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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 62

MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 9

# BEAR CREEK DAM SITE

( MAP AND PRELIMINARY REPORT )

BY

E. B. OWEN

OTTAWA

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# BEAR CREEK DAM SITE

## General Description

Bear Creek dam site is one of several potential power sites in a multiple stage power development proposed for the McDougall Pass area, Northwest Territories. The site is located about 9 miles east of Summit Lake which marks the divide between Yukon River and MacKenzie River watersheds. Fish Creek dam site which is the farthest upstream site in the proposed development is about 3 miles west of Bear Creek site and Horne Lake site is a similar distance to the east. All the sites in the development lie within the MacKenzie River drainage basin.

At the present time a small stream known as Rat River flows easterly through McDougall Pass. The gradient of the Rat is about 25 feet per mile. Consequently it is a fast-flowing stream which is constantly cutting new channels through the erodible silty clay covering the floor of the Pass and leaving behind numerous shallow, crescentic, oxbow lakes.

At Bear Creek site Rat River flows along the north side of a narrow constriction in the Pass. Low, vertical bedrock bluffs rise abruptly from each side of the River to heights of about 20 feet. Above the bluff on the right side ground surface slopes steeply upward to a height greater than 200 feet. A fairly level terrace, 1,000 feet in width, extends north from the left side of the River to the toe of a steep bluff in which it is proposed to locate the left abutment.

Bedrock exposed at the site consists of thin-bedded sandstone and shale believed to be Mesozoic in age. Overburden consists chiefly of

clayey silt with minor quantities of sand and gravel. Talus occurs in one small locality on the right abutment slope. Much of ground surface is covered with moss and decayed organic material the lower part of which is usually frozen. Consequently the only places where overburden was visible during the investigation was above the bedrock exposed along the sides of Rat River and in the shot holes blasted during the seismic investigation.

## Unconsolidated Deposits

Four types of unconsolidated deposits were identified in the area about Bear Creek dam site. These are as follows:

1. Recent alluvium: This is an unimportant deposit formed by Rat River. It consists of silt, sand and gravel containing rounded boulders up to 12 inches in diameter. Very little Recent alluvium is visible in the centre part of the site area. However, it constitutes the material forming several wide bars in Rat River near the east and west limits of the area. Also, considerable thicknesses probably exist beneath the present river channel.

2. Alluvium: This material consists chiefly of grey to brown clayey silt. It is believed to cover the terrace between Rat River and the slope forming the left abutment some 1,000 feet to the north. It is exposed along the top of the rock bluff which forms the left bank of the river and in the shot holes for the seismic line located near the centre of the terrace. The presence of several low, river-cut bluffs on the terrace between approximate elevations 855 and 895 suggests the material was

deposited by Rat River when it was flowing at a higher elevation than present. The clayey silt is covered with a 9- to 12-inch layer of moss and decayed vegetation. All the material exposed by the blast holes was frozen and vertical ice lenses up to 2 inches in width are common. The thickness of the clayey silt exposed along the river ranges from 2 to 4 feet. In places it overlies 4 to 5 feet of coarse gravel which in turn directly overlies bedrock. Here the silt is not frozen. It has a medium dry strength and some horizontal stratification is evident.

3. Glacio-lacustrine and/or alluvium: This material consists of grey clayey silt. It exists on the left abutment slope and on the terrace above the slope which extends north beyond the limit of the area mapped. It is similar to the alluvial clayey silt which covers the lower terrace between the abutment and Rat River. The boundary between the two deposits has been arbitrarily set at elevation 895. The glacio-lacustrine and/or alluvial clayey silt was observed only in the shot holes on a seismic line located near the top of the abutment slope. Here the material was covered with a layer of moss and decayed vegetation about 12 inches in thickness. It was frozen throughout and contained numerous irregular ice lenses up to 2 inches in thickness.

4. Talus: One small exposure of talus occurs on the downstream part of the right abutment slope. The material consists of platy fragments of grey sandstone ranging in thickness up to 6 inches and in diameter up to 2 feet. The rock is similar to that outcropping along Rat River at the toe of the abutment. With the exception of the talus the entire abutment slope is covered with a thick layer of moss which is frozen to within a few inches

of ground surface. Overburden beneath the moss probably consists of a thin layer of talus directly overlying bedrock.

## Bedrock

### General Description

At the site bedrock is exposed only in the relatively low bluffs which rise vertically from both sides of the river. It consists of thin-bedded, fine-grained, grey, argillaceous sandstone interbedded with black laminated shale. The sandstone beds vary from one-quarter inch to six inches in thickness and the shale beds range up to two inches in thickness. Bedrock exposed along the left side of the river in the downstream part of the site area consists almost entirely of shale. In the remaining part the proportions sandstone and shale are approximately equal.

### Bedrock Structures

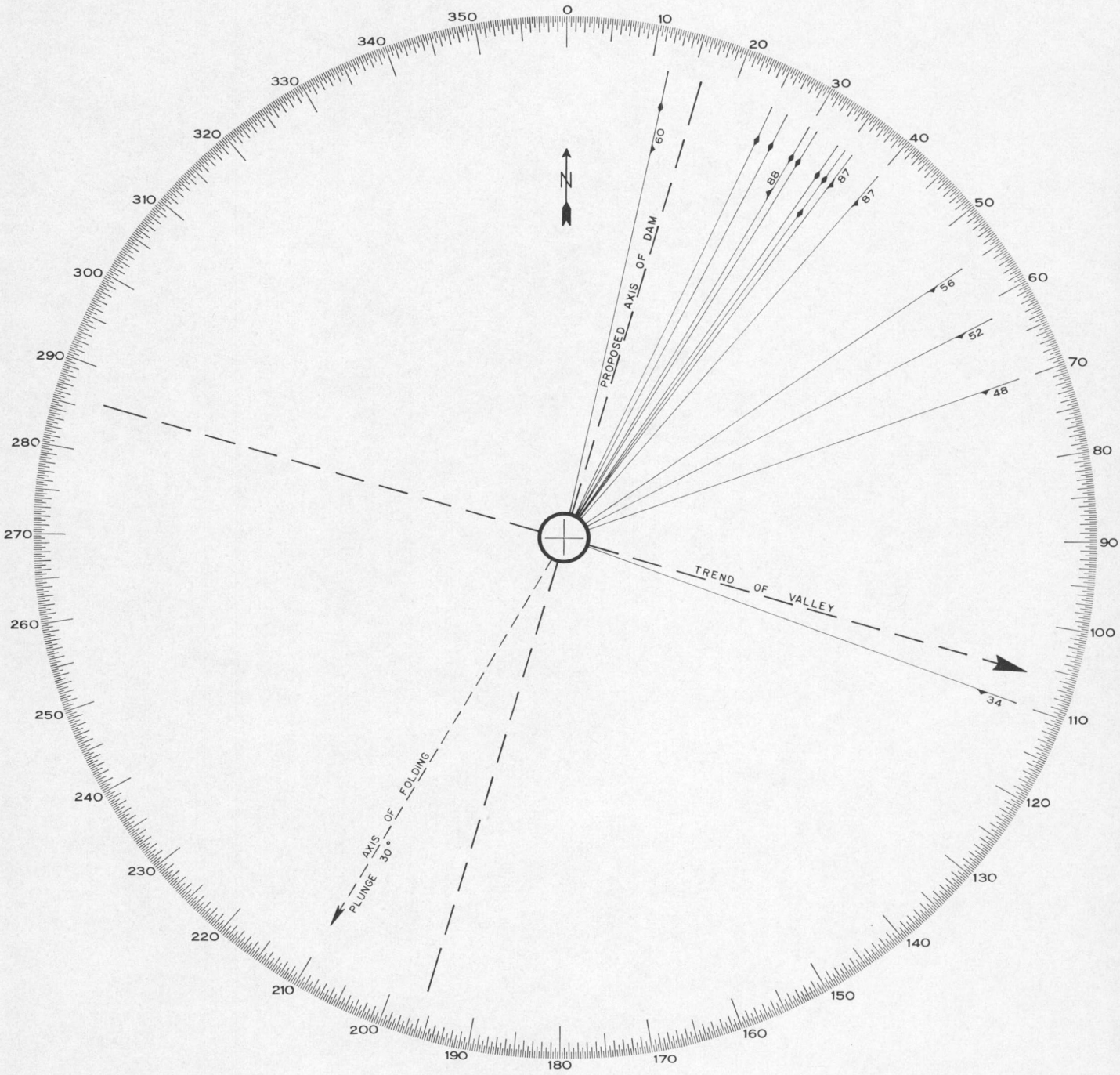
The trend of the valley at the site is about south 74 degrees east. The axis of the proposed dam would be approximately at right angles to this direction. Most bedrock strata at the site intersect the axis at angles varying from 10 to 25 degrees. The dip is either vertical or steeply downstream.

One small, tight, synclinal fold occurs on the right side of the river about 175 feet upstream from station No. G-4. The axis of the fold intersects the dam axis at 14 degrees and plunges at 30 degrees into the right abutment. The fold doubtless extends to the left side of the river where it is concealed by alluvium. Two similar, parallel folds occur on

the left side of the river about 70 feet upstream from station No. L-14. As a result of the folding some strata intersect the dam axis at angles between 39 and 54 degrees and dip 48 to 56 degrees into the right abutment. The competency of the rock has probably not been lowered by the presence of the folding. However, the folds represent potential zones of weakness and should be investigated further.

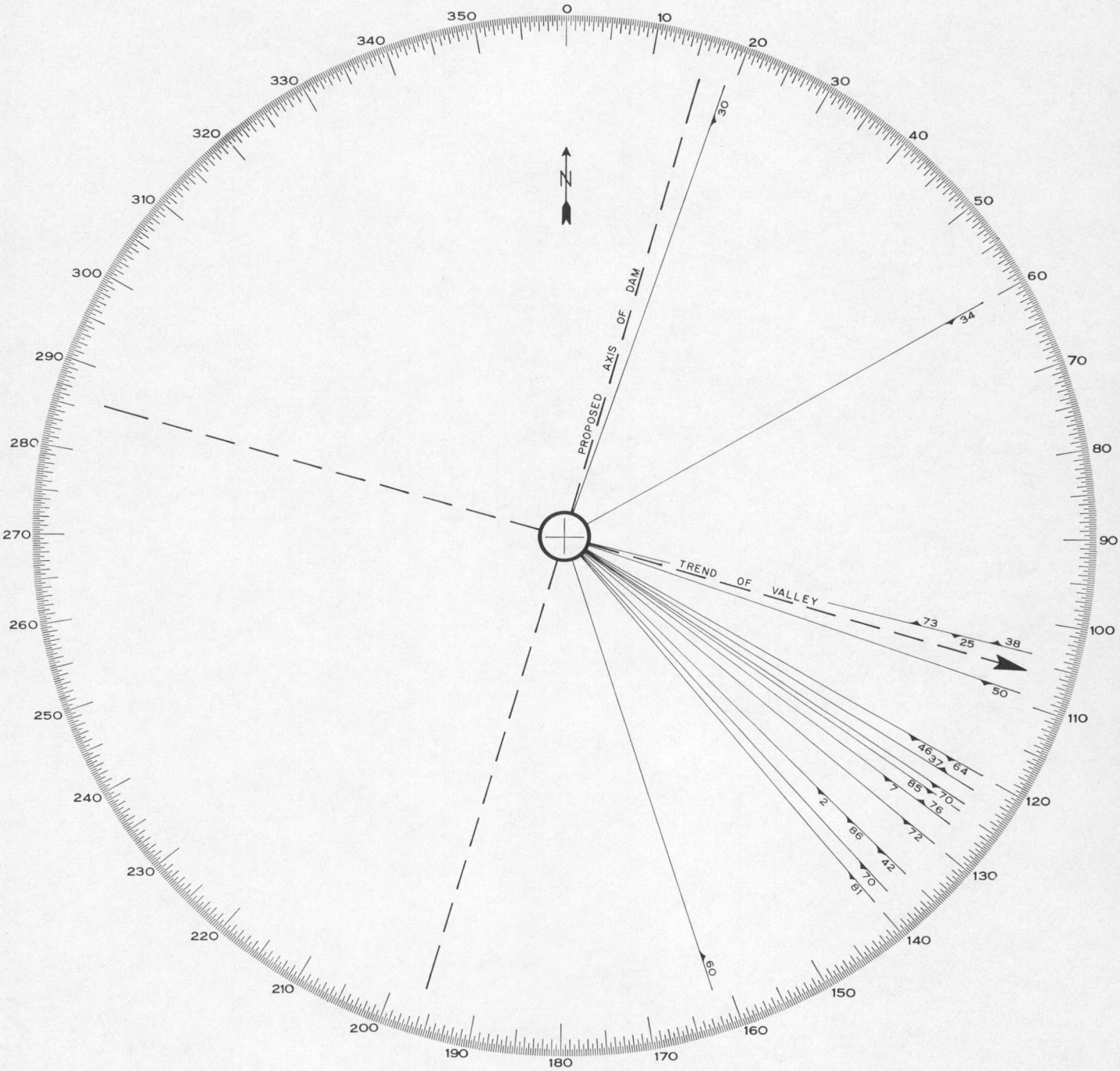
There is one prominent joint set in bedrock exposed at Bear Creek site. This set intersects the dam axis at angles from 58 to 78 degrees and dips 42 to 86 degrees into the right abutment. A few other joint sets are present but are irregular and not believed important. Spacing in the jointing usually ranges from 1 to 6 inches.

A fault parallel to the bedding is located a few feet upstream from station No. L-11. The strike of the fault is north 35 degrees east and the dip is vertical. Considerable slickensliding indicating vertical movement occurs along the bedding planes for a distance of about 2 feet from each side of the fault. An irregular seam of black, clayey gouge occurs along the fault. The presence of this relatively impervious material probably exerts some control over the movement of groundwater through the adjacent rock. There are no springs, seeps or other evidences of the presence of groundwater associated with the fault. A few small gash fractures extend obliquely out from the fault zone into the adjacent rock for a distance of several feet. These are seldom greater than one-half inch in width and are usually filled with white calcite.




BEDDING ROSETTE

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




JOINT ROSETTE

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

Quality of Bedrock

The vertical dip of the shale and sandstone strata exposed at Bear Creek site suggests these rocks should be thoroughly investigated before a decision is reached regarding their competency. Their soundness is questionable and it is doubtful if they would provide satisfactory riprap. The presence of large quantities of shale indicates they should not be considered as a source of aggregate. Many of the closely-spaced joint fractures are open to depths of 4 to 5 feet beneath bedrock surface. Consequently, in places, the upper part of bedrock is badly weathered and would have to be removed before fresh, solid rock would be obtained. This is especially true in areas where shale predominates.

## Engineering Considerations

Depth of Overburden

Overburden on the steep, moss-covered slope forming the right abutment is believed to consist chiefly of a thin deposit of talus which is nowhere greater than 10 feet in thickness. The thickness of overburden on the left abutment and on the terrace separating the abutment from Rat River is not known. Two seismic lines were located in this area, one on the terrace and the other near the top of the abutment, but the seismic data was not available at the time this report was written. It is believed bedrock surface north of the river slopes gently upward away from the rock exposures along the river. Consequently the thickness of overburden beneath the terrace is relatively thin ranging from 4 to 6 feet at the river to about 25 feet at the toe of the left abutment. The thickness of overburden

on the abutment is probably considerably greater. The present channel of Rat River is believed to be filled with about 20 feet of permeable sand and gravel.

Abutments and Foundations

There is little variation in the quality of bedrock or unconsolidated materials occurring throughout Bear Creek dam site area. Consequently the final location of the axis will depend on some other criteria beside the physical properties of the materials present at the site. The thickness of overburden on the valley floor between the abutments and on the right abutment is relatively thin. Consequently any structures in these areas will be founded upon bedrock. Test borings will be required to determine the material in the left abutment. The frost line in the site area is seldom more than 24 inches from ground surface and consequently all materials which are excavated will be in a frozen condition. Any diversion tunnel would have to be located in the right abutment. The presence of large quantities of easily eroded shale in bedrock would necessitate the tunnel being lined throughout. Bedrock at the site is relatively insoluble and it is doubtful if caverns or underground solution channels exist in them. Grouting will probably be necessary, however, because of the numerous joint fractures present.

## Construction Materials

### Aggregate

Limited quantities of natural aggregate occur at the site. These include the following:

1. Coarse-grained, sandy gravel directly overlying bedrock exposed along the left side of Rat River. The deposit varies from 3 to 5 feet in thickness and where visible is overlaid by 2 to 4 feet of clayey silt. The quantity available is uncertain, but could be determined by test pits put down on the terrace north of the river. The material should also be encountered by test borings put down to investigate foundation conditions and during excavations to bedrock for the dam structures.

2. Medium- to coarse-grained sand and sandy gravel which is exposed in a low, river-cut bluff along the right side of Bear Creek about three-quarters of a mile upstream from its junction with Rat River. The deposit is about 10 feet in thickness and overlies a dense, frozen, silty clay which is till-like in appearance. It is overlaid with about 2 feet of moss and decayed vegetation. The extent of the deposit is unknown. It is exposed for about 500 feet along the creek but test pitting would be required to determine its lateral extent. A sample of the material was taken and forwarded to the soils laboratory for mechanical analyses. The resultant curve is included at the end of this report.

3. The Recent deposits of silt, sand and gravel occurring along the present channels of Rat River. This material is probably the best potential source of natural aggregate in the site area. It is not frozen and

is readily accessible from the site. It is, however, dirty containing considerable organic material and a relatively high percentage of silt. The quantity available is unknown but could be readily determined by test borings.

The high shale content and thin-bedded character of bedrock at the site indicates it will not yield suitable aggregate.

Impervious Material

The clayey silt covering the terrace north of the river may provide satisfactory material for an impervious earth core of an earth dam. The material is frozen but readily thaws when the overlying layer of moss has been stripped. The clayey silt above the left abutment could be similarly used. The material resulting from thawing is extremely fluid and could possibly be transported to the dam site by sluiceways or by pumping. The high percentage of fine material in the clayey silt may increase the time for the pore water to dissipate into the pervious shell and consequently increase the consolidation time of the core.

Pervious Material

Material suitable for the pervious shells, filters or drains of an earth dam could be obtained from the gravel deposits described under the aggregate heading.

Riprap and Rock Fill

It is not believed bedrock exposed at Bear Creek dam site will provide suitable riprap or rock fill. The presence of shale and the thin-bedded character of the sandstone interbeds will result in thin,

slab-like rock fragments when bedrock is excavated. Fragments with this shape are not considered desirable in rock fill. The durability of these rocks is low which also limits their use as riprap or rock fill.

## Groundwater

There is little information concerning groundwater conditions in the area about the proposed dam site. Groundwater does exist above the frost line because most shot holes rapidly filled with water flowing down their sides after they had been blasted. This was true even in localities where before blasting the moss-covered ground surface was dry. It is unlikely groundwater under pressure occurs in the gravel beds beneath the clayey silt covering the terrace north of the river. Seeps were not observed in places where the gravel is exposed along the river.

## Frozen Ground

In the site area the frost line frequently exists only a few inches beneath ground surface. It usually occurs in the thick layer of lichens, moss and decayed vegetation which covers the area. It is believed all bedrock and overburden in the site area are frozen except that within a few feet of Rat River. There is no information concerning the existance of the frost line beneath the river.

## Further Investigations - Conclusions

It should be remembered this geological investigation is a preliminary one designed to furnish the engineer with general geological information regarding the proposed dam site. The report is based upon a

rapid, field examination of the soils and bedrock exposed along the sides of Rat River and in several seismic shot holes situated on the terrace north of the river and in the left abutment area.

More information is required before the suitability of the site can be determined. The bearing capacity of the upturned sedimentary beds should be investigated. With the exception of the left abutment the dam will be constructed on frozen rock. Test borings will be required in the left abutment area to determine the elevation of bedrock surface and the quality of overburden overlying it. The dam could be a rock fill type. Bedrock at the site will not provide satisfactory material for a rock fill dam but large quantities of massive quartzite and sandstone are readily available about a mile north of the site and also about 3 miles east near Horne Lake site. The clayey silt deposits north of the river may provide impervious material for the dam although the presence of frost would make the excavation of this material very costly.

Test borings should be put down to ascertain the elevation of bedrock surface beneath both Rat River and the terrace immediately north of the river. Soil samples should be taken every 5 feet or where there is a change in material. The presence and extent of any gravel deposits beneath the terrace should be ascertained.

## Chemical Analyses of Rat River Water

During the 1962 field season samples of Rat River 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.

## Grain Size Analysis Curve

The grain size analysis curve included in this report was prepared in the Soils Laboratory of the Water Resources Branch in Vancouver. Its purpose was to investigate the grading of the material in a sand deposit near the site to determine if it would be suitable for the pervious shells, filters or drains of an earth dam.

Description of Potential Pervious Material for the following Grain Size Analysis Curve

| Sample Number | Location | Field Description of Material | Field Description of Overburden | Thickness of Deposit | Areal Extent (Estimated) | Remarks |
|---|---|---|---|---|---|---|
| 3 | Right side of Bear Creek; 3/4 mile upstream from its junction with Rat River | Medium- to coarse-grained sand; stratified, well graded; large percentage of black shale; numerous rounded pebbles of sandstone up to 2 inches; includes some fine-grained gravel | None | 10 feet | length: 500 feet<br>width: unknown | Overlies a dense, till-like, silty clay; is frozen |

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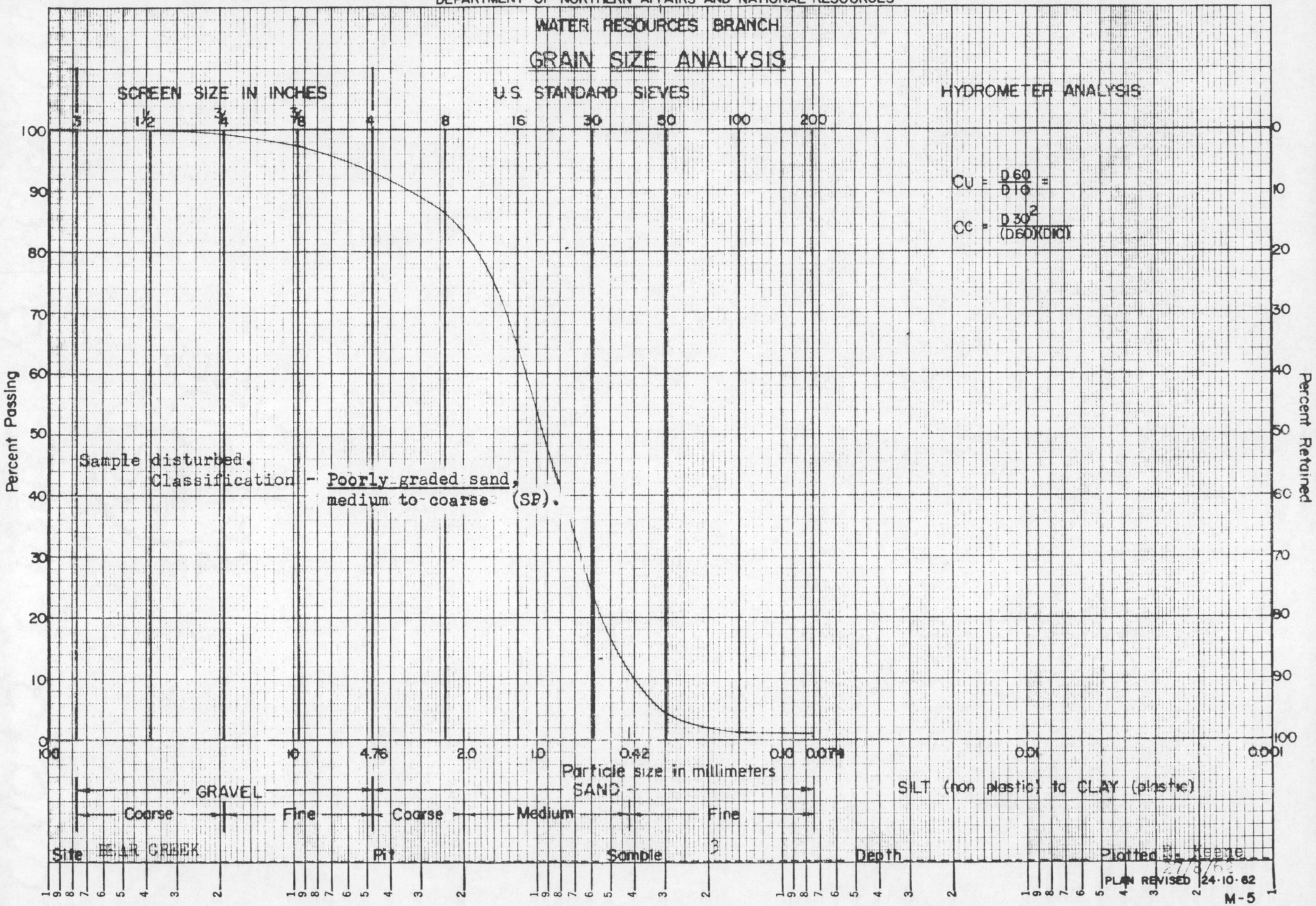
WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS




PLAN REVISED 24·10·62

M-5

Plate 1

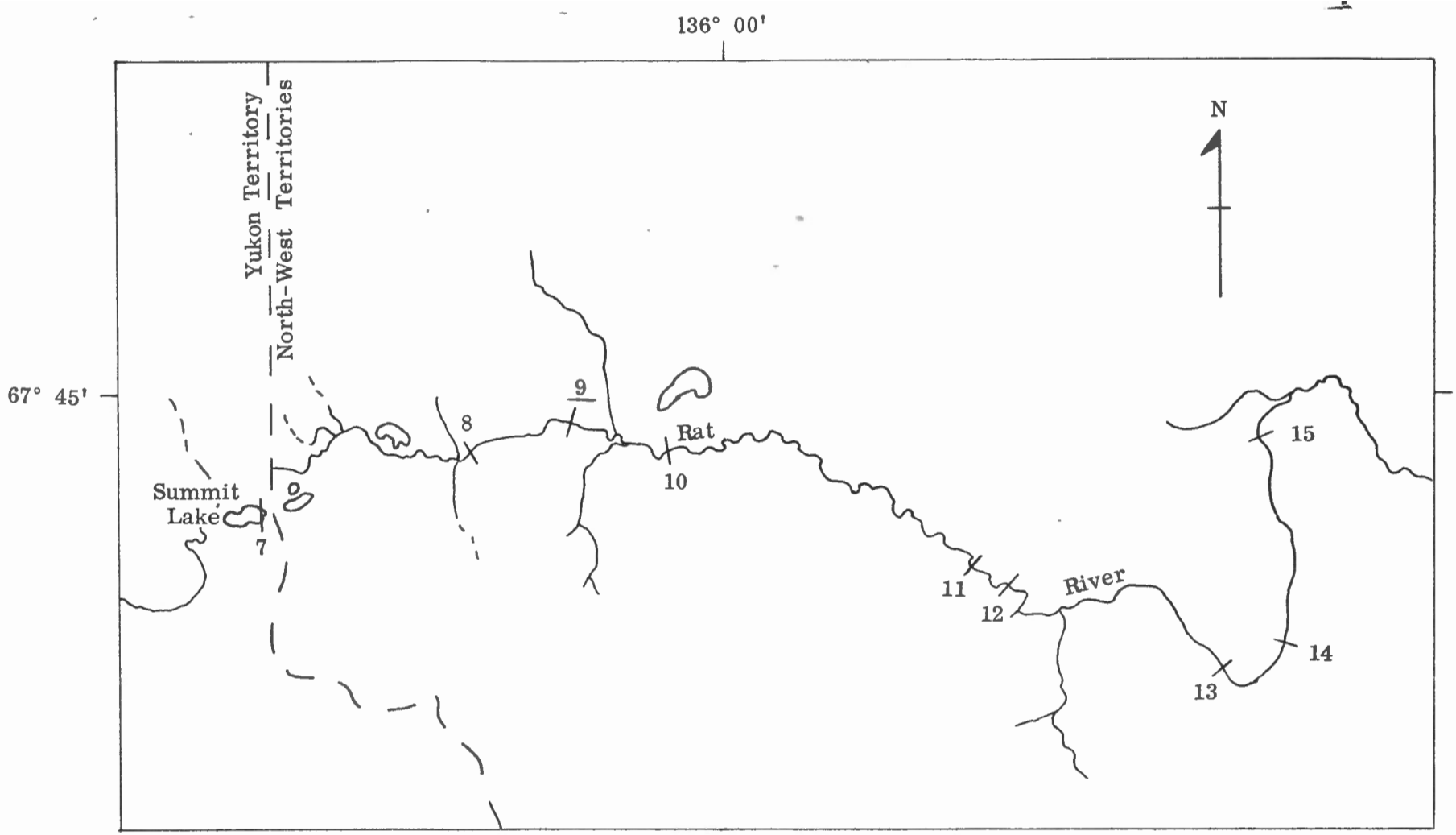
Vertical shale and sandstone beds exposed along left side of Rat River; terrace is covered with clayey silt and extends north about 1,000 feet to toe of left abutment.

G.S.C. 12-4-62

Plate 2

Moss-covered right abutment slope taken opposite plate 1.

G.S.C. 13-1-62




LOCATICN 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 |