GEOLOGICAL INVESTIGATIONS AT MORAN IN 1957

By Stuart S. Holland

92I/13W

GEOLOGICAL INVESTIGATIONS AT MORAN IN 1957

BY STUART S. HOLLAND.

BRITISH COLUMBIA DEPARTMENT OF MINES

VICTORIA, B.C.

ILLUSTRATIONS

Drawings

Photographs

Preliminary geological investigations in the vicinity of the proposed damsite at Moran in 1956 left several points unresolved. As a consequence field work undertaken in 1957 was primarily directed towards determining whether a strand of the Fraser River fault lies close to the proposed damsite.

Summary of Geological Observations:

1. A major fault, a strand of the Fraser River fault zone, separates the Cache Creek group from the Spences Bridge group. This contact (and fault) lies more than 2,000 feet west of the west abutment at Moran damsite.
2. Drilling since September 1956 for B.C. Engineering Co. Ltd. discloses the presence of a deep channel of the Fraser River lying at least 240 feet below low water level. The centre line of this deep channel is presumed to be 100 to 150 feet east of the rock island at Moran damsite. This deep channel will probably persist upstream and downstream for a considerable distance.

Three weeks from May 9 to May 29, 1957, were spent in the vicinity of the proposed damsite at Moran.

The damsite at Moran is on the Fraser River about 4 miles north of the ferry crossing at the mouth of Pavilion Creek and about 20 miles north of Lillooet (see Plate I and Plate II A and B). The west abutment may be reached by wagon road and trail about 5 miles nnrth from Pavilion ferry. The trail continues northward along the west side of the river to the mouth

of Watson Bar Creek. A wagon road and trail runs downstream along the west side of the river for about 6 miles. The east abutment is reached by a short branch road from the Pavilion Mountain road to the Pacific Great Eastern Railway track, thence by trail 3 miles to the site.

Moran damsite is in the northwest corner of the Ashcroft map sheet (Geol. Surv., Canada, Map 1010A) on which the regional geology at a scale of 4 miles to 1 inch is shown. A detailed geological study was begun in 1957 by H. Trettin who mapped a strip along the river from Lillooet as far upstream as Pavilion ferry. This mapping is expected to continue in 1958.

Bedrock exposed along the Fraser River between Pavilion ferry and Kelly Creek consists very largely of argillaceous and tuffaceous sediments, volcanic rocks, and some limestone and calcareous beds of the Cache Creek group. At the mouth of Kelly Creek these rocks are cut by an intrusion of massive diorite. Elsewhere dykes of similar diorite a few feet to a few tens of feet wide intrude the older rocks (see Plate III B). On the west side of the river at Moran the Cache Creek rocks are in contact with volcanic, sedimentary, and flow rocks of the Spences Bridge group of Lower Cretaceous age, and with basaltic lavas of the Kamloops group of Miocene (or earlier) age. The contact between the Cache Creek and Spences Bridge groups is faulted. This fault, here called the Moran fault, is considered to be a strand of the Fraser River fault zone.

The Fraser River fault zone is a structural feature of

great size. It is composed of ramifying and diverging fault strands along which there has been intermittent movement at least as late as post-Eocene. The Fraser River, as shown on geological maps 737A and 1010A Hope and Ashcroft sheets, follows along the trace of this large, multiple fault which has a total length of some 150 miles.

At the damsite the Moran fault lies on the west side of the river and possibly 2,500 feet west of the river bank.

Field work during the summer of 1957 shows that the Moran fault is a northern continuation of a large fault extending northwesterly through Fountain Valley. One strand swings northwestward up Slok (Red) Creek Valley and the other passes by Moran and extends up the Fraser River. The faults may consist of one hundred feet or more of broken and shattered rock which may also be hydrothermally altered. The Moran fault is not exposed in the vicinity of the damsite, consequently before any tunnelling is planned in it or in its vicinity the fault should be diamond drilled to determine its exact position and also the physical character of the rock affected by it.

A seismic station installed at Lillooet in 1957 will provide information on the seismic activity of the region and whether or not the fault zone is a locus of current earthquake activity.

About 800 feet west of the river at the west abutment of Moran damsite the Cache Creek rocks have been hydrothermally altered to a carbonate rock that weathers a bright red brown. This hydrothermally altered rock extends northwesterly for about 1,000 feet and may be as much as 300 feet wide. The alteration may have

been localized along sheared zones. The zone is sufficiently close to the west abutment that diamond drilling of the zone should be undertaken before any underground tunnelling in it is planned.

The rocks of the abutments at the damsite are tuffaceous and argillaceous sediments and andesitic volcanics striking about north 40 degrees west. Complex folding is suggested by rock attitudes, but the absence of any marker makes recognition of the structure difficult. The rocks are cut by several sets of fractures, one set strikes north 20 degrees west and dips steeply east, another strikes north 85 degrees east and stands more or less vertical. Some carbonate alteration is localized along the easterly striking fractures and numerous dioritic dykes occupy the easterly striking fractures. These fractures represent systematic joints or shear directions of small displacement.

There is no fault between the rock island and the rock wall on the west side of the river.

During the late autumn of 1956 and until February 1957 Boyles Bros. Ltd. drilled at Moran damsite for B.C. Engineering Co. Ltd. with the following results:

A vertical hole drilled to a depth of 244 feet without reaching bedrock indicates that a buried channel of the Fraser River at least 240 feet below low water level lies east of the island at the damsite.

Down holes in rock indicate that bedrock in the channel between the island and the west abutment is at least 75 feet below low water level.

The amount of drilling done was quite insufficient to determine the depth, position, and outline of the deep channel.

The deep channel probably connects with the buried channel visible on the west bank at upper Moran canyon. The channel west of the island has been excavated by the river in the present cycle of erosion.

It is probable that the deep channel persists both upstream and downstream from the damsite: upstream the deep channel persists at least as far as High Bar canyon and is more likely to deepen than to shallow. Downstream it is believed that the deep channel ultimately approaches the present river channel, but between Moran and Lillooet the amount of shallowing is probably slight. The deep channel lies beneath the hop farm on the west side of the river upstream from the railway bridge at Lillooet.

Bedrock outcrops on the west side of the river for about 1,900 feet downstream from the centreline of the proposed dam (see Plate III A). Farther downstream from that point to beyond McKay Creek bedrock up to an altitude of 1,700 feet is overlain by horizontally bedded silts (see Plate IV B). These unconsolidated sediments lie as a veneer over the bedrock and effectively hide its position. The position of bedrock in this area can only be determined by drilling. The surface topography in several places indicates that the silts have slumped. Consequently the entire silt-covered area must be considered to be potentially if not actually unstable ground.

An area of unstable ground is outlined on the accompany-

ing sketch map. It is on the west side of the river close to the damsite. The material involved is hydrothermally altered bedrock and unconsolidated silt. The movement appears to be induced annually by seepage and drainage of irrigation water from the bench above. The depth of material involved is not known.

On the east side of the river, bedrock is exposed at river level only on the centreline of the proposed dam (see Plate IV A). Upstream and downstream for several thousand feet bedrock is overlain up to an altitude of 1,200 feet by coarse bouldery gravel which stands in bluffs and pinnacles along the river. The gravel in turn lies beneath a veneer of silts. There is no indication of the contour of bedrock beneath the gravels and silts so that the position of bedrock at any point will have to be determined by drilling. However, it is certain that no buried channel of the Fraser River lies in the bank to the east of the east abutment at the damsite.

Interpretive cross-sections (see Figure 2) drawn at intervals along the river show the changing relations of bedrock and unconsolidated meterial, and the inferred position and depth of the deep channel.

At this stage information is lacking on the precise location, width, and nature of the rock in the Moran fault; the location, extent and physical characteristics of the carbonate alteration zone near the west abutment; the precise location, depth, and width of the deep channel of the Fraser River; and the location and surface contour of bedrock beneath the mantle of unconsolidated silt and coarse bouldery gravel. All these can only be determined by systematic drilling on an extensive scale.

November 5, 1957.

Dr. H. Sargent,

Chief, Mineralogical Branch.

December 21 56

Re: Seismic Observations at Moran

Seismographs installed after the construction of Hoover Dam and the filling of the reservoir recorded "the occurrence of microseisms of reputed increasing intensity and frequency. The lack of data for previous years leaves doubt about the close connection between filling the reservoir and these disturbances."

The effect in fourteen years of the reservoir load upon the earth's crust was to depress bench marks at Hoover Dam a total of 120 millimetres and a maximum of 170 millimetres at the centre of gravity of the reservoir area.

A crustal movement of that order along the Fraser River near Moran might be localized along active faults or might tend to reactivate fault zones only temporarily inactive.

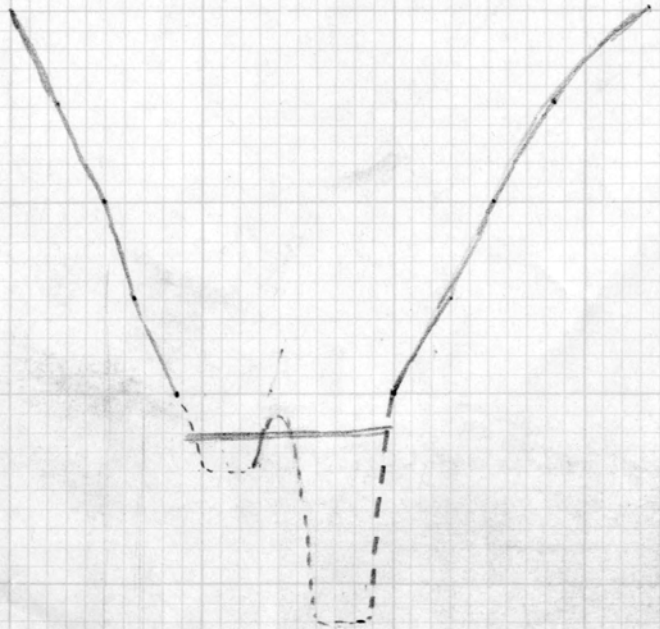
In view of the size of the dam contemplated at Moran, the safety consideration involved, and the lack of seismic information in the region I believe that the establishment of a suitably located seismic recording station should be advocated to the proper federal agency.

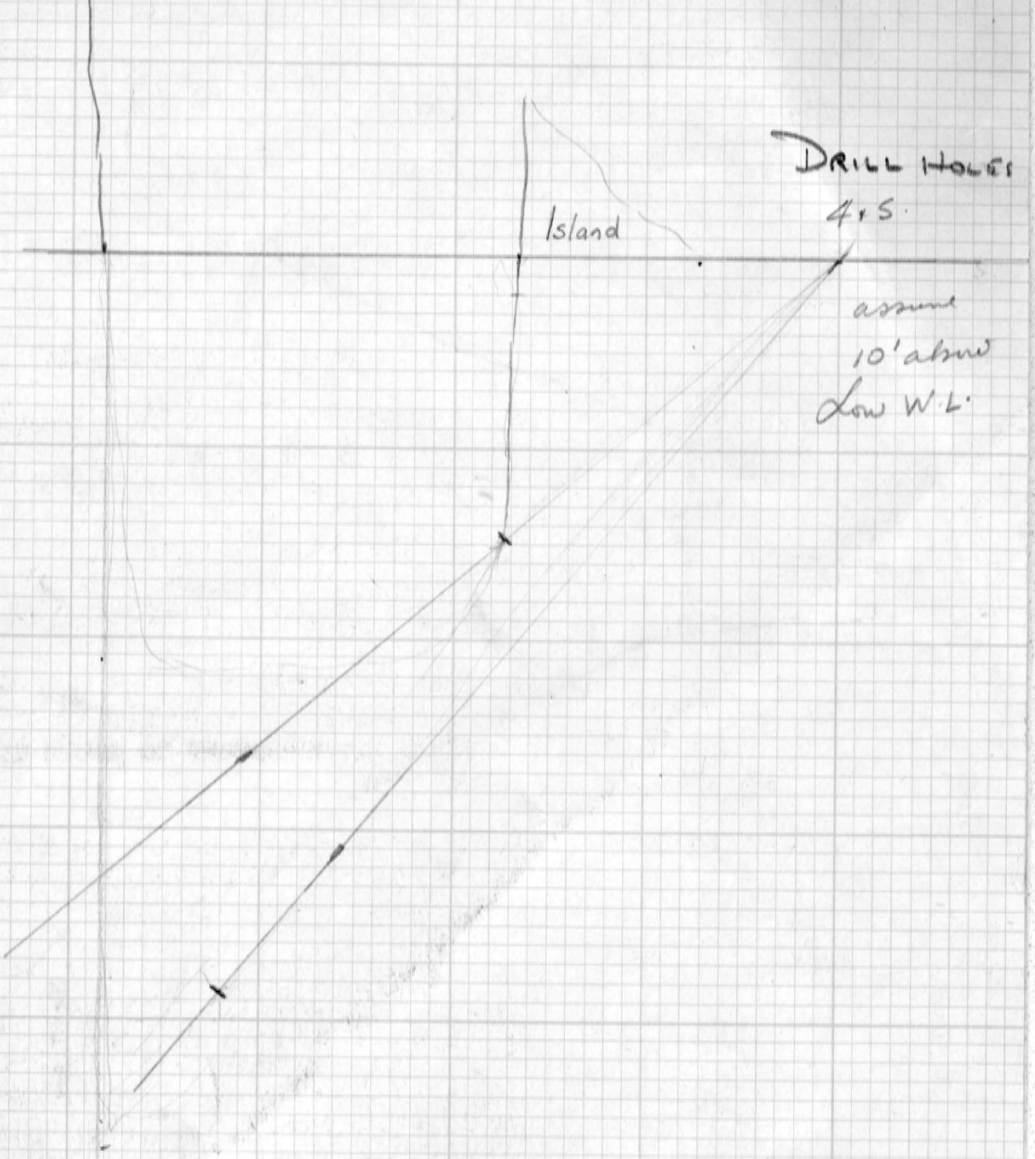
Stuart S. Holland,
Geologist.

SSH/cs

X SECTION on ℄ of Dam.

200' = 1" vert
400' = 1" Horz.




DRILL HOLES
4, 5.
Island
assume
10' above
Low W.L.

5M-349-8330 (2)

MEMORANDUM

TO Dr. H. Sargent,
Chief, Mineralogical Branch,
BUILDINGS.

FROM THE
DEPARTMENT OF MINES

VICTORIA, B.C., December 18th, 19 56

WHEN REPLYING PLEASE REFER TO FILE No.

Re: Moran Damsite.

Summary:

1. A vertical drill hole suggests that a buried channel about 240 feet below present low water level lies east of the island at Moran damsite.

2. Drill holes indicate that the channel between the island and the west abutment is at least 75 feet below present low water level.

3. The core indicates that no fault lies between the island and the west abutment though further drilling still is necessary to prove conclusively that none exists.

Observations:

Boyles Bros. Ltd. have been drilling at the Moran damsite since September 1956 for B.C. Engineering Co. Ltd. Drill core is being boxed for shipment to Vancouver.

Two drill holes (Nos. 4 & 5) were collared in rock on the east side of the island and drilled westerly. No. 4 inclined at minus 40 degrees broke out of rock into gravel at 136 feet, indicating a depth to bedrock below present low water level of at least 75 feet. Hole No. 5 inclined at minus 50 degrees was stopped at 300 feet. The end of the hole is 40 feet east of being vertically beneath the west side of the river. The core was examined and no evidence of faulting is apparent. Nevertheless, it is still possible for a westerly dipping fault to lie between the island and the west abutment. Information regarding this point could be secured by deepening No. 5 drill hole about 60 feet and drilling a vertical hole on the west bank to a depth of 275 below present water level. At present, however, the chance of a fault lying in the channel between the island and the west abutment appears less than was previously thought from geological observation.

At the present stage of water the island is connected to the east bank by a bar and bedrock outcrops for 100 feet downstream and approximately 600 feet upstream from the island.

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Three vertical holes have been drilled through gravel to bedrock. One (No. 1) about 800 feet south of the south end of the island reached bedrock at a depth of 244 feet, about 240 below present low water level. In it 3 inches of coaly material was encountered at a depth of 221 feet in the hole. The other two holes (Nos. 2 and 3) 550 and 150 feet south of the island reached bedrock at 135 feet and 140 feet respectively. Hole No. 6 currently being drilled is 150 feet east of the island.

Interpretations: The deep hole (240 feet below present low water level) is interpreted as indicating that a deep, preglacial, filled channel of the Fraser River is being re-excavated by the present river. The deep channel is thought to lie east of the island and probably connect with the buried channel visible west of upper Moran canyon. The channel west of the island probably has been excavated by the river in the present cycle of erosion.

It is probable that the deep channel will persist upstream and downstream from Moran damsite. One would expect therefore that exploratory drilling at other possible damsites near by will disclose a deep channel of comparable but not identical depth. Upstream it is probable that the deep channel will persist for a considerable distance and is more likely to deepen than to shallow. Downstream it is believed that the deep channel ultimately approaches the present river channel but between Moran and Lillooet the amount of shallowing is probably slight.

Downstream from Moran the valley of the Fraser is narrow and it is probable that for the most part the deep channel coincides closely with the present channel in a situation much like at Moran. Upstream the valley is somewhat wider and there is room for the deep channel to lie to one side or the other of the present channel as a buried cut-off segment. In situations of that sort bedrock in the present river channel is apt to be at shallow to moderate depth. Such a situation might present a more attractive site than does Moran.

Conclusions: The presence of a deep gravel filled channel undoubtedly

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makes the Moran damsite less attractive than was initially thought. A similar physical condition probably exists at other sites along a considerable length of the Fraser. Situations where a buried side channel exists probably would provide shallower excavations to bedrock.

S.S. Holland,
Geologist.

SSH:md

Title Moran

Author ssh

Date and Typist Nov. 30/56 cs 1

PRELIMINARY GEOLOGICAL INVESTIGATIONS AT MORAN IN 1956

By S. S. Holland

This preliminary report is based on eight days field observations and a study of the published geological data.

Summary of Geological Observations:

1. A major fault*, a strand of the Fraser River fault zone, is thought to lie a few hundred feet west of the west abutment at the proposed Moran damsite.
2. No evidence of any other major fault was seen. No major fault is thought to lie along the course of the Fraser River at Moran.
3. The rocks exposed along the centreline of the proposed dam are considerably jointed and sheared.
4. Further detailed field investigations are necessary, especially to evaluate silt and hydrothermally altered rock if cost and safety of the dam and related tunnels and power-house are to be predicted.

Eight field days, September 3rd to 11th, were spent in the company of H. Nasmith in the vicinity of the proposed Moran damsite on Fraser River. In this period preliminary geological observations were made in the immediate

*Crushed and broken ground having a possible width of 100 feet.

vicinity of the proposed site and in the surrounding region; one day was spent on the east side of the Fraser River, and one day was spent on the west side of the river near the damsite; and regional observations were made during traverses along the Pacific Great Eastern track north of Pavilion as far as Kelly Creek and south along the track and road as far as Fountain Creek.

The proposed damsite at Moran is on the Fraser River about 4 miles north of the ferry crossing at the mouth of Pavilion Creek. The river itself is navigable upstream from Pavilion ferry only with difficulty during low water. The west side may be reached by wagon road and trail about 5 miles north from Pavilion ferry, and the east side may be reached by a short road branching from the Pavilion Mountain road. It takes one to the Pacific Great Eastern track about 2 miles north of Pavilion station, thence a trail leads down hill to the site. During the examination, September 3 to 11, the river was sufficiently low for one to walk along the beach on the east side of the site. The rock face on the west side is precipitous and if a close examination of it were to be made some safety precautions would be required.

Moran lies in the northwestern corner of the Ashcroft map sheet (Geol. Surv., Canada, Geological map 1010A) on which the regional geology at 4 miles to the inch is shown. Geological mapping does not extend northward beyond Leon Creek

some 7 miles north of Moran. As a consequence geological information to the north is meagre. To the south, however, adequate geological mapping at a 4-mile scale extends down river to Chilliwack and beyond.

In the vicinity of Moran damsite the rocks are tuffaceous and argillaceous sediments and volcanics of the Cache Creek group which are intruded at the mouth of Kelly Creek by a small dioritic intrusion. These rocks in turn are overlain on the west side of the river by volcanic, sedimentary and flow rocks of the Spences Bridge group of Lower Cretaceous age, and by basaltic lavas of the Kamloops group of Miocene or earlier age. The rocks exposed on both sides of the gorge at the proposed damsite are Cache Creek group sediments and volcanics striking about north 40 degrees west, these lie at a small oblique angle to the river at that point.

The geological feature of fundamental importance to any evaluation of the proposed damsite at Moran or elsewhere on this part of the Fraser River is the fact that geological mapping on the Hope and Ashcroft sheets (Geol. Surv., Canada, Maps 737A and 1010A) shows that the Fraser River between Fountain and North Bend follows along the trace of a very large, multiple fault zone which has a total length of at least 175 miles. The fault zone is composed of ramifying and diverging strands marking a major break along which there has been intermittent movement at least as young as post-Eocene in age.

Title Morar

Author ssh

Date and Typist Nov. 30/56 cs 4

The published geologic maps show no strand of the Fraser River fault zone closer than Slok Creek and west of the upper part of McKay Creek. Nevertheless attitude and hydrothermal alteration of the Spences Bridge formation and ankeritic carbonate alteration of the Cache Creek formation along their contact, only a few hundred feet west of the west abutment at the damsite, strongly suggest that the contact is faulted. If that be so the fault would probably be a further strand or offshoot of the Fraser River zone.

The presence of a major fault so close to the abutment of the proposed dam would undoubtedly introduce considerations regarding design and safety of the dam itself as well as have a considerable bearing on the location and cost of pressure tunnels and power-house downstream from the dam itself.

At the time of examination the rock island which lies a few hundred feet upstream from the centreline of the dam was connected by a gravel bar to the east side. There seems to be no indication of any major faulting parallel to the river and running up through the gorge itself.

Close examination was not made of the rocks which would form the abutments of the dam. They appear to be intersected by two sets of fractures, one set striking north 20 degrees west dips steeply to the east, the other striking north 85 degrees east stands more or less vertical. These fractures

represent systematic jointing or shear directions of small displacement, no major faults were observed.

Bedrock 1,000 feet downstream from the centreline of the dam on the west side is overlain by horizontally bedded silts which extend downstream past the mouth of McKay Creek and which rise to an elevation of 1,500 feet and more. These unconsolidated sediments lying as a veneer over the solid bedrock have a variable depth and horizontal extent which change with the outline of bedrock and with the present topographic surface. It is possible only to guess their actual thickness at specific points. The surface topography at several places indicates that this material has slumped, and consequently the entire silt-covered area must be considered to be potentially if not actually unstable ground.

An area of unstable ground is outlined in orange on the accompanying sketch map. It is on the west side of the river a few hundred feet downstream from the damsite. An area 800 feet long and 200 feet wide extending from 1,450 feet elevation to about 1,000 feet elevation and involving for the most part hydrothermally altered Spences Bridge volcanics is completely unstable and appears to experience annual movement southward. The depth of material involved is unknown.

Coarse bouldery gravel standing in bluffs and pinnacles extends for several thousand feet upstream from the damsite on the east bank. There is however no indication that

a buried channel of the river lies either on the east or west sides of the proposed dam. Similar coarse bouldery gravel extends downstream from the damsite on the east bank and lies back from the bank for a considerable but unknown width and depth. Its presence, extent and stability undoubtedly will have an influence on the location of pressure tunnels and power-houses on the east side.

Although bedrock is exposed at water level on both sides of the river there is no way of knowing the depth to bedrock in the bottom of the river except by drilling. Drilling is currently being done by Boyles Bros. for B.C. Engineering Corporation, and the information should shortly become available.

Further geological work at Moran will be necessary if engineering studies continue. In the first place sufficient regional geologic work should be done to define and describe the large strand of the Fraser River fault which is thought to be just west of the west abutment of the proposed dam. Sufficient field work should be done to confirm the presence or absence of the postulated fault, and if the fault is confirmed, to map its position accurately, to determine the width of the fault zone and the nature and condition of the broken and altered rock in it, and to determine if possible if any recent movement has taken place. Some stripping or trenching might advantageously be done at an early date.

Detailed mapping in the vicinity of the dam should

Title Moran

Author ssh

Date and Typist Nov. 30/56 cs 7

outline the areas of bedrock and of unconsolidated materials as well as provide information on the strength and stability of the several formations. Ultimately it might be desirable or necessary to prepare a series of cross-sections drawn at right angles to the river and at several hundred foot intervals.

Detailed work on the abutments and nearby may be desirable but should not be undertaken until collaboration with engineers working on design and feasibility studies has been attained.

There is no point at this stage in going ahead with detailed geological work unless the problems of the design engineers are known. However, the question of the Fraser River fault should be investigated as early as possible because it may have an important bearing on the feasibility of the project as a whole and on considerations of design, cost and safety.

5M-349-8330 (2)

MEMORANDUM

TO Mr. A.F. Paget,
Comptroller of Water Rights,
Department of Lands,
BUILDINGS.

FROM THE
DEPARTMENT OF MINES

VICTORIA, B.C., November 6th, 1957.

WHEN REPLYING PLEASE REFER
TO FILE No.....

Re: Geological Investigations of Moran Damsite, 1957.

The attached report by Dr. Holland incorporates further observations by him on the geology of the small area surrounding the proposed Moran Damsite.

Dr. Holland devoted three weeks in May and three days in August to work in the area represented by Figure 1 in his report, and to less detailed work in the surrounding area.

Before long we expect to receive and to forward to you an interim report from Dr. K.C. McTaggart dealing with geology along the valley of the Fraser River, from Lillooet upstream, incorporating observations recorded by Mr. H.P. Trettin who spent the summer mapping that area under the general supervision of Dr. McTaggart.

H. Sargent,
Chief, Mineralogical Branch.

HS:md
cc. In Author's File.

Plate I.--Vertical aerial photograph of Fraser River at Moran damsite.

GEOLOGICAL INVESTIGATIONS AT MORAN IN 1957

BY STUART S. HOLLAND.

BRITISH COLUMBIA DEPARTMENT OF MINES

VICTORIA, B.C.

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A seismic station installed at Lillooet in 1957 will provide information on the seismic activity of the region and whether or not the fault zone is a locus of current earthquake activity.

About 800 feet west of the river at the west abutment of Moran damsite the Cache Creek rocks have been hydrothermally altered to a carbonate rock that weathers a bright red brown. This hydrothermally altered rock extends northwesterly for about 1,000 feet and may be as much as 300 feet wide. The alteration may have

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On the east side of the river, bedrock is exposed at river level only on the centreline of the proposed dam (see Plate IV A). Upstream and downstream for several thousand feet bedrock is overlain up to an altitude of 1,200 feet by coarse bouldery gravel which stands in bluffs and pinnacles along the river. The gravel in turn lies beneath a veneer of silts. There is no indication of the contour of bedrock beneath the gravels and silts so that the position of bedrock at any point will have to be determined by drilling. However, it is certain that no buried channel of the Fraser River lies in the bank to the east of the east abutment at the damsite.

Interpretive cross-sections (see Figure 2) drawn at intervals along the river show the changing relations of bedrock and unconsolidated meterial, and the inferred position and depth of the deep channel.

At this stage information is lacking on the precise location, width, and nature of the rock in the Moran fault; the location, extent and physical characteristics of the carbonate alteration zone near the west abutment; the precise location, depth, and width of the deep channel of the Fraser River; and the location and surface contour of bedrock beneath the mantle of unconsolidated silt and coarse bouldery gravel. All these can only be determined by systematic drilling on an extensive scale.

November 5, 1957.

Plate II A.--View northward up Fraser River to Moran damsite.

Plate II B.--View southward down Fraser River to Moran damsite.

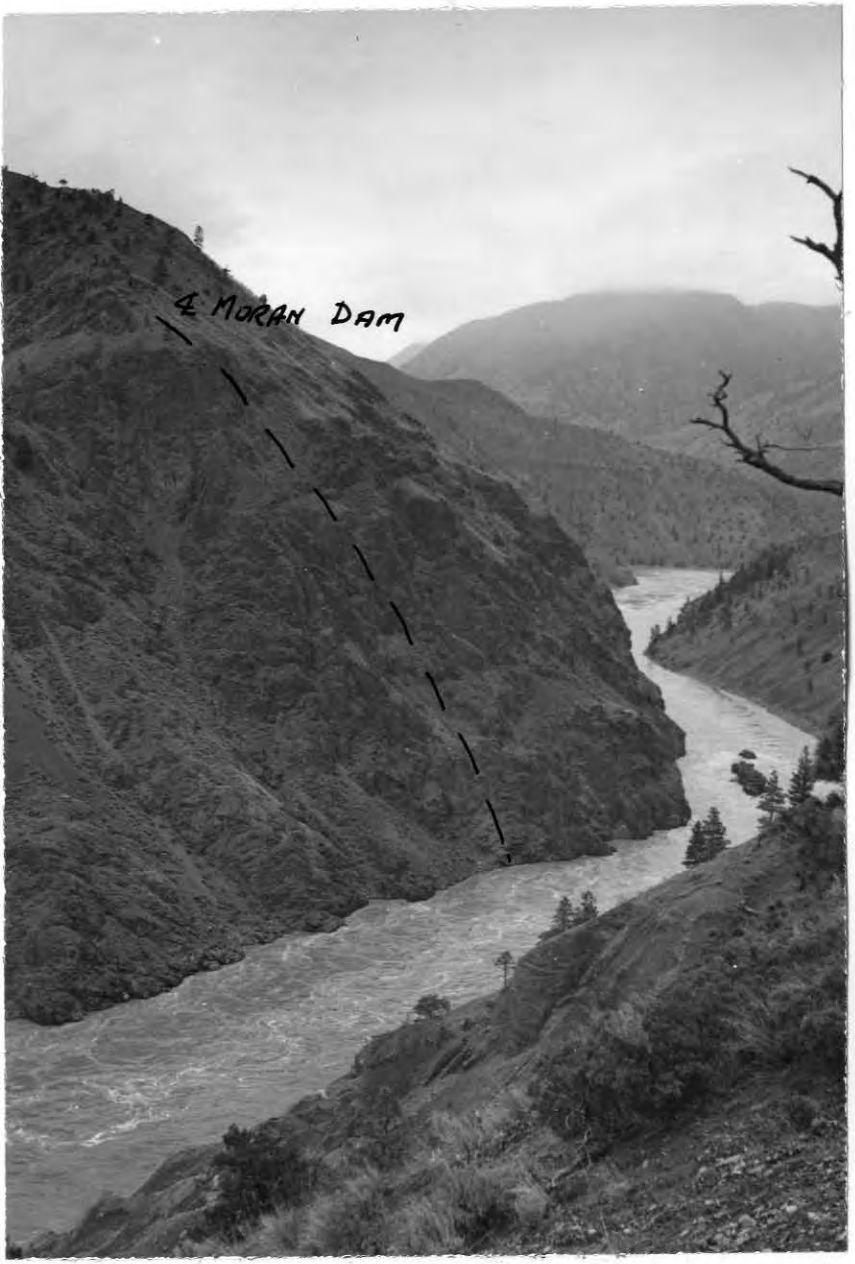


Plate III A.--West abutment at Moran damsite.

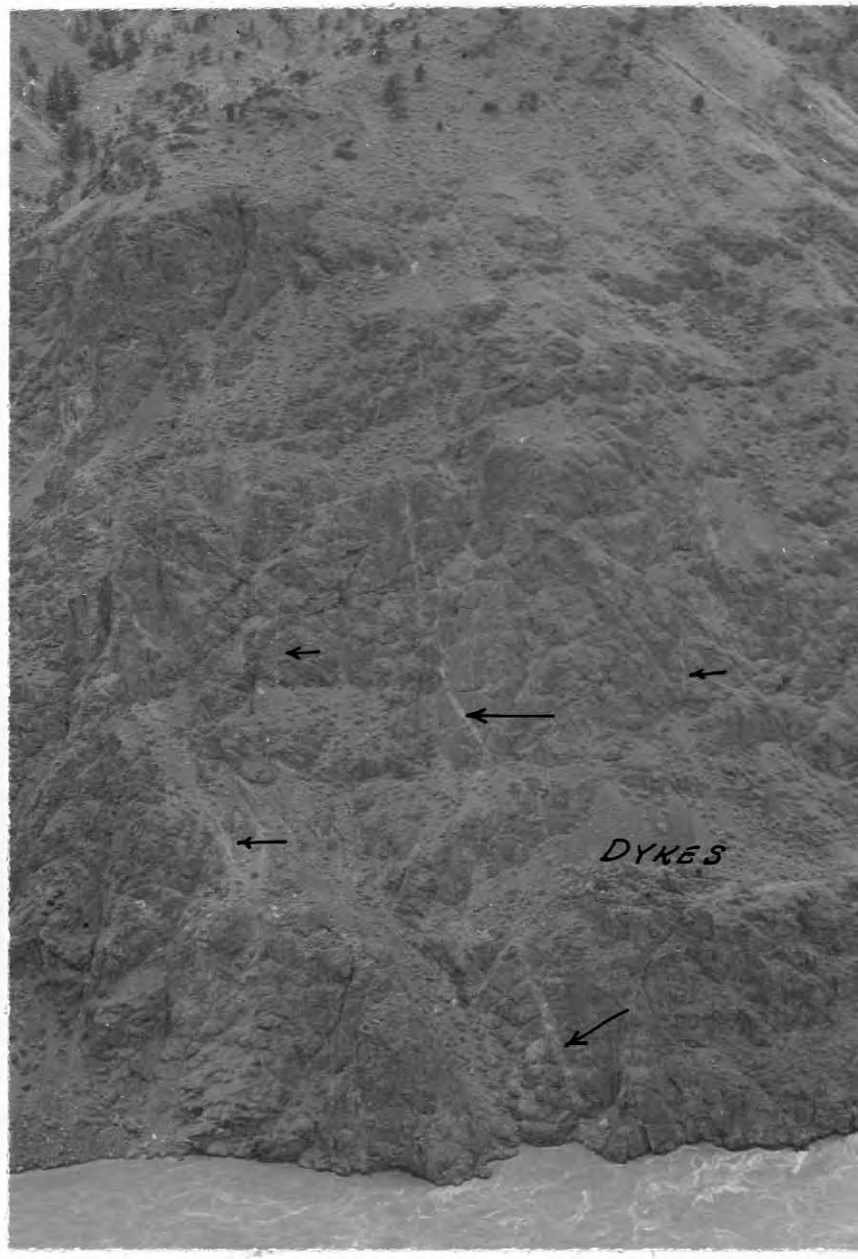


Plate III B.--Light coloured dykes in west abutment at Moran damsite.

Plate IV A.--East abutment at Moran damsite - with old drilling camp in centre foreground.

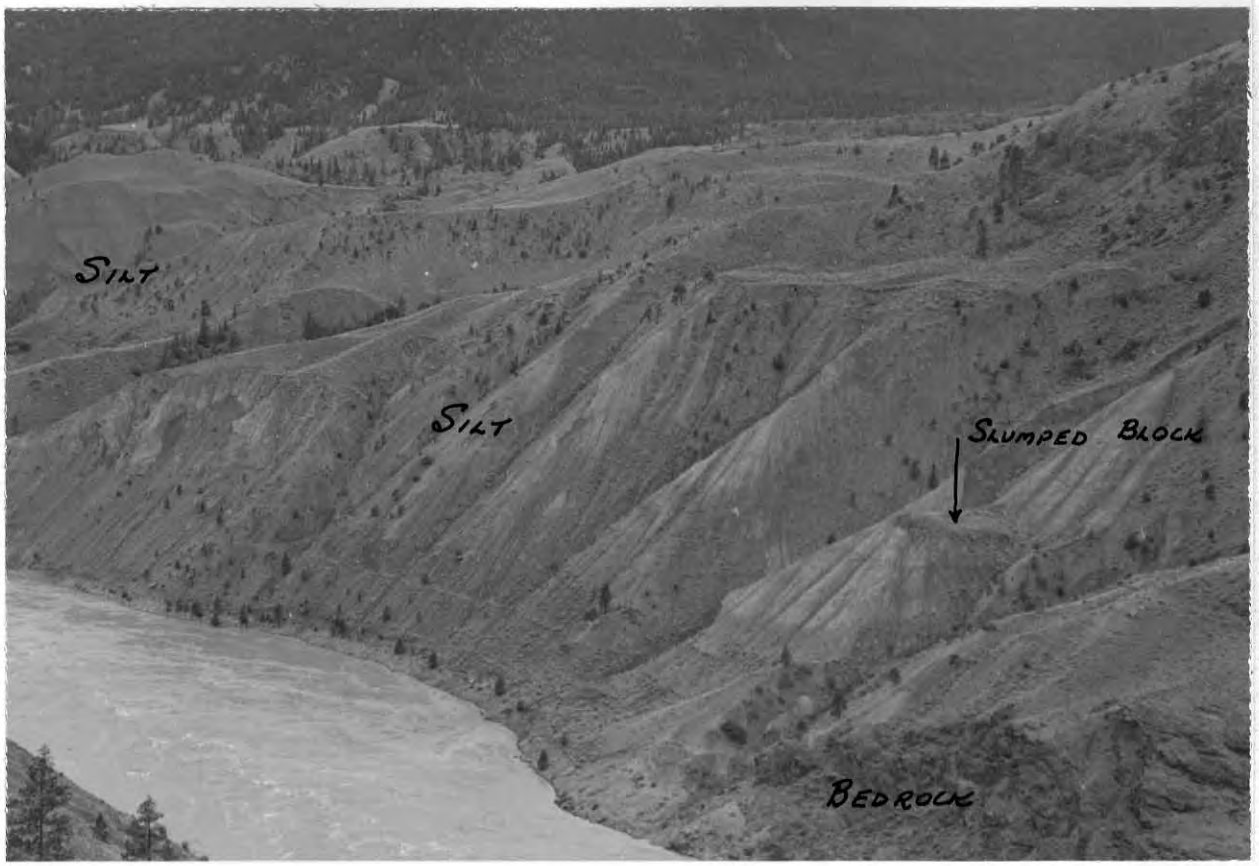


Plate IV B.--Laminated silt overlying bedrock downstream on west side at Moran.

Sliding ground, largely induced by irrigation water from bench above

Coarse gravel overlain by laminated silt

Laminated silts

ARKEITIC alteration of Cache Creek greenstone

MOUNT LYTTON DIORITE
Stocks & dykes of grey diorite

CACHE CREEK GROUP
MOSTLY SHEARED VOLCANICS, some black cherty argillites, limestone beds, & tuffaceous sediments

Sliding ground

Slump

RUSTY ZONE

FRASER RIVER

BAR DEEP

PROPOSED DAM

SHORELINE BAR DEC. 1956

400 @ 52°

TRAIL

TO PAVILION

PSM 1
TOPO MORAN

GRID NORTH

92I/13W

MORAN
1" = 400'

inches
0 1 2
0 1 2 3 4 5
centimetres

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

F R A S E R R I V E R

PROPOSED ℄ DAM

GRID NORTH

Shoreline Dec 1956

400'@ 52°

#1 244+ (No bedrock)

#2 135'

#3 144'

#4 166'

#5 40'

#6 40'

#7 35'

#8 40'

#9 35'

#10 35'

TO PAVILION

PBM.1 TOPO MORAN

PBM.2

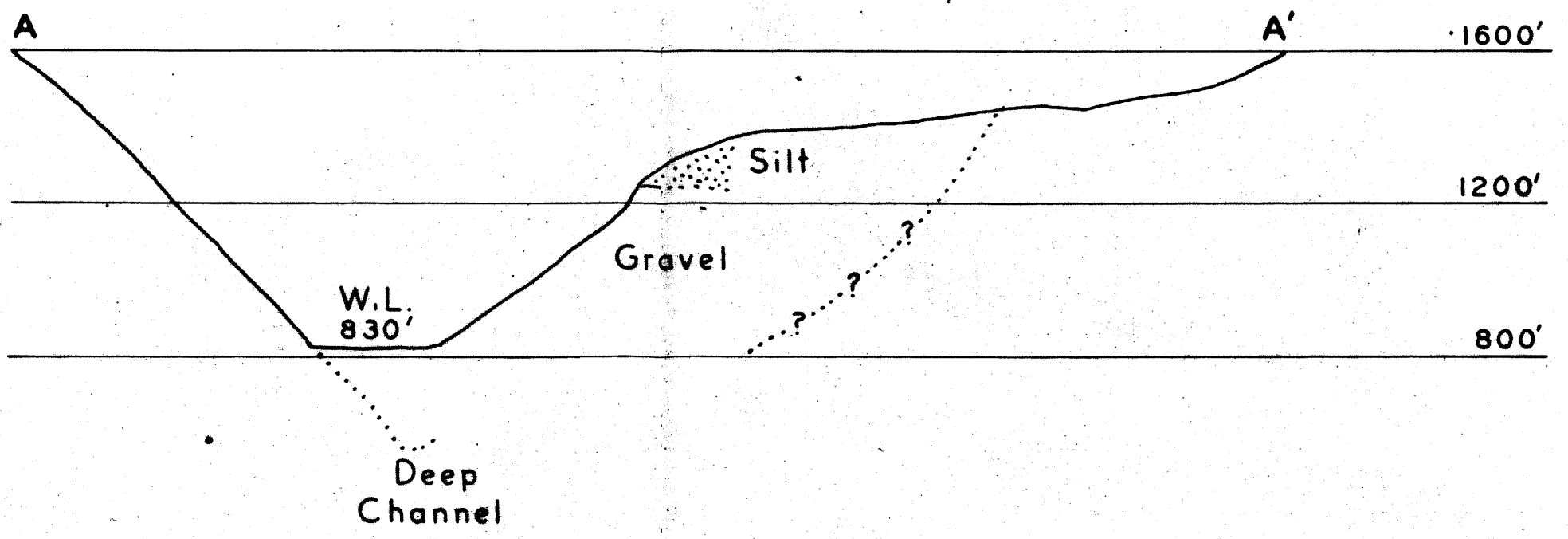
92I/13W

Drilling terminated about Feb. 15/57

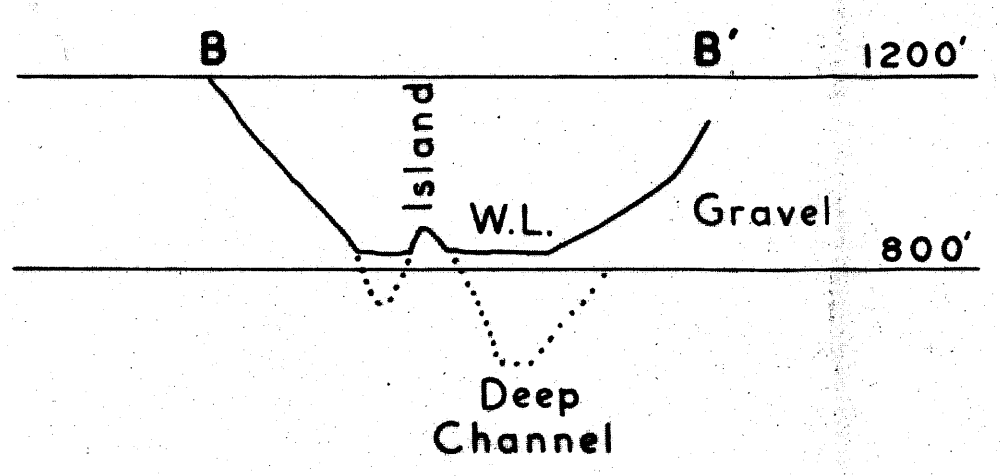
inches
0 1 2
0 1 2 3 4 5
centimetres

BRITISH COLUMBIA GEOLOGICAL SURVEY

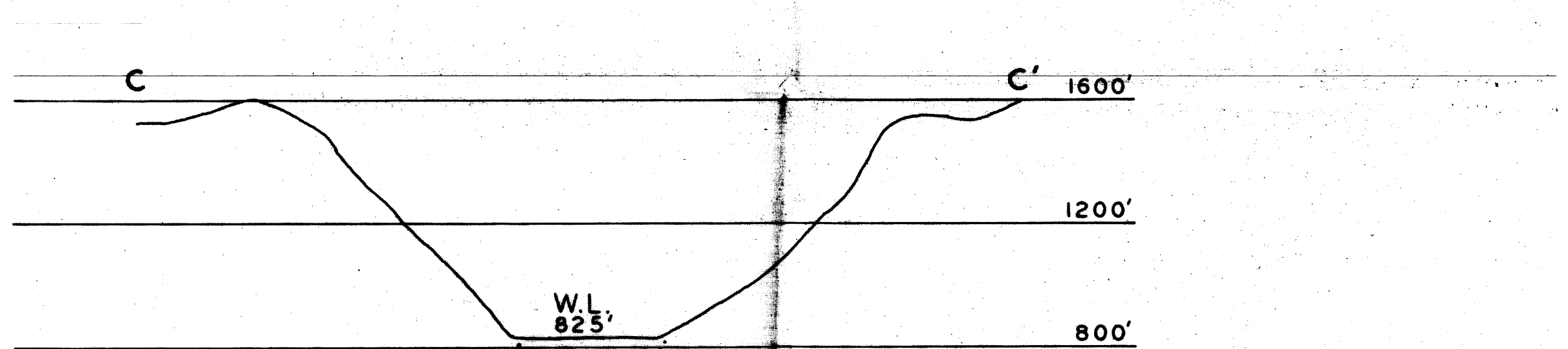
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.



SECTION A-A'



SECTION B-B'



SECTION C-C'

SECTION D-D'

Scale: 1 Inch = 400 Feet
Horizontal and Vertical

92I/13W

Spences Bridge gr.
mostly lavas.

Cache Cr.
greenstones, argillaceous
and cherty sediments

Sliding ground,
mostly hydrothermally
altered Spences
Bridge volcanic
rocks.

Ankeritic carbonate
alteration

VENEER OF BEDDED SILTS OVERLYING ROCK

SLUMPED SILTS

FRASER DEEP

RIVER DEEP

PROPOSED ℄ DAM
#1-244'
#2-135'
#3-140

GRID NORTH

TRAVERSE LINE

TRAIL

TO PAVILION

PBM 1
TOPO MORAN

PBM 2

92I/13W

1" = 400'

MORAN

inches
0 1 2
0 1 2 3 4 5
centimetres

This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.

BRITISH COLUMBIA GEOLOGICAL SURVEY

F R A S E R

R I V E R

PROPOSED ℄ DAM

GRID NORTH

TRAIL

TO PAVILION

PBM.1 TOPO MORAN

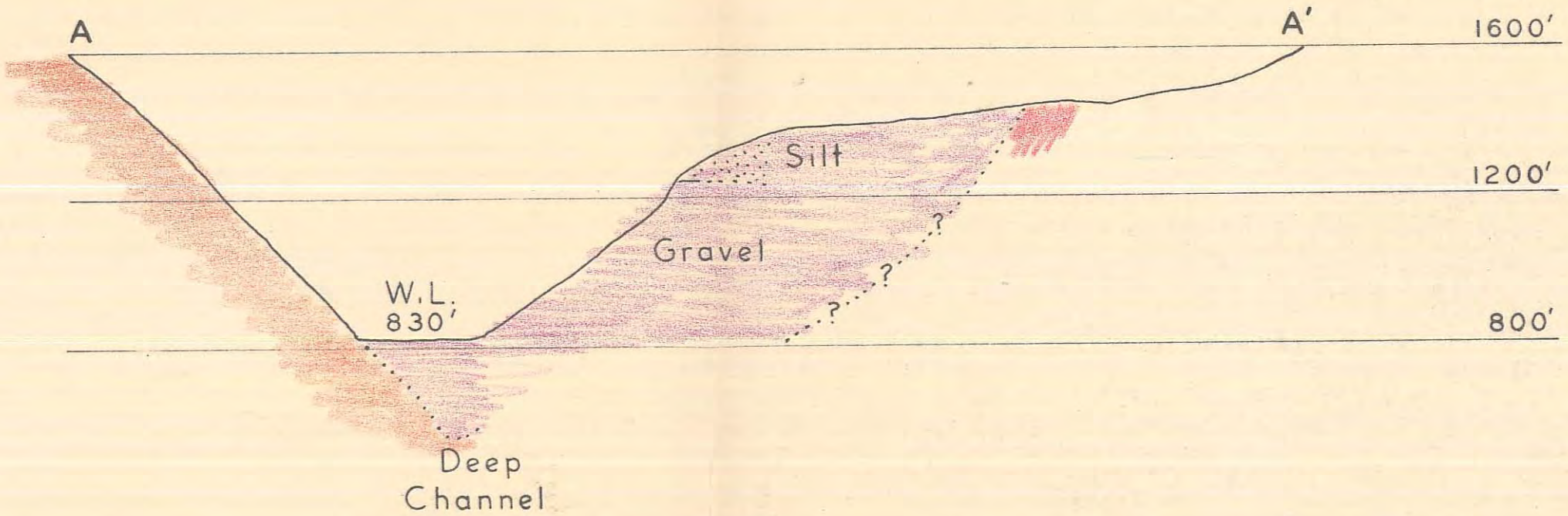
PBM.2

B.C.1234

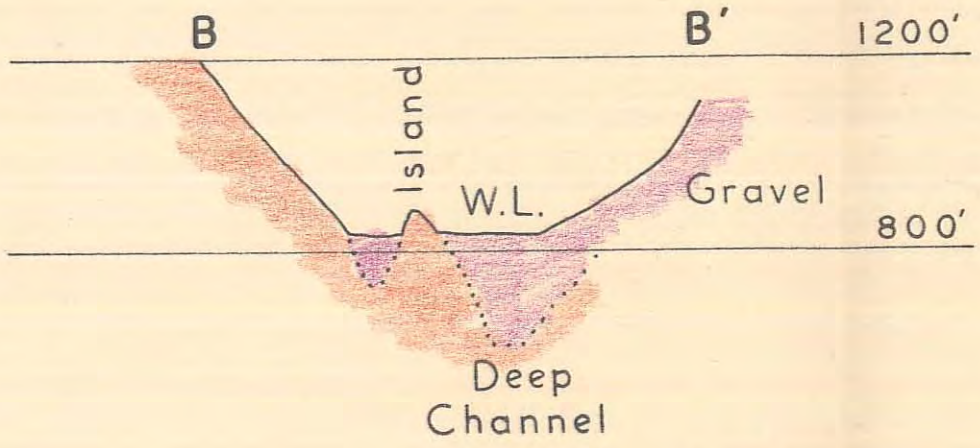
inches
0 1 2
0 1 2 3 4 5
centimetres

BRITISH COLUMBIA GEOLOGICAL SURVEY

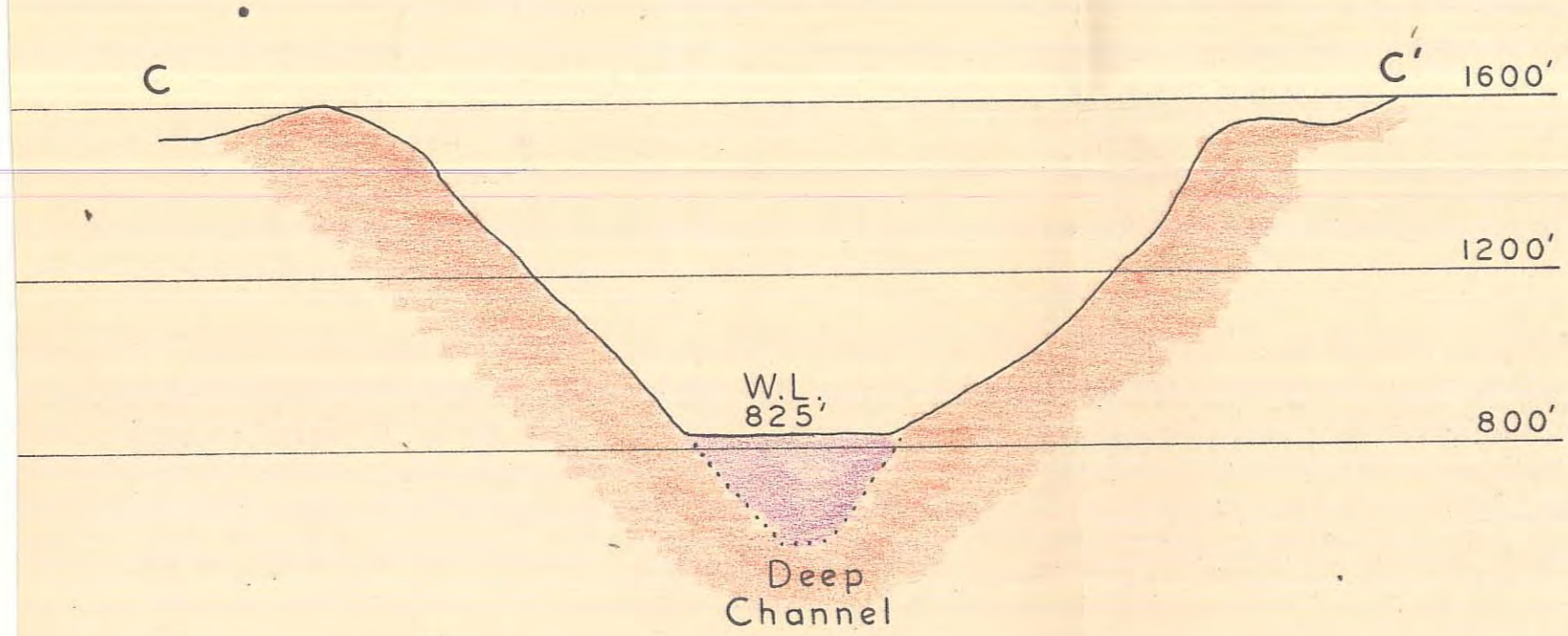
This reference scale bar has been added to the original image. It will scale at the same rate as the image, therefore it can be used as a reference for the original size.



SECTION A-A'



SECTION B-B'



SECTION C-C'

SECTION D-D'

Scale: 1 Inch = 400 Feet
Horizontal and Vertical