No. 2

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

78

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 78

MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 13

BARRIER RIVER DAM SITE

(MAP AND PRELIMINARY REPORT)

BY

E. B. OWEN

OTTAWA
1963

CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 78

MACKENZIE RIVER DRAINAGE BASIN

DAM SITE INVESTIGATION

Site No. 13

BARRIER RIVER DAM SITE

(Map and Preliminary Report)

by

E.B. Owen

OTTAWA

1963

CONTENTS

Illustrations

BARRIER RIVER DAM SITE

General Description

Barrier River dam site is situated in McDougall Pass 8 miles downstream from Upper Rat Canyon site described in Topical Report No. 65. It is about 5 miles southeast of the junction of Rat and Barrier Rivers. The site is the fifth in the multiple stage power development proposed for McDougall Pass. The site would be by-passed, however, if the alternate scheme to divert the water from Upper Rat Canyon site directly to Delta site, some 7 miles downstream, was carried through.

At Barrier site McDougall Pass is trending southeast. It continues in this direction for about a mile downstream from the site and then makes an abrupt turn to the north. Eight miles further it turns east and almost immediately enters MacKenzie delta. Longstick and Delta sites which are described in other reports are both situated in the north-trending part of the Pass downstream from Barrier site.

At Barrier site McDougall Pass is about 2,500 feet wide. Here Rat River is flowing along its northeast side against the toe of a steep, rocky bluff which ascends more than 300 feet above the water. The face of this bluff is not continuous but is dissected by several narrow, steep-walled valleys which extend back and upwards to the terrace above the bluff. The bluff along the opposite side of the valley is less steep and is almost entirely covered with vegetation. Up to approximate elevation 665 test pits put down on the slope encountered talus beneath the organic

material. Above this elevation unconsolidated materials consisting of silt, sand and gravel were encountered. Consequently the elevation of bedrock surface here is believed to be close to 665 feet above sea level. A deposit of glacio-fluvial sand and gravel, 40 feet in thickness, overlies bedrock. A similar thickness of yellow, sandy silt overlies the glacio-fluvial material. The silt, although it is an extensive deposit, does not occur within the area included by the accompanying geological map.

In the site area the flood plain of Rat River extends over about half of the valley floor. This area is covered with Recent alluvium consisting of silt, sand and minor gravel. A few large boulders probably transported by river ice are scattered on its surface. Small, water-cut bluffs, two to three feet in height, are common. The remaining part of the valley flow has a gentle slope upwards to the southwest. It is covered with a thick layer of moss and decayed vegetation overlying frozen, alluvial, clayey silt containing minor quantities of sand.

Above the bluffs an undulating terrace dotted with numerous, shallow lakes extends for many miles north and south of the Pass.

Unconsolidated Deposits

Four types of unconsolidated deposits were identified at Barrier River dam site. A fifth material, glacio-lacustrine silt which consists of about 50 per cent fine-grained sand, occurs on the terraces above the bluffs. The quantities of silt available are unlimited and the deposits are easily accessible from the site.

1. Recent alluvium (silt, sand, gravel): This material consists of silt, sand and gravel which has been deposited by the present Rat River. The gravel contains numerous rounded boulders of hard, durable rocks, chiefly quartzite and sandstone, which are not of local origin. It is well exposed in a large bar in Rat River in the downstream part of the area mapped. The flood plain of Rat River extends southwest several hundred feet from the right side of the river. With the exception of a few scattered boulders the alluvium here consists chiefly of sand and fine-grained gravel. It is usually frozen where it is covered with moss. The Recent alluvium is not considered an important deposit because of the limited quantity available.

2. Alluvium: This material consists of grey, clayey silt with minor quantities of fine-grained sand. It occurs on the floor of the valley between the Recent alluvial material and the toe of the right abutment slope where it was probably deposited by Rat River when this stream flowed at a higher elevation. The material could probably be used for the impervious core of an earth-fill dam. Test pitting would be required to determine the quantity available. At the time of the investigation (July 16, 1962) the material which is overlaid by a thick layer of moss and decayed vegetation was frozen to within 2 or 3 inches of its surface. It was observed that whenever the overlying layer of moss was removed the alluvium immediately commenced to thaw forming a thick, soupy material.

3. Talus: Talus is material resulting from the mechanical disintegration of adjacent bedrock. The talus on both sides of the Pass

at Barrier River site consists chiefly of rock fragments ranging from sand-size particles to boulders 4 feet in diameter. In places the talus contains considerable clay and silt-size particles resulting from the weathering of thin beds of shale and siltstone associated with the sandstone. The talus also contains minor quantities of silt and gravel which have slumped from deposits of these materials overlying bedrock. The larger rock fragments in the talus are usually highly weathered. Consequently their durability is low and it is doubtful they could be used as riprap..

4. Glacio-fluvial (sand and gravel): This material consists of coarse-grained gravel containing minor quantities of sand-size particles. It is similar to the material in sample No. 6 taken at Upper Rat Canyon site and described in Topical Report No. 65. It is estimated about 70 per cent by weight of the material consists of cobbles and boulders greater than 3 inches in diameter. The silt content is low, probably less than 5 per cent. The boulders are mainly sandstone with about 20 per cent consisting of hard, fine-grained, grey to white quartzite. It is exposed in thicknesses up to 40 feet directly overlying bedrock in the downstream part of the bluff along the left side of the river. Similar material was encountered in test pits put down on the upper part of the bluff forming the right abutment.

The gravel is a potential source of natural aggregate. It would, however, be relatively expensive to obtain large quantities. The thick deposit of sandy silt overlying it would have to be removed. Also the gravel occurs beneath the frost line and in places is doubtless solidly frozen.

Bedrock

General Description

Bedrock consists chiefly of fine-grained, grey, calcareous sandstone which weathers to a soft, porous, buff-coloured rock. It is uniform in texture with 99 per cent of the sand grains varying between 0.6 and $0.^{.07}_{.\mp}$ millimetres in diameter. It is exposed throughout most of the steep bluff along the left side of the river in which it is proposed to locate the left abutment of the dam and in one small outcrop on the less precipitous right abutment slope. The sandstone strata vary in thickness from 1 inch to massive, 8-foot beds. Three of the thicker beds, plainly visible on the left abutment slope, are continuous throughout the site area.

Thin beds of soft, black, laminated shale and brown-weathering siltstone are interbedded with the narrower sandstone strata. The thin-bedded material constitutes about 80 per cent of bedrock exposed in the site area. These strata usually consist of narrow lenses which are not continuous for more than a few feet.

Most bedrock exposed at the site, especially the sandstone, is weathered to a soft, brown, porous rock. This is probably the result of leaching of the calcareous matrix binding the sand grains.

Bedrock Structures

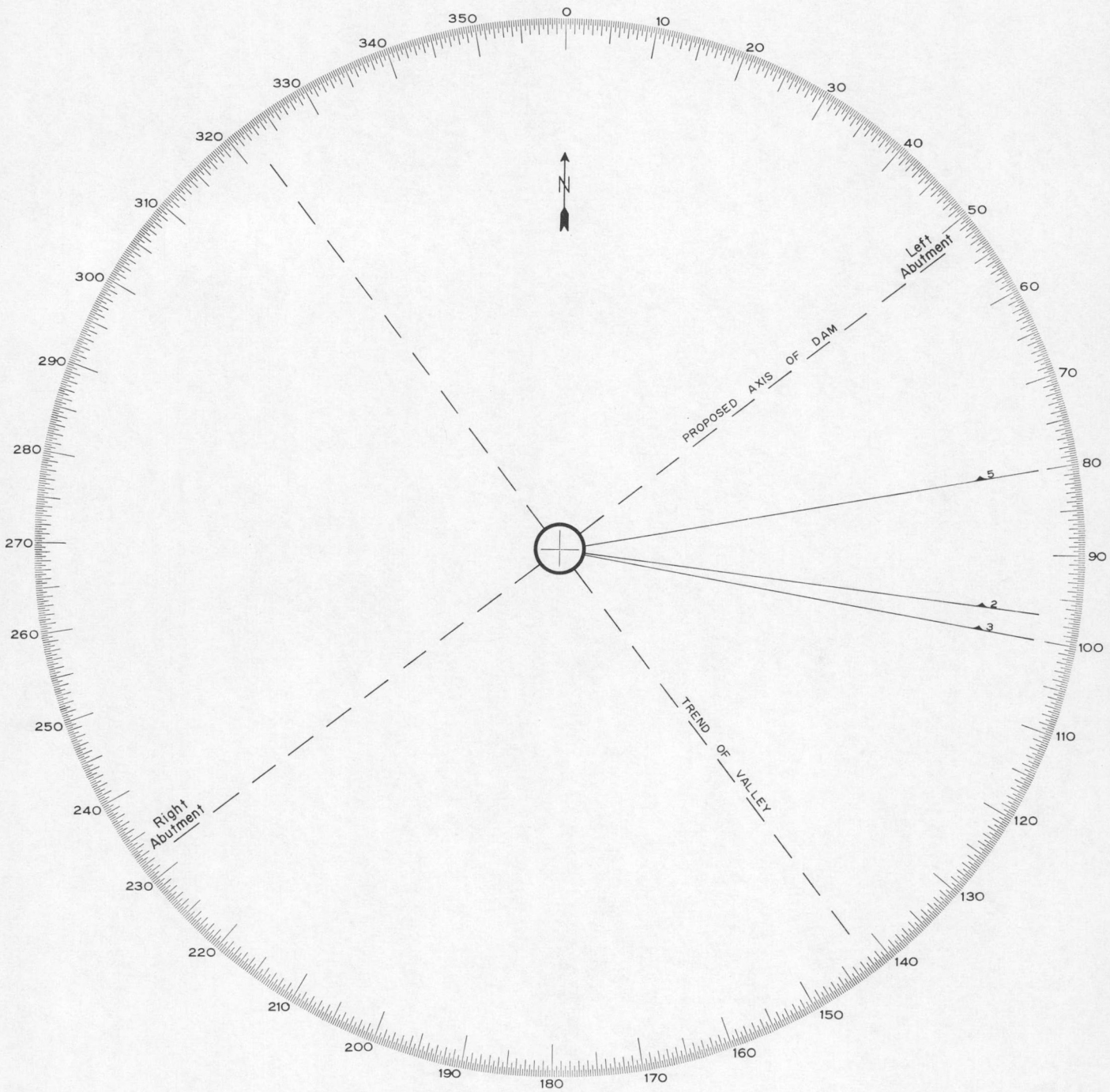
Bedding at the site is, in general, horizontal. However, there are minor, local undulations in the strata which have resulted in shallow upstream dips of 2 to 5 degrees. Here the bedding intersects

the proposed centre line at angles varying between 28 and 48 degrees.

There are 2 prominent joint sets in bedrock exposed at the site. One is close to vertical and intersects the proposed centre line at angles between zero and 20 degrees. The second set is almost at right angles to the first. It intersects the proposed centre line at angles between 70 and 90 degrees and dips steeply toward the right abutment. This set is parallel to the river and the other is approximately at right angles to it. As a consequence the faces of the strata exposed in the bluffs are frequently vertical and parallel to the river. A second result of these two intersecting joint sets is that many of the rock fragments in the talus are roughly squared and flat faced. Faulting was not observed at the site.

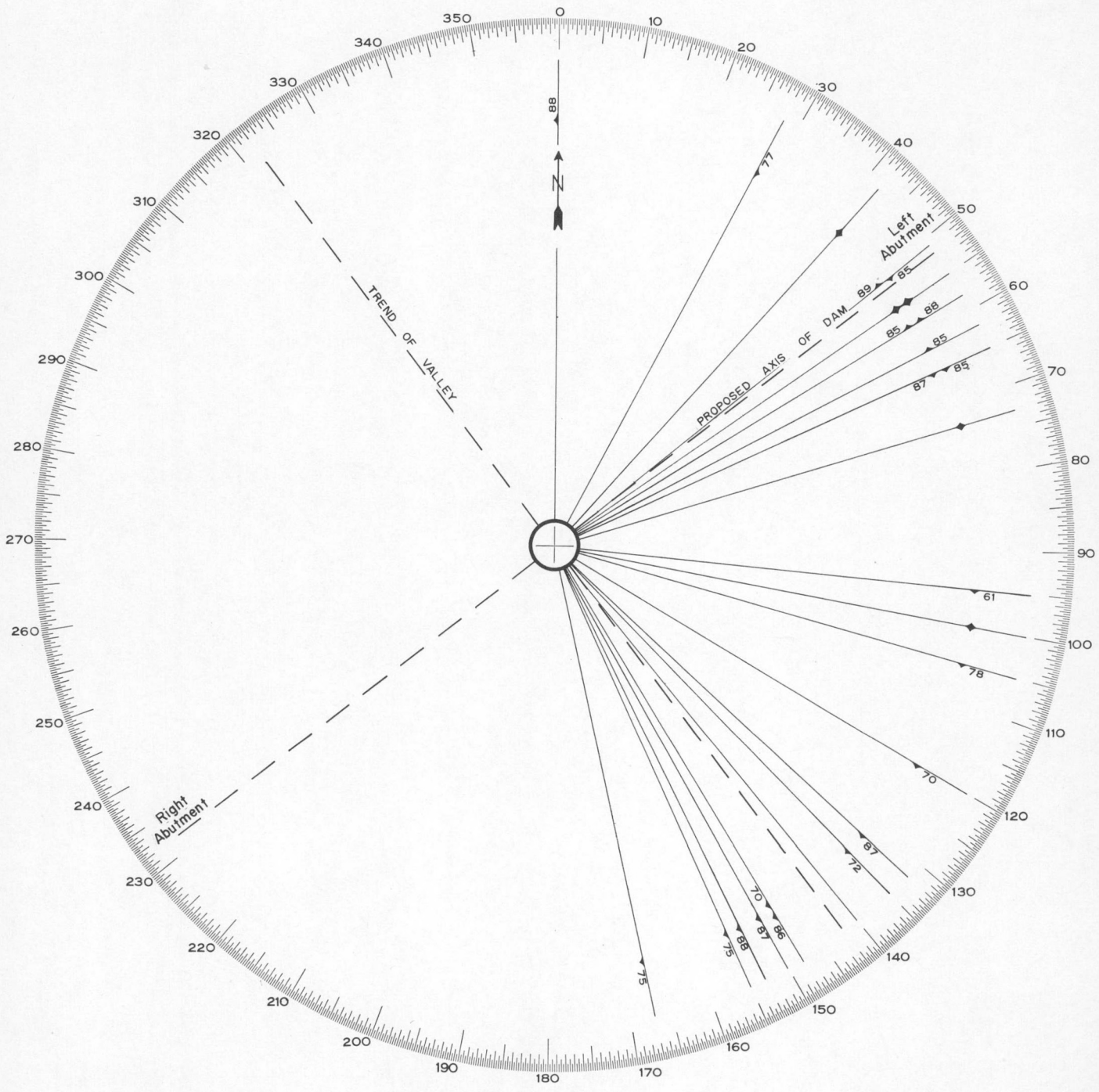
Quality of Bedrock

The thick sandstone beds visible in the left abutment constitute the most competent rock exposed at the site. If similar beds exist beneath the river they would probably provide satisfactory foundation material. These beds form about 20 per cent of bedrock exposed at the site. The remainder consist of thin beds of shale, sandstone and siltstone. The presence of these narrow interbeds would adversely effect the properties of the more massive rock and would decrease the ability of bedrock in the abutments to withstand the thrust of an arch dam. Bedrock at Barrier site is similar to that exposed at Longstick and Delta sites further downstream. The results of several laboratory tests made on samples of these rocks are included in the report on Delta site.



BEDDING ROSETTE

The above illustration presents diagrammatically the direction and dip of bedding in bedrock exposed at Barrier site



JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of jointing in bedrock exposed at Barrier site

Bedrock exposed at Barrier site is highly weathered with the result the surface rock is soft, porous and, in the case of the sandstone, poorly cemented. The depth of weathering is not known. It must, however, be considerable, because in places where 2 to 3 feet of rock has broken off the exposed rock is usually weathered. Test borings will be required to determine the depth of weathering and the quantity of rock which will have to be removed before fresh, solid rock against which concrete or dyke material can be placed will be exposed.

Engineering Considerations

Depth of Overburden

Overburden covering bedrock on both abutment slopes consists of a layer of talus mixed with gravel and silt which have slumped from above. It is seldom believed to be greater than 10 feet in thickness.

The thickness of overburden covering the terraces above the bluffs is variable. It ranges from 5 feet in one place on the left abutment slope to about 80 feet along the top of the right abutment.

The results of one seismic profile located on the floor of the Pass about halfway between the abutments indicate the thickness of overburden here is greater than 67 feet. It is not believed this figure is true throughout the site area. Test borings will be required to accurately determine the elevations of bedrock surface.

Proposed Centre Line

The horizontal attitude of the bedding indicates bedrock is continuous throughout the site. Consequently from the viewpoint of

bedrock there is little choice regarding the location of the dam. The possibility of leakage through the permeable sand and gravel directly overlying bedrock would greatly increase the cost if the height of the dam was sufficiently great to include this material in the abutment. Consequently it is believed the elevation of bedrock surface limits the height of the dam. To construct the highest possible dam and at the same time utilize only bedrock as abutment and foundation material it is suggested the dam be located in the upstream end of the site area. Here bedrock surface is believed to be slightly higher in the abutments.

Abutments and Foundations

The horizontal attitude of the bedding at the site indicates the compressive strengths of these rocks would be at their highest and consequently they should be sufficiently competent to provide satisfactory foundations for the dam structures. There is no evidence of groundwater movement either through the sandstone or along the contacts of the sandstone and adjoining shale and siltstone. Any diversion tunnels planned for the site should be located in the left abutment. It might be possible to locate these structures so that one of the thick, competent sandstone beds present would form the roof of the tunnel.

Construction Materials

Aggregate

The glacio-fluvial gravel which overlies bedrock at the site is a potential source of natural aggregate. The deposit is extensive

throughout the east end of McDougall Pass and the quantity available is unlimited. It should be noted the material is overlaid with as much as 40 feet of frozen silt. Also about 70 per cent by volume of the material consists of cobbles and boulders greater than 3 inches in diameter. These large rock fragments consist chiefly of local sandstone with about 20 per cent of hard, fine-grained, grey quartzite. The amount of crushing that would have to be done would depend on the maximum size of coarse aggregate decided upon. The results of the laboratory tests indicate satisfactory aggregate could be obtained from the sandstone but the process would have to be selective to avoid contamination by weathered material, shale or siltstone. A grain size analyses curve made from a representative sample of similar gravel is included in the report on Upper and Lower Canyon sites (Topical Report No. 65). Similar material is also described in the report on Longstick site.

Impervious Material

The glacio-lacustrine sandy silt covering the terraces above the abutments is a possible source of impervious material. The average thickness of the silt as exposed along the top of the bluff forming the left abutment is about 20 feet. Thicknesses as much as 40 feet are believed to exist in the right abutment area. The quantity available is unlimited. A major construction problem will be to excavate the silt which at the time of this investigation (July 16, 1962) was completely frozen. A description of similar material is included in the report on

the Longstick site. From the grain size curve which accompanies the description it is indicated about half of the particles are in the fine sand range. The remainder is silt with about 14 per cent clay.

Pervious Material

Material suitable for the shells, filters and drains of an earth dam can be obtained from the gravel deposits described under the aggregate heading. As at adjacent sites the gravel may have to be washed, screened and reblended to obtain some of the types of granular material required.

Riprap and Rock Fill

The results of the laboratory tests on samples of unweathered sandstone indicate it is suitable for riprap and rock fill. It is estimated only about 20 per cent of bedrock would provide sufficiently large rock fragments to be used as riprap. This indicates the quarrying operation would be selective in character with a resultant increase in cost. The soft, weathered, porous sandstone on surface as well as the thin interbeds of shale and siltstone which constitute about 80 per cent of bedrock would have little use.

Groundwater

There is little indication of groundwater conditions in the site area. Seepages were not observed in either abutment nor is there any indication they have occurred in the past. Considerable surface water

exists on the floor of the Pass especially on the lower terraces along the right side of the river. The frost line here is close to ground surface and this along with poor surface drainage is the probable cause of the swamp conditions.

Frozen Ground

Frozen ground exists throughout the site area. On July 16, 1962 it occurred within a few inches of ground surface in the sandy silt covering the terraces above the abutments and in the alluvium on the low terraces along the right side of the river. In all places it was covered with a 6- to 8-inch, insulating layer of moss.

Further Investigations - Conclusions

It should be remembered this report is based upon a preliminary geological investigation designed to furnish the engineer with general geological information regarding the proposed dam site. The report is based upon a rapid field examination of bedrock and soils exposed at the site. The proximity of the frost line to ground surface prevented more than a casual examination of the soils. However, it is believed the data compiled is sufficiently precise to permit office studies and obtain general cost estimates.

There are no bedrock structures, such as faulting or folding, present at the site. Structures such as these usually result in a considerable increase in the cost of both earth and concrete work.

The chief problem is associated with the quality of bedrock which, because of the relative inaccessibility of the site and the high cost of transportation, would be used not only as abutment and foundation material but also as riprap, rock fill and possibly as aggregate. It is believed the rock would be suitable for use as riprap and fill provided the required fracture size and shape can be obtained. The material could also be considered for use in the manufacture of concrete aggregate.

The height of the dam is limited by the elevation of bedrock surface which is believed to be about 665 feet in the right abutment area and varies from 550 to 650 feet in the left abutment. Test borings will be required, however, to determine the actual elevation. To construct a dam with a higher elevation would mean the coarse-grained, permeable gravel directly overlying bedrock would form part of the abutment. This would increase the probability of leakage not only through the abutment but also around the rim of the reservoir where similar gravel exists. Test borings will also be required across the floor of the Pass to investigate the quality and quantity of the overburden present and to check the data obtained from the seismic profile. Permeability tests should be conducted in the borings on both the overburden and bedrock. Samples should be taken of the overburden at intervals of 5 feet or where there is a change in material.

Chemical Analyses of Rat River Water

During the 1962 field season samples of Rat River water were taken at Fish Creek dam site and at the point where Rat River leaves McDougall Pass and enters MacKenzie Delta. The samples were analysed for their mineral content by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The results of the analyses are included in the report on the Fish Creek site (Topical Report No. 71, site No. 8).

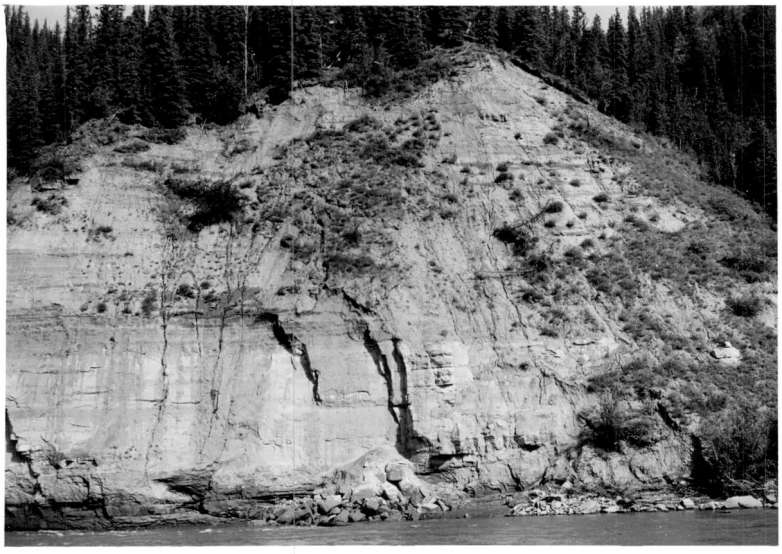


Plate 1

Steep, rocky bluff forming left abutment,
Barrier River dam site.

G.S.C. 25-3-62

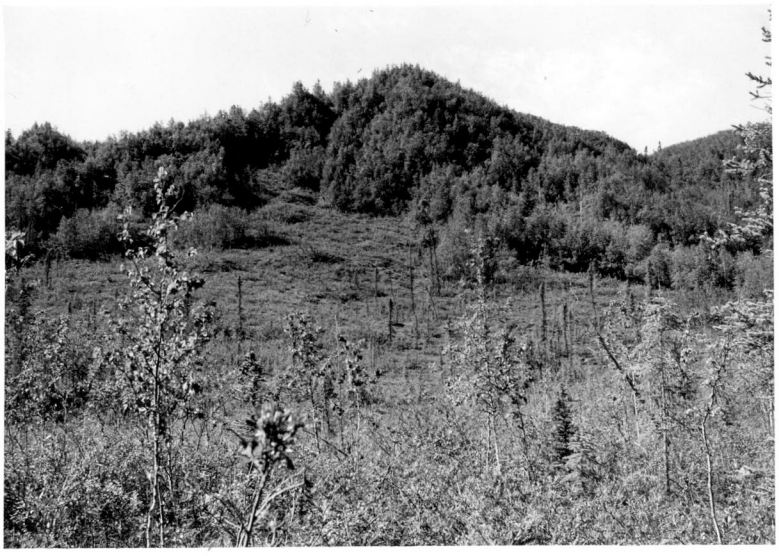
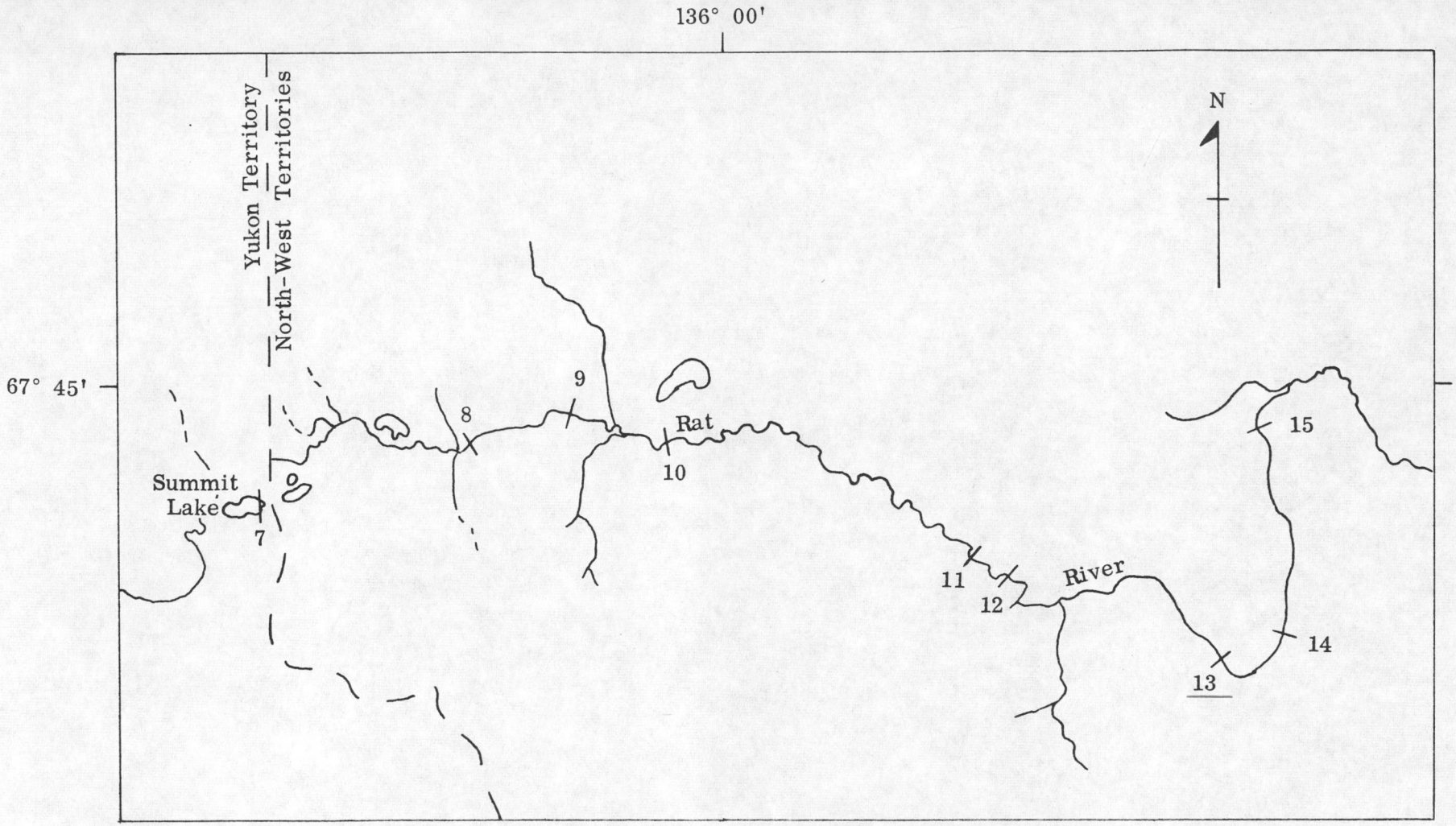


Plate 2

Vegetation-covered right abutment,
Barrier River dam site.

G.S.C. 22-4-62



LOCATION OF PROPOSED DAM SITES
MACKENZIE RIVER DRAINAGE BASIN
Scale: 1 inch to 4 miles (approx.)

Site No.	Name	Site No.	Name	Site No.	Name
7 -	Summit Lake	10 -	Horn Lake	13 -	Barrier
8 -	Fish Creek	11 -	Rat Canyon (Upper)	14 -	Longstick
9 -	Bear Creek	12 -	Rat Canyon (Lower)	15 -	Delta