CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

GEOLOGICAL SURVEY OF CANADA

TOPICAL REPORT NO. 36

YUKON RIVER DRAINAGE BASIN
DAM SITE INVESTIGATION

SITE NO. 32

# KLUANE CANYON DAM SITE

(MAP AND PRELIMINARY REPORT)

BY

E. B. OWEN

OTTAWA

1961

Canada

Department of Mines and Technical Surveys

---

Geological Survey of Canada

Topical Report No. 36

Yukon River Drainage Basin

Dam Site Investigation

Site No. 32

# KLUANE CANYON DAM SITE

(Map and Preliminary Report)

by

E. B. Owen

---

Ottawa

1961

# CONTENTS



## Illustrations

# Kluane Canyon Dam Site

## General Description

Kluane Canyon dam site is situated on Kluane River about 4 miles downstream from Kluane Lake, which is drained by the River.

In the site area Kluane River is a shallow, rapid-flowing stream with an average width of about 175 feet. The water is relatively clear and its temperature at the time of this investigation (July 1, 1961) was 56 degrees fahrenheit.

Kluane River flows along the northeast side of the drift-covered floor of Shakwak Trench for a distance of about 56 miles. It joins Donjek River about 19 miles downstream from the Alaska Highway Bridge over the Donjek at mile 1132.

At the site Kluane River is flowing in a northwest direction between low bluffs 40 to 60 feet in height. Till and glacio-fluvial sand and gravel are the principal materials exposed on the bluffs. Northeast of the River the topography of the ground surface is irregular, with a maximum relief of about 50 feet. A steep rock bluff about 2,000 feet to the northeast marks the edge of Shakwak Trench. A line of shallow ponds and swamps near the toe of the bluff suggests a former course of Kluane River may exist in this area. The elevations of the water surfaces in the ponds are about 60 feet higher than that of the River.

Southwest of Kluane River ground surface is gently undulating with a general northwest trend parallel to Shakwak Trench. A low, elongated ridge about 900 feet southwest of the River consists of till overlaid with a thin deposit of glacio-lacustrine silt.

Limited exposures of bedrock occur on both sides of Kluane River and in several places within the area mapped northeast of the River. It consists of intensely metamorphosed rocks of the Yukon Group described by Bostock[1] as Precambrian and Later.

The greater part of ground surface about the site is covered with a thin layer of glacio-lacustrine silt. In some places below approximate elevation 2,580 the silt has been replaced by alluvial sand and gravel deposited by Kluane River when it flowed at a higher elevation.

Material exposed in the bluff along the left side of the River is composed chiefly of silt overlying till. The thickness of the silt deposit varies from 4 to 6 feet. Slumped material consisting of a mixture of silt and till covers much of the lower portion of the bluff and effectively conceals any material beneath the till which normally would be exposed. The thickness of the till directly overlying bedrock exposed on the left side of the River is about 20 feet.

Till is exposed for a distance of about 900 feet along the right side of the River. The maximum thickness observed was about 20 feet. Underlying the till is a well stratified, clean, sandy gravel believed to be glacio-fluvial in origin.

There is no lack of overburden suitable for construction purposes in the site area. Frozen ground was encountered (June 27, 1961) in many shallow test pits put down on both sides of the River.

---

[1] Bostock, H. S.: "Geology of Northwest Shakwak Valley, Yukon Territory"; Geol. Surv., Canada, mem. 267, 1952, p. 15.

## Unconsolidated Deposits

Six types of unconsolidated deposits were identified about Kluane Canyon dam site. These are as follows:

1. Recent Alluvium: This material has been deposited by the present River. It consists of silt, sand and gravel containing boulders up to 12 inches in diameter. Much of this material was probably carried down by Duke River during times of flood and deposited at its junction with the Kluane. Similar material is exposed in numerous dry channels which cross the wide flood plain of Duke River between Alaska Highway and Kluane River.

2. Slump: Much of the lower portion of the bluff along the left side of Kluane River is covered with slumped material. It consists chiefly of glacio-lacustrine silt which has moved down from the top of the bluff frequently carrying large quantities of vegetation with it. In some localities till is mixed with the silt. Slump is included in the legend because it is extensive and sufficiently thick that the underlying material could not be determined by the shallow test pits put down during this investigation.

3. Alluvium (silt, sand, gravel): This material is believed to have been deposited by Kluane River at some earlier stage in its history when it flowed at a higher elevation. The material consists of silt, sand and gravel containing boulders up to 24 inches in diameter. Extensive deposits occur along the right side of Kluane River up to elevation 2,578, or about 40 feet above the normal water level of the River. About 18 feet of alluvium

is exposed in the bluff along the right side of the River some 800 feet downstream from the rock outcrop. Here it directly overlies till.

4. Glacio-Lacustrine (silt): This material consists of thinly-bedded, yellowish-brown, sandy silt which covers much of the ground surface in the area included in the accompanying geological map. The thickness of the deposit varies from a few inches to several feet. The silt is well exposed along both sides of Kluane River and in the cut banks of the dry stream channel in the southwest part of the map-area. It usually directly overlies till.

5. Till: Till is exposed in the bluffs along both sides of Kluane River. It consists of a grey, silty, sandy material containing numerous angular rock fragments up to 10 inches in diameter. The maximum observed thickness was 20 feet. It is usually overlaid with a thin deposit of glacio-lacustrine silt.

The till appears to be impervious, with satisfactory shear strength. However, removal of the larger boulders will be necessary for it to be compacted satisfactorily. The density is relatively high.

Considerable till is believed to occur in the area about the proposed dam site. A long, low ridge which parallels the River about 900 feet to the southwest consists of till with a thin capping of silt. Till probably constitutes most of the material forming the bluff along the left side of the River.

6. Glacio-fluvial (sand and gravel): This material consists of well stratified, medium- to coarse-grained sand and sandy gravel. It is exposed beneath the till along the right side of the River downstream

from the rock outcrop. The attitude of the cross-bedding, which is common, indicates the material was deposited by water flowing in the same direction as the present River. The permeability is probably high.

The most likely location of the proposed dam would be in the approximate centre of the map-area between the rock knob on the right side of the River and the till bluff on the left side. Test borings will be required on both sides of the River to determine the extent of the glacio-fluvial material. The presence of permeable sand or gravel underlying or associated with the till could result in piping of reservoir water and ultimate failure of the left abutment.

## Bedrock

### General Description

Bedrock exposed at the site consists of well-foliated, quartz-biotite schists and gneisses. They do not exhibit any distinct stratification which might represent original sedimentary bedding. Their uniformity in composition gives them a massive appearance suggestive of altered batholithic rocks. Weathering is not extensive.

### Bedrock Structures

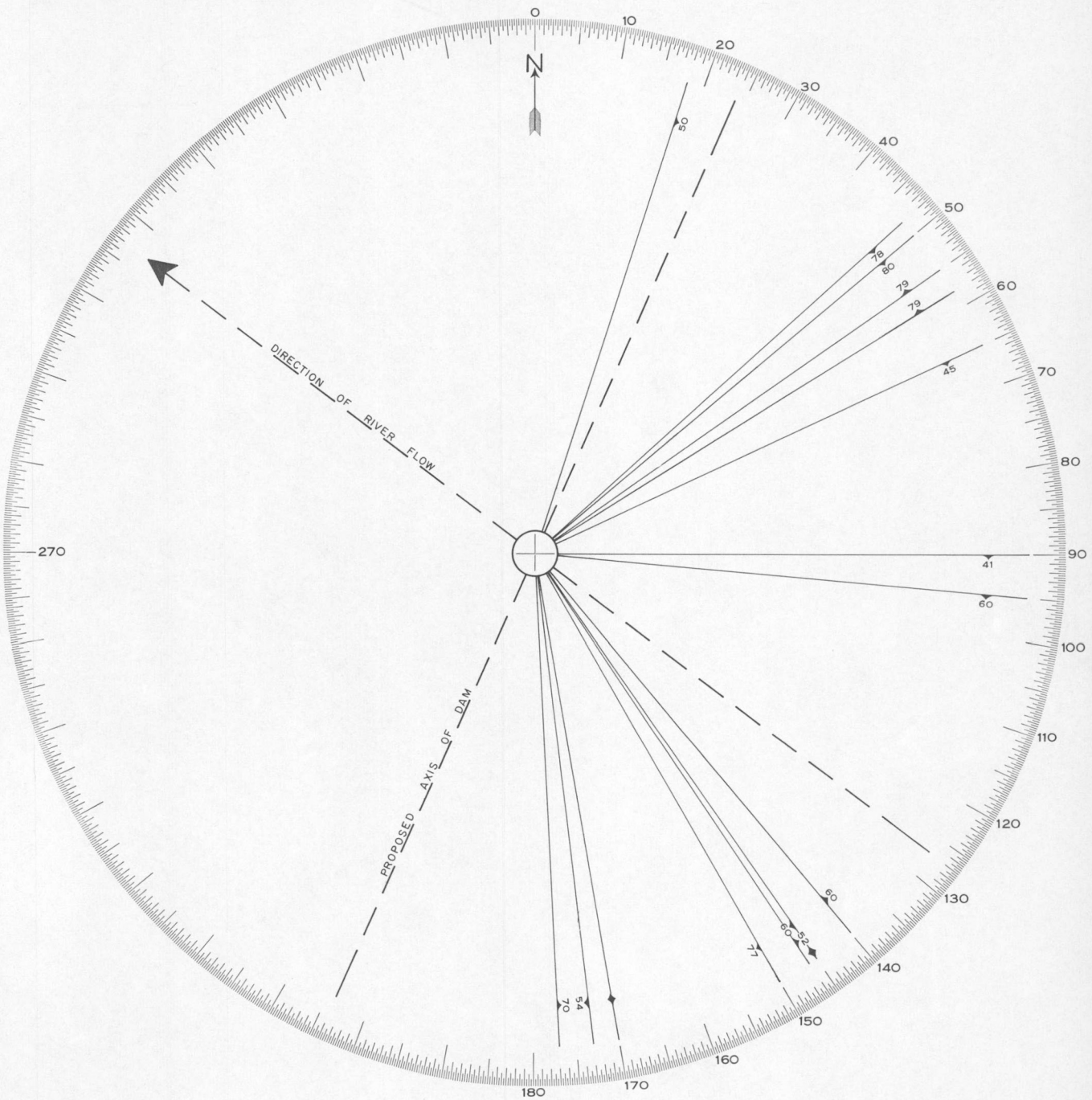
The attitudes of the foliation of bedrock at the site differ widely. According to Bostock[1] the general foliation of these rocks in the Kluane

---

[1] Bostock, H. S.: "Geology of Northwest Shakwak Valley, Yukon Territory"; Geol. Surv., Canada, Mem. 267, 1952, p. 16.

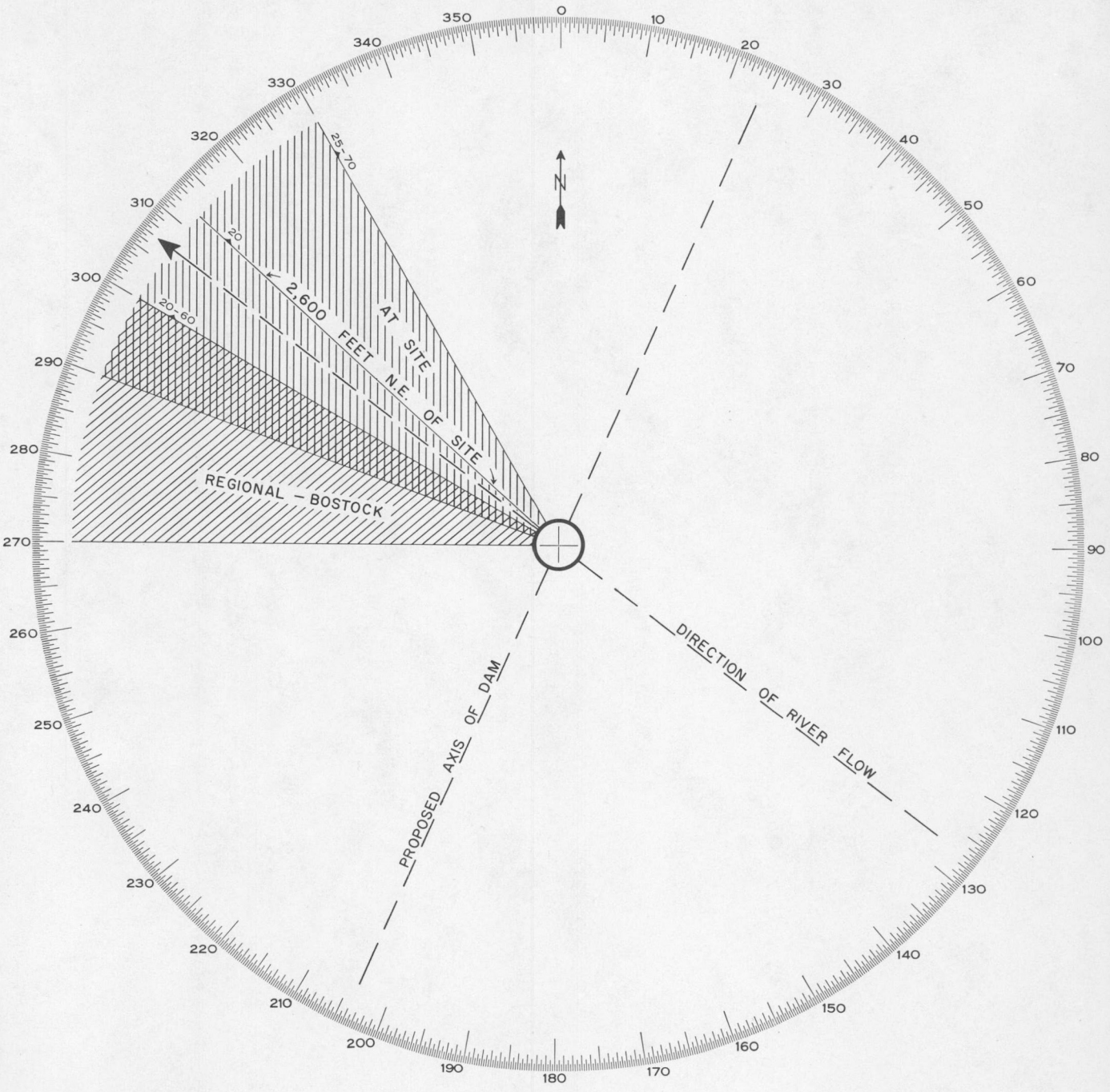
Lake area strikes between north 60 degrees west and west and dips northeasterly to northerly at 20 to 60 degrees. The foliation in the rock exposed at the base of Outlet Hill northeast of the site strikes about north 48 degrees west and dips northerly at 20 degrees. At the site Kluane River is flowing north 53 degrees west or nearly parallel to the general trend of the foliation in this portion of Shakwak Trench. The foliation at the site strikes north 30 to 70 degrees west and dips northeasterly from 25 to 70 degrees. It intersects the River at angles from 20 to 30 degrees and dips toward the right abutment.

The most prominent joint set intersects the River at angles between 11 and 28 degrees and dips steeply in both upstream and downstream directions. Other less pronounced jointing intersects the River at angles as great as 70 degrees and usually dips steeply downstream or toward the right abutment. A rosette indicating the relation between the jointing and the direction of flow of the River accompanies this report. It should be noted that on the rosette the proposed axis of the dam is not at right angles to the River. The reason for this is that the bedrock exposure on the right side of the River is about 150 feet downstream from that on the left. As bedrock forms the best abutment material at the site, the axis has been swung to take advantage of this fact. Faulting was not observed in the rock exposed in the site area. The foliation has little effect upon the competency of the rock.




JOINT ROSETTE

The above illustration presents diagrammatically the direction and dip of the jointing in bedrock exposed at Kluane Canyon dam site.




FOLIATION ROSETTE

The above illustration presents diagrammatically the range of the direction and dip of local and regional foliation in rocks of the Yukon Group exposed at and near Kluane Canyon dam site

Quality of Bedrock

It is believed bedrock exposed at Kluane Canyon dam site will provide satisfactory foundation and abutment material. It is massive, competent and not highly weathered. Test borings will be required to investigate the vertical extent of the considerable jointing visible on surface. It is believed the rock could be successfully grouted.

## Engineering Considerations

Depth of Overburden

At the site Kluane River is flowing close to the northeast side of Shakwak Trench. The presence of rock outcrops and the results of seismic lines Nos. 4 and 5 (bedrock surface at 28 to 70 feet) indicate the thickness of overburden between the River and the northeast side of the Trench is relatively thin. The elevation of the lowest spot on bedrock surface as indicated by the seismic investigations is about 2,530 feet above sea level. This is slightly lower than the water surface of Kluane River at the site. It is possible a buried stream channel eroded into the underlying bedrock surface may exist in this area. Numerous elongated ponds and sloughs extend for several miles along the toe of the rock bluff forming the northeast side of Shakwak Trench. These probably indicate a former course of Kluane River when it flowed at a higher elevation.

The nearest bedrock exposure southwest of the River occurs on the southwest side of Shakwak Trench, a distance of about 4 miles.

There is no information available concerning the thickness of drift across Shakwak Trench. It probably is considerable, especially in the vicinity of Shakwak fault. The surface of bedrock underlying the Trench is believed to be undulating, with the areas of greatest relief trending in a northwest direction parallel to the movement of the last ice sheet. The thickness of the overburden indicated by seismic lines Nos. 1 and 2 (80 to 170 feet), located 200 and 1,150 feet southwest of the River, are probably correct. An extensive test boring program will be required to accurately contour bedrock surface in the site area. It is doubtful if there is more than 50 feet of overburden beneath the River.

### Abutments and Foundations

Bedrock exposed at the site should provide satisfactory abutments and foundations. Weathering is not extensive and little stripping will be necessary before fresh, solid rock against which concrete or dyke material can be placed will be obtained.

Permeable sand and gravel underlie the till exposed in the bluff along the right side of the River at the site. If it is decided to utilize the till as abutment material, the extent and permeability of these sands and gravels as well as any similar material included in the till should be thoroughly investigated with test borings.

## Construction Materials

### Aggregate

The alluvial sand and gravel exposed along both sides of

Kluane River constitute the only deposits of natural aggregate within the area mapped at the site. The quantity available, however, is limited. A grain size analysis curve for a representative sample of this material is included at the end of this report (Sample No. 24).

A potential source of natural aggregate is the gravel exposed on the flood plain of Duke River. This extensive alluvial deposit occurs on both sides of the River between the Alaska Highway and its junction with Kluane River. It includes the area known as Duke Meadows. The material is within 2 miles of the site and easily accessible. The quantity is unlimited. Similar material taken from the upstream end of the deposit was used as aggregate and fill for the Alaska Highway bridge over Duke River.

Impervious Material

The till and the glacio-lacustrine silt, both of which occur at the site, are potential sources of impervious material. The till is probably the better. It usually produces excellent impervious material because the gradation is such that piping of the fines is prevented. However, if used as dyke material or for the impervious core of an earth-fill dam, the larger boulders will have to be removed before it can be compacted properly.

Till with a thin capping of silt is believed to form a long, low ridge which parallels the River 900 feet southwest of the site. The deposit is readily accessible from the site and could be easily worked by one or more borrow pits. Test pits should be put down on

the ridge to determine the quantity and quality of till available.

The silt is a relatively thin deposit and nowhere was found to be more than a few feet in thickness. It would probably be more expensive to obtain a large quantity of this material than of the till. Borrow pits opened in the silt would be shallow and would extend over a large area.

Previous Material

Except as a need for a special blending material arises, pervious material implies a material with substantial amounts of gravel-size particles. Free-draining material for filters and drains can be obtained from the gravel deposits described under the aggregate heading. The gravel will have to be processed by washing or screening to separate out objectionable material such as silt and clay.

Riprap and Rock Fill

Bedrock exposed at the site should provide excellent riprap and rock fill. It is a tough, durable rock with a relatively high specific gravity. The only objection to using this rock as riprap is its habit of breaking into slab-like fragments along the bedding planes. Rock fragments obtained during excavation for the dam could be stockpiled until required as riprap. Another source of riprap is the bedrock exposed on the hillside some 2,600 feet northeast of the site.

## Groundwater

There is little information concerning groundwater conditions in the area about the proposed dam site. The water table is believed to be high northeast of the River where a large pond exists, and to be low in the southwest part of the map-area in the vicinity of the dry creek. Most of the swampy areas are underlaid with frozen soil, suggesting perched goundwater conditions. Accurate information concerning the water table can only be obtained by installing groundwater observation holes and taking readings at regular intervals.

## Frozen Ground

Frozen glacio-lacustrine silt was encountered in several test pits put down on both sides of Kluane River. The frozen material usually occurred in the more dense bush, underlying 4 to 8 inches of moss. Localities where frozen ground was encountered on June 27, 1961 are indicated on the accompanying geological map.

## Proposed Location of the Dam

It is suggested the axis of the proposed power dam be located so that bedrock exposed on the right side of the River will form the right abutment. The left abutment would consist either of till if the dam were constructed directly across the River or of bedrock if it were angled upstream to the bedrock exposures on the left side of the River.

If it is desired to construct a dam using local materials an earth-fill dam should be considered. There are unlimited quantities of construction materials readily accessible from the site.

## Further Investigations

Many test borings will be required before the suitability of Kluane Canyon as a dam site can be determined. Shakwak Trench is filled with many different types of unconsolidated materials and as a consequence it may be necessary to locate some borings considerable distances from the River to investigate the permeability and quality of the material and the possibility of leakage around the proposed dam. It is suggested test borings be put down in the site area to determine the following:

1. Elevations of bedrock surface beneath Kluane River.
2. The quantity, quality and permeability of the till.
3. The quality and permeability of bedrock, especially with regards to its suitability as abutment and foundation material.
4. Fluctuations in the elevation of the groundwater table.
5. The possibility of a buried stream channel eroded into bedrock between the right side of Kluane River and the bedrock exposures along the northeast side of Shakwak Trench.

## Chemical Analysis of Kluane River Water

A sample of Kluane River water was taken from the centre of the River at the site. The sample was analyzed for its mineral content by the Industrial Waters Section, Mines Branch, Department of Mines and Technical Surveys, Ottawa. The result of the analysis is included on the following page. The reported value of the turbidity should be considered only as indicative. Flash floods may cause a rapid increase in the sediment load. A proper sediment study, therefore, requires regular sampling, often in the case of flash flooding, at hourly intervals.

Chemical Analyses of Kluane River Water
(parts per million)

| Location | Date | River Discharge | pH | $SiO_2$ | Ca | Mg | Na | K | Fe | $CO_3$ | $HCO_3$ | $SO_4$ | Cl | F | $NO_3$ | Turbidity | Total Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| At Kluane Canyon; centre of Kluane River; 4 miles downstream from Kluane Lake | July 1, 1961 | Medium high | 7.9 | 3.2 | 33.0 | 9.4 | 2.2 | 2.4 | 2.7 | 0.0 | 97.2 | 42.7 | 0.6 | 0.18 | 0.6 | 45 | 121 |

## 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.

Samples Nos. 23 and 24 were analyzed as potential aggregate; the remainder as potential impervious material.

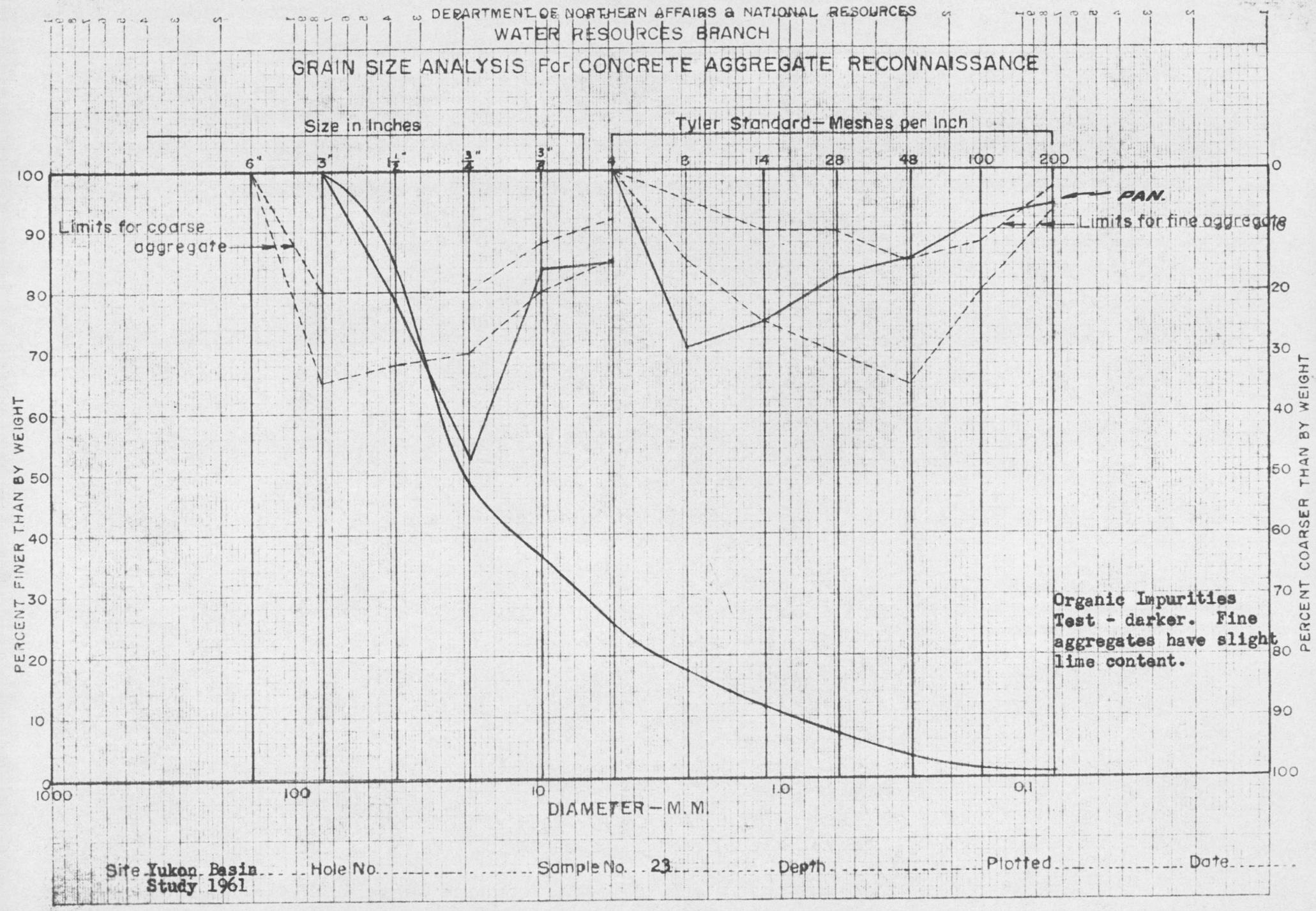
Description of Potential Aggregate for the following Grain Size Analyses Curves

| Sample Number | Location | Field Description of Material | Field Description of Overburden | Thickness of Deposit | Areal Extent (Estimated) | Remarks |
|---|---|---|---|---|---|---|
| 23 | Pit on south side of Alaska Highway at mile 1095.2; 5 feet below ground surface. | Well graded, sandy gravel; very little silt; many pebbles in the 1- to 3-inch range; a few rounded boulders up to 12 inches; roughly stratified; material is similar to alluvial gravels immediately downstream from Lower Canyon dam site on White River.<br>Pebble and Cobble Lithology<br>Granitic (granite, syenite) - 40%<br>Volcanic (ryholite, andesite, basalt) - 30%<br>Sedimentary (sandstone, limestone) - 20%<br>Metamorphic (gneiss, schist) - 10% | 3 feet of silt and fine sand. | 10+ feet | Unlimited; pit is 500 feet wide, 1,000 feet long and average 10 feet in depth. | Material was crushed to 1-inch size and used to surface Burwash Flight Landing strip. |

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE




Site Yukon Basin Study 1961 Hole No. Sample No. 23 Depth Plotted Date

PLAN No. 100 – 13

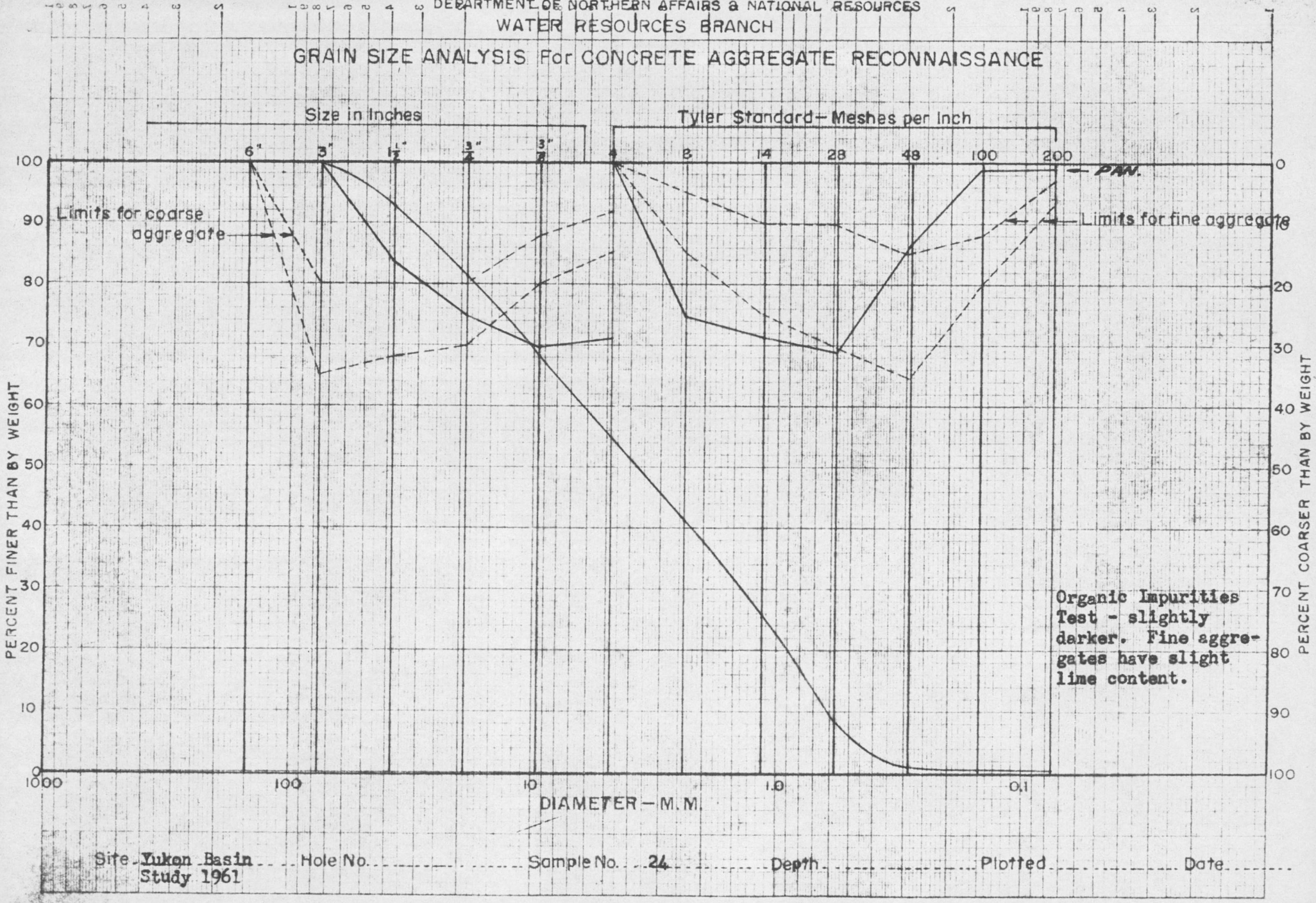
Description of Potential Aggregate for the following Grain Size Analyses Curves

| Sample Number | Location | Field Description of Material | Field Description of Overburden | Thickness of Deposit | Areal Extent (Estimated) | Remarks |
|---|---|---|---|---|---|---|
| 24 | From 15-foot bluff on right side of Kluane River; 800 feet upstream from rock outcrop; 4 feet below ground surface. | Fairly well graded sandy gravel; very little silt; numerous, rounded cobbles up to 6 inches in diameter; poorly stratified; no weathering. | 2 feet of silt. | 10 feet | Limited quantity available; width: 300+ feet length: 300+ feet height: 10 feet | Probably alluvium; overlies stratified sand and silt. |

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE




Site Yukon Basin Study 1961 Hole No. Sample No. 24 Depth Plotted Date

PLAN No. 100 – 13

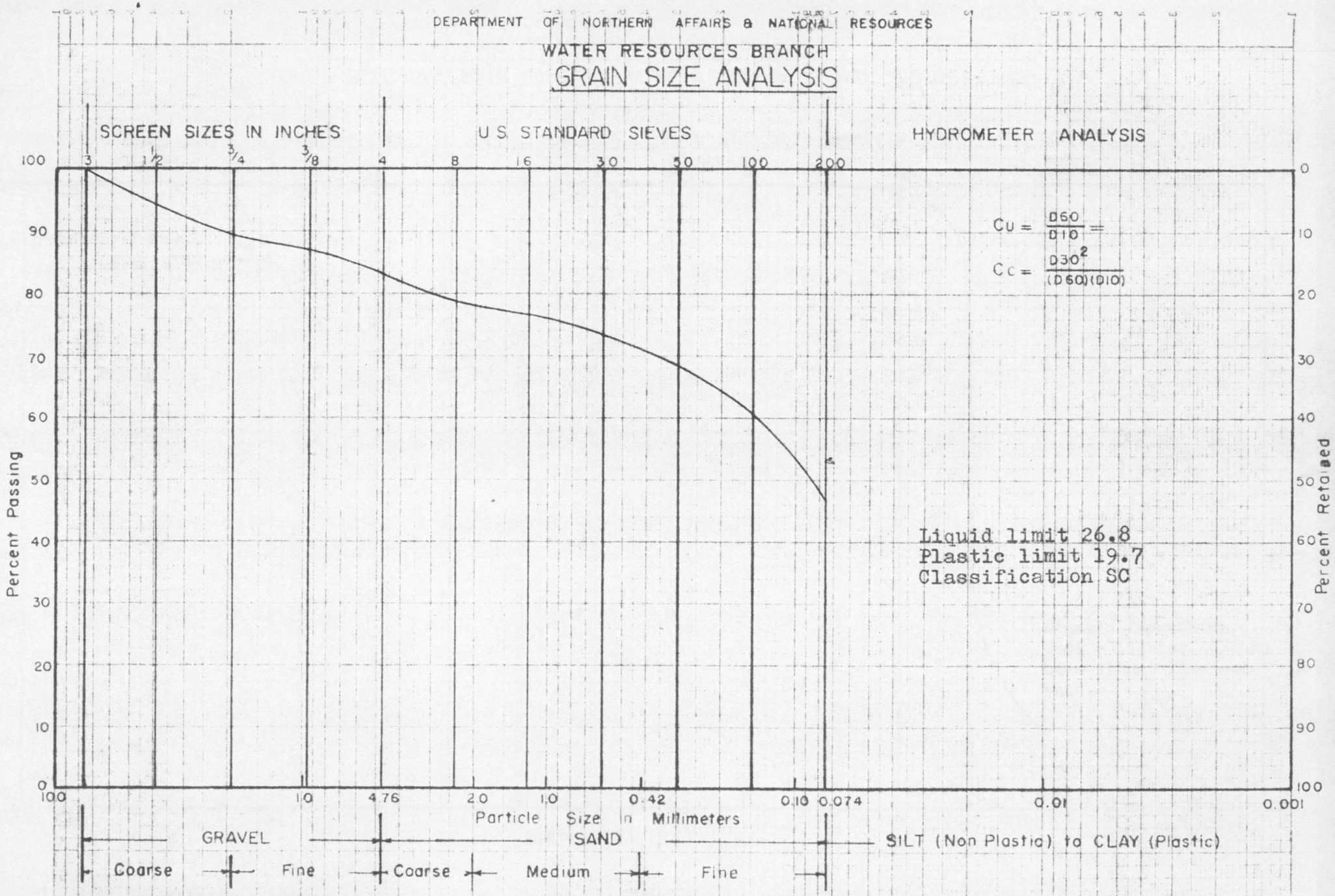
Description of Potential Impervious Material for the following Grain Size Analyses Curves

| Sample Number | Location | Field Description of Material | Field Description of Overburden | Thickness of Deposit | Quantity Available | Permeability (cm./sec.) |
|---|---|---|---|---|---|---|
| 25 | From a 45-foot bluff on right side of Kluane River; 600 feet downstream from rock outcrop; 5 feet below ground surface. | Dense, grey, silty, sandy till; numerous, angular cobbles up to 4 inches in diameter; underlaid by glacio-fluvial sand. (sample No. 26). | 12 inches of silt. | 12+ feet | Large | - |
| 26 | From a 35-foot bluff on right side of Kluane River; 1,000 feet downstream from rock outcrop; 18 feet below ground surface and 4 feet below till. | Poorly graded (well sorted), fine-grained sand; loose when dry; about 10 percent silt; underlies till. | 24 inches of silt. | 10+ feet | Limited | $10^{-3}$ |

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS



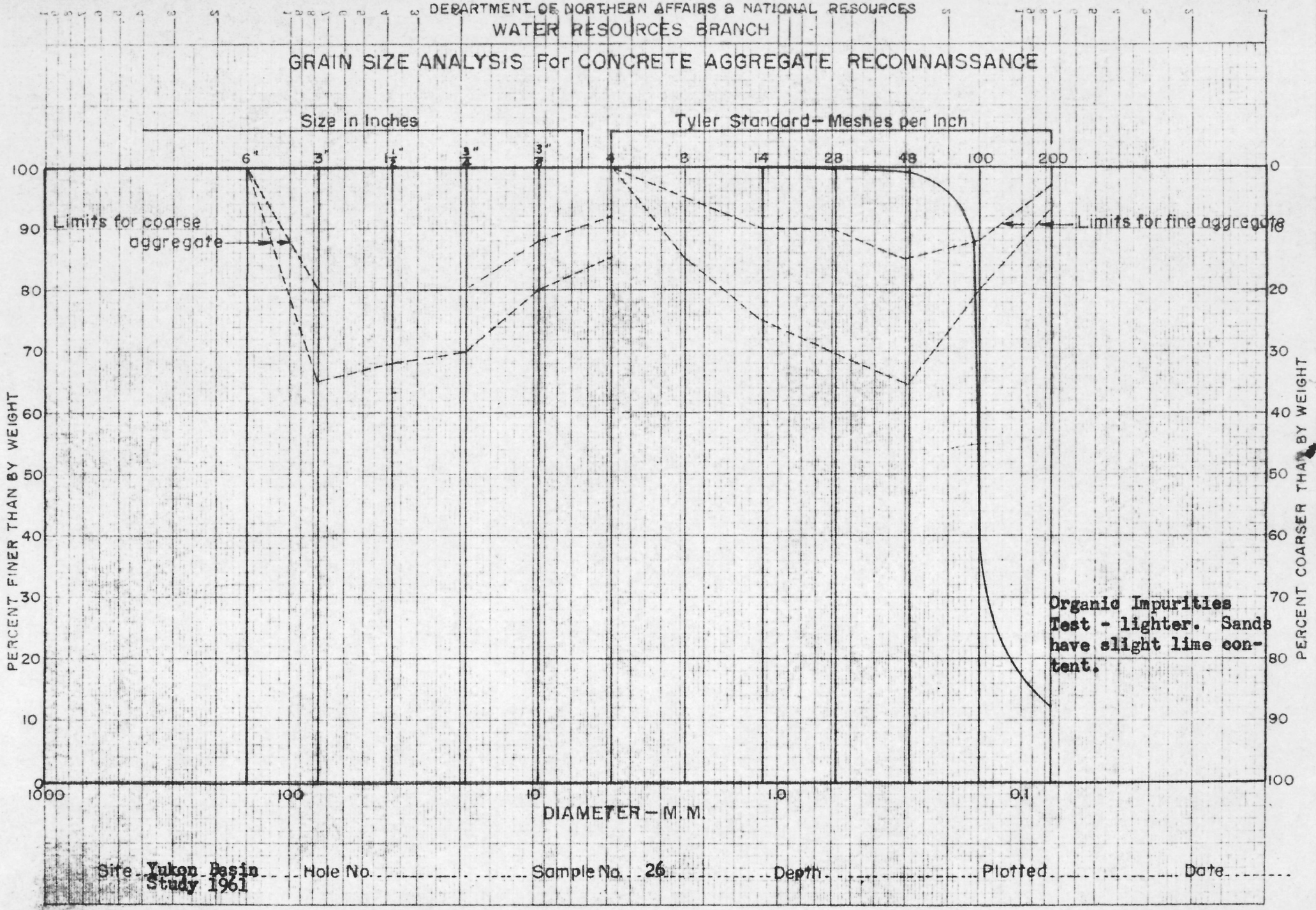

Site Yukon Basin Study 1961 Pit _____ Sample 25 _____ Depth _____ Plotted _____

PLAN _____

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS For CONCRETE AGGREGATE RECONNAISSANCE




Site Yukon Basin Study 1961 Hole No. Sample No. 26 Depth Plotted Date

PLAN No. 100 – 13

M-6

Description of Potential Impervious Material for the following Grain Size Analyses Curves

| Sample Number | Location | Field Description of Material | Field Description of Overburden | Thickness of Deposit | Quantity Available | Permeability* (cm./sec.) |
|---|---|---|---|---|---|---|
| 27 | Immediately above outcrop on right side of Kluane River; 2 feet below ground surface. | Yellowish-brown, sandy silt; considerable weathering; very little dry strength. | None | 6 inches to several feet | Test pitting required here to determine thickness of deposit. | $10^{-4}$ |

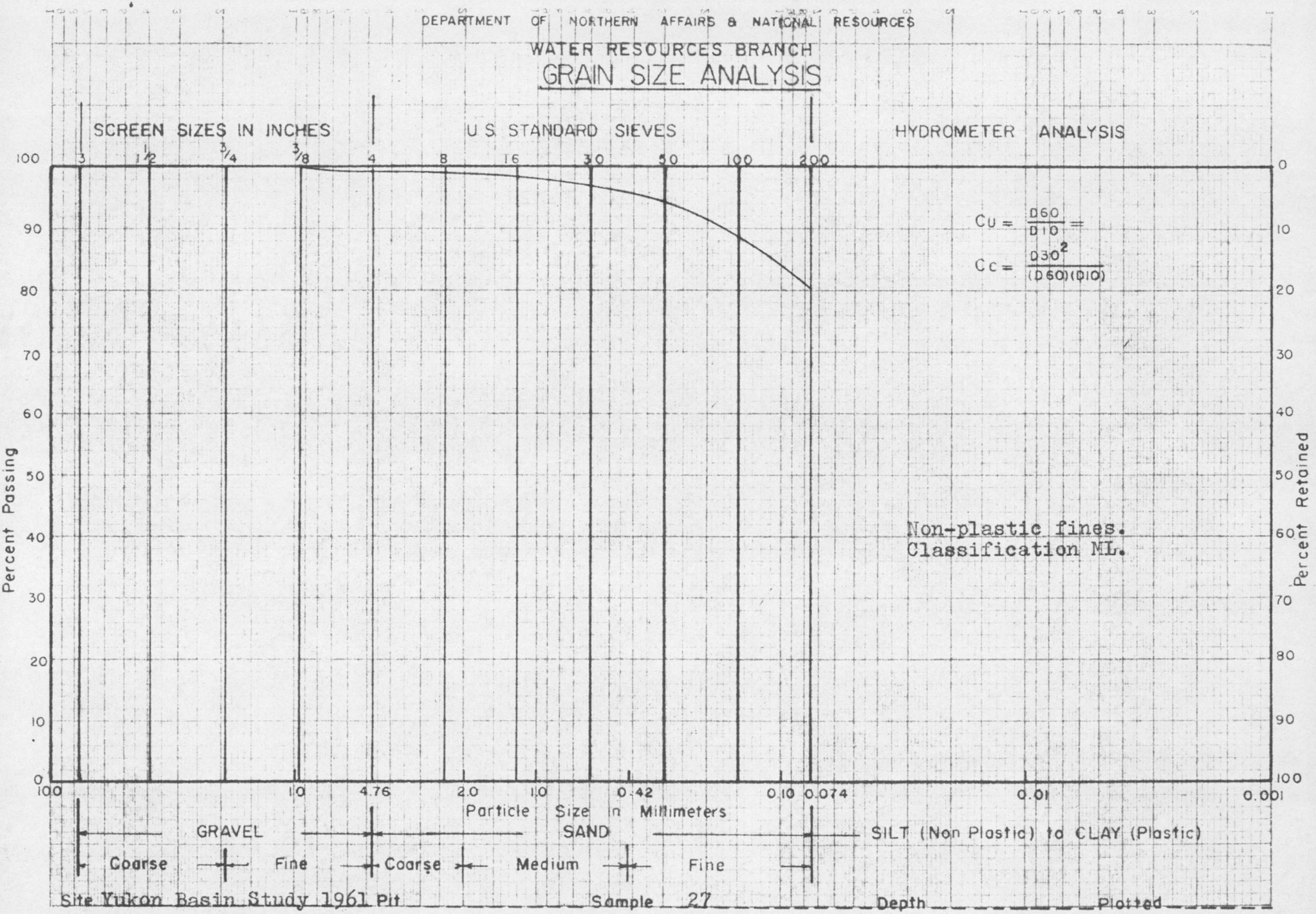


*Permeabilities computed in the field using a Soiltest Permeameter, Model K-620.

DEPARTMENT OF NORTHERN AFFAIRS & NATIONAL RESOURCES

WATER RESOURCES BRANCH

# GRAIN SIZE ANALYSIS




Site Yukon Basin Study 1961 Pit Sample 27 Depth Plotted

PLAN

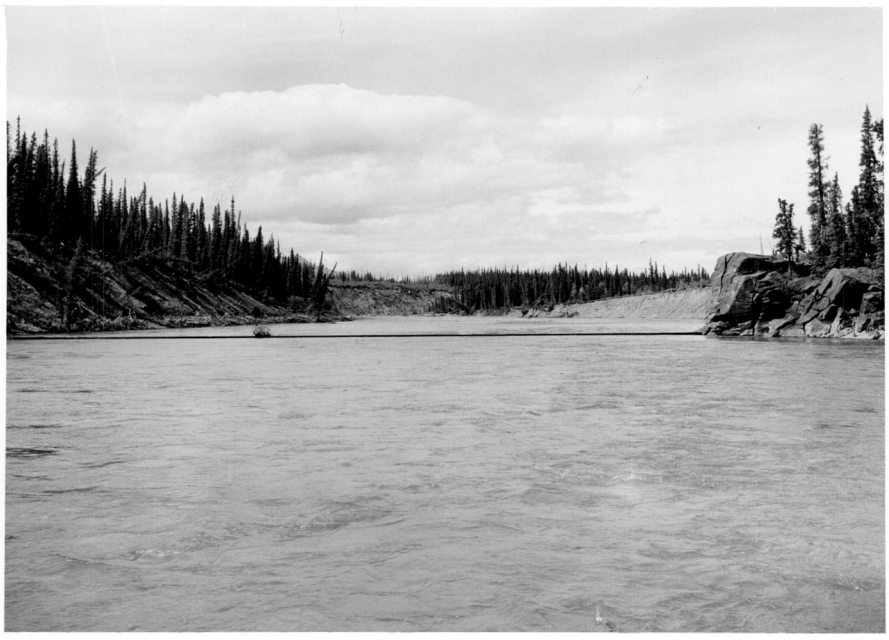


Plate 1

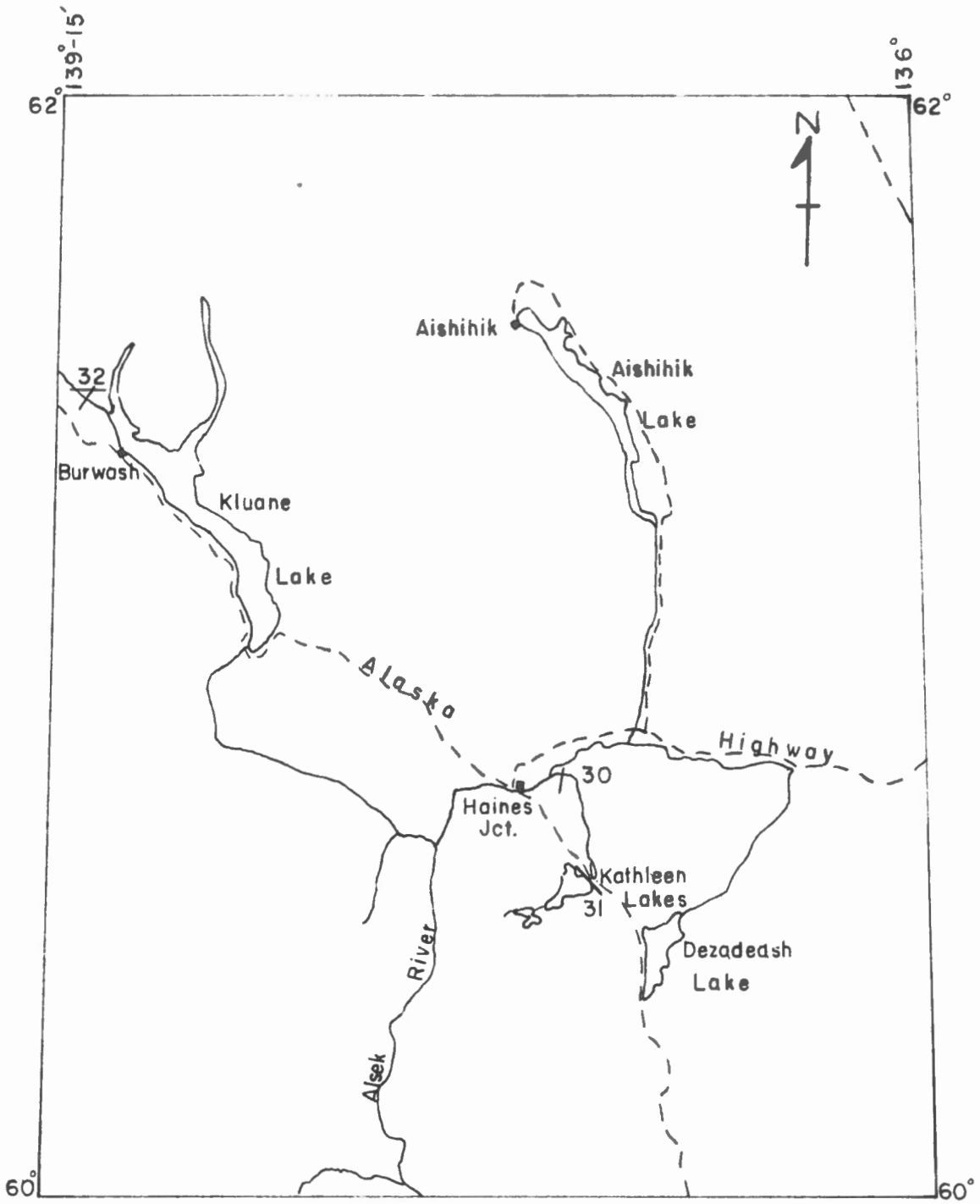
Kluane Canyon looking downstream; it is proposed that bedrock on the right side of the photograph form the right abutment of the dam and that either the till bluff directly opposite or bedrock exposed some 150 feet upstream form the left abutment.

G.S.C. 3-1-61

Plate 2

Right abutment; prominent jointing in bedrock is parallel to the proposed axis and dips steeply downstream; northeast side of Shakwak Trench in background.

G.S.C. 3-3-61




LOCATION OF PROPOSED DAM SITES
YUKON RIVER DRAINAGE BASIN
AND PACIFIC COAST DRAINAGE
Scale: 1 inch = 20 miles

| Site No. | Name |
|---|---|
| 30 | — Kathleen Canyon |
| 31 | — Kathleen Lake |
| 32 | — Kluane Canyon |