GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

GRANULAR RESOURCE INVENTORY - SOUTHERN MACKENZIE VALLEY FORT LIARD (95B) 1:125,000

Gretchen V. Minning
J. A. Rennie
J. L. Domansky
A. N. Sartorelli
Terrain Sciences Division
Geological Survey of Canada

December, 1972

101

Table of Contents

SUMMARY

In the Fort Liard map-area, sources of granular material are plentiful and widely scattered. Good quality natural granular material is available primarily in alluvial deposits. Glaciofluvial, glaciolacustrine, and morainal deposits also contain sand and gravel. Competent, crushable bedrock is exposed in the Liard Range and along rivers and streams in the western half of the map-sheet.

Liard River alluvial plain and terrace deposits are generally made up of silt and sand. Where the Liard River floodplain widens, shot hole records show thick gravel in some alluvial plain deposits. Liard River tributaries also have scattered bodies of coarse-grained alluvial material. Organic cover and poor drainage may make some alluvial terraces and plains difficult to exploit.

Scattered glaciofluvial outwash plain, ridge, and esker deposits are small. These deposits are well drained, have little organic cover and consist almost entirely of sand and gravel.

Glaciolacustrine and morainal deposits contain fine material with minor sand and gravel. They are often poorly drained and have ground ice and heavy organic cover.

Bedrock that can be crushed to provide granular material includes limestone, chert, sandstone, and conglomerate of six geologic formations. These formations outcrop in the Liard Range and in banks of the Liard River and its tributaries.

INTRODUCTION

Granular material for construction purposes can be obtained from unconsolidated deposits or competent bedrock. This report will discuss the distribution and physical characteristics of these sources of granular material and will also present an estimate of the quantity of material available in unconsolidated deposits.

Unconsolidated deposits resulting from various geologic processes, i.e. glacier activity, river deposition, wind action, and mass wasting, are a source of natural granular material of gravel (> 2 mm), sand (1/16-2 mm), silt (1/16-1/256 mm), and clay (< 1/256 mm) sizes.

Good natural granular material for construction uses is generally larger than silt size (1/16 mm)[1]. In the southern Mackenzie Valley good granular material comes primarily from deposits of glaciofluvial and glaciolacustrine origin, and secondarily from morainal, eolian, alluvial, and colluvial deposits.

Bedrock that can be crushed by mechanical means can also supply granular material. Competent bedrock suitable for crushing includes limestone, dolomite, sandstone, and certain igneous and metamorphic rock types. Other less resistant rock types, i.e. shale, can be used for fill material but will not be included here as a bedrock source of granular material. In the southern Mackenzie

---

[1] Silt and clay size material < 1/16 mm can be used for fill. This material is unlimited in the unconsolidated deposits of this map-sheet and will not be included in the numerical estimate of the quantity of granular material available.

Valley limestone and dolomite are the best sources of rippable bedrock.

Published and unpublished Geological Survey of Canada maps and reports, personal communication with officers of the Geological Survey, and field investigation have provided the basic data for this report. Supplementary information on distribution, thicknesses, and textures of unconsolidated deposits was obtained from unpublished oil and pipeline company shot hole and drilling records (see sources of information, Appendix A).

A Geological Survey surficial geology map at a scale of 1:125,000 (Rutter, N.W., et al., in press) provided data on location and areal extent of unconsolidated deposits containing good granular material. This map will be indexed as GSC Open File and when published it may be viewed in the Geological Survey of Canada offices in Ottawa, Calgary and Vancouver. Copies will be obtainable at a nominal cost from Riley's Data-Share International, 631 - 8 Avenue South West, Calgary, Alberta.

Quantities of natural granular material in unconsolidated deposits have been computed using data on areal extent and thicknesses obtained from the surficial geology map, drilling results, and field observations. Variables such as ground ice and height of water table were considered when deriving final volumes of material available in each deposit[2]. The tabular summary at the end of this report contains detailed volumetric data.

Information on bedrock that can supply granular material comes mainly

---

[2] The area of each deposit was measured on the surficial geology map with a planimeter. The average thickness of the deposit was multiplied by the area to get the total volume of the deposit. Variables, i.e, water table, type of deposit, were assessed to obtain the final percentage of the total volume that is listed in the table as material available for exploitation.

from Geological Survey of Canada Paper 59-6. Map 31-1959 which accompanies this paper, has been used as a base for indicating competent bedrock that is available at or near the surface.

GENERAL GEOLOGY AND PHYSIOGRAPHY

The Fort Liard map-area lies within several physiographic regions. East of the Liard River from north to south are portions of the Great Slave Plain, the Alberta Plateau, and the Fort Nelson Lowland. The Liard Range of the Mackenzie Mountains is the dominant physiographic feature west of the Liard River. The Great Slave Plain, Liard Plateau, and Fort Nelson Lowland are also represented here (see location map, Figure 1).

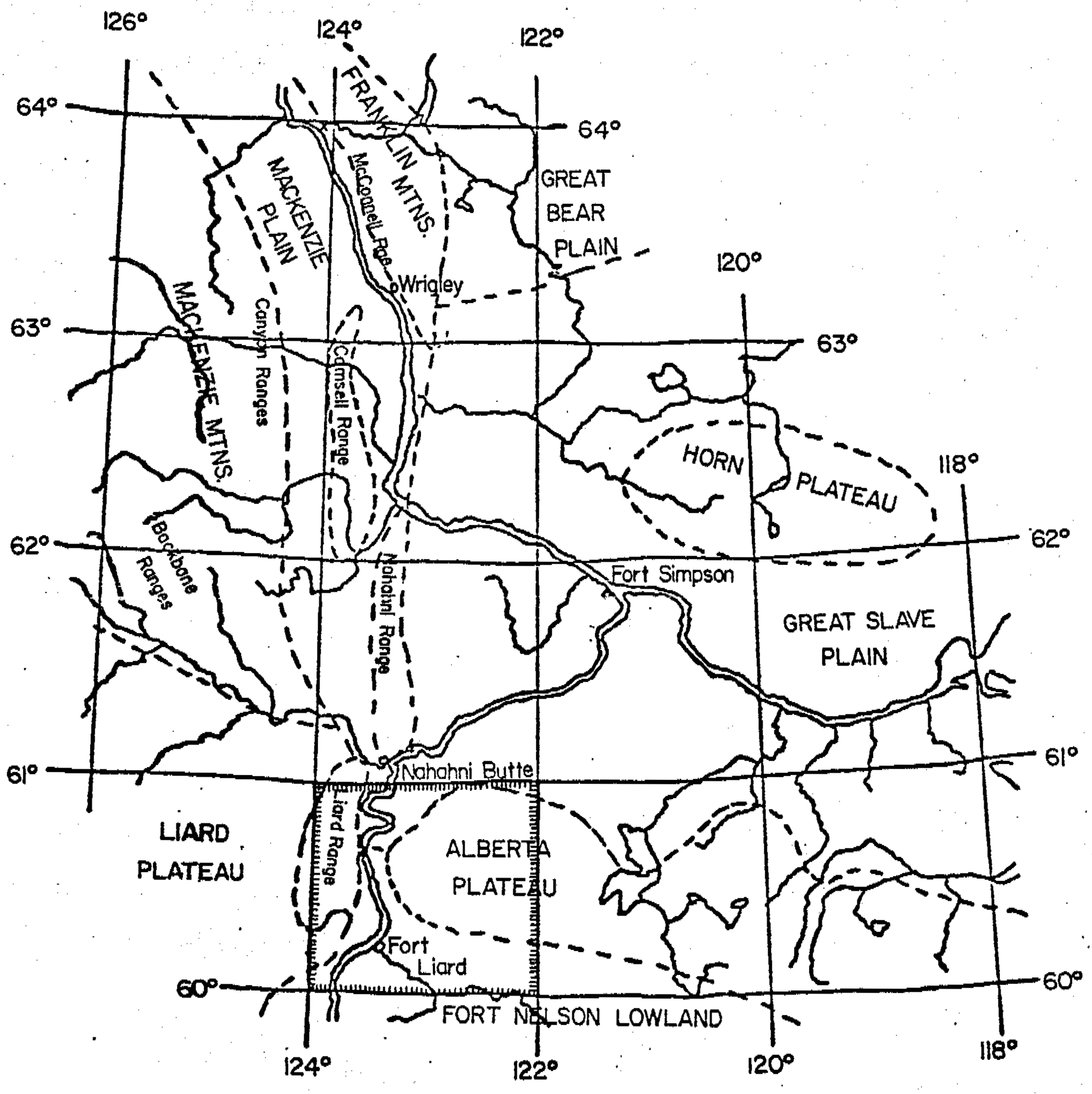
Bedrock geology was mapped by the Geological Survey on Operation Mackenzie in 1957 (Douglas and Norris, 1959). A reconnaissance surficial geology investigation was undertaken by B. G. Craig as part of this operation (Douglas and Norris, 1959; Craig, 1965). A detailed surficial geology map based on airphoto interpretation and field investigations is being compiled by the Geological Survey (Rutter et al., in press).

Bedrock formations[3] are basically Mesozoic (Cretaceous shales, sandstones, and minor conglomerates) and Paleozoic (Devonian, Mississippian, Permian limestones, sandstones, conglomerates, shales, and cherts).

The shales which generally occur in lowland areas both east and west of the Liard River are poor sources of granular material.

---

[3]A formation is a bed (of rocks) or assemblage of beds with well-marked upper and lower boundaries that can be traced and mapped over a considerable tract of country (Holmes, 1965).



PHYSIOGRAPHIC REGIONS – FORT LIARD, 95B

1 miles 50 Scale

Figure 1

after Bostock 1969

Competent sandstones, conglomerates, cherts, and limestones found at or near the surface in the Liard Range and along major rivers could be used to supply construction materials.

Morainal deposits mantle the bedrock with shot hole records showing them to be at least 50 feet thick in most places[4]. In addition to the ground moraine cover, glacier activity has produced minor glaciofluvial channel and esker deposits, and glaciolacustrine plain deposits. Rivers and creeks have reworked unconsolidated material into alluvial plain and terrace deposits.

GEOLOGIC DESCRIPTION OF EXPLOITABLE MAP UNITS

Unconsolidated deposits and bedrock that can supply granular material appear on Figures 2 and 3 respectively.

Figure 2 is adapted from a Geological Survey of Canada surficial geology map. Unconsolidated deposits with good natural granular material are labelled with the appropriate map-unit name and assigned a pattern designation (see Figure 2, 2b). Pattern designations are based on geologic origin and texture of material in the deposit. Where map-unit names are used without pattern designations, the deposit either consists almost entirely of material less than 1/16 mm or has organic material and high water table present throughout 50% of its surface area.

Figure 3 is a Geological Survey of Canada bedrock geology map. Bedrock at or near the surface is indicated by heavy dashed lines or an x.

[4] There might by > 50 feet of till over bedrock, but shot holes usually end at 50 feet even if bedrock is not encountered.

Bedrock formations preceded by an asterisk (*) in the legend (see legend, Fig. 3) could be crushed to obtain granular material.

Unconsolidated Deposits

Glacial Deposits

Glaciofluvial deposits contain high quality granular material of gravel and sand size. Glaciolacustrine plain deposits consist mainly of silt and sand. Morainal plain deposits are generally fine material, but fluted areas may contain some sand and gravel.

Glaciofluvial Deposits (Gp, Gr, eskers)

Glaciofluvial deposits scattered throughout the area consist of sand and gravel. They have been indicated by a dot and circle pattern or an esker symbol on the natural granular materials map (see Figure 2).

The capital G in the unit mapped indicates the glaciofluvial origin of the deposit and the lower case prefix denotes the principal types of material, e.g. silt (si), sand (s), and gravel and sand (g). It should be noted that if two prefixes are used, the first refers to the most abundant constituent (see legend for surficial geology maps, Figure 2b).

Topographic expression of the unit is indicated by the suffix attached, e.g. ridge (r), plain (p). Symbols like esker (ᵥᵥ) also show surface form. Glaciofluvial units vary from flat and gently sloping (Gp) to ridged (Gr, eskers). Thicknesses of deposits range from 15 to 50 feet[5].

---

[5]There might be more than 50 feet of gravel in esker area B-60, but shot holes end near 50 feet.

Glaciofluvial deposits are generally well drained and have little ground ice or organic cover.

Glaciolacustrine Deposits
(Lp, $\frac{\text{Lpv}}{\text{tm}}$)

Glaciolacustrine deposits consist of fine sand and silt. On the natural granular materials map the sandy lake deposits have been assigned a striped pattern (see Figure 2). Silty deposits are outlined on the map but not shaded or included in the tabular summary.

The capital L in the glaciolacustrine map-unit indicates its origin and the lower case prefixes and suffixes give textural and morphologic information respectively.

Glaciolacustrine plain deposits are generally flat or gently sloping (Lp, $\frac{\text{Lpv}}{\text{tm}}$). They range in thickness from 5 feet[6] ($\frac{\text{Lpv}}{\text{tm}}$ units) to 30 feet (some Lp units). An average thickness of 23 feet was used in computations when exact thicknesses were unknown. Glaciolacustrine deposits may be difficult to exploit because of ground ice and organic cover.

Morainal Deposits
(Mpsd, Mps)

Morainal deposits generally do not contain sufficient gravel to be classified as a source of granular material. Morainal deposits have been mapped as M with appropriate textural and morphologic modifiers. No morainal deposits contain enough coarse material to be shaded on the natural granular materials map, but several fluted moraine plain units

---

[6]Glaciolacustrine veneer deposits ($\frac{\text{Lpv}}{\text{tm}}$) are indicated by map-unit names. They have not been assigned a pattern designation nor included in the tabular summary because they are too thin to exploit economically.

have been outlined because shot hole records and field investigations indicate that they contain minor gravel along with till (see Figure 2). These ridged deposits are generally well drained and would be a good source for dry fill material even though they are not listed as a granular resource on the tabular summary.

Alluvial Deposits
(Ap, At, Apc, Af, Afx)

Alluvial deposits consist of silt, sand, and gravel-sized material. Only those with significant coarse material have been assigned a cross-hatched or open circle pattern on the accompanying natural granular materials map (see Figure 2). All alluvial deposits are mapped as A with textural and morphologic modifiers. Alluvial deposits with coarse material generally occur along rivers, streams and bedrock ridges.

Alluvial deposits form plains (Ap, Apc) with little relief along present river and stream channels and terraces (At) above present channels. Alluvial plain and terrace deposits vary in thickness from 3 to 150 feet. When no information on thicknesses was available an average figure of 9 feet was used in volume calculations for alluvial plain deposits and 40 feet for the terrace deposits.

Alluvial plain and terrace deposits along Liard River tributaries are variable in type, distribution, and thickness. Liard River alluvial deposits, especially in the northern third of the map-sheet, are extensive and contain up to 150 feet[7] of silt, sand, and gravel. In many of these

[7] More than 150 feet of gravel might be present in B-69 but deepest shot holes ended near 150 feet.

deposits-- especially unshaded units on the granular materials map-- high water table, organic cover, and channelled topography may make exploitation of the granular materials expensive.

Alluvial fan deposits (Af, Afx) adjacent to bedrock ridges in the western third of the map-sheet also contain granular material. These deposits vary in thickness and texture. An average thickness of 25 feet was used in volume estimates when thickness data was unknown after field investigations.

Bedrock

Limestone, sandstone, conglomerate and chert of six geologic formations can be used to supply granular material. Outcrop areas of these formations are indicated on figure 3 with heavy dashed lines or an x symbol. All of these formations occur at or near the surface in the Liard Range. East of the Liard River, bedrock is mantled by glacial deposits and is exposed only along rivers.

High Quality Bedrock for Construction Materials

Bedrock formations are described in order of their suitability for construction materials.

The Mattson Formation, unit 8, is Carboniferous and Permian in age. It consists of sandstone, shale, and limestone and is the dominant formation in the Liard Range. At many localities the Mattson can be divided into three parts. The lower part 8a is a fine-grained, sandstone with minor shale and coal near the top. In measured sections it ranges from 1,164 to 1,732 feet in thickness.

The middle division (8b) is mostly fine to medium-grained but partly coarse-grained to finely conglomeratic sandstone. It ranges in thickness from 752 to 1,574 feet.

The upper part of the formation (8c) consists of limestone interbedded with sandstone, shale, and dolomite. It has measured thicknesses ranging from 1,176 to 1,740 feet.

All three divisions of unit 8 would be good to excellent sources for granular materials, especially the coarse sandstone of 8b.

Unit 18, the Upper Cretaceous Fort Nelson Formation, is widespread in the Fort Liard map-area. East of the Liard River it is often covered by thick till. Best exposures occur along the conyon of the Petitot River where the formation is 450 to 500 feet thick. The lower part consists of sandstone overlain by mudstone with coal and lenses of conglomerate. The upper part consists of a conglomerate with chert and quartzite pebbles. Along Kotaneelee River, unit 18 is incompletely exposed and consists mainly of sandstone with chert pebbles. Except for the mudstone member the formation is a good source for granular materials.

Unit 7 is a Mississippian limestone formation that occurs in the Liard Range and along the Petitot River. Near the northern border of the map-sheet it is approximately 1,000 feet thick. The limestone of the formation is fossiliferous and is interbedded with sandstone and dolomite. It is a good bedrock unit for granular materials.

Unit 9 is Permian(?) in age and consists of chert, sandstone, and mudstone. The chert is in the lower part of the formation and ranges in thickness from 75 to 150 feet. The sandstone and mudstone overlie it and are up to 300 feet thick just west of the Fort Liard map-area. Both the sandstone and chert in this formation could be crushed to obtain granular material.

Secondary Bedrock Sources for Construction Materials

Two formations, units 11 and 15, of the Lower Cretaceous Fort St. John Group can be used as sources of rippable bedrock. Their lithologies and outcrop patterns, however, may make them less desirable than the four units mentioned above.

Unit 11 contains shale, conglomerate, and quartzose sandstone. The sandstone and conglomerate would be good for crushing but the incompetent shale with bentonite beds would provide no granular material. Unit 11 outcrops mostly along the western flank of the Liard Range.

Unit 15 consists of quartzose sandstone with glauconite overlain by argillaceous siltstone with some shale. The lower sandstone member which ranges in thickness from 185 to 300 feet could be used for construction materials, especially if low in glauconite. Unit 15 is exposed along the Petitot, Liard, and Kotaneelee Rivers. At some localities (i.e. Fisherman Lake) unit 15 is overlain by a fairly thick cover of glacial sediments.

GEOGRAPHIC DISTRIBUTION OF EXPLOITABLE MATERIALS

All natural granular deposits have been assigned an identification number, i.e. B-1, for use in assembling data. Roman numerals I to III and geographic names designate groups of natural granular deposits discussed in this report. The same system of Roman numerals and geographic names has been used to assemble bedrock information for different localities on the map-sheet (see Figure 3).

Further details on volume estimates of natural granular material and types of bedrock available in each Roman numeral area are found in the tabular summary of this report.

I. Liard Range

This area west of the Liard River has exploitable unconsolidated deposits and bedrock units. Unconsolidated deposits are basically alluvial sands and gravels which form plains along river channels and fans near bedrock ridges. Alluvial plain deposits are fairly thin and have been estimated to be approximately 9 feet thick and contain 25% to 70% usable sand and gravel. Alluvial fan deposits are thicker (25 feet and more) and are estimated to be 50% coarse granular material.

Scattered glaciofluvial and glaciolacustrine deposits also contain sand and gravel. Coarse material comes from four glaciofluvial plain deposits and sand and silt are available in two glaciolacustrine units.

Most of the unconsolidated deposits are fairly well drained and have little organic cover.

Sandstone, conglomerate, chert, and limestone of six formations could supply colluvial granular material or would be good for crushing. These formations are exposed in the Liard Range and along river banks.

II. Liard River Complex

Deposits along the Liard River fall into this group. They are glaciolacustrine and alluvial in origin and contain mostly sand and silt.

Drilling has shown thick alluvial gravels (150 feet in some places) in the northern third of the map-area. Surface conditions like high water table, channelled topography, and organic cover will make these deposits difficult to exploit. However, this concentration of coarse material accounts for more than 50% of the natural granular resources in the map-area and may have to be utilized if major construction projects are undertaken.

Competent bedrock units are exposed along the Liard River but are not abundant enough to provide a quantity of crushable rock for construction purposes.

III. Alberta Plateau - Fort Nelson Lowland Area

Natural granular material east of the Liard River comes mostly from scattered glaciofluvial and alluvial deposits. Some morainal areas could also provide dry fill for construction purposes.

Glaciofluvial deposits are in the form of eskers, plains, and ridges. Shot holes show some of these deposits to be at least 45 feet thick.

Alluvial deposits are mainly sand with lesser amounts of gravel and silt. Thicknesses of alluvial deposits are highly variable.

Competent bedrock (sandstone, limestone, conglomerate and chert) of 5 formations is exposed along the Petitot, Arrowhead, and Muskeg rivers. At some localities enough rock is present to be used for construction materials.

TABULAR SUMMARY

	Description & Material	Thickness (ft.)	Area (sq. mi.)	Volumes Total	(Million yds.^{3}) Available
	I. Liard Range				
B-3	glaciofluvial plain	50	2.87	151.13	105.79
B-16	deposits of sand and	50	0.77	40.96	16.38
B-17	gravel	50	2.80	147.39	58.95
B-18		50	0.27	14.33	5.74
B-37	alluvial fans of	25	3.11	77.17	38.55
B-39	gravel, some sand	25	0.58	14.40	7.20
B-40		25	4.28	106.03	53.01
B-41		25	0.97	24.09	12.05
B-45		25	0.78	19.27	9.63
B-46		25	0.78	19.27	9.63
B-47		25	2.33	57.83	28.91
B-48		25	1.55	38.55	19.27
B-38	alluvial plain deposits,	9	0.58	5.42	3.79
B-42	mostly sand and gravel	9	12.64	117.48	82.24
B-50	with some silt	9	4.39	40.77	10.19
B-51		9	2.13	19.77	4.94
B-54		9	12.06	112.06	28.01
B-55		9	1.67	15.51	3.87
B-68	lacustrine plain deposit of sand, some silt	23	3.11	67.47	26.99
	Bedrock - sandstone of Unit 8a (good), conglomeratic sandstone of Unit 8b (excellent), somestone of Unit 8c (good), sandstone and conglomerate of Unit 18 (good), limestone, sandstone, and dolomite of Unit 7 (good), chert and sandstone of Unit 9 (good), conglomerate and sandstone of Unit 11 (fair), sandstone of Unit 15 (fair)				
				I TOTAL	525.14

TABULAR SUMMARY

	Description & Material	Thickness (ft.)	Area (sq. mi.)	Volumes Total	(Million $yds.^3$) Available
	II. Liard River Complex				
B-66	lacustrine plain deposits	23	20.11	436.07	174.43
B-67	of sand and silt	23	50.18	1088.08	435.23
B-49	alluvial terrace of sand and silt	40	4.08	164.19	32.83
B-69	alluvial plain deposits of gravel and sand, channelled, high water table, considerable organic cover (see area III)	75	98.8	7651.53	1912.88
	Bedrock - a few exposures along the Liard River, no good areas to exploit for granular materials				
				II TOTAL	2555.37

TABULAR SUMMARY

	Description & Material	Thickness (ft.)	Area (sq. mi.)	Volumes Total	(Million yds.^{3}) Available
	III. Alberta Plateau - Ft. Nelson Lowland Area				
B-2	glaciofluvial plain, terrace	50	1.40	73.61	51.52
B-4	and ridge deposits of sand	50	1.94	102.00	40.80
B-5	and gravel; well drained,	50	0.194	10.20	4.08
B-13	little to no organic cover	50	1.86	97.92	39.16
B-15		50	0.27	14.33	5.74
B-20	eskers of sand and gravel	30		0.22	0.18
B-21		30		0.34	0.27
B-23		30		0.46	0.37
B-25					
B-26		30		2.06	1.65
B-27					
B-28					
B-29					
B-30		30		0.23	0.18
B-60		45		3.59	2.87
B-43	alluvial plain deposits of	9	11.47	106.63	26.65
B-44	silt, sand, and gravel	9	2.83	26.38	6.59
B-56		9	5.09	47.35	11.83
B-57		9	3.50	32.53	8.13
B-58		9	9.33	86.75	21.68
B-59		9	9.06	84.22	21.05
B-61	alluvial plain deposits of	9	44.73	415.71	103.92
B-62	sand and gravel	9	1.75	16.26	4.06
B-63		9	2.33	21.68	5.42
B-64	alluvial plain deposits	9	22.95	213.27	53.31
B-65	of sand	9	3.89	36.12	9.03

Description & Material	Thickness (ft.)	Area (sq. mi.)	Volumes Total	(Million yds.^{3}) Available
Bedrock - exposures of competent units along the Petitot, Arrowhead, and Muskeg Rivers: sandstone of Unit 8 (good to excellent), sandstone of Unit 18 (good), sandstone, limestone and dolomite of Unit 7 (good), sandstone of Unit 9 (good), sandstone of Unit 15 (fair)				
			III TOTAL	418.49

Total natural granular materials resource estimate: 3531.83 million yds.^{3}

Appendix A

Sources of Information

American Geological Institute
1960: Glossary of geology and related sciences; Am. Geol. Institute.

Amoco Canada Petroleum Ltd.
1971: Seismic Shot Hole Data (unpublished).

Bostock, H. S.
1948: Physiography of the Canadian Cordillera, with special reference to the area north of the fifty-fifth parallel; Geol. Surv. Can., Mem. 247.

1969: Physiographic regions of Canada; Geol. Surv. Can., Map 1254A.

Craig, B. G.
1965: Glacial Lake McConnell, and surficial geology of parts of Slave River and Redstone River map-areas, District of Mackenzie; Geol. Surv. Can., Bulletin 122.

Douglas, R. J. W., and Norris, D. K.
1959: Fort Liard and La Biche map-areas, Northwest Territories and Yukon; Geol. Surv. Can., Paper 59-6.

Holmes, A. H.
1965: Principles of physical geology, Thomas Nelson and Sons Ltd., London.

Imperial Oil Ltd.
1961, 1970: Seismic Shot Hole Data (unpublished).

Northern Oil Explorers Ltd.
1972: Seismic Shot Hole Data (unpublished).

Prest, V. K., Grant, D. R., and Rampton, V. N.
1967: Glacial Map of Canada; Geol. Surv. Can., Map 1253A.

Rutter, N. W., et al.
(in press); Surficial geology and geomorphology of Fort Liard, 95B; Geol. Surv. Can., Open Files Series

Texaco Exploration Canada Ltd.
1970: Seismic Shot Hole Data (unpublished).