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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA
TOPICAL REPORT NO. 79

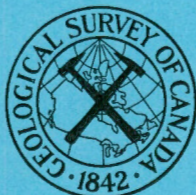
MACKENZIE RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 14

LONGSTICK DAM SITE

(MAP AND PRELIMINARY REPORT)

BY
E. B. OWEN



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OTTAWA
1963

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LONGSTICK DAM SITE

General Description

Longstick dam site is situated in McDougall Pass about 7 miles from the east end of the Pass where it joins MacKenzie River delta. It is about 3 miles downstream along Rat River from Barrier River site described in Topical Report No. 78.

About a mile upstream (southwest) from Longstick site McDougall Pass, which trends east and southeast throughout most of its length, swings abruptly north and continues in this course for several miles before it turns east to connect with the delta. In its northerly course the Pass is separated from the delta by a long ridge, less than a mile in width, bordered on the west by the east side of the Pass and on the east by a broad, sloping scarp facing the delta. The topography and geology at Longstick site closely resembles that at Barrier River site. The chief difference is that at Longstick site McDougall Pass is trending in a northerly direction whereas at Barrier River site it is in a southeast direction. This, however, has little significance in comparing the two sites. Both sites would be by-passed if the alternate scheme to divert the water from Upper Rat Canyon site directly to Delta site some 4 miles downstream from Longstick is carried through.

At Longstick site Rat River is flowing in a northerly direction along the west side of McDougall Pass. As at Barrier River site the left abutment consists of a steep, rocky bluff which ascends abruptly from the edge of the river. The right abutment consists of a

more gentle slope almost completely covered with vegetation. One small outcrop of bedrock exists in the right abutment area whereas bedrock is exposed throughout much of the steeper, left abutment.

The width of the Pass between the two abutments is about 2,000 feet. Several terraces separated by low, water-cut bluffs, up to 6 feet in height, cover the floor of the Pass. These are believed to have been formed by Rat River when it flowed at a higher elevation.

Overburden covering the floor of the Pass at the site consists chiefly of alluvial deposits of clayey silt and sand. On both abutments bedrock is overlaid directly by irregular deposits of glacio-fluvial sand and gravel which in turn are overlaid by glacio-lacustrine sandy silt. Unlike Barrier River site the area included in the map of Longstick site extends sufficiently high to include the glacio-lacustrine material. Talus mixed with silt, sand and gravel covers large parts of both abutment slopes.

Unconsolidated Deposits

Five types of unconsolidated deposits exist at Longstick dam site. These are as follows:

1. Recent alluvium (silt, sand, gravel): This material consists of silt, sand and gravel deposited by the present Rat River. The gravel contains numerous rounded to subrounded boulders of hard, durable rocks, chiefly sandstone and quartzite, which are not local in origin. A large bar in Rat River in the upstream part of the site area

consists of this material. Doubtless the material directly underlying the river is similar in character.

The flood plain of Rat River extends southeast across the floor of the pass for a distance of several hundred feet from the right side of the river. With the exception of a few scattered boulders the Recent alluvium here consists of sand and fine-grained gravel. In places where it is covered with moss it is usually frozen.

The Recent alluvium in the river would probably be acceptable as material for the shell of an earth dam providing sufficient quantities are available. Its potential as a source of coarse aggregate is limited by the high percentage of large boulders which range up to 20 inches in diameter, the poor grading and the presence of large quantities of deleterious substances especially organic material.

2. Alluvium (clayey silt, sand): This material consists chiefly of clayey silt with minor quantities of sand and fine-grained gravel. It covers the floor of the pass between the flood plain of Rat River and the toe of the right abutment. The limits of the deposit were difficult to define because the frost line usually occurs in the overlying moss and organic material. This prevented test pits from penetrating sufficiently deep to encounter the alluvium. This material as well as the Recent alluvium was identified chiefly in the shot holes along the seismic line. It is believed, however, the alluvium extends up to approximate elevation 295. The material is believed to have been deposited by Rat River when it flowed at a higher elevation, before it settled in its present course. It is a

possible source of impervious material for an earth dam. However, the quantity and quality available would have to be determined by a program of test pitting and test borings.

3. Talus: Talus is material resulting from the mechanical disintegration of adjacent bedrock. At Longstick site it occurs on both abutment slopes as angular rock fragments ranging from sand-size particles to boulders several feet in diameter. The size and shape of the fragments depends, in general, upon the spacing and angles of intersection of the jointing and bedding. About 40 per cent of bedrock exposed at the site consists of massive, thick-bedded sandstone and the remainder of black, laminated shale containing numerous narrow, lenticular, sandstone interbeds. The thickness of the sandstone strata varies from 2 inches to more than 4 feet. Fragments derived from the thin-bedded rock are usually platy with one narrow dimension whereas those from the thicker beds are larger, roughly squared blocks.

Most rock fragments in the talus have been weathered to a relatively soft, brown, porous rock. It is doubtful if they could be used as rock fill or riprap. They are not representative of the fresh rock which occurs at depth.

The large quantity of sand which is mixed in the talus is mostly the result of the disintegration of the sandstone bedrock. This is due to leaching of the carbonate matrix binding the sand grains. The talus also contains quantities of silt, sand and gravel which have slumped from deposits of these materials exposed along the top of the bluff.

4. Glacio-fluvial (gravel, sand): This material consists of poorly sorted, coarse-grained, sandy gravel believed to have been deposited on bedrock surface by glacial melt waters which flowed west through McDougall Pass. The silt and clay content are low. The material is exposed in many places along both sides of McDougall Pass between Upper Rat Canyon site and the east end of the pass. At Longstick site it is exposed on both abutment slopes in thicknesses up to 40 feet.

A representative sample of the material was forwarded to the Soils Laboratory of the Water Resources Branch in Vancouver for grain size analyses. A description of the sample and resultant grain size curve is included at the end of this report. Similar material is described in the report on Upper and Lower Rat Canyon sites (Topical Report No. 65). It is believed the gravel is a potential source of natural aggregate but would have to be processed before it could be used. As at Barrier River site the gravel is overlaid by glacio-lacustrine sandy silt. The cost of excavating the gravel would be relatively high because of the silt which would have to be removed and the fact that both materials are frozen. The permeability of the gravel is undoubtedly high.

5. Glacio-lacustrine (sandy silt): This material consists of yellowish-brown, stratified, sandy silt which overlies the glacio-fluvial gravel in thicknesses varying from 5 to 20 feet. It is an extensive deposit occurring along both sides of McDougall Pass between Upper Rat Canyon site and the east end of the pass at MacKenzie Delta. It also covers the undulating terrace which extends for many miles away from both sides of

the pass. A description of a representative sample of the material is included at the end of this report.

The sandy silt should be considered as a potential source of material for the impervious core of an earth dam. It readily thaws when the overlying layer of mass has been stripped. The resultant material is very fluid and as the elevation of the deposit is greater than that of the dam it could possibly be transported to the site by gravity.

Bedrock

General Description

Bedrock consists of fine-grained, grey, calcareous sandstone in beds up to 4 feet in thickness separated by thin, lenticular beds of similar sandstone associated with black, laminated shale. These rocks are similar to those at Barrier River site with the exception siltstone is not present. As at Barrier River site they are exposed chiefly in the steep, rocky bluff forming the left abutment. Only one small bedrock outcrop occurs in the right abutment area. The upper and lower parts of bedrock exposed in the left abutment consists, in general, of relatively thick beds of sandstone. The centre part consists chiefly of soft, black, laminated shale with thin beds of sandstone up to 2 inches in thickness. A large part of the sandstone has been highly weathered to a soft, porous, poorly cemented rock and the shale to a soft, black, clayey material containing small, angular fragments of more resistant shale.

The following are the results of laboratory tests made on a representative sample of fresh sandstone from the left abutment of Longstick site:

Unit weight	-	161.0 pcf
Absorption	-	1.3 %
Specific gravity	-	2.65
Particle size	-	uniform, fine sandstone; 99% - 0.6 to 0.07 mm

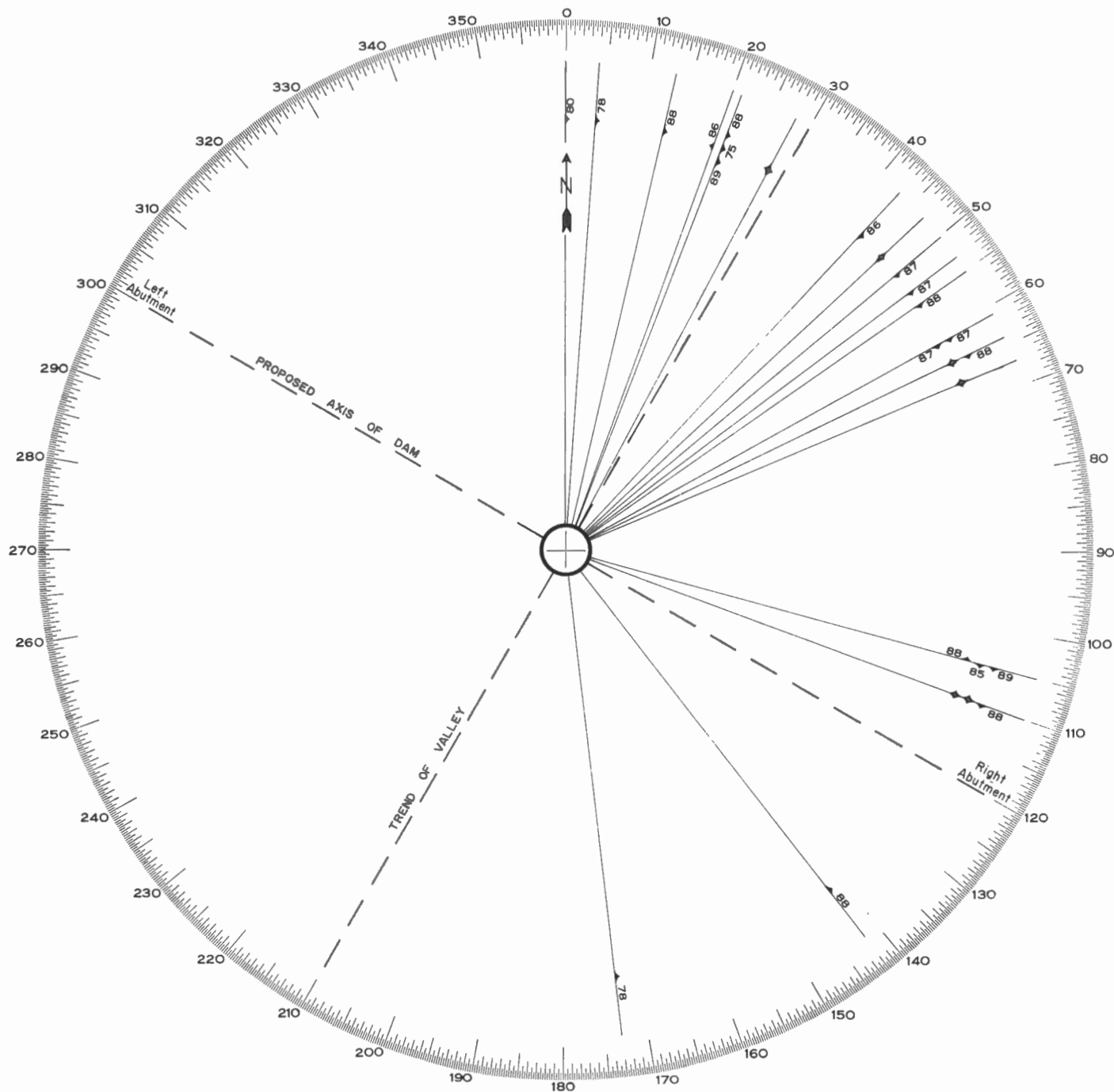
The results of other tests made on samples of similar sandstone from Upper and Lower Rat Canyon sites and from Delta site are included in the report on Delta site.

Bedrock Structures

Bedding and jointing are the two most important structures in bedrock at Longstick site. There are two prominent joint sets which intersect at approximately 60 degrees. One set intersects the proposed axis of the dam at angles varying from 55 to 75 degrees and dips steeply into the right abutment. The second set which in some places closely parallels Rat River intersects the axis at angles between 60 and 90 degrees and also dips steeply toward the right abutment. The spacing between the jointing varies considerably from 2 inches to 4 feet. The attitude of the bedding throughout the site is horizontal. Consequently it was not necessary to include a bedding rosette in this particular report. Faulting was not noted in the site area.

Quality of Bedrock

From the engineering viewpoint bedrock at Longstick site



JOINT ROSETTE

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

can be divided into two types. One is the thick-bedded sandstone which occurs in the upper and lower parts of bedrock exposed in the left abutment and the other is the thin-bedded sandstone and shale which exists between the two more massive units. The results of laboratory tests on samples of unweathered sandstone from the thick beds indicate the rock has a relatively high specific gravity and a low porosity. These rocks in the unweathered state are probably competent and would provide satisfactory abutment and foundation material. However, the presence of considerable thin-bedded sandstone and shale between the more massive rock will adversely effect the properties of the entire rock mass. Test borings will be required to determine the extent of the thin-bedded rocks in both abutments and laboratory tests made to obtain information regarding their physical properties. The weathered sandstone is too soft, porous and poorly cemented to have any use as a construction material except possibly as road fill. This would also include most of the rock fragments in the talus.

Engineering Considerations

Depth of Overburden

The thickness of the mixture of talus residual soil derived chiefly from the shale, and slumped silt and gravel on the abutment slopes is believed to be generally less than 10 feet. Bedrock is exposed on both abutments although most of the outcrops occur on the left side. The thickness of the glacio-fluvial gravel directly overlying bedrock is irregular. Its maximum is about 40 feet. The glacio-lacustrine sandy silt overlying the gravel has a levelling effect upon the irregular surface of the glacio-fluvial

material. The thickness of the silt changes considerably over short distances. In general it varies between 5 and 20 feet.

There is little information regarding the thickness of overburden across the floor of the pass in the site area. The results of the seismic profile located about halfway between the abutments indicated the depth of overburden at this point is about 17 feet. This figure is believed to be low and should not be accepted as representative of the depth of overburden across the entire floor of the pass. The results of the seismic profile at Barrier River site located in about the same position in relation to the abutments indicated the thickness of overburden was greater than 67 feet. At Delta site some 4 miles downstream from Longstick the results of one seismic line indicated overburden varied in thickness from 145 to 170 feet. At the latter site, however, the seismic line was located near the steep bluff forming the right abutment against which Rat River is flowing and not in the centre of the pass.

Test borings will be required at Longstick site to determine the thickness of overburden across the floor of the pass and confirm the results of the seismic work. Borings will also be necessary to determine the elevation of bedrock surface in the abutments as this, as at Barrier River site, will probably limit the height of the dam.

Proposed Centre Line

The geology throughout the site area is much the same. Consequently for preliminary designs and cost computations the dam can

be located anywhere in the site area. The final location, type and height of the dam will depend upon the results of the test borings and laboratory tests suggested previously.

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. At low water in Rat River beds of soft, black, laminated shale are exposed along the base of the left abutment immediately underlying the thick-bedded sandstone exposed in the bottom part of the abutment. The shale is similar to that which exists in the centre part of the abutment between the massive sandstone units. The thickness of the lower shale is unknown. It can only be determined by test borings.

The presence of the narrow beds of sandstone and shale between the more massive beds would adversely effect the strength of the rock in the left abutment. These rocks should be thoroughly investigated to determine if they are sufficiently competent to withstand the thrust of an arch dam if such a structure is contemplated.

Bedrock exposed at Longstick 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 unknown but it is probably considerable. Test borings will be required to determine the extent 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.

Bedding and jointing are the structures which might influence the method of excavation in bedrock. The bedding is horizontal and should present no difficulties. The steep dip of the jointing into the right abutment might cause the entire abutment slab to be unstable when excavated.

The rock mass is believed to be impermeable. There is no evidence of groundwater movement through the sandstone or along the contacts of the sandstone and shale. The prominent joint set in the sandstone which closely parallels the valley might cause excessive leakage in the foundations. These joints would be open at bedrock surface and wedge out in depth. Test borings put down at shallow angles will be necessary to investigate them. The presence of open joint fractures in bedrock could greatly increase construction costs as either stripping or an elaborate program of pressure grouting will be necessary. Diversion tunnels planned for the site should be located in the left abutment. It might be possible to locate these structures so that the more massive, thick-bedded sandstone would form the roof or floor of the tunnel.

The permeability of the glacio-fluvial gravels overlying bedrock in the abutments is probably high. Hence a leakage problem may result if the dam is sufficiently high that its upper part is keyed into the gravel. Leakage might also occur in the reservoir rim.

The coarse-grained, alluvial gravels in and along the edges of Rat River are likewise permeable. The numerous large boulders in the material would interfere with steel sheet piling if it is used in the construction of coffer dams at the site.

Construction Materials

Aggregate

The same sources of aggregate described for Barrier River site would be available for Longstick site. The most probable source are the extensive deposits of glacio-fluvial gravel which occur throughout the east end of McDougall Pass. A sample of this material taken from near the top of the left abutment was forwarded to the soils laboratory of the Water Resources Branch in Vancouver for grain size analyses. The resultant curve is included at the end of this report. A description of similar material accompanies the report on Upper and Lower Rat Canyon sites (Topical Report No. 65). The high proportion of hard, durable rocks, such as quartzite, among the cobbles and boulders would probably result in relatively high crushing costs compared to crushing the softer sandstone bedrock.

Suitable coarse aggregate could be obtained from the fresh sandstone. The process would have to be selective to avoid contamination by the weathered rock and the shale. This would not be as difficult as at Barrier River site because the shale at Longstick is confined more or less to one zone and not scattered throughout the rock as narrow interbeds. It was estimated about half the rock exposed in the left abutment could be used as aggregate. This rock almost entirely occurs in the upper and lower parts of the abutment.

Impervious Material

The glacio-lacustrine sandy silt which covers the undulating

terrace above the abutments is a potential source of impervious material for an earth dam. A description and grain size analyses curve of a representative sample of the material taken from near the top of the bluff along the left hand side of the river is included at the end of this report. As at Barrier River site a major construction problem will be to excavate the material which at the time of the investigation (July 27, 1962) was completely frozen.

Another potential source of impervious material is the alluvial deposit of clayey silt which exists on the floor of McDougall Pass between the edge of the flood plain of Rat River and the toe of the right abutment. A test boring or test pitting program will be required here to determine the quantity and quality of material available. As in the case of the glacio-lacustrine sandy silt the alluvial material is frozen.

Pervious Material

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

Riprap and Rock Fill

The results of laboratory tests on samples of unweathered sandstone indicate it is suitable for riprap or rock fill. It is estimated about 40 per cent of bedrock exposed in the left abutment will provide sufficiently large rock fragments to be used as riprap. The rock fragments

in the talus are, in general, highly weathered and would be unsuitable as construction material.

Groundwater

There is little information regarding groundwater conditions in the site area. Springs or seeps were not observed in either abutment slope nor is there any indication they have existed in the past. The swamp conditions on parts of the valley floor are due to the proximity of the frost line to ground surface and the lack of proper surface drainage.

Frozen Ground

Frozen ground is believed to exist throughout the entire site area. Test pits put down on the floor of the pass, on the right abutment and on the terrace above the left abutment encountered the frost line frequently within a few inches of ground surface (July 27, 1962). Frozen ground was not encountered in the overburden along the top of the steep, east-facing left abutment by test pits put down to maximum depths of 5 feet. Test borings will be required to determine if frozen ground exists beneath Rat River. Small, irregular ice lenses, up to 1/4 inch in width and 3 inches long, were observed in alluvial clayey silt in the shot holes along the downstream end of the seismic line.

Further Investigations - Conclusions

As at the other sites in the multiple stage power development proposed for McDougall Pass this report is based upon a rapid field

examination of the soils and bedrock exposed in and adjacent to the site area. A few samples were taken upon which laboratory tests were made. The frozen condition of the soil prevented, in many places, positive identification of the material. Consequently the contacts between the various deposits as drawn on the accompanying map are only approximate. However, it is believed the information in this report is sufficiently precise to permit office studies and obtain general cost estimates.

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. Bedrock is similar to that at adjacent Barrier River and Delta sites. The results of tests made on samples of bedrock from these sites as well as from Rat Canyon sites are included in the report on Delta site. The tests indicated the fresh sandstone is suitable for most purposes. Test borings will be required to determine the elevations of bedrock surface beneath the floor of McDougall Pass in the site area and also in the abutments. Permeability tests should be conducted on both overburden and bedrock as they are encountered in the borings. 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 east end of McDougall Pass where

the river leaves the 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 Fish Creek dam site (Topical Report No. 71, site No. 8).

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. The grain size sheet for potential aggregate shows the following information:

- (a) Limits of fine and coarse aggregate based upon a 6-inch maximum size.
- (b) A cumulative grain size curve for the sample.
- (c) A curve 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.

Sample No. 10 was analysed as potential impervious material and sample No. 11 as potential aggregate.

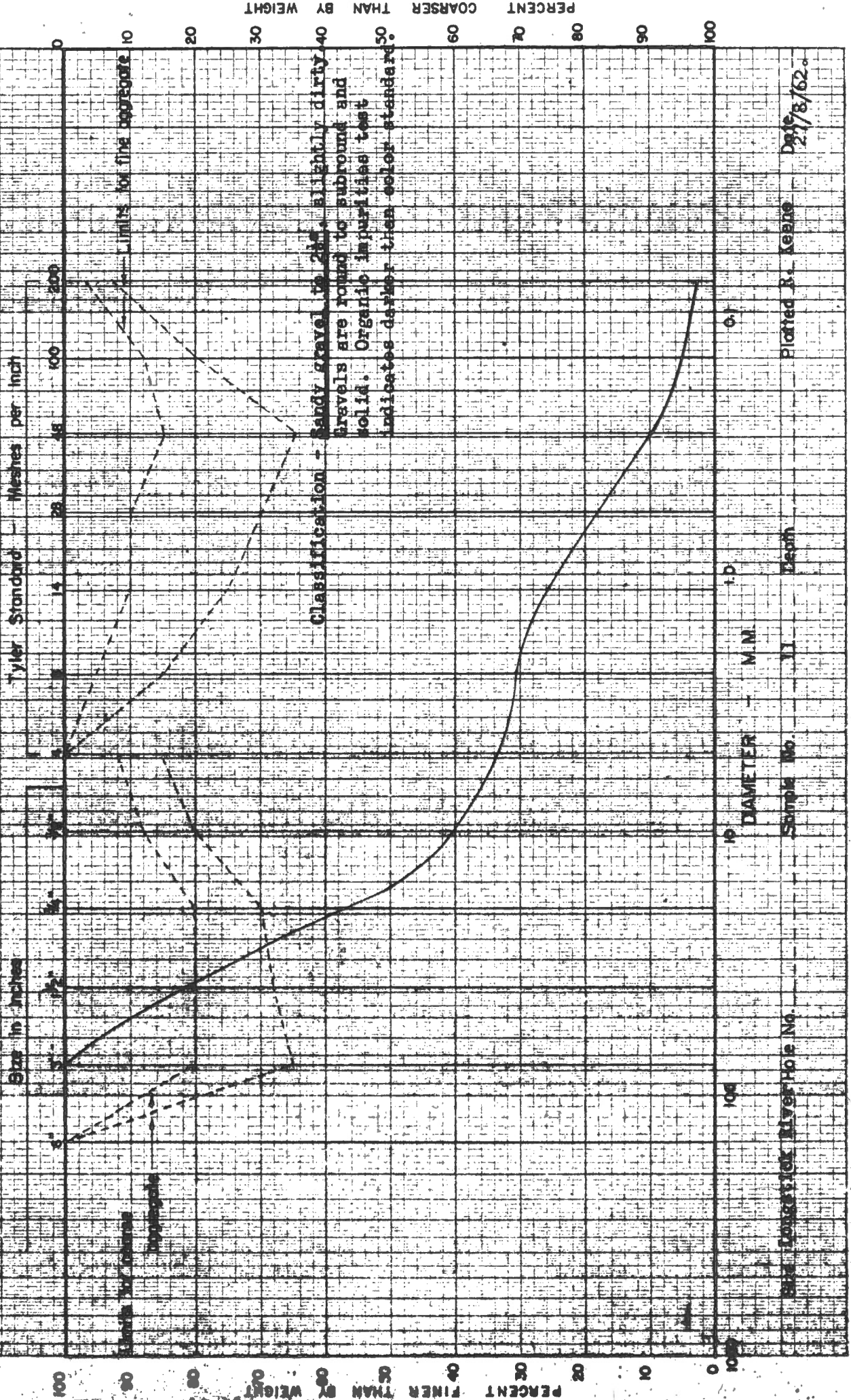
Description of Potential Impervious Material for the following Grain Size Analysis Curve

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
10	Left abutment; 15 feet from top of bluff near minor centre of site area; 3 feet beneath ground surface	Sandy silt; yellowish-brown, stratified; minor clay.	None	30 feet	Unlimited	Extensive deposit on terrace above abutments; sample taken 25 feet above sample No. 11.

Description of Potential Aggregate for the following Grain Size Analyses Curve

Sample Number	Location	Field Description of Material	Field Description of Overburden	Thickness of Deposit	Areal Extent (Estimated)	Remarks
11	Left abutment; 40 feet from top of bluff near centre of site area; 3 feet beneath ground surface	Coarse-grained, fairly well graded gravel, minor sand; very little silt or clay; indistinct stratification; about 40% by volume consists of rounded to subrounded cobbles and boulders over 3 inches in diameter. <u>Cobble and Boulder Lithology</u> Sandstone - 65% Quartzite - 25% Granite, minor diorite and volcanics - 10%	30 feet of sandy silt as in Sample No. 10.	30 feet	Unlimited	Deposit exposed for many miles along both sides of McDougall Pass; similar material described in report on Upper and Lower Rat Canyon sites; sample taken 25 feet below Sample No. 10.

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 WATER RESOURCES BRANCH
 GRAIN SIZE ANALYSIS FOR CONCRETE AGGREGATE RECONNAISSANCE



Sample No. 11
 Diameter - M.M.
 Depth
 Plotted B. Keane
 Date 2/18/62

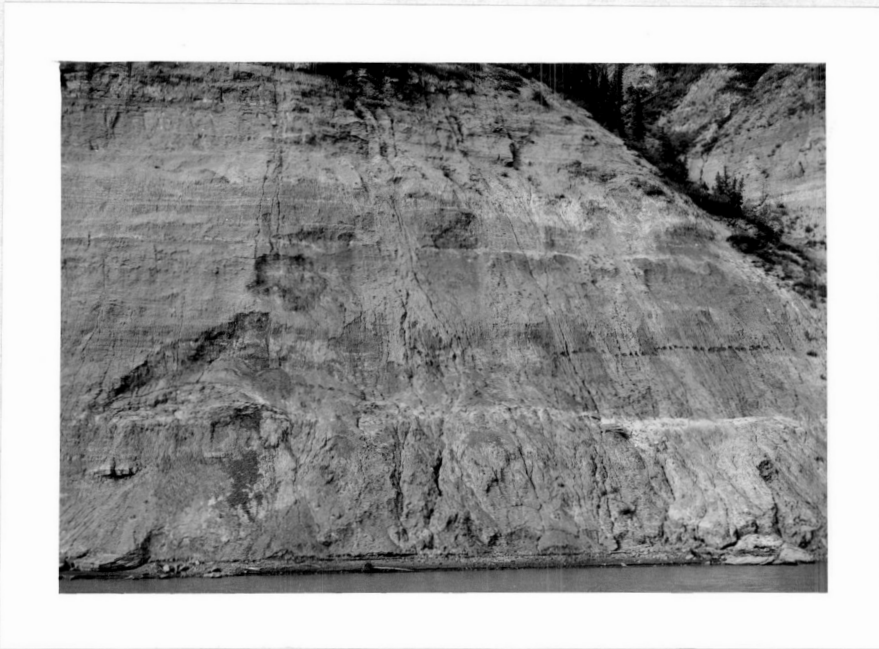


Plate 1

Lower part of left abutment, Longstick dam site,
bedrock consists of sandstone and shale.

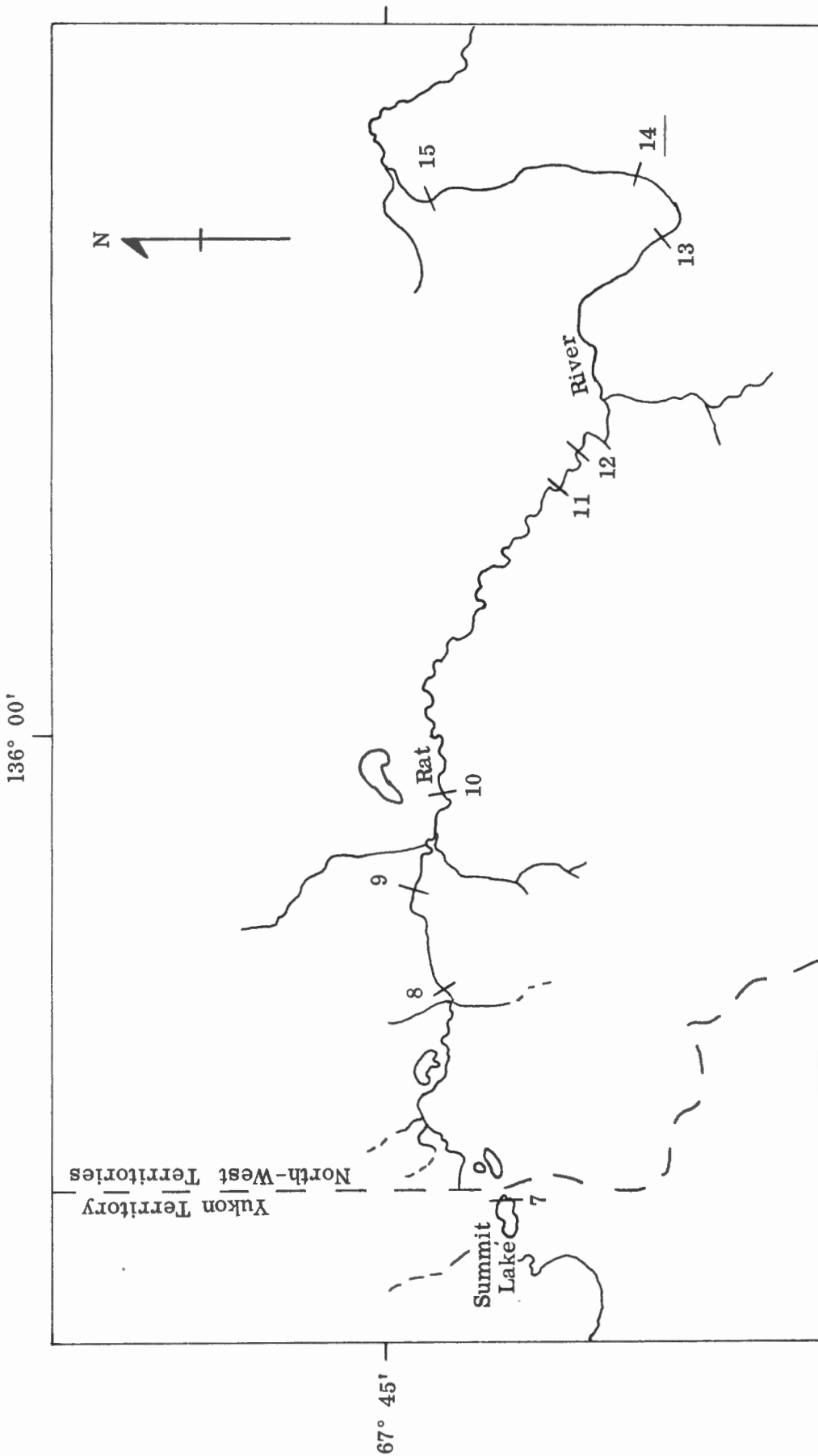
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Plate 2

Vegetation - covered right abutment,
Longstick dam site.

G.S.C. 31-6-62



**LOCATION OF PROPOSED DAM SITES
MACKENZIE RIVER DRAINAGE BASIN**

Scale: 1 inch to 4 miles (approx.)

<u>Site No.</u>	<u>Name</u>	<u>Site No.</u>	<u>Name</u>	<u>Site No.</u>	<u>Name</u>
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