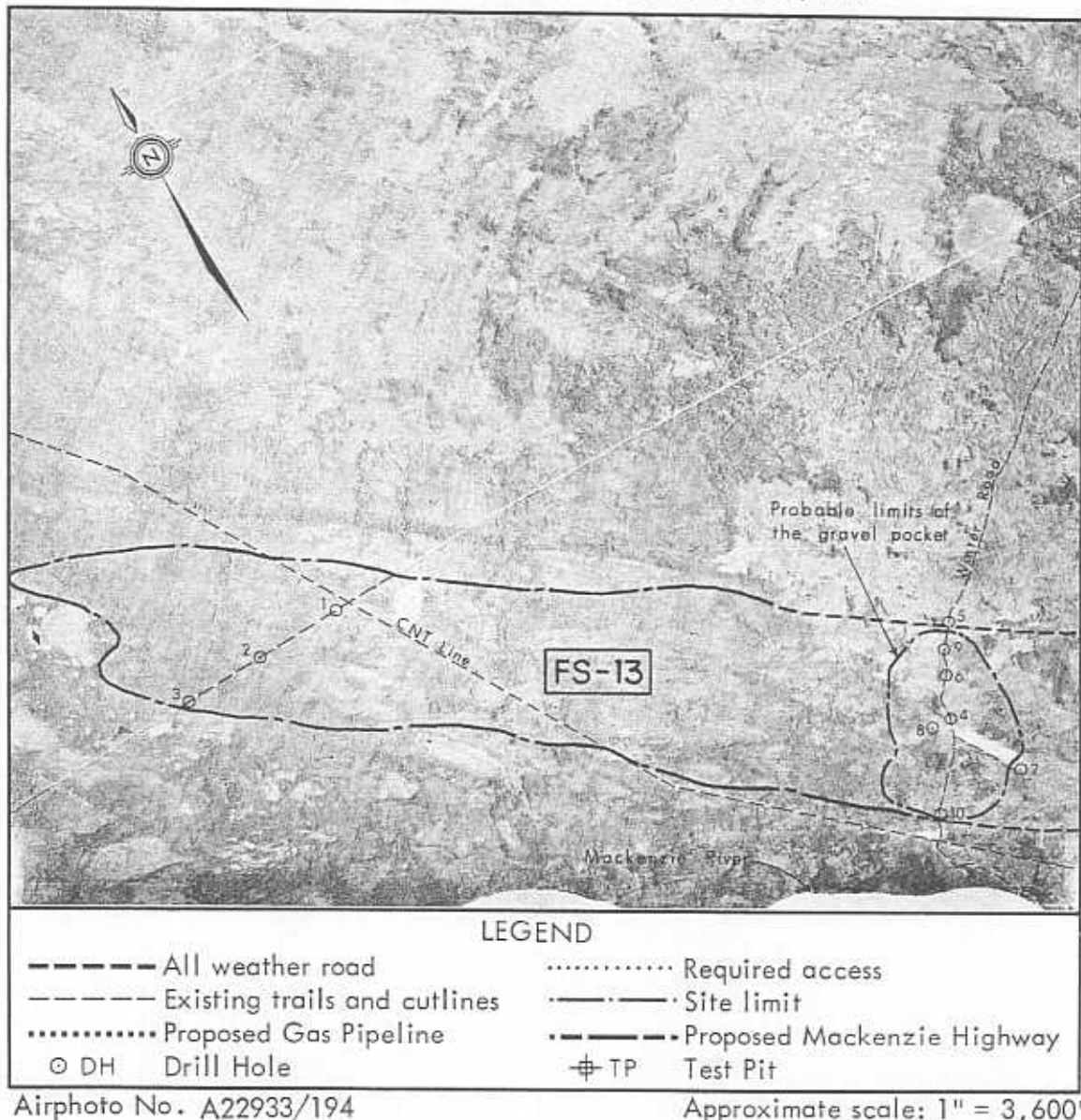
SITE NO. FS 13

Located $2\frac{1}{2}$ miles north of Fort Simpson and about $\frac{1}{2}$ mile inland from the north bank of the Mackenzie River, Site FS 13 consists of a morainal deposit, which is predominantly glacial till with large isolated pockets of granular material.

Type of Material: Gravel; little sand, trace silt, medium grained.

Estimated Volume: 1,500,000 cubic yards.

Assessment: Good quality material suitable for various construction requirements such as road bases, utility backfill, building pads, base course, and possible concrete aggregates. Site FS 13 is recommended for development.





ENVIRONMENT

Site FS 13 is located approximately $2\frac{1}{2}$ miles north of Fort Simpson and $\frac{1}{2}$ mile inland from the north bank of the Mackenzie River. The site area is approximately 6 miles in length and 1 mile in width. Site FS 13 represents the only large exposure of morainal deposits in the Study Area and consists of a coarse glacial till deposit, which is a heterogeneous mixture of silt, sand and clay, interspersed with scattered pebbles and cobbles. Erosional processes associated with melt waters and with the development of the Mackenzie River channel have removed the majority of the glaciolacustrine sediments from the glacial till. A large isolated pocket of medium grained, poor to well graded gravels with a little silt was encountered in the glacial till formation.

The general surficial drainage over the site area and adjacent terrain is fair towards the south into the Mackenzie River valley. The eastern portion of the site exhibits poorer drainage conditions and is pocketed with muskeg bogs. The site area is characterized by growths of spruce, birch and poplar.

There are no known critical wildlife areas in the immediate vicinity of the site.

The access to this site involves the crossing of the Mackenzie River and utilization of existing seismic cutlines, CNT pole line right-of-way and the winter road. In general, the overall access to this site area is poor.

DEVELOPMENT

The information obtained from the exploratory drill holes carried out during the winter field program has outlined the following conditions relative to the quality and quantity of available granular materials within Site FS 13.

- The three drill holes, DH-1 to DH-3 inclusive, carried out along an existing seismic line in the northwestern portion of Site FS 13 showed the sub-surface material to consist of a silty glacial till to depths of 22 feet or more.
- The group of test holes, DH-4 to DH-10 inclusive, in the southeastern portion of Site FS 13 outlined a sizeable pocket of medium grained, poor to well graded gravel with an areal extent of approximately 4000 feet in length and 2000 feet in width.
- The gravel pocket varies in thickness from 5 feet to in excess of 15 feet with an average overburden thickness of about 3 feet. An estimated quantity of 1.5 million cubic yards of gravel is potentially available from this pocket.
- The gravels are considered suitable for utilization in general backfill, road bases, base course aggregates, airport runway bases and building pads. Furthermore, the gravels from this pocket can be considered for production of concrete aggregates if proper crushing, screening and washing operations are implemented.



- The drill holes indicated a relatively high ground water table in the gravel stratum at a depth varying from 3 to 11 feet below existing ground surface.

In view of critical scarcity of good quality granular materials in this Study Area, Site FS 13 may be considered as a major and primary source of granular materials for the community of Fort Simpson. The following operational guidelines should be considered in the development of borrow pit areas at FS 13.

- The existing tree growth and related vegetation should be cleared and removed in accordance with current land use guidelines.
- The layer of organic peat, topsoil and silt should be stripped, removed and stockpiled adjacent to the borrow pit areas in designated locations.
- In view of the required Mackenzie River crossing, exploitation of granular materials during both the winter and summer months should be considered. Such procedures will entail barge hauling during the summer months and truck haul utilizing an ice bridge during the winter season. Transportation of material from this site during spring breakup and winter freezeup periods will have to be curtailed.
- The seasonal nature of material exploitation from Site FS 13 will necessitate the need for holding stockpiles for various aggregate types to ensure a continual supply of material.
- The short access road from the south end of the site area to the north Mackenzie River bank should be upgraded to an all weather status.
- Generally, dozers, overhead loaders, backhoes and standard ripping equipment should be adequate for the removal of material from this site.
- Stands of natural growth should be retained between borrow pit areas to promote natural regeneration of vegetation after abandonment of the site area.
- The "winter road" which passes through the centre of the large gravel deposit provides natural prime access for the overall development of borrow pit areas at this site.
- In view of the relatively high ground water table, predraining of borrow pit areas may have to be considered during various stages of development. It is suggested that the borrow pit is opened at the southern extremity of the gravel pocket and worked gradually northward. This will facilitate draining of the area into the Mackenzie River system.



ABANDONMENT AND REHABILITATION

Abandonment and rehabilitation procedures should include:

- Recontouring of the borrow pit areas to provide general drainage that is compatible with the natural drainage of the adjacent terrain.
- Replacing stockpiled surficial waste material and organic topsoil onto the abandoned recontoured borrow pit areas.
- Reseeding of the recontoured borrow pit areas should be considered in areas that may pose erosional problems. At these locations, the artificial reseeding of annuals and perennials will result in a semi-permanent cover growth prior to the reestablishment of native vegetation growth.

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-1

DATE: FEB. 18, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		Pt	PEAT: organic, fibrous, muskeg, dark brown					0
3					Vr	M-H		3
6		ML-CI	SILT: some clay, little sand, trace rust and coal specks, occas- ional pebbles to 1", light brown (TILL)					6
9			- from 9.0' frequent pebbles, medium grey					9
12					Nbn	L		12
15								15
18								18
21								21
22.0			TOTAL DEPTH 22.0'					22.0
24								24

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-2

DATE: FEB. 18, 1973

LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0								0
1		Pt	PEAT: organic, trace silt, fibrous, dark brown					1
2								2
3		ML	SILT: some clay and sand, pebbles to 1/8" size, greyish brown (TILL)		Vx	L		3
4								4
5								5
6								6
7								7
8								8
9							MC	9
10								10

10.0 TOTAL DEPTH 10.0'

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-3

DATE: FEB. 18, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR <input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	TOPSOIL: organic, little silt, few boulders, dark brown					0
1			1.0					1
2								2
3		ML	SILT: little sand, occasional pebbles to 1" size, brown (TILL)					3
4								4
5					Vx	L		5
6			- some clay from 6.0'					6
7								7
8								8
9					Nbn	L	MC	9
10			10.0 TOTAL DEPTH 10.0'					10

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-4

DATE: FEB. 18, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL <input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:			

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		Pt	PEAT: organic, fibrous, muskeg, black		VS	M-H		0
3			3					
5.0								
6		GM-GP	GRAVEL: little sand, trace silt, pebbles to 3/4" size, occasional boulders, poorly graded, brown	UF			GS P M	6
9			9					
12			12					
15			15					
18			18					
20.0		GM-GW	<div style="border: 1px solid black; padding: 5px; margin: 5px 0;"> - some sand and silt, trace clay, fine to coarse grained, well graded, 1 1/2" maximum size </div>				GS M	20.0
21.0								21.0
			TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

PEMCAN SERVICES "72"

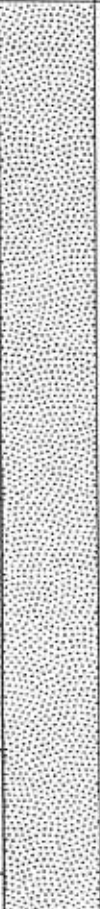

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-5

DATE: FEB. 18, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		SM-SW	SAND AND SILT: some gravel, trace clay, fine to coarse grained, well graded, frequent pebbles to 3/4" size, scattered boulders, brown (TILL) ----- becoming medium grey from 9.0'		Vs	M		0
3								3
6					Nbn	L	GS MC	6
9								9
12								12
15								15
18								18
21								21
22.0								
24								24
			TOTAL DEPTH 22.0'					

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-6

DATE: FEB. 20, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL <input type="checkbox"/> AIR <input type="checkbox"/> AIR REVERSE <input type="checkbox"/> CIRCULATION <input type="checkbox"/> OTHER:			

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)					
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.							
0	[Vertical line pattern]	ML	SILT: little sand, brown	[Cross-hatch pattern]	Vx	L-M		0					
2								2					
3.0													
4	[Vertical line pattern]	ML-GM	- some gravel, pebbles to 3" size, occasional cobbles, brown to light brown, dry	[Cross-hatch pattern]	Nf	L		4					
6									6				
6.0													
8	[Circular pattern]	GM-GP	GRAVEL: some sand, little silt, medium to coarse grained, poorly graded, pebbles 1/16" to 2 1/2" size, subangular to subrounded, greyish brown	[Cross-hatch pattern]				8					
10													
11.0													
12	[Circular pattern]		- little sand, trace clay, grey, from 13.0' to 17.0'	[Cross-hatch pattern]				12					
14													
16													
17.0	[Vertical line pattern]	ML	SILT: some clay, trace sand, occasional pebbles, dark grey (TILL)	[Cross-hatch pattern]				17.0					
18.0													
18.0													
TOTAL DEPTH 18.0'								20					

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-7

DATE: FEB. 20, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>					
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:					
DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS	ICE CONDITIONS	SAMPLE TYPE	DEPTH (feet)
0		Pt	PEAT: organic, fibrous		Vs-Vx	M	0
2							2
3.0							
4							4
6							6
8		SM-SP	SAND: trace silt, medium grained, poorly graded, grey, damp	UF			8
10							10
12							12
13.0							
14							14
16							16
18							18
20						20	
			TOTAL DEPTH 18.0				

DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-8

DATE: FEB. 20, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND & ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT		
0		Pt	PEAT: very organic, fibrous, dark brown		Vs	M		0
1								1
2								2
2.5 ---								
3		GM-GW	3.0 - layer of silt, with some sand and gravel from 2.5' to 3.5'	UF			GS M P	3
3.5								4
4			4					
5								5
6								6
7								7
8								8
9								9
10			TOTAL DEPTH 10.0'					10

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY







PEMCAN SERVICES "72"


DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-9

DATE: FEB. 20, 1973		LOGGED BY: <input checked="" type="checkbox"/> PEMCAN <input type="checkbox"/>	
DRILLING METHOD: <input checked="" type="checkbox"/> CONVENTIONAL		<input type="checkbox"/> AIR REVERSE CIRCULATION <input type="checkbox"/> OTHER:	

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			ICE CONT.	SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D			
0		OL	TOPSOIL: some silt, little organic, dark brown		Vx	M			0
1.5		SM	SILT: little sand, trace gravel, occasional cobbles, brown		Nf	L			2
3.0		GM-GW	GRAVEL: some sand, medium to coarse grained, well graded, predominantly limestone and quartzite, occasional cobbles, greyish brown	UF					4
6									6
8.0		MH	SILT: some clay, trace sand, occasional pebbles, dark grey (TILL)						8
10									10
11.0			TOTAL DEPTH 11.0'						12

GOVERNMENT OF CANADA DEPARTMENT OF INDIAN AFFAIRS AND NORTHERN DEVELOPMENT	 PEMCAN SERVICES "72"
GRANULAR MATERIALS INVENTORY	



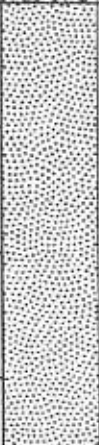


DETAILED DRILL HOLE LOG

SITE NO. FS 13

HOLE NO. DH-10

DATE: FEB. 1, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	ICE EST'D CONT.		
0		OL	TOPSOIL: organic, little silt, roots, fibrous, dark brown		Nf	L	GS	0
3		GM-GW	GRAVEL: some sand, trace silt, medium to coarse grained, predom- inantly limestone and quartzite pebbles to 2", rounded to sub- angular, greyish brown					3
6			6					
9		GM-GP	SAND: some silt, little gravel, trace clay, fine grained, poorly graded, occasional pebbles, dark grey (TILL)	Vx	L			9
12			- becoming moist at 16.0'					12
15								15
18		GM-GP	GRAVEL: little sand and silt, poorly graded, rounded to sub- angular pebbles to 1" in size, wet, grey	UF				18
21			TOTAL DEPTH 21.0'					21
24								24

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY

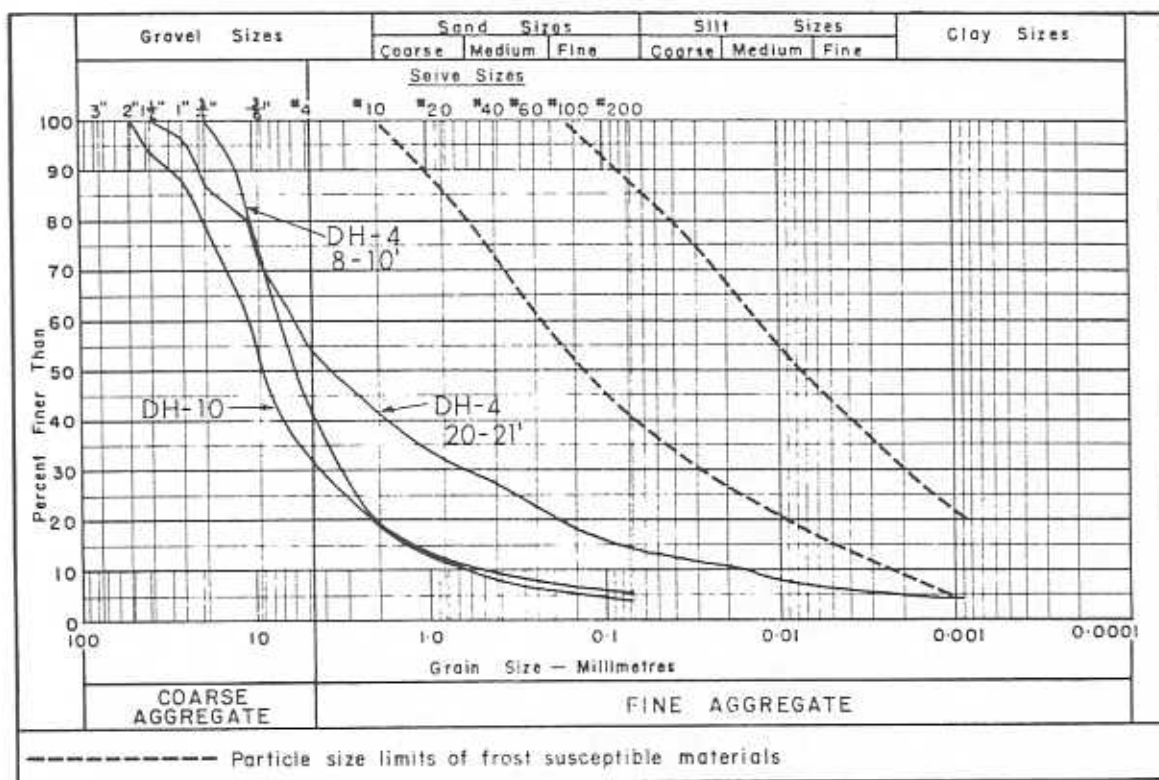


PEMCAN SERVICES "72"

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 13/DH 4	FS 13/DH 4	FS 13/DH 10
Sample Depth (Feet):	8.0-10.0	20.0 21.0	3.0-5.0
Moisture Content (%):	5.5	12.1	-
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



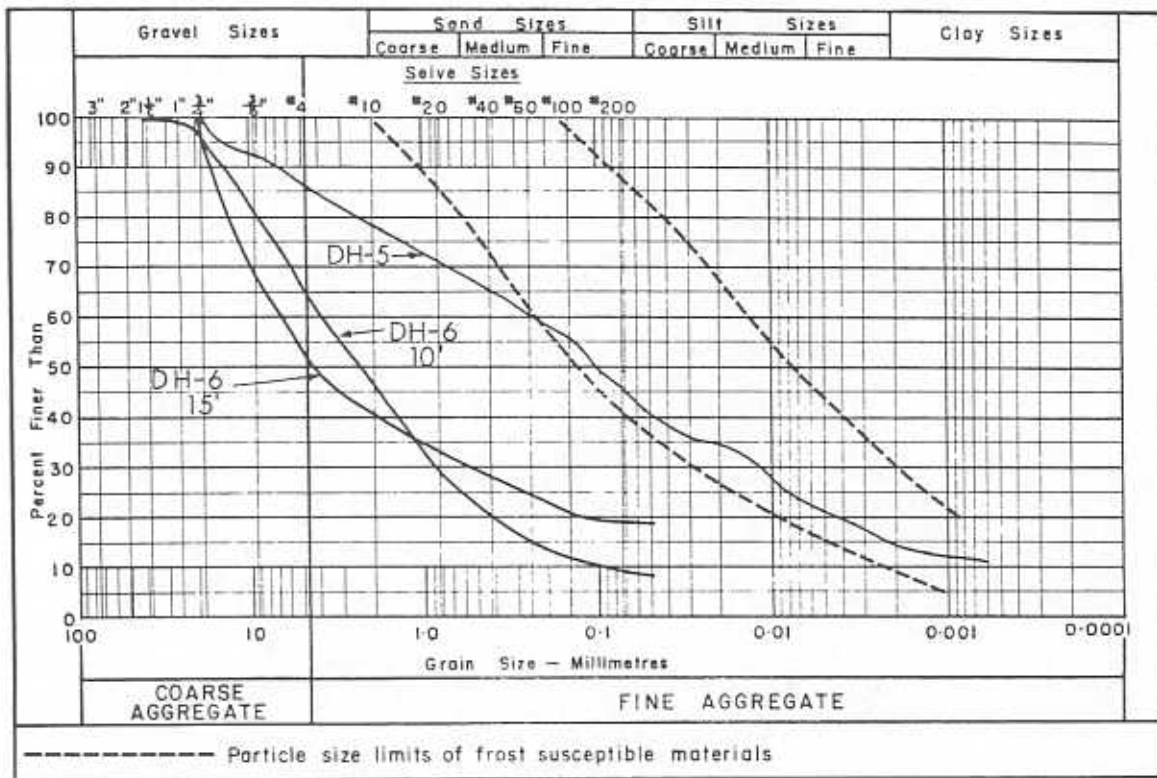
PETROGRAPHIC ANALYSIS: (FS 13/DH 4 at 8.0' - 10.0')

Quartzite	41.4%
Igneous rock	22.4%
Limestone and dolomite (sound)	26.8%
Chert	2.7%
Deleterious shale, siltstone and sandstone	6.7%

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 13/DH 5	FS 13/DH 6	FS 13/DH 6
Sample Depth (Feet):	9.0-10.0	10.0	15.0
Moisture Content (%):	7.5	6.9	5.4
Ice Content (%):	-	-	-
Organic Content (%):	-	-	-

GRAIN SIZE DISTRIBUTION:



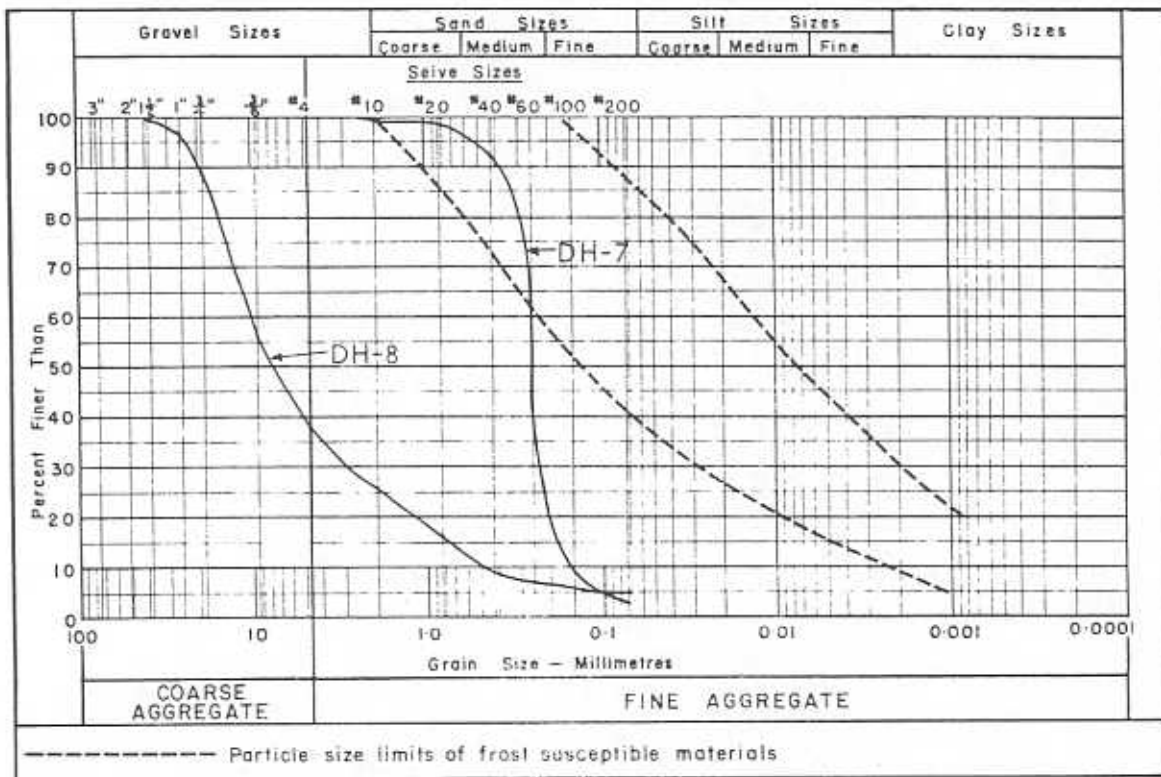
PETROGRAPHIC ANALYSIS: (FS 13/DH 6 at 15.0')

Quartzite	52.6%
Limestone and dolomite (sound)	27.9%
Igneous	15.7%
Deleterious shale, siltstone and sandstone	3.8%

SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 13/DH 7	FS 13/DH 8
Sample Depth (Feet):	10.0	7.0
Moisture Content (%):	18.4	7.2
Ice Content (%):	-	-
Organic Content (%):	-	-

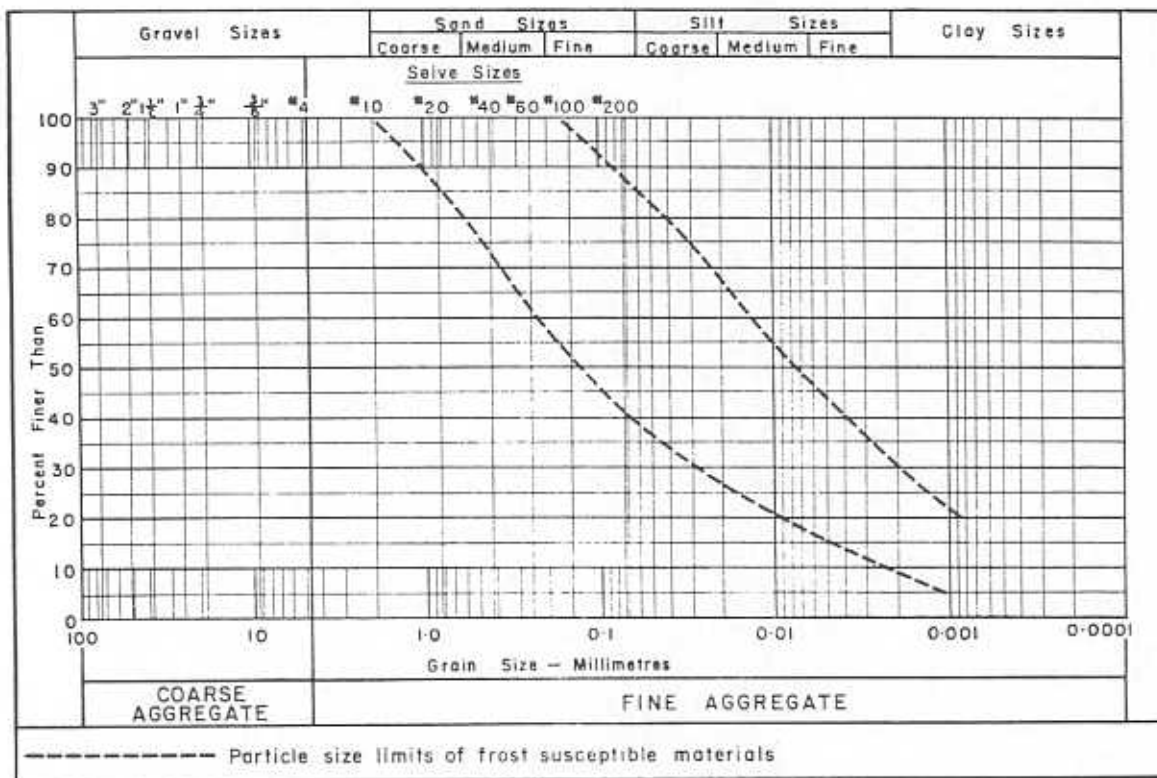
GRAIN SIZE DISTRIBUTION:



SUMMARY OF LABORATORY TEST DATA

Sample Location:	FS 13/DH 2	FS 13 DH 3
Sample Depth (Feet):	8.0	8.0
Moisture Content (%):	16.4	19.0
Ice Content (%):	-	-
Organic Content (%):	-	-

GRAIN SIZE DISTRIBUTION:



PETROGRAPHIC ANALYSIS:



PEMCAN SERVICES

GLOSSARY



GLOSSARY

Alluvium	Stream deposits of comparatively recent time, does not include subaqueous deposits of seas and lakes.
Anhydrite	A mineral, anhydrous calcium sulfate, CaSO_4 . Orthorhombic, commonly massive in evaporite beds.
Annuals	A plant that lives only one year or season.
Autoclave Expansion	Laboratory test procedure as designated by ASTM-C151-63 for determination of expansive qualities for all types of Portland Cement and aggregate reactions.
Berm	A horizontal portion of an earth embankment to ensure greater stability of a long slope.
Biotic	Of or pertaining to life or mode of living.
Boreal	Pertaining to the North.
Boulder	A rock fragment larger than 8" in diameter.
Cartographic	Pertaining to a map. In geology a cartographic unit is a rock or group of rocks that is shown on a geologic map by a single color or pattern.
Clay	Soil particles smaller than 0.002 mm. in diameter.
Cobble	A rock fragment between 3" and 8" in diameter.
Colluvium	A general term applied to loose and incoherent deposits, usually at the foot of a slope or cliff and brought there chiefly by gravity.
Conglomerate	Rounded water-worn fragments of rocks or pebbles, cemented together by another mineral substance which may be of a siliceous or argillaceous nature.
Cretaceous	The third and latest of the periods included in the Mesozoic era; also the system of strata deposited in the Cretaceous period.
Crystalline	Of or pertaining to the nature of a crystal; having regular molecular structure.
Delta Deposits	An alluvial deposit, usually triangular, at the mouth of a river.



Devonian	In the ordinarily accepted classification, the fourth in order of age of periods, comprised in the Paleozoic era, following the Silurian and succeeded by the Mississippian. Also the system of strata deposited at that time.
Dolomite	A mineral, $\text{CaMg}(\text{CO}_3)_2$, commonly with some iron replacing magnesium; a common rock-forming mineral.
Ecology	The study of the mutual relationships between organisms and their environments.
Eolian	Deposits which are due to the transporting action of the wind.
Escarpment	The steep face of a ridge of high land.
Esker	A narrow ridge of gravelly or sandy drift, deposited by a stream in association with glacier ice.
Excess Ice	Ice in excess of the fraction that would be retained as water in the soil voids upon thawing.
Fauna	The animals collectively of any given age or region.
Flood Plain	That portion of a river valley, adjacent to the river channel, which is built of sediments during the present regime of the stream and which is covered with water when the river overflows its banks at flood stages.
Flora	The plants collectively of any given formation, age or region.
Fossiliferous	Containing organic remains.
Geomorphology	The study of landscape and of the geologic forces that produce it. It is the dynamic geology of the face of the earth. It concerns that branch of physical geography dealing with the origin and development of the earth's surface; features (landforms) and the history of geologic changes through the interpretation of topographic forms.
Glacial Till	Non sorted, non stratified sediment carried or deposited by a glacier.
Glaciofluvial	Fluvioglacial. Pertaining to streams flowing from glaciers or to the deposits made by such streams.



Glaciolacustrine	Pertaining to glacial-lake conditions, as in glaciolacustrine deposits.
Gravel	Soil particles smaller than 3" in diameter and larger than 2.0 mm in diameter.
Ground Moraine	A moraine with low relief, devoid of transverse linear elements.
Gypsum	Alabaster. Selenite. Satin Spar. A mineral, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. Monoclinic. A common mineral of evaporites.
Heterogeneous	Differing in kind; having unlike qualities; possessed of different characteristics; opposed to homogeneous.
Hummock	A mound or knoll.
Icing	Mass of surface ice formed during winter by successive freezing of sheets of water seeping from the ground, a river or spring.
Kames	A mound composed chiefly of gravel or sand, whose form is the result of original deposition modified by settling during the melting of glacier ice against or upon which the sediment is accumulated.
Karst	A limestone plateau marked by sinkholes and underlain by cavernous carbonate rocks having subterranean drainage channelways that largely follow solution-widened joints, faults, and bedding planes.
Lacustrine	Produced or belonging to lakes.
Lichen	Any of a group of low growing plant formations composed of a certain fungi growing close together with certain algae.
Massif	A French term adopted in geology and physical geography for a mountainous mass or group of connected heights, whether isolated or forming a part of a larger mountain system.
Meandering	Condition of river that follows a winding path owing to natural physical causes not imposed by external restraint. Characterized by alternating shoals and bank erosion.
Moraine	Drift, deposited chiefly by direct glacial action, and having constructional topography independent of control by the surface on which the drift lies.



Morphological	The scientific study of form. Used in various connections, e.g. landforms (geomorphology).
Muskeg	The term designating organic terrain, the physical condition of which is governed by the structure of peat it contains and its related mineral sublayer, considered in relation to topographic features and the surface vegetation with which the peat co-exists.
Ordovician	The second of the periods comprised in the Paleozoic era, in the geological classification now generally used. Also the system of strata deposited during that period.
Perennial	Lasting through the year.
Permafrost	The thermal condition under which earth materials exist at a temperature below 32°F continuously for a number of years.
Petrography	The branch of science treating of the systematic description and classification of rocks.
Proglacial	Pertaining to features of glacial origin beyond the limits of the glacier itself, as...streams, ...deposits, ...sand.
Sand	Soil particles smaller than 2.0 mm. in diameter and larger than 0.06 mm. in diameter.
Screes	A heap of rock waste at the base of a cliff or a sheet of coarse debris mantling a mountain slope.
Silurian	The third in order of age of the geologic periods comprised in the Paleozoic era, in the nomenclature in general use. Also the system of strata deposited during that period.
Sinuuous	Winding or curving in and out.
Slope Wash	Soil and rock material that is being or has moved down a slope predominantly by the action of gravity assisted by running water that is not concentrated into channels.
Taiga	A Russian word applied to the old, swampy, forested region of the north...that region between the Tundra in the north and the Boreal in the south.



Talus	Coarse angular fragments of rock and subordinate soil material dislodged by weathering (temperature and moisture changes) and collected at the foot of cliffs and other steep slopes and moved downslope primarily by the pull of gravity.
Terrace	A relatively flat elongate stairstepped surface bounded by a steeper ascending slope on one side and a steep descending slope on the other.
Tertiary	The earlier of the two geologic periods comprised in the Cenozoic era, in the classification generally used. Also the system of strata deposited during that period.
Thermal Regression	The thawing of frozen ground due to surface disturbance, increasing temperature, etc.
Thermokarst Lake	(Cave-in Lake), lakes which occupy depressions resulting from subsidence caused by thawing of ground ice.
Tundra	Any of the vast, nearly level, treeless plains of the Arctic Regions.
Turbid.	Having the sediment stirred up hence muddy, impure.



PEMCAN SERVICES

EXPLANATION OF TERMS AND SYMBOLS



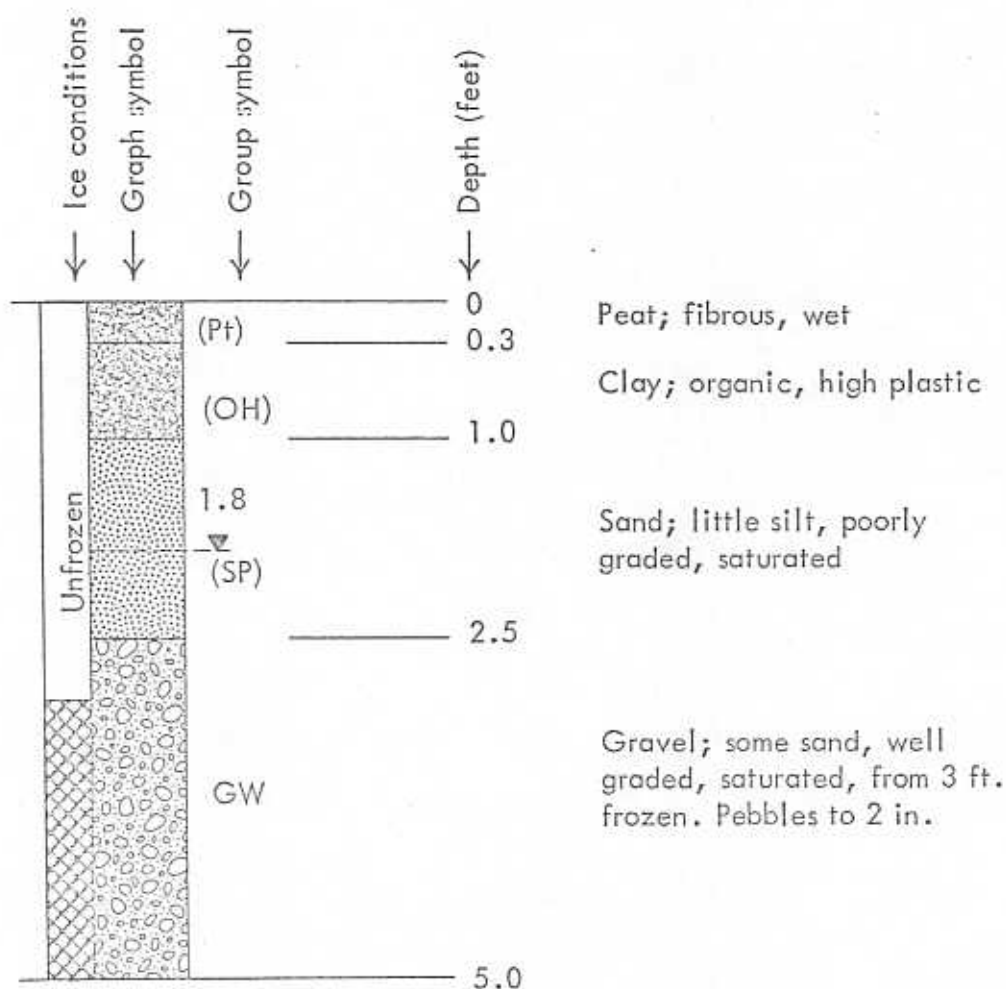
EXPLANATION OF TERMS AND SYMBOLS

DRILL HOLES AND TEST PITS

These pages present an explanation of the terms and symbols used in summarizing the results of field investigations as presented under Site Descriptions. Specifically, the explanations refer to the sheets entitled "Log Description and Laboratory Test Data". The materials, boundaries, and conditions have been established only at the test locations and could differ elsewhere on the site.

TEST PIT LOG DESCRIPTION

Soils of different engineering classification are commonly grouped generically for ease of reference. Seepage and the water level are indicated beside the graphical representation. They are followed by group symbols (according to the Unified Soil Classification System) and depths at individual soil type boundaries. Frost penetration is indicated to the left of the graph symbol as illustrated below:





DRILL HOLE LOG DESCRIPTION

The general information, indicating Site No., Hole No., Date drilled, Drilling Method and the firm responsible for the acquisition of the drill hole data designated under "Logged By", is noted in the upper portion of the standard "Detailed Drill Hole Log" form.

The detailed sub-surface information at each drill hole location has been presented in a columnar form as noted on the "exhibit" drill hole log data sheet on the following page. A description of each column used is outlined herewith:

- Column 1 and 9: Depth scale outlining increasing depth of drill hole below existing ground surface.
- Column 2: Graph Symbol to pictorially illustrate major soil divisions encountered in the drill hole. A detailed definition of each graph symbol is explained in the Materials Classification section of the Terms and Symbols.
- Column 3: Unified Group Symbol indicating the abbreviated material classification in accordance with the Unified Soil Classification system. A detailed definition of each Unified Group Symbol is explained under the Materials Classification heading in the Terms and Symbols section of the glossary.
- Column 4: Materials Description contains the engineering classification of each soil strata encountered in accordance with the criteria outlined in the Materials Classification heading in the Terms and Symbols section of the Glossary.
- The depths of ground water level and the interface between different soil strata are indicated on the extreme left of this column.
- Column 5: General Classification of Ground Ice Conditions indicates whether the material was frozen or unfrozen at the time of drilling.
- Column 6: N.R.C. Classification of Ground Ice Conditions contains abbreviated symbols for ground ice in accordance with the National Research Council of Canada's "Guide to a Field Description of Permafrost for Engineering Purposes", Technical Memorandum 79. A detailed outline of the N.R.C. classification is contained in the "Ground Ice Classification" heading in the Terms and Symbols Section of the Glossary.
- Column 7: Estimated Content of Ground Ice Conditions refers, generally, to the visual estimate of ice content in the soil formations encountered during the drilling program. The following abbreviations have been utilized for estimated ice content:



- "L":- indicates Low ice content with generally less than 10% ice.
- "M":- indicates Medium ice content with generally 10% to 50% ice.
- "H":- indicates High ice content with generally in excess of 50% ice.

Column 8:

Sample Type indicates the depth intervals where field samples were secured during the drilling program and the subsequent types of laboratory tests conducted on each respective sample. The following abbreviations have been utilized for the various types of laboratory tests conducted:

- MC:- designates moisture content determinations.
- GS:- designates grain size analyses including hydrometer tests.
- P:- designates Petrographic analyses.
- H:- designates Hardness Tests in accordance with the standard "Morr" classification for rocks and minerals.
- O:- designates Organic Content determinations.

DETAILED DRILL HOLE LOG

SITE NO. 131

HOLE NO. DH-1

DATE: FEB. 15, 1973 LOGGED BY: ☒ PEMCAN ☐

DRILLING METHOD: ☒ AIR CONVENTIONAL ☐ AIR REVERSE CIRCULATION ☐ OTHER:

DEPTH (feet)	GRAPH SYMBOL	UNIFIED GROUP SYMBOL	MATERIAL DESCRIPTION	GROUND ICE CONDITIONS			SAMPLE TYPE	DEPTH (feet)
				GEN'L CLASS	N.R.C. CLASS	EST'D CONT.		
0		OL	1.0 TOPSOIL: organic, dark brown		Nf	L		0
2		GM-GP	GRAVEL: some silt, little sand, frequent pebbles to 1/2" size, occasional boulders, medium brown		Vs	L-M		2
4								4
6		ML	7.0 SILT: some clay, trace of rust and coal specks, frequent pebbles to 1" size, occasional boulders, medium brown					6
8								8
10								10
12			12.0 TOTAL DEPTH 12.0'					12

GOVERNMENT OF CANADA
DEPARTMENT OF INDIAN AFFAIRS
AND NORTHERN DEVELOPMENT

GRANULAR MATERIALS INVENTORY



PEMCAN SERVICES "72"



MATERIAL CLASSIFICATION

Soil types are designated by a modified version of the Unified Soil Classification System ("The Unified Soil Classification System", Technical Memorandum No. 3-357, Vol.1, 1953, the Waterways Research Station, U.S.A.). The following page defines these terms and symbols. Letters appearing in parentheses denote visual identification which have not been verified in the laboratory. If the soil falls close to the boundaries established between the various groups a double symbol (for example GW-GP) is used.

Since the Unified Soil Classification System does not contain detailed subdivisions of granular soils according to percentage proportions of secondary components, the ASTM suggested method for identification of granular soils ("Suggested Methods of Test for Identification of Soils", ASTM Procedures for Testing of Soils, 4th edition, December, 1964) is adopted for soil description as defined below:

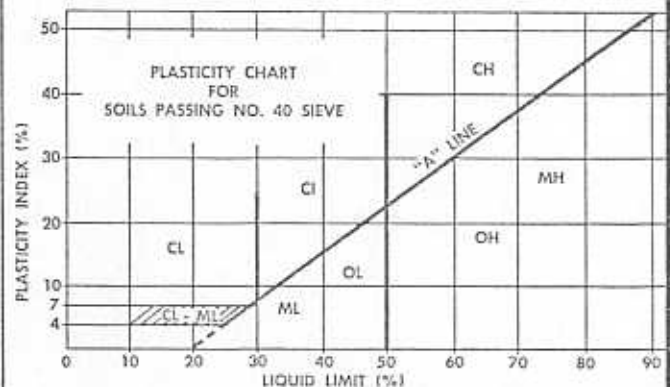
Composite Sand-Gravel Soils		Composite Sand-Silt Soils	
Percentages	Identification	Percentages	Identification
90 to 10	Gravel; trace Sand	95 to 5	Sand; trace - Silt
80 to 20	Gravel; little Sand	90 to 10	Sand; trace + Silt
65 to 35	Gravel; some Sand	80 to 20	Sand; little Silt
50 to 50	Gravel and Sand	65 to 35	Sand; some Silt
35 to 65	Sand and Gravel	50 to 50	Sand and Silt
20 to 80	Sand; some Gravel	35 to 65	Silt and Sand
10 to 90	Sand; little Gravel	20 to 80	Silt; some Sand
	Sand; trace Gravel	10 to 90	Silt; little Sand
			Silt; trace Sand

MODIFIED UNIFIED CLASSIFICATION SYSTEM FOR SOILS

MAJOR DIVISION			GROUP SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 200 SIEVE)	GRAVELS MORE THAN HALF COARSE GRAINS LARGER THAN NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			GP		POORLY GRADED GRAVELS, AND GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY GRAVELS (WITH SOME FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			GC		CLAYEY GRAVELS, GRAVEL-SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
	SANDS MORE THAN HALF FINE GRAINS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1 \text{ to } 3$	
			SP		POORLY GRADED SANDS, LITTLE OR NO FINES	NOT MEETING ABOVE REQUIREMENTS	
		DIRTY SANDS (WITH SOME FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES	CONTENT OF FINES EXCEEDS 12%	ATTERBERG LIMITS BELOW "A" LINE P.I. LESS THAN 4
			SC		CLAYEY SANDS, SAND-(SILT) CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE P.I. MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT PASSES 200 SIEVE)	SILTS BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY SANDS OF SLIGHT PLASTICITY	CLASSIFICATION IS BASED UPON PLASTICITY CHART (see below)	
		$w_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART NEGLIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS	WHENEVER THE NATURE OF THE FINE CONTENT HAS NOT BEEN DETERMINED, IT IS DESIGNATED BY THE LETTER "F", E.G. SF IS A MIXTURE OF SAND WITH SILT OR CLAY	
		$30\% < w_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, SILTY CLAYS		
		$w_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE ON CHART	$w_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY		
		$w_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY		
	HIGHLY ORGANIC SOILS		Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOR OR ODOR, AND OFTEN FIBROUS TEXTURE	

SPECIAL SYMBOLS

	BEDROCK (UNDIFFERENTIATED)		OVERBURDEN (UNDIFFERENTIATED)
	SANDSTONE		LIMESTONE (fragments & blocks)
	SHALE		
	LIMESTONE		
	TALUS (angular rock fragments)		
	TILL (mixed silty sand & clay)		



- ALL SIEVE SIZES MENTIONED ON THIS CHART ARE U.S. STANDARD, A.S.T.M. E.11.
- BOUNDARY CLASSIFICATIONS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE GIVEN COMBINED GROUP SYMBOLS, E.G. GW-GC IS A WELL GRADED GRAVEL SAND MIXTURE WITH CLAY BINDER BETWEEN 5% AND 12%.

GROUND ICE CLASSIFICATION

TABLE I
ICE DESCRIPTIONS
A. ICE NOT VISIBLE^(a)

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
N	Poorly bonded or friable	Nf	Identify by visual examination. To determine presence of excess ice, use procedure under note ^(b) and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation: medium, low. Note presence of crystals or of ice coatings around larger particles.
	No excess ice	Nbn	
	Well-bonded Excess ice	Nbe	

^(a) Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group (see p. 14).

^(b) When visual methods may be inadequate, a simple field test to aid evaluation of volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of total volume.

FIG A. ICE NOT VISIBLE

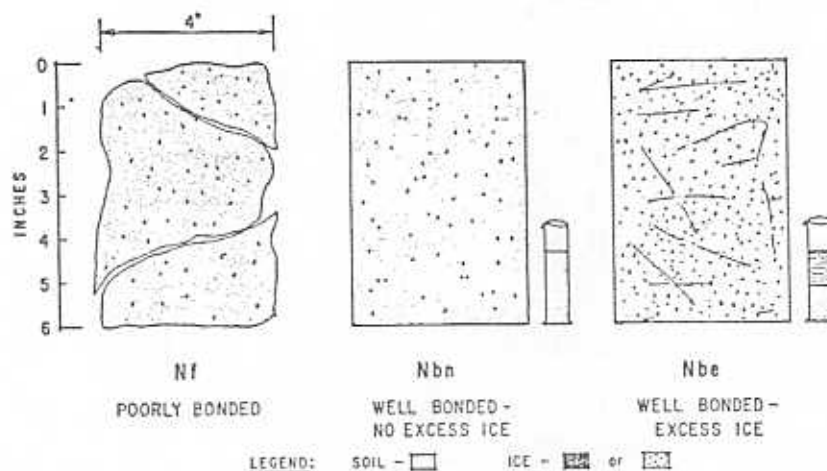


TABLE I (cont'd)
ICE DESCRIPTIONS
B. VISIBLE ICE—LESS THAN 1 INCH THICK^(a)

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
V	Individual ice crystal or inclusions	Vx	For ice phase, record the following when applicable: Location Size Orientation Shape Thickness Pattern of arrangement Length Spacing Hardness Structure } per Group C (see p. 16) Colour Estimate volume of visible segregated ice present as percentage of total sample volume.
	Ice coatings on particles	Vc	
	Random or irregularly oriented ice formations	Vr	
	Stratified or distinctly oriented ice formations	Vs	

^(a) Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group.

FIG B. VISIBLE ICE LESS THAN ONE INCH THICK

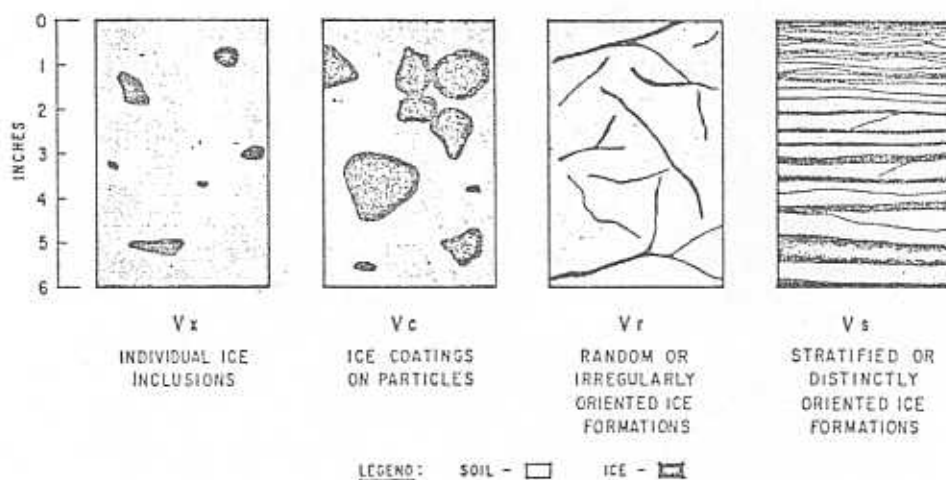


TABLE I (cont'd)
ICE DESCRIPTIONS
C. VISIBLE ICE—GREATER THAN 1 INCH THICK

Group Symbol	Subgroup		Field Identification
	Description	Symbol	
ICE	Ice with soil inclusions	ICE + soil type	Designate material as ICE ^(a) and use descriptive terms as follows, usually one item from each group, when applicable: <u>Hardness</u> HARD SOFT (of mass, not individual crystals) <u>Colour</u> (Examples): COLOURLESS GRAY BLUE <u>Structure^(b)</u> CLEAR CLOUDY POROUS CANDLED GRANULAR STRATIFIED <u>Admixtures</u> (Examples): CONTAINS FEW THIN SILT INCLUSIONS
	Ice without soil inclusions	ICE	

^(a) Where special forms of ice such as hoarfrost can be distinguished, more explicit description should be given.

^(b) Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.

FIG C. VISIBLE ICE GREATER THAN ONE INCH THICK

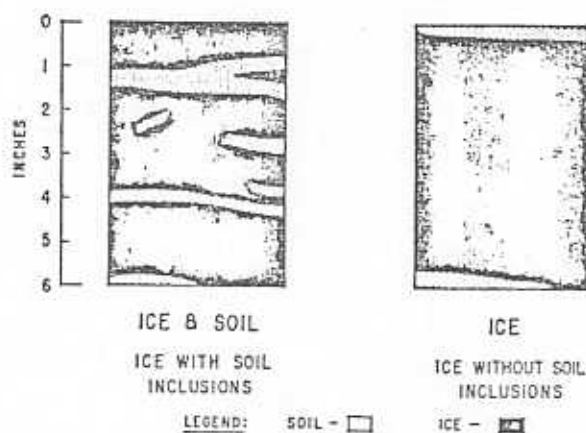




TABLE II

TERMINOLOGY

Ice Coatings on Particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

Ice Crystal is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.

Clear Ice is transparent and contains only a moderate number of air bubbles.

Cloudy Ice is relatively opaque due to entrained air bubbles or other reasons, but which is essentially sound and non-pervious.

Porous Ice contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.

Candled Ice is ice that has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

Granular Ice is composed of coarse, more or less equidimensional, ice crystals weakly bonded together.

Ice Lenses are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

Ice Segregation is the growth of ice as distinct lenses, layers, veins, and masses in soils commonly but not always, oriented normal to direction of heat loss.

Well-bonded signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

Poorly-bonded signifies that the soil particles are weakly held together by the ice and that the frozen soil consequently has poor resistance to chipping or breaking.

Friable denotes extremely weak bond between soil particles. Material is easily broken up.

Excess Ice signifies ice in excess of the fraction that would be retained as water in the soil voids upon thawing.

For a more complete list of terms generally accepted and used in current literature on Frost and Permafrost see Hennion, F. "FROST AND PERMAFROST DEFINITIONS", Highway Research Board, Bulletin 111, 1955.



EXPLANATION OF TERMS AND SYMBOLS

WILDLIFE AREAS

Wildlife boundaries and information presented in the Community and Intercommunity reports has been extracted for the most part from publications prepared by the Canadian Wildlife Service, Government of Canada.

The terms "critical" and "important" as used to designate certain wildlife areas can be generally defined as habitat areas which are critical and/or important to the subsistence and survival of various wildlife species.

COMMUNITY REPORTS

In each Community Study Area, known "critical" and "important" wildlife, waterfowl and fishery resource areas are outlined on the respective map presentations. Any wildlife, waterfowl or fishery resource area which is acknowledged as being "critical" is outlined in red and is noted with the word "critical" within the boundary of the respective area. Non-critical areas are outlined as follows:

- Wildlife areas are outlined in red.
- Waterfowl areas and, in the case of Fort Simpson, hunting locales, are outlined in yellow.
- Fishery resource areas are outlined in blue.

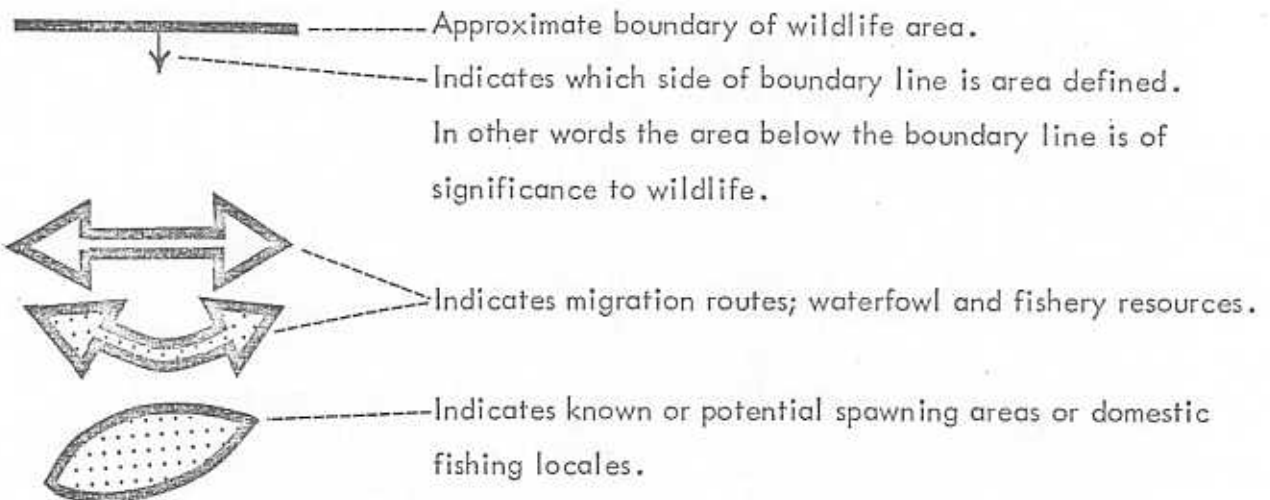
Outlined wildlife areas include both regions of known wildlife habitation and regions which have been historically trapped by northern residents.

Waterfowl areas include migration, staging, molting and nesting locales which are of significance in the respective Study Areas.



Fishery resource areas include migration, spawning and domestic fishing locales which are of significance in the respective Study Areas.

Symbols used on the maps are illustrated and explained as follows:

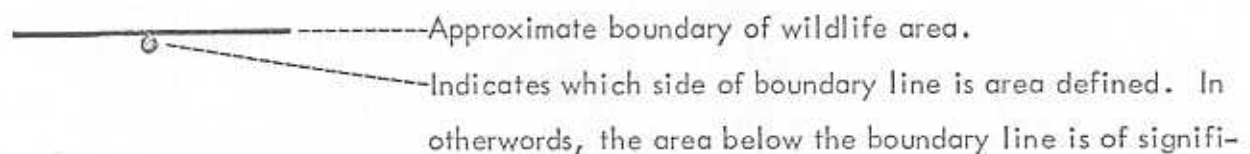


Pertinent wildlife areas are discussed in the Methodology-Evaluation section of the text in each community report. Similar documentation is also presented for sites which occur in significant wildlife areas in the Site Description section of the report.

INTERCOMMUNITY REPORTS

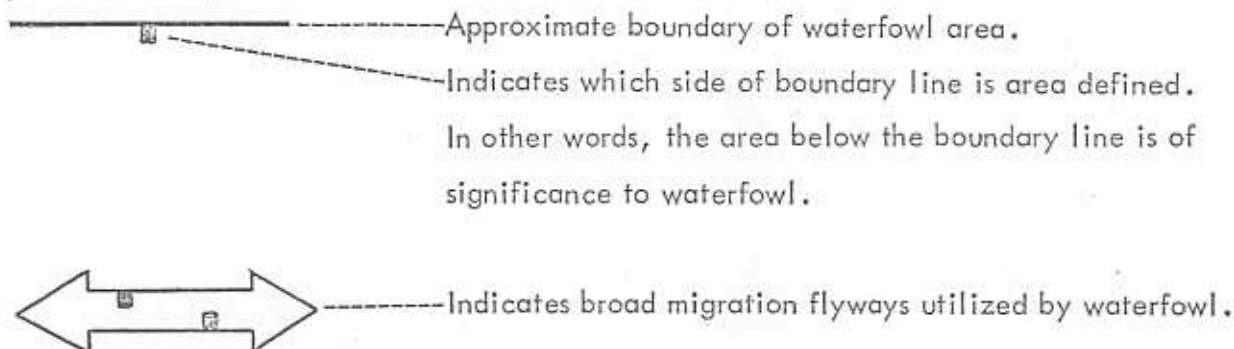
In each Intercommunity Study Area, known "critical" and "important" wildlife, waterfowl and fishery resource areas are outlined on the respective map presentations. A brief description relating to the significance of each area is included within the outlined boundary. Areas that are classified as "critical" are so noted on the maps.

Symbols used on the maps are illustrated and explained as follows:





cance to wildlife.



Significant fishery resource information such as migration routes and potential spawning areas is noted directly on the maps.

Pertinent wildlife areas are discussed in the Methodology-Evaluation section of the text in each Intercommunity report. Similar documentation is also presented for sites which occur in significant wildlife areas in the Site Description section of the report.



PEMCAN SERVICES

BIBLIOGRAPHY



BIBLIOGRAPHY

Alyeska Pipeline Service Co., 1971. Exhibit I, (U.S.) Dept. of Interior Hearings, February 16, 1971.

Alyeska Pipeline Service Co., 1972. Alyeska Project Statement, Excerpts from Project Description. V. 2, 3, 5.

Alyeska Pipeline Service Co., Exhibit I, (U.S.) Hearings, 1971.

American Geological Institute, Glossary of Geology and Related Sciences: Glossary Review Committee. Reprint September, 1966.

Benninghoff, W.S., 1952. Interaction of vegetation and soil frost phenomena: Arctic, V.5, p. 34-44.

Bliss, L.C., 1962. Adaptation of Arctic and Alpine plants: Arctic, V.15, p. 117-144.

Brandon, L.V., 1965. Groundwater Hydrology and Water Supply in the District of Mackenzie, Yukon Territory, and adjoining parts of British Columbia. Paper 64-39: Geological Survey of Canada, Dept. of Mines and Technical Surveys.

Canadian Wildlife Service, Arctic Ecology Map Series, (Preliminary) 1972.

Cayford, J.H., and Birkerstaff, A., 1968. Man-made Forests in Canada: Dept. of Fisheries and Forestry, Forestry Branch Publication No. 1240.

Day, J.H., 1966. Reconnaissance Soil Survey of the Liard River Valley, Northwest Territories: Research Branch, Canada Dept. of Agriculture, Soil Research Institute, Central Experimental Farm, Ottawa.

Day, J.H., 1968. Soils of the Upper Mackenzie River Area, Northwest Territories: Soil Research Institute, Central Experimental Farm, Ottawa, Research Branch of Canada, Dept. of Agriculture.

Dept. of Energy, Mines & Resources, Indian and Northern Affairs, Terrain Classification and Sensitivity Series (Preliminary) 1972.

Dept. of Mines and Technical Surveys. Indian and Northern Affairs. Land Use Information Series Maps: Dept. of the Environment, 1972.

Dept. of Mines and Technical Surveys. Geographical Branch, Ottawa, 157. Atlas of Canada.



Geological Survey of Canada, 4th Edition, 1957; 5th Edition, 1968. Geology and Economic Minerals of Canada.

IUCN (International Union for the Conservation of Nature and Natural Resources), Survival Service Commission. 1966 (and subsequent updatings). Red Book Data: Morges, Switzerland, IUCN.

Jones, M.J., 1971. Mackenzie Delta Bibliography: Dept. of Indian Affairs and Northern Development. (MDRP-6).

Lavkulich, L.M., 1972. Soils, Vegetation and Landforms of the Fort Simpson area, N.W.T.: Dept. of Soil Science, University of British Columbia: Dept. of Indian Affairs and Northern Development.

Lawrence, D.E.; Shnay, F.G.; VanDine, D.F.; 1972. Granular Resource Inventory - Mackenzie - Fort Norman Addendum, NTS 96E (November)
- Norman Wells Addendum, NTS 96E (September 22)(July)
- Carcajou Canyon, NTS 96D (September 22)(July)
- Fort Good Hope, NTS 106I (November):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Lawrence, D.E.; Shnay, F.G.; VanDine, D.F.; Theroux, L.L., 1972. Granular Resource Inventory - Mackenzie
- Carcajou Canyon, NTS 96D (July)
- Sans Sault Rapids, NTS 106/H (July)
- Norman Wells, NTS 96/E (September 22)(July)
- Fort Norman, NTS 96/C (July):
Dept. of Energy, Mines & Resources, Geological Survey of Canada.

Lindsey, A.A., 1953. Notes on some plant communities in the northern Mackenzie Basin, Canada: Botanical Gazette, V. 115, No. 1, p. 44-55.

MacKay, J.R., 1970. Lateral mixing of the Liard and Mackenzie Rivers downstream from their confluence: Can. Jour. Earth Sci., V. 7, p. 111-124.

McPhail, J.D., and Lindsey, C.C., 1970. Freshwater fishes of northwestern Canada and Alaska: Fisheries Research Board, Ottawa. Bulletin 173.

Minning, Gretchen V.; Domansky, Jeff, 1972. Granular Resources and Bedrock Construction Materials - Camsell Bend (95J)(July): Dept. of Energy, Mines & Resources, Geological Survey of Canada.



- Minning, Gretchen V.; Rennie, Jim; Domansky, Jeff, 1972. Granular Resources and Bedrock Construction Materials - Dahadinn River (95N)(July)
- Dahadinn River (95N)(Unedited Preliminary Rpt. July)
 - Wrigley (950)(Unedited Preliminary Rpt. July)
 - Wrigley (950)(July):
- Dept. of Energy, Mines & Resources, Geological Survey of Canada.
- Minning, Gretchen V.; Rennie, J.A.; Domansky, J.L.; Sartorelli, A.N., 1972. Granular Resource Inventory - Southern Mackenzie Valley -
- Camsell Bend (95J)(First Revision)(October)
 - Fort Simpson (95H)(First Revision)(November)
 - Bulmer Lake (95I)(December):
- Dept. of Energy, Mines & Resources, Geological Survey of Canada.
- Minning, Gretchen V.; Rennie, J.A.; Domansky, J.L.; Sartorelli, A.N., 1973. Granular Resource Inventory - Southern Mackenzie Valley
- Wrigley (950)(January)
- Dept. of Energy, Mines & Resources, Geological Survey of Canada.
- Rowe, J.S., 1959. Forest Regions of Canada: Canada Dept. Northern Affairs and Natural Resources, Forestry Branch, Bulletin 123.
- Stein, J.N.; Hatfield, C.T.; Falk, M.R.; Jessop, C.S. February 28, 1972. Fish Resources of the Mackenzie River Valley, Interim Report I, Volume I: Environment Canada, Fisheries Service.
- Stein, J.N.; Hatfield, C.T.; Falk, M.R.; Jessop, C.S.; Sheperd, D.N. February 28, 1972. Fish Resources of the Mackenzie River Valley, Interim Report I, Volume II: Department of the Environment, Fisheries Services.