BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
DIVERSION OF
HAT AND FINNEY CREEKS

PRELIMINARY DESIGN REPORT

HYDROELECTRIC DESIGN DIVISION

Report No. 913

March 1978

HAT CREEK PROJECT

DIVERSION OF HAT AND FINNEY CREEKS

PRELIMINARY DESIGN REPORT

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SYNOPSIS

The British Columbia Hydro and Power Authority is currently proceeding with preliminary engineering design, and related cost estimating, for a 2000 MW coal-fired thermal generating station at Hat Creek, located about 25 km west of Ashcroft, B.C. as shown on Plate 2-1.

Because the open pit coal mine would be more or less centred over Hat Creek, diversion works would be required to convey the creek flow around the pit and mining facilities and back into Hat Creek. The works necessary to accomplish this, shown on Plate 6-1, would comprise a 16 m high headworks dam to divert the flows into a 4 m deep canal some 6.4 km in length along the east valley slope, and a 2.4 m diameter buried conduit nearly 2 km in length to convey the flows back down to Hat Creek. A secondary pit rim dam, located between the headworks dam and the mine pit, would be constructed to intercept any local downstream runoff, groundwater and any seepage losses which might occur in small quantity from the upper diversion works. A second minor diversion canal about 2.7 km in length would intercept the flows from Finney Creek on the west side of Hat Creek.

After about 12 years of plant operation the mine pit would have grown to a size that would require realignment, or replacement by other means such as tunnel or conduit, of some 1400 m of the Hat Creek diversion canal. Subsequent realignment of the canal to suit the ultimate pit slope is considered to be the most economical arrangement.

The site investigations and preliminary design studies detailed in this report indicate that construction of the necessary works will require no unusual structural components and involve no special engineering problems. However, some further engineering, environmental and economic assessments are desirable to determine the need for modifications or additions to the diversion works to prevent excessive temperature rise of low flows during the summer.

Principal data for the Hat Creek and Finney Creek diversion works are as follows:

<u>Hat Creek Diversion</u>

Normal design capacity (100 yr. return frequency)	18 m^3/s
Emergency capacity (1000 yr. return frequency)	27 m^3/s
Average annual discharge	0.7 m^3/s

<u>Finney Creek Diversion</u>

Normal design capacity (100 yr. return frequency)	3.5 m^3/s
Emergency capacity (1000 yr. return frequency)	5.5 m^3/s
Average annual discharge	approx. 0.03 m^3/s

The estimated total capital costs, at September 1977 price levels, of the Hat Creek and Finney Creek diversions are as follows:

1. Initial construction of the Hat Creek and Finney Creek Diversions - $14.0 million

2. Future realignment of the Hat Creek diversion canal - $ 3.3 million

These estimated costs include contingencies, engineering, investigations, supervision and corporate overhead but no allowances have been made for inflation, interest during construction or present worth discounting of future costs.

SECTION 1.0 - INTRODUCTION

1.1 TERMS OF REFERENCE AND SCOPE OF WORK

Under Assignment No. 477-028 dated 6 June 1977, the Hydroelectric Design Division (HEDD) was authorized to provide engineering services as required to conduct preliminary design studies for:

1. The diversion of Hat Creek around the proposed mine pit area.

2. A storage reservoir for the powerplant cooling water supply.

3. A retention structure for the ash disposal area in upper Medicine Creek.

This report deals solely with Item 1 above, and includes the diversion of both Hat and Finney creeks. It was arranged to have the geotechnical design of the water supply and ash embankments of Items 2 and 3 above performed by Klohn Leonoff Consultants Ltd., under the direction of the Hydroelectric Design Division. Their work plus the preliminary design of associated flood control and spillway facilities by the Hydroelectric Design Division is described in a companion report, "Hat Creek Project, Water Supply and Ash Disposal Reservoirs, Preliminary Design Report" dated March 1978.

The detailed Terms of Reference related to the diversion of Hat Creek are presented in Appendix II and, in general, can be summarized as follows:

1.1 TERMS OF REFERENCE AND SCOPE OF WORK - (Cont'd)

1. Review and refine the conceptual design studies previously completed by Monenco Consultants Pacific Ltd.

2. Conduct comparative engineering studies of alternative Hat Creek diversion schemes including:

   a. A canal diversion scheme around the east side of the mine pit area.

   b. A pump/storage diversion scheme with Hat Creek water pumped to the plant site to augment the plant cooling water supply.

3. Prepare preliminary designs for the recommended diversion scheme. A final report is to be completed prior to 1 February 1978.

4. Metric units are to be used exclusively for all studies and reports. (For the convenience of readers unfamiliar with the standard of SI metric units, a list of conversion factors for the most commonly used units is given in Appendix IV.)

While this report has been entitled a preliminary design report, it might, for at least some of the project components, be more appropriately considered an advanced feasibility study in view of several significant data and study limitations. These limitations include:

1. The lack of long-term reliable hydrologic records for Hat Creek, the complete lack of hydrological data for the Hat Creek subbasins, and the lack of base data to predict rainstorm-produced flood runoffs.

1.1 TERMS OF REFERENCE AND SCOPE OF WORK - (Cont'd)

2. The limited time and access restrictions for drilling which prohibited subsurface investigations entirely in some areas and in others prevented the definition of subsurface horizons with reliable continuity.

3. The insufficiently advanced studies of the mine pit and associated facilities. Detailed refinement of some of the diversion works designs was unwarranted because of their dependence on the mine facilities.

Short-term and long-term stability of the mine pit slopes are currently being assessed by others. Should their studies indicate conditions of eventual instability that would affect the security of the Hat Creek diversion canal in its ultimate location, the canal arrangement may have to be modified. However, based on the assumptions outlined in this report, it has been possible to define the most suitable and economic means of diverting Hat and Finney creeks and to prepare cost estimates with a reliability generally consistent with preliminary design.

The scope of work for this study is defined in considerable detail in the Terms of Reference in Appendix II and therefore, need not be repeated here. As the studies progressed, however, it was necessary to modify several of the work items on the basis of the ongoing study results. The more significant of these modifications include:

A. General

1. The pit development studies by the mining consultant were not sufficiently advanced to permit evaluation of the effects of flooding the mine pit and hence selection of the optimum diversion capacity. Arbitrary design criteria as defined in Sub-section 3.1(a) were therefore adopted.

1.1 TERMS OF REFERENCE AND SCOPE OF WORK - (Cont'd)

2. With mining studies still under way, the 35-year pit geometry and intermediate stagings for the shovel/conveyor scheme provided by Cominco Monenco Joint Venture on 10 January 1978 were used as a basis to assess the cost of necessary future modifications to the Hat Creek diversion canal.

B. Hydrology

1. Due to the paucity of hydrological and meteorological records within the Hat Creek basin an exhaustive regional analysis was required to derive reliable flood/frequency relationships.

C. Comparison of Alternative Diversion Schemes

1. On the basis of cost estimates made in Monenco's previous diversion study and the status of current mining studies, consideration of a tunnel for combined diversion and pit slope drainage use was not warranted. However, it is understood that this and other tunnel alternatives will be reassessed when the current mining studies are more advanced.

2. With the exception of minimizing the number and size of diversion or storage facilities within the Pit No. 2 area, no special considerations, diversion designs or cost estimates were made to incorporate future diversion needs arising from the possible but indefinite development of Pit No. 2 which, as shown on Plate 2-1, is located some 5 km south of Pit No. 1.

1.2 BACKGROUND

The first powerplant feasibility and preliminary environmental impact reports on the Hat Creek coal-fired thermal plant were completed

1.2 BACKGROUND - (Cont'd)

in the summer of 1975. Since that time numerous conceptual design studies and detailed environmental studies have been completed and others are still under way.

In the spring of 1976 B.C. Hydro appointed a joint venture of Intercontinental Engineering Ltd., Vancouver and Ebasco Services of Canada, Toronto to conduct a conceptual design study for the thermal plant. Working as a sub-consultant to the joint venture (Integ-Ebasco), Monenco Consultants Pacific Ltd. carried out the conceptual design for the diversion of Hat Creek and submitted their findings in the report "Hat Creek Diversion Study" dated January 1977.

This current report by the Hydroelectric Design Division presents the results of the preliminary design studies subsequent to Monenco's work and, where data have been available, the latest requirements or recommendations of the Thermal Division and its consultants have been incorporated.

1.3 AVAILABLE INFORMATION

(a) Reports

1. "Hat Creek Project, Power Plant Conceptual Design Report", by Integ-Ebasco, January 1977.

2. "Hat Creek Diversion Study", by Monenco Consultants Pacific Ltd., January 1977.

3. "Hat Creek Project, Project Description", by B.C. Hydro, September 1977.

4. "Evaluation of Ash Disposal Schemes for Hat Creek Thermal Plant", by Integ-Ebasco, July 1977.

1.3 AVAILABLE INFORMATION - (Cont'd)

5. "Hat Creek Project, Environmental Impact Assessment, Minerals and Petroleum", B.C. Hydro (undated draft).

6. "Preliminary Feasibility Study for Oregon Jack Creek Irrigation Proposals", by Water Investigations Branch, Ministry of the Environment, British Columbia, June 1977.

7. "Terrain Inventory and Quaternary Geology, Ashcroft, British Columbia" (paper 74-49), by J.M. Ryder, Geological Survey of Canada, 1976.

8. "Hat Creek Geotechnical Study, Report No. 6", by Golder Associates, March 1977.

9. "Hat Creek Coal Development, No. 1 Coal Deposit, Exploration Report" by Dolmage, Campbell and Associates Ltd., 15 June 1977.

10. "Ashcroft Map Area, British Columbia, Memoir 262", S. Duffell and K.C. McTaggart, Geological Survey of Canada, 1952.

11. "Hat Creek Project; Water Resources Subgroup; Hydrology, Drainage, Water Quality and Use, Inventory Report - Draft", by Beak Consultants Ltd. et al, August 1977 (this report is not yet completed and published).

12. "Provincial Power Study, Appendix III, Hydrology" by B.C. Energy Board, Vancouver Study Group (IPEC), March 1972.

(b) Topography

General mapping of the entire region is available at scales of 1:250,000 and 1:50,000 but, as shown on Plate 2-1

1.3 AVAILABLE INFORMATION - (Cont'd)

which was reproduced from the 1:50,000 scale mapping, the ground contours and elevations are depicted in imperial units. The grid system shown however, is based on the Universal Transverse Mercator (UTM) system used for the metric mapping presented in this report.

Topographic mapping in imperial units to a scale of 1 inch = 400 feet (1:4800) with 10-foot (3.05 m) contours was available prior to the start of the studies and covers the complete area of the diversion works south to about the mid point of the reservoir for Storage Damsite No. 3, about 1 km north of Upper Hat Creek and approximately at UTM northing 5,613,000. This mapping was prepared from aerial photographs taken in 1975 and 1976 at a scale of approximately 1:24,000 with ground control established to third order accuracy. The grid system, though oriented to astronomic north, was based on an arbitrary coordinate origin.

All subsequent topographic mapping was prepared in metric units to a scale of 1:5000 with contour intervals of 2.5 m and the UTM grid system was used throughout. Conversion formulae to transform coordinates from the earlier imperial system to the UTM system are given in Appendix III.

In September 1977, mapping was prepared to cover the remaining portion of the reservoir for Storage Dam No. 3 and was extended south to approximately UTM northing 5,606,700 to cover the point of diversion of the Oregon Jack Creek diversion which, although no longer operational, is currently being studied by the provincial government to determine the feasibility of reconstructing the diversion for irrigation purposes. The mapping in this area was prepared by conventional photogrammetric methods from 1:24,000 scale aerial photographs flown in 1976.

1.3 AVAILABLE INFORMATION - (Cont'd)

In October 1977 the Hat Creek valley between UTM northings 5,613,000 and 5,619,000 was remapped to metric scales also by conventional photogrammetric methods.

The area north of UTM northing 5,619,000 covering the mine pit, the diversion works, the thermal plant site and all of Medicine Creek was remapped to metric units between October 1977 and January 1978 by B.C. Hydro's Computer Sciences Division using digital modelling techniques. Two sets of topographic map sheets were prepared each having 5 m contour intervals but offset by 2.5 m thus resulting in overall coverage with 2.5 m contours. Since this mapping procedure is not capable of plotting such detail as roads, buildings, creeks, lakes, fences, etc., this detail has had to be superimposed from reductions of the original 1:4800 scale imperial mapping.

Overall coverage of the digital model topography comprises the area between UTM northings 5,619,000 and 5,628,500 and UTM eastings 595,000 and 609,000.

Because most of the design work was done on the basis of the imperial mapping, and differences in elevations have subsequently been observed in the metric mapping, it is evident that some modification to selected reservoir levels may be desirable during the final design stage. For example, it has been found that elevations on the metric mapping in the vicinity of the water supply reservoir are in the order of 3 m lower, requiring two additional relatively small saddle dams with the selected reservoir level. Since more control was available for the metric mapping, it is presumably more reliable.

1.3 AVAILABLE INFORMATION - (Cont'd)

(c) Aerial Photography

Aerial photography covering the project area comprises two east-west flight lines of black and white photography at a scale of 1:24,000 between Ashcroft and the Pit No. 1 site in the Hat Creek valley and 10 north-south flight lines of colour photography covering the entire project site and extensive surrounding areas. The colour coverage totals approximately 2000 km^2. Both sets of aerial photography were flown in September 1976.

(d) Geology and Subsurface Investigations

General descriptive geology and mapping of the Hat Creek region is limited to the brief report by the Geological Survey of Canada, Item 7 in Sub-section 1.3(a).

The only other geological and subsurface data available have been assembled in connection with the Hat Creek Thermal Plant Project. More specifically this data was obtained primarily to investigate the coal deposit and little attention was devoted to the surficial soils which would most influence design of the diversion works. Other investigations were made relative to selecting a site for the thermal plant and are therefore located in areas remote from the diversion facilities. These previous investigations are described more fully in Section 4.0.

(e) Hydrology and Meteorology

Hydrological information within the Hat Creek basin is generally limited to the records of four hydrometric stations established on Hat Creek by the Water Survey of Canada. Three of the stations were located on Hat Creek with the fourth located on a long-abandoned diversion canal in the upper part of the basin. None of the stations have long periods of record and most are non-concurrent.

1.3 AVAILABLE INFORMATION - (Cont'd)

Meteorological records by the Atmospheric Environment Service are limited to a single station with a 15-year period of record, located on the Hat Creek valley floor.

Details of the above hydrological and meteorological records are presented in Section 5.0.

An extensive hydrologic study for the Hat Creek area is currently under way as part of the detailed environmental studies for the Hat Creek Project. The report on this work, Item 11 in Sub-section 1.3(a), is still unpublished and only a draft of the incomplete work was available for the HEDD studies.

SECTION 2.0 - PROJECT AREA

2.1 AREA LOCATION AND DESCRIPTION

The Hat Creek basin, shown on the key map of Plate 2-1, has mainly a north-south alignment and is situated about midway between the Fraser River on the west and the Thompson River on the east. The area of the basin above the confluence with the Bonaparte River, about 11 km north of Cache Creek, is about 666 km^2. Above the Medicine-Hat Creek confluence, just downstream of where Hat Creek would be diverted, the basin comprises an area of 350 km^2.

From the confluence of Blue Earth Creek (El. 1190) in the upper reach of the Hat Creek basin, Hat Creek flows at an average gradient of about 1.6 percent over a distance of 44 km to its confluence with the Bonaparte River (El. 500). Hat Creek is generally a small stream having an average annual flow, at Hydrometric Station 08LF061 near the mine pit, of about 0.7 m^3/s. However, during the snowmelt freshet the flows are very much higher, having peaked at 14.6 m^3/s during the station's short period of record beginning in 1960.

The mountains forming the west boundary of the Hat Creek basin rise to as high as El. 2330 and, acting as a barrier, place Hat Creek generally in a rain shadow of the wetter Fraser River regions to the west. Mountains on the east boundary of the basin rise to as high as El. 2040.

With an average annual precipitation of only 300 mm and a unit runoff of only about 62 mm, occurring primarily as spring snowmelt runoff, the area is generally quite arid and forest cover is generally limited to the higher levels. The lower open areas are used primarily

2.1 AREA LOCATION AND DESCRIPTION - (Cont'd)

for cattle grazing and, adjacent to Hat Creek and its tributaries where numerous irrigational diversions have been constructed, for cultivation of cattle feed crops.

2.2 REGIONAL GEOLOGY AND TOPOGRAPHY

The Hat Creek valley is an upland valley 26 km in length and 3 to 6 km in width located in the eastern foothills of the Coast Mountains. This is a grassland valley where rock outcrops are few, small and widely scattered on the floor of the valley, most of which is covered by up to 150 m of surficial material.

The surficial deposits of the Hat Creek valley are varied and have diverse origins, indicating a complex recent geological history. These deposits consist of till, glaciofluvial and lacustrine deposits of glacial origin, slide deposits of post-glacial age along the valley walls and recent alluvial, colluvial and lacustrine deposits. The distribution of these materials is very irregular.

The Coldwater Formation which is known to underlie the entire valley consists of shales, claystones, siltstones, sandstones, conglomerates and coal of Tertiary age. The total formation thickness may be as much as 1650 m with up to 550 m consisting of coal with an overall average of 20 to 25 percent intercalations of claystone, siltstone and sandstone. Most of the Coldwater sedimentary rocks are weakly cemented and are easily broken. Exceptions are the relatively well cemented sandstone beds, conglomerates and much of the coal itself. Minor quantities of calcareous beds, limestone and iron carbonate are widely distributed within the coal deposit. Thin tuff (ash) beds, some of which have been altered to montmorillonite, are also widely distributed.

2.2 REGIONAL GEOLOGY AND TOPOGRAPHY - (Cont'd)

The coal sequence in the No. 1 deposit was originally overlain by about 600 m of uniform claystone-siltstone of the Medicine Creek formation which contains a significant proportion of fine grained volcanic material. A heavily eroded surface was developed into this sequence, and this eroded surface was in turn covered in part by late Tertiary volcanic rocks.

A prominent feature of the Tertiary bedrock underlying Upper Hat Creek valley is the presence of major, steeply dipping block faults, two of the more prominent being the east boundary fault and the west boundary fault which lie along each side of the valley. Faults within the Coldwater Formation commonly strike northeasterly and northwesterly. Some exhibit considerable vertical displacement (600+ m). The coal bearing Tertiary rocks underlying the valley have been faulted down into the adjoining older formations as a graben structure, which has been extensively dislocated in turn by the steeply dipping longitudinal and cross block faults.

The Coldwater Formation, including the coal sequence, is folded into an open anticline with an axis striking approximately north-south. In the northern portion of the valley the eastern limb of the anticline appears to be truncated and the western limb flexed upwards to the west. The result is that the principal portion of the No. 1 coal deposit is synclinal in form although modified somewhat by faulting.

2.3 CLIMATE

The Hat Creek valley lies on the western extremity of a dry belt which extends from Lytton through Ashcroft to Kamloops. As previously stated, precipitation is very light and some 140 mm of the average annual 300 mm precipitation falls as snow primarily in the higher levels of the basin.

2.3 CLIMATE - (Cont'd)

Winters are cold and summers are warm with many very hot days. Summer nights, however, are generally cool and sometimes even cold. The mean daily temperature recorded on the valley floor is 3.4°C with a measured range between 36°C in July and -43°C in January. The mean frost free period is 50 days but has varied from 13 to 86 days.

Temperature and precipitation summaries for the Hat Creek meterological station located on the valley floor are presented in Table 2-1.

2.4 WATER USE

In accordance with the Terms of Reference, schemes involving the use of a portion of the Hat Creek runoff to augment the plant water supply, and thereby reduce the amount of costly pumping from the Thompson River, were also investigated. Such use of the Hat Creek water, if indiscriminantly diverted, could have significant impacts on fish and other aquatic wildlife within Hat Creek, and the Bonaparte River, and could conflict with the present and potential agricultural demand for water.

Comprehensive studies of the water requirements for fish, irrigation, cattle watering and domestic uses are presented in the report by Beak Consultants et al, Item 11 in Sub-section 1.3(a). Assuming that no treatment of the comparatively poor quality Hat Creek water would be required, it was found that approximately 0.4 m^3/s, based on long-term average flows, could be diverted to the plant with considerable financial benefit. These flows are based on the assumption that there would be no major diversion further upstream such as the Oregon Jack Creek diversion currently being studied by the provincial government.

2.4 WATER USE - (Cont'd)

The original Oregon Jack Creek diversion, via the Hammond diversion ditch, was first licenced in 1883 and had a diversion canal capacity of about 0.4 to 0.6 m^3/s. The diversion was operated for a number of years for irrigation in the Thompson River valley but was abandoned apparently in the 1920s and has since fallen into a state of disrepair.

The B.C. Water Investigations Branch, on behalf of the Ministry of Agriculture, carried out a feasibility study (Item 6 in Sub-section 1.3(a)) for possible reconstruction of the Oregon Jack Creek diversion. Their report, completed in June 1977, indicated that up to 617 ha-m of Hat Creek water could be diverted annually with a benefit/ cost ratio in the order of 1.2.

Numerous discussions were held between HEDD and both the Water Investigations Branch and the Ministry of Agriculture to determine the likelihood of this diversion proceeding. Until further cost studies are completed and firm commitments are obtained from participating ranchers, no decision regarding the diversion will be made. Such a decision could possibly be a year or even more away.

Next to the possible Oregon Jack Creek diversion, the most significant single diversion with respect to the Hat Creek Project is the existing irrigational diversion from upper Medicine Creek into MacLaren Creek (see Plate 2-1). Under existing water licences, up to 223 ha-m of Medicine Creek water can be diverted annually out of the basin.

Complete details of the water licences in the Hat Creek basin can be found in Items 2 and 11 listed in Sub-section 1.3(a). Although there are minor differences in the totals of the two references, the water licences are generally summarized as shown on Table 2-2. As

2.4 WATER USE - (Cont'd)

shown on this table, the total of the water licences upstream of and including Finney Creek is 979 ha-m per year. The average annual runoff volume at Hydrometric Station 08LF061 just upstream of Finney Creek is 2100 ha-m and hence the licenced withdrawals represent nearly 50 percent of the residual flow. Downstream of the mine pit and diversion works the licenced withdrawals total 188 ha-m or roughly 40 percent of the natural incremental residual runoff in that downstream area.

It is evident therefore that agricultural requirements, particularly if expanded beyond the present level by increased irrigation within the basin or by reconstruction of the Oregon Jack Creek diversion, would have a significant effect on the proposed Hat Creek diversion whether or not the diversions incorporated systems to supply water for the thermal plant.

Water requirements to satisfy the Hat Creek fish populations downstream of the mine pit were estimated by Monenco in their report as approximately 30 percent of the historical average monthly flows. As presented in their report, these requirements would have varied from a minimum of 0.06 m^3/s in January and February to a maximum of about 0.84 m^3/s in June with an annual average of about 0.21 m^3/s.

Subsequent fishery requirements downstream of the mine pit were obtained from Beak Consultants Ltd. in December 1977. From Table 5-2, Section 5 of their draft report "Hat Creek Project, Fisheries and Benthos Study" recommended downstream requirements are as follows:

2.4 WATER USE - (Cont'd)

Mean Flow (m^3/s)		Mean Flow (m^3/s)	
January	0.21	July	0.28
February	0.21	August	0.28
March	0.21	September	0.28
April	0.28	October	0.21
May	0.28	November	0.21
June	0.85*	December	0.21

Annual average = 0.29 m^3/s

2.5 WATER QUALITY

The quality of Hat Creek water with respect to the diversion works is a major consideration only for the diversion schemes incorporating supply of Hat Creek water to augment the main Thompson River supply system. The diversion facilities of schemes excluding plant supply should result in no measureable change in water quality other than temperature.

Extensive water quality data are presented in the report by Beak Consultants Ltd. et al, Item 11 listed in Sub-section 1.3(a). These data include water quality analyses of both ground and surface waters with numerous sample analyses from Hat Creek and its tributaries and from the Bonaparte and Thompson rivers.

The water quality data have shown Hat Creek to typify very hard alkaline waters indicative of substantial groundwater inflow, whereas the Thompson River is a soft water river subject to quality variations of only small magnitude. On the basis of comparisons of the Hat Creek and Thompson River water qualities it was concluded by the Thermal Division that, because of potentially serious cooling tower scaling problems, substantial quantities of Hat Creek water would not be suitable for plant use without extensive treatment.

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* Includes 2-week flushing period with flow of 1.14 m^3/s.

2.6 MINE PIT, THERMAL PLANT AND OTHER PROPOSED FACILITIES

As shown on Plate 2-1, Pit No. 1 is centred about 3 km south of the junction where Highway No. 12 leaves the Hat Creek valley and heads toward Pavilion Lake. Via Highway No. 12, Pit No. 1 is located approximately 32 km from Cache Creek and about 44 km from Ashcroft. A second coal deposit, known as Pit No. 2, could be developed in the future but, since it appears that such development would not take place for at least 20 years and probably longer, no major consideration has been given to it in terms of design of the Hat Creek and Finney Creek diversion works.

The 2000 MW thermal plant site is about 5 km east of Hat Creek in the vicinity of Harry Lake. Situated at El. 1400, the plant is some 535 m above the level of Hat Creek.

A new main access road to the thermal plant and Pit No. 1 may be constructed over a more direct route through upper Medicine Creek directly from Ashcroft thereby shortening the present 44 km distance to Pit No. 1 to about 27 km.

Pit No. 1, after its currently projected life of 35 years, would occupy an area of about 5.7 km^2 centred roughly over Hat Creek and, in its deepest central portion, would reach a depth of about 200 m below the creek level of El. 865. Waste materials from the pit would be deposited primarily in the Houth Meadows area northwest of the pit but some quantity is likely to be deposited as well in the lower portion of Medicine Creek valley.

To date the location and size of the Medicine Creek waste dump has not been determined, and it has therefore been assumed that it will have no significant bearing on the diversion works for Hat and Finney creeks or on the runoff handling facilities around the ash disposal reservoir in upper Medicine Creek.

2.6 MINE PIT, THERMAL PLANT AND OTHER PROPOSED FACILITIES - (Cont'd)

The remaining major facilities of the Hat Creek Project are the water supply and ash disposal reservoirs in upper Medicine Creek and the water supply pipeline which would convey the plant's entire water requirements from a pumping plant on the Thompson River near Ashcroft to the water supply reservoir near the thermal plant. The 23.5 km pipeline would have a maximum capacity of 1.58 m^3/s with a static lift of about 1083 m.

SECTION 3.0 - CRITERIA FOR DESIGN AND COST ESTIMATES

For preliminary design and cost estimating of the diversion works for Hat and Finney creeks it was necessary to establish specific criteria in three areas; design capacities for the Hat Creek and Finney Creek diversions, temporary creek diversion capacities during construction of the major diversion works, and cost estimating and scheduling criteria to ensure compatibility with the many other studies under way for the Hat Creek Project.

3.1 CREEK DIVERSION DESIGN CAPACITIES

(a) Hat Creek

As the consequences of flooding the mine pit have not yet been determined, the design capacities to be adopted for the Hat Creek diversion works should be conservative until a proper risk analysis can be undertaken.

Accordingly, the criteria adopted for this study were as follows:

1. Provide for a 100-year return period flood as an operational condition for the diversion system.

2. Provide for a 1000-year return period flood as an emergency condition.

3. Provide for safe spillage of the probable maximum flood to the No. 1 mine pit rim.

These criteria should be reviewed when the mining consultant, Cominco Monenco Joint Venture, has better defined the mine pit and can assess the impact of mine flooding. This impact assessment could be made either as part of subsequent ongoing studies or in conjunction with final design of the diversion works.

(b) Finney Creek

No specific criteria were defined for design of the Finney Creek diversion works. Because of its basin size of only 13 km^2 as compared to the 350 km^2 Hat Creek diversion runoff area, it is apparent that it would be far less significant in terms of mine pit flooding. However, considering the complete lack of sub-basin hydrological records to facilitate flood prediction and the fact that the difference between 100-year and 1000-year flood discharges would not have a major effect on the size and costs of the diversion facilities, the 1000-year frequency rainstorm flood was adopted with provision of minimum freeboard.

(c) Medicine Creek

The hydrological studies for the runoff canals around the ash disposal reservoir in upper Medicine Creek were done in conjunction with the Hat and Finney creek studies, and it has been considered more appropriate to describe the Medicine Creek studies in this report than in the report on water and ash disposal reservoirs.

Because the ash disposal area would remain even after decommissioning of the thermal plant and would have to be secure in perpetuity, it has been considered that the runoff canals and associated outlet works should be designed with a capacity sufficient to handle the probable maximum flood. Because of its comparatively small capacity, the existing diversion from upper Medicine Creek into MacLaren Creek has been totally disregarded in terms of handling a portion of the probable maximum flood runoff.

3.2 DIVERSION DURING CONSTRUCTION

(a) Hat Creek Diversion

Temporary diversion of Hat Creek past the damsites during construction of the headworks dam and pit rim dam can be deferred until well after the usual snowmelt runoff flood peak in May or June has passed and the flows have receded to comparatively small magnitude. It is considered that the construction can be scheduled during the fall recession period such that the diversion works need only be sized with a capacity sufficient to pass the highest daily flow recorded after 31 July in the 16-year period of record - approximately 1.7 m^3/s.

(b) Finney Creek Diversion

No temporary diversion facilities are required for the Finney Creek diversion works.

(c) Medicine Creek Ash Dam - Axis 3B

Hydrologic analyses were conducted by HEDD to provide Klohn Leonoff Consultants Ltd. with the data required to design temporary diversion works for the main ash dam at Axis 3B. The design floods used for both snowmelt and rainstorm-produced runoff were based on a return frequency of 10 years.

3.3 COST ESTIMATING AND SCHEDULING CRITERIA

Cost estimating and scheduling criteria adopted for the diversion works and the water supply and ash disposal reservoirs are as follows:

1. All costs are presented in terms of September 1977 price levels.

2. The costs of lands and rights are excluded.

3.3 COST ESTIMATING AND SCHEDULING CRITERIA - (Cont'd)

3. No allowances are made in the cost estimates for interest during construction, inflation or present worth discounting of future costs.

4. Contingency allowances have been included to reflect both the level of detail in the estimates and the extent of site investigations.

5. The costs of engineering, site investigations and supervision have been included in the estimates assuming a cost equivalent to 15 percent of the total direct cost plus contingencies.

6. A corporate overhead allowance is included in the estimates based on 5 percent of the total direct cost plus contingenices, engineering, investigations and supervision.

7. The cost of electrical energy at site has been assumed as 20 mills per kWh.

8. The design life of the thermal plant and mine has been assumed as 35 years.

9. The following key dates have been assumed for scheduling:

   a. Commence final design - after 1 January 1979

   b. Project construction authorization - 1 April 1980

   c. Complete Hat Creek and Finney Creek diversion - 1 October 1982

3.3 COST ESTIMATING AND SCHEDULING CRITERIA - (Cont'd)

d. Complete water supply reservoir - 1 July 1984

e. Complete Stage 1 of ash disposal reservoir - 1 April 1985

f. On-line date of thermal plant - 1 January 1986

SECTION 4.0 - SITE INVESTIGATIONS

4.1 FOUNDATION INVESTIGATIONS

(a) Previous Investigations

Prior to early 1977 about 350 holes had been drilled by various types of rigs to explore the coal deposit and examine the stability of excavation slopes for the mine pit. Prior to 1975 the drill holes were located mainly within the No. 1 and No. 2 coal deposits and were triconed to depths of 20 m or more before being logged in detail. As a result these holes are of very little use in relation to design of any of the diversion works.

In 1976 and 1977 a number of holes, excluding those described in the following Sub-section 4.1(b), were drilled on the east bank of Hat Creek. About 10 of these are close to the proposed Hat Creek diversion canal route. Several holes were also drilled in the lower and mid-Medicine Creek areas for waste disposal embankment studies. Samples were obtained in these holes for gradation analyses and shear strength determinations.

The locations of the previous holes are shown on Plates 4-1 and 4-2 together with those drilled specifically for the diversion works.

(b) 1977 Exploration Program

During the latter half of 1977, 21 holes numbered P77-49 to P77-66 and P77-69 to P77-71 inclusive were drilled, using a Becker diesel hammer drill, at the locations shown on Plates 4-1 and 4-2. These 21 holes comprised three at the headworks damsite, two at the pit rim damsite, nine along the diversion canal route, two on the discharge conduit route, two at Storage Damsite No. 2 and three at Storage Damsite No. 3.

At the headworks and pit rim damsites four of the five holes were drilled to bedrock. The fifth, P77-51, was drilled some 250 m east of the pit rim dam right abutment to a depth of nearly 31 m without reaching rock.

Of the nine holes along the canal route, two holes at the Medicine Creek canal crossing were drilled to depths of 23 m and 31 m. The remaining seven holes along the canal route and the two along the discharge conduit were all drilled to about 15 m depth.

The five holes at the storage damsites varied between 25 m and 55 m in depth.

The total drilling depth of holes for the diversion works totalled approximately 472 m.

In all of the drill holes, disturbed samples were taken for identification at about 1.5 m intervals up to a depth of 15 m and at 3 m intervals below that depth. At approximately 3 m to 6 m intervals split spoon or Shelby tube samples were obtained. In-situ permeability tests were conducted in pervious zones for analysis of potential seepage patterns and rates.

Sixteen test pits were excavated by backhoe to depths of about 5 m. Seven of the pits were located along the canal and conduit route, two at the pit rim dam abutments, one in the headworks reservoir and the remaining six in potential upstream borrow areas.

4.1 FOUNDATION INVESTIGATIONS - (Cont'd)

All of the site investigations were done under the direct supervision of Klohn Leonoff Consultants Ltd. and the testing of samples was done in their laboratories.

(c) Laboratory Test Results

Disturbed and Shelby tube samples were tested for specific gravity, gradation, Atterberg limits, compaction and direct shear. The test results are shown on Plates IA-5, IA-6 and IA-7 in Appendix IA.

The gradation tests indicate that the foundation material for the Hat Creek diversion structures varies from sandy gravel to clayey till to silts and clays. However, most of the material encountered is clayey sandy gravel or clay till with a fines content varying from 20 to 60 percent. Pockets of gravel and silts and clays were observed at various locations.

In general the liquid limit for the cohesive materials sampled varied from 40 to 70 and the plasticity index from 17 to 45. However, in test pits TP4 and TP5 near Medicine Creek, highly plastic clay was found with a liquid limit of 159 and a plasticity index of 122. The high liquid limit indicates that bentonitic material is present in the area.

Three compaction tests were carried out to determine the characteristics of the till material that would be excavated from the diversion works and its suitability for embankment construction. Till from test pits TP3 and TP5 with silt contents greater than 60 percent showed an optimum moisture content of about 20 percent and a maximum dry density of about 1.72 t/m^3. Till with a silt content of about 35 percent indicated an optimum moisture content of 9 percent and a maximum dry density of 2.17 t/m^3.

Four undrained direct shear tests were carried out on Shelby tube samples. The silty clayey till samples containing pea gravel showed a residual friction angle of about 30° with cohesion of zero. However, one sample containing larger gravel particles showed much higher shear strength.

The average specific gravity of all the test samples is about 1.72.

(d) Geotechnical Factors Affecting Design

Based on the information available and the results of the 1977 exploration program, the geotechnical factors affecting the design are as follows:

1. The hard and compact clayey till would be a good foundation material for the diversion canal and its embankment. However, in areas containing highly plastic and bentonitic clays the embankment should be designed to take some differential settlement. In areas containing pervious sand and gravel, the canal would have to be lined with an impervious material to minimize leakage which would have to be pumped from the pit rim dam or the mine pit.

2. The upper levels of the reservoirs for the headworks and pit rim dams would be generally in impervious till. However, the valley bottom consists primarily of alluvial material and some form of cutoff structure or blanket should be constructed to control leakage.

3. For the canal crossings over Ambusten and Medicine creeks where deep alluvial-type deposits occur, pervious non-impounding embankments would be preferred in order to

4.1 FOUNDATION INVESTIGATIONS - (Cont'd)

avoid foundation saturation with resultant stability and seepage problems.

4. Bentonitic material which is found in local pockets along the canal route should not be used for canal lining material as it exhibits large volume changes upon wetting and drying.

5. Post glacial kettle lakes which exist between Finney and Anderson creeks may contain compressible deposits. The extent and characterisitics of these materials will require further examination to ensure a canal design for the Finney Creek diversion that will not be subject to bank slumping.

6. The contact between volcanic rock and siltstone at the left abutment of the headworks dam may contain faults or unconformities. Measures should be taken to prevent excessive seepage from the reservoir in this area.

4.2 CONSTRUCTION MATERIALS

(a) Canal Excavation

Along the 6.4 km Hat Creek diversion canal route, till-like materials occur generally in the portion south of Medicine Creek with sandy gravel materials predominating to the north.

In general, the southern till materials would be suitable for canal lining in the pervious areas to the north, while the excavated pervious sands and gravels could be used throughout for the canal embankment.

4.2 CONSTRUCTION MATERIALS - (Cont'd)

(b) Mine Pit Surficials and Wastes

The mining consultant, Cominco Monenco Joint Venture, has indicated that surficial materials from required pit excavation would contain large quantities of suitable impervious till and sands and gravels. The materials would be delivered at no cost to the vicinity of lower Medicine Creek where a waste dump is required.

(c) Borrow Areas

In the unlikely event that suitable construction materials for the diversion works are not available in sufficient quantity and at the required time from the mine pit, a few small borrow areas were investigated. As shown on Plates 4-1 and 4-2, they include:

(i) Borrow Area A

Borrow Area A is located on the right bank of lower Medicine Creek and contains a clay-rich till material. This material would be highly impervious and is suitable for the canal lining.

(ii) Borrow Areas B, C and D

These areas contain till materials with a silt content ranging from 20 to 60 percent.

(iii) Borrow Area E

This is a sand and gravel deposit presently containing a small gravel pit near the road to Upper Hat Creek. It is a good source of clean gravel that is fairly well graded with a silt content less than 5 percent. However, the source is some 7 to 10 km south of the diversion works.

4.2 CONSTRUCTION MATERIALS - (Cont'd)

(iv) Borrow Area F

This area which lies within the early excavation stages of Pit No. 1 contains vast sources of sand and gravel. If not available as pit wastes at the Medicine Creek dump, sands and gravels could be obtained directly from Area F.

(v) Borrow Area G

This borrow area, on the east side of Hat Creek about 1.5 km downstream of Medicine Creek, should be a good source of impervious till but requires further investigation.

Laboratory analyses of samples from Borrow Areas A, F and G are presented in Appendix 1A.

SECTION 5.0 - HYDROLOGY

5.1 STREAMFLOW CHARACTERISTICS

The hydrologic regime of the entire Hat Creek basin is relatively uniform, characterized by high snowmelt spring freshets with flood peaks normally occurring in May or June, and a rapidly declining flow during the summer. Fall and winter flows are generally low.

Average annual discharge at the mouth of Hat Creek is approximately 0.83 m^3/s. The distribution of monthly flows is shown on Plate 5-1.

5.2 HYDROLOGICAL AND METEOROLOGICAL RECORDS

(a) Hydrometric Data

Streamflow records on Hat Creek are available from the Water Survey of Canada at the following stream gauging stations:

Station Designation	Station Name	Drainage Area Above Station (sq km)	Period of Record
08LF013	Hat Creek near Ashcroft	73	1911 to 1922*
08LF015	Hat Creek near Cache Creek	666	1911 to 1913* and 1961 to 1973
08LF061	Hat Creek near Upper Hat Creek	350	1961 to 1976

The locations of these stations are shown on the Key Map of Plate 2-1.

* Seasonal data only.

5.2 HYDROLOGICAL AND METEOROLOGICAL RECORDS - (Cont'd)

A summary of the monthly average flows for Station 08LF061, which is nearest to the point of which Hat Creek would be diverted, is presented in Table 5-1.

Published flow data are also available at nine other stream-gauging stations which were selected for regional analysis. The names of these stations and their periods of record are tabulated in Table 5-2.

No data are available on tributaries of Hat Creek at this time. Four streamflow gauges were installed in the spring of 1977 on Medicine Creek (2), Ambusten Creek and Anderson Creek, but no data have yet been published by the Water Survey of Canada.

(b) Meteorologic Data

Only one meteorologic station is presently maintained by the Atmospheric Environment Service in the middle of Hat Creek valley. Daily precipitation, rainfall, snowfall and temperature data have been recorded since 1961 and are summarized in Table 2-1. However, short duration rainstorm data have not been collected.

The seasonal distribution of mean monthly precipitation based on the Canadian Normals, 1941-1970, is shown on Plate 5-2.

5.3 WATER BALANCE

The long-term mean annual total precipitation based on the Canadian Normals, 1941-1970, for the Hat Creek valley is 317 mm.* The

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* Differs from the 300 mm shown on Table 2-1 because different periods are represented. The Canadian Normals are derived in part from correlations with adjacent stations.

5.3 WATER BALANCE - (Cont'd)

mean annual runoff volume observed at the stream gauging station "Hat Creek near Upper Hat Creek" is 2100 ha-m or 62 mm over the 350 km^2 drainage area, representing an average evapo-transpiration loss of 255 mm. Potential evapo-transpiration losses, however, are in the order of twice this amount.

5.4 FLOOD FREQUENCY STUDIES

As discussed in Sub-section 3.1, the design of the main Hat Creek diversion facilities was to be based on provision of sufficient capacity to divert a 100-year return period flood as a normal operational condition, and a 1000-year return period flood as an emergency condition. For the Finney Creek diversion, a 1000-year return period was also selected as an emergency condition with minimum canal freeboard.

Examination of the flow records at Station 08LF061, which is near the Hat Creek diversion point, indicated that for its 350 km^2 drainage area, spring snowmelt floods clearly would be the most significant. However, for the Finney Creek diversion which has a drainage area of only about 13 km^2 with a very steep gradient, it appears that short duration rainstorm-produced floods could be more severe. Flood frequency studies were therefore carried out to enable prediction of both snowmelt and rainstorm-produced floods with return periods of up to 1000 years.

(a) Regional Analysis of Snowmelt Floods

The three stream gauging stations on Hat Creek provide only 15 years of runoff data. The relatively short period of records is not sufficient for a meaningful frequency analysis.

5.4 FLOOD FREQUENCY STUDIES - (Cont'd)

Comparison of flood peak data between Stations 08LF015 and 08LF061 on Hat Creek indicates that the annual maximum daily flows at the upstream station were higher than those at the downstream station for 7 of the 12 years in which concurrent records were published. First it was thought that the anomaly might have been caused by the consumptive use of irrigation waters between the two gauges. However, examination of water licence distribution indicates that the amount of irrigation water licenced between the two gauges is less than 15 percent of the total volume licenced in the Hat Creek valley. Therefore it is unlikely that the discrepancies in the annual flood peaks could be attributed solely to irrigation withdrawals.

It has been reported that streamflow records of these gauges were based on once-a-day staff gauge readings by local observers. For a drainage basin the size of Hat Creek, where significant variations in flows can occur within hours, it is probable that some of the flood peaks may have been missed by the observers. The Water Survey of Canada has been requested to replace the manual gauge at Station 08LF061, Hat Creek near Upper Hat Creek, with an automatic recorder.

For the above reasons, it was decided that the flood frequency analysis should be based on a regional approach using data from nearby gauged basins having similar hydrologic characteristics.

The regional frequency analysis was conducted in accordance with the standard procedures developed by the U.S. Geological Survey. Dimensionless flood peak and flood volume frequency curves were derived for the Hat Creek region and are shown on Plate 5-3.

5.4 FLOOD FREQUENCY STUDIES - (Cont'd)

(i) Flood Peaks

A curve was developed relating mean annual flood peaks of the gauged basins used in the regional analysis to their corresponding drainage areas. Due to the shortage of data, an envelope curve was used instead of a trend line. This relationship was used in conjunction with the dimensionless regional flood peak frequency curve to produce flood peak frequency curves for the Hat Creek mainstream and a number of tributaries such as Medicine Creek, Ambusten Creek, Finney Creek and Harry Creek. The resulting frequency curves are shown on Plates 5-4 and 5-5. Flood peaks obtained from these curves and those presented in reports on previous studies by other consultants are listed in Table 5-3 for comparison.

(ii) Flood Volumes

The flood volume frequency curve for Hat Creek near Upper Hat Creek (Plate 5-6) was derived from a correlation between flood volumes and flood peaks. The annual flood volume was computed by summing the daily flows over the flood period. A regression analysis was made of the flood volume data and their corresponding peaks from the three stream gauging stations on Hat Creek. An excellent correlation was obtained with a coefficient of determination greater than 0.90. Since the prediction of flood volumes upstream of the mine pit is of most concern, the regression line was shifted to better fit the data points representing larger floods at Station 08LF061 near Upper Hat Creek. The resulting correlation equation is;

$$V = 2.834\ P^{0.852}$$

where V is the annual flood volume in millions of cubic metres and

P is the annual flood peak in cubic metres per second.

The flood volume frequency curve shown on Plate 5-6 will yield more conservative estimates of flood volume for larger floods than those derived from the regional flood volume frequency curve.

(b) Rainstorm Floods

(i) Analysis of Rainfall Data

The distribution of daily flows at the mainstem stations on Hat Creek indicates that rainstorm flood peaks can occur in summer but do not reach the magnitude of snowmelt floods. However, in small sub-basins or tributaries the rain-caused peaks could conceivably be greater than the spring freshet flows.

Fifteen years of published daily precipitation records from 1962 to 1976 observed at the Hat Creek meteorological station were analyzed. The monthly total rainfalls and greatest 24-hour rainfalls for the four summer months from June to September over the period of record are tabulated in Table 5-4. The maximum recorded monthly total rainfall is 113.3 mm and the greatest 24-hour rainfall is 38.9 mm.

5.4 FLOOD FREQUENCY STUDIES - (Cont'd)

A log-normal frequency distribution of the maximum monthly total rainfall is shown on Plate 5-7. A similar plot for the greatest rainfall in 24 hours based on results from the report by Beak Consultants Ltd. et al is also shown on Plate 5-7.

(ii) Rainstorm Flood Peaks

The response of Hat Creek runoff to rainstorms and the frequency distribution of rainfall intensity-duration had been investigated by Dr. Kellerhals in the study by Beak Consultants Ltd. et al. In the absence of additional data, the results presented in their report have been adopted for estimating rainstorm floods.

In an attempt to correlate the maximum daily discharge caused by a rainstorm as recorded at the Upper Hat Creek gauge (Sta 08LF061) with the greatest 24-hour rainfall contributing to the peak as observed at the Hat Creek meteorological station, Dr. Kellerhals found the daily rainstorm flood peaks in summer and fall to vary between 1 percent and 3.5 percent of the greatest 24-hour rainfall. Since very limited data were available for Dr. Kellerhals' analysis, a safety factor of two was incorporated in the derivation of the rainstorm flood peak frequency curve for the Hat Creek basin as shown on Plate 5-8. Since the rainfall data are based on daily observations the flood peak frequency curve given on Plate 5-8 should only be applied to drainage basins having a lag time of 24 hours or longer. It would not be applicable to the small tributary creeks within the Hat Creek basin.

5.4 FLOOD FREQUENCY STUDIES - (Cont'd)

The flood peak frequency curve for short duration rainstorms was derived on the basis of an empirical formula developed by the U.S. Soil Conservation Service basing the flood peak on drainage area, rainfall excess and the time to peak. The rainfall excess data were estimated on the basis of rainfall-runoff analyses made by Dr. Kellerhals and increased by a safety factor of two. The resulting design curves for 10-year, 100-year and 1000-year return periods are shown on Plate 5-9.

5.5 PROBABLE MAXIMUM FLOODS

The probable maximum flood was derived for Hat Creek near Upper Hat Creek by Monenco Consultants Pacific Limited in their Hat Creek Diversion Study using maximized meteorological conditions with a simulated watershed model. A similar analysis by a simplified method was used by HEDD to obtain an order-of-magnitude estimate for comparison.

The method used was based on the generalized frequency distribution proposed by V.T. Chow* and modified for the probable maximum condition using a method similar to that adopted by Hershfield** for maximum 24-hour rainfall. In this analysis the probable maximum values were expressed in terms of mean values which were increased by a factor consisting of the coefficient of variation multiplied by a constant. Based on probable maximum flood data from the Peace River and Columbia River projects, envelope values of the above constant were determined

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* Chow, V.T., "A General Formula for Hydrologic Frequency Analysis", Transactions, Amer. Geophysical Union, Vol. 32, 1951, p 231.

** Hershfield, D.M., "Estimating the Probable Maximum Precipitation", Journal of Hydr. Div. ASCE, Sept. 1961, pp. 99-116.

5.5 PROBABLE MAXIMUM FLOODS - (Cont'd)

as 18 and 10 for probable maximum flood peaks and flood volume respectively in the Provincial Power Study carried out by the B.C. Energy Board in 1972.

By this approach the probable maximum flood peak for Hat Creek near Upper Hat Creek was estimated to be about 74.5 m^3/s as compared to 105.7 m^3/s derived by Monenco. Similarly, a flood volume of 79 million m^3 was obtained compared to Monenco's 308 million m^3. It should be noted that the Monenco flood volume figure represents the annual total flow volume as compared to the volume during the flood period used in the present study. Although Monenco's estimates appear to be too high, in the absence of a better analysis, they were adopted for the main stem of Hat Creek in the present study.

In order to estimate probable maximum flood peaks for subbasins and tributaries, a graph relating drainage area to the extreme maximum daily flows as presented in the Beak Consultants Ltd. report was utilized. In this graph the extreme maximum daily flows observed from 85 basins in the Southern Interior Plateau of B.C. were plotted against drainage areas. The probable maximum flood peak derived for Hat Creek falls onto the envelope curve of these plots. The design curve adopted for estimating probable maximum flood peaks as shown on Plate 5-10 was obtained by adjusting the slope of the envelope curve parallel to the curve best fitting the data points relating to the Hat Creek basin. This curve was used for selecting the design flows for the runoff canals surrounding the ash disposal reservoir in Medicine Creek.

5.6 RECOMMENDED DESIGN FLOODS

(a) General

Snowmelt and rainstorm flood frequency curves have been developed for both the Hat Creek main stem and tributaries based

5.6 RECOMMENDED DESIGN FLOODS - (Cont'd)

on limited data and relatively short periods of record. Although frequency curves have been extrapolated to a return period of 1000 years, the estimated values for recurrence intervals greater than 100 years should be used with caution.

(b) Diversion Headworks and Canal

The Water Survey of Canada stream gauging Sta 08LF061, Hat Creek near Upper Hat Creek, is located in the vicinity of the proposed diversion headworks. Therefore, despite the minor effects of Finney Creek and Medicine Creek modifications, the data derived for that gauge can be used directly for estimating design floods for the diversion structures (Plates 5-4, 5-6 and 5-8).

The design capacity for the canal and intakes may be estimated from the appropriate curve given in Plate 5-4. The spillway should be designed to pass the probable maximum flood peak of 106 m^3/s less the diversion capacity of 27 m^3/s or a net peak of 79 m^3/s.

(c) Pit Rim Dam

The spillway at the pit rim dam should be designed for the same capacity as the headworks spillway. Since about 24.5 ha-m of storage capacity is available upstream of the dam, the pumping capacity could be determined on the basis of maximum monthly total runoff volume from rainfall. The runoff volume may be conservatively assumed to be about 20 percent of the total rainfall input.

(d) Tributaries and Sub-basins

Design capacities of structures required to divert or regulate the tributary and sub-basin flows may be estimated from the appropriate curves provided on Plates 5-5, 5-8, 5-9 and 5-10.

5.6 RECOMMENDED DESIGN FLOODS - (Cont'd)

A summary of adopted design discharge capacities is presented in Table 5-5.

SECTION 6.0 - HAT CREEK DIVERSION

6.1 DIVERSION ALTERNATIVES

(a) Previous Studies

In Monenco's Hat Creek diversion study report a wide variety of diversion schemes were investigated including:

1. Gravity schemes with flow via canal, conduit, tunnel or flume. Their report also included schemes with reduced diversion capacities afforded by provision of upstream storage.

2. Pumping schemes with upstream storage.

3. A brief investigation of one possible scheme incorporating water supply to the thermal plant. Because of a much reduced pumping head compared to the main Thompson River source, supply of water from Hat Creek would result in significant energy savings.

Excluding the water supply scheme which was identified as requiring further study, Monenco's report conclusively determined that the most economic scheme was that of gravity diversion via an earth lined canal. The second and third ranking schemes, considering not only costs but engineering and environmental factors as well, were indicated to cost almost twice as much as the canal scheme. The chief disadvantage of the canal scheme as identified by Monenco was the need to replace, by tunnel, a short central portion of the canal after an estimated 26 years of operation because the expanding mine pit would encroach on the canal route. The present worth of this tunnel was included in their overall cost estimate.

6.1 DIVERSION ALTERNATIVES - (Cont'd)

No definitive cost estimates of the water supply scheme or evaluations of its energy benefits were provided in the Monenco report. Further study of the scheme, however, was strongly recommended.

As a result of the very extensive work by Monenco it was quite evident that subsequent preliminary design could be confined to two basic schemes comprising either a water supply arrangement or simply a refinement of the canal diversion scheme proposed by Monenco.

(b) Modified Water Supply Scheme

The water supply scheme has been ruled out on the basis of poor water quality and the high cost of remedial water treatment. However, it is felt that a description of the modified water supply scheme developed during the HEDD studies is warranted on the basis that future developments in the plant water requirements or in treatment processes may alter some of the factors involved in the conclusion to abandon this scheme.

The water supply scheme developed by HEDD differed significantly from the arrangement shown in the Monenco report. With the Monenco scheme the water supply components were combined with an all pumping diversion arrangement having some 1776 ha-m of storage in three reservoirs and 1.42 m^3/s of pumping capacity which would have served both the plant supply system and the diversion system under a static pumping head of 488 m. Such a scheme would have been somewhat costly to operate due to the pumping of the diversion water through the same high head as the plant water supply, and dissipating most of the input energy in the control valve governing the flow through the diversion works back to Hat Creek. Monenco estimated that a mean flow of about 0.42 m^3/s would have been available for plant water supply.

6.1 DIVERSION ALTERNATIVES - (Cont'd)

Between July and September 1977 the Hydroelectric Design Division prepared preliminary designs and cost estimates for a modified water supply scheme that, allowing for downstream flow requirements and the spillage that would occur in years of very high runoff, would have enabled provision of a long-term average of 0.43 m^3/s from Hat Creek to augment the Thompson River supply. Since, in very dry years, there would be periods during which no plant water could be supplied from Hat Creek, reduction in the capacity of the Thompson River water supply pipeline would not be possible. However, because the Hat Creek supply system would involve a static lift of only 427 m compared to 1083 m with the Thompson River system, use of Hat Creek water whenever possible as a substitute for Thompson River water would result in very substantial energy benefits.

The water supply diversion scheme developed by HEDD comprised basically the same gravity arrangement of headworks dam - diversion canal - discharge conduit as is finally proposed in this report (see Plate 6-1) except that an upstream storage dam was provided which would provide the regulation necessary for water supply and, in turn, would enable a major reduction in diversion canal capacity. A 4.8 km long pipeline with a maximum capacity of 0.57 m^3/s would be constructed between a pumphouse located at the downstream end of the diversion canal and the main water supply reservoir near the thermal plant.

Mass curves were prepared for the period 1963 to 1976 to determine long term average water availability relative to plant water supply. Analysis of these mass curves was made on the basis of the following assumptions:

6.1 DIVERSION ALTERNATIVES - (Cont'd)

1. A reservoir would be provided at Storage Damsite No. 2 with a live storage volume of 1360 ha-m.

2. A diversion canal with a capacity of approximately 3 m^3/s would be provided. This capacity was selected on the basis of the storage/discharge relationships given in the Monenco report. (Design flood criteria subsequently adopted would have required an operational capacity of approximately 5 m^3/s.).

3. A water supply pipeline with a maximum capacity of 0.57 m^3/s would be provided.

4. Any storage volume from the proceeding year's runoff that remained on 1 April would be spilled to provide storage capacity for the coming year's runoff.

5. Downstream releases equivalent to an annual average of 0.23 m^3/s for fishery and agricultural needs would be made.

The analysis showed that for the 13-year period 1 April 1963 to 1 April 1976, the average pumping rate to the plant reservoir would be 0.43 m^3/s. The number of months per year of pumping at full capacity, based on that period, varied from a low of 2.8 months in the dry year of 1970/71 to a full 12 months in the extremely wet year of 1964/65.

The water supply facilities developed for this study comprised the following:

1. A reinforced concrete pumphouse located at the downstream end of the diversion canal containing two 2500 hp, 9-stage

6.1 DIVERSION ALTERNATIVES - (Cont'd)

vertical turbine pumps operating under a maximum total dynamic head of 518 m. Two travelling water screens would also have been provided.

2. A buried pipeline 4.8 km long consisting of some 3960 m of 500 mm steel pipe between the pumphouse and the divide at El. 1402 (about 700 m west of the water supply reservoir) and about 730 m of 750 mm buried, free-flow culvert between the divide and the reservoir. The pipeline alignment would have followed a direct route between the pumphouse and reservoir, generally along the route of the main project access road as shown on Plate 2-1.

The storage reservoir at Damsite No. 2 would have had a crest level of El. 1055, a crest length of about 365 m and a maximum height of approximately 30 m. Earthfill totalling nearly 400 000 m^3 would have been required. Allowances were made in the cost estimates also for a slurry trench cutoff to control seepage through the foundations, an outlet works with a capacity of up to 3 m^3/s and a spillway capable of discharging the probable maximum flood. The storage and regulation afforded by this dam would have permitted a significant reduction in the capacity and cost of the main Hat Creek diversion works.

The combined costs of the pumphouse, pipeline and storage dam less the savings in the Hat Creek diversion works were estimated to have a present worth, at September 1977 price levels, of $3.96 million. Costs considered in the present worth evaluation included contingency allowances, engineering, escalation at 5 percent, and interest during construction at 10 percent. A discount rate of 10 percent was used for present worthing.

6.1 DIVERSION ALTERNATIVES - (Cont'd)

The present worth of the energy benefits of the water supply scheme was based on a net difference in the total dynamic heads of the Thompson River and Hat Creek sources of 760 m and an overall efficiency of 80 percent. The evaluation was made using a September 1977 energy value of 20 mills per kWh, escalation at 5 percent and a present worth discount rate of 10 percent. For the 35-year project life, the September 1977 present worth of the energy benefits was found to be $8.67 million resulting in an overall benefit/cost ratio of 2.2.

Subsequent to these studies the downstream release requirements were increased from the annual average of 0.23 m^3/s to the 0.29 m^3/s discussed in Sub-section 2.4. Before the effects of this minor increase in downstream flow requirements could be assessed and before studies could be carried out to optimize the sizes and capacities of the water supply, diversion and storage dam facilities, HEDD was instructed to terminate studies of the water supply scheme. This decision was made primarily on the basis of the poor quality of the Hat Creek water.

(c) Peak Flow Attenuation with Upstream Storage

In Monenco's report it was shown that with upstream storage on Hat Creek, the design capacities for the diversion works could be significantly reduced. With the flows from Finney Creek included in the diversion discharge, Monenco indicated the following relationship between upstream storage volume and design discharge for the diversion works:

Storage Volume* ha-m	Diversion Capacity m^3/s
617	5.66
1258	2.83
1776	1.42

* The storage volume was based on the 1964 flood hydrograph, considered by Monenco to be representative of a flood having a 100-year return period.

6.1 DIVERSION ALTERNATIVES - (Cont'd)

Storage requirements based on the HEDD hydrologic studies indicated that, for the 5.66 m^3/s design discharge shown above, 100-year and 1000-year hydrographs would require upstream storage volumes in the order of 1200 and 2350 ha-m respectively, considerably higher than the volume indicated by Monenco.

Since, as discussed in Sub-section 3.1(a), the HEDD preliminary design is based on an emergency canal capability equivalent to the 1000-year flood, assessments of the costs and benefits of upstream storage were made using the derived 1000-year flood hydrograph. To reduce the emergency design capacity of 27 m^3/s by 50 percent or more the costs would have exceeded the benefits by factors of about 4.3 to 5.0. It is apparent, therefore, that peak attenuation with upstream storage is uneconomic for a canal diversion scheme with no water supply facilities.

6.2 PROPOSED DIVERSION ARRANGEMENT

(a) General Description

The proposed Hat Creek diversion arrangement, as shown on Plate 6-1, comprises a headworks dam with a canal intake and emergency spillway immediately downstream of Anderson Creek; approximately 6.4 km of canal on the east side of the valley at about El. 975; some 1.9 km of buried conduit with intake and outlet works to convey the flow back down to Hat Creek, and a pit rim dam, spillway, pumphouse and pipeline between the headworks dam and mine pit to intercept seepage and local inflows immediately upstream of the pit.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

The diversion works have been sized to accommodate, as a normal operating condition, a flow of 18 m^3/s and, as an emergency condition, a flow of 27 m^3/s. For protection of the headworks and pit rim dams, emergency spillways capable of discharging 79 m^3/s into the present Hat Creek watercourse are provided. Their capacity is equivalent to the difference between the emergency canal capability of 27 m^3/s and the probable maximum flood peak of 106 m^3/s.

(b) Headworks Dam

The location of the headworks dam is dependent on the canal elevation which has been set generally as high as possible to minimize infringement by the eventual mine pit boundary and at the same time to lie below the steep colluvial slopes in the vicinity of Medicine Creek. As shown on the drawings this level occurs generally at about El. 975. The headworks dam, shown in detail on Plate 6-2, is situated immediately downstream of Anderson Creek where the right bank of Hat Creek extends prominently into the lower valley, creating a desirable site in terms of earthfill quantity. A higher dam located further downstream to shorten the canal route was found to be uneconomic.

The dam, with its crest at El. 978, would have an overall length of about 230 m and a maximum height of about 16 m. The reservoir level would vary from a minimum of about El. 973.5 during periods of low flow in late summer and fall to a maximum of El. 976.6 during passage of the 1000-year design discharge of 27 m^3/s during the period of snowmelt runoff. After eroding the earthfill fuse plug in the spillway, the PMF discharge of 106 m^3/s through the canal and spillway would be passed with the same maximum reservoir level of El. 976.6.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

The headworks reservoir would have a total volume of 28.4 ha-m at maximum reservoir level and an active storage volume of about 15.4 ha-m. At its maximum level the reservoir would occupy a total area of 6.1 ha, all of which would be confined within the narrow, undeveloped portion of the lower valley.

The central portion of the headworks embankment would be founded on alluvial material about 25 m in depth and the abutments on 2 to 4 m of sand and gravel overlying 15 m of dense till which in turn overlies bedrock. The alluvial material consists of sand and gravel interbedded with sandy clays. Drill Holes P77-56 and 56A showed perched ground water tables in the foundation strata. Falling head tests in the alluvial material indicated that the permeability coefficient ranges from 10^{-4} to 10^{-5} cm/sec. Direct shear tests on Shelby tube samples of till gave a residual friction angle of about 30°.

Two embankment designs were investigated for the headworks dam, one incorporating a slurry trench cutoff and the second utilizing an upstream blanket of impervious till to control seepage. Because of the considerable depth of alluvium above bedrock and the necessity to flatten some areas of the reservoir shoreline for stability, the blanket scheme was selected. The blanket would extend about 100 m upstream from the toe of the dam with a thickness decreasing from 2 to 0.6 m.

The proposed dam section would have a 3:1 upstream slope and a 2.5:1 downstream slope. A wide vertical central core would have a base width approximately equal to the water depth. Free draining sand and gravel would be used for both the upstream and downstream shell zones. Both slopes would be protected with rip-rap.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

The natural slopes in the upper reservoir area are generally flat and should remain stable upon reservoir filling. However, slopes near the left abutment of the dam are relatively steep (up to 1:1) and will have to be flattened to ensure stability under reservoir operating conditions. The excavated till from the left abutment area could be used as a source of impervious blanket material.

The Dominion Observatory in Victoria has recently carried out a seismicity study of the Hat Creek area based on a statistical analysis of earthquakes recorded since 1899. Golder Associates have presented a copy of the original study in their 1977 report, Item 8 in Sub-section 1.3(a).

This study indicates that an earthquake of Modified Mercalli Intensity V has a probability of being felt once every 100 years at the site. Such an earthquake would cause a maximum ground particle acceleration of 0.02 g (2 percent of the acceleration due to gravity) in firm soils such as the local tills and moraine. A ground particle acceleration of 0.10 g has a probability of occurring approximately once in 1000 years. These statistics place the Hat Creek area in Zone 1 of the Seismic Zoning Map of the National Building Code of Canada (1970).

All known and inferred faults at Hat Creek are considered inactive. The possibility of an earthquake originating due to movement along one of these faults is considered very remote.

Stability analyses by Bishop's method using the Lease II computer program and conservative assumptions indicate that both upstream and downstream slopes would have a factor of safety of above 1.5 for rapid drawdown and steady seepage conditions and about 1.1 for an earthquake loading of 0.1 g. The assumptions and results of the analyses are summarized in the following tables:

Shear Strength Parameters Assumed

Zone	Effective Friction Angle, Ø'	Cohesion C'
Core or clayey till in foundation	27^{o}	0*
Shells or sandy gravel in foundation	35^{o}	0

* For the construction case a cohesion value of 120 KN/m^2 for the clayey till foundation and a pore pressure ratio $r_u = 0.5$ for the core are assumed.

Results of Stability Analyses

Case	Minimum Factor of Safety	
	Static	With Earthquake of 0.1 g
Steady seepage U/S and D/S slopes	1.5	1.1
Rapid drawdown U/S slope	1.7	-
Construction	1.6	-

Based on the limited foundation data and permeability values available, preliminary calculations indicate that the seepage through the pervious foundation would be about 50 to 100 L/s without a cutoff or blanket. The seepage quantity would be reduced to about one-fifth with the proposed blanket.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

The earthfill materials for the dam would be available in abundant quantities from sources no further than 5 km from the damsite: the core material most probably from selected waste till from the canal excavation or the mine pit surficials, and the sand and gravel shell materials from the east side of the valley where gravel pits are currently developed. It has been indicated by the mining consultant that competent material from pit surficial excavation, including till, sand and gravels would be available at no cost as mine wastes in the vicinity of the lower portion of Medicine Creek (Coord: 5,623,450 N, 600,895 E) 3 km from the damsite.

Since construction of the headworks dam does not involve major fill quantities (about 65 000 m^3 total required) it is evident that the final phases of work and closure of the dam can be deferred until the yearly snowmelt flood has receded to a comparative small discharge. On the basis of the criteria described in Sub-section 3.2(a) a diversion capacity during construction of 1.7 m^3/s has been used for design. The Hat Creek flows would be passed through the damsite area via a 1.0 m square reinforced concrete box culvert until completion of the entire Hat Creek diversion works. Once the diversion canal became operational, the culvert would be closed with a concrete plug.

On the basis of suspended sediment values given in the report by Beak Consultants Ltd., Item 11 in Sub-section 1.3(a), sedimentation of the headworks reservoir would not be a concern. The inactive storage capacity is sufficient for well over 100 years of sediment accumulation.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

(c) Emergency Spillway

The emergency spillway, as shown on Plate 6-2, would be located on the right abutment between the earthfill dam and diversion canal intake. It would comprise a reinforced concrete baffled chute having a width of 17 m and an overall length including the approach apron of about 55 m. The total drop through the spillway would be about 12 or 13 m. Although most of the energy of the spillway discharge would be dissipated within the chute, a riprap apron would be necessary adjacent to the chute outlet to prevent erosion of the embankment toe or of the right abutment.

An erodible earthfill plug would be placed on the approach apron with a crest level of El. 976.6, equal to the reservoir level which would occur with discharge of the 1000-year flood through the canal. The spillway would thus become operational with any flow exceeding the 1000-year design discharge of 27 m^3/s. For the 100-year flow of 18 m^3/s, freeboard on the earthfill plug would be about 0.6 m.

Various alternatives to this spillway were examined including a conventional chute and stilling basin type spillway, protection of the crest and downstream face of the main embankment to permit a broad width of overtopping, and a simple chute and stilling basin constructed from rollcrete or soil-cement. These studies indicated that a rollcrete or soil-cement chute may be a more economical solution but, in the time available, sufficient data on actual prototype experience could not be assembled to prepare a reliable design and cost estimate. It is recommended, however, that further consideration be given to this alternative in the final design phase.

(d) Diversion Canal

(i) Canal Intake

The canal intake structure, located just to the east of the emergency spillway, would consist basically of a reinforced concrete box culvert having three conduits each 2.5 m wide by 3.0 m high (see Plate 6-2). Stoplogs would be provided to permit brief emergency closures for canal maintenance. The total live storage capacities of the headworks and pit rim dams could, if necessary, absorb a normal fall or winter Hat Creek discharge of 0.3 m^3/s for a period of up to 15 days. Under such conditions the tributary inflows of Ambusten and Medicine creeks would be small and could be handled within the canal.

(ii) Canal

The canal route and typical cross sections for the portion of canal between the headworks dam and Medicine Creek are shown on Plate 6-3, with the remaining portion downstream of Medicine Creek shown on Plate 6-4. The canal is located generally along the El. 975 contour because of topographic limitations and to minimize infringement into the mine pit area. That portion lying within the 35-year pit perimeter, shown on Plate 6-4, would of course have to be realigned or replaced by some other facility such as a conduit or tunnel to convey the water around the pit. Approximately 1400 m of the total 6375 m length of canal could be affected by the eventual 35-year pit excavation.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

Between the canal intake, Sta 0+000, and the south bank of Medicine Creek, Sta 2+800, the canal route is located on undulating till ground moraine having a number of minor drainage gulleys in addition to Ambusten Creek which has eroded the moraine to a depth of about 30 m at the canal crossing. The sidehill slopes in this 2.8 km section vary from 10:1 to as steep as 2:1 and, as indicated by the irregular profile, numerous areas requiring either large excavation or fill volumes occur. Although for the greatest part of this section the soils are till-like, some zones of pervious materials are indicated by the drill holes and test pits. Lining of the canal would be required in these pervious areas.

From Sta 2+800 at Medicine Creek to the conduit intake at Sta 6+375, the canal route is located generally in alluvial fan materials comprising sand, gravel and silt and, further downstream, in ground moraine containing mainly sands and gravels. As shown on the profile on Plate 6-4 the ground is less irregular in this area, particularly near the downstream end. Also, side hill slopes flatten generally from about 4:1 near Medicine Creek to 10:1 near the conduit intake. Although silty in some areas the soils are primarily pervious sands and gravels which, near the conduit intake, reach depths of up to 150 m. Because of the pervious nature of the soils and the canal's close proximity to and eventual interception by the mine pit, it is apparent that a highly impervious lining of the canal is required for this entire reach.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

From an examination of 10 alternative canal lining methods varying from rather simple impervious earthfill linings to costly shotcrete or concrete paving, four schemes were selected for more detailed examination; they comprised:

1. Rubber (1.14 mm Hypalon) lining covered with impervious till.

2. Sprayed asphalt covered with gravel.

3. Plastic sheeting covered with impervious till.

4. Impervious till.

On the basis of watertightness, durability and economics the last two were selected for the initial canal construction with the plastic sheeting to be used where a high level of security against canal leakage is mandatory. Following detailed examination of the canal route it was found that the impervious till lining alone could have been used for only a short length upstream of the pit rim dam where some seepage would be tolerable and it was therefore decided to use the plastic sheet wherever any lining was considered necessary.

The earth material for the lining would be a low plastic till containing from 20 to 40 percent silt and little or no bentonitic material.

The bentonitic materials found in one area along the canal and in abundant quantities on the west side of Hat Creek were studied at some length to assess their suitability for canal lining. Because of swelling and shrinkage characteristics when alternately wetted and dried, and because of uncertainties in the material's behaviour under severe frost conditions, the use of bentonite was ruled out.

The canal cross sections shown on the drawings were developed on the basis of the following considerations:

1. The canal should pass the 100-year discharge of 18 m^3/s with a freeboard of at least 1.0 m and the 1000-year discharge of 27 m^3/s with a freeboard of at least 0.5 m.

2. The canal velocities must be low enough to avoid erosion of the till lining materials.

3. The canal gradient must be flat enough to enable, via downstream control, raising the water level during winter to avoid icing problems that would otherwise occur with small, shallow flows.

4. The canal side slopes must be flat enough to avoid sloughing of the till from the plastic sheeting.

5. The invert width should be as narrow as possible to minimize the cross-sectional water area with low flows in the summer and fall months when water temperature rise in the canal would be a major environmental consideration.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

6. A berm should be provided on the uphill side of the canal to facilitate canal maintenance and compaction of lining materials and to enable the upper excavation slope to be steepened.

7. Some canal movement or differential settlement is expected in areas where bentonitic materials are encountered or where high canal embankments may be unavoidable. A canal lining combining both a plastic membrane and an impervious till lining is considered self-healing in terms of the movement anticipated in such areas.

The geometric and hydraulic characteristics selected for the canal are as follows:

Geometrical Characteristics

Length	6375 m
Depth	4.0 m
Invert width	1.2 m
Side slopes	2.5:1
Gross cross-sectional area	4.48 m^2
Gradient	0.02%
Upstream invert level	El. 973.1
Downstream invert level	El. 971.8

Hydraulic Characteristics

Assumed friction factor (Manning's n) 0.025

	Discharge - m^3/s				
	27	18	10	1	0.3
Return frequency, years	1000	100	10	-	-
Flow depth (m)	3.42	2.91	2.29	0.85	0.48
Freeboard (m)	0.58	1.09	1.71	3.15	3.52
Average velocity (m/s)	0.81	0.73	0.63	0.35	0.26

During the Monenco diversion study the development schedule of the mine pit was such that replacement of that portion of the canal within the 35-year pit outline would not have been required until after some 26 years of plant operation. The present worth of the future construction cost of about 1460 m of tunnel was included in their estimate of overall diversion costs.

On the basis of currently projected mine pit development it would be necessary to realign or replace some 1400 m of the canal after only about 12 years of plant operation. Considering the nature of the subsurface materials it is felt that, rather than tunnelling around the eventual pit outline, it would be more economical to simply realign the canal on the ultimate pit slope when the mine pit excavation approaches the intitial canal location. Because of uncertainties in the eventual pit outline and because large quantities of excavation would be required much earlier than necessary for the mine pit, initial alignment of the canal to match the ultimate pit slope is not considered practical. A high quality and secure lining would be essential for the realigned portion of the canal. A 1.14 mm Hypalon or equivalent rubber lining covered by 0.3 m of till has been assumed for the cost estimate.

Based on experience in the U.S. with irrigation canals, the seepage loss over the length of Hat Creek diversion canal with only an earth lining would probably be in the order of 30 to 75 liters/sec. However, with most of the canal lined with plastic sheeting, the proposed scheme should reduce the seepage to about one-third of the above values.

(iii) Creek Crossings

Arrangements for the two major canal crossings over Ambusten and Medicine creeks are shown on Plate 6-5. Because of the very steep banks of these deeply incised creeks and limitations in the minimum desirable canal radius, the embankments at these two crossings are of considerable size. Also, the earlier arrangements involving small sidehill canals to conduct the creek discharges into the main diversion canal have been found to be impractical.

At Ambusten and Medicine Creeks, the canal will cross alluvial deposits consisting of silty sands and gravels. At Medicine Creek the abutments are composed of till but in the valley bottom the deposits are sandy gravel interbedded with clayey sand. At Ambusten Creek a till cover occurs at the abutments, while gravelly sand and clayey till are present in the creek bed.

Two alternatives for the canal crossing at these two creeks were studied:

1. Build a water barrier at the crossing point to form a small reservoir on each tributary creek. The creeks and canal would meet at these reservoirs.

2. Fill each creek valley with semi-pervious to pervious sand and gravel to a height sufficient to

raise the creek bed to the level of the canal invert, construct a channel for the tributary creek and connect it to the canal, and provide an impervious lining for both the canal and creek channel in those portions of the alignment running through pervious sand and gravel.

Since the embankment sites at these creeks contain very deep deposits of various types of material, provision of a seepage cut-off would be complicated and expensive. Further, if the foundation and abutments were saturated by reservoir impoundment they may present stability problems and/or settlements that may in turn increase seepage through the embankments.

For the second alternative, provision of a gravel blanket drain in the creek fill to collect seepage would control groundwater levels in the fill and minimize potential stability problems in the abutments.

Because of the availability of excavated materials from the canal and free pit waste materials delivered to Medicine Creek, the concept of filling in the creek beds upstream of the primary embankments was adopted. Basically the crossings would comprise an embankment of free-draining spoil fill with 3:1 upstream and downstream slopes that would contain the main canal section. Upstream of these embankments the creek valleys would be filled with selected spoil materials creating a convenient surface in which to locate the tributary canals.

Since the costs of the tributary canals are not significantly affected by capacities ranging between the tributary flow and the Hat Creek diversion canal capacity, the tributary canals have been detailed with the same dimensions and with the same linings as the main Hat Creek canal. For added protection against saturation of the upstream spoil material, a free-draining blanket has been located beneath the tributary canals.

The maximum heights of the Ambusten and Medicine creek crossings measured from their downstream toes are approximately 24 m and 38 m respectively. As shown, the Hat Creek valley road would be located about midway up the downstream slope of the Medicine Creek crossing.

(e) Discharge Conduit

The arrangement of the discharge conduit is shown on Plate 6-6. From the end of the diversion canal, which would be expanded and deepened slightly to provide a sedimentation basin, the diversion flows would pass through a conduit intake structure and some 1930 m of buried conduit, then discharge into an energy dissipating outlet works and flow via a short length of excavated open channel back to Hat Creek. The overall drop from the canal to Hat Creek is about 155 m.

(i) Conduit Intake

The principal functions of the conduit intake are to accelerate the flow into the conduit, prevent the entry of debris and ice into the conduit, permit the control of water levels in the canal during winter and, in general, provide the hydraulic control necessary to maintain desirable velocities within the canal.

The conduit intake would be a reinforced concrete structure having an ogee overflow crest at El. 972.1. With a crest width of 2.4 m and no side contractions its hydraulic rating curve would match very closely the uniform flow depths in the canal throughout the full range of discharges. During winter periods of low flows, however, stoplogs would be installed on the crest to a level of approximately El. 973.7 to increase the canal flow depth enabling the formation of a protective ice cover throughout the canal. This ice cover would permit flow beneath it without the danger of ice build up that would otherwise likely occur with very shallow flow depth.

A concrete headwall would be constructed upstream to act as an ice skimmer. It is far enough upstream of the crest so that it would not impede the structure's flood discharge capability. The entire intake works would be enclosed to prevent ice formation at the overflow section. A trashrack would also be provided.

(ii) Conduit

The discharge conduit would comprise 1930 m of 2400 mm diameter galvanized corrugated steel pipe. From the conduit intake, Sta 0+000, to Sta 1+000 the buried conduit would be located generally between the pit haulage road and the pit maintenance and service area with the conduit some 60 to 70 m to the north of the road. From Sta 1+250 to Sta 1+550 the conduit would pass under the southern fringes of the coal blending and storage area.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

From the intake to Sta 1+450 the pipe gradient would be about 5.8 percent resulting in burial depths, to the pipe invert, of up to 20 m based on the original ground surface. Flow depth in the conduit with the 1000-year discharge of 27 m^3/s would be about 80 percent of the pipe diameter with a velocity of about 7 m/s.

From Sta 1+450 to the outlet works at Sta 1+960 the conduit would slope at about 12.1 percent with burial depths to the original ground surface again up to a maximum of 20 m. Flow depth in this section with the maximum 27 m^3/s discharge would be about 60 percent with a maximum velocity at the outlet of 9.5 m/s.

To withstand the high depths of burial in some areas and the earthfill that would be added for the storage and service area, and because of the passage of the conduit under roads subject to earth and coal hauling equipment with extremely high axle loads, the thickness of the multi-plate pipe required would range from 2.77 mm to 4.27 mm.

With the present conduit alignment the entire route would be in excavation, whereas with previously considered alignments some lengths would have been above the original ground surface with earthfill cover provided from waste excavation. With the present route, however, any waste excavation could probably be used for fill in the storage and servicing areas.

No problems should be encountered in terms of excavation and backfill as the entire route is located in an area dominated by sands and gravels.

To facilitate conduit inspection, manholes would be provided at intervals of about 300 m. As discussed in Sub-section 6.2(d), discharge could be suspended for brief periods when the natural inflows are low. If necessary to eliminate all flow from the conduit, small inflows into the canal downstream of the canal intake could be pumped or even channelled into Harry Creek (see Plate 6-6).

(iv) Outlet Works

The outlet works would comprise a reinforced concrete impact-type energy dissipator 9.5 m long and 7.0 m wide. From the outlet works to Hat Creek the diversion flows would be conveyed in a short earthfill channel about 2.5 m deep with an invert width of 7 m.

(f) Pit Rim Dam

The general location of the pit rim dam is shown on Plates 6-1 and 6-4. It is some 300 m downstream of the Medicine Creek confluence with Hat Creek and about 500 m upstream of the projected 35-year surface intercept of the mine pit.

Overall facilities at the pit rim dam comprise the earthfill dam, emergency spillway, and a pumphouse and pipeline to convey inflows up to the main Hat Creek diversion canal. Details of these facilities are shown on Plate 6-7.

(i) Dam

The pit rim dam is a comparatively small structure with a maximum height of only 13 m. The crest, at El. 917.5, is some 8 to 10 m below the tops of both abutments and has an overall length of about 200 m.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

With a maximum normal reservoir level of El. 914.6 the pit rim dam would have a total storage capacity of 25.9 ha-m. The live storage capacity above a minimum reservoir level of El. 909.0 would be 24.7 ha-m. The maximum flood level required to spill the emergency PMF discharge of 79 m^3/s to the pit would be El. 916.5, 1 m below the dam crest.

The dam would be founded on about 10 m of interbedded sandy gravel and clayey silt containing occasional cobbles and boulders. The results of in situ falling head tests indicate permeability coefficients for the foundation varying from 10^{-4} to 10^{-6} cm/sec.

The embankment would have a wide central impervious core and shells of free-draining sand and gravel. The upstream slope would be 3:1 and the downstream slope 2.5:1. Both slopes would be protected by rip-rap. The embankment materials most likely would be obtained from the mine pit excavations.

Since it is desirable to reduce seepage into the mine pit to avoid excessive pumping and to minimize pit wall stability problems resulting from high groundwater flows, the pit rim dam has been provided with a positive slurry trench cutoff extending to bedrock through the alluvium in the creek bed.

This slurry trench cutoff would be about 1.5 m wide and about 10 to 15 m deep. After excavation, the slurry in the trench would be replaced by glacial till. The cutoff would tie into till material at the left abutment. At the right abutment Test Pit TP9 indicated pervious sand and gravels and the cutoff trench has therefore been extended about 30 m into the creek bank.

The factors of safety for the embankment are about 1.5 for steady seepage and 1.2 for rapid drawdown. For earthquake loading of 0.1 g, the minimum calculated factor of safety is 1.2. The assumptions used in the analyses were the same as those adopted for the headworks dam, see Sub-section 6.2(b). The results of the analyses are shown in the following table:

Results of Stability Analyses

	Minimum Factor of Safety	
Case	Static	With Earthquake of 0.1 g
Steady seepage, U/S and D/S slopes	1.5	1.2
Rapid drawdown to bottom of reservoir	1.2	-
Construction	1.6	-

(ii) Emergency Spillway

Since the emergency spillway would have the same capacity as that for the headworks dam, its width and general properties would be exactly the same as described in Sub-section 6.2(c). However, because the dam is not as high, its overall length would be shorter. Also, no earthfill fuse plug would be required.

Because of the high abutments it was not possible to locate the spillway on original ground without an excessive amount of excavation. However, since the dam is not high, settlement would be of little significance to the spillway founded, as shown, on the embankment.

(iii) Pumphouse and Pipeline

A reinforced concrete pumphouse would be located near the right abutment immediately upstream of the pit rim dam. It would be of the deep well type housing two 75 hp, 5-stage, vertical shaft pumps which, operating together, would have a total capacity of about 120 L/s. Although this pumping capacity combined with the live storage available should be ample for anticipated storm and seepage inflows, provisions have been made in the pumphouse and in the size of pipeline selected to permit installation of a third pump, if necessary. The maximum static head of the system would be approximately 67 m. Operation would be automatic with reservoir level control.

The pipeline would comprise about 625 m of 250 mm steel pipe buried with a minimum cover of 1.5 m for frost protection. A reinforced concrete stilling box would be provided where the pipe would discharge into the canal. The pipeline route is shown on Plate 6-4.

6.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

(g) Access Roads

Because of the mine pit and diversion facilities, that portion of the Hat Creek valley road north of Medicine Creek would require relocation. As shown on Plates 6-1, 6-3 and 6-4, some 1.9 km of replacement road would be constructed from the main Hat Creek Project access road to a crossing over the canal at Sta 4+200. From this point south to another canal crossing at Sta 2+500, the original Hat Creek valley road would be used. In this area only minor relocation would be required, including the crossing over Medicine Creek on the canal embankment and some 450 m of realignment to maintain acceptable road grades.

Access to the headworks dam would be provided on the canal embankment which would provide, as well, access along the entire canal length.

About 1 km of new access road would be constructed to the pit rim dam from the Hat Creek valley road in the vicinity of Medicine Creek. The route of this access road is shown on Plate 6-4.

Access to the conduit intake would be provided by some 300 m of road connecting directly with the main project access road.

6.3 OPERATION AND MAINTENANCE

In general, the Hat Creek diversion works have been designed with the intention of minimizing the need for manual operation of any of the facilities. Apart from the annual installation and removal of the stoplogs in the conduit intake at the downstream end of the

6.3 OPERATION AND MAINTENANCE - (Cont'd)

diversion canal related to water flow conditions, no specific operational procedures would be necessary. Regular maintenance would be required only for the pit rim pumping equipment.

However, in view of the importance of assuring the stability of the mine pit slopes, it would be necessary to have a network of seepage and earth movement monitoring equipment installed within and adjacent to the dams and diversion canal. A program of regular monitoring and analysis of the results would be essential.

For monitoring the performance of the headworks dam and the pit rim dam, about 10 piezometers for each should be installed in the embankments and in their foundations. A dozen displacement markers would also be required for monitoring the movement of the structures.

For the canal embankments, 6 piezometers and several displacement markers would be installed.

Although most sedimentation would take place in the headworks reservoir, some annual maintenance may be necessary after the run-off peak to remove sediment or other debris carried into the canal by Ambusten and Medicine creeks.

6.4 ENVIRONMENTAL IMPACTS

Although other minor impacts have been identified by the environmental consultants, the only significant impact that could have a substantial bearing on the arrangement and costs of the diversion works is the increase in water temperatures in the canal during low flow periods in the late summer and fall.

6.4 ENVIRONMENTAL IMPACTS - (Cont'd)

Studies conducted by Monenco during their diversion study indicated a temperature rise of as much as 8°C on the basis of what was considered a "worst case" in terms of discharge (0.71 m^3/s) and meteorologic conditions. Very recent studies by HEDD using the canal geometry proposed in this report and a reduced flow of only 0.28 m^3/s, considered more representative of late summer discharge, have indicated a possible water temperature rise in passing through the canal of as much as 12°C.

This preliminary estimate by HEDD of the possible rise in water temperature was based on the dynamic process of heat exchange at the surface of the water using a simplified energy equation.

The computation was based on an average August flow of 0.28 m^3/s with an assumed ambient air temperature of 32°C and zero cloud cover. Other weather conditions assumed in the analysis included:

Relative humidity	-	20 percent
Wind Speed	-	37 km/hr
Air pressure	-	102.5 kPa
Net solar radiation	-	312 joules/hr/cm^2

The temperature of water entering the canal was assumed to be 12°C. The resulting water temperature at the downstream end of the canal was estimated to be about 24°C, a net rise of 12°C.

The only apparent method of preventing this impact would involve provision of a buried pipe that would convey all flows up to about 0.5 m^3/s during the critical period. Since this would involve as much as $1.7 million in additional costs, it is felt that a detailed study of this problem from both engineering and biological points of view, including an economic evaluation of the fishery foregone within the lower part of Hat Creek, should be carried out before such a conveyance scheme is incorporated into the diversion works.

SECTION 7.0 - FINNEY CREEK DIVERSION

7.1 PREVIOUS STUDIES

Previous study of the diversion of Finney Creek was made in connection with Monenco's diversion study report. However, detail provided in their report was limited to an estimate of ditching cost based on a capacity of 0.85 m^3/s. The basis for this capacity and its recurrence interval were undefined.

The requirements for the diversion of Finney Creek as defined in this HEDD report are considerably more extensive, primarily as a result of increased flow capacity. A rainstorm-produced flood with a recurrence interval of 1000 years has been adopted and it has been assumed that Finney Lake would be drained, thereby eliminating the flow regulation it currently provides.

7.2 PROPOSED DIVERSION ARRANGEMENT

(a) General Description

At the present time Finney Creek drains a basin area of about 13 km^2 extending from Hat Creek at about El. 900 up to El. 1965 over a distance of about 9 km. At about El. 1180 Finney Creek flows into Finney Lake (see Plate 2-1) which serves as a storage reservoir with releases regulated for agricultural purposes. The area of Finney Lake is about 17 ha. However, the depth over which it is regulated and its live storage capacity are unknown.

Below Finney Lake the creek appears to have been split into numerous diversion ditches to the extent that the principal creek channel cannot be identified on existing topography. However, it appears that if, as shown on Plate 7-1, the diversion canal is started near the north end of the existing airstrip, all or at least most of the agricultural ditches will be intercepted. It should be noted also that since the Finney Creek diversion canal will follow a route back to the reservoir created by the headworks dam, it will likely intercept a number of agricultural diversions out of Anderson Creek as well.

The diversion canal would have an overall length of about 2.75 km and would discharge via a conduit type outlet works into the headworks reservoir.

As described in Section 5.0, the design capacities for the Finney Creek diversion works have been derived as 3.5 m^3/s based on rainstorm runoff with a 100-year return frequency and 5.5 m^3/s based on a 1000-year frequency. Because of the uncertainties in these flood peaks, as described in Section 3.0, the 5.5 m^3/s value has been adopted for design. However, in adopting the higher value, freeboard allowance has been minimized to only 0.3 m.

Because of the desirability of having the diversion canal outlet works discharge directly into the headworks reservoir, the location of the canal is consequently established at about the El. 985 contour. The route of the canal is through an area having numerous kettle lakes likely to contain organic sediment deposits which could create problems in respect to slumping or creeping of the canal banks. However, the numerous lakes indicate generally impervious soils.

(b) Diversion Canal

The 2.75 km diversion canal would have a minimum total depth of 2.2 m, an invert width of 1.5 m and side slopes of 2:1.

7.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

On the basis of a Manning friction coefficient of $n = 0.030$, the flow depth at the design discharge of 5.5 m^3/s would be 1.9 m leaving a freeboard of 0.3 m. The maximum velocity would be about 0.6 m/s. The canal gradient has been made very flat (0.03 percent) to provide a flow depth of at least 0.4 m which will permit formation of a protective ice sheet in winter.

The canal embankment, assumed to be formed from material excavated from the canal, would have a top width of 5 m surfaced with sand and gravel for use as an access and service road.

Although very little data is available on the soils along the canal route it is expected that little of the canal would require lining. For estimating purposes it has been assumed that 30 percent of the canal length would be lined with a 60 cm thickness of impervious till. Subsequent site investigations may indicate a need to flatten the canal slopes to 2.5:1 in local areas of compressible deposits.

(c) Outlet Works

The outlet works would comprise basically a reinforced concrete intake that would act as the hydraulic control for the canal and accelerate the flow into the 1500 mm corrugated metal conduit leading down to the headworks reservoir. The structure would have a crest width of 3.1 m at El. 983.2.

The 1500 mm culvert would have an overall length of about 28 m and would be sloped at 2.5:1. The downstream end of this culvert would terminate below the minimum headworks reservoir level in a reinforced concrete structure to prevent outlet erosion. However, the velocities at this point would not be high since generally all energy dissipation would occur in the hydraulic jump forced to occur within the culvert.

7.2 PROPOSED DIVERSION ARRANGEMENT - (Cont'd)

At least 1.5 m of earthfill and riprap would be placed over the pipe to prevent formation of ice in the conduit.

7.3 DRAINING OF FINNEY LAKE

Because of its proximity to the mine pit it has been considered that Finney Lake (and Aleece Lake) would be drained. It has been agreed that the cost of this work would be included with the mine drainage costs and has therefore been excluded from this report.

7.4 OPERATION AND MAINTENANCE

No special control works requiring maintenance over the winter would be required, since the crest of the outlet structure is high enough to force a flow depth throughout the canal length sufficient to form an ice cover.

Although Finney Lake itself is assumed to be drained, other small lakes that will be created within the canal embankment will serve as sedimentation ponds. Because of low canal velocities, however, some sediment removal will probably be necessary.

SECTION 8.0 - COST ESTIMATES

A summary of the cost estimates for the Hat and Finney creek diversions is shown on Table 8-1.

Including contingencies based on 20 percent of the total estimated direct cost, engineering based on 15 percent of the total direct cost including contingencies, and a 5 percent corporate overhead allowance on overall costs, the total initial capital cost, at September 1977 price levels, for the diversion of Hat and Finney creeks is estimated to be $14.0 million.

The cost of realigning that portion of the Hat Creek creek diversion canal that would be affected by the eventual mine pit excavation is estimated to be $3.33 million. Indirect costs have been included at the same rates as for the initial diversion construction above, and costs are also at September 1977 price levels.

The annual operating cost of the Hat Creek and Finney Creek diversions is estimated to $25,000. This cost includes allowances for maintenance, monitoring and analysis of seepage and earth movement detection equipment, and electrical energy costs for pumping from the pit rim dam. No indirect costs such as interest, amortization etc. are included.

Also shown on Table 8-1 is the estimated cash flow for the initial construction of the diversion works and for the future modifications to the Hat Creek diversion canal. As discussed in Sub-section 6.2(d) this realignment would be required after about 12 years of plant operation. The expenditures for engineering, investigations, design and construction are therefore shown as occurring during the three fiscal years 1995/96 to 1997/98.

SECTION 9.0 - ENGINEERING AND CONSTRUCTION SCHEDULE

A simplified bar schedule of previous, current and future engineering work together with a proposed construction schedule for the diversion of Hat and Finney creeks is shown on Plate 9-1. This schedule is based on the actual dates of past work and on the future scheduling data given in Sub-section 3.3.

The past engineering work includes Monenco's diversion study in 1976 and the HEDD preliminary design comprising this report. Ongoing studies during 1978 should include investigations of the economic and environmental viability of installing works to minimize temperature rise in the diversion canal, and investigation of prototype spillways constructed of rollcrete or soil-cement. Further site investigations and final design are assumed to be carried out during 1979 and 1980, with the award of the construction contract in January of 1981 so that, allowing for mobilization, construction could begin in March 1981.

As defined in Sub-section 3.3, the diversion works are to be operational by 1 October 1982. The March 1981 start of construction is governed, therefore, by the diversion canal and conduit construction.

SECTION 10.0 - FURTHER STUDIES AND INVESTIGATIONS

As mentioned in previous sections some ongoing studies during 1978 and prior to the start of final design are recommended. These ongoing studies should include:

1. A combined engineering, environmental and economic assessment of the net effect of increased water temperatures in Hat Creek as a result of passage through the diversion canal. Investigations of alternative, mitigative or compensatory measures that are compatible with the impact should be examined.

2. Periodic discussions with the Provincial Water Investigations Branch and the Ministry of Agriculture should be continued in relation to the potential Oregon Jack Creek diversion.

3. Design data on prototype spillways constructed with rollcrete or soil-cement should be collected.

4. A program should be developed and implemented to obtain base data necessary to more accurately assess rainstorm-produced flood peaks in the Hat Creek tributary basins.

5. Aerial photography and metric topographic mapping at scales suitable for final design should be obtained.

Detailed site investigations at all of the major diversion components should be started early in 1979 to provide sufficient geotechnical data for final design. These site investigations should include:

1. Additional drill holes and seismic surveys of the headworks damsite to permit better definition of the subsurface horizons.

2. As in 1 above, additional drill holes and seismic surveys at the pit rim dam. During the 1977 site investigations, access for the drill rig was refused in critical areas and hence the bedrock horizon and extent of the required cutoff trench is poorly defined.

3. Drill holes and test pits along the Finney Creek diversion canal route. To date no site investigations have been conducted here.

4. A few test pits and occasional drill holes along the route of the Hat Creek diversion discharge conduit.

5. Additional drill holes and seismic surveys at the Ambusten and Medicine Creek canal embankments.

6. Additional test pits and occasional drill holes to enable continuity in the interpretation of soil profiles along the canal route.

TABLE 2-1

HAT CREEK TEMPERATURE AND PRECIPITATION SUMMARIES
(1961-1975)

	Unit	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Mean Daily Temperature	°C	-10.5	-4.9	-1.2	3.8	8.7	12.8	15.0	14.8	10.2	4.3	-3.1	-8.7	3.4
Mean Daily Maximum Temperature	°C	-4.6	1.6	5.3	10.7	16.4	20.8	23.9	23.7	18.5	11.1	2.1	-3.4	10.5
Mean Daily Minimum Temperature	°C	-16.1	-11.4	-7.7	-3.2	1.3	4.8	6.1	5.8	2.1	-2.4	-8.3	-13.9	-3.4
Mean Rainfall	mm	4.3	2.3	1.8	8.4	18.3	25.1	28.4	29.2	21.1	14.7	5.8	2.5	162
Mean Snowfall	cm	35.3	13.7	11.4	6.6	2.8	0	0	0	0	5.3	25.4	36.1	137
Mean Total Precipitation	mm	39.6	16.3	13.2	15.0	21.1	25.1	28.4	29.2	21.1	20.1	31.5	39.1	300

Data shown is for the Hat Creek meteorological station located on the valley floor (El. 900 m approximately) in the vicinity of the confluence of Hat and Medicine creeks.

TABLE 2-2

HAT CREEK BASIN WATER LICENCE SUMMARY

			Annual Volume (ha-m)
A.	Upstream of and including Finney Creek*		
	1. Hat Creek		342
	2. Tributaries		637
		SUBTOTAL	979
B.	Downstream of Finney Creek*		
	1. Hat Creek		165
	2. Tributaries		23
		SUBTOTAL	188
		TOTAL	1167
C.	Licences for diversion out of Hat Creek basin		
	1. Via Oregon Jack Creek		206
	2. From Medicine Creek		224
	3. Downstream of Finney Creek*		37
		TOTAL	467

* All flows upstream of and including Finney Creek would have to be handled by the Hat Creek Diversion Works.

Data extracted from Item 11 of Sub-section 1.3(a).

TABLE 5-1

HAT CREEK NEAR UPPER HAT CREEK-STA 08LF061
MONTHLY AND ANNUAL MEAN DISCHARGES
(m^3/s)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Mean	Year
1960	--	--	--	--	--	--	--	--	--	0.19	0.25	0.22	--	1960
1961	0.19	0.16	0.33	0.30	1.54	1.41	0.29	0.12	0.15	0.24	0.23	0.20	0.43	1961
1962	0.20	0.27	--	1.55	2.65	3.00	0.63	0.27	0.27	0.43	0.33	--	--	1962
1963	--	--	0.44	0.50	1.68	1.81	0.67	0.28	0.25	0.26	0.25	0.24	--	1963
1964	0.23	0.22	0.26	0.62	1.19	7.16	1.70	0.50	0.88	0.76	0.55	0.40	1.20	1964
1965	0.31	0.29	0.37	1.32	2.48	2.62	1.24	0.71	0.53	0.36	0.34	0.23	0.90	1965
1966	0.24	0.20	0.65	0.70	1.71	1.84	2.07	0.83	0.34	0.43	0.37	0.29	0.81	1966
1967	0.19	0.17	0.18	0.42	2.57	4.45	0.76	0.23	0.13	0.22	0.29	0.20	0.82	1967
1968	0.18	0.18	0.24	0.29	1.52	2.73	1.08	0.31	0.25	0.28	0.31	0.26	0.63	1968
1969	0.20	0.16	0.19	0.42	3.03	1.53	2.36	0.39	0.32	0.35	0.33	0.29	0.80	1969
1970	0.18	0.17	0.22	0.25	0.51	0.81	0.18	0.10	0.09	0.12	0.12	0.14	0.24	1970
1971	0.16	0.20	0.13	0.36	2.29	2.94	0.93	0.16	0.11	0.19	0.21	0.16	0.65	1971
1972	0.17	0.18	0.37	0.34	2.20	3.99	1.33	0.46	0.32	0.34	0.28	0.21	0.85	1972
1973	0.18	0.21	0.26	0.39	0.80	0.57	0.21	0.09	0.12	0.18	0.18	0.20	0.28	1973
1974	0.18	0.19	0.29	0.46	0.99	4.56	0.95	0.35	0.20	0.20	0.22	0.25	0.74	1974
1975	0.24	0.18	0.19	0.40	1.23	3.06	0.82	0.20	0.24	0.18	0.21	0.19	0.59	1975
1976	0.17	0.12	0.13	0.30	0.86	0.95	0.43	0.63	0.31	0.24	0.25	0.20	0.38	1976
Mean	0.20	0.19	0.28	0.54	1.70	2.71	0.98	0.35	0.28	0.29	0.28	0.23	0.67	Mean

Discharge area = 350 km^2

TABLE 5-2

HYDROMETRIC STATIONS SELECTED FOR REGIONAL ANALYSIS

Station Designation	Station Name	Drainage Area (sq km)	Period of Record
08LF036	Pukaist Creek near Ashcroft	146	1922-27
08LF038	Clinton Creek near Clinton	77	1923-28, 1956-60
08LF069	Pukaist Creek below Woods Creek	102	1967-76 (flow being regulated since 1971)
08LG003	Guichon Creek above Mamit Lake	806	1912-16, 1918-28
08LG009	Witches Brook near Merritt	138	1912, 1921-22, 1957-58, 1961-63, 1967-76
08LG014	Guichon Creek Diversion to Tunkwa Lake	-	1919-22, 1924-25, 1927-29
08LG032	Guichon Creek below Quenville Creek	799	1934-38, 1940-60, 1962-67
08LG033	Quenville Creek near Merritt	41	1934-47, 1949-50
08LG055	Bethsaida Creek above Highland Valley Road	15	1967-76

TABLE 5-3

COMPARISON OF FLOOD PEAK ESTIMATES

Gauging Station or Sub-basin	Drainage Area (sq km)	Recurrence Internal (yr)	Present Study (m^3/s)	Monenco Study* (m^3/s)	Beak Consultants Ltd. Study** (m^3/s)
Hat Creek near Ashcroft (08LF013)	73	2.33	1.8	-	1.9
		100	6.1	-	7.5
		1000	9.1	-	9.5
Hat Creek near Upper Hat Creek (08LF061)	350	2.33	5.2	7.4	5.0
		100	17.8	22.7	16.2
		1000	26.5	32.6	23.0
Hat Creek near Cache Creek (08LF015)	666	2.33	6.5	-	7.0
		100	22.5	-	23.0
		1000	33.4	-	33.8
Medicine Creek	61	2.33	1.6	-	1.2
		100	5.5	-	3.1
		1000	8.1	-	4.4
Ambusten Creek	34	2.33	0.9	-	0.5
		100	3.1	-	1.6
		1000	4.6	-	2.5
Finney Creek	12.5	2.33	0.3	-	0.2
		100	1.1	-	0.5
		1000	1.6	-	0.6
Harry Creek	9.7	2.33	0.2	-	0.1
		100	0.7	-	0.2
		1000	1.0	-	0.4

* Item 2 in Sub-section 1.3(a).

** Item 11 in Sub-section 1.3(a).

TABLE 5-4

HAT CREEK METEOROLOGICAL STATION
SUMMARY OF RAINFALL IN SUMMER MONTHS

Year	June		July		August		September	
	Monthly Total	Maximum 24 hours	Monthly Total	Maximum 24 hours	Monthly Total	Maximum 24 hours	Monthly Total	Maximum 24 hours
1962	12.4	9.4	16.5	5.8	39.6	12.7	27.4	22.4
1963	27.7	9.4	22.4	7.4	19.8	5.1	-	-
1964	93.2	22.6	9.4	4.1	50.0	27.2	58.4	26.7
1965	8.9	5.1	56.1	20.6	71.4	30.0	23.6	11.9
1966	9.1	2.8	113.3*	38.9*	15.5	5.6	25.9	12.2
1967	25.9	9.7	8.1	4.8	11.7	11.7	2.5	2.5
1968	21.1	6.9	10.4	4.8	34.0	9.7	40.1	12.2
1969	42.7	12.4	63.0	14.5	9.1	4.6	25.7	11.2
1970	32.0	9.7	14.0	9.9	4.6	1.8	6.4	2.8
1971	18.5	5.6	14.7	4.6	16.0	6.4	14.0	6.6
1972	47.0	13.7	12.4	5.1	47.8	15.2	20.3	7.1
1973	5.6	3.6	11.7	4.1	10.9	3.3	12.4	3.8
1974	1.5	1.5	14.7	6.9	47.5	23.6	1.0	0.5
1975	29.0	13.5	8.6	5.3	27.9	5.1	11.2	8.4
1976	27.7	6.4	39.6	23.4	48.5	19.8	4.8	4.8

* Maximum for period of record.

Note: All rainfall figures are in millimetres.

TABLE 5-5

SUMMARY OF ADOPTED DESIGN DISCHARGE CAPACITIES

Facility	Design Discharge (m^3/s)	Recurrence Interval (years)	Flood Type	Drainage Area (km^2)	Applicable Curves
Hat Creek Diversion*					
1. Emergency spillway for headworks and pit rim dams	79**	PMF***	PMF	350	Plate 5-10
2. Diversion canal and discharge conduit					
a. Emergency condition	27	1000	Snowmelt	350	Plate 5-4
b. Normal condition	18	100	Snowmelt	350	Plate 5-4
Finney Creek Diversion	5.5	1000	Rainstorm	13	Plate 5-9
Ash Disposal Reservoir†					
1. North canal (at outlet)	7.8	PMF	PMF	11.7	Plate 5-10
2. South canal (at outlet)	14.4	PMF	PMF	26	Plate 5-10

* Capacities shown are for the proposed scheme with no upstream storage.

** Capacity is based on 106 m^3/s (Plate 5-10) less emergency diversion capacity of 27 m^3/s.

*** Probable maximum flood is a maximized combination of snowmelt and rainstorms.

† See companion HEDD report "Hat Creek Project - Water Supply and Ash Disposal Reservoirs - Preliminary Design Report", March 1978.

TABLE 8-1

DIVERSION OF HAT AND FINNEY CREEKS
SUMMARY COST ESTIMATE
(All costs at September 1977 price levels)

A. INITIAL CAPITAL COST

			$ Thousands
		Hat Creek Diversion	
1.	Access roads		940
2.	Headworks dam		
	a.	Dam	480
	b.	Spillway	270
3.	Diversion canal		
	a.	Intake	160
	b.	Canal	2,530
	c.	Creek crossings	1,540
4.	Diversion conduit		
	a.	Intake	180
	b.	Conduit	1,780
	c.	Outlet works	130
5.	Pit rim dam		
	a.	Dam	930
	b.	Spillway	250
	c.	Pumphouse and pipeline	270
		Subtotal	9,460
		Finney Creek Diversion	
6.	Diversion canal		160
7.	Outlet works		60
		Subtotal	220
		Total Direct Cost	9,680
8.	Contingencies (20%)		1,940
9.	Engineering, investigations and supervision (15%)		1,740
10.	Corporate overhead (5%)		670
		Total Initial Capital Cost	14,030

15,150

TABLE 8-1 - (Cont'd)

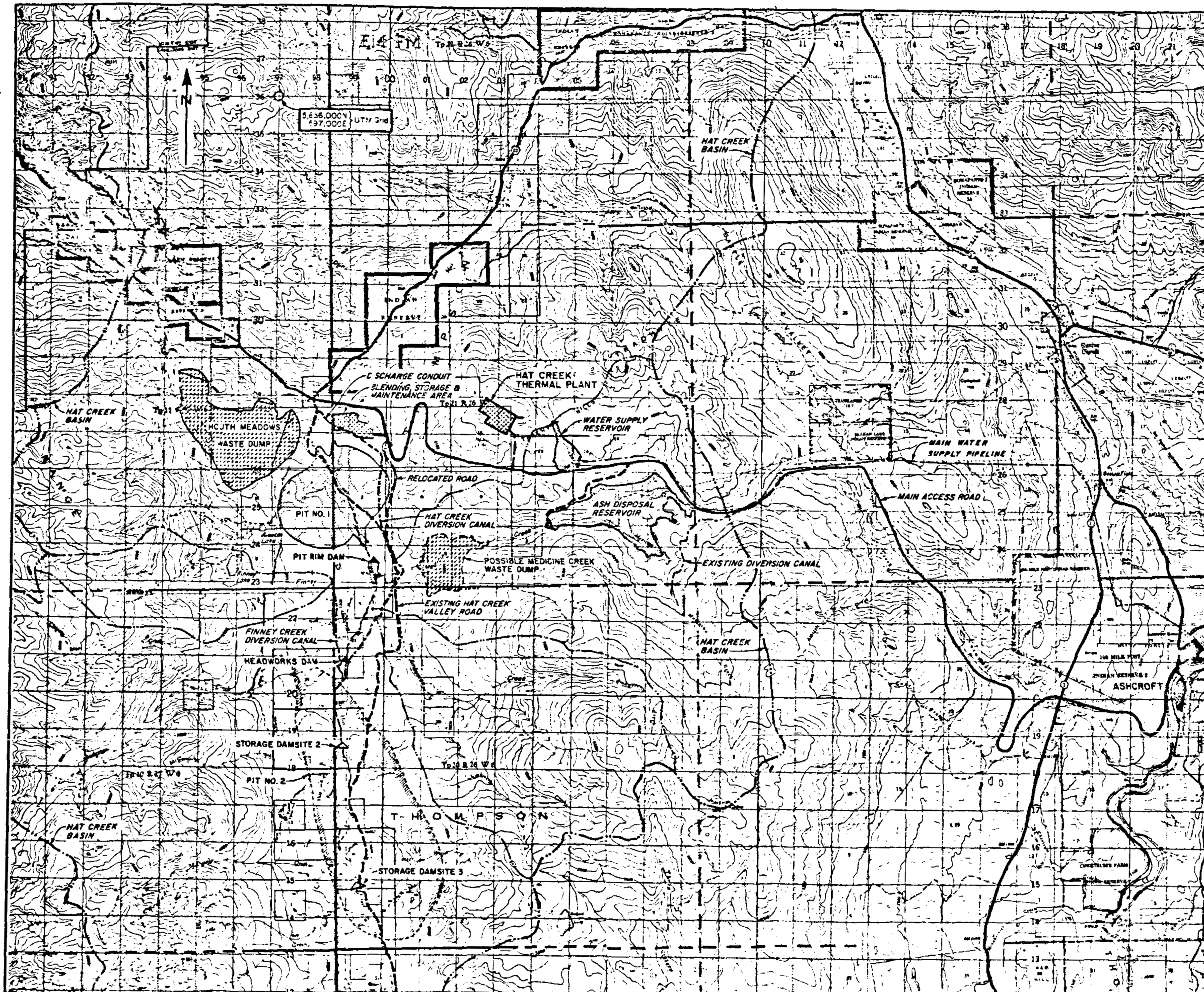
B. FUTURE MODIFICATIONS TO HAT CREEK DIVERSION CANAL

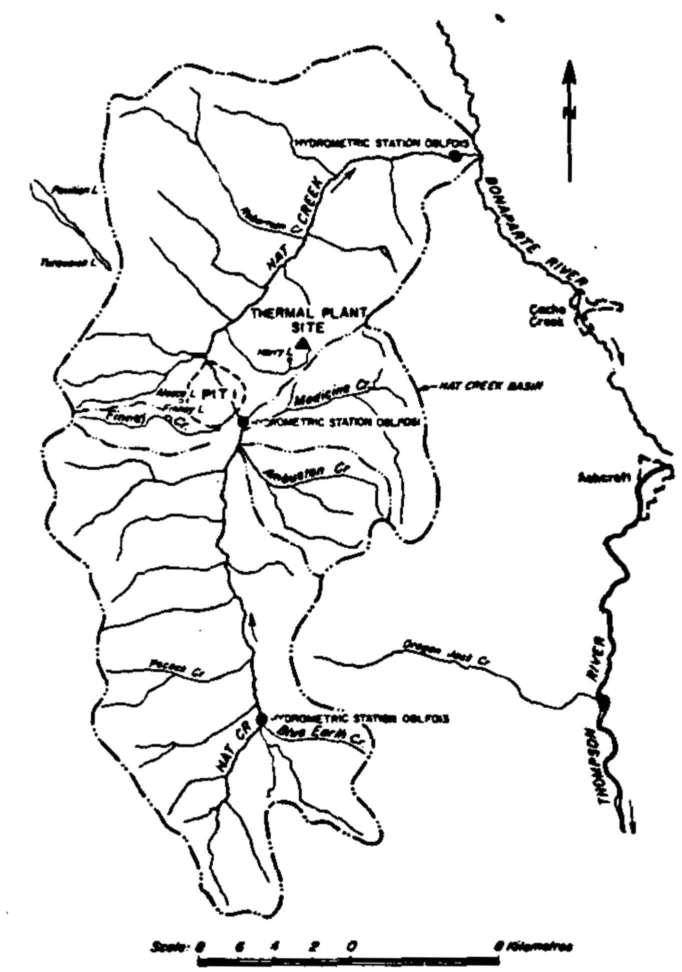
		$ Thousands
1.	Direct construction cost	2,300
2.	Contingencies (20%)	460
3.	Engineering, investigations and supervision (15%)	410
4.	Corporate overhead (5%)	160
	Total Future Capital Cost	3,330

C. ANNUAL OPERATING COSTS 25

D. ESTIMATED CASH FLOW

Fiscal Year	Expenditure $ Thousand
1. Initial Costs	
1979/80	750
1980/81	500
1981/82	5280
1982/83	7500
2. Future Costs (excluding operating costs)	
1995/96	230
1996/97	200
1997/98	2900





KEY MAP

NOTES:

1. THE ELEVATIONS SHOWN ON THIS DRAWING ARE IN FEET. (ALL OTHER DRAWINGS IN THIS REPORT ARE IN METRIC UNITS.)

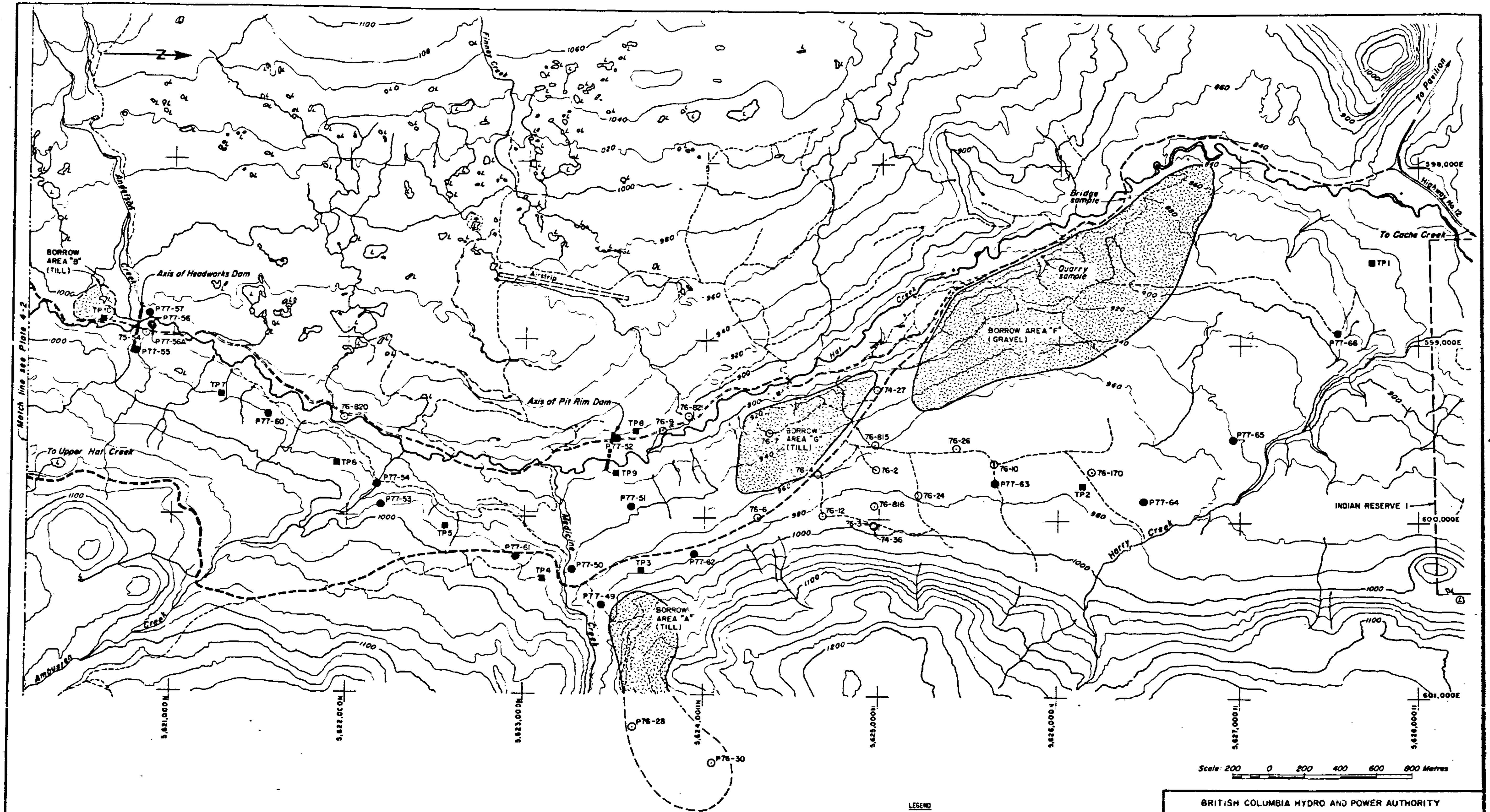
Scale: 1000 0 1000 2000 3000 4000 Metres

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

LOCATION MAP

DATE MAR 1978	PLATE 2-1 R
DWN A.V.	DWG No. 604H-C14-D35



LEGEND

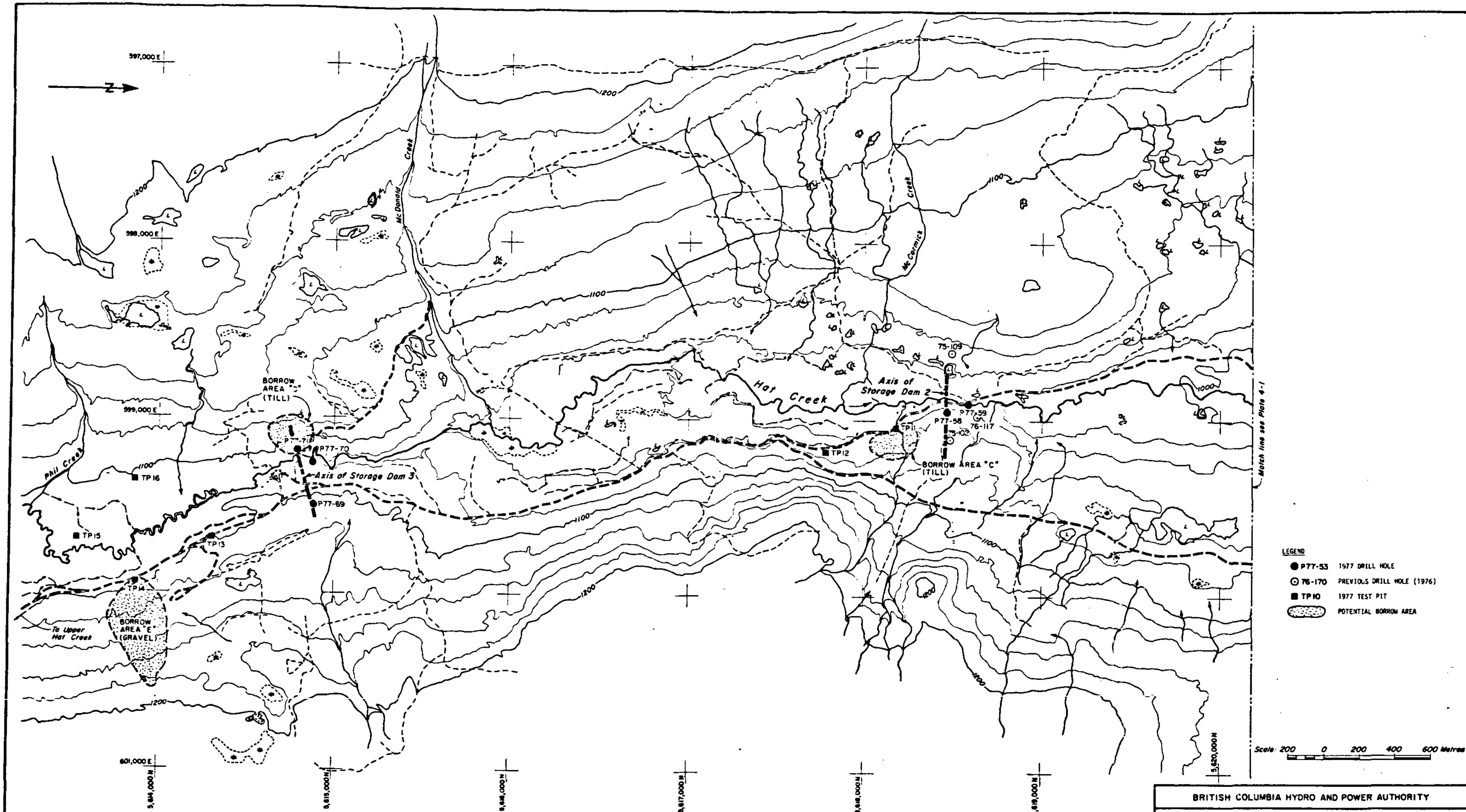
● P77-53	1977 DRILL HOLE
⊙ 76-170	PREVIOUS DRILL HOLE (1976)
■ TP10	1977 TEST PIT
(stippled)	POTENTIAL BORROW AREA

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

DIVERSION OF HAT AND FINNEY CREEKS SITE INVESTIGATIONS AND BORROW AREAS DIVERSION AREA

DATE	MAR 1978	PLATE 4-1	R
DWN	C.Y.	DWG No. 604H-C14-D36	

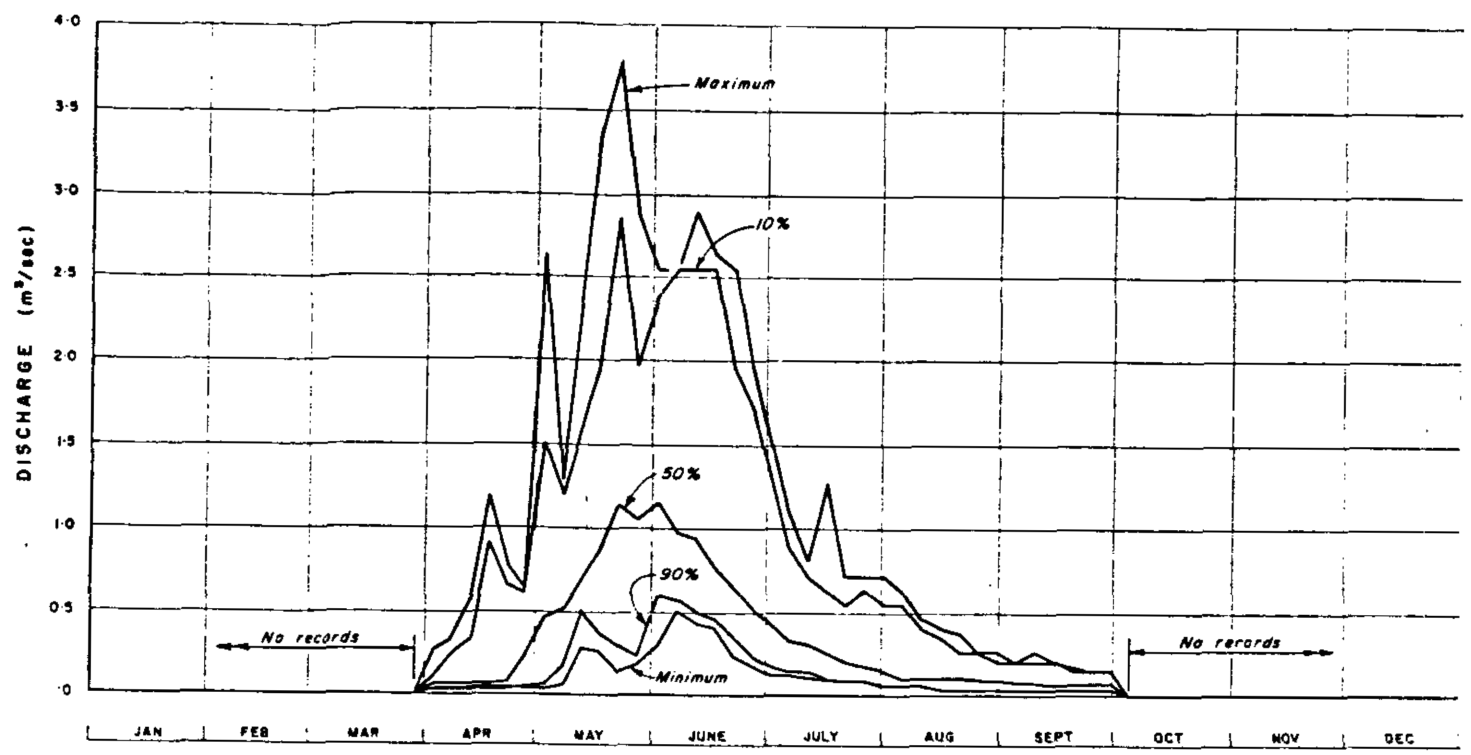


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

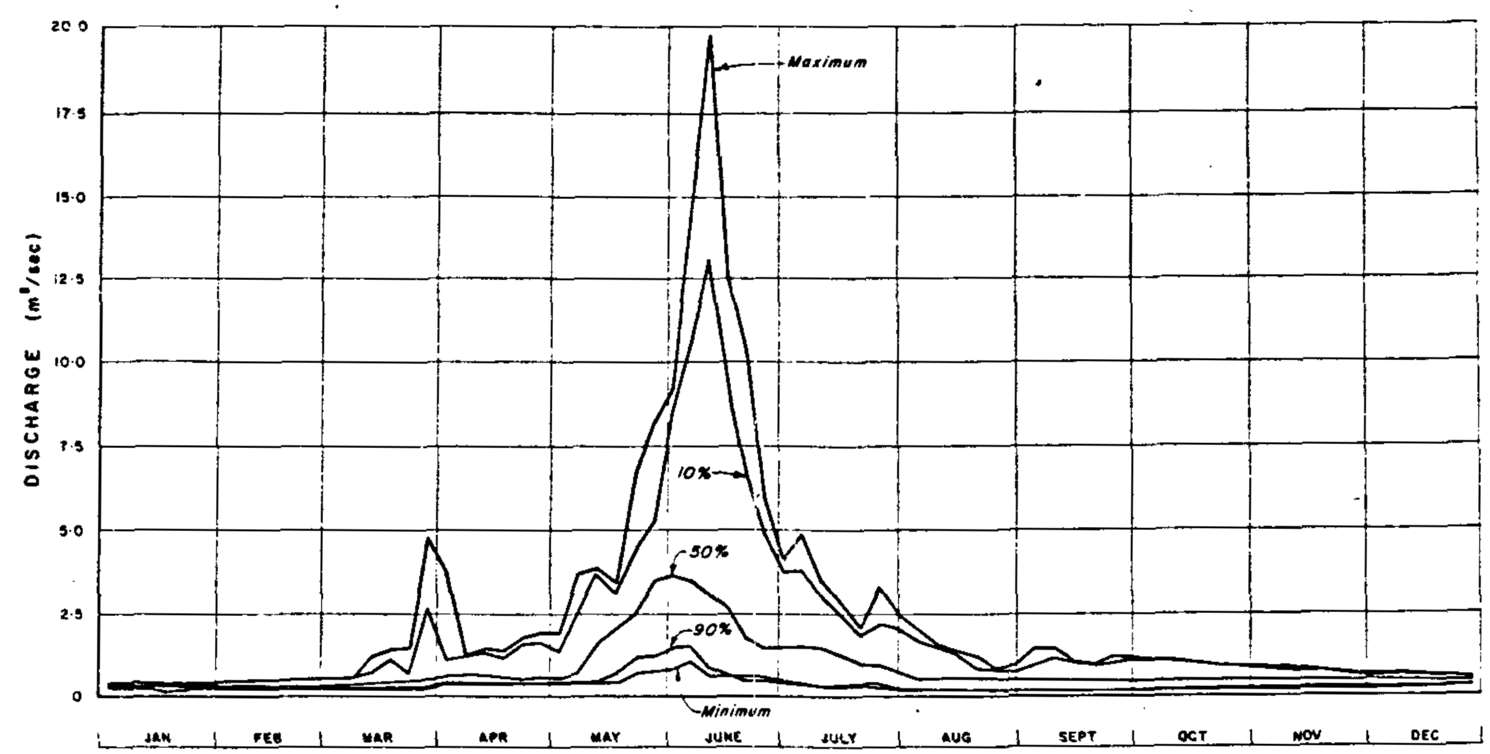
HAT CREEK PROJECT

DIVERSION OF HAT AND FINNEY CREEKS
SITE INVESTIGATIONS AND BORROW AREAS
STORAGE DAM AREA

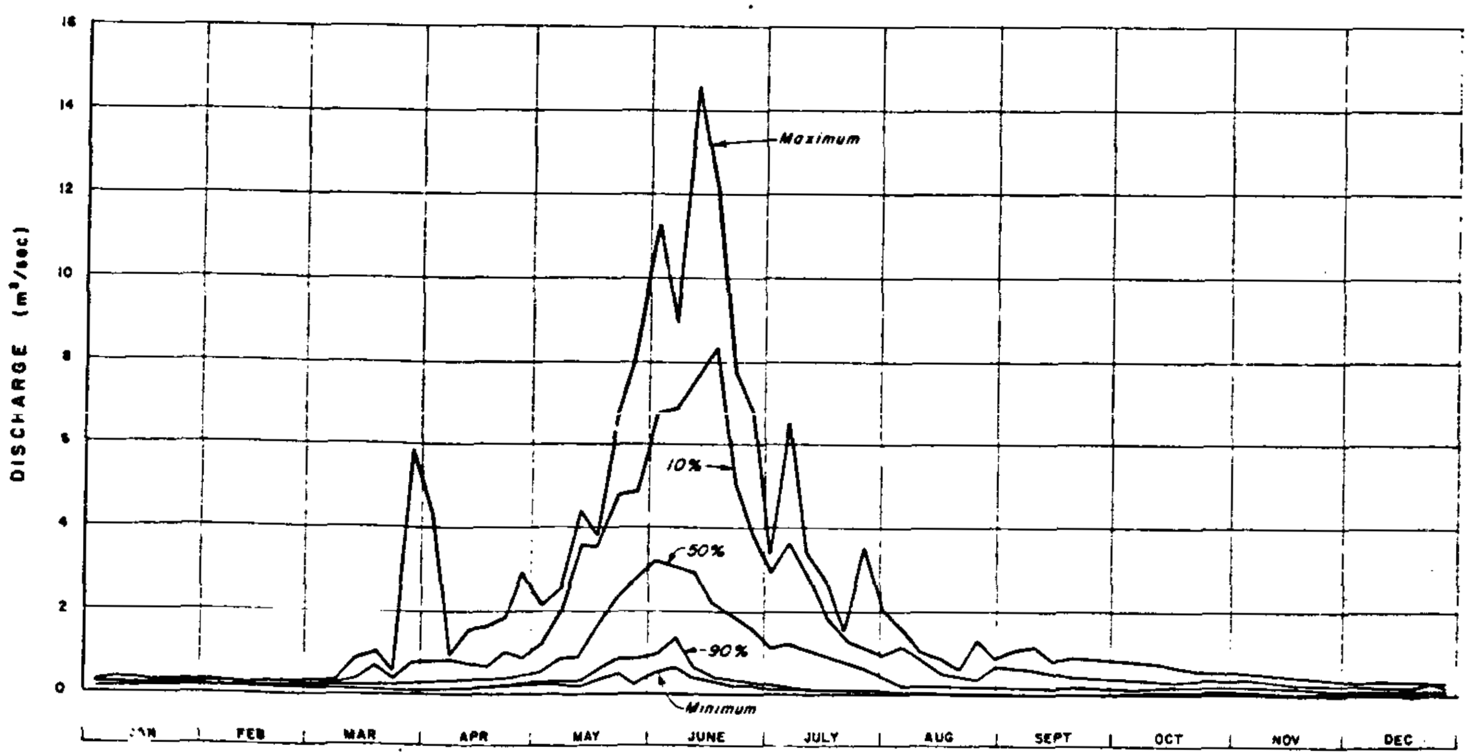
DATE MAR 1978	PLATE 4-2	R
DWN D.J. A.V.	DWG No. 604H-C14-D37	



STATION 08LF013 - HAT CREEK NEAR ASHCROFT
(1911 - 1922)



STATION 08LF015 - HAT CREEK NEAR CACHE CREEK
(1961 - 1973)



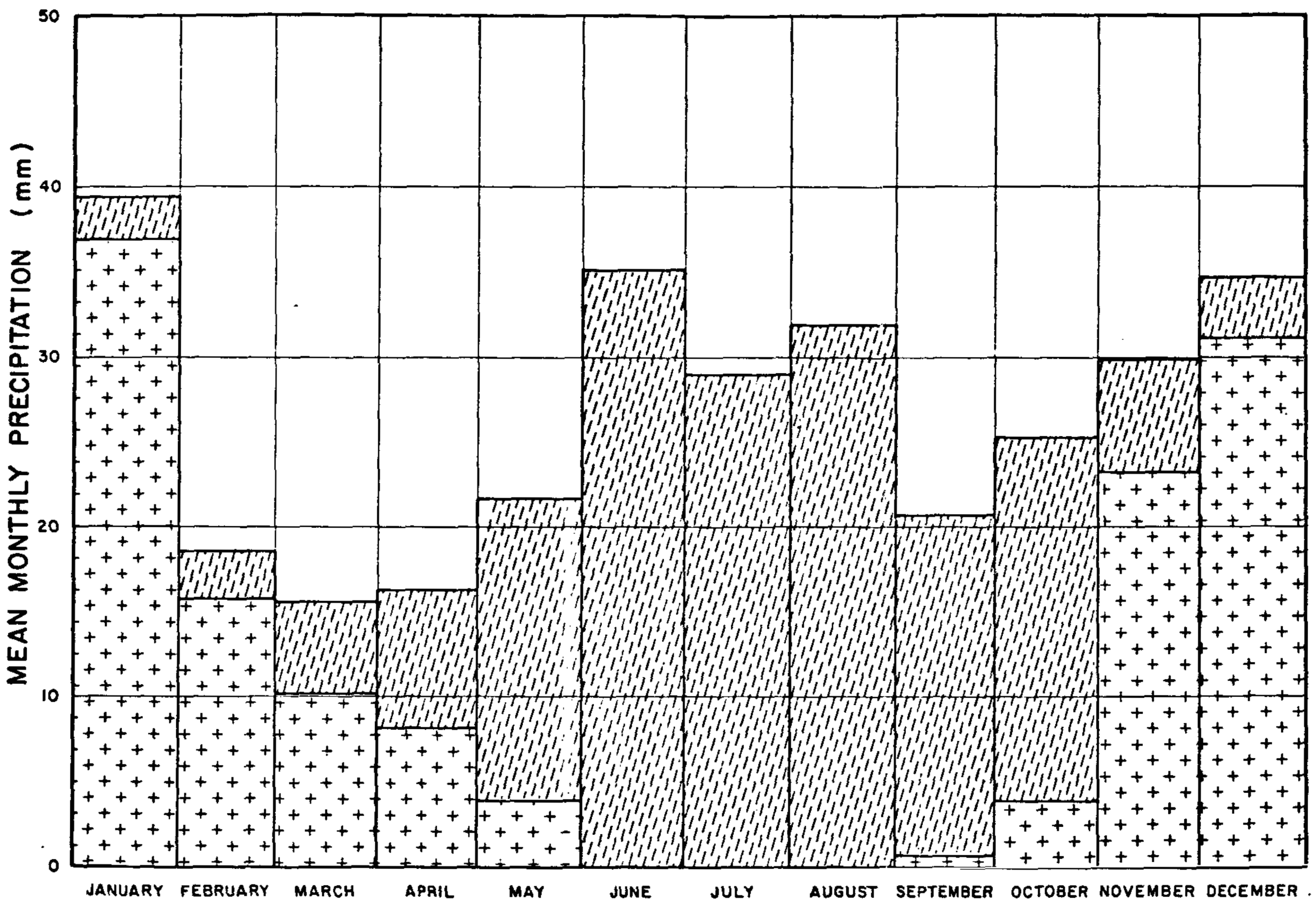
STATION 08LF061 - HAT CREEK NEAR UPPER HAT CREEK
(1961 - 1975)

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

5-DAY FLOW PROBABILITY CURVES FOR HAT CREEK

DATE	MAR 1978	PLATE 5-1	R
DWN	D. J.	DWG No. 604H-C14-D38	



LEGEND

RAIN

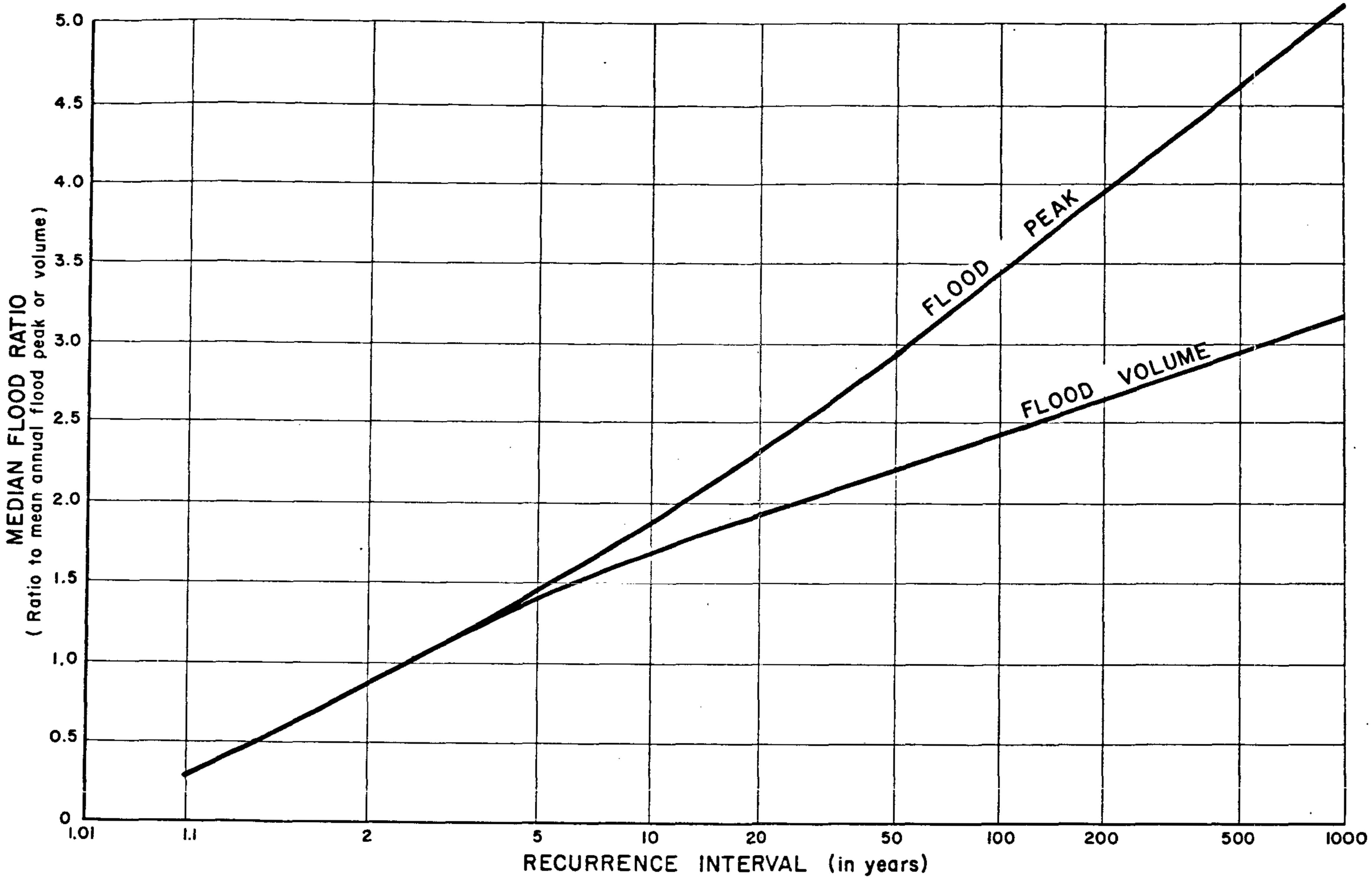
SNOW (As rain equivalent)

NOTE

1. Figures are based on "Canadian Normals, 1941 - 1970" by Atmospheric Environment Service

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT MONTHLY DISTRIBUTION OF RAINFALL AND SNOWFALL	
DATE MAR 1978	PLATE 5-2 R
DWN A.H	DWG No. 604H-C14-B39

REPORT No. 913

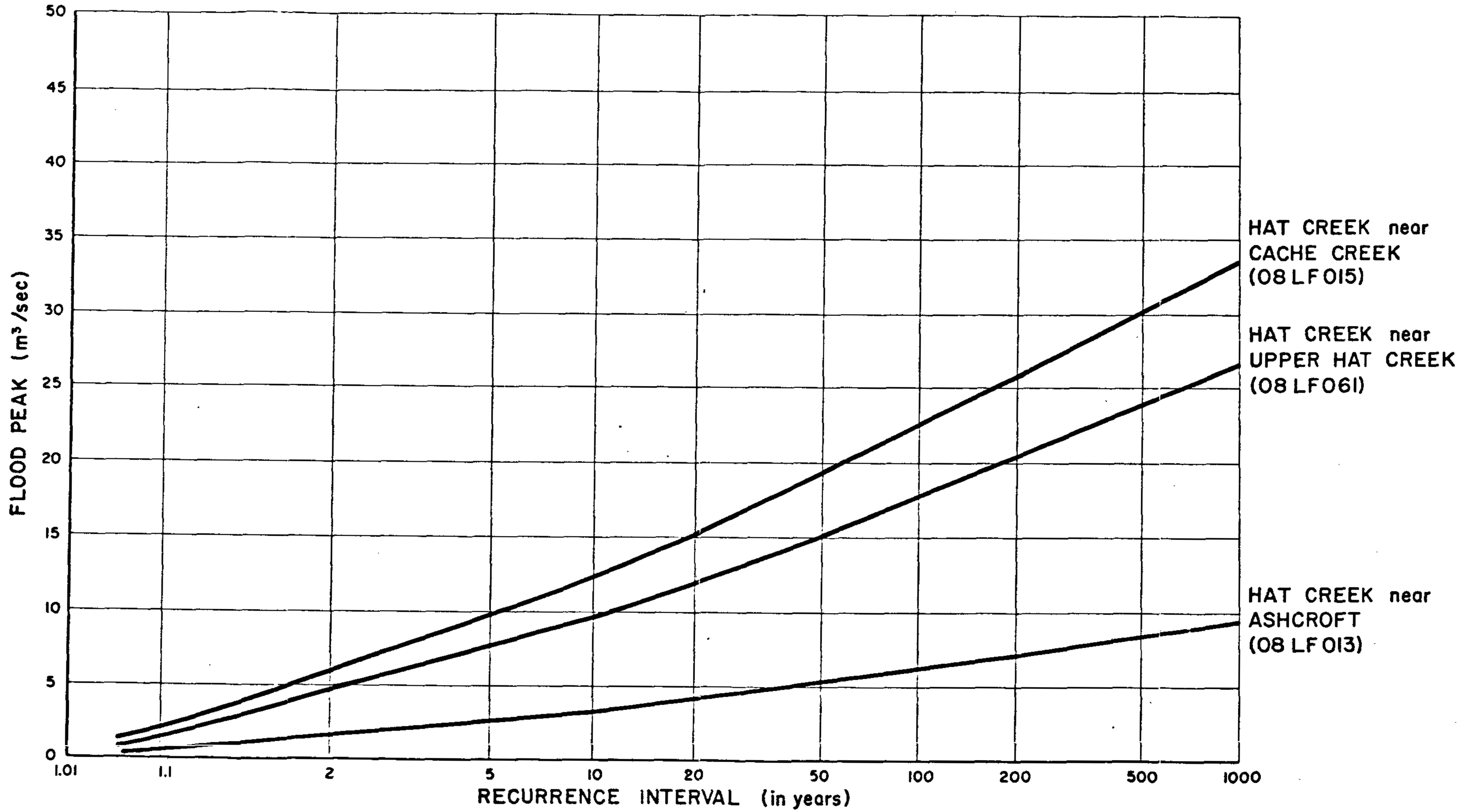


NOTE:

1. CURVES SHOWN ARE FOR ANNUAL SNOWMELT FLOODS.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT REGIONAL FLOOD FREQUENCY CURVES	
DATE MAR 1978	PLATE 5-3 R
DWN A.H.	DWG No. 604H-C14-B40

REPORT No. 913



NOTE:

1. CURVES SHOWN ARE FOR ANNUAL SNOWMELT FLOODS.

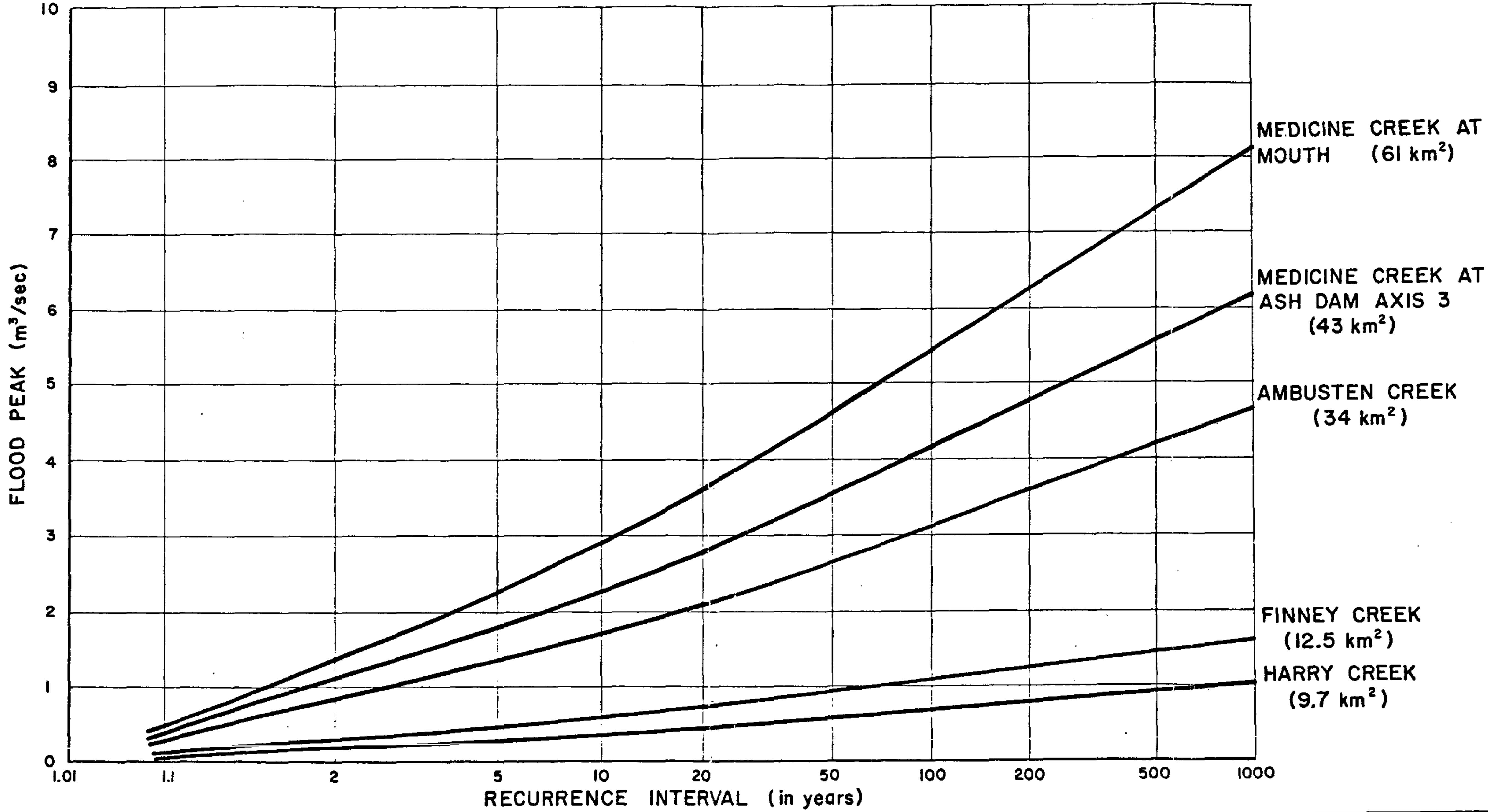
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

FLOOD PEAK FREQUENCY CURVES FOR HAT CREEK

DATE MAR 1978	PLATE 5-4 R
DWN A.H.	DWG No. 604H - C14 - B41

REPORT No. 913



NOTE:

1. CURVES SHOWN ARE FOR ANNUAL SNOWMELT FLOODS.

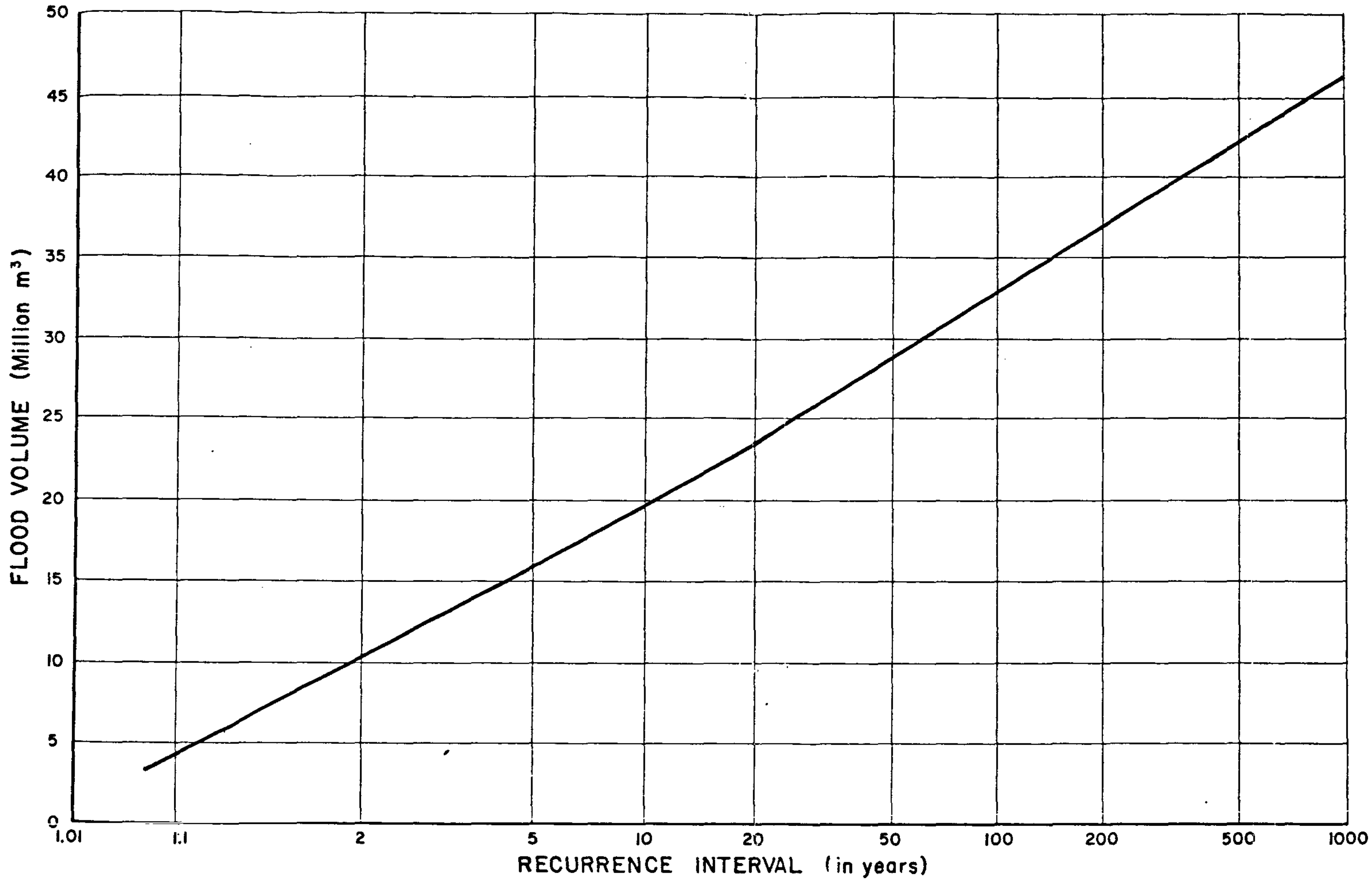
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

FLOOD PEAK FREQUENCY CURVES FOR TRIBUTARIES OF HAT CREEK

DATE MAR 1978	PLATE 5-5 R
DWN A.H.	DWG No. 604H-C14-B42

REPORT No. 913



NOTE:

1. VOLUME IS FOR DURATION OF FLOOD ONLY; IT IS NOT THE ANNUAL RUNOFF VOLUME.
2. STA 08LF061, "HAT CREEK NEAR UPPER HAT CREEK" IS LOCATED IMMEDIATELY DOWNSTREAM OF THE MEDICINE CREEK CONFLUENCE.

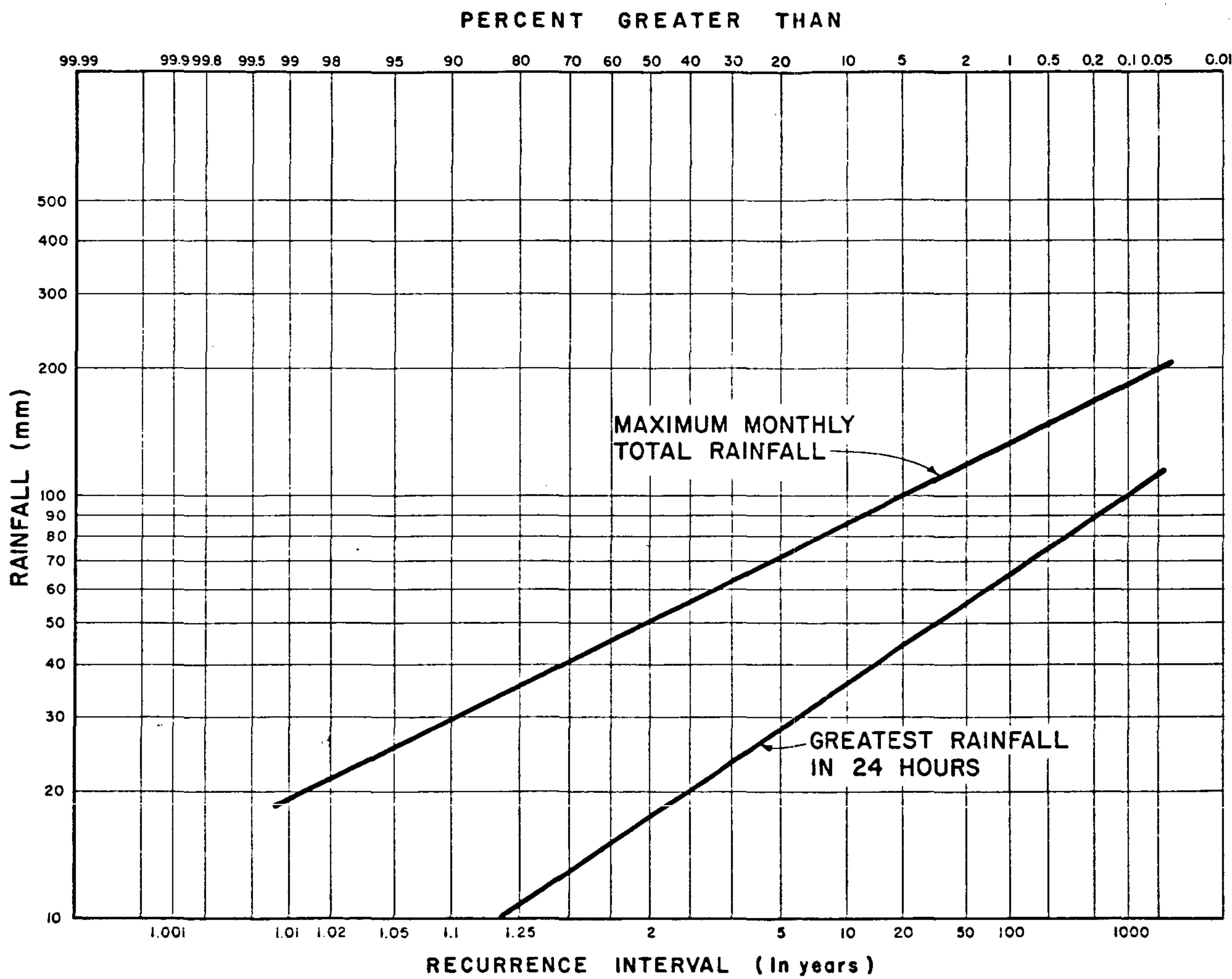
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

FLOOD VOLUME FREQUENCY CURVE FOR HAT CREEK AT STATION 08LF061

DATE MAR 1978	PLATE 5-6 R
DWN A.H.	DWG No. 604H-C14-B43

REPORT No. 913



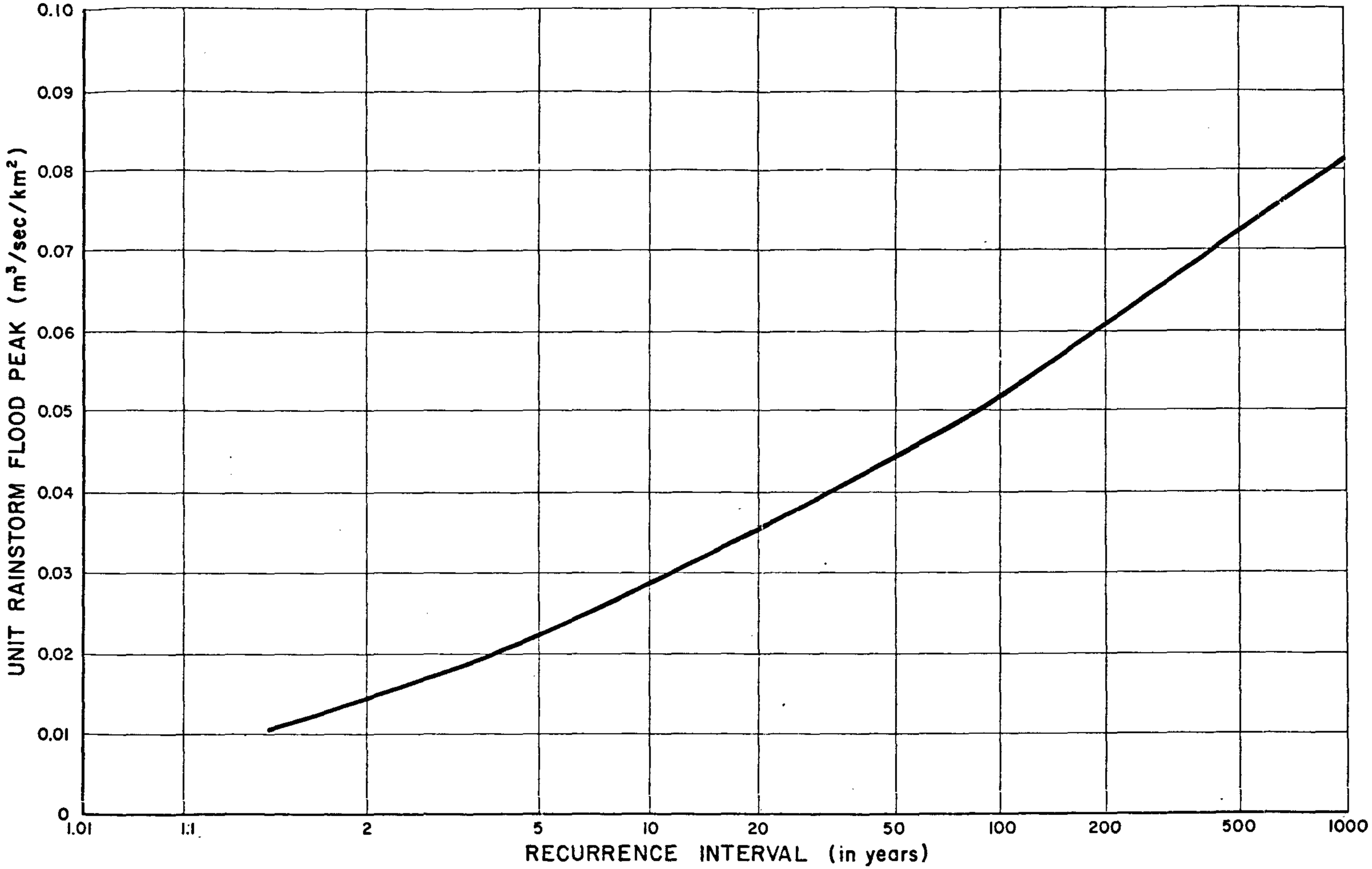
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

RAINFALL FREQUENCY CURVES FOR HAT CREEK STATION

DATE MAR 1978	PLATE 5-7 R
DWN A.H.	DWG No. 604H-C14-B44

REPORT No. 913



NOTE:

1. CURVE APPLICABLE ONLY TO BASINS WITH LAG TIMES EXCEEDING 24 HOURS.

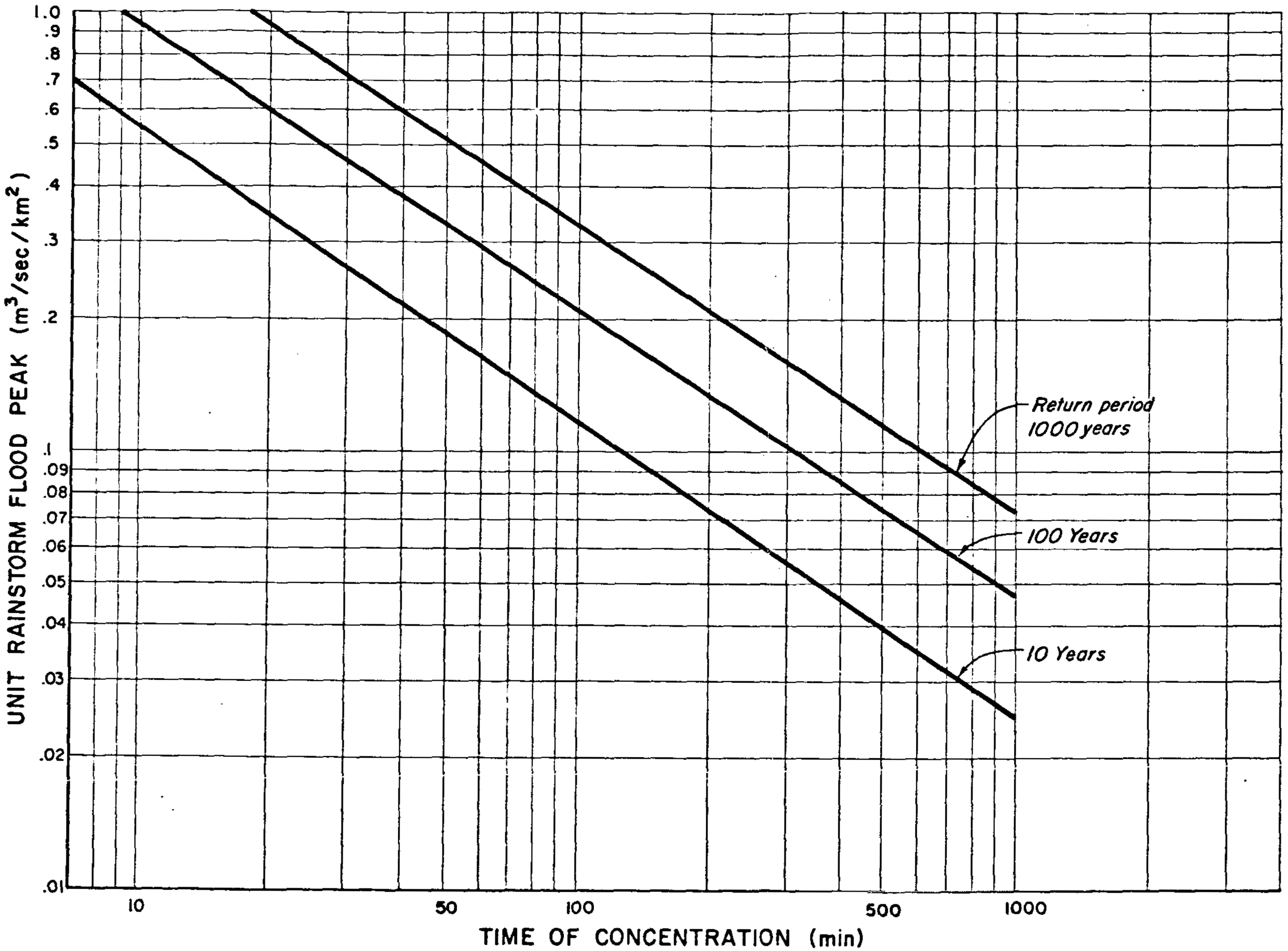
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

FREQUENCY CURVE FOR RAINSTORM FLOODS

DATE MAR 1978	PLATE 5-8 R
DWN A.H.	DWG No. 604H-C14-B45

REPORT No. 913



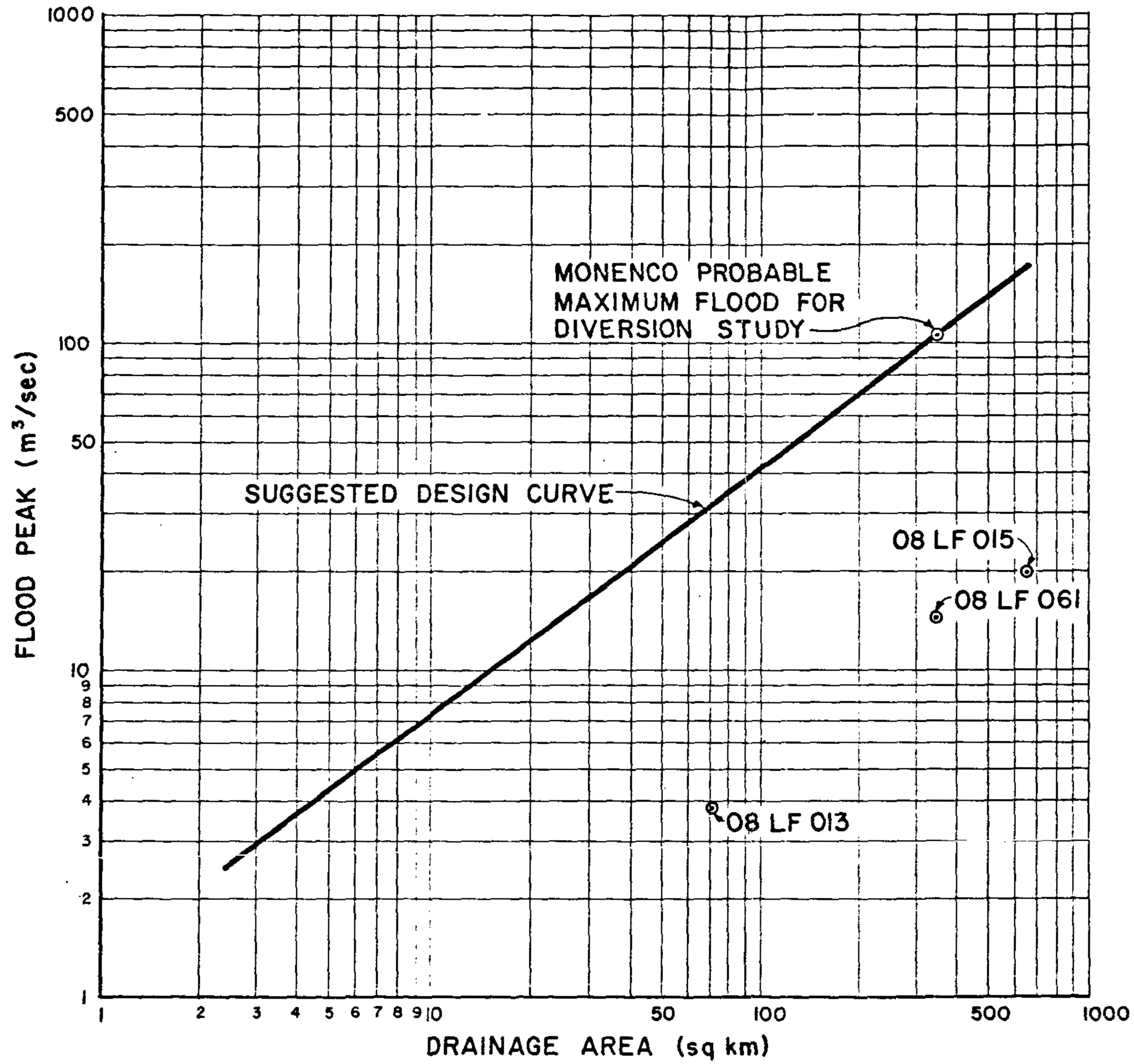
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

SHORT DURATION RAINSTORM PRODUCED FLOOD PEAKS

DATE MAR 1978	PLATE 5-9	R
DWN A.H.	DWG No. 604H-C14-B46	

REPORT No. 913

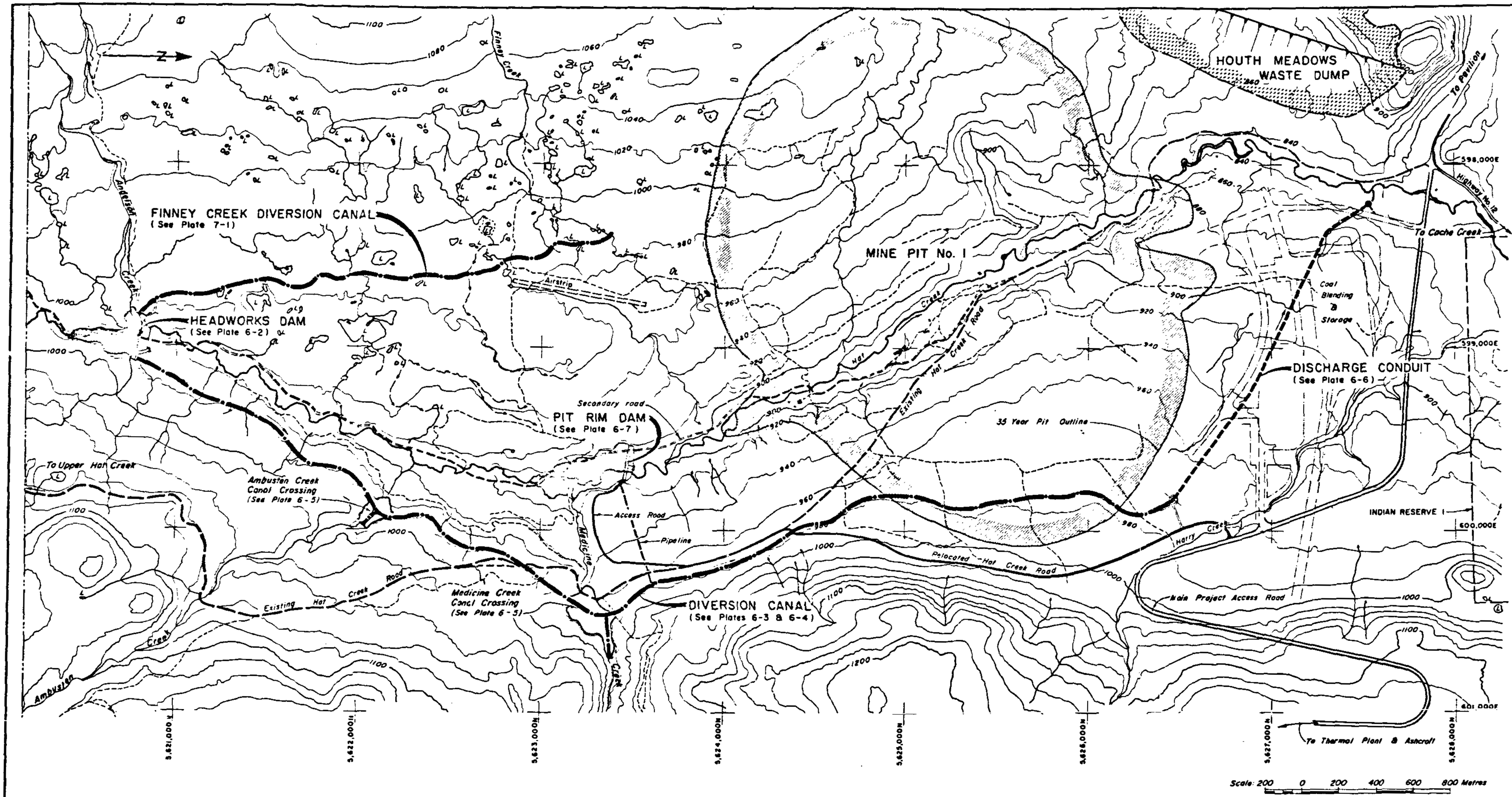


NOTE:

1. ⊙08LF061 ETC ARE ACTUAL RECORDED EXTREME DAILY DISCHARGES AT THE RESPECTIVE HAT CREEK STATIONS.

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT	
PROBABLE MAXIMUM FLOOD PEAK / AREA RELATIONSHIP	
DATE MAR 1978	PLATE 5-10 R
DWN A.H.	DWG No. 604H-C14-B47

REPORT No. 913



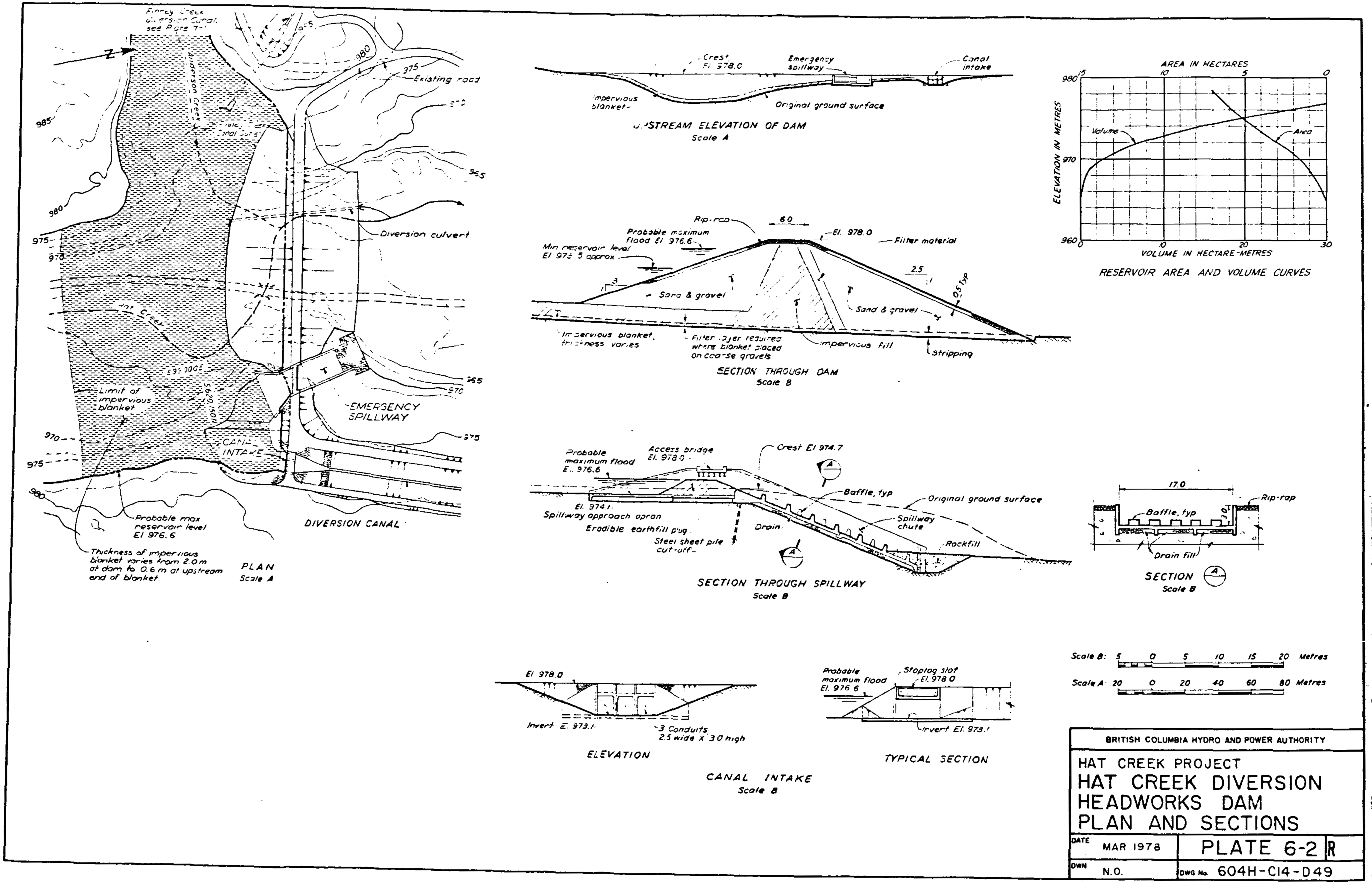
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

HAT CREEK DIVERSION GENERAL ARRANGEMENT

DATE MAR 1978	PLATE 6 - 1 R
DWN C.Y. / C.C.	DWG No. 604H - C14 - D48

REPORT No. 913

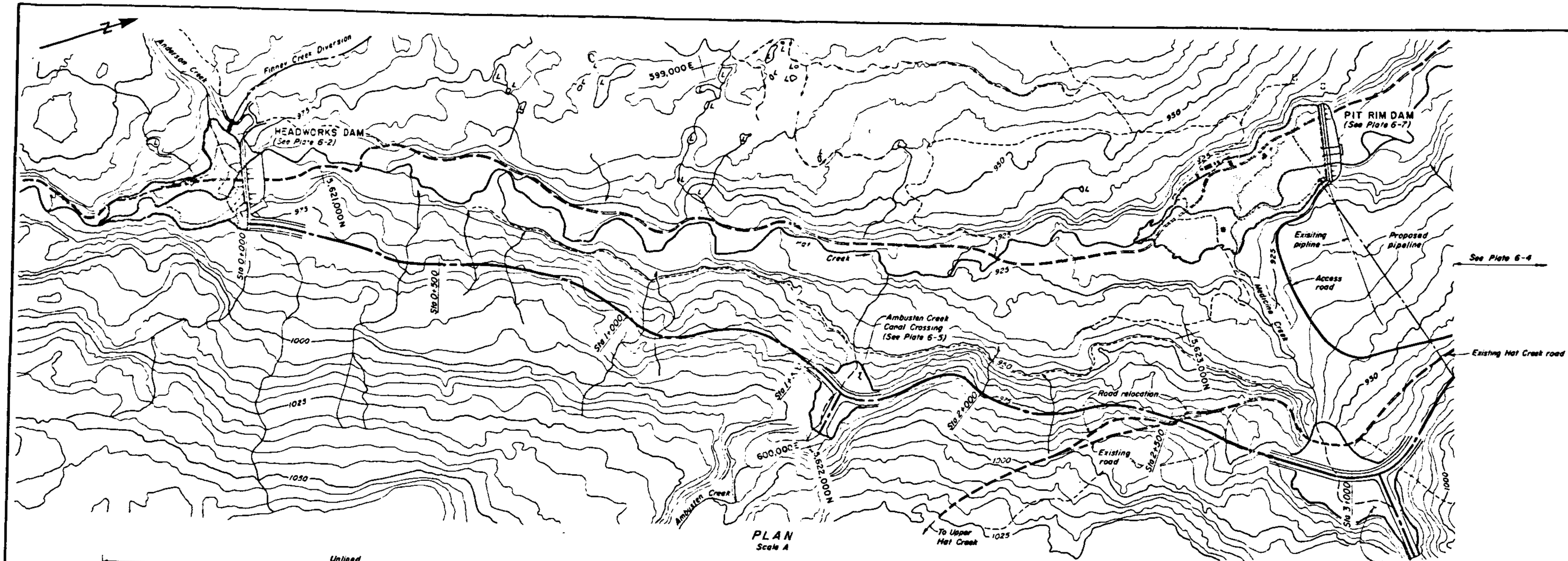


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

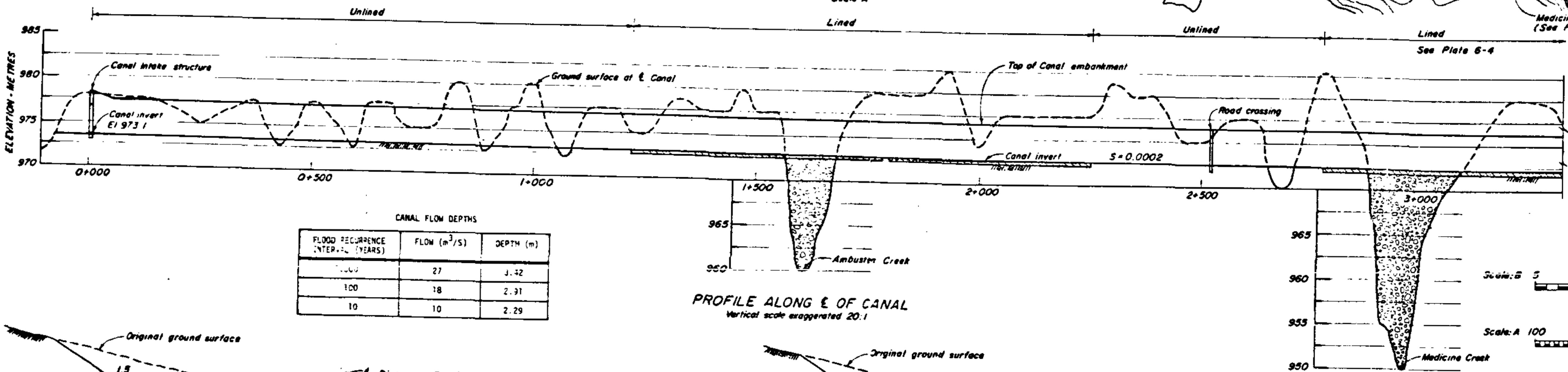
HAT CREEK PROJECT

HAT CREEK DIVERSION HEADWORKS DAM PLAN AND SECTIONS

DATE MAR 1978	PLATE 6-2 R
DWN N.O.	DWG No. 604H-C14-D49



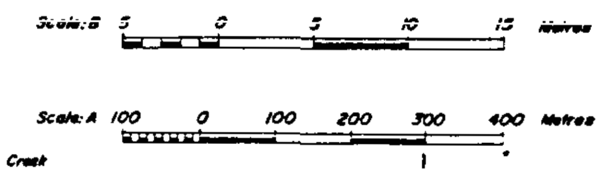
PLAN
Scale A

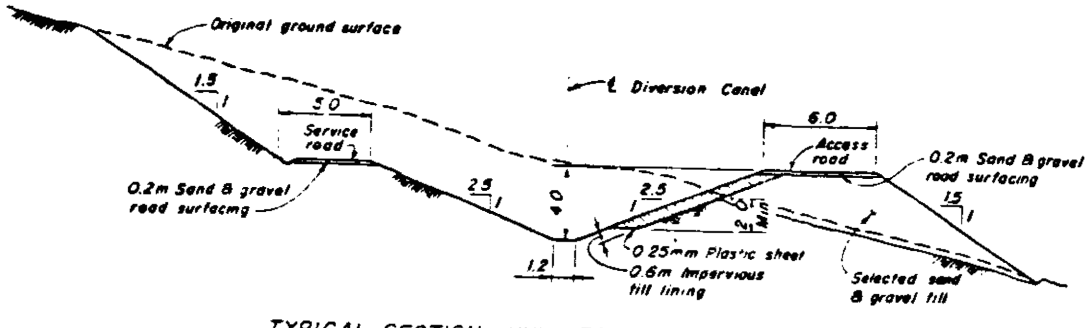


PROFILE ALONG ℄ OF CANAL
Vertical scale exaggerated 20:1

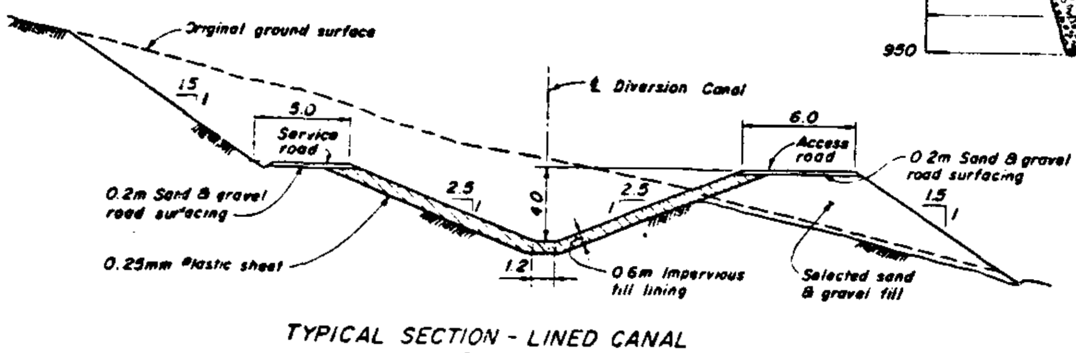
CANAL FLOW DEPTHS

FLOOD RECURRENCE INTERVAL (YEARS)	FLOW (m^3/S)	DEPTH (m)
[illegible]	27	3.42
100	18	2.31
10	10	2.29



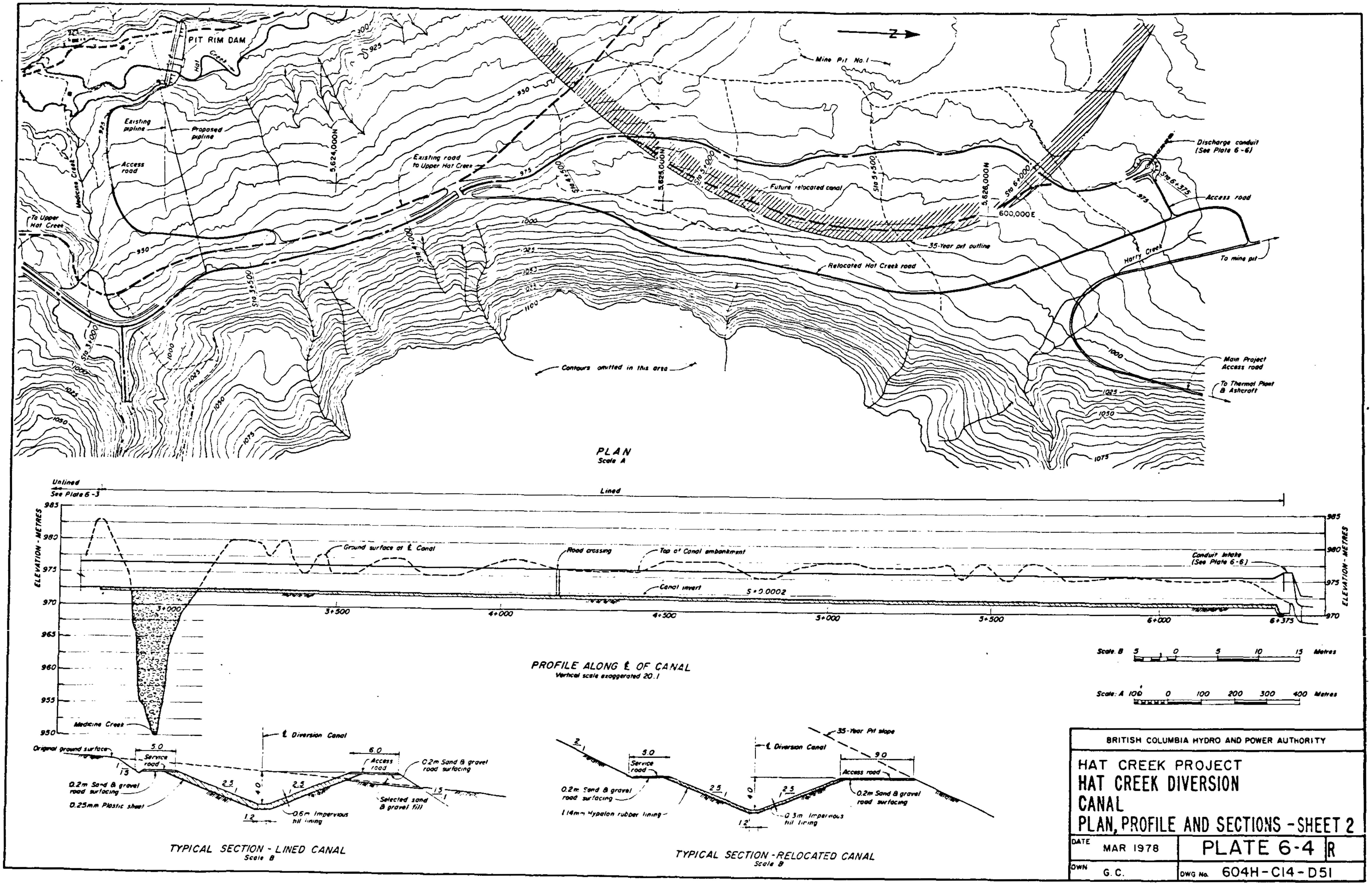


TYPICAL SECTION - UNLINED CANAL
Scale B



TYPICAL SECTION - LINED CANAL
Scale B

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT HAT CREEK DIVERSION CANAL PLAN, PROFILE AND SECTIONS - SHEET 1	
DATE MAR 1978	PLATE 6-3 R
DWN G.C.	DWG No. 604H-C14-D50



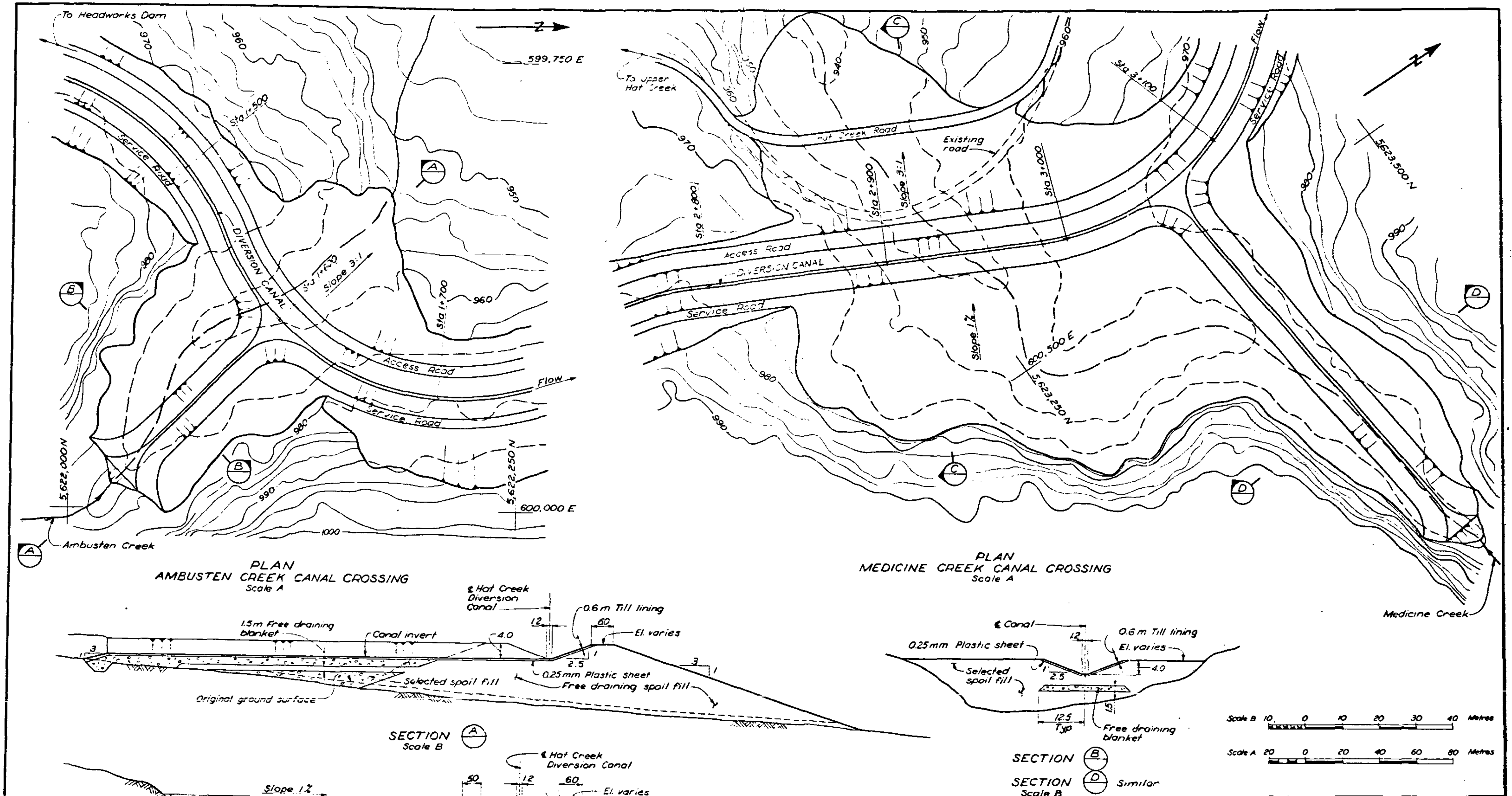
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

HAT CREEK DIVERSION CANAL

PLAN, PROFILE AND SECTIONS - SHEET 2

DATE MAR 1978	PLATE 6-4 R
DWN G.C.	DWG No. 604H-C14-D51



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

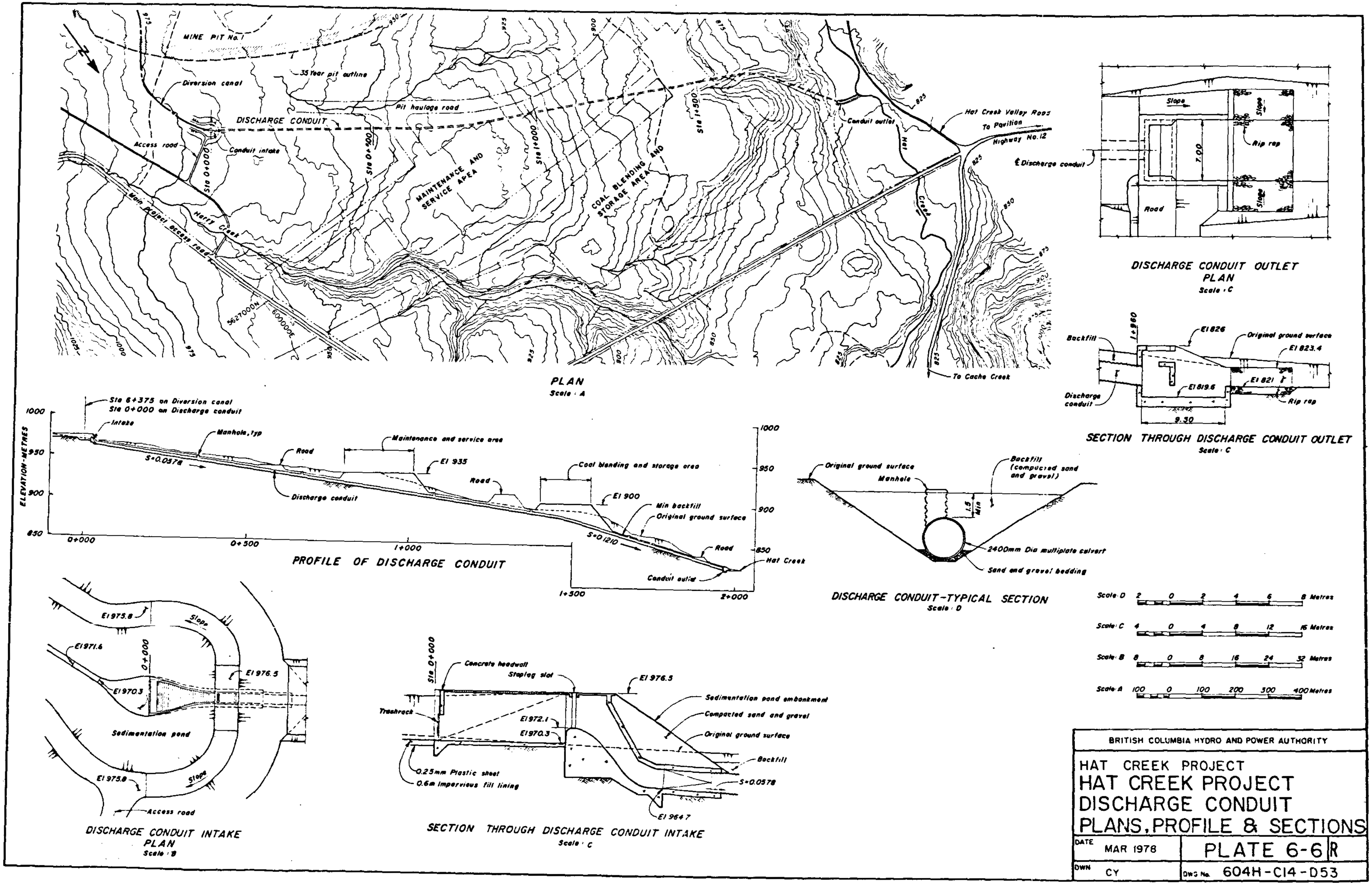
HAT CREEK PROJECT

HAT CREEK DIVERSION

AMBUSTEN & MEDICINE CREEK CANAL CROSSINGS

PLANS AND SECTIONS

DATE MAR 1978	PLATE 6-5 R
DWN D.S.	DWG No. 604H - C14 - D52



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

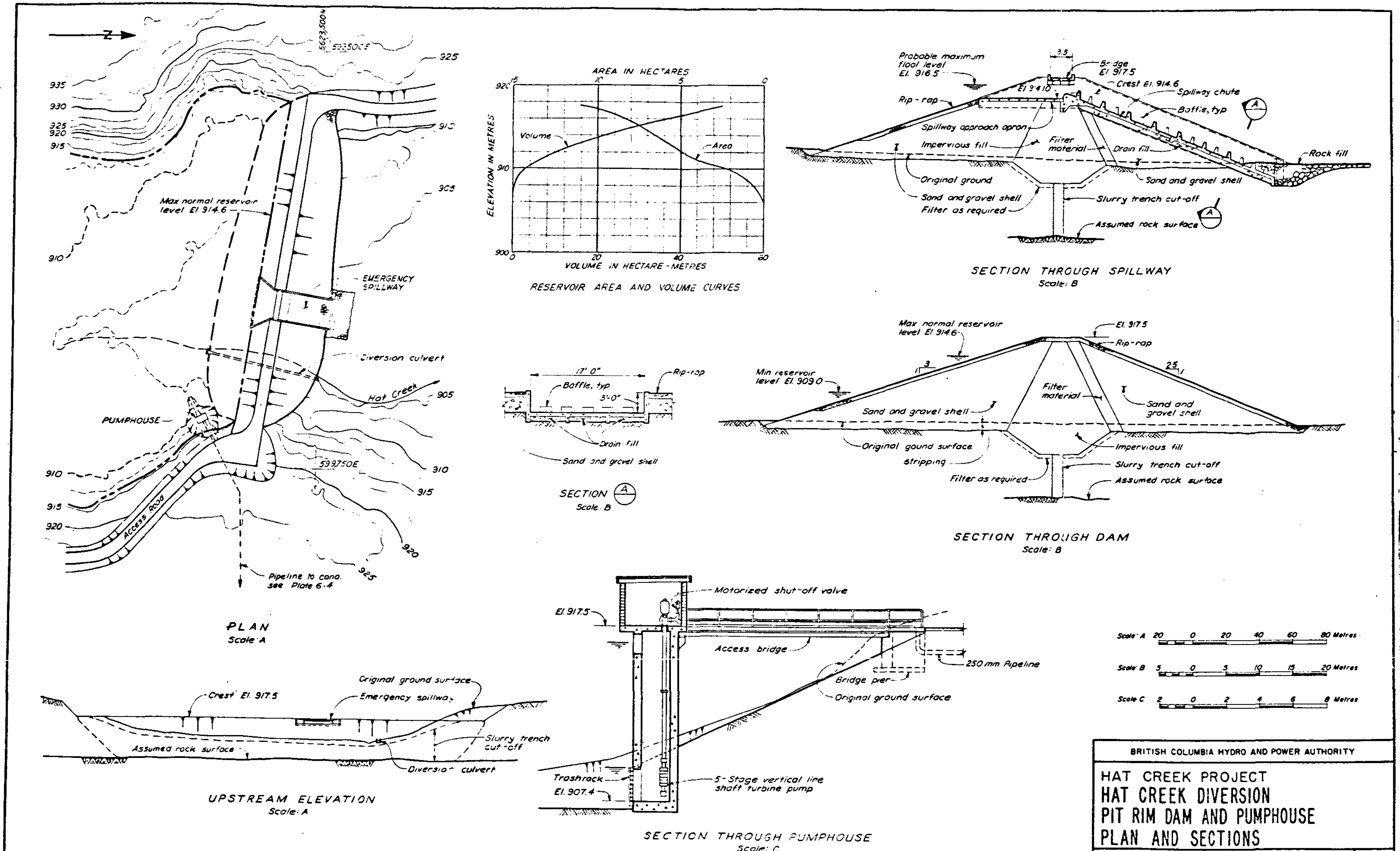
HAT CREEK PROJECT
DISCHARGE CONDUIT
PLANS, PROFILE & SECTIONS

DATE MAR 1978

PLATE 6-6 R

DWN CY

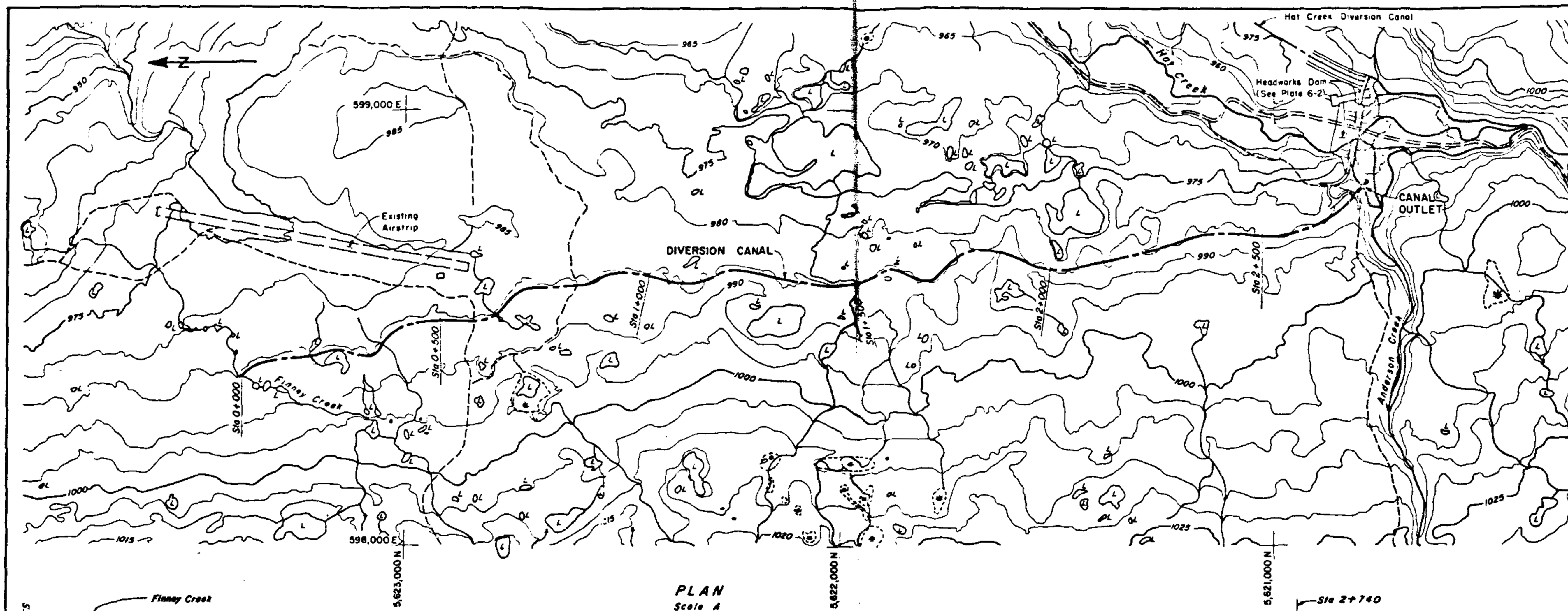
DWG No. 604H-C14-D53



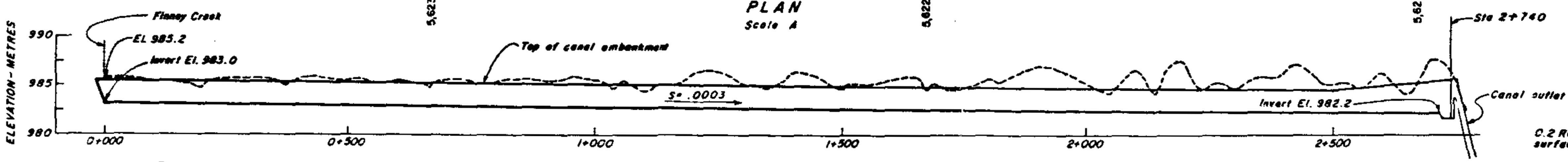
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
HAT CREEK DIVERSION
PIT RIM DAM AND PUMPHOUSE
PLAN AND SECTIONS

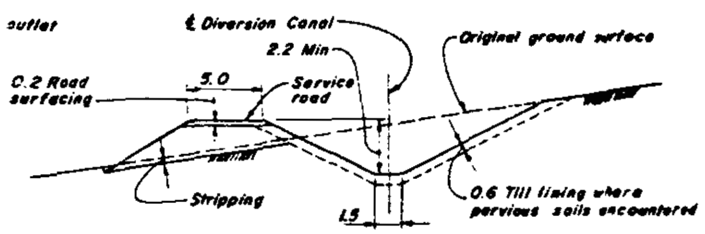
DATE	MAR 1978	PLATE 6-7	R
DWN	K.L.	DWG No. 604H-C14-D54	



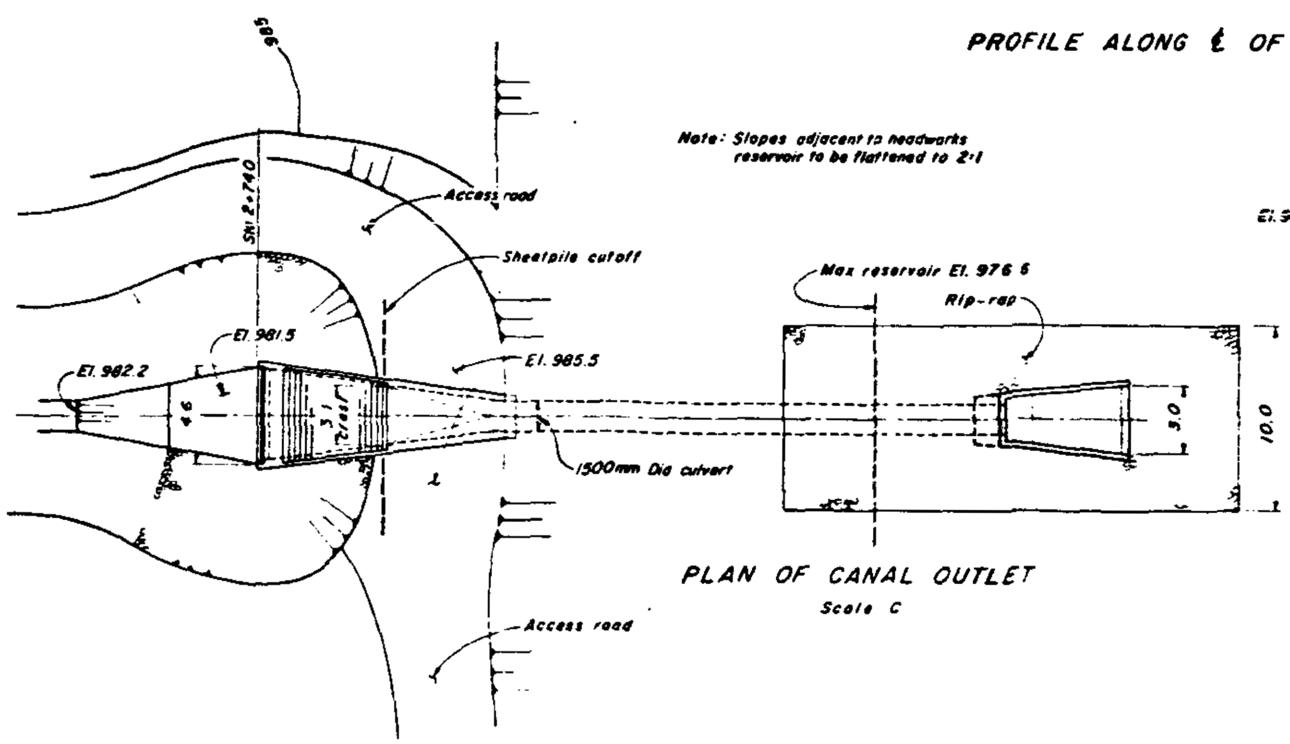
PLAN
Scale A



PROFILE ALONG ℄ OF CANAL

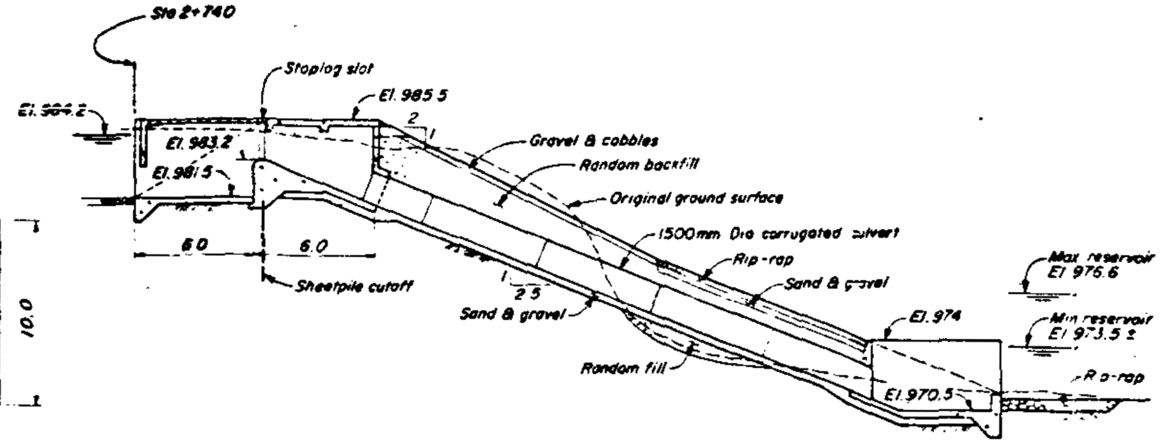


TYPICAL CANAL SECTION
Scale B



Note: Slopes adjacent to headworks reservoir to be flattened to 2:1

PLAN OF CANAL OUTLET
Scale C



SECTION THROUGH ℄ OF CANAL OUTLET
Scale C

Scale						
Scale: C	5	0	5	10	15	Metres
Scale: B	5	0	5	10	15	20 Metres
Scale: A	100	0	100	200	300	400 Metres

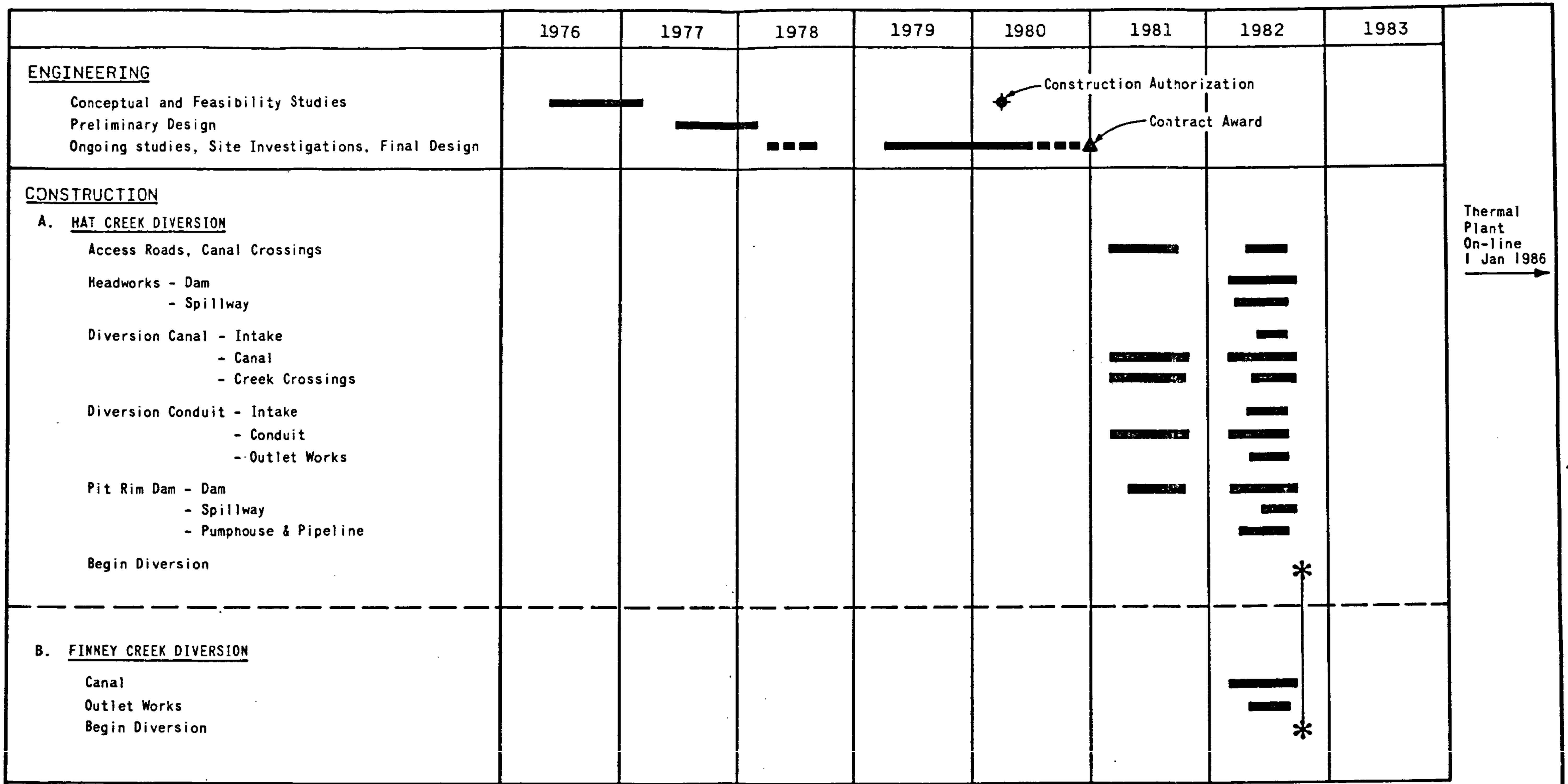
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

FINNEY CREEK DIVERSION PLAN, PROFILE AND SECTIONS

DATE MAR 1978 — PLATE 7-1 R

DWN K.L. / D.S. — DWG No. 604H-C14-D55



BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
DIVERSION OF HAT & FINNEY CREEKS
ENGINEERING & CONSTRUCTION SCHEDULE

DATE MAR 1978	PLATE 9-1 R
DWN D.S.	DWG No. 604H-C14-B56

REPORT No. 913

APPENDIX I

HAT CREEK DIVERSION

GEOLOGY AND 1977 SITE INVESTIGATIONS

APPENDIX I

HAT CREEK DIVERSION
GEOLOGY AND 1977 SITE INVESTIGATIONS

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IA.2		Test Results for the Diversion and Borrow Areas	IA - 3

PLATES

Plate No.	
IA-1	Diversion of Hat and Finney Creeks - Surficial and Bedrock Geology
IA-2	Hat Creek Diversion - Headworks and Pit Rim Dams - Geological Profiles
IA-3	Hat Creek Diversion - Canal - Geological Profile - Sheet 1
IA-4	Hat Creek Diversion - Canal - Geological Profile - Sheet 2
IA-5	Hat Creek Diversion - Headworks and Pit Rim Dams - Laboratory Test Results
IA-6	Hat Creek Diversion - Canal Foundation Materials - Laboratory Test Results
IA-7	Hat Creek Diversion - Borrow Areas - Laboratory Test Results

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	Legend and Abbreviations on Drill Hole and Test Pit Logs	i

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Plate No.	
IB-1	Logs of Test Pits
IB-2	Logs of Test Pits
IB-3 to IB-11	Logs of Percussion Drill Holes
	Geologic Drill Hole Logs of Holes P77-53, P77-57 and P77-58

TABLES

Table No.	
IB-1	Permeability Test Results for Drill Holes

APPENDIX IA

SURFICIAL GEOLOGY

APPENDIX IA
SURFICIAL GEOLOGY

IA.1 SURFICIAL GEOLOGY OF THE DIVERSION AREA

The Hat Creek valley is located within an intermontane basin filled with a thick accumulation of volcanic and clastic sedimentary materials deposited during the Tertiary period. These Tertiary rocks overlie faulted and eroded Upper Paleozoic rocks. During the Pleistocene Epoch, glaciation modified the Tertiary surface and deposited a complex series of glacial and glaciofluvial sediments. Alluvial fans and mud flows have since been deposited over the Pleistocene sediments along some of the tributary creek valleys.

Most of the area in which the Hat Creek diversion works are located is underlain by siltstone-claystone bedrock of the Medicine Creek Formation (Plate IA-1). These rocks are soft and form a monotonous, generally massive sequence. One occurrence of volcanic rock was found in a drill hole on the left abutment of the headworks dam. However, at both the headworks and pit rim damsites and along the canal route, there are no bedrock outcrops. The surficial geology of the diversion area is shown on Plate IA-1. Geological profiles for the headworks and pit rim dams are shown on Plate IA-2 with profiles of the canal route on Plates IA-3 and IA-4. A brief description of the surficial deposits follows:

Ground Moraine and Till Blanket

This material covers much of the area and underlies other surficial deposits. It is a dense, gravelly basal till with a silt and clay matrix. Its thickness ranges from a thin veneer to several hundred meters. Permeability is generally low, as evidenced by numerous lakes in the area.

IA.1 SURFICIAL GEOLOGY OF THE DIVERSION AREA - (Cont'd)

From Anderson Creek to Medicine Creek, along the canal route, there is a thin cover of gravel and sand 1 to 4 m thick overlying the moraine. This gravel and sand may be of glaciofluvial origin.

Glaciofluvial Sands and Gravels with Interbedded Till

A large area between Medicine Creek and Harry Creek on the right bank is covered by this mixed deposit. In general there appears to be a basal till layer underlying a sand and gravel deposit which progressively thickens towards the north. On a smaller scale, mixed interbeds of till, sand, gravel and sometimes silt, occur locally. Borrow areas for both till and sand and gravel have been proposed within this unit.

Alluvial Plain Deposits

A narrow floodplain exists along most of Hat Creek downstream from Anderson Creek. The floodplain generally consists of a surficial veneer of silt overlying up to about 5 m of sand and gravel. In the lower reaches of Hat Creek, the thickness of the sand and gravel probably increases. Till generally underlies the floodplain deposits throughout the area.

Alluvial Fan Deposits

Alluvial fans resulting from fluvial deposition by Ambusten and Medicine creeks extend along part of the right bank of Hat Creek to the valley bottom. These deposits consist of interlayered sands and gravels with some silts. In general, the material is moderately loose and drains well. It overlies till or ground moraine within the area shown on Plate IA-1.

IA.2 TEST RESULTS FOR THE DIVERSION AND BORROW AREAS

Samples obtained from drill holes and test pits at the damsites and along the canal route were tested in the laboratory by Klohn Leonoff Consultants Ltd. The test results are shown on Plates IA-5 and IA-6.

Headworks and Pit Rim Damsites

At these damsites the test results show that mixed deposits containing zones of pervious sandy gravel, till and silt exist. Atterberg Limits indicate that the silty clayey till has medium to high plasticity. Undrained direct shear tests on unsaturated till samples at their natural water content show a residual friction angle of about 30^{o}.

Canal Route

Over the upstream third of the canal length, the overburden consists of a thin layer of sand and gravel overlying glacial till. Mixed deposits containing zones of silty clay, till and sandy gravel occur over the remainder of the canal alignment. Gradation curves and other tests data are shown on Plate IA-6. The silts and clays encountered exhibit medium to high plasticity. The glacial till is compact to dense and has a fines content varying from about 20 to 60 percent. Sands and gravels range from pervious to semi-pervious.

Borrow Areas

The total volume of the fill required for the dams and canal embankments is about 1.4 million m^3 comprising:

Earthfill dam core and impervious lining	=	150 000 m^3
Sandy gravels for dam shells and canal dykes	=	1 250 000 m^3

IA.2 TEST RESULTS FROM THE DIVERSION AND BORROW AREAS - (Cont'd)

As discussed in Sub-section 4.2 of the main report it is expected that much of the canal embankment and lining material would be available from the required canal excavation while the remaining earthfill quantities would be obtained from suitable mine wastes disposed of in the Medicine Creek waste dump. Should suitable materials be unavailable at the waste dump as required, the remaining quantities could be obtained directly from Borrow Areas A, F and G (see Plate 4-1). Laboratory test results for samples from these borrow areas are shown on Plate IA-7. The borrow areas are briefly described as follows:

(a) Borrow Area A

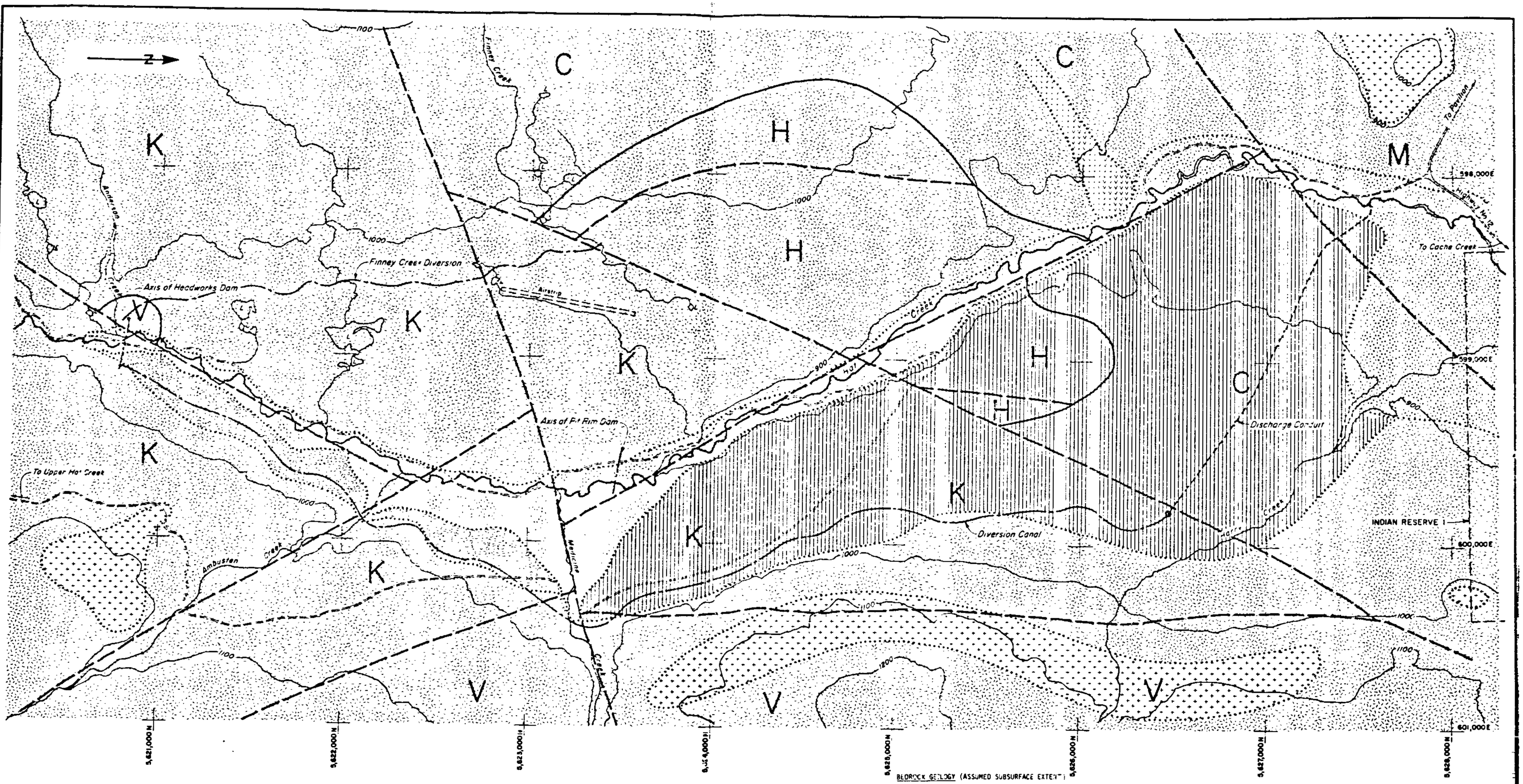
Borrow Area A, located on the east side of the diversion canal near Medicine Creek, contains well graded till material with a fines content ranging from 30 to 55 percent. The natural moisture content averages about 14 percent. The estimated quantity available in Area A is about 2 million m^3.

(b) Borrow Area F

Borrow Area F is located east of Hat Creek within the area of early mine pit excavation. It contains well graded gravel with a fines content less than 12 percent. The estimated quantity of clean sand and gravel in this area is at least 10 million m^3.

(c) Borrow Area G

Borrow Area G, also located on the east side of Hat Creek within the area of early mine pit excavation, contains well graded till material with a fines content ranging from 15 to 70 percent. The quantity and quality of suitable fill from this area requires further investigation.



Scale: 200 0 200 400 600 800 Metres

LEGEND

SURFICIAL GEOLOGY

- LANDSLIDE
- ALLUVIAL FAN, FLOODPLAIN DEPOSITS
- THIN SILTY SAND AND GRAVEL LAYER OVERLYING GROUND MORAINE
- GROUND MORAINE, TILL VENEER, TILL BLANKET
- SAND AND GRAVEL AND TILL, OCCURS IN POCKETS, SOME INTERBEDDING
- ROCK OUTCROPS, ROCK HUMMOCKS
- ASSUMED SURFICIAL GEOLOGY CONTACTS

BEDROCK GEOLOGY (ASSUMED SUBSURFACE EXTENT)

- FAULTS & LINEAMENTS (TOPOGRAPHIC AND GEOPHYSICAL)
- ASSUMED GEOLOGICAL CONTACTS

EOCENE

CENOZOIC

- K KAMLOOPS GROUP: MEDICINE CREEK FORMATION: SILTSTONE, CLAYSTONE
- H HAT CREEK COAL FORMATION: COAL (NEAR SURFACE)
- C COLDWATER BEDS: SANDSTONE, SILTSTONE, CONGLOMERATE, MINOR SHALE AND CLAYSTONE
- V VOLCANICS: DACITE, VESICULAR BASALT RHYOLITE, ANDESITE

PALEOZOIC

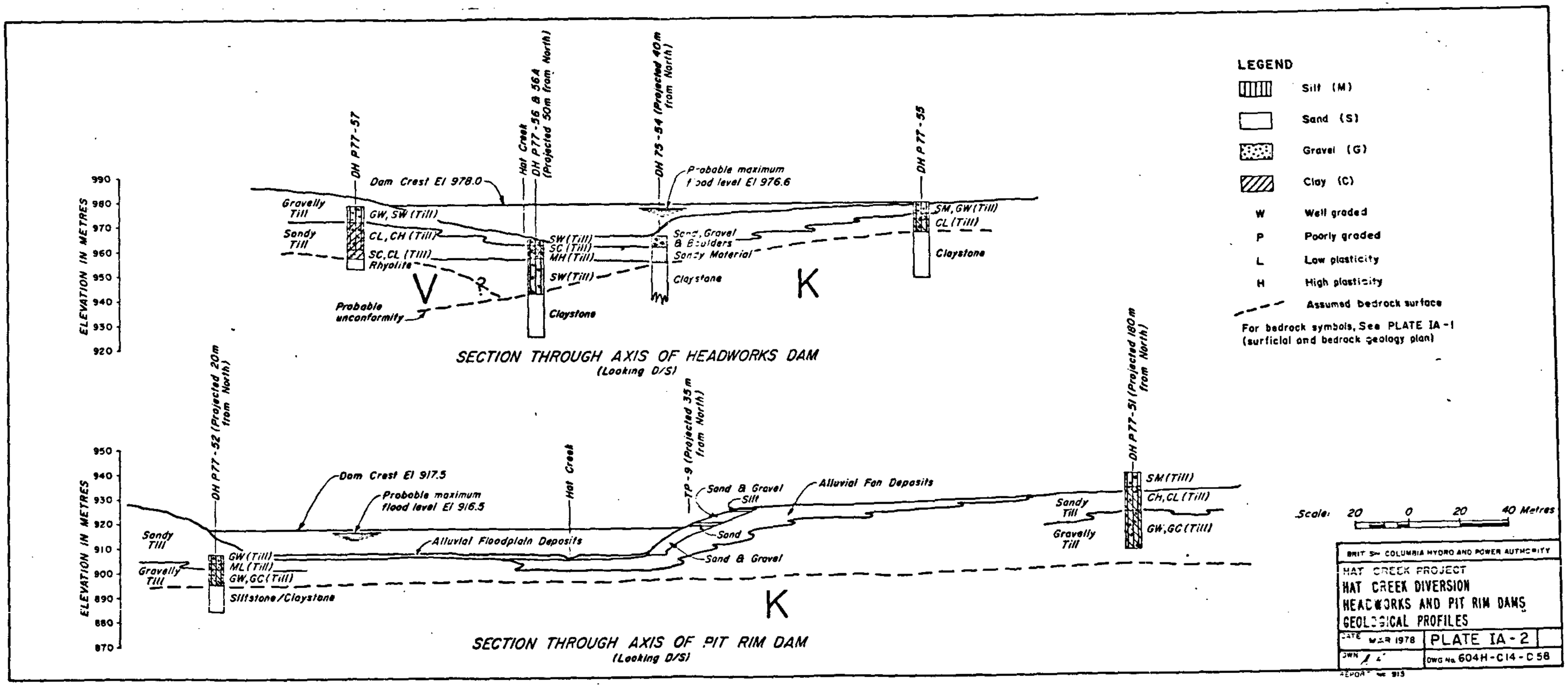
- M CACHE CREEK GROUP: MARBLE CANYON FORMATION: LIMESTONE

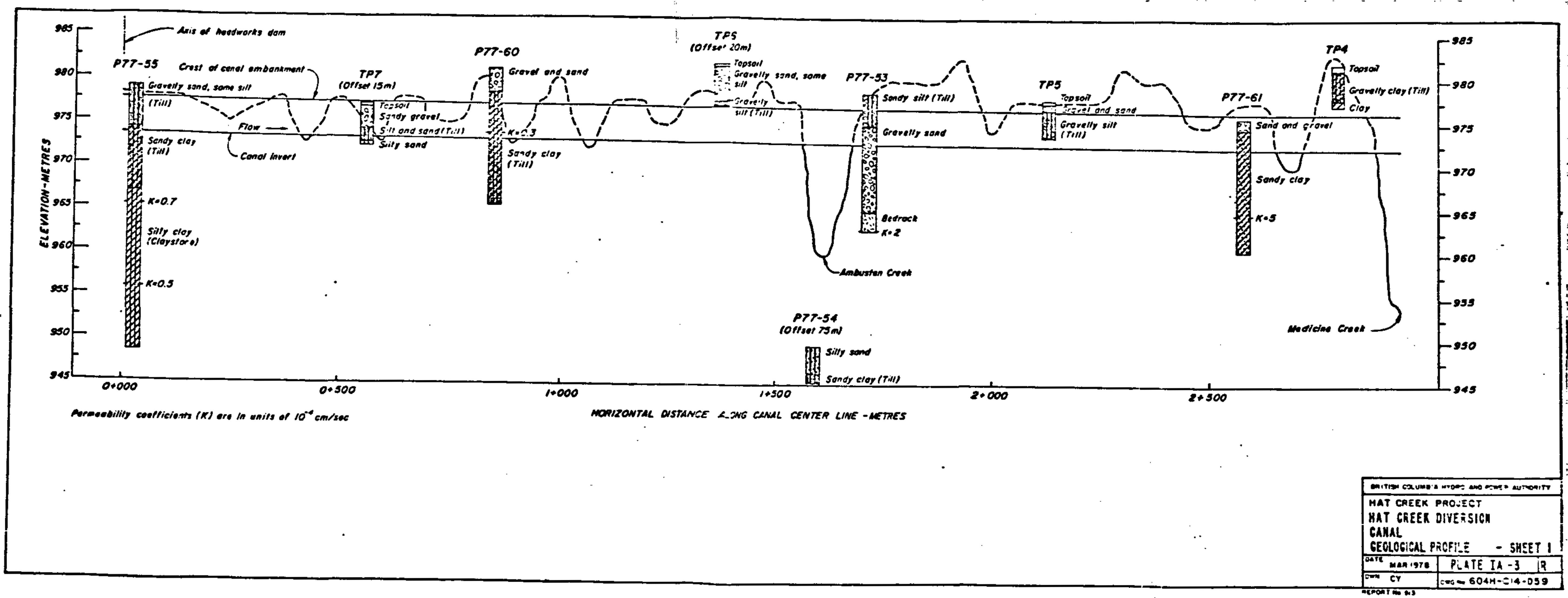
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

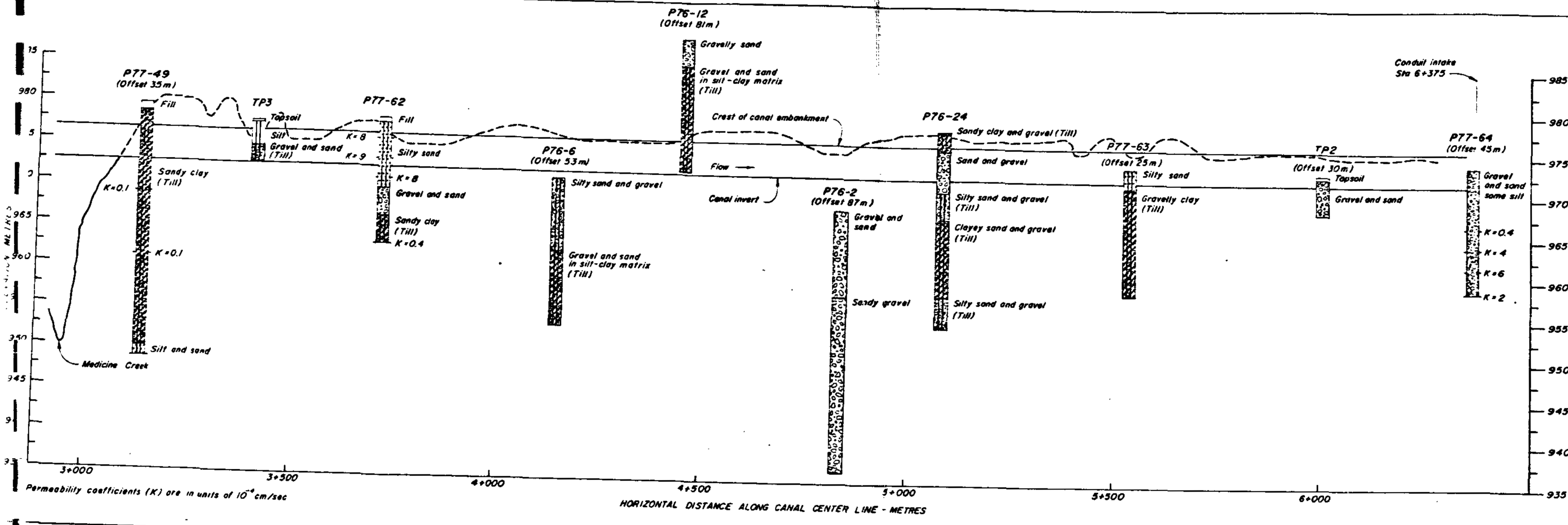
DIVERSION OF HAT AND FINNEY CREEKS SURFICIAL AND BEDROCK GEOLOGY

DATE	MAR 1978	PLATE IA-1	R
DWN	A.V.	DWG No. 604H-C14-D57	


LEGEND
Silt (M)
Sand (S)
Gravel (G)
Clay (C)
W Well graded
P Poorly graded
L Low plasticity
H High plasticity
Assumed bedrock surface
For bedrock symbols, See PLATE IA-1 (surficial and bedrock geology plan)
ELEVATION IN METRES
DH P77-57
Hat Creek
DH P77-56 & 56A (Projected 50m from North)
DH 75-54 (Projected 40m from North)
DH P77-55
Dam Crest El 978.0
Probable maximum flood level El 976.6
Gravelly Till
Sandy Till
GW, SW (Till)
CL, CH (Till)
SC, CL (Till)
Rhyolite
SW (Till)
SC (Till)
MH (Till)
SW (Till)
Sand, Gravel & Boulders
Sandy Material
SM, GW (Till)
CL (Till)
Claystone
V
K
Probable unconformity
SECTION THROUGH AXIS OF HEADWORKS DAM
(Looking D/S)
DH P77-52 (Projected 20m from North)
Hat Creek
TP-9 (Projected 35m from North)
DH P77-51 (Projected 180m from North)
Dam Crest El 917.5
Probable maximum flood level El 916.5
Sand & Gravel
Silt
Alluvial Fan Deposits
Alluvial Floodplain Deposits
Sand
Sand & Gravel
Sandy Till
Gravelly Till
GW (Till)
ML (Till)
GW, GC (Till)
Siltstone/Claystone
SM (Till)
CH, CL (Till)
GW, GC (Till)
SECTION THROUGH AXIS OF PIT RIM DAM
(Looking D/S)
Scale: 20 0 20 40 Metres
HAT CREEK PROJECT
HAT CREEK DIVERSION
HEADWORKS AND PIT RIM DAMS
GEOLOGICAL PROFILES
DATE MAR 1978
PLATE IA-2
DWG No. 604H-C14-C58



Axis of headworks dam
P77-55
Crest of canal embankment
Gravelly sand, some silt
(Till)
Sandy clay
(Till)
K=0.7
Silty clay
(Claystone)
K=0.5
Flow
Canal invert
TP7
(Offset 15m)
Topsoil
Sandy gravel
Silt and sand (Till)
Silty sand
P77-60
Gravel and sand
K=0.3
Sandy clay
(Till)
TP5
(Offset 20m)
Topsoil
Gravelly sand, some silt
Gravelly silt (Till)
P77-53
Sandy silt (Till)
Gravelly sand
Bedrock
K=2
Ambusten Creek
P77-54
(Offset 75m)
Silty sand
Sandy clay (Till)
TP5
Topsoil
Gravel and sand
Gravelly silt
(Till)
P77-61
Sand and gravel
Sandy clay
K=5
TP4
Topsoil
Gravelly clay (Till)
Clay
Medicine Creek
ELEVATION-METRES
985
980
975
970
965
960
955
950
945
0+000
0+500
1+000
1+500
2+000
2+500
Permeability coefficients (K) are in units of 10⁻⁴ cm/sec
HORIZONTAL DISTANCE ALONG CANAL CENTER LINE - METRES
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
HAT CREEK DIVERSION CANAL
GEOLOGICAL PROFILE - SHEET 1
DATE MAR 1978
PLATE IA-3 R
DWN CY
DWG No 604H-C14-059

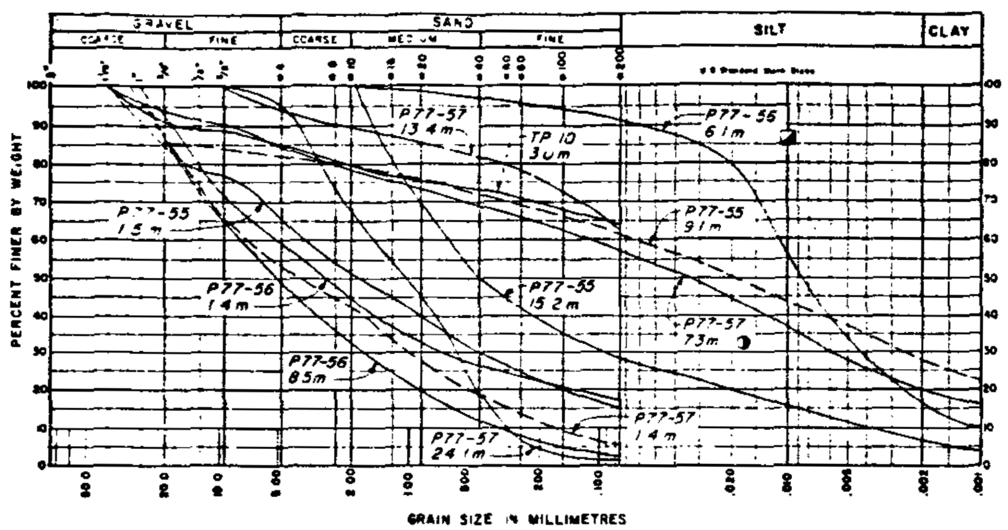


BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

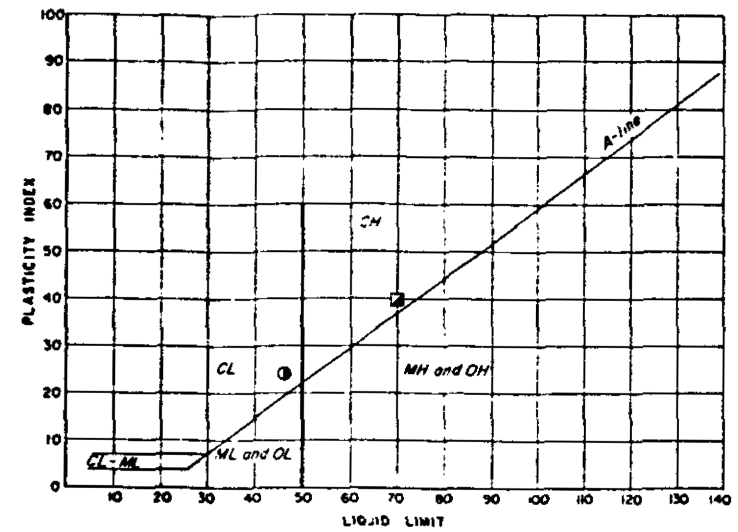
HAT CREEK PROJECT
HAT CREEK DIVERSION CANAL
GEOLOGICAL PROFILE - SHEET 2

DATE MAR 1978	PLATE IA-4	R
DWN CY	DWG No 604H-C14-U6C	

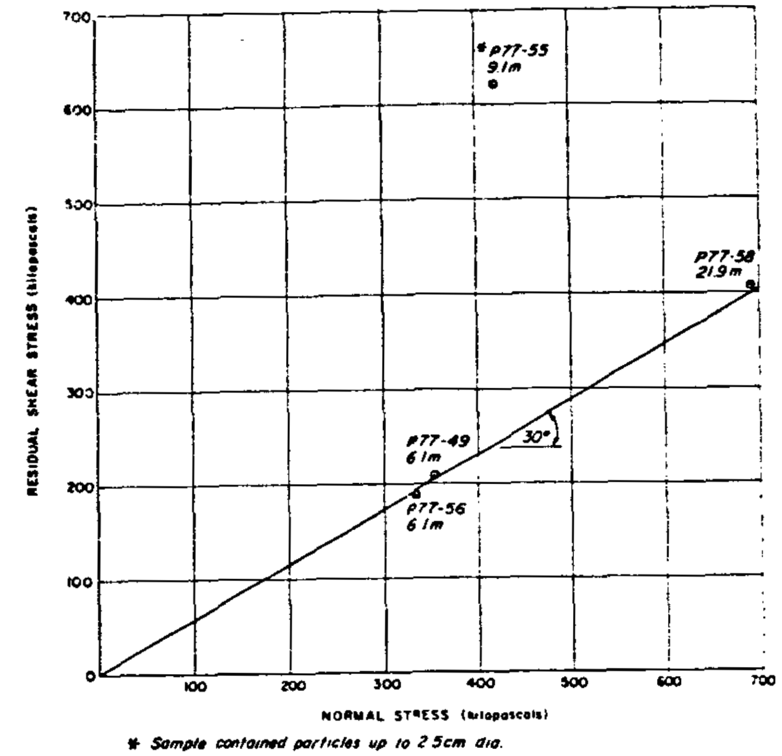
REPORT No. 913



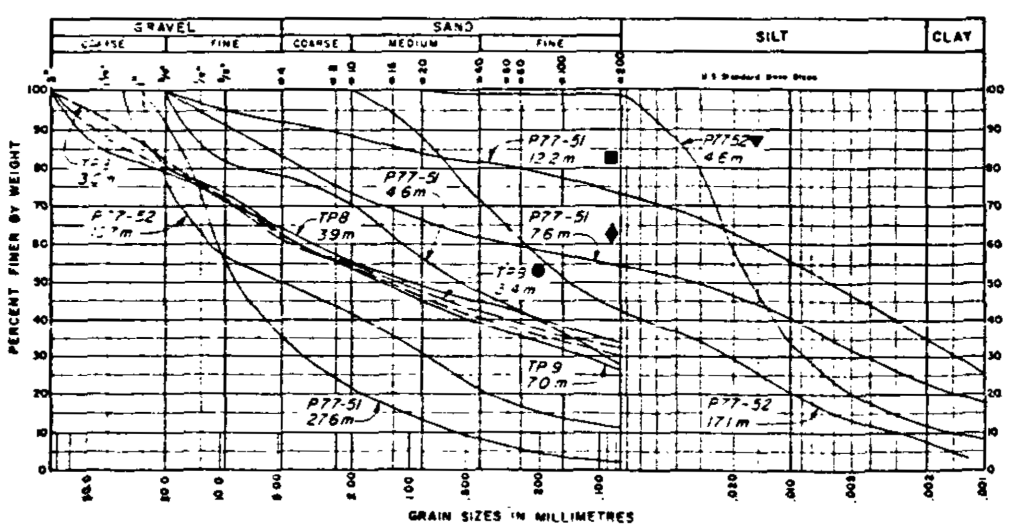
GRADATION CURVES - CANAL HEADWORKS DAMSITE FOUNDATION MATERIALS



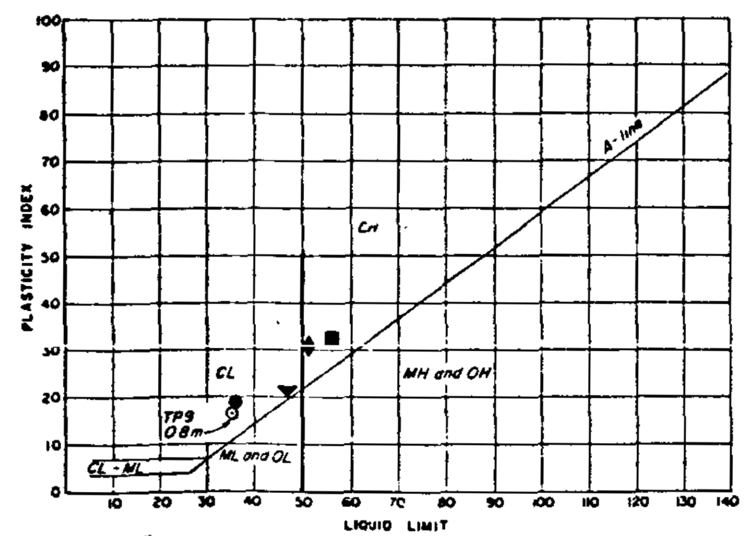
ATTERBERG LIMITS FOR SAMPLES OF TILL FROM CANAL HEADWORKS DAMSITE



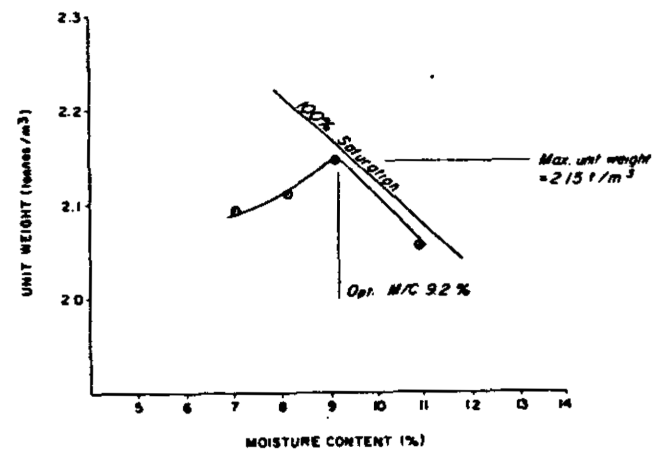
UNDRAINED DIRECT SHEAR TESTS ON CLAYEY FOUNDATION MATERIAL



GRADATION CURVES - PIT RIM DAMSITE FOUNDATION MATERIALS



ATTERBERG LIMITS FOR SAMPLES OF TILL FROM PIT RIM DAMSITE

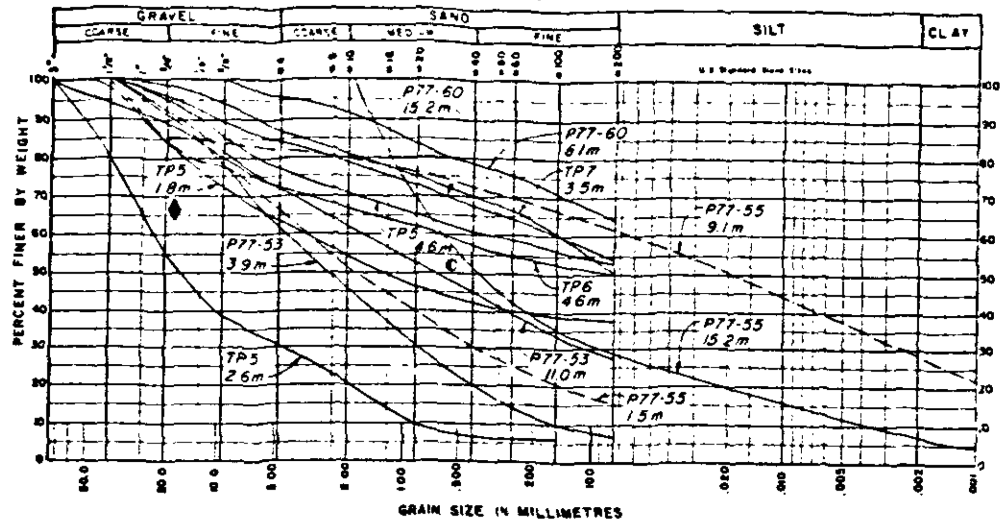


COMPACTION TEST RESULTS - PIT RIM DAM

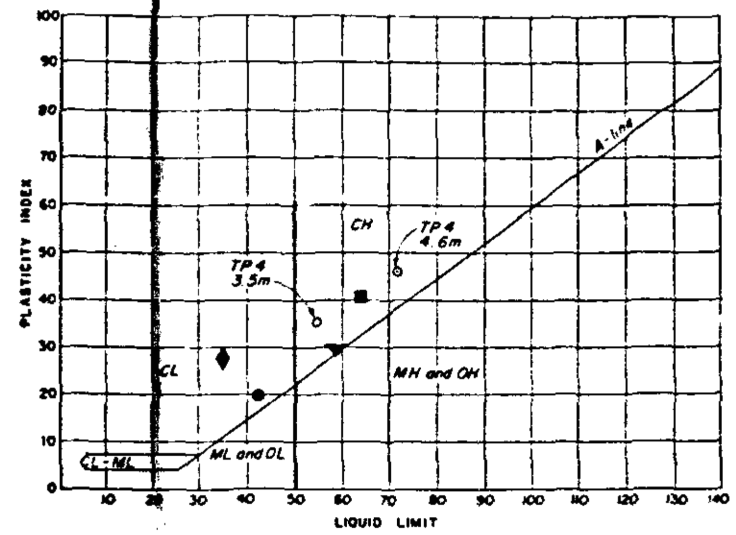
Modified Proctor - ASTM Method C

TP8 at 3.0 and 3.7m ●

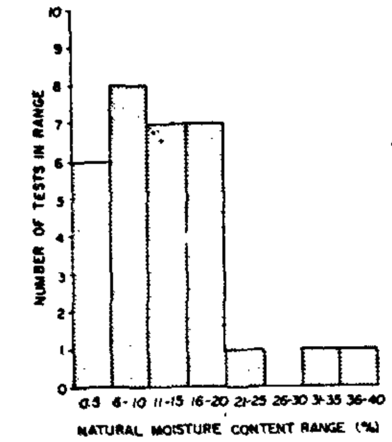
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT HAT CREEK DIVERSION HEADWORKS AND PIT RIM DAMS LABORATORY TEST RESULTS	
DATE MAR 1978	PLATE IA-5 R
DWN K. L.	DWG No. 604H-C14-D61



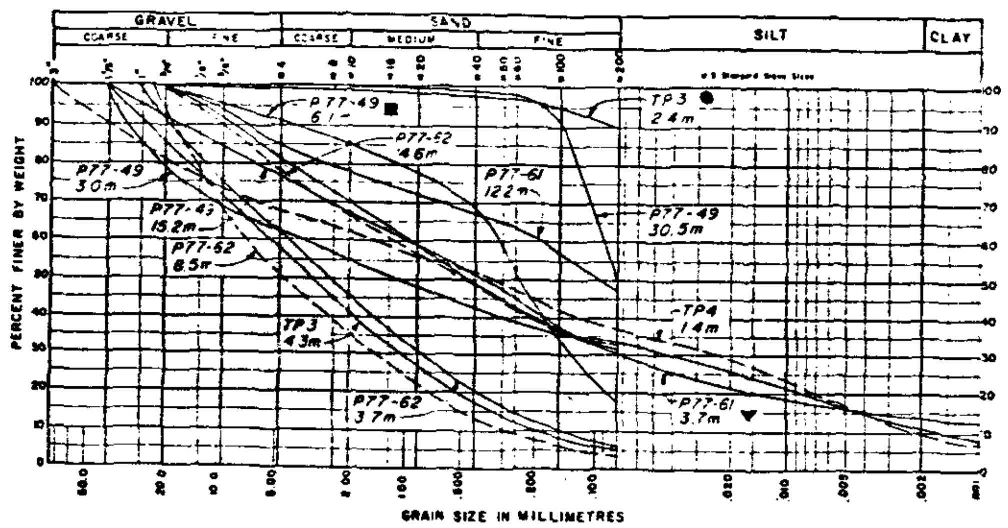
GRADATION CURVES - CANAL ROUTE - UPSTREAM SECTION
Sta 0+000 to Sta 2+500



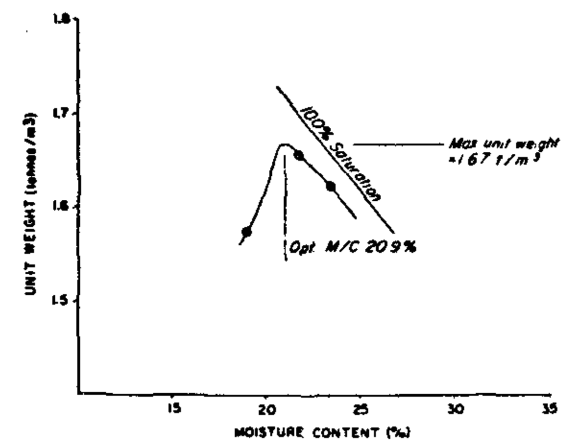
ATTERBERG LIMITS FOR SAMPLES OF TILL AND SILTY CLAY ALONG CANAL ROUTE



NATURAL MOISTURE CONTENTS FOR TILL ALONG CANAL ROUTE
Upper 10m of holes only



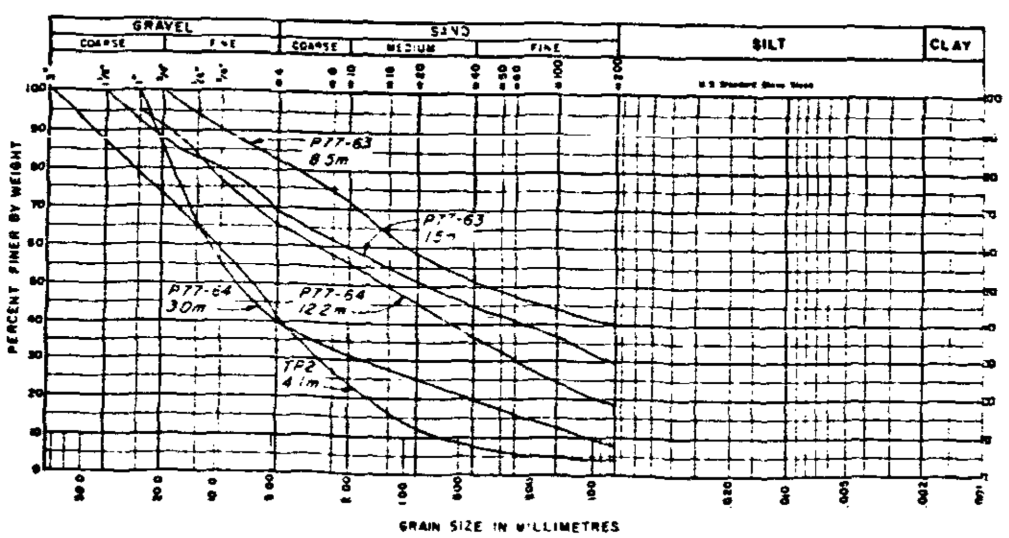
GRADATION CURVES - CANAL ROUTE - CENTER SECTION
Sta. 2+500 to Sta. 4+500



COMPACTION TEST RESULTS - CANAL ROUTE
Modified Proctor - ASTM Method C
TP5 at 4.6m

AREA	HOLE #	DEPTH (m)	AVERAGE SPECIFIC GRAVITY
CANAL ROUTE	P77-49	3.0	2.69
PIT RIM DAM	P77-51	4.6	2.72
CANAL HEADWORKS DAM	P77-57	14	2.74

SPECIFIC GRAVITY MEASUREMENTS

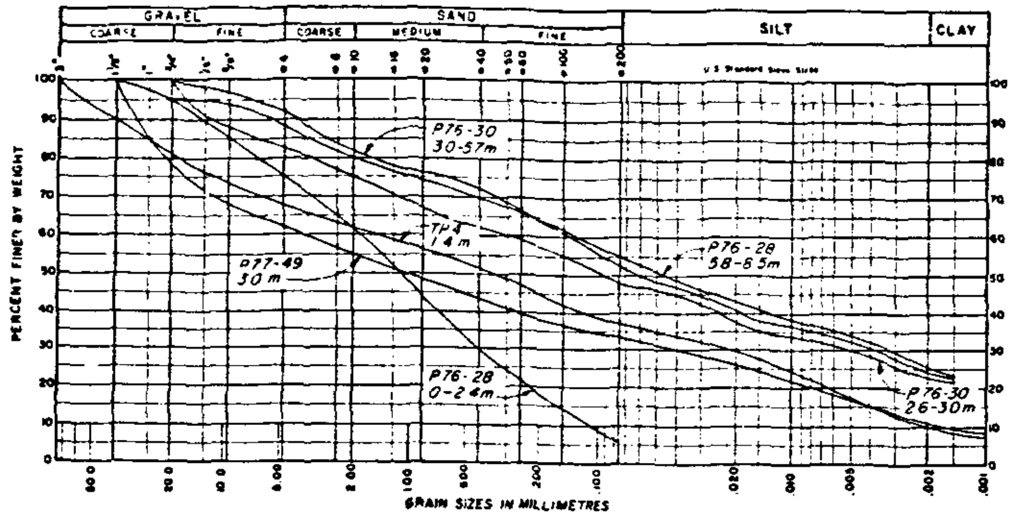


GRADATION CURVES - CANAL ROUTE - DOWNSTREAM SECTION
Sta 4+500 to Sta 6+375

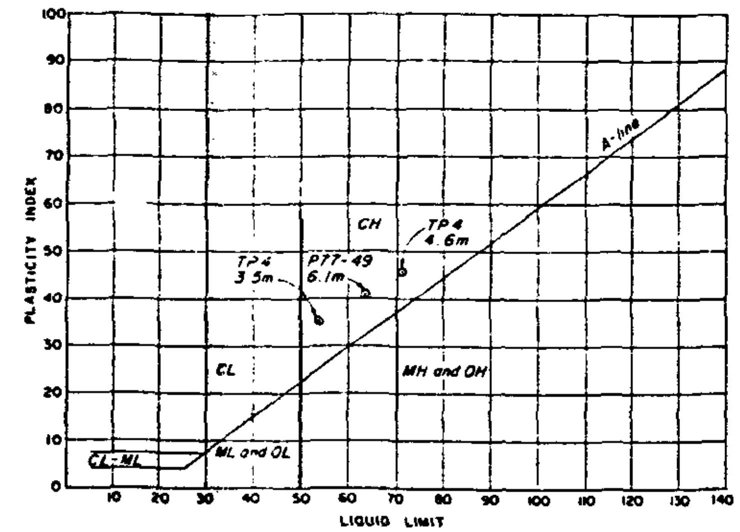
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT
HAT CREEK DIVERSION
CANAL FOUNDATION MATERIALS
LABORATORY TEST RESULTS

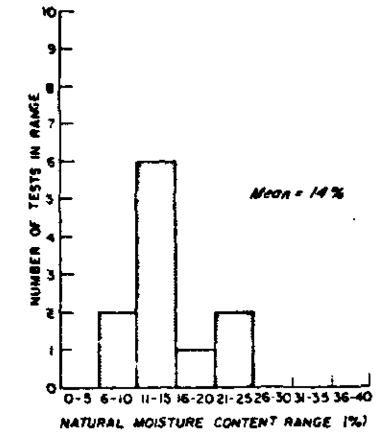
DATE MAR 1978	PLATE IA-6 R
DWN KL.	DWG No. 604H-C14-D62



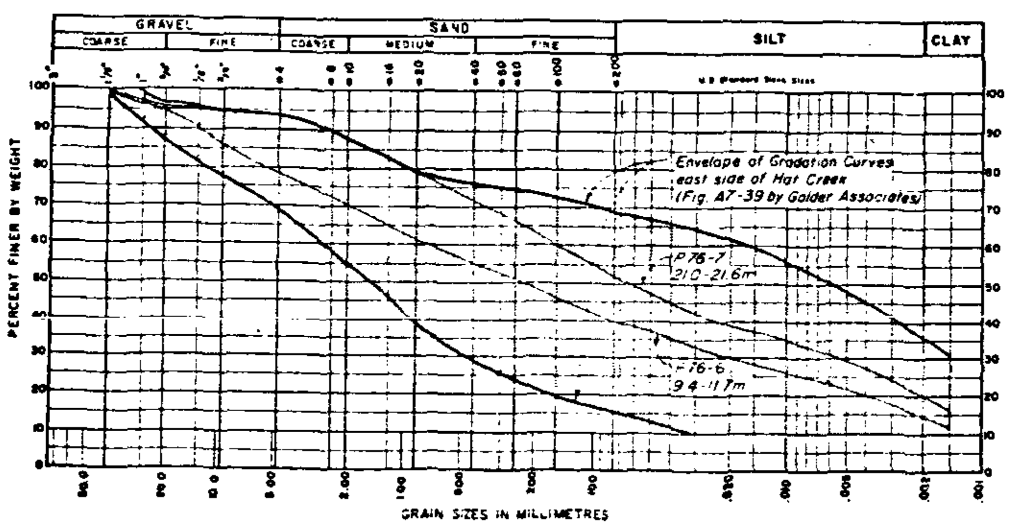
GRADATION CURVES REPRESENTING TILL FROM BORROW AREA "A"



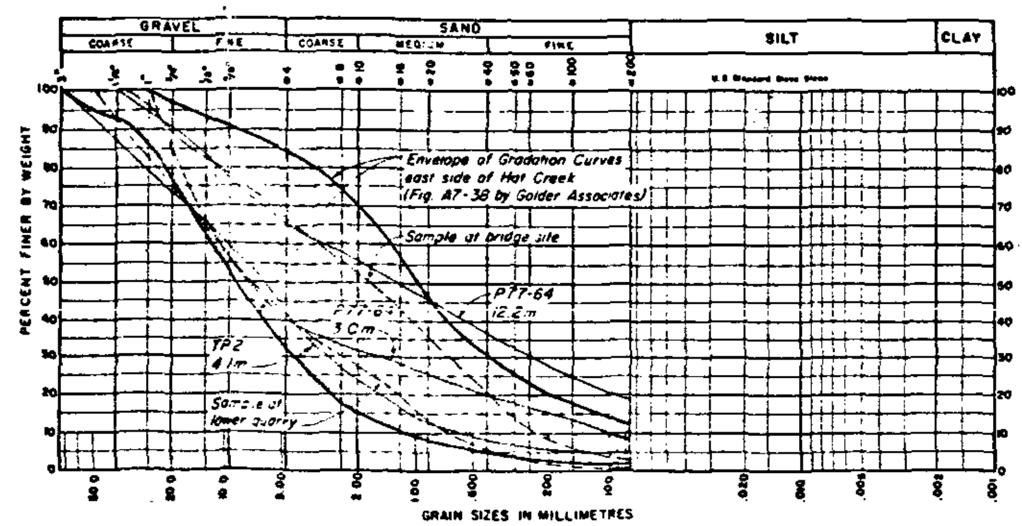
ATTERBERG LIMITS FOR SAMPLES REPRESENTING TILL AT BORROW AREA "A"



NATURAL MOISTURE CONTENTS FOR SAMPLES REPRESENTING TILL FROM BORROW AREA "A"



GRADATION CURVES REPRESENTING TILL FROM BORROW AREA "G"



GRADATION CURVES REPRESENTING GRAVEL FROM BORROW AREA "F"

N O T E:

ALL TEST DATA WERE TAKEN FROM GOLDER ASSOCIATES REPORT ENTITLED "HAT CREEK GEOTECHNICAL STUDY - REPORT NO. 6", MARCH 1977 EXCEPT THOSE FOR TP-2, TP-4, P77-49 AND P77-64 WHICH WERE CARRIED OUT BY B. C. HYDRO.

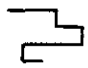
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY	
HAT CREEK PROJECT HAT CREEK DIVERSION BORROW AREAS LABORATORY TEST RESULTS	
DATE MAR 1978	PLATE IA-7 R
DWN G.C	DWG No. 604H-C14-D63

APPENDIX IB

1977 SITE INVESTIGATIONS

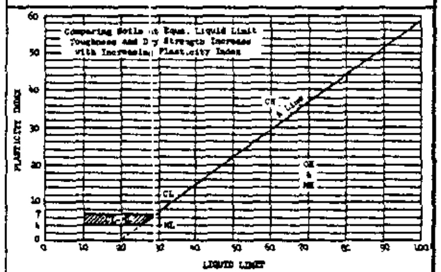
DRILL HOLE AND TEST PIT LOGS

LEGEND AND ABBREVIATIONS
ON DRILL HOLE AND TEST PIT LOGS

SYMBOL	DESCRIPTION	UNIT
SS	Split Spoon Sample (SPT), driven	
HW	Heavy Walled Shelby Tube Sample, driven	
C	Drill Cuttings from air or water return	
(24)	Standard Penetration Resistance (N Value) - 140 lb. Hammer, 30 in. drop	blows/30 cm
	Penetration Resistance for 5½ in. dia. Becker Drill casing driven open ended with 8000 ft-lb deisel hammer	blows/30 cm
o	Natural Water Content	percent
x-----------x	Plastic and Liquid Limits	percent
	3/4 in. dia. PVC standpipe	
	Sand-cement grout	
	Pea gravel	
	Bentonite clay seal	
	#16 Silica Sand	
	1½ in. dia. slotted PVC pipe	
▼	Water level in standpipe at date shown	
✳	Location of falling head permeability test	
■	Location of pressure (packer permeability test)	
	Sand & Gravel	
	Silt	
	Clay	
	Till	
	Bedrock	
bdrk	Bedrock	
bldr(s)	Boulder(s)	
cbl(s)	Cobble(s)	
fgmt(s)	Fragment(s)	
lyrd	Layered	
org	Organic	
pkt	Pocket	
Rt	Root	
tpsl	Topsoil	
sm(s)	Seam(s)	
wx	Weathered bedrock	

UNIFIED SOIL CLASSIFICATION
(Including Identification and Description)

Major Divisions (1)	Major Divisions (2)		Group Symbols (3)	Typical Names (4)	Field Identification Procedures (Excluding particles larger than 3 inches and basing fractions on estimated weights) (5)			Information Required for Describing Soils (6)	Laboratory Classification Criteria (7)	
Coarse-grained Soils. More than half of material is LARGER than No. 200 sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels. More than half of coarse fraction is larger than No. 4 sieve size. (For visual classification, the 1/4-in. size may be used as equivalent to the No. 4 sieve size)	Clean Gravels (Little or no fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.			For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics.	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse-grained soils are classified as follows: Less than 5%: GW, GP, SW, SP. More than 12%: GM, GC, SM, SC. 5% to 12%: Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.					Not meeting all gradation requirements for GW
		Gravels with Fines (Appreciable amount of fines)	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).			Give typical name; indicate approximate percentages of sand and gravel, max. size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses.		Atterberg limits below "A" line or PI less than 4. Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7
	Sands. More than half of coarse fraction is smaller than No. 4 sieve size.	Clean Sands (Little or no fines)	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain size and substantial amounts of all intermediate particle sizes.					$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.			Example: Silty sand, gravelly; about 20% hard, angular gravel particles 1/2-in. maximum size; rounded and subangular sand grains coarse to fine; about 15% nonplastic fines with low dry strength; well compacted and moist in place; alluvial sand; (SM).		Not meeting all gradation requirements for SW
		Sands with Fines (Appreciable amount of fines)	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity (for identification procedures see ML below).					Atterberg limits below "A" line or PI less than 4. Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols.
			SC	Clayey sands, sand-clay mixtures.	Plastic fines (for identification procedures see CL below).					Atterberg limits above "A" line with PI greater than 7
					Identification Procedures on Fraction Smaller than No. 40 Sieve Size					
					Dry Strength (Crushing characteristics)	Dilatancy (Reaction to shaking)	Toughness (Consistency near PL)			
Fine-grained Soils. More than half of material is SMALLER than No. 200 sieve size.	Silts and Clays. Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight	Quick to slow	None	Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses.		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.	Medium to high	None to very slow	Medium			
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium	Slow	Slight			
	Silts and Clays. Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium	Slow to none	Slight to medium	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions.		
			CH	Inorganic clays of high plasticity, fat clays.	High to very high	None	High			
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high	None to very slow	Slight to medium	Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess, (ML).		
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by color, odor, spongy feel and frequently by fibrous texture.					



PLASTICITY CHART

For laboratory classification of fine-grained soils

(1) Boundary classifications: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well-graded gravel-sand mixture with clay binder. (2) All sieve sizes on this chart are U. S. standard.

FIELD IDENTIFICATION PROCEDURES FOR FINE-GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus No. 40 sieve size particles, approximately 1/64 in. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests.

Dilatancy (Reaction to shaking)

After removing particles larger than No. 40 sieve size, prepare a pat of moist soil with a volume of about one-half cubic inch. Add enough water if necessary to make the soil soft but not sticky.
Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens, and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.
Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics)

After removing particles larger than No. 40 sieve size, mold a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun, or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.
High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour.

Toughness (Consistency near plastic limit)

After removing particles larger than the No. 40 sieve size, a specimen of soil about one-half inch cube in size, is molded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about one-eighth inch in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.
After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.
Highly organic clays have a very weak and spongy feel at the plastic limit.

Adopted by Corps of Engineers and Bureau of Reclamation, January 1952

3-0119535

Ref: Corps of Engineers, U.S. Army, Technical Memorandum No. 3 - 357

DEFINITIONS OF TERMS IDENTIFYING THE COMPOSITION OF SOILS						DEFINITIONS OF TERMS IDENTIFYING THE GRADATION COMPONENTS		
Component	Identification		Terms Identifying Proportions		Defining Range of Percentages by Weight	Gradation Designation for Identification		Defining Proportions
	Written	Symbol	Written	Symbol		As Written	Symbol	
Principal Component	GRAVEL	G			50 or more	coarse to fine	cf	All fractions greater than 10% of the component, but the medium component predominates
	SAND	S				or		
	SILT	$\bar{S}$				coarse medium to fine	cmf	
	CLAY	C						
						coarse to medium	cm	less than 10% fine
Minor Component	Gravel	G	and	a.	35 to 50			
	Sand	S	some	s.	20 to 35	medium to fine	mf	less than 10% coarse
	Silt	$\bar{S}$	little	l.	10 to 20			
	Clay	C	trace	t.	1 to 10	medium	m	less than 10% coarse and fine
						fine	f	less than 10% coarse and medium

modified from Burmister, D.M. (1964) "Suggested Methods of Test for Identification of Soils", ASTM Procedures for Testing Soils, 4th Ed.

TP 1

N 5627 7359
E 598 5348

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 8516

- TOPSOIL 046
- SILT
  - s insd S&G
  - l C (ML)
  - t cbls 2:3
- GRAVELLY SILT (TILL)
  - s cmf S
  - l C (GM,ML)
  - hard, brown 375
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C

TP 2

N 5626 138.7
E 599 8070

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9729

- TOPSOIL 03
- GRAVEL & SAND
  - cf G
  - cm S
  - t cbls
  - dense to v dense
  - brown (GW) 488
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C

TP 3

N 5623 6490
E 600 299.1

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9775

- TOPSOIL 015
- SILT
  - s C
  - l f S
  - hard
  - brown (ML) 305
- GRAVEL & SAND (TILL)
  - s S
  - t cbls
  - v dense (GM) 512
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C

TP 4

N 5623 101.4
E 600 349.1

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9821

- TOPSOIL 061
- GRAVELLY CLAY (TILL)
  - cf G
  - s cmf S
  - s S
  - l C
  - hard
  - brown (GC) 412
- CLAY (Wx)(CH)
  - l f S&S 488
  - bentonite
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C

TP 5

N 5622 553.4
E 600 057.8

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9778

- TOPSOIL 030
- SAND & GRAVEL (GW)
  - l bldrs 110
- GRAVELLY SILT (TILL)
  - cf G
  - s cmf S
  - l C
  - t cbls
  - S&G sm@244-305
  - Bentonite sm @427 (GM) 4 27
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C, C. Moisture content: 59%

TP 6

N 5621 940.2
E 599 703.7

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9818

- TOPSOIL 024
- GRAVELLY SAND
  - t S
  - l cbls & bldrs
  - bldrs sm@152-200
  - m dense
  - brown (SW) 4 27
- GRAVELLY SILT (TILL)
  - s mf S (GM)
  - l C 488
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C

TP 7

N 5621 271.7
E 599 323.3

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9772

- TOPSOIL 03
- SANDY GRAVEL
  - t S
  - cbls & bldrs sm@ 183-243, dry
  - m dense
  - brown (GW) 290
- SILT & SAND (TILL)
  - s C
  - l G & cbls (SM)
  - v dense 442
- SILTY SAND (Wx)(SM)
  - mf S, green 493
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C

TP 8

N 5623 612.8
E 599 5166

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9190

- SILT
  - S & fS sms
  - C pkts (ML)
  - mS sm@137-152 152
- GRAVEL & SILT (TILL)
  - s mf S
  - l C
  - t cbls & bldrs
  - v dense (GM) 387
- END OF TEST PIT

Depth: 0, 2, 4, 6. Sample type: C, C, C

TP 9 (EXPOSED BANK)

N 5623 504.5
E 599 750.3

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

SURFACE ELEVATION 9205

- SILT (ML) 046
- SAND & GRAVEL
  - cf G
  - cmf S
  - t S
  - dense (GW)
  - brown 518
- SAND
  - c S (SP)

Depth: 0, 2, 4, 6. Sample type: C, C

TP 9 CONT.

SOIL DESCRIPTION | DEPTH METRES | SAMPLE TYPE | MOISTURE CONTENT - % (20, 40, 60)

- s cbls 646
- SAND & GRAVEL
  - cf G
  - cmf S
  - s S
  - dense
  - brown (GM)

Depth: 6, 8, 10, 12. Sample type: C

REPORT No. 913 DWG. No. 604H-C14-D67

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION		
B.C. HYDRO AND POWER AUTHORITY HAT CREEK PROJECT	TEST PITS TP 1 to TP 9		
	APPROVED	PROJECT NO. VA-2330	DATE JAN. 1978 PLATE 18-1

TP 9 CONT.

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
	12	C	
	14		
	16		
END OF TEST PIT 18.11	18		

TP 10

N 5620 610.
E 598 912.2

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 972.9	0		
TOPSOIL 0.18		C	o
SANDY GRAVEL (GW) 0.56			
GRAVELLY CLAY (TILL) -l cf G -l cmf S -l C -hard -brown (ML)	2	C	o
4.57	4		
END OF TEST PIT	6		

TP 11

N 5618 176.1
E 599 040.6

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1038.8	0		
TOPSOIL 0.30		C	
SANDY GRAVEL (GW) 0.61			
SANDY CLAY (TILL) -cmf S -cf G -C -t cbls -m dense to dense -brown (SM)	2	C	o
-bldrs @ 4.73	4	C	o
4.73			
END OF TEST PIT			
Water seepage @ 4.57	6		

TP 12

N 5617 781.1
E 599 182.2

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1055.5	0		
TOPSOIL 0.15			
SANDY GRAVEL (GW) 0.61			
SANDY SILT -org. -f S -l C (OL) 2.04	2	C	o
GRAVELLY SILT (TILL) -org. -l f S -t C -t cbls -bentonite sms (GM,MH) 4.63	4	C	o
CLAYEY SAND (SM)		C	o
END OF TEST PIT 5.09	6		

TP 13

N 5614 304.2
E 599 687.0

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1103.4	0		
TOPSOIL 0.18			
SILTY SAND (SM) 0.61			
GRAVELLY SILT (TILL) -l cm S -t bldrs -v dense -brown (GM,MH)	2	C	
4.42	4		
END OF TEST PIT	6		

TP 14 (FACE OF GRAVEL PIT)

N 5613 874.8
E 599 942.0

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1096.7	0		
TOPSOIL 0.18			
SAND & GRAVEL (GW) 0.61		C	o
SILTY SAND (SM) -f S 1.52			
GRAVEL & SAND -cmf S -t cbls -s 150mm sms of mS -dense -brown (GW)	2		
	4		
	6		

TP 14 CONT.

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
	6		
	8	C	
Water seepage @ 11.58	10		
11.58			
SILTY SAND (TILL) -t f G (SM)		C	o
END OF TEST PIT 12.19	12		

TP 15

N 5613 540.9
E 599 695.3

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1092.1	0		
TOPSOIL 0.30			
SILT -org. -s C -soft -s f S from 0.92 -grey brown (OL) 2.00	2	C, C, C	o
SANDY GRAVEL -cmf S -cf G -s S & C (GW) 3.05		C	o
END OF TEST PIT	4		
Water seepage @ 2.59	6		

TP 16

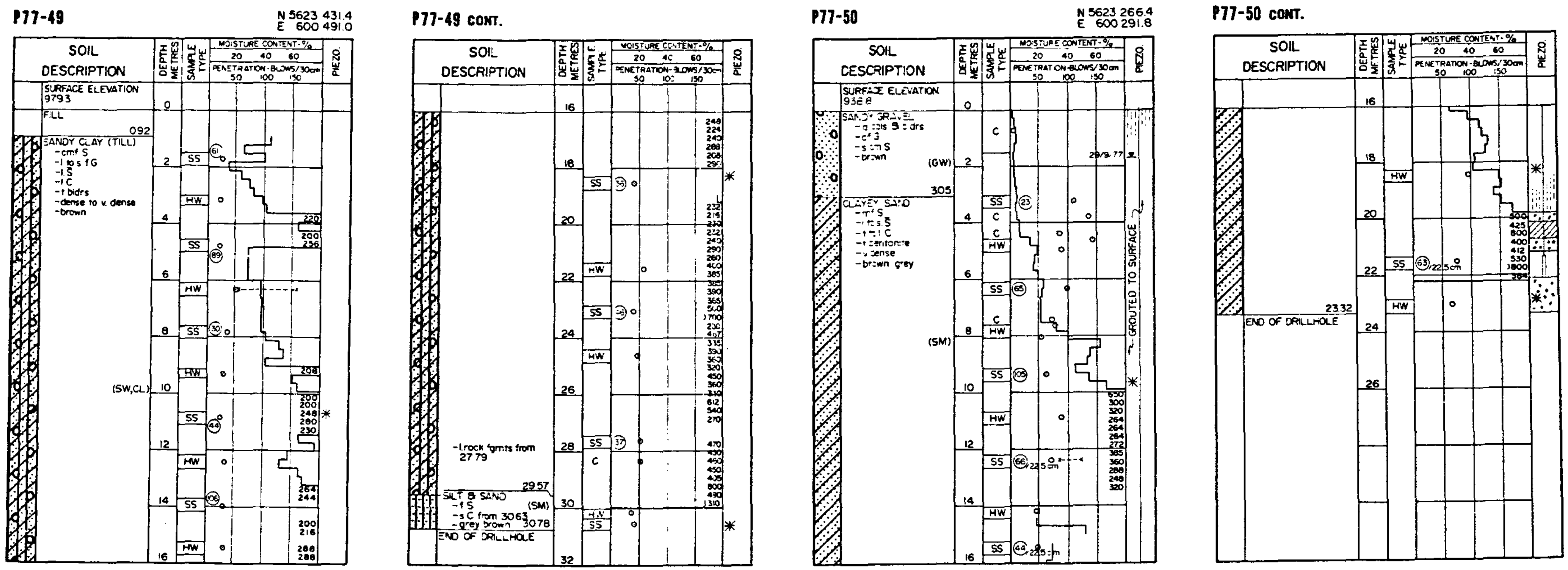
N 5613 868.4
E 599 363.0

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION 1097.9	0		
TOPSOIL 0.15		C	o
SANDY SILT (ML) 0.61			
SANDY CLAY (TILL) -s S -l f G -t cbls -v stiff -brown (CH)	2		
4.57	4	C	o
END OF TEST PIT			
Water seepage @ 4.42	6		

SOIL DESCRIPTION	DEPTH METRES	SAMPLE TYPE	MOISTURE CONTENT - % (20, 40, 60)
SURFACE ELEVATION	0		
	2		
	4		
	6		

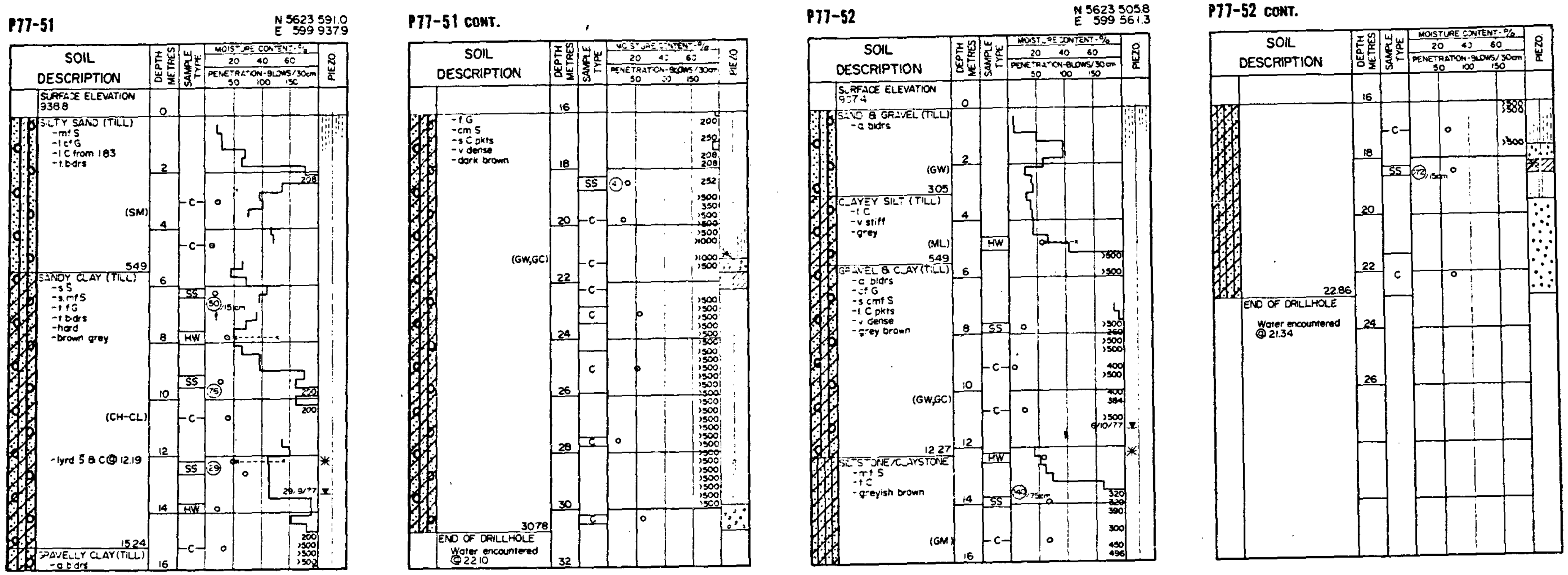
REPORT No. 913 DWG. No. 604H-C14-D68

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY	TEST PITS TP 9 to TP 16
HAT CREEK PROJECT	APPROVED; PROJECT NO. VA-2330; DATE JAN. 1978; PLATE 18-2



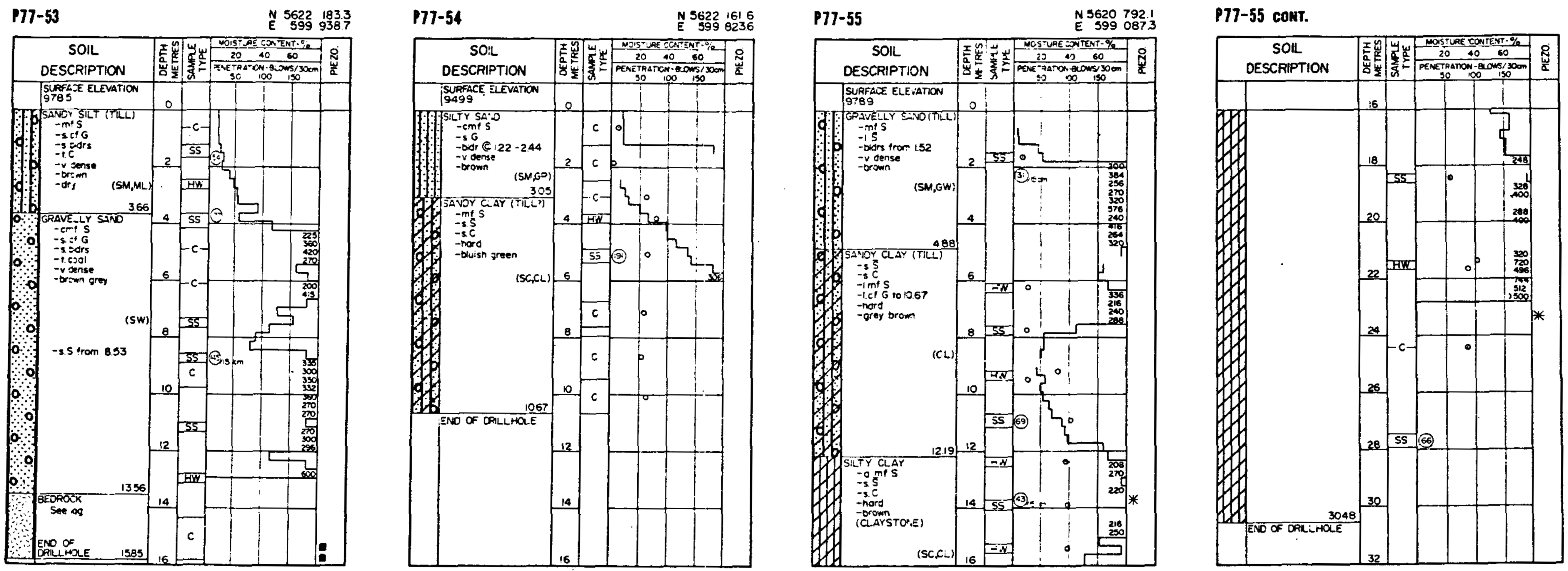
REPORT No. 913 DWG. No. 604H-C14-D69

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION	
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-49 to P77-50	
APPROVED	PROJECT NO. VA-2330	DATE JAN. 1979 PLATE IB-3



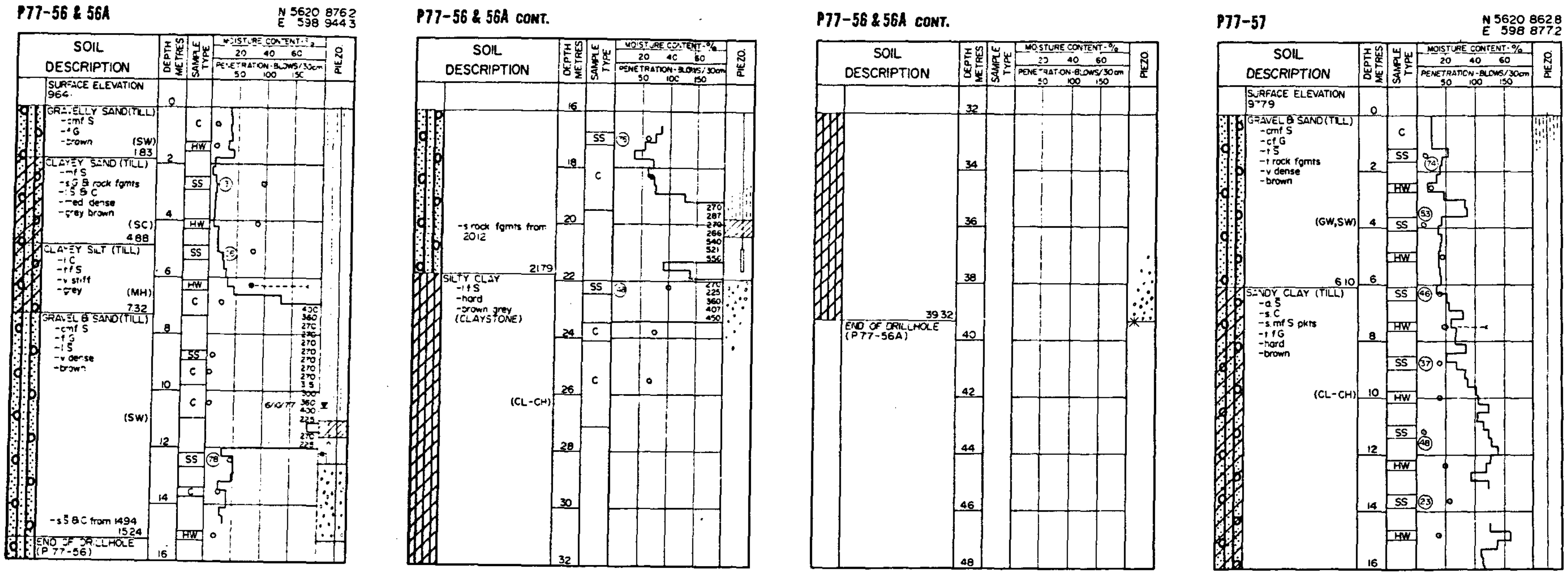
REPORT No. 913 DWG. No. 604H-C14-D70

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY HAT CREEK PROJECT	PERCUSSION DRILL HOLES P77-51 to P77-52
	APPROVED · PROJECT No. VA-2330 · DATE JAN. 1979 · PLATE IB-4



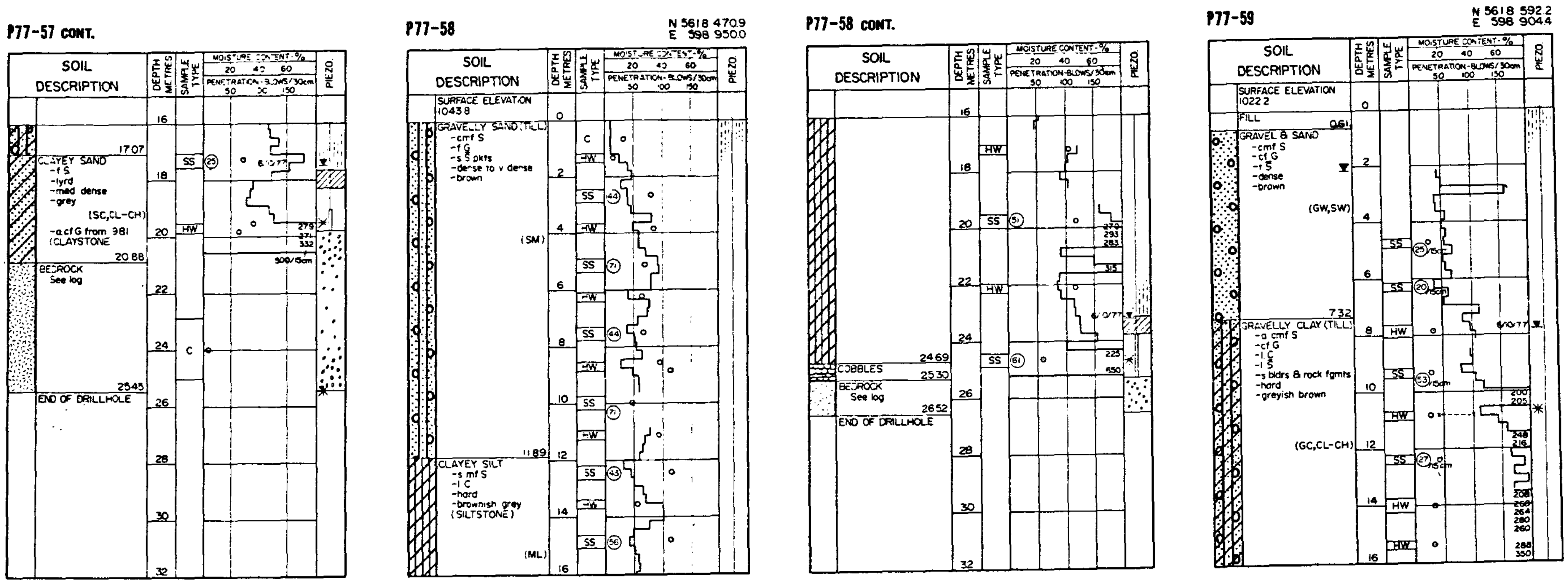
REPORT No. 913 DWG. No. 604H-C14-D71

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-53 to P77-55
	APPROVED
	PROJECT NO. VA-2330
	DATE JAN. 1978
	PLATE 18-5



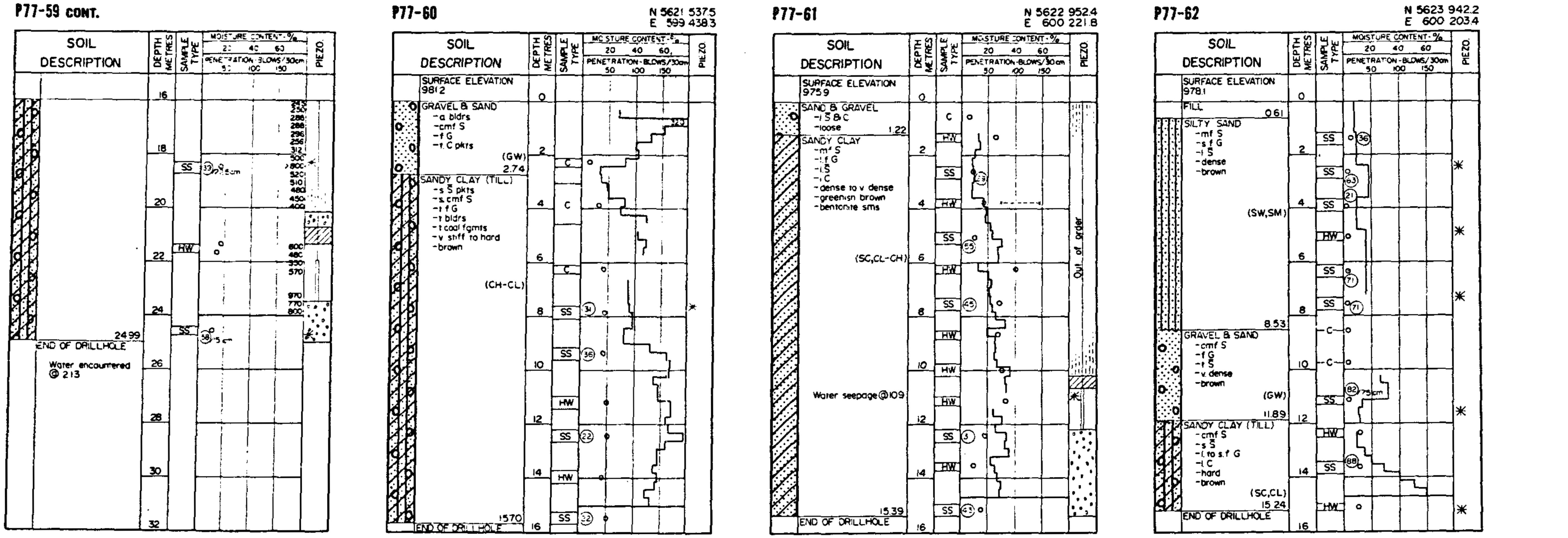
REPORT No. 913 DWG. No. 604H-C14-D72

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-56 & 56A to P77-57
	APPROVED · PROJECT NO. VA-2330 · DATE JAN. 1978 · PLATE IB-6



REPORT No. 913 DWG. No. 604H-C14-073

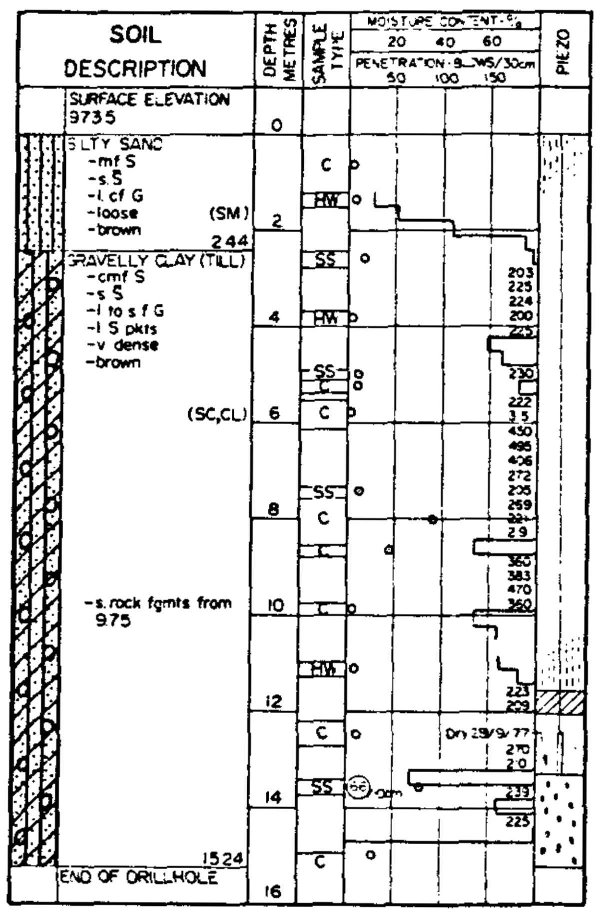
KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY HAT CREEK PROJECT	PERCUSSION DRILL HOLES P77-57 to P77-59
APPROVED	PROJECT NO. VA-2330
DATE JAN. 378	PLATE 18-7



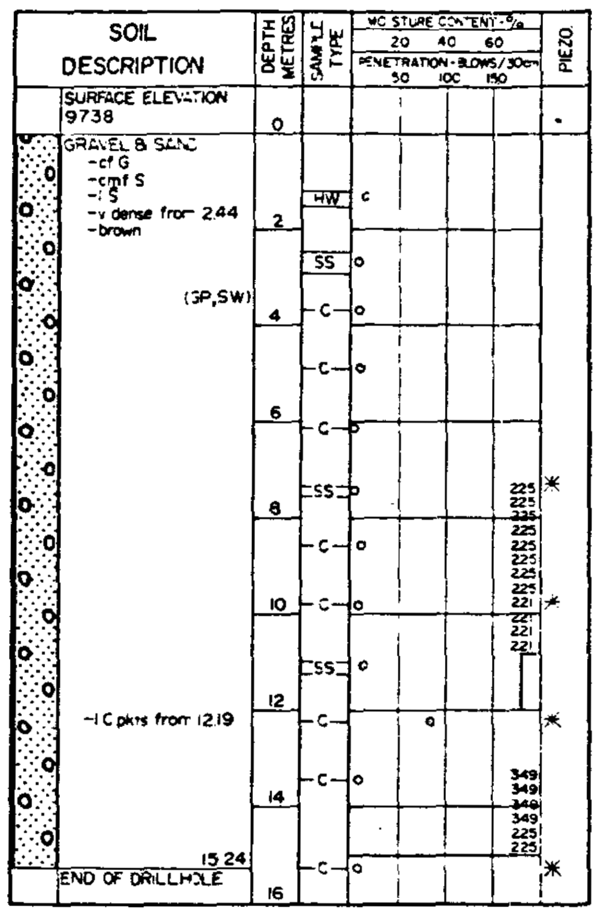
REPORT No. 913 DWG. No. 604H-C14-074

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-59 to P77-62
APPROVED	PROJECT NO. VA-2330
DATE JAN. 978	PLATE IB-8

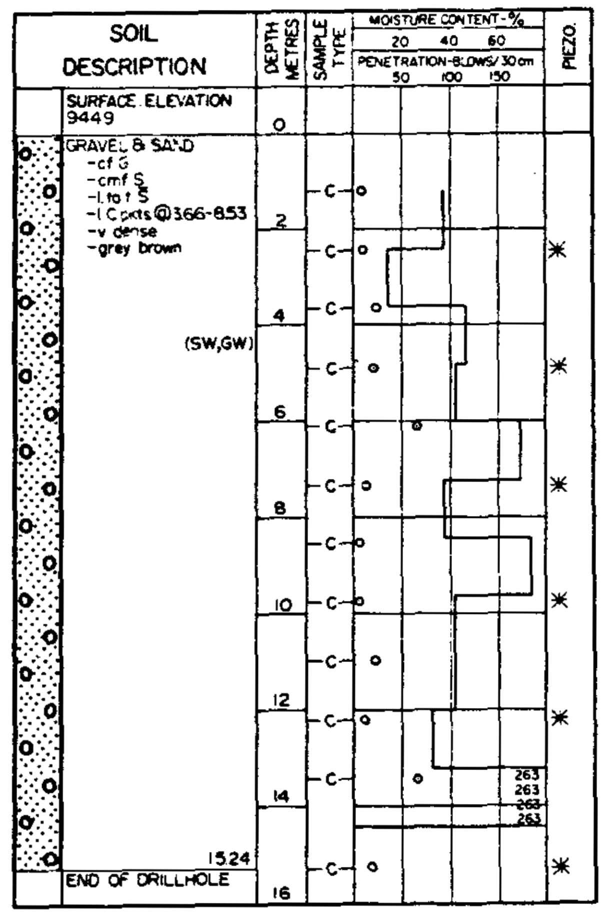
P77-63 N 5625 650.8 E 599 794.9



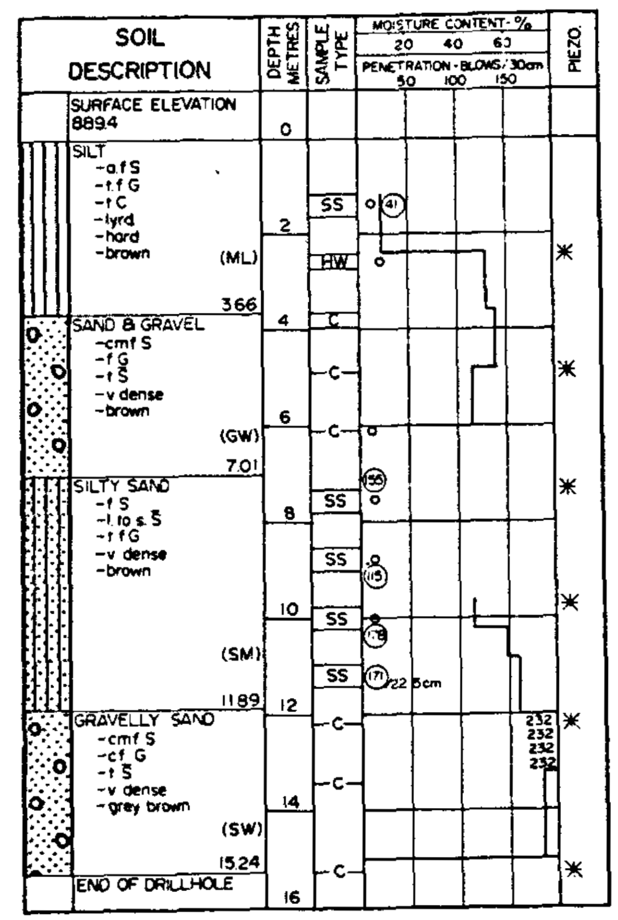
P77-64 N 5626 469.3 E 599 883.0



P77-65 N 5626 958.9 E 599 537.3

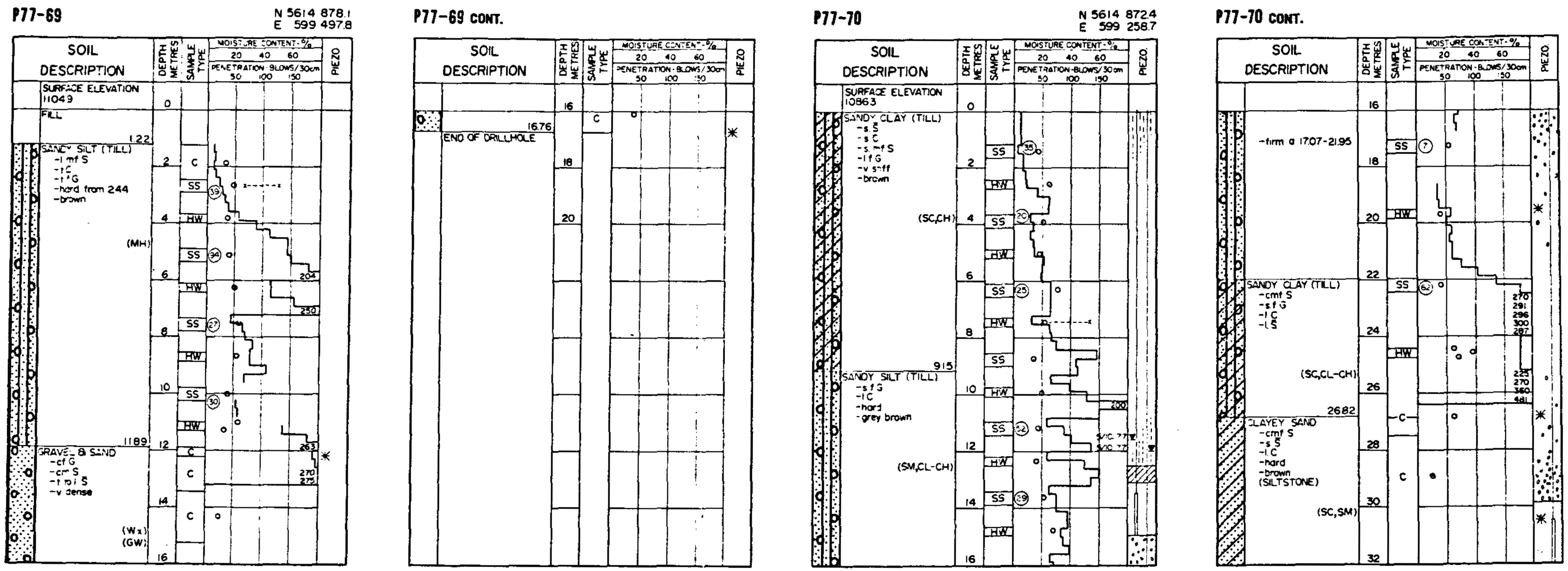


P77-66 N 5627 540.8 E 598 934.1



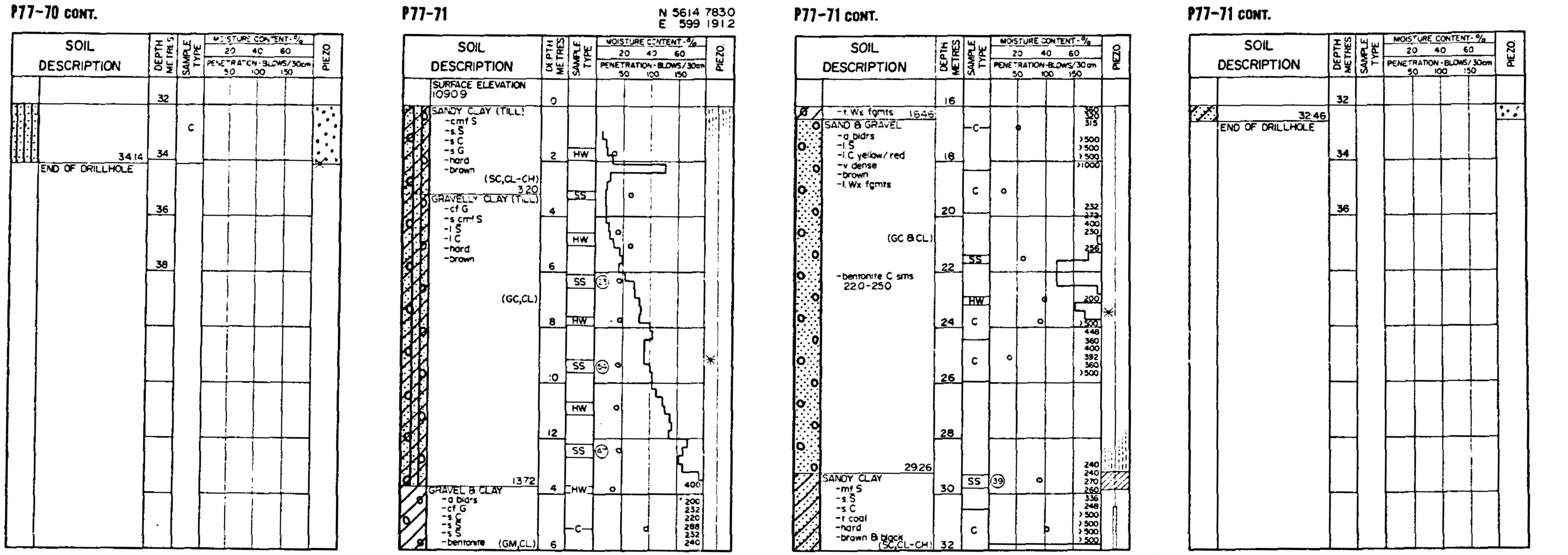
REPORT No. 913 DWG. No. 604H-C14-D75

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-63 to P77-66
APPROVED	PROJECT NO. VA-2330 · DATE JAN.1978 · PLATE IB-9



REPORT No. 913 DWG. No. 604H-C14-076

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-69 to P77-70
	APPROVED / PROJECT No. VA-2330 / DATE JAN. 1978 / PLATE 18-10



REPORT No. 913 DWG. No. 604H-C14-D77

KLOHN LEONOFF CONSULTANTS LTD.	HAT CREEK DIVERSION
B.C. HYDRO AND POWER AUTHORITY **HAT CREEK PROJECT**	PERCUSSION DRILL HOLES P77-70 to P77-71
APPROVED	PROJECT NO. VA-2330 / DATE JAN. 1978 / PLATE IB-11

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GEOLOGIC DRILL HOLE LOG

CLIENT: B.C. Hydro — JOB No. VA 2330

PROJECT: HAT CREEK — HOLE No. P-77-53

SITE: Axis of Canal Embankment — SHEET No. 1 OF 1

CONTRACTOR: Becker

STARTED .M. Sept. 18 19 77

FINISHED .M. Sept. 18 19 77

METHOD OF DRILLING: SOIL Hammer Drilling; ROCK Diamond Coring & Rotary

CASING DIA. 140 mm

CASING DEPTH 13.0 m

CORE DIA. BW

LOCATION: LATITUDE / DEPARTURE / BEARING / INITIAL DIP / OTHER DIPS

ELEVATIONS: DATUM / DRILL PLATFORM / GROUND SURFACE / ROCK SURFACE / BOTTOM OF HOLE / WATER TABLE

DEPTH	ROCK TYPE	DESCRIPTION	WATER PRESS. TEST	LENGTH OF RUN	% RQD	% CORE REC.
0.0 13.56						
13.56 13.72	Boulder or cobble layer	Boulder or cobble layer at top of weathered bedrock. One core piece 50 mm long of light-weight pumiceous rhyolite. Several small pebbles of pumice and volcanic agglomerate.		0.15	0	100
13.72 14.35	Boulder	Same as 13.56 to 13.72 size of volcanic agglomerate showing round fragments from medium sand up to 12 mm gravel in hard aphanitic groundmass. Fragments are rounded and predominantly of a dark grey rock with abundant Na-Ca feldspar (some phenocrysts visible) probably andesite groundmass. Some of the pebbles are medium green coloured reflecting the colour of the Na-Ca spar.				
14.35 15.85		No core recovered. Bedrock is assumed to be Rhyolite tuff or breccia.				
15.85		End of Drillhole				

LOGGED BY R. Lopez

DATE 27/09/77

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GEOLOGIC DRILL HOLE LOG

CLIENT B.C. Hydro JOB No. VA 2330

PROJECT HAT CREEK HOLE No. P-77-57

SITE Axis of Canal Headworks SHEET No. 1 OF 1

CONTRACTOR: Becker STARTED .M. Sept. 15 19 77
FINISHED .M. Sept. 16 19 77

METHOD OF DRILLING: SOIL Hammer Drilling CASING DIA. 140 mm
CASING DEPTH 20.88 m
ROCK Diamond Coring CORE DIA. BW

LOCATION: LATITUDE ELEVATIONS: DATUM
DEPARTURE DRILL PLATFORM
BEARING GROUND SURFACE
INITIAL DIP ROCK SURFACE
OTHER DIPS BOTTOM OF HOLE
WATER TABLE

DEPTH	ROCK TYPE	DESCRIPTION	WATER PRESS. TEST	LENGTH OF RUN	% RQD	% CORE REC.
0.0						
20.88						
20.88	Rhyolite	Rhyolite or rhyolite tuff, dense		0.46	0	61
21.33	or Rhyolite	massive. Core fragments up to 50 mm.				
	tuff	Reddish grey. Appears to be a				
		weathered bouldery layer at top of bed-				
		rock				
21.33	Rhyolite	Same as 20.88 to 21.33		0.46	0	72
21.79	or Rhyolite					
	tuff					
21.79		No core recovered				
25.45						
25.45		End of Drillhole				

LOGGED BY R. Lopez DATE 27/09/77

Klohn Leonoff Consultants Ltd.

CIVIL & GEOTECHNICAL ENGINEERS

GEOLOGIC DRILL HOLE LOG

CLIENT: B.C. Hydro | JOB No. VA 2330

PROJECT: HAT CREEK | HOLE No. P-77-58

SITE: Axis of Site 2 Storage Dam | SHEET No. 1 OF 1

CONTRACTOR: Becker

STARTED .M. Sept. 12 1977

FINISHED .M. Sept. 13 1977

METHOD OF DRILLING: SOIL Hammer Drilling; ROCK Diamond Coring

CASING DIA. 140 mm

CASING DEPTH 25.60 m

CORE DIA. BW

LOCATION: LATITUDE ____ DEPARTURE ____ BEARING ____ INITIAL DIP ____ OTHER DIPS ____

ELEVATIONS: DATUM ____ DRILL PLATFORM ____ GROUND SURFACE ____ ROCK SURFACE ____ BOTTOM OF HOLE ____ WATER TABLE ____

DEPTH	ROCK TYPE	DESCRIPTION	WATER PRESS. TEST	LENGTH OF RUN	% RQD	% CORE REC.
0.0						
25.60						
25.60	Felsite	Felsite (probably andesite). Core		0.91	9	30
26.52		pieces up to 25 mm. This is probably				
		a surface weathered layer. Rock pieces				
		are dense and massive, with minor				
		stainings along surfaces. Medium green-				
		ish grey (probably Na-Ca spar is the				
		major constituent).				
26.52		End of Drillhole				

LOGGED BY R. Lopez

DATE 27/09/77

TABLE 1B-1

PERMEABILITY TEST RESULTS FOR DRILL HOLES

Hole	Depth of Test (m)	K (cm/sec)
P77-49	10.67	1×10^{-5}
	18.28	1×10^{-5}
P77-50	9.60	1×10^{-6}
	18.28	4×10^{-5}
	22.86	3×10^{-4}
P77-51	12.19	4×10^{-6}
	21.07	4×10^{-4}
P77-52	12.19	5×10^{-5}
	18.28	6×10^{-6}
P77-53	15.85	2×10^{-4} (Packer test)
P77-55	13.72	7×10^{-5}
	23.16	5×10^{-5}
P77-56	12.19	2×10^{-4}
	39.32	4×10^{-5}
P77-57	19.5	7×10^{-5}
	25.45	8×10^{-5}
P77-58	24.68	Very high - could not fill with water for test
P77-59	10.67	1×10^{-5}
	24.69	3×10^{-5}
P77-60	7.62	3×10^{-5}
P77-61	11.28	5×10^{-4}
P77-62	2.43	8×10^{-4}
	4.88	9×10^{-4}
	7.32	8×10^{-4}
	11.58	No result
	15.24	4×10^{-5}
P77-64	7.32	4×10^{-5}
	9.75	4×10^{-4}
	12.19	6×10^{-4}
	15.24	2×10^{-4}

TABLE 1B-1 - (Cont'd)

Hole	Depth of Test (m)	K (cm/sec)
P77-65	2.44	4×10^{-4}
	4.88	2×10^{-4}
	7.32	3×10^{-5}
	9.75	2×10^{-4}
	12.19	1×10^{-4}
	15.24	7×10^{-5}
P77-66	4.88	2×10^{-4}
	7.32	5×10^{-5}
	9.75	2×10^{-4}
	12.19	3×10^{-4}
	15.24	5×10^{-4}
P77-69	12.19	2×10^{-4}
	16.76	4×10^{-5}
P77-70	26.82	2×10^{-5}
	30.48	1×10^{-5}
	34.14	1×10^{-5}
P77-71	9.14	2×10^{-5}
	23.47	5×10^{-5}

PERMEABILITY VALUES FROM TESTS IN PIEZOMETERS

Hole	Depth of Piezometer Tip (m)	K (cm/sec)
P77-52	19.5	1×10^{-5}
P77-57	19.82	5×10^{-6}
P77-59	23.0	8×10^{-7}

APPENDIX II

HAT CREEK DIVERSION

TERMS OF REFERENCE

HAT CREEK PROJECT

HAT CREEK DIVERSION - TERMS OF REFERENCE

A. GENERAL

1. Obtain and review all available geological and topographical data.

2. Obtain and review latest power plant water supply requirements.

3. Obtain and review latest mine pit data including:

   a) pit side slopes, depth and boundaries at various stages of development.

   b) pit drainage facilities and the effect of flooding the mine pit on plant operation.

   c) scheduling of pit #1 and pit #2 development.

   d) mine waste disposal plans, particularly in Medicine Creek Area.

4. Obtain and review latest data for ash disposal in Medicine Creek Area.

B. HYDROLOGY

1. Obtain and review all available hydrological data.

2. Review and refine Hat Creek flood peak frequency curves and flood hydrograph volume-frequency relationships.

3. Review and refine annual runoff pattern (average monthly flows).

4. Review downstream domestic, irrigation and fishery water requirements and assess volume of water available from Hat Creek for plant use.

C. COMPARISON OF ALTERNATIVE DIVERSION SCHEMES

1. Review and refine the Canal Diversion Scheme described in the Conceptual Design Report, as required for compatibility with other alternatives. (A range of canal design capacities are to be considered to determine cost sensitivity.)

2. Review and refine the Pumped Diversion Scheme outlined in the Conceptual Design Report, utilizing Hat Creek water to augment the plant cooling water supply. (A range of pump capacity/storage volume and a range of minimum downstream release are to be considered.)

C. <u>COMPARISON OF ALTERNATIVE DIVERSION SCHEMES</u> (Cont'd)

3. Investigate the feasibility of a combined diversion/pit slope drainage tunnel scheme as described in the Conceptual Design Report.

4. Investigate the feasibility of any other diversion scheme which appears to be economically and environmentally advantageous.

5. Alternative diversion schemes are to be designed for compatibility both for pit #1 development and future pit #2 development.

6. The diversion of irrigation/flood flows through the divide to Oregan Jack Creek should be considered.

7. Compare costs of alternative schemes including:

   a) capital cost for pit #1 diversion

   b) present worth of costs for pit #2 diversion

   c) present worth of operating costs

   d) present worth of water supply benefits

   for a range of interest rates and pit development schedules.

8. Review and discuss with Environmental Consultants the environmental impact of alternative diversion schemes including:

   a) Effect of Hat Creek flow regulation on downstream environmental conditions.

   b) Effect of use of Hat Creek water to augment plant cooling water supply to permit shutdown of the Thompson River pump station during juvenile salmon migration.

9. Select preferred diversion scheme and review recommendation with Offsites Project Manager.

10. Prepare design memo outlining rational for selection of recommended diversion scheme.

D. PRELIMINARY DESIGN STUDIES

1. Arrange for any additional mapping, site surveys or hydrological information required for preliminary design.

2. Plan and arrange for a subsurface exploration program (including investigation of construction materials) to confirm the feasibility of the recommended diversion scheme.

3. Undertake preliminary design studies to confirm the location, type and size of all components of the proposed diversion scheme.

4. Prepare a preliminary design report including a detailed cost estimate and construction schedule for the proposed diversion scheme. A preliminary design memorandum confirming the feasibility of the recommended scheme is required prior to 1 November 1977 and the final report is to be completed by 1 February 1978.

LJP/fc

18 April 1977

APPENDIX III

TOPOGRAPHIC GRID SYSTEM CONVERSIONS

APPENDIX III
TOPOGRAPHIC GRID SYSTEM CONVERSIONS

The topographic grid used throughout this report is based on the Universal Transverse Mercator (UTM) grid system. To convert coordinate locations based on the arbitrary grid system used in earlier Hat Creek mapping (prepared in imperial units by McElhanney Surveying and Engineering Ltd.) to the UTM system, the following equations may be used:

$$E = 0.304648\ X - 0.0057747\ Y + 592{,}882.2$$
$$N = 0.0057747\ X + 0.304648\ Y + 5{,}600{,}773.5$$

where E = UTM easting in metres
N = UTM northing in metres
X = McElhanney easting in feet
Y = McElhanney northing in feet

The accuracy of the conversion is within approximately ±1.0 meters.

APPENDIX IV

METRIC CONVERSIONS

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METRIC CONVERSIONS

MULTIPLY S.I. Metric Units	Symbol	BY	TO OBTAIN Imperial Units	Symbol
centimetres	cm	0.3937	inches	in
centimetres per second	cm/s	3.2808×10^{-2}	feet per second	ft/s
cubic metres	m^3	35.3145	cubic feet	ft^3
cubic metres	m^3	1.30794	cubic yards	yd^3
cubic metres per second	m^3/s	1.58503×10^{-4}	U.S. gallons per minute	USgpm
cubic metres per second	m^3/s	35.3145	cubic feet per second	ft^3/s
hectares	ha	2.47104	acres	acre
joules per hour per square centimetre	$J/hr/cm^2$	0.88055	British thermal units per hour per square foot	$Btu/hr/ft^2$
hectare-metres	ha-m	8.10713	acre-feet	acre ft
kilograms	kg	2.205	pounds	lb
kilometres	km	0.62137	miles	mi
kilopascals	kPa	20.8855	pounds per square foot	psf
litres per second	L/s	15.85032	U.S. gallons per minute	USgpm
litres per second	L/s	0.03531	cubic feet per second	ft^3/s
metres	m	3.28083	feet	ft
millimetres	mm	0.03937	inches	in
square kilometres	km^2	247.104	acres	acre
square metres	m^2	10.7639	square feet	ft^2
tonnes per cubic metre	t/m^3	62.4283	pounds per cubic foot	lb/ft^3