No. 2

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 43

MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 5

LIARD CANYON (Lower) DAM SITE

(MAP AND PRELIMINARY REPORT)

BY

E. B. OWEN

OTTAWA

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LIARD CANYON (LOWER) DAM SITE

General Description

The Lower site at Liard Canyon is located on Liard River about 6 miles southeast of the community of Watson Lake Wye, Yukon Territory. The boundary between the province of British Columbia and Yukon Territory (60th parallel) crosses the upstream part of the site area. The approximate location of the boundary has been indicated on the accompanying geological map. The proposed site is accessible by walking along the boundary from Alaska Highway some one and a quarter miles to the east.

The Lower site is situated near the downstream end of the canyon. An alternate site, designated as Liard Canyon (Upper) dam site is located about one mile upstream. The Upper site is described in Topical No. 42, site No. 4.

At the Lower site, Liard River is flowing in a southeast direction between two steep, rocky bluffs which rise almost vertically from the edges of the river. The bluffs vary considerably in height. That along the left side of the river is 50 to 90 feet high, whereas the bluff on the opposite side reaches a maximum height of about 170 feet. The width of the river, which has a 5-foot drop as it passes through the site area, varies between 200 and 450 feet.

Bedrock exposed at the site consists of thin-bedded, sedimentary rocks similar to those occurring at the Upper site. It is exposed continuously on the bluff along the left side of the river. Above this bluff a narrow, bedrock terrace, the elevation of which is 2,025 feet above sea level, extends northeast to the toe of a second bluff which passes upward beyond the limits of the area mapped.

Several narrow, steep-walled valleys, parallel to the schistosity of the underlying bedrock, are incised into the terrace. They are probably the result of differential weathering of the rock and consequent erosion by small, intermittent streams originating along the toe of the adjacent bluff. Contours on the accompanying geological map show up the valleys distinctly. They do not enter Liard Canyon at grade but hang many feet above it in the canyon wall.

Much of the bluff along the right side of the river is covered with a thin layer of talus and residual soil. Above the bluff there is a narrow, bedrock terrace, 100 to 300 feet in width, with an elevation of about 2,035 feet. This terrace extends to the toe of a second bluff above which there is another terrace with an elevation of 2,110 feet. The upper terrace extends southwest beyond the limit of the area mapped. Material exposed on the terrace surface consists of silt, sand and gravel with a few, small bedrock outcrops. There is no shortage of construction materials in the area about the site with the exception of riprap and rock fill.

Unconsolidated Deposits

Three types of unconsolidated deposits were identified in the area about the Lower site at Liard Canyon. They are similar to those occurring at the Upper site and have been described in some detail in the report on that site (Topical Report No. 42, site No. 4).

1. Talus and Residual Soil: A thin layer of talus and residual soil occurs on both walls of the canyon. It is more extensive on the right side where it covers about 75 per cent of the bluff. The material ranges from clay-size particles resulting from the decomposition of bedrock to boulders 24 inches in diameter. Much of the material consists of pebbles and cobbles

up to 6 inches in diameter. The shape of the rock fragments is usually platy reflecting the influence of the thin-bedded, parent rock. It is not believed the talus would provide satisfactory riprap or rock fill.

2. Glacio-lacustrine (silt): This material consists of a thin deposit of yellowish-brown silt which covers much of the surfaces of the terraces on both sides of the river. In some places it has slumped onto the adjoining bluffs. In places it directly overlies glacio-fluvial sand and gravel. The silt deposit is extensive but is not believed to exist in sufficient quantities to be useful.

3. Glacio-fluvial (silt, sand, gravel): This material consists of fine- to medium-grained, silty sand interbedded with lesser quantities of coarse, well-graded, sandy gravel containing boulders up to 12 inches in diameter. Much of the sand and gravel exposed in the upper bluff northeast of the river consists of this material. Similar gravel occurs southwest of the river. Here it contains many cobbles and boulders of porous, volcanic rocks some of which are scattered among the talus deposits along the wall of the canyon. The permeability of the gravel is undoubtedly high.

Bedrock

General Description

Bedrock occurring at the site consists of thin-bedded limestone, shale and sandstone which, in many places, have been altered to a soft, grey, calcareous schist of low durability. The rock is highly contorted and fractured and cut by numerous, irregular seams and veins of quartz and calcite. Weathering is extensive especially along the numerous fault zones.

Bedrock Structures

The attitudes of the various bedrock structures at the Lower site at

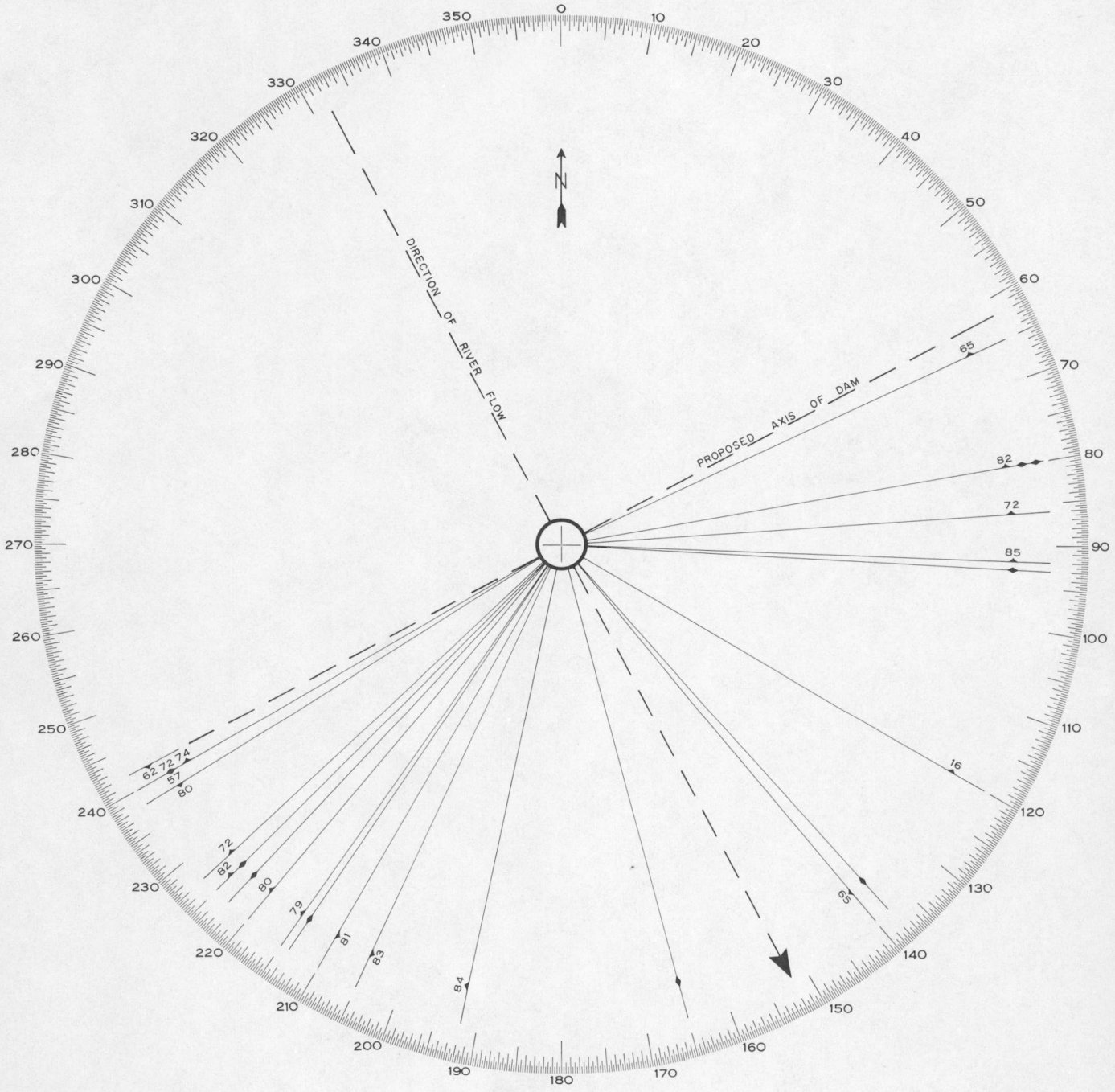
Liard Canyon are similar to those at the Upper. The direction of the river, however, has changed from a south to a southeast direction and, as a result, the angles at which the faulting and other structures intersect the river at the Lower site are different to those at the Upper.

Faulting is common throughout the Lower site area especially in the downstream part of the right wall of the canyon. The faults vary in strike from south 25 degrees east to south 20 degrees west and intersect the river at angles from zero to 45 degrees. The dips are extremely irregular. Clayey gouge up to 6 inches in thickness is frequently present along the shear planes. Bedrock adjacent to the gouge is usually badly broken and weathered. In many places it is covered with a thin coating of brown carbonate probably deposited by circulating groundwater. There is no doubt many of the fault zones are potential aquifers and could cause considerable leakage of reservoir water through the foundations and abutments of the dam. Bedding faults whose attitudes are parallel to the dip and strike of the strata occur in some places.

As at the Upper site, bedrock is tightly folded and highly contorted and consequently the attitudes of the bedding are extremely irregular. A rosette showing the relation of the bedding to the direction of flow of the river accompanies this report.

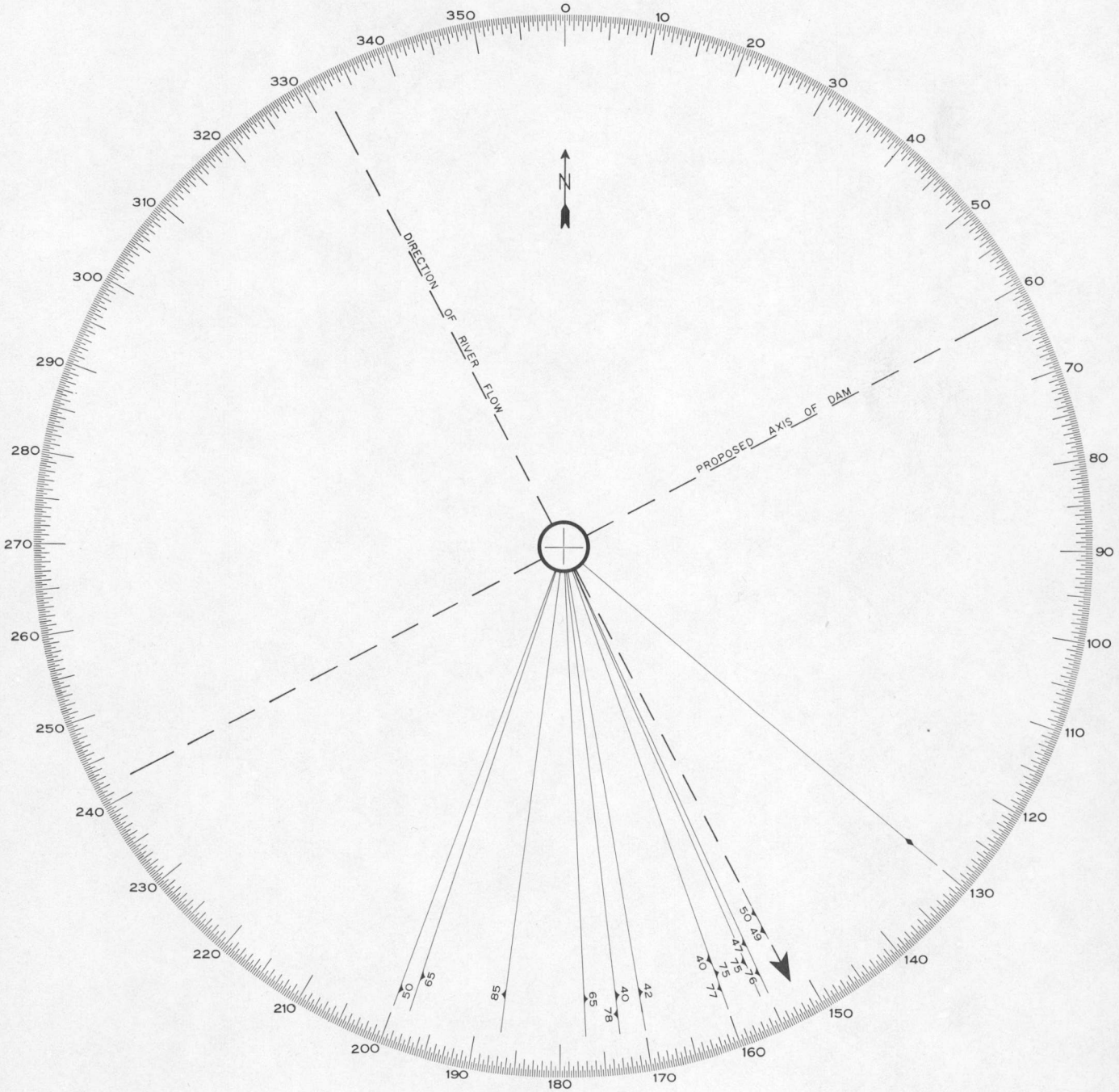
In general the jointing intersects the faulting and bedding at angles close to 90 degrees. The most prominent joint set strikes between north 10 degrees east and north 60 degrees east. The dips are usually steep toward the northwest. The set intersects the river at angles ranging between 45 and 90 degrees and dips generally upstream.

The considerable faulting and numerous, closely spaced joints present in bedrock has undoubtedly lowered its competency. However, the intersecting of the joint fractures with the faulting and folding suggests the rock could be grouted.



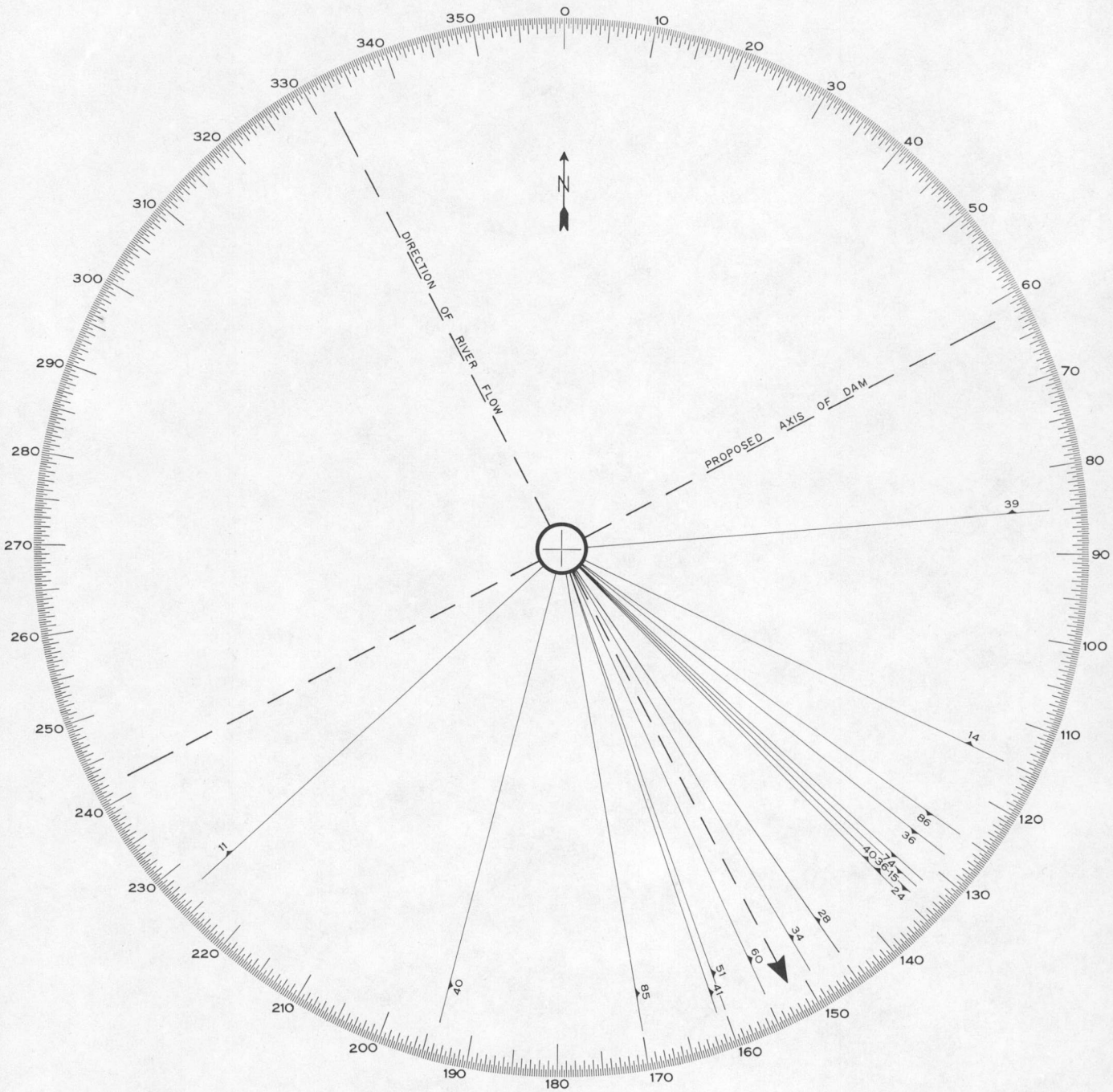
JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of the jointing in bedrock exposed at Liard Canyon (lower) dam site



FAULT ROSETTE

The above illustration presents diagrammatically the direction and dip of the faulting in bedrock exposed at Liard Canyon (lower) dam site



BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of the bedding in bedrock exposed at Liard Canyon (lower) dam site

Quality of Bedrock

Much of bedrock exposed at the site is badly shattered and distorted and is not believed suitable foundation or abutment material. This is especially true in the downstream part of the area mapped where many faults exist. The most competent rock occurs in the upstream part and it is in this area any further investigations should be made.

Engineering Considerations

Depth of Overburden

Overburden on both walls of the canyon consists of talus and residual soil along with small quantities of silt, sand and gravel which have slumped from the terraces above the bluffs. It is nowhere believed to be greater than 10 feet in thickness. Residual soil was encountered in several shallow test pits located on the terrace above the right wall of the canyon suggesting overburden here is thin.

The presence of several small, bedrock islands and shoals in the river indicates the thickness of overburden beneath the river is not great. However, it is possible a buried stream channel, eroded into bedrock beneath the river, exists at the site. Such a channel would be in the form of a narrow depression in bedrock surface located close to one of the canyon walls. It would probably be filled with permeable, alluvial material.

Abutments and Foundations

Much of bedrock exposed at the site will not provide suitable foundation and abutment material. The zones of broken rock associated with the faulting are potential aquifers and could cause considerable leakage of reservoir water. The presence of interbedded hard and soft rocks with thin layers of clayey gouge along bedding faults is significant in regard to

construction of an arch dam. Investigations should be made to determine if the rock has sufficient shear strength to resist the thrust of the arch. Lining would be an essential part of any diversion tunnel driven through these rocks.

Construction Materials

Aggregate

The glacio-fluvial material exposed on the lower terrace and bluff northeast of the river is a potential source of natural aggregate. The thickness of material on the terrace is probably not great but large quantities could be obtained from pits opened along the base of the bluff. The silt content of the material is relatively high and consequently it is suggested it be accurately sampled to determine the quality of the material available. The thin deposit of glacio-lacustrine silt overlying the gravel could be easily removed by stripping. The extensive deposits of glacio-fluvial sand and gravel described in the report on the Upper site could also be used as sources of natural aggregate for the Lower site. Grain size analyses curves for two representative samples taken from recently used pits on Alaska Highway near the site are included in this report. The curves were prepared in the soils laboratory of the Water Resources Branch in Vancouver.

Impervious Material

Sufficient quantities of material suitable for the impervious core of an earth-fill dam are not exposed in the area about the Lower site. The quantity of silt available on the terraces is limited. It is possible a dense, silty, sandy till may exist beneath the silt covering the terrace southwest of the river. Such material occurs beneath the silt covering a

similar terrace at the Upper site. The till is exposed in a cut on the east side of Alaska Highway where it crosses the British Columbia - Yukon Territory boundary. Other occurrences of similar material, all within 8 miles of the site, are described in the report on the Upper site.

Pervious Material

Material suitable for the pervious shells, filters or drains of an earth dam can be obtained from the gravel deposits described under the aggregate heading of this report and in the report on the Upper site.

Riprap and Rock Fill

Bedrock exposed at the site will not provide suitable riprap or rock fill. The most accessible sources of suitable material are described in the report on the Upper site.

Groundwater

There is little information concerning groundwater conditions in the area about Liard Canyon. Seepages were not observed in the canyon walls at either the Upper or Lower site. However, many of the rock fragments in the fault zones at the Lower site have a brown coating of iron-bearing carbonate probably deposited by circulating groundwater. Accurate information concerning the groundwater table can be only obtained by installing groundwater observation holes and measuring them at regular intervals.

Frozen Ground

On August 22, 1961, frozen silt was encountered about two feet below ground surface in a shallow test pit put down on the terrace southwest

of Liard River. The silt was overlain by about 12 inches of moss and decayed organic material. The location has been indicated on the accompanying geological map.

Further Investigations — Conclusions

The results of the investigations conducted at Liard Canyon indicate that, geologically, the Upper site is more favourable for construction of a dam than the Lower. Consequently it is believed any further investigations, such as a test boring program, should be centered in the area about the Upper site. However, because of the proximity of the two sites, the results of any tests made on construction materials for the Upper site could be used in assessing the potential of the Lower.

Comparison between Upper and Lower Sites at Liard Canyon

A comparison between the two alternate sites at Liard Canyon is contained in the report on the Upper site.

Chemical Analyses of Liard River Water

The results of chemical analyses of samples of Liard River water taken in 1952 and 1961 are included in the report on the Upper site.

Grain Size Analyses Curves

The grain size analyses curves included in this report were prepared in the Soils Laboratory of the Water Resources Branch in Vancouver. Each grain size sheet for potential aggregate shows the following information:

(a) Limits of coarse and fine aggregate based upon a 6-inch maximum size.

(b) A cumulative grain size curve for each sample.

(c) Curves showing the individual percentages of the coarse and fine fraction retained on each screen or sieve size. For these purposes the sample is divided at the No. 4 sieve into coarse and fine fractions. The samples (Nos. 43 and 44) described in this report were both analysed as potential aggregate.

Description of Potential Aggregate for the following Grain Size Analyses Curves

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
43	Small pit on southwest side of Alaska Highway at mile 616.4; 4 feet above pit floor; 5 feet beneath ground surface	Fairly well graded, sandy gravel; loose; dry; numerous hard, igneous boulders up to 12 inches in diameter; no clay; weathering confined to upper 8 inches Pebble and Cobble Lithology Igneous (granitic, volcanic) - 50% Sedimentary (sandstone) - 35% Metamorphic (gneiss, quartzite) - 10% Chert: black - 5%	None	9+ feet	Unlimited	Glacio-fluvial material; used in Highway maintenance.
44	Pit on southwest side of Alaska Highway 1/8 mile north of the community of Lower Post;	Material similar in appearance to that in sample No. 43	None	12+ feet	Unlimited	Glacio-fluvial material; groundwater at 12 feet; used in Highway maintenance.

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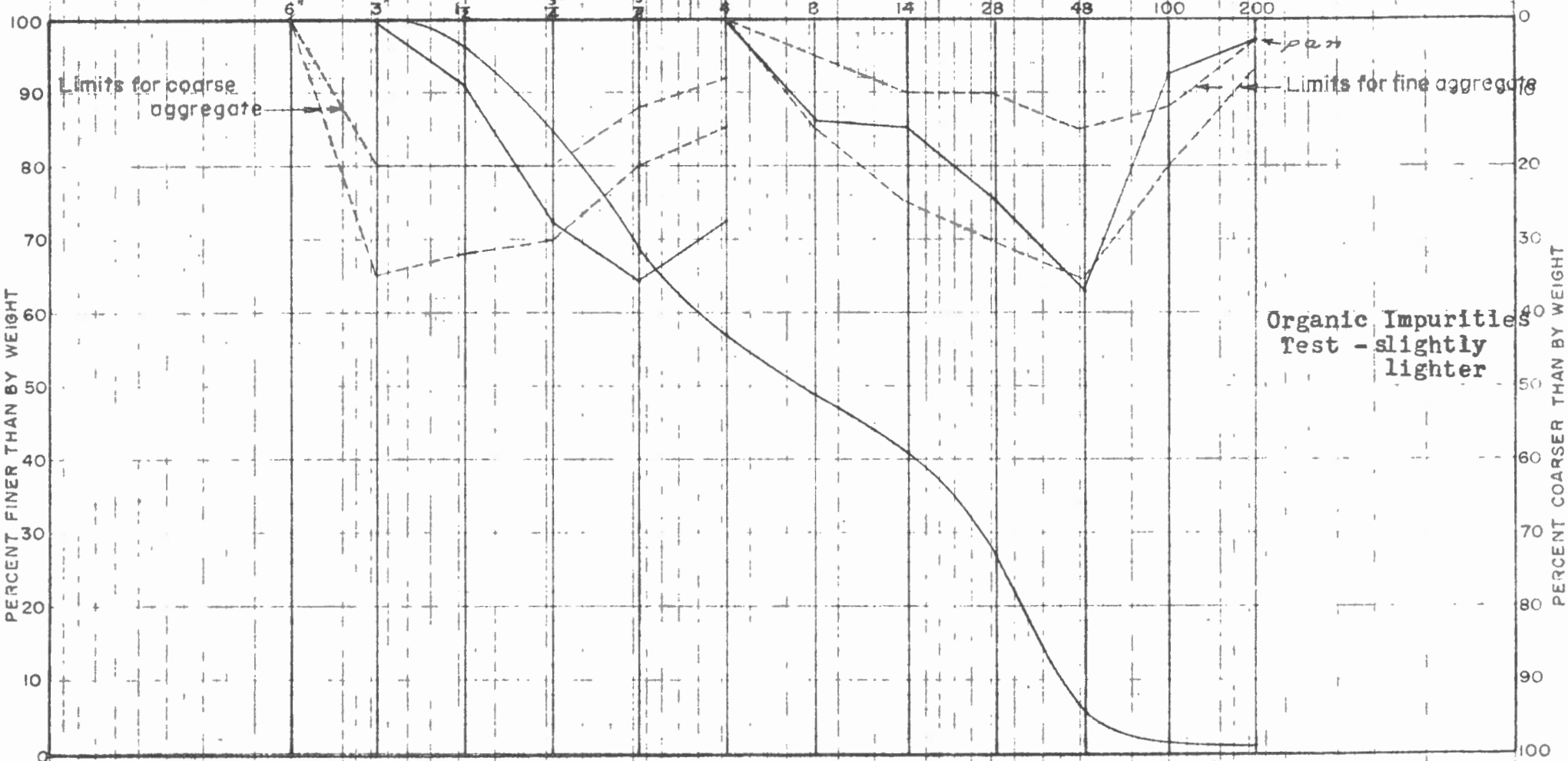
WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE



Site Lower Site, Liard River Hole No. Sample No. 43 Depth Plotted Date

PLAN No. 100 – 13

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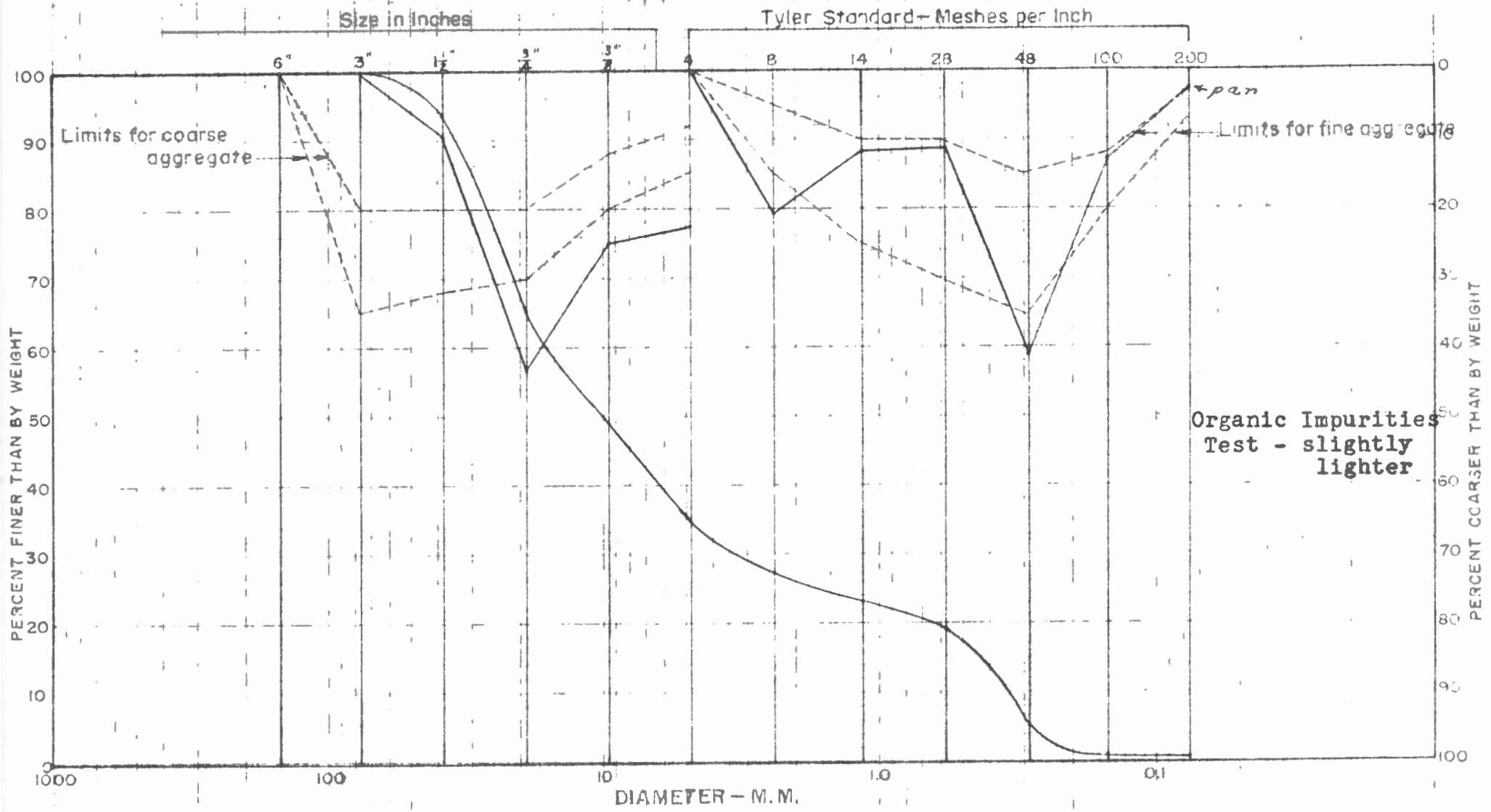
WATER RESOURCES BRANCH

GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE



Site Lower Site, Liard River Hole No. Sample No. 44 Depth Plotted Date

PLAN No 100 – 13

Plate 1

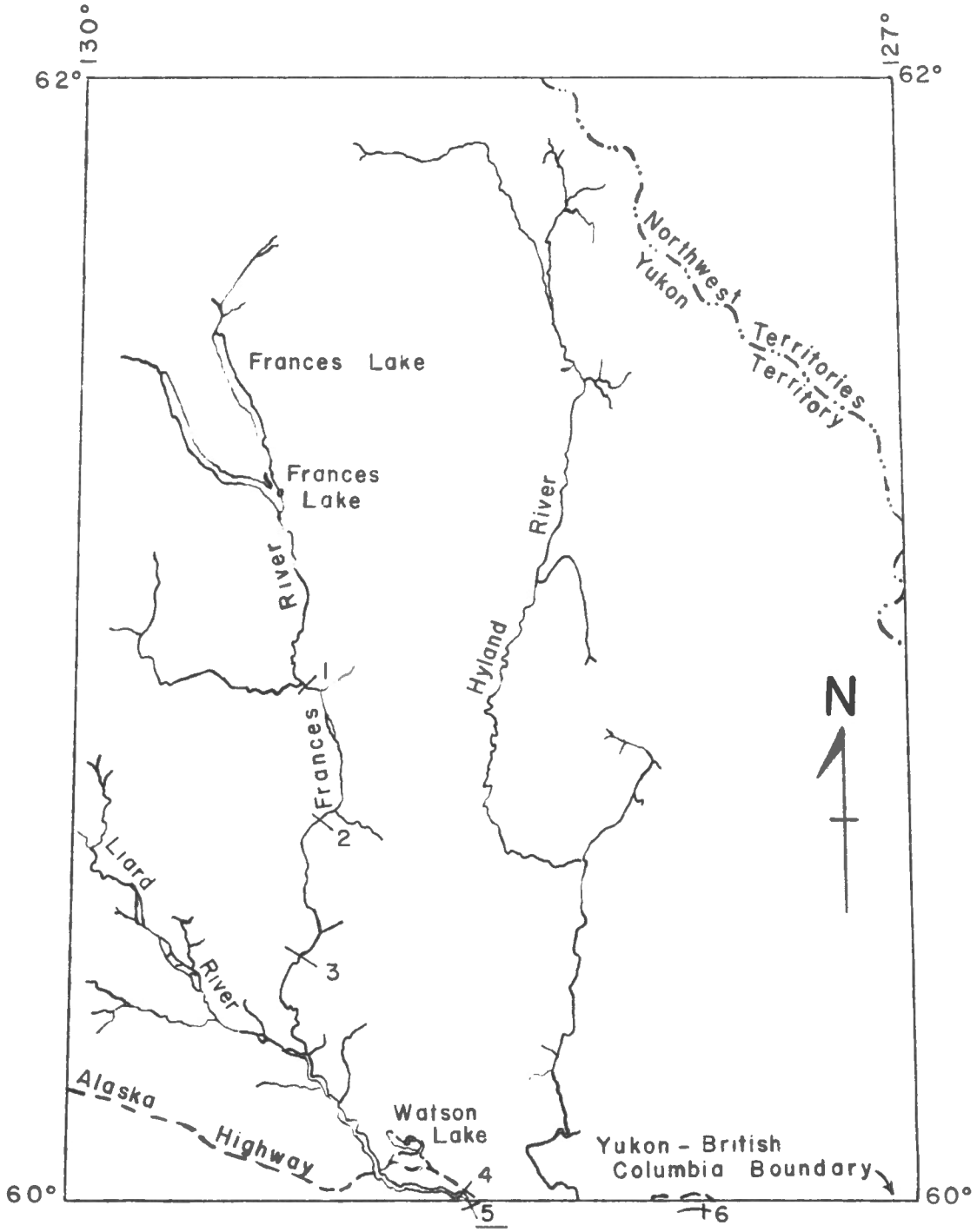
Liard Canyon looking upstream from the top of the right wall of the canyon. The British Columbia-Yukon Territory boundary is approximately as indicated.

G.S.C. - 9-3-61

Plate 2

Thin-bedded, close jointed limestone, sandstone and shale exposed in the left wall of Liard Canyon at the British Columbia-Yukon Territory boundary. The shallow dip of the strata is into the wall. The jointing dips steeply downstream. This is the most competent rock exposed at the Lower site.

G.S.C. - 9-2-61



LOCATION OF PROPOSED DAM SITES
MACKENZIE RIVER DRAINAGE BASIN
Scale 1 Inch = 20 miles

Site No.	Name	River
1 —	Upper Canyon	Frances
2 —	False Canyon	Frances
3 —	Lower Canyon	Frances
4 —	Liard Canyon(upper)	Liard
5 —	Liard Canyon(lower)	Liard
6 —	Contact Creek	Liard