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Ministry of Environment
RESOURCE ANALYSIS BRANCH

Working Report

SOILS IN THE CARIBOO RIVER VALLEY, B.C.

WITH SELECTED ENGINEERING INTERPRETATIONS

1979

Terje Vold, R.P.F.
Forest Pedologist

Victoria, B.C.

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CHAPTER ONE
GENERAL DESCRIPTION OF STUDY AREA

1.1 INTRODUCTION

The study was requested by the Fish and Wildlife Branch, B.C. Ministry of Environment when a proposed major logging haul road appeared to be in conflict with critical moose winter range. The B.C. Ministry of Forests plan to extend an existing road northward from Cariboo Lake along the Cariboo River floodplain. The floodplain area is considered one of the best moose winter range in the Quesnel Lake Public Sustained Yield Unit. The Fish and Wildlife Branch are concerned that the road extension will result in severe winter road kill and provide unrestricted access and increased legal and illegal hunting pressures which may be difficult to regulate. Consequently, the Fish and Wildlife Branch were interested in assessing alternative areas for the road, such as an upslope route above the critical valley bottom winter range. The Fish and Wildlife Branch have proposed that a wildlife management reserve be placed on the critical winter range (Beets, 1979).

The purpose of this study was to ascertain the main soil and terrain constraints which affect road construction in the valley area. Physical characteristics of the land which affect road construction are described for each land area mapped; this package of map and report information with selected engineering interpretations will provide forest engineers and planners with additional information which can be used as a preliminary assessment of alternative routes. It is recognized that detailed assessments of route options and actual route locations must be done by qualified engineers in conjunction with resource managers responsible for making the difficult trade-off decisions between important timber and wildlife values. Nevertheless, the data base provided here can serve as a guide for assessing options.

1.2 STUDY AREA LOCATION

The study area is located approximately 100 km northeast of Williams Lake, 160 km southeast of Prince George and 90 km due east of Quesnel (see Figure 1). The area surveyed covers approximately 110 km^2, extending nearly 25 km north of Cariboo Lake and two to three km on both sides of the Cariboo River. The study area is located on National Topographic System (NTS) map sheet 93A/14.

1.3 PHYSIOGRAPHY

The Cariboo River area lies within the Quesnel Highland of the Interior Plateau (Holland 1976). The Quesnel Highlands have upland areas which are remnants of a highly dissected plateau of moderate relief. The upland areas are above 1500 m with the higher summits such as Roundtop Mountain and Mount Kimball being approximately 2000 m in elevation. Most of the summits were rounded by Pleistocence ice which covered most of the high areas during the last glaciation.

The Cariboo River dissects the highlands in a northeast/southwest direction. Cariboo Lake is at 810 m elevation at the south end of the study area, with the Cariboo River rising 30 m to 840 m elevation in the north end of the study area at Limestone Creek.

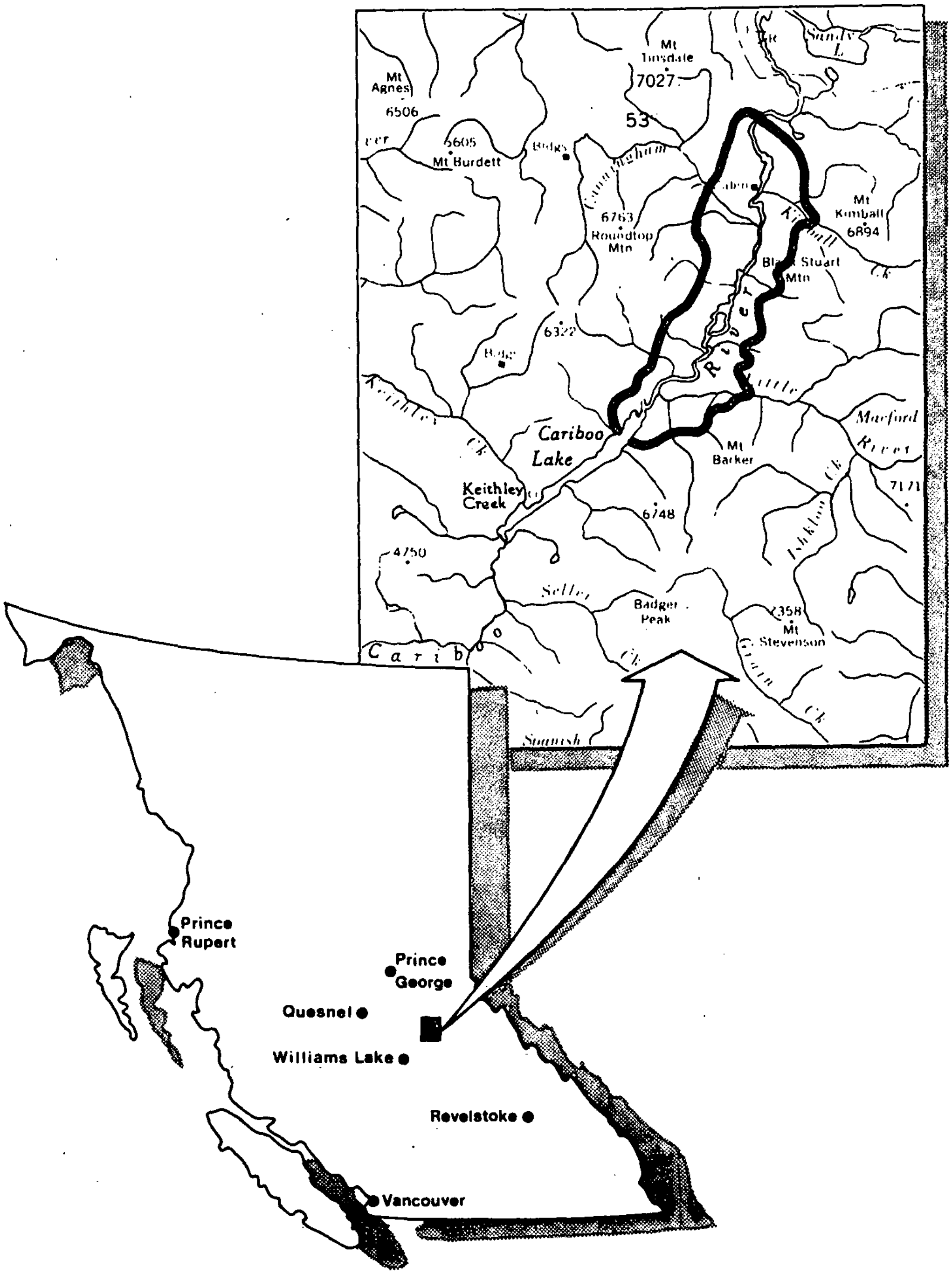

Figure 1: General Location of Study Area

1.4 BEDROCK GEOLOGY

The Geological Survey of Canada's open file map (#574) for the Quesnel Lake map sheep (93A) indicates that the study area dominantly contains fine-grained metamorphic bedrock (argillite, shale, phyllite, schist) with local outcroppings of limestones, quartzite, chert, greywacke and siltstone.

1.5 CLIMATE

There are no climate stations in the study area. The nearest climate station at Likely has only been operational since 1974; thus long term averages have yet to be calculated. The Cariboo River study area should be climatically drier and warmer than the higher-elevation station at Barkerville to the north, and wetter and cooler than the lower-elevation Horsefly station to the south. Some climatic data for these two stations are presented in Table 1 below:

TABLE 1: AVERAGE CLIMATIC DATA FROM HORSEFLY AND BARKERVILLE

Station	Elev. (m)	Annual Precip. (mm)	May-Sept. Precip. (mm)	Annual Snowfall (cm)	Mean Jan. Temp (0°C)
Horsefly	788	703	378	193	-8.7
Barkerville	1274	1149	474	581	-9.8

Source: Atmospheric Environment Service (1970).

1.6 VEGETATION

Annas and Coupe (1979) recently completed a report on the biogeoclimatic zones and subzones of the Cariboo Forest Region which includes the study area. Their map indicates that the lower elevations (approximately below 1200 m) of the Cariboo River study area lie within the wet subzone of the interior western hemlock biogeoclimatic zone (IWHb). This subzone corresponds more or less directly to the IWHb subzone described by Krajina (1969). Higher elevation areas lie within the wet subzone of the Engelmann spruce-subalpine fir zone (ESSFb).* This subzone is generally outside the area evaluated in this study. The IWHb subzone described by Annas and Coupe (1979) follows:

Heavy winter snowpack, which prevents the ground from freezing, and relatively high growing season precipitation allow western hemlock to successfully compete with most species in this subzone. Since western hemlock is an abundant tree species in this subzone and very shade tolerant, it forms the climax tree species on mesic sites. Mesic sites occur on medium-textured, moderately well drained soils on moderate slopes. The most common trees of the IWHb subzone are western red cedar (Thuja plicata), western hemlock (Tsuga heterophylla), white spruce (Picea glauca), Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta) and black cottonwood (Populus trichocarpa). Western yew (Taxus brevifolia) also occurs sporadically in the IWHb subzone.

* new symbol is ESSFh

Where the forest canopy is sufficiently open, the shrub and herb layers are well developed. The most common shrubs are Paxistima myrsinites, Vaccinium ovalifolium, V. membranaceum and Rubus parviflorus with Oplopanax horridus occurring on seepage sites. Herbs common to this subzone include Cornus canadensis, Linnaea borealis, Rubus pedatus, Tiarella trifoliata and Gymnocarpium dryopteris. Also, Lysichitum americanum occurs infrequently in this zone on wet sites.

Where the canopy is sufficiently closed on mesic sites a nearly continuous carpet of mosses occurs. The most common of these being Hylocomium splendens, Pleurozium schreberi, Rhytidiopsis robusta and Ptilium crista-castrensis with the lichen Peltigera apthosa also being common.

1.7 LAND CAPABILITY

Some general comments on land capability for recreation, waterfowl and ungulates are presented based on Canada Land Inventory (CLI) maps for the study area. Some preliminary observations on agriculture and forestry capability are also provided based on Canada Land Inventory maps in nearby areas. Comparisons of land capability for each soil type are given in general terms in Section 4.4.

Recreation Capability

The Cariboo River area and Cariboo Lake shoreline were recognized by Benn and Yeomans (1970) as having moderately high to moderate capability (CLI Classes 3 and 4) for outdoor recreation. A wide range of water-based recreational features were responsible for this regionally significant capability rating. Recreational opportunities in the study area include angling, beach use, canoeing, lodging and camping.

In contrast, upslope areas in the valley were generally rated as having a low capability (CLI Class 6) for recreation due to the limited features and opportunities for recreational use.

Waterfowl Capability

The marshes along the Cariboo River in the study area were mapped by Taylor and Carreiro (1967) as CLI Class 3M. This indicates that the area is not important for waterfowl production, but is important as a migration or wintering area. Few such areas exist in the region. Surrounding upland areas have very severe limitations (CLI CLass 7) for waterfowl due to adverse topography.

Ungulate Capability

The Cariboo River marshes were rated by the B.C. Land Inventory as being extremely important winter range (CLI CLass 1W) for moose. This is the highest rating given to ungulates in the region. Areas surrounding the marshes and Cariboo Lake are classed as important winter range (CLass 3W).

Further upslope of this fringe area snow depths limit ungulate use in the winter time. These forested uplands are rated as CLI Class 5 areas for moose and caribou. High elevations lying in alpine and subalpine areas have CLI Class 4 for moose and caribou.

Agriculture Capability

Agriculture capability assessments or maps have not been prepared for the study area. However, on the basis of climate capability for agriculture map 93A/NW (B.C. Land Inventory 1974), only low capabilities exist. Land adjacent to Cariboo Lake, to the south of the study area, are rated climate capability class 4, with severe limitations due to danger of frost during the growing season. The study area itself, adjacent to the Cariboo River, and including most of the area below 1200 m elevations, is rated climate capability class 5 for agriculture due to insufficient heat units (growing degree days) and short frost-free period. Higher elevation areas have climate capability classes 6 and 7 due to low temperatures during the growing season which severely limits heat unit accumulation.

In addition to these climatic limitations on agricultural capability, soil conditions impose additional limitations on land capability for agriculture. For example, some Cariboo River floodplain soils are also limited by frequent flooding, active river erosion, and excess soil moisture. Upslope forested areas are also limited by stoniness and adverse topography.

Forest Capability

Although forest capability maps have not been prepared for the study area, the map sheet just north of the study area (93H/3) has been mapped by the B.C. Land Inventory. In addition, Annas and Coupe (1979) provide an assessment of forest capability for each of their biogeoclimatic subzones.

Most forest land within the wet subzone of the interior western hemlock biogeoclimatic zone have moderately high capability (CLI Class 3) for forestry, although some high capability (Class 2) and moderate capability (Class 4) areas also exist. In terms of timber production, this subzone is the most productive in the region. Many of the stands in this subzone are, however, mature or overmature with both hemlock and cedar exhibiting a very high level of heart rot (Annas and Coupe 1979).

Further upslope, in the wet subzone of the Englemann spruce - subalpine fir biogeoclimatic zone, forest capability is generally moderately low (CLI Class 5), although some moderate capability and low capability (CLI Class 6) areas also exist.

The Cariboo River floodplain and adjacent fan deposits from tributary rivers and creeks probably have a wide range of forest capability. In poorly drained areas, excess soil moisture severely restricts forest growth and low to very low capabilities (Class 6 to 7) for forestry are anticipated. Some imperfectly to moderately well drained soils probably have the highest capability for forestry in the study area, probably Class 2.

CHAPTER TWO
SOIL MAPPING AND SURVEY METHODS

2.1 SURVEY PROCEDURES

Prior to field work, soil map units were delineated on 20 chain (approximate scale = 1:16 000) aerial photographs. An existing reconnaissance soils map (scale 1:50 000) prepared by Lord (1975) was utilized to aid map unit delineations and in the initial development of a soil legend.

A one-day field survey by helicopter provided limited field checking of air-photo interpretation. Soils were examined at eleven stops, with samples taken to determine engineering properties of parent materials.

Following field examination, the soils legend and soil mapping was finalized. Map unit boundaries were transferred to 1:50 000 topographic base map for compilation. The soils map and legend are located in the back pocket of this report.

2.2 MAPPING METHODS

Soils in the study area were mapped and described on the basis of surficial materials, drainage, texture, depth-to-bedrock, soil subgroup and slope. Landscape features observed on aerial photographs were used to delineate map units and in inferring these soil characteristics. In addition, information from sites actually visited on the ground were extrapolated to similar landscapes.

Soil map symbols contain a capital letter indicating surficial material (C = colluvium; F = fluvial; M = morainal; O = organic; R = bedrock). A number is used, when necessry, to indicate additional differences such as depth-to-bedrock or flooding hazard. A small "x" follows in areas where seepage is suspected.

A number in the denominator of each map unit symbol indicates slope. The percent slopes for each number are indicated on the map legend in the back pocket.

An example of a map symbol is shown on the legend attached to the soil map (see back pocket).

CHAPTER THREE
SOILS RESOURCES

The soil resources of the study area are discussed in relation to the parent materials from which they have developed. Four major types of soil parent materials (surficial materials) were identified in the study area: morainal, colluvial, fluvial and organic. These parent materials and their distribution are discussed below. Additional information is shown on the map legend which accompanies the soil map located in the back pocket and on Table 2. Definitions used for surficial materials are according to the Terrain Classification System (Resource Analysis Branch, 1976).

3.1 MORAINAL SOILS

Morainal (till) materials refer to materials deposited directly from glaciers. The loamy texture of the till material reflects the underlying bedrock which is dominantly fine-grained metamorphic bedrock. Coarse fragment content is generally less than 20%.

Morainal deposits are the dominant materials between 900 m and 1050 m. The Cariboo River appears to have undercut morainal materials adjacent to the floodplain resulting in steeper slopes (30-60%) and many small gullies.

Most till deposits are moderately well to well drained, however, in lower slope (receiving) landscape positions, seepage from above may result in imperfect drainage conditions. Devil's club (Oplopanax horridus) is a good indicator plant for the presence of seepage.

3.2 COLLUVIAL SOILS

Colluvial materials are products of mass wastage and have reached their present position by direct, gravity-induced movement. The loamy texture of colluvium in the study area reflects the fine-grained metamorphic bedrock from which it was derived. Coarse fragment content is generally greater than 20%.

Colluvium is the dominant material above 1050 m elevation; it usually occurs on steep slopes exceeding 46%. Nearly all of the colluvium in the study area occurs on forested slopes as either a blanket of material (depth-to-bedrock exceeds one metre) or a veneer (depth-to-bedrock less than one metre).

Most colluvial deposits are well to rapidly drained; they usually occur in normal or shedding landscape positions.

3.3 FLUVIAL SOILS

Fluvial materials are deposits which have been transported and deposited by streams and rivers; they may or may not be subject to flooding.

Active fluvial materials are those floodplain and fan deposits which are subject to periodic flooding. Floodplain soils are generally level and, in the study area, appear to be dominantly silty in

TABLE 2: SOIL TYPE CHARACTERISTICS AND SELECTED ENGINEERING INTERPRETATIONS

Soil Type	Surficial Materials	Textural Classification CDA[1]	Unified[3]	AASHO[3]	Drainage	Flooding	Depth to Bedrock	Slope Range	Soil[1] Subgroup	Soil[2] Name	Value as[3] Subgrade	Sand or[3] Gravel Source	Limitations[3] for Logging Roads
C1	Colluvium (blanket)	gravelly loam to sandy loam	SM	A-2 A-2-4	well to rapidly drained	none	> 1 m	46-100%	O.HFP	Bearpaw Ridge	Good to Fair	Poor	Moderate to severe: slope
C2	Colluvium (veneer)	gravelly loam to sandy loam	SM	A-2 A-2-4	well to rapidly drained	none	< 1 m	> 31%	O.HFP	Bearpaw Ridge	Good to Fair	Unsuited	Moderate to severe: slope
F1	Active Fluvial (flood-plain)	silt to silt loam	ML	A-4	imperfectly to poorly drained	occasional to frequent	> 3 m	< 5%	GL.R R.G.	McGregor	Poor to Fair	Unsuited	Moderate to severe: drainage, flooding, subgrade
F2	Active Fluvial Fans	gravelly sandy loam to loamy sand	SM, SW GM	A-1	imperfectly to moderately well drained	occasional to frequent	> 3 m	< 15%	GL.R CU.R	---	Good to Fair	Good to Poor	Moderate: flooding, drainage
F3	Inactive Fluvial & Glacio-Fluvial blankets	gravelly sand loam to loamy sand	SW, SM	A-1	moderately well to rapidly drained	none	> 3 m	< 70%	O.HFP	Tumuch Fontaniko	Good to Fair	Good to Poor	Slight to moderate: slope
F4	Fluvial Terraces	gravelly sandy loam to loamy sand	GW,GM SW,SM	A-1	well to rapidly drained	none	> 3 m	< 10%	O.HFP	Ramsey	Excellent to Good	Good to Poor	Slight
M1	Morainal (till)	loam to silt loam	SM, SC	A-4, A-2	moderately well to well drained	none	> 0.5 m	10-60%	O.HFP	Captain Creek	Fair to Good	Unsuited	Slight to moderate: slope
M1x	Morainal (till)	loam to silt loam	SM, SC	A-4 A-2	imperfectly to moderately well drained	none	> 0.5 m	10-30%	GL.HFP O.HFP	Captain Creek	Fair to Good	Unsuited	Moderate: drainage, slope
O	Organic	--	Pt	--	poorly to very poorly drained	frequent, none	> 3 m	> 5%	Organic order	--	Unsuited	Unsuited	Severe: drainage, subgrade
R	Bedrock	--	--	--	--	none	--	> 46%	--	--	Unsuited	Unsuited	Severe: rock, slope

[1] Soil Subgroup symbols according to Canada Soil Survey Committee's (1978) The Canadian System of Soil Classification

O.HFP = Orthic Humo - Ferric Podzol
GL.HFP = Gleyed Humo - Ferric Podzol
GL.R = Gleyed Regosol
CU.R = Cumulic Regosol
R.G = Rego Gleysol

[2] Soil name as indicated by Lord's (1975) existing reconnaissance map for 93A/14

[3] These interpretations discussed in Chapter 4

texture with few coarse fragments observed. Drainage is generally imperfect to poor due to high water tables.

Active fluvial fan deposits generally occur on less than 15% slopes and originate from the many tributary creeks that enter the Cariboo River, such as Cunningham and Kimball Creeks. The apex of most fan deposits (near the creek channel) is coarse-textured and most subject to periodic flooding, while the apron of the fan occurs on gentler slopes, consists of finer-textured materials and is less subject to flooding. Most fans are imperfectly to moderately well drained due to seasonally high water tables.

Inactive fluvial deposits occur above contemporary floodplains; many of these deposits are glaciofluvial since they were originally deposited in contact with glaciers. Most of these deposits occur below 900 m on a variety of slopes. Fluvial terraces have nearly level slopes and are well suited, in terms of their physical characteristics, for most engineering uses. Fluvial blankets (often over till) and hummocks occur on steeper slopes. Most inactive fluvial deposits are well-drained and consist dominantly of sands and gravels.

3.4 ORGANIC SOILS

Organic soils have resulted from accumulation of organic matter. In the study area, these deposits occur on the Cariboo River floodplain and in small, localized areas on the benches above the floodplain. Most organic soils have few, if any, trees growing on them. Poor to very poor drainage due to high water tables limits tree establishment. Topography is usually level.

Note:

Lacustrine deposits (sediments that have settled from suspension in bodies of standing freshwater) were not observed during this study. Watt (pers. comm.) reports that such deposits occur adjacent to the Cariboo River and have been encountered during construction of the forest road in the Little River drainage. These deposits are likely small in areal extent at the scale of mapping (1:50 000), and probably occur as unmapped inclusions. Nevertheless, they may be important from a road construction standpoint (see Section 4.3).

CHAPTER FOUR
SOIL INTERPRETATIONS

Soil types are interpreted in this chapter for selected engineering uses. The general methods used to develop these interpretations are presented here, while the actual interpretations for the selected uses are given in Table 2 as well as on the soil map legend located in the back pocket of the report. Section 4.4 provides some broad comparisons of land capability for each soil type. This information may be of use in resource planning.

The first step in assessing soil characteristics with respect to engineering uses was to determine soil texture according to established engineering soil classification systems.

4.1 ENGINEERING SOIL CLASSIFICATION SYSTEMS

The two systems most commonly used in classifying soils for engineering are the Unified system used by most engineers and the AASHO system adopted by some highway officials. The relatively unweathered parent materials for each soil were sampled at approximately 1 m depth to determine Unified and AASHO classes.

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit and organic matter. Fifteen soil classes are recognized: there are eight classes for coarse-grained soils, identified as GW, GP, GM GC for gravelly materials and SW, SP, SM and SC for sandy materials; six classes for fine-grained soils, identified as ML, CL, OL, MH, CH and OH and one class of highly organic soils identified as Pt.

Many engineering characteristics can be inferred from the Unified soil class, including value as subgrade, shear strength, compressibility and expansion characteristics, compaction characteristics and frost action potential. These inferred engineering characteristics are presented on Table 3 for each Unified soil class. Unified soil classes are indicated for each soil type on the soil legend.

The AASHO system is used in classifying soils according to those properties that affect use in road construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A-1 to A-7 on the basis of grain-size distribution, liquid limit and plasticity index. In group A-1 are gravelly soils of high bearing strength, the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest mineral soils for subgrade. AASHO soil classes are indicated for each soil type on the soil legend (see back pocket).

For more detail on both the AASHO and Unified systems, refer to Asphalt Institute (1969) and U.S.D.A. Soil Conservation Service (1971).

TABLE 3: ENGINEERING CHARACTERISTICS OF UNIFIED SOIL GROUPS[1]

Unified Soil Class	Value as Subgrade	Shear Strength	Compressibility and Expansion	Compaction Characteristics	Frost Action Potential
GW	Excellent	High	Almost none	Good	None to very slight
GP	Good to excellent	High	Almost none	Good	None to very slight
GM	Good to excellent	High to medium	Very slight to	Good	Slight to medium
GC	Good	Medium	Slight	Fair	Slight to medium
SW	Good	High	Almost none	Good	None to very slight
SP	Good to fair	Medium	Almost none	Good to fair	None to very slight
SM	Good to fair	Medium	Very slight to medium	Good to fair	Slight to high
SC	Fair to good	Medium to low	Slight to medium	Fair	Slight to high
ML	Fair to poor	Medium to low	Slight to medium	Fair to poor	Medium to very high
CL	Fair to poor	Medium to low	Medium	Fair to good	Medium to high
MH	Poor	Low	High	Poor to very poor	Medium to very high
CH	Poor	Low	High	Fair to poor	Medium
OL	Poor	Low	Medium to high	Fair to poor	Medium
OH	Poor to very poor	Low	High	Poor to very poor	Medium
Pt	Unsuitable	Very low	Very high	Fair to poor	Slight

[1] This chart is adapted from similar tables presented by the USDA Soil Conservation Service (1971), the USDI Bureau of Land Management and the Asphalt Institute (1969).

4.2 ENGINEERING INTERPRETATIONS

Interpretations are provided on the soil map legend and in Table 2 for each soil type's value as subgrade, suitability as a source of sand and gravel, and limitations for logging roads.

Value as Subgrade

The general suitability of different soils for use as road subgrade is based solely on the materials Unified soil classification (Table 3). Soils are rated either excellent, good, fair, poor or unsuited. Characteristics such as slope, drainage, and bedrock are not considered in this rating.

Suitability for Sand and Gravel

These ratings are designed to indicate the probability of sizeable quantities of sand and/or gravel. The main purpose of the ratings is to guide users to local sources since these materials are less expensive to transport. Good or fair suitabilities must have probable sources of sand or gravel greater than one metre thick. Table 4 indicates how the Unified soil classification is used to develop the ratings.

TABLE 4: GUIDE FOR ASSESSING SOIL SUITABILITY FOR SAND AND GRAVEL[1]

	GOOD	FAIR	POOR	UNSUITED
Unified Soil Class	GW, GP SW, SP	SW-SM SP-SM GP-GM GW-GM	GM, GC SM, SC	All other groups
Depth to Bedrock	>200 cm	100-200 cm	50-100 cm	<50 cm

[1] Adapted from U.S.D.A. Soil Conservation Service (1971).

Soil Limitations for Logging Roads

Soil limitation ratings for unpaved logging roads were developed by modifying an existing guide by Craul (1975). The modified guide (Table 5) reflects the information base available in the study area. Craul discusses the importance of soil items affecting logging roads.

TABLE 5: GUIDE FOR ASSESSING SOIL LIMITATIONS FOR LOGGING ROADS[1]

Item Affecting Use	Degree of Soil Limitation		
	Slight	Moderate	Severe
Drainage	Rapidly, well and moderately well drained	Imperfectly drained	Poorly and very poorly drained
Flooding	None	Occasional (less than once in 5 years)	Frequent (more than once in 5 years)
Subgrade (a) AASHO Group Index	0-4	5-8	More than 8
(B) Unified Soil Classes	GW, GP, GM, GC, SW, SP, SM, SC	ML CL (PI<15)[2]	MH, CH, OH, OL, CL (PI<15)
Slope Percent (Slope Class)	0-15% (1, 2, 3, 4, 5)	16-70% (6, 7, 8)	> 70% (9, 10)

[1] Adapted from Craul (1975).

[2] PI refers to the Plasticity Index.

Limitation ratings indicate the relative cost and difficulty in constructing and maintaining logging roads. Soils rated as having severe limitations do not imply that logging roads cannot or should not be constructed, but does indicate that construction and maintenance costs are likely to be high and alternative routes should be considered.

4.3 DISCUSSION

Inactive fluvial and glaciofluvial deposits (soil types F3 and F4) are physically suitable for logging roads. On gentle slopes, such as terraces (F4), they have few or no limitations for logging roads. Slope limitations exist on the steeper topography associated with fluvial blankets and hummocky glaciofluvial deposits (F3). These deposits are also usually good aggregate sources.

Active fluvial fans (F2) have moderate limitations for logging roads due to potential flooding and areas with imperfect drainage. They can be fair sources of sand and gravel provided care is taken to minimize the amount of sediments in streams.

Floodplain soils (F1) have moderate to severe limitations for logging roads depending on flooding frequency and drainage (wetness) limitations. Their silty textures render these deposits as unsuitable sources of sand and gravel.

Morainal (till) soils (M1) generally have moderate limitations for logging roads. Fair to poor subgrade, and moderate slopes are the main limitations. Morainal soils present engineering stability problems on moderate to steep slopes (Krajczar, pers. comm.).

Colluvial soils (C1 and C2) have moderate to severe limitations for logging roads due to steepness of slopes. Slopes exceeding 70% require substantial cuts and fills which increase road construction costs. In the study area, the metamorphic bedrock is relatively easy to rip and no additional limitations were assigned to the colluvial veneers which are shallow-to-bedrock. In fact, where hazards associated with mass movement are suspected, deliberately routing logging roads on more stable bedrock may be desireable.

Organic soils (O) are ill-suited for all engineering uses due to unsuitable subgrade, and poor drainage. Along the Cariboo River, flooding hazard is an additional major constraint.

As previously mentioned, lacustrine deposits have been reported in the study area (Watt, pers. comm.). These deposits probably occur as unmapped inclusions at the scale of mapping (1:50 000). Where they occur on valley sides, they pose severe limitations for logging roads due to poor subgrade conditions and steep slopes.

4.4 GENERALIZED LAND CAPABILITY OF MAP UNITS

Table 6 indicates the general land capability of each soil type for agriculture, forestry, recreation, waterfowl and ungulates based on relationships derived from existing Canada Land Inventory maps in the study area or adjacent areas as discussed in Section 1.7. The general capabilities indicated are broad averages for the each soil; individual sites where these soils have been mapped may deviate from the capabilities indicated. For the purposes of providing general capability ratings, the seven C.L.I. classes are grouped as high (classes 1 and 2), moderate (classes 3 and 4), low (classes 5 and 6), and nil (class 7).

TABLE 6: GENERALIZED LAND CAPABILITY OF SOIL TYPES[1]

Soil Type	Agriculture	Forestry	Recreation	Waterfowl	Ungulates	Engineering[2]	General Comments
C1	Low to Nil	Moderate	Low	Nil	Moderate to Low	Moderate to Low	Few resource conflicts anticipated in these areas; moderate to low capabilities exist for most uses
C2	Low to Nil	Moderate to Low	Low	Nil	Moderate to Low	Moderate to Low	Few resource conflicts anticipated in these areas; moderate to low capabilities exist for most uses
F1	Low to Moderate	High to Low	Moderate	Moderate	High	Moderate to Low	High to moderate capabilities for a number of uses may result in serious resource conflicts
F2	Low to Moderate	High to Moderate	Moderate	Nil	High	Moderate	High to moderate capabilities for a number of uses may result in serious resource conflicts
F3	Low	Moderate	Moderate to Low	Nil	Moderate	High to Moderate	Some resource conflicts may result since moderate capabilities exist for most uses
F4	Low	Moderate	Moderate to Low	Nil	Moderate	High	Some resource conflicts may result since moderate capabilities exist for most uses
M1	Low	High to Moderate	Low	Nil	Moderate to Low	Moderate	Few resource conflicts anticipated in these areas; moderate to low capabilities exist for most uses
O	Low	Nil	Moderate	Moderate	High	Low	Few conflicts anticipated in these areas; moderate to low capabilities exist for most uses
R	Nil	Nil	Low	Nil	Low	Low	Very few resource conflicts anticipated due to low capabilities

[1] C.L.I. Classes 1-2 rated high
C.L.I. Classes 3-4 rated moderate
C.L.I. Classes 5-6 rated low
C.L.I. Class 7 rated nil

[2] Engineering capability assessed according to the severity of limitations affecting use for logging roads, where
high = slight limitations low = severe limitations
moderate = moderate limitations
(see Table 2)

In addition, for comparative purposes, the engineering interpretations provided in Section 4.2 are generalized in order to provide an overall rating of high, moderate, or low capability for most engineering uses.

General comments are given on Table 6 for each soil type which summarize apparent land use conflicts. Areas with a potential for many conflicts (e.g. floodplain soils) due to high values for a number of resources require greater attention than areas with few apparent resource conflicts (e.g. colluvial and morainal soils). When possible, developments such as roads should avoid areas with a potential for several resource conficts.

CHAPTER FIVE
ROUTE OPTIONS

Two route options for a log hauling road from Cariboo Lake to Kimball Creek have been proposed. The B.C. Forest Service route would follow the extreme east side of the Cariboo River floodplain at the base of the forested slopes between 820 and 860 m in elevation. This route would be on the border between the C.L.I. Class IW ungulate capability lands on the floodplains and adjacent C.L.I. Class 3W lands.

Due to the affect that this route would have on overwintering moose, the B.C. Fish and Wildlife Branch have proposed an alternative route to the east of the Forest Service route, on the benchlands upslope of the floodplain. The Fish and Wildlife road option would largely lie between 1000 m and 1060 m in elevation. This route would be above the high value moose winter range and occur on lands rated C.L.I. Class 5 for ungulates.

The objective of this soil survey is to provide forest engineers and planners with additional information on the physical characteristics of lands which these and other possible route options may encounter. This information base may permit better estimates of the costs of constructing and maintaining a log hauling road for each option.

Both route options are located by a dotted line directly on the soils map. By using the soil legend which contains selected engineering interpretations (e.g. soil limitations for logging roads) a general physical assessment of route options is possible on a map unit by map unit basis.

Table 7 summarizes the dominant soil conditions and limitations encountered for each route option from Little River to Kimball Creek. Each route option has some advantages and disadvantages.

The B.C. Forest Service proposed route traverses more map units which potentially contain sand and gravel and are considered more suitable as road subgrade. However, it also crosses over steep colluvial slopes where greater cut and fill is required and where bedrock ripping may be necessary. Once constructed, however, bedrock is considered a stable and firm subgrade for roads. The active fluvial fans encountered have good subgrade, but are limited by flooding and drainage. Lacustrine deposits have been reported which are additional limitations for road construction.

The B. C. Fish and Wildlife Branch proposed route mainly traverses over morainal deposits on moderate slopes. The subgrade of the morainal material is not as suitable as the coarser-textured fluvial material. A sizeable aggregate source exists approximately 2 km north of Little River; no other sources were observed until Kimball Creek. Gullies exist on the morainal slopes which are additional limitations for road construction.

Translating soil limitations to an estimate of road construction costs is beyond the scope of this study. Road engineers will have to use the additional information provided by a soil survey as an aid in determining what the actual costs for each route alternative are. For example, overcoming slope limitations may (or may not) be deemed less costly than subgrade limitations. On the basis of this study, there are few severe soil limitations associated with either route and thus both appear feasible.

In addition to the costs of constructing a road, many (perhaps more important) other factors must also be considered. Which road is providing the best access to commercial stands of timber? What is the hauling time associated with each road? How do yarding systems match road location? Complete road layout options to extract timber are not indicated; this should be a major factor in the decision on which road to use. If there are additional disadvantages to the proposed Fish and Wildlife Branch route, how do these compare to the advantages of not encroaching on important moose winter range and recreation features associated with the Cariboo River floodplain?

TABLE 7: GENERAL EVALUATION OF SOIL LIMITATIONS FOR LOGGING ROADS ENCOUNTERED ON TWO ROUTE OPTIONS

B.C. Forest Service Route Option[1]		B.C. Fish and Wildlife Branch Route Option	
Dominant Map[2] Units Encountered	Limitations for Roads	Dominant Map[2] Units Encountered	Limitations for Roads
$\frac{\text{C1/C2}}{8}$, $\frac{\text{C1/M1}}{8}$	Moderate: slope	$\frac{\text{M1}}{567}$, $\frac{\text{M1/C1}}{678}$[3]	Moderate: slope
$\frac{\text{F34}}{3456}$	Slight to moderate: slope	$\frac{\text{F3}}{56}$	Slight to moderate: slope
$\frac{\text{F2}}{23}$	Moderate: flooding, drainage		
$\frac{\text{M1}}{67}$, $\frac{\text{M1/F3}}{7}$	Moderate: slope		
$\frac{\text{C2/R}}{9}$	Severe: slope, rock		

1 Assumes road will not be constructed on floodplain as stated by Krajczar (pers. comm.); lacustrine deposits have been reported (Watt, pers. comm.) which pose additional limitations.
2 Map units listed in order of dominant occurrence.
3 Gullies exist on these morainal slopes which pose additional limitations.

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