HAT CREEK PROJECT

MINING FEASIBILITY REPORT

VOLUME IV

SECTION 3A

MINE DRAINAGE

prepared for

British Columbia Hydro and Power Authority

by

Cominco Monenco Joint Venture

October
1979

This report incorporates and supercedes

HAT CREEK PROJECT

MINING FEASIBLITY REPORT

JULY 1978

VOLUME IV

MINE SUPPORT FACILITIES

SECTION 3

MINE DRAINAGE

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HAT CREEK PROJECT

MINING FEASIBILITY REPORT

SECTION 3A

MINE DRAINAGE

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SUMMARY

A mine drainage system will be required at the proposed Hat Creek Open Pit Coal Mine to:-

- Prevent flood damage to excavations, waste dumps, stockpiles and mining equipment.
- Keep mine operation areas dry enough to permit continuous coal production.
- Improve the stability of Pit slopes.
- Protect the environment of Hat Creek Valley.

The proposed mine drainage system will include:

<u>Diversion Drains</u> — Runoff entering the mine development area from Upper Hat Creek Valley, Houth Meadows and Medicine Creek Valley will be collected by a system of sidehill canals and reservoirs to be discharged to Hat Creek downstream of the mine.

<u>Pit Drainage</u> — Surface water and seepage from surficials on the upper benches of the pit will be collected in open bench drains and discharged to sedimentation lagoons to the North of the pit for sediment removal. Drainage from the coal and bedrock strata in the lower pit will be collected in bench drains and pumped to a leachate holding lagoon to the North of the pit. Up to 75 pairs of wells will be drilled inside and outside the ultimate pit perimeter to dewater and depressurise groundwater in pit slopes.

<u>Slide Area Drainage</u> — Measures to improve the stability of this area to the south and west of the pit will include perimeter drains at the back of the slide, drainage of 62 lakes and small ponds within the slide area; improvement of natural watercourses and the installation of 20 wells to dewater and depressurise critical areas.

<u>Wastewater Treatment Systems</u> — Sediment laden drainage from within the mine area will be treated in sedimentation lagoons prior to discharge to Hat Creek.

Water of unacceptable quality such as leachate from waste dumps, coal and low grade coal stockpiles and coal and bedrock strata will be drained to a "zero discharge" system which will dispose of effluent by recycling it to dust control operations and spray irrigation.

Sewage from the mine services area will be collected in buried sewers, given pre-treatment in a package treatment plant then recycled to dust control use.

Work on mine drainage will commence at year -5 with the Diversion of Hat Creek and the drainage system will thereafter expand in pace with mine development. When mining is complete, perimeter drainage and sedimentation lagoon systems will stay in operation as part of the mine reclamation scheme.

INTRODUCTION

The Hat Creek Project lies in the Southwest Interior of British Columbia as shown on the Project Location Map. The Project will consist of a 2000MW thermal power station fueled with coal from an open pit mine located in the bottom of Hat Creek Valley.

Mine planning studies have determined the proposed layout of the mine and waste dumps shown on BCH Plan 604H-Z31-X020002 R4.

Mine drainage systems are required within the proposed mine development to:

- keep mine areas, both in-pit and out-of-pit, dry enough to allow continuous operation.
- prevent flood damage to excavations and equipment.
- improve the stability of pit slopes by reducing the infiltration of surface water and by reducing ground water pressures.
- provide continuity of existing streams and creeks which may be disturbed by mining activities.
- protect the environment from discharge of sediment or dissolved material which may be hazardous to human or aquatic life.
- comply with present government regulations regarding mine operation and protection of the environment.

This report describes the potential sources, quantities and quality of drainage flow expected during the first 35 years of mining of the No. 1 Hat Creek Coal Deposit; it also presents a comprehensive drainage system required to collect and dispose of the drainage in accordance with existing environmental guidelines and regulations.

3.1 MINE WATER: SOURCE AND QUANTITY

Principal sources of mine water within the proposed mine development are:

- Direct precipitation and runoff
- Creeks entering the mine site which is located in the bottom of Hat Creek Valley
- Standing surface water in lakes and ponds
- Groundwater flow
- Wastewater from mine operations

311 Direct Precipitation and Runoff

Annual precipitation at the mine site is low, averaging 317 mm per year of which 55% is received as rain and the balance as snow.

Summer and winter are the wettest seasons with the highest monthly precipitation occurring in December, January and June.

As it is an upland valley it may snow between September and May, however, there is generally little snow in the valley bottom between mid-April to mid-October. Approximately 16% of the annual precipitation in the valley above the mine is recorded as streamflow in Hat Creek at the mine site. If diversion and irrigation losses in the upper watershed are accounted for then annual runoff amounts to 19% of precipitation.

Most runoff occurs in spring and early summer when the ground is most saturated and early summer rainstorms fall on a snowpack which is melting away. Direct runoff coefficients of up to 17% (Beak 1978) have been calculated for precipitation events at this time.

The most intense rainstorms occur in mid-summer i.e. July and August when most of the snowpack has melted away. Direct runoff coefficients of 2-4% (Beak 1978) have been calculated for rainstorms in this period indicating very high losses to soil-cover storage and evapotranspiration.

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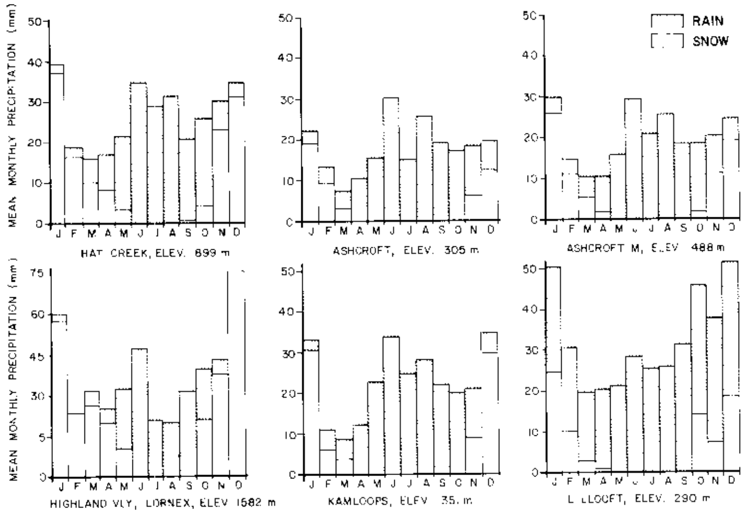
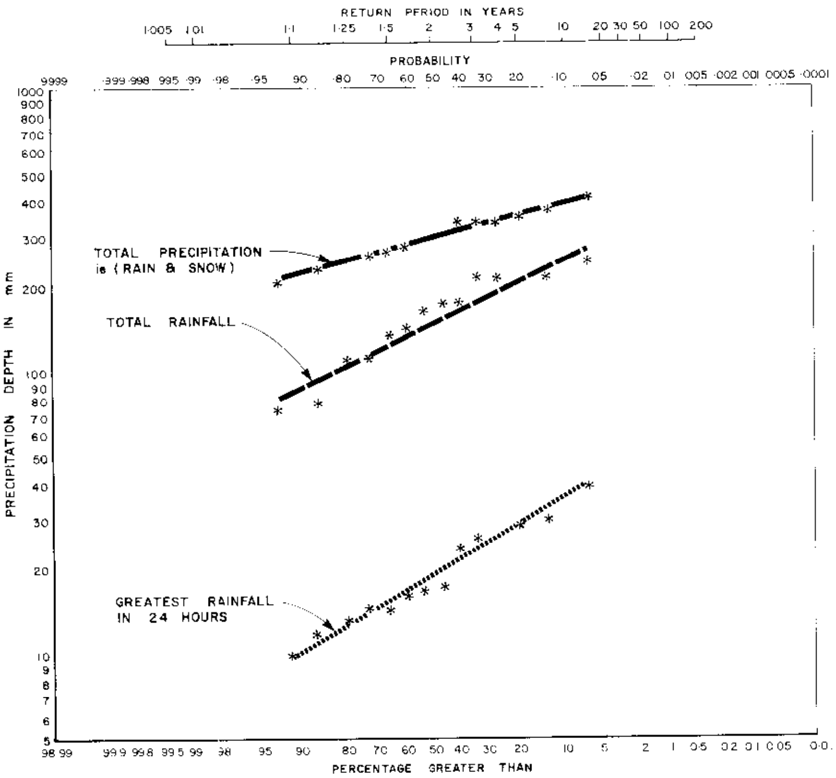


SEASONAL DISTRIBUTION OF MEAN MONTHLY PRECIPITATION IN THE HAT CREEK REGION

from Atmospheric Environment Service Canadian Normals, 1973



DISTRIBUTION OF PRECIPITATION DATA FOR HAT CREEK VALLEY

from Atmospheric Environment Service, Climatological Station Data

FIGURE 3-1

BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
PRECIPITATION DATA

Source: Beak Hydrology Inventory Study, Draft March 1978

Mining activities such as stripping, excavating and dumping of spoil may reduce this surface storage capability and increase runoff.

Rainulator (a sprinkler which imitates rainfall) tests carried out on a mine site in North Dakota using high application intensities of 64 mm of water per hour (10 year 24 hour Hat Creek rainfall = 35 mm) measured 12% runoff from natural rangeland as opposed to 60% to 70% from mine spoil (Gilley, Gee et al 1976). Similar tests with snowmelt resulted in an increase from 41% runoff for rangeland to 48-56% for mine spoil (Gilley, Gee Bauer 1976). These values are not directly applicable to Hat Creek conditions as the climate differs, they do however, give evidence of a trend to increased water yield assumed.

An estimate of the mean annual surface runoff yield within the mine site was made using a water budget accounting method. Natural soil storage values of 100 mm and 200 mm yielded runoff of 22 mm and 0 mm per annum respectively. (Beak 1978) Calculations using reduced soil storage values of 50 mm and 25 mm yielded runoff in the order of 50 mm and 80 mm respectively. The 50 mm value was considered representative of general disturbed land in the mine development area and the 80 mm value was adopted for estimates of annual runoff yield from pit slopes. The adoption of these values is largely subjective, however, experience gained during later years of project investigation and during mine operation will permit these estimates to be upgraded.

Mining activity should also increase peak flow rates from watersheds; this will be most noticeable on smaller ones. Maximum flow rates should occur during high intensity rainfall in summer when the snowpack has retreated from the lower valley. Estimates of flow were made using the method presented by the USDA Soil Conservation Service 1964. In this method runoff is given by

$$R = \frac{(P - Ia)^2}{(P - Ia) - S}$$

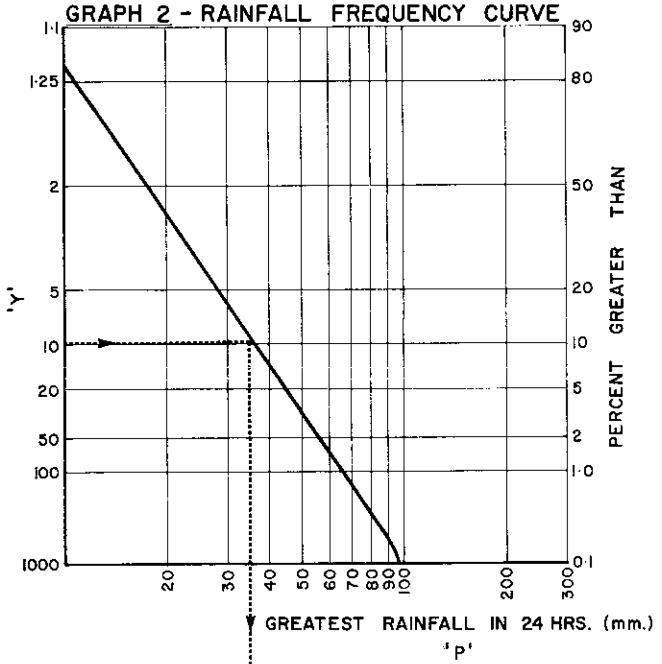
Where R = Direct Runoff
P = Potential Maximum Rainfall
Ia = Initial abstraction of water by the soil
S = Potential maximum soil retention plus the initial abstraction

Solutions to this equation are given graphically on Figure 3-2, Graph 3 which permits estimation of 24 hour volumes of runoff given precipitation input and soil cover conditions. This volume of runoff is correlated to peak flow rates using Graphs 4, 5, or 6, which have been assembled from field data for small agricultural watersheds.
(USDA SCS 1975)

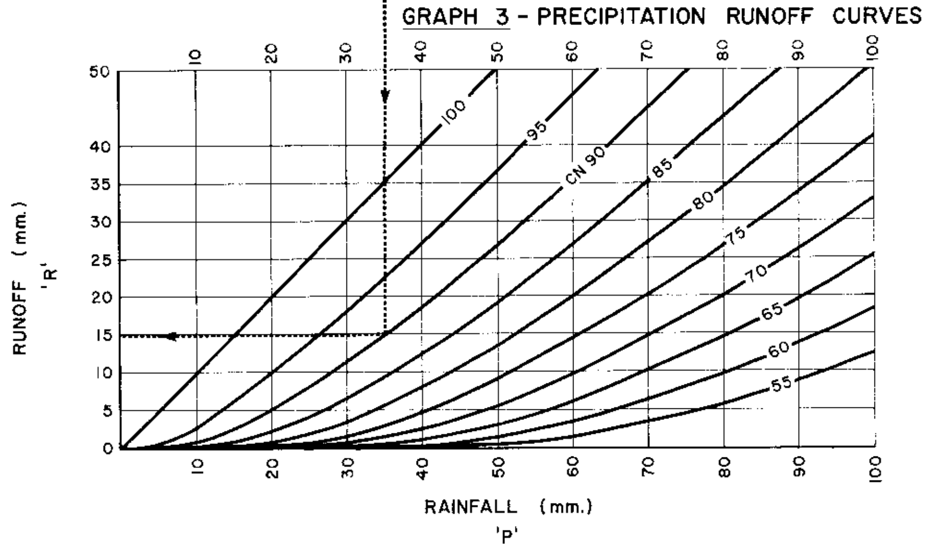
TABLE 1 - SOIL COVER COMPLEXES

		CURVE NUMBERS (CN)
NATURAL WATERSHEDS	=	60 - 70
REVEGETATED AREAS	=	70 - 80
DUMP SURFACE	=	90 (Surface storage not accounted for by this parameter)
PIT SLOPE	=	90
STORAGE YARDS	=	90
PAVED AREAS	=	98

GRAPH 2 - RAINFALL FREQUENCY CURVE



GRAPH 3 - PRECIPITATION RUNOFF CURVES

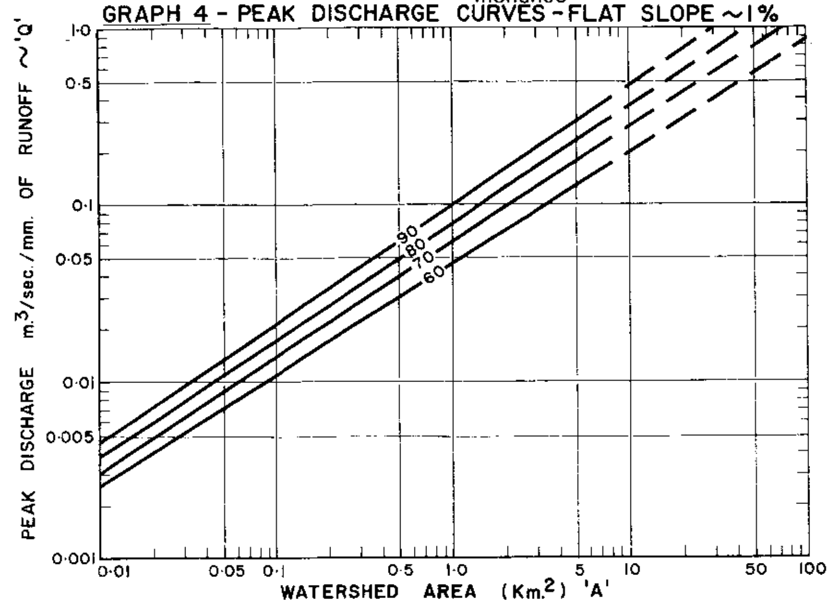


ASSUMPTIONS:

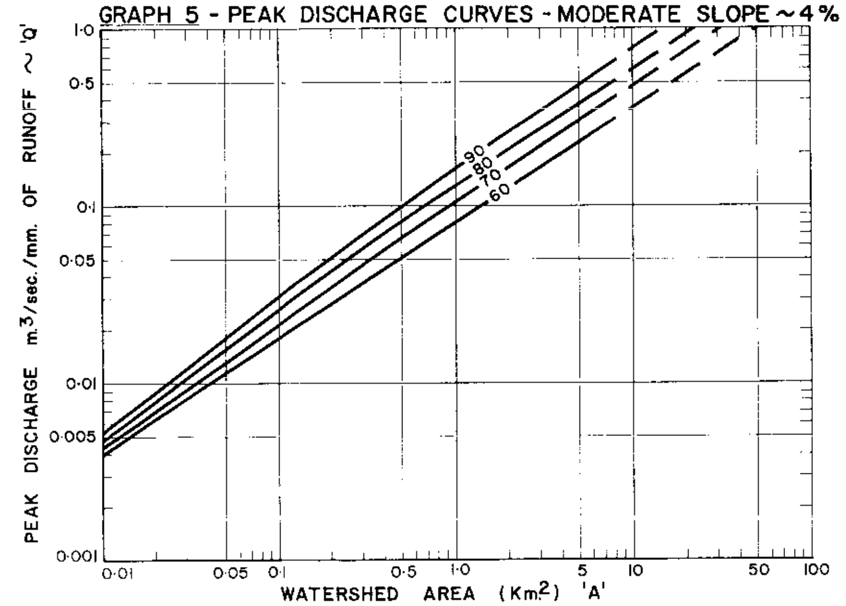
Antecedent Moisture Condition AMC = II

Initial Abstraction Ia = 0·2S ~ Potential Abstraction

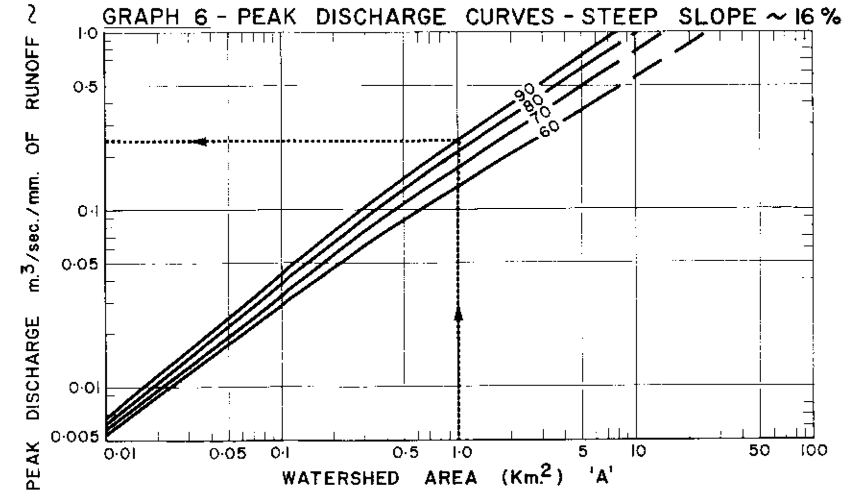
GRAPH 4 - PEAK DISCHARGE CURVES - FLAT SLOPE ~ 1%



GRAPH 5 - PEAK DISCHARGE CURVES - MODERATE SLOPE ~ 4%



GRAPH 6 - PEAK DISCHARGE CURVES - STEEP SLOPE ~ 16%



EXAMPLE CALCULATION

DATA:

DESIGN STORM

Recurrence Interval	10 Yrs.
Duration	24 Hrs.

WATERSHED

Area	1 Km²
Slope	Steep (16 %)
Surface	Pit Slope

CALCULATION:

(i) From Table 1

CN = 90

(ii) From Graph 2

Design Rainfall 'P' = 35 mm.

(iii) From Graph 3

Runoff 'R' = 15 mm.

(iv) From Graph 6

Unit Peak Discharge 'Q' = 0·25 m³/sec./mm.

(v) Peak Watershed Discharge = 'R' x 'Q' = 3·75 m³/sec.

NOTE:

This nomograph is for preliminary estimates of flows from watersheds in mine area < 10 Km²

SOURCE:

Table 1 and Graphs 3,4,5 & 6

Adapted from U.S. Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology (1964) & Technical Release No. 55, Urban Hydrology For Small Watersheds. (1975)

Graph 2

B.C. Hydro, H.E.D.D., Report No. 913. (1978)

FIGURE 3-2

BRITISH COLUMBIA HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

MINING FEASIBILITY REPORT

RAINSTORM FLOOD NOMOGRAPH

312 Creeks, Lakes and Ponds

312.1 Creeks

The principal creeks which flow through the proposed mine site are Hat Creek, Medicine Creek, Houth Creek and Finney Creek. Locations of these creeks and their watersheds are shown on Figure 3-3 and the watershed areas are shown on Table 3-1.

Hat Creek is the largest creek and flows have been continuously recorded since 1960 at two Water Survey of Canada gauge stations; one above the mine (08LF061) and one at the mouth of the valley (08LF015).

Mean flow at the mine site is 0.72 m^3/s and the peak discharge measured during the period of record 1960-1978 is 14.64 m^3/s on June 11, 1964. Figure 3-4 shows the monthly variation of flow in Hat Creek. It can be seen that wide variations of flow are possible during summer months and that winter flow, which probably stems from groundwater flows, is more steady.

Flow recording gauges were established on Ambusten Creek, Anderson Creek, Medicine Creek and the Upper Medicine Creek diversion to Cornwall Creek in 1977. Insufficient data is presently available for a statistical analysis of flood flows but the data collected indicates that the flow regime is essentially similar to that of Hat Creek. Flood frequency curves shown on Figure 3-4 indicate the expected magnitude of flood flows on Hat Creek and tributary creeks. These curves were derived from a regional analysis of streamflow data.

The proposed development of the open pit in the bottom of Hat Creek Valley and the waste dumps in the bottoms of Medicine Creek Valley and Houth Meadows will require diversion of flows from various small natural sub-watersheds and tributary creeks. It was assumed that peak flow rates from these undisturbed watersheds at higher elevation would result from the rain-on-snowmelt cycle in early summer and therefore be of similar flow regime to Hat Creek. Regional streamflow data was transformed into a flood nomograph shown on Figure 3-5 which gives estimates of flood flows for watersheds greater than 10 km^2 in area.

TABLE 3-1

Areas of Natural Watersheds

(Refer Figure 3-3)

Hat Creek Project Mining Feasibility Report 1979

Watershed	Reference No.	Plan Area (km^2)
Houth Meadows	1	5
	2	3
	3	2.5
	4	19
HOUTH MEADOWS SUBTOTAL		29.5
Finney Creek	5	13
West Pit	6	8.1
South West Pit	7	5.0
South East Pit	8	1.3
Ambusten Creek	9	35
Medicine Creek	10	12.6
	11	43.1
	12	5.9
MEDICINE CREEK SUBTOTAL		61.6
Harry Creek	13	9.9
East Pit	14	6.5
North West Pit	15	0.4
North East Pit	16	0.8
Marble Canyon	17	10.0
WATERSHEDS IN PROJECT AREA SUBTOTAL		182
Hat Creek Watershed (upstream)	18	248
Hat Creek Watershed (downstream)	19	236
HAT CREEK WATERSHED TOTAL		666

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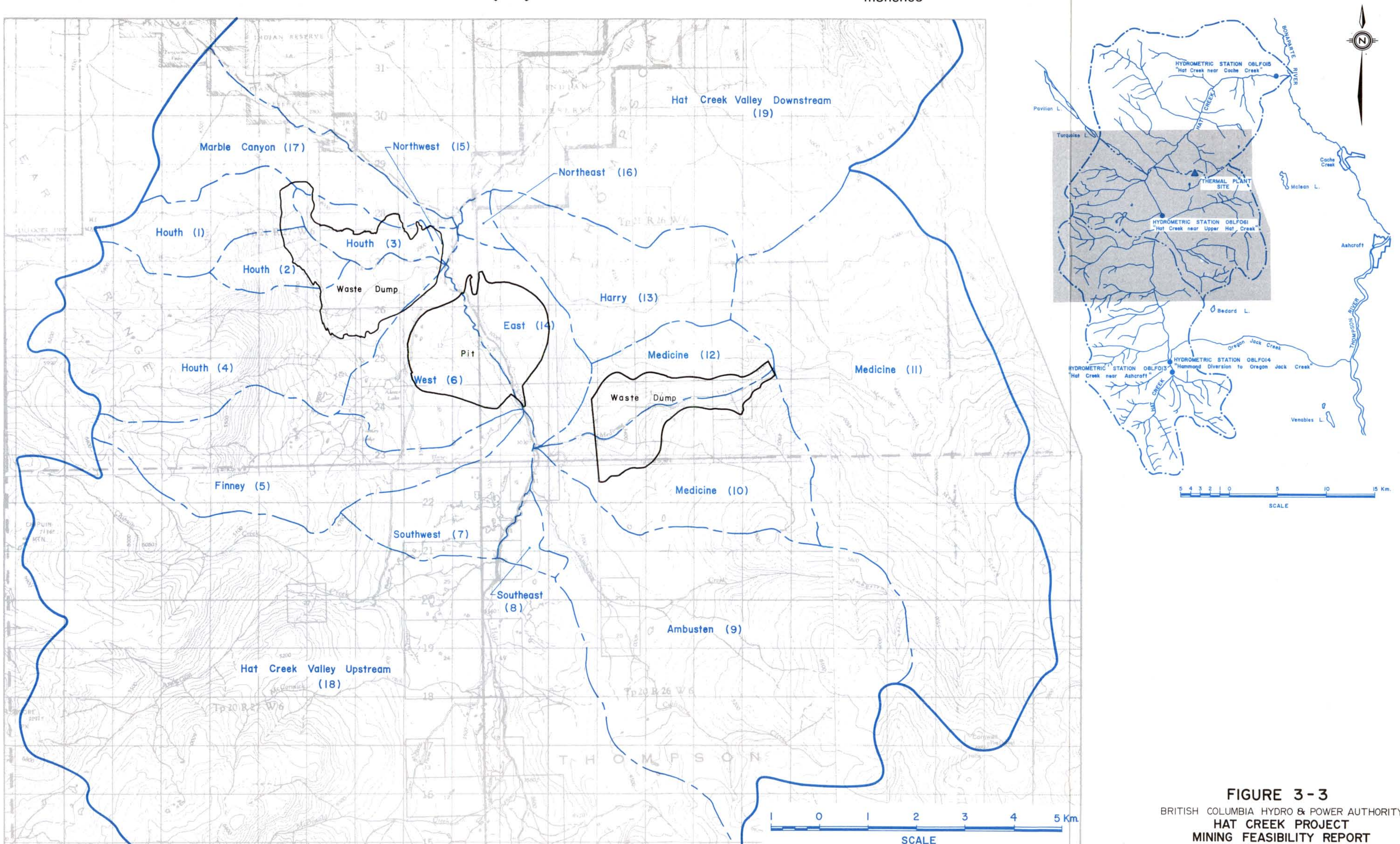
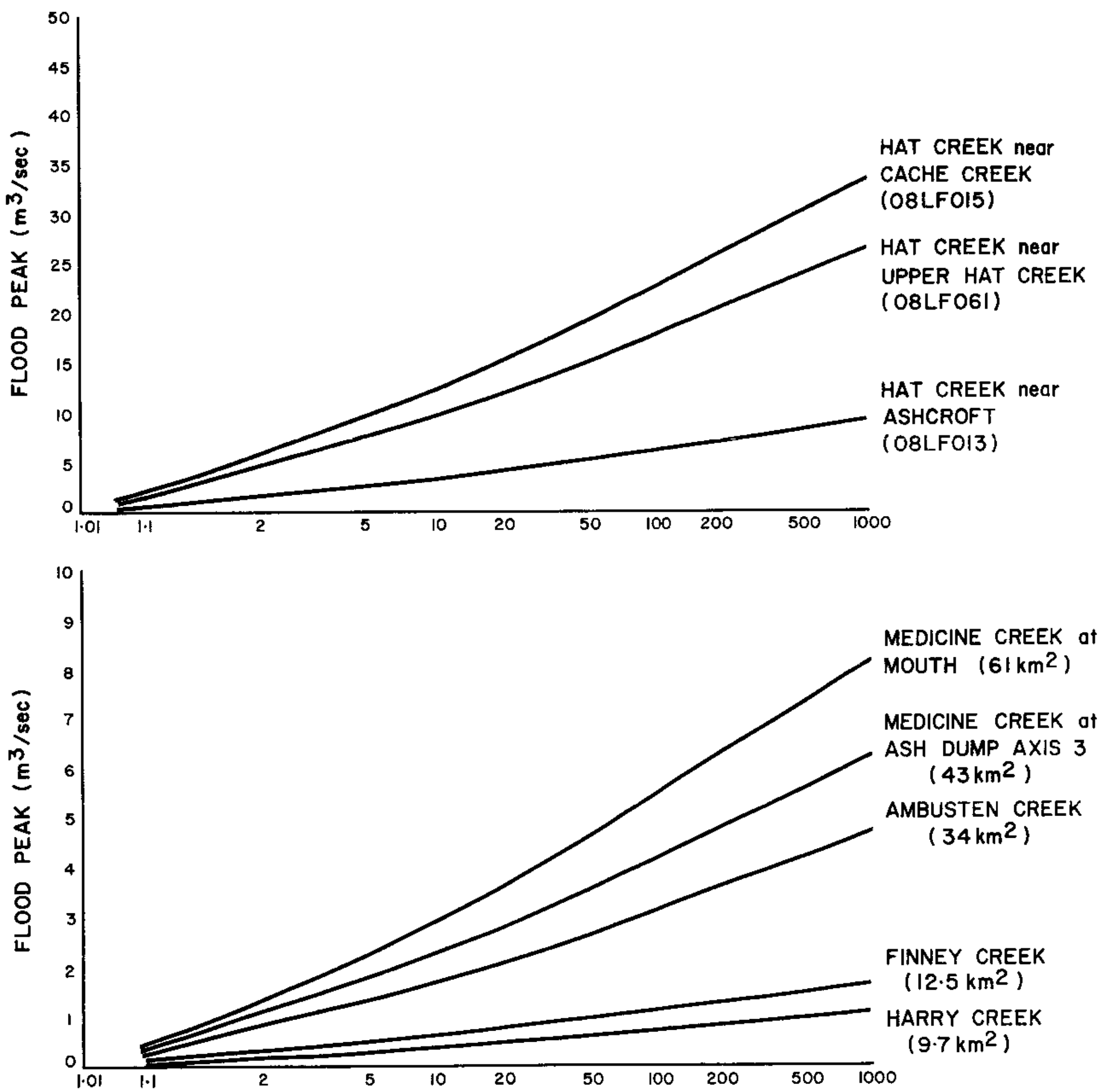


FIGURE 3-3
BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
HAT CREEK WATERSHED

FLOOD FREQUENCY CURVES DERIVED FROM REGIONAL DATA



NOTE:
CURVES SHOWN ARE FOR ANNUAL SNOWMELT FLOODS

Source: B.C. Hydro H.E.D.D. Report 913, 1978.

MONTHLY FLOW IN HAT CREEK JUST ABOVE THE MINE SITE

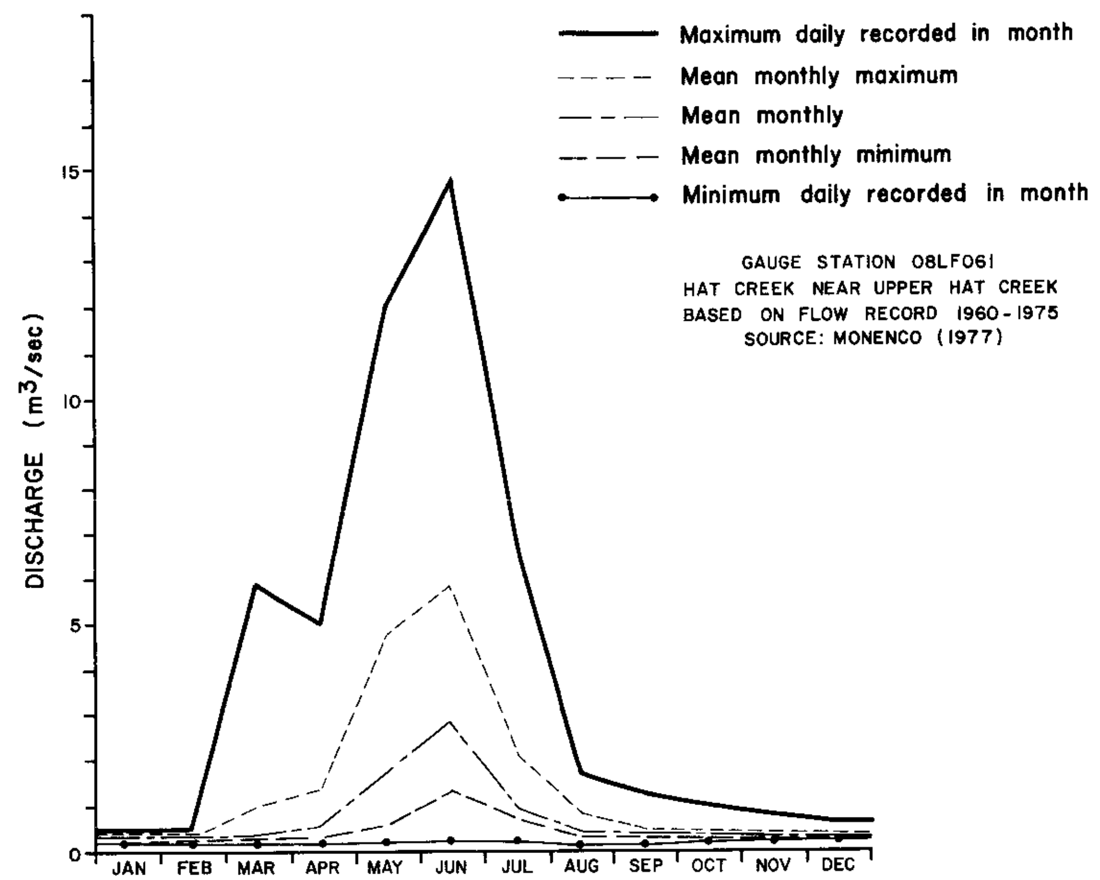


FIGURE 3-4

BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
STREAMFLOW DATA

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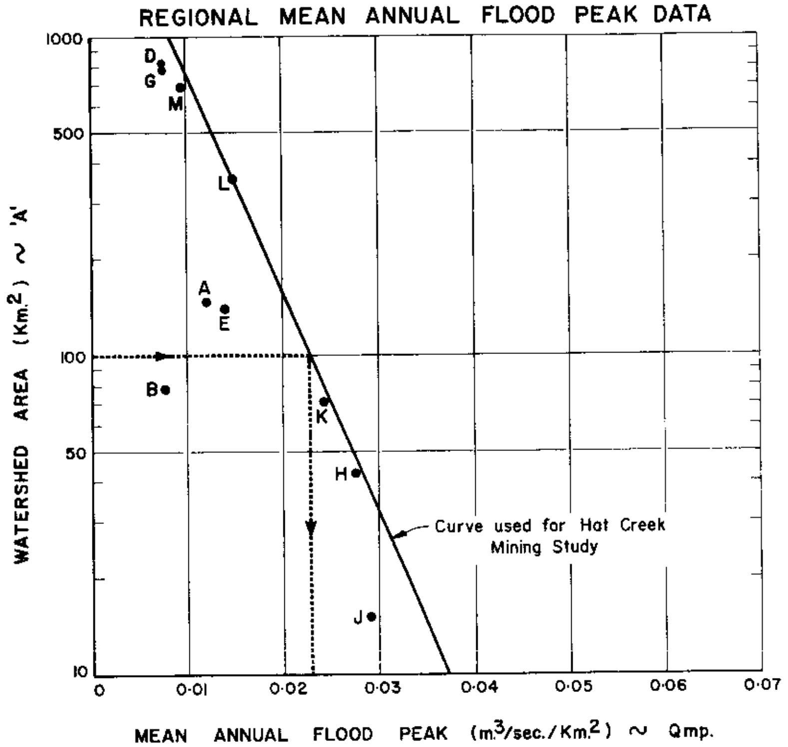
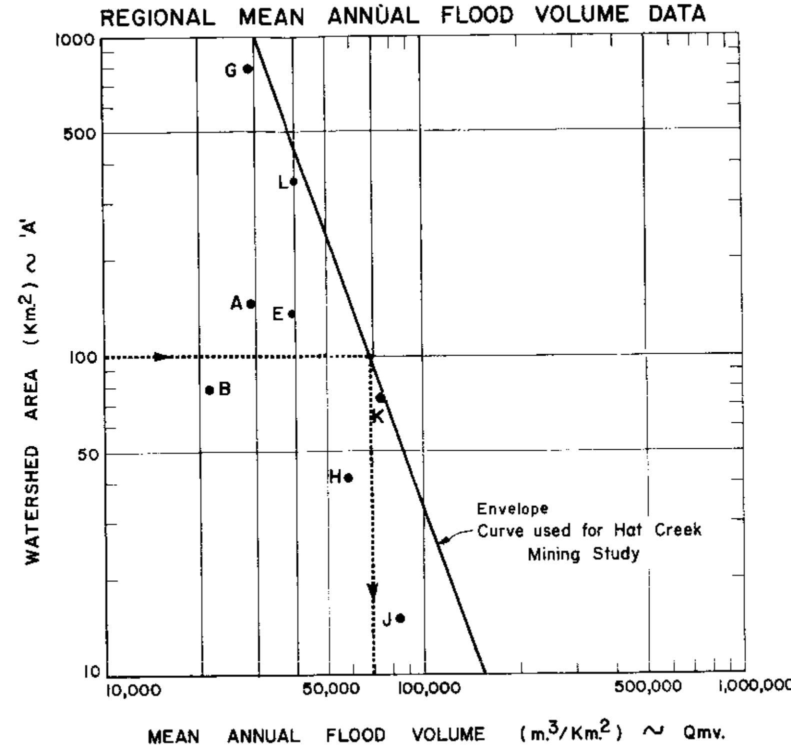
GRAPH 1
REGIONAL MEAN ANNUAL FLOOD PEAK DATA



GRAPH 2
REGIONAL MEAN ANNUAL FLOOD VOLUME DATA



EXAMPLE CALCULATION

DATA:

Watershed Area = $100 Km^2$

Design Recurrence Interval = 10 Yrs.

CALCULATION:

From Graph 1, Qmp = $0{\cdot}023 m^3/sec./Km^2$

From Graph 3, Mp = 1·9

Flood Peak Discharge = $1{\cdot}9 \times {\cdot}023\ m^3/sec./Km^2 \times 100 Km^2$

= $4{\cdot}4\ m^3/sec.$

From Graph 2, Qmv = $70,000\ m^3/Km^2$

From Graph 3, Mv = 1·7

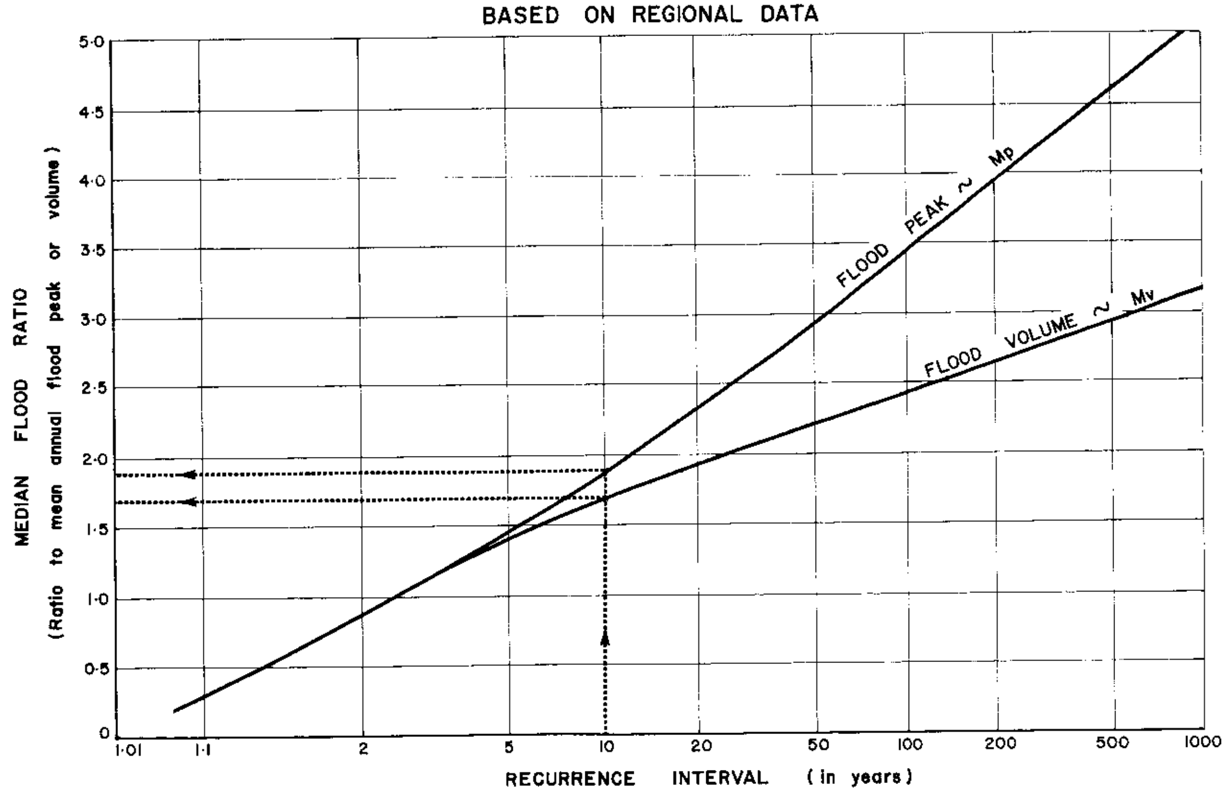
Flood Volume = $1{\cdot}7 \times 70,000\ m^3/Km^2 \times 100\ Km^2$

= $11{\cdot}90 \times 10^6\ m^3$

NOTE:

For preliminary estimates of floods from natural watersheds $10 Km^2$ or greater in mine area.

GRAPH 3
FREQUENCY AND RATIO OF ANNUAL FLOODS TO MEAN ANNUAL FLOODS BASED ON REGIONAL DATA



KEY	WATER SURVEY OF CANADA GAUGE STATION	
A	08LF036	
B	08LF038	
C	08LF069	
D	08LG003	
E	08LG009	
F	08LG014	
G	08LG032	
H	08LG033	
J	08LG055	
K	08LF013	Stations in Hat Creek valley
L	08LF061	Stations in Hat Creek valley
M	08LF015	Stations in Hat Creek valley

SOURCE:

Adapted from Regional Analysis Of Streamflow Data in B.C. Hydro, H.E.D.D. Report No. 913. "Hat Creek Project - Diversion of Hat and Finney Creeks."

FIGURE 3-5

BRITISH COLUMBIA HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

MINING FEASIBILITY REPORT

RAIN - SNOWMELT FLOOD NOMOGRAPH

312.2 Lakes and Ponds

Most lakes and ponds in the project area occur on the west side of Hat Creek Valley due to the low permeability of the overburden and the hummocky terrain. There are approximately 80 small lakes and ponds to the West of the proposed pit perimeter which vary in area from 15 ha (Finney Lake) to less than 100 m^2.

Geotechnical studies of this area have identified both active and inactive slide masses in the overburden which may cause instability of the west pit slope during mining (Golder 1977,78,79). Stabilization measures require that Aleece Lake and 61 other lakes and ponds within presently active or previously active slide areas be drained to reduce recharge of water to the slide area ground water system.

Finney Lake and 15 other small ponds lie in a more stable and remote area, therefore, drainage is not considered essential at the outset of the project. Monitoring of piezometric levels and slope movements of the slide during mining should indicate in advance any need for drainage of Finney Lake and these other ponds.

There are also 15-20 small lakes and ponds in the Houth Meadows waste dump area which would be drained prior to being covered with waste.

313 Groundwater

Studies to date have identified three major geohydrologic units within the general mine area (Golder 1978), which comprise:

(a) the surficial deposits which vary from slide debris and till in the west to gravels in the east. This is the major water bearing unit of highest average hydraulic conductivity 10^{-6} m/s;

(b) the coal which exhibits highly variable conductivity which is estimated to average 5×10^{-9} m/s;

(c) the upper and lower Coldwater sediments which are essentially impermeable with an average conductivity of 5×10^{-11} m/s.

General groundwater flow within the Upper Hat Creek Valley may be characterized by recharge in upland areas and discharge in the valley bottom. Most of the groundwater flow occurs through surficial deposits; less than 2% is estimated to move through clastic sediments in the valley bottom.

The eastern areas of the proposed open pit are reasonably well drained due to greater depths of surficial deposits and their moderately high rates of hydraulic conductivity. Surficial deposits in the western areas of the open pit are thinner and most materials are of lower permeability resulting in springs and groundwater seeps.

The two main aquifers in the vicinity of the pit are a small alluvial aquifer along the central valley and a buried bedrock channel on the east side of the valley. Flow in each is estimated to be in the order of 3×10^{-2} m^3/s.

Due to the low permeability of the coal and bedrock units, water yield from seepage and dewatering operations during mining is predicted to be minimal (Golder 1978). Extensive depressurization of pit slopes is not likely and dewatering wells will therefore be selectively located in pervious zones where higher benefits can be realized, or in areas where stability is considered essential to maintain operations.

Mean flow from peripheral dewatering wells is estimated to be 0.02 m^3/sec one year prior to commencement of mining, decreasing to a steady rate of 0.017 m^3/sec throughout the remainder of the project.

Groundwater which bypasses this system and appears as seepage in the pit is expected to average .0047 m^3/sec of which .0037 m^3/sec is from the bedrock zone at the base of the pit. (Golder 1979)

314 Mine Wastewater

Three main sources of wastewater produced by mining operations have been identified as effluent from the mine services area, runoff and leachate from coal handling areas, waste dumps, and low-grade coal stockpiles, and runoff and seepage from coal and bedrock strata within the open pit.

The mine service area will include an administration building, mine dry building ("change" rooms, shower, and laundry), maintenance workshops for mining equipment, and a laboratory. The major source of wastewater will be sanitary effluent from the daily work force which will peak at about 700 persons. The corresponding mean daily flow is estimated at 140 m^3/day. Allowance will also be made for approximately 90 m^3/day of wastewater discharged from vehicle washdown and steam cleaning operations to leachate disposal systems.

Runoff and leachate from coal and low-grade coal stockpiles will require special drainage and disposal systems due to the predicted elevated levels of total dissolved solids, magnesium and sulphate (Beak 1979) Water yield from the 33 ha low grade coal stock pile is estimated to average 50 mm per year and the yield from the 22 ha Coal Blending Area is estimated at 80 mm per year due to a higher antecedent moisture condition created by dust control sprays at the stockpiles. These yields correspond to annual volumes of 16500 m^3 and 17600 m^3.

The overburden and the waste rock material from the open pit will be retained in valley-fill type dumps in Houth Meadows and Medicine Creek Valley by embankments at the valley mouths. Any runoff and leachate from mine waste disposal areas will require special drainage systems because of predicted level of dissolved solids and trace elements in excess of regulatory guidelines for discharge to streams (Beak 1978, 1979).

Surface runoff from the top of the dumps is expected to be neglible due to the fact that the surface will be level during construction and the material as dumped by the spreader will develop a terrain of curved furrows which will trap water to either infiltrate into the dump surface or be lost to evaporation. This topography is illustrated on Figure 3-9 later in the report.

Leachate from waste dumps will appear at the toe of the downstream waste embankments where it will be collected for disposal. These flows should be low due to the low hydraulic conductivity of the dumped waste.

Seepage and runoff from the coal and waste rock strata within the pit may be of similar quality to the stockpile and waste dump effluents. An average water yield of 80 mm has been assumed for these areas giving mean annual flows of .003 m^3/sec to .01 m^3/sec during the life of the mine.

The flow rates for dump leachate dewatering well flow and pit seepage have been estimated by the geotechnical consultant (Golder 1979) and are presented in Table 3-2.

TABLE 3-2

Projected Groundwater Yield From The Mine Development

Hat Creek Project Mining Feasibility Report 1979

	YEAR 5 ANNUAL VOLUME $m^3 \times 10^3$	YEAR 15 ANNUAL VOLUME $m^3 \times 10^3$	YEAR 35 ANNUAL VOLUME $m^3 \times 10^3$
OPEN PIT			
Periferal Wells	520	520	520
Seepage:			
- Surficials	90	120	120
- Bedrock	20	50	30
Total	630	690	670
HOUTH MEADOWS DUMP			
Embankment Seepage			
- No 1	9.5	11	11
- No 2	1.5	3	4
- No 3	0	2	5
Subtotal	11	16	20
To Regional Groundwater	0.3-3	1.5-15	6-32
Total	11-14	17-31	26-52
MEDICINE CREEK DUMP			
Embankment Seepage	0	4	12
To Regional Groundwater	0	0.3-3	1-6
Total	0	4-7	13-18

Source: Golder 1979

3.2 MINE DRAINAGE SYSTEM

The proposed mining drainage collection system will consist of:

- Diversion canals to divert creeks which presently flow through the mine site.
- perimeter drains around the proposed open pit, slide area and waste dumps to prevent inflow of surface water from upper valley slopes.
- Dewatering wells around the pit perimeter and in the potentially unstable slide area to the southwest.
- Surface water drains to collect stormwater within the open pit and mine service areas.
- Field drains to collect leachate from waste dumps and stockpiles.
- Sanitary sewers to collect sewage from the mine service areas.

A schematic of the proposed mine drainage system is shown on Figure 3-6 and a layout plan of project drainage is shown on Figure 3-7.

In the following sections, criteria used for drainage system design are presented and the drainage of each particular area of mine development is discussed.

321 Design Criteria and Selection of System Capacity

The capacities of various elements of the system have been selected according to their function and the potential risks of flood damage, should the system fail. Design Flow criteria adopted at this feasibility study stage, are shown on Table 3-3.

Larger drains or canals which pose a greater flood risk if breached have been designed on the basis of the 1000 year average return period flood which has a 3% chance of being exceeded during the 35 year mining period. Smaller drains which pose less of a flood risk have been assigned lesser design floods.

Floods from watersheds greater than 10 km^2 in area were estimated using figure 3-5; floods from watersheds of area less than 10 km^2 were estimated using the larger of the floods estimated from figure 3-2 or figure 3-5. This criterion accounts for the higher flows possible from small watersheds.

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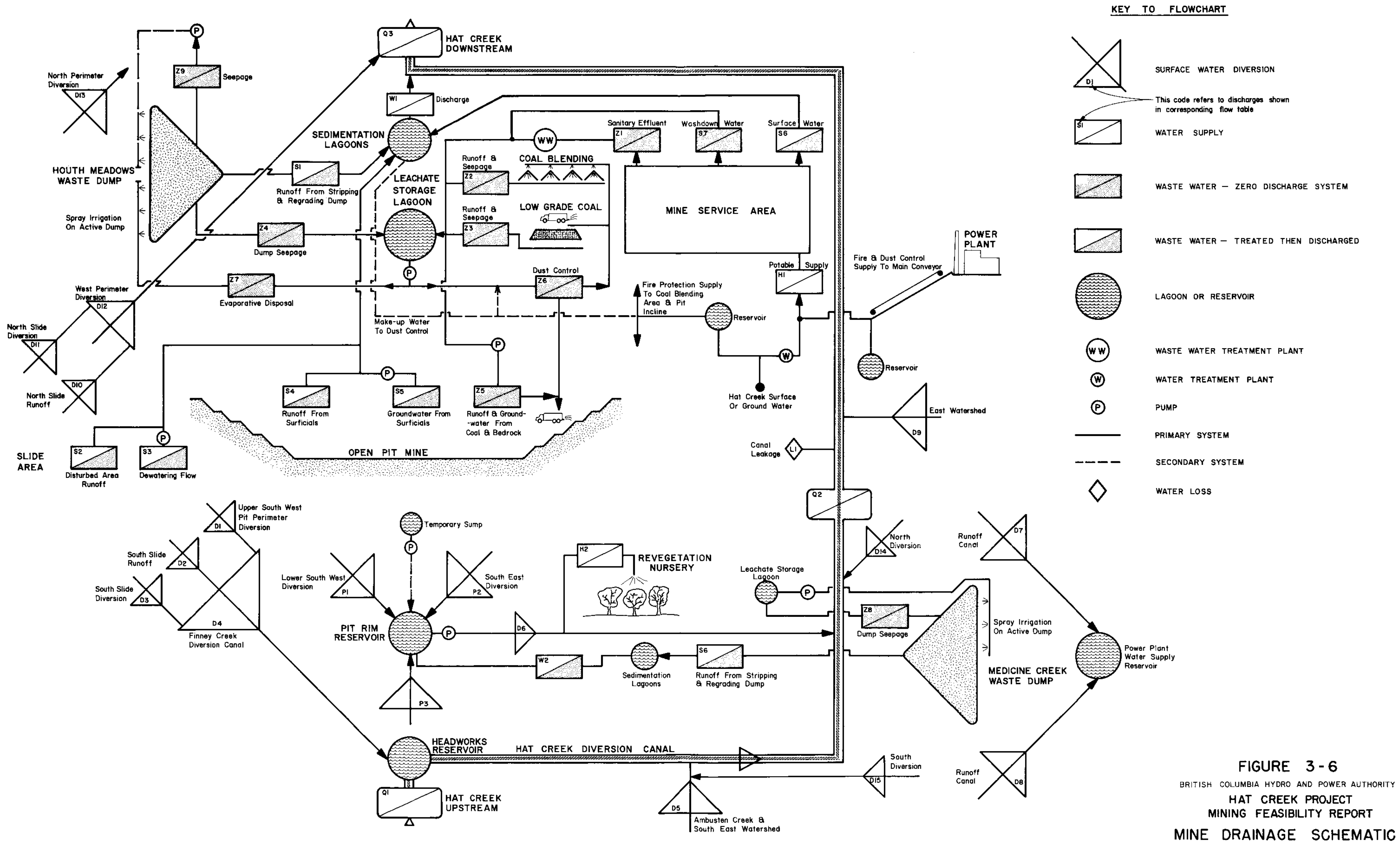


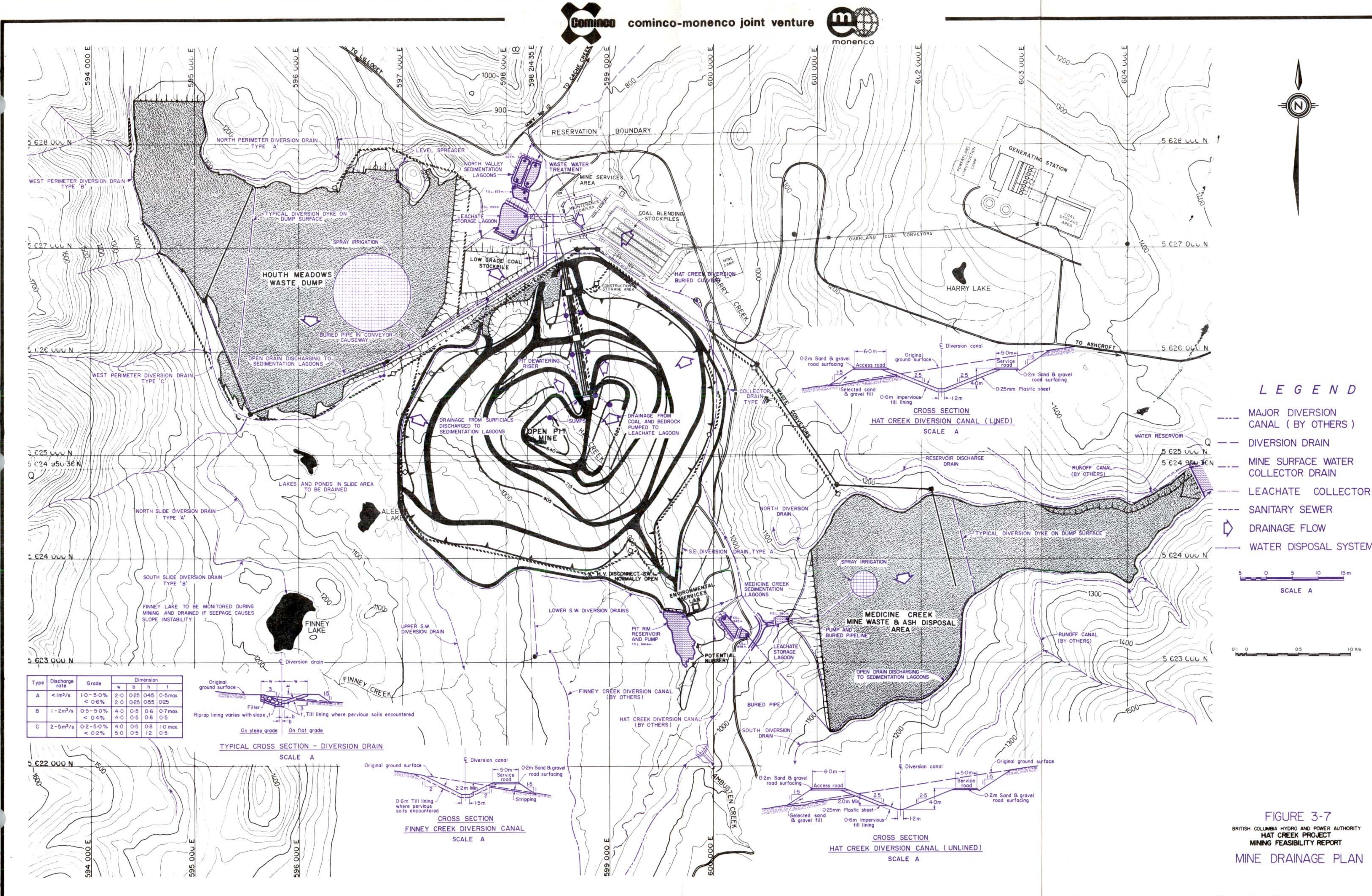
FIGURE 3-6

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

MINING FEASIBILITY REPORT

MINE DRAINAGE SCHEMATIC



Type	Discharge rate	Grade	Dimension			
			w	b	h	t
A	< 1m³/s	1·0 - 5·0%	2·0	0·25	0·45	0·5 max.
		< 0·6%	2·0	0·25	0·55	0·25
B	1 - 2m³/s	0·5 - 5·0%	4·0	0·5	0·6	0·7 max.
		< 0·4%	4·0	0·5	0·8	0·5
C	2 - 5m³/s	0·2 - 5·0%	4·0	0·5	0·8	1·0 max.
		< 0·2%	5·0	0·5	1·2	0·5

FIGURE 3-7
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
MINE DRAINAGE PLAN

TABLE 3-3

Design Criteria for Planning of Mine Drainage System

Hat Creek Project Mining Feasibility Report 1979

Type of Drainage Element	Description	Design Flood	Probability of Exceedence in 35 year Mine Life
Major Creek Diversions	Hat Creek	1,000 yr F*	3%
	Finney Creek	1,000 yr R*	3%
	Houth Creek	1,000 yr F	3%
	Upper Medicine Creek	Probable Max. Flood *	---
Perimeter Drains	Around Pit Waste Dumps & Slide Area	100 yr R	30%
Surface Water Drains within mine development	Permanent Major Drains	100 yr R	30%
	Temporary Minor Drains	10 yr R	97%
Leachate Collection Systems	Field Drains	Max. Seepage Rate	---
Dewatering Wells	Collection Systems	Max. Pumping Rate	---
Sedimentation Lagoons	Emergency Spillways	1,000 yr R	3%
	Treatment Capacity	10 yr R	97%
Leachate Storage Lagoons	Emergency Spillways	1,000 yr R	3%
	Storage and Disposal Capacity	2x Mean Annual Flow	---

* Refer BCH HEDD 1978 and Monenco 1977 for Design Criteria

Note:

1,000 yr F - refers to the 1,000 year average recurrence interval flood during spring freshet caused by rain and snowmelt

100 yr R - refers to the 100 year average recurrence interval flood caused by high intensity rainfall alone.

Table 3-4 gives the design flows estimated for all elements of the drainage scheme; the discharges calculated are indexed to Figure 3-6, the mine drainage schematic, for reference.

322 Drainage of the Mine Development

322.1 Open Pit

Diversion of Hat and Finney Creeks

In order for mining to proceed in the valley bottom, Hat Creek and Finney Creek must be diverted to prevent flooding of the excavation.

The proposed Hat Creek Diversion arrangement comprises a headworks dam with a canal intake and an emergency spillway located immediately downstream of Anderson Creek; approximately 6.4 km of diversion canal on the east side of Hat Creek Valley at about elevation 975 m ASL; and some 1.9 km of buried conduit with intake and outlet works to convey the flow back to Hat Creek (Monenco 1977; BCH-HEDD, 1978). A pit rim dam, spillway, pumphouse, and pipeline between the headworks dam and mine pit will intercept seepage and local inflow immediately upstream of the pit. The diversion works have been sized to accommodate, as a normal operating condition, a flow of 18 m^3/s (100 year recurrence interval flood) and as an emergency condition, a flow of 27 m^3/s (1000 year recurrence interval flood).

The proposed Finney Creek Diversion canal is 2.75 km long and will divert Finney Creek flows south, along the west side of Hat Creek Valley and discharge to the Hat Creek Diversion headworks pond. The design capacity of the canal is 5.5 m^3/s corresponding to the estimated 1000 year return period flood. Detailed plans and cost estimates for this system are provided under separate cover (BCH-HEDD, 1978).

Perimeter Drainage

The proposed open pit will be surrounded by approximately 6 km of open perimeter drainage ditches which will lie near the major perimeter access road and will intercept small amounts of local surface runoff. Five such drains are illustrated on Figure 3-7. The drain to the northeast, between the mine service area and the open pit will collect runoff from areas of heavy traffic for discharge to sedimentation lagoons north of the mine. Northwest of the open pit, an open drain, will discharge to the buried drainage pipe located in the conveyor causeway. To the south of the mine there will be three similar drains: the upper southwest perimeter drain which will discharge to the Finney Creek canal, and the lower southwest and southeast perimeter drains which discharge to the pit rim reservoir.

TABLE 3-4

Design Flows for Preliminary Planning of the Mine Drainage System

Hat Creek Project Mining Feasibility Report 1979

Code (As on Schematic) Fig. 3-6	Description	Watershed Area Km²	Flow Frequency	Flow Type	Estimated Flow M³/sec	Estimated Volume M³ x 1000	Data Sources	Remarks
HAT CREEK								
Q1	Hat Creek u/s of mine	248	A	M	0.63	-	1	-
Q2	Hat Creek d/s Medicine Creek	308	A	M	0.67	-	1	52km² to PP Res
Q3	Hat Creek d/s of Mine	383	A	M	0.72	-	1	-
-	Diversion Canal Capacity	-	1000F	P	27	-	3	Under emergency
DIVERSION DRAINS								
D1	Upper SW pit	2.0	100R	P	0.75	-	1	
D2	South Slide runoff	3.7	100R	P	1	-	1	
D3	South Slide Diversion	1.3	100R	P	1	-	1	
D4	Finney Ck Canal	21	1000F	P	3.50	-	1	
D5	Ambusten & SE Watershed	35	1000F	P	7	-	1	
D6	Pit Rim Pump	4.4	-	P	0.12	-	3	Pump capacity
D7	Medicine Ck Runoff Canal	-	PMF	P	2.0	-	3	
D8	Medicine Ck Runoff Canal	-	PMF	P	5.4	-	3	
D9	East Watershed	2	100R	P	1.2	-	1	
D10	North Slide Runoff	1.2	100R	P	.6	-	1	
D11	North Slide Diversion	4.5	100R	P	1.75	-	1	
D12	West Perimeter Diversion	25(31)	1000F	P	4.2 (5)	-	1	()=Post Reclamation
D13	North Perimeter Diversion	1	100R	P	1	-	1	
D14	North Med Dump Diversion	1.0	100R	P	0.75	-	1	
D15	South Med Dump Diversion	2.4 (6.5)	100R	P	1.5 (3.5)	-	1	()=Post Reclamation
P1	Lower SW Diversion	1.7	100R	P	0.7	-	1	
P2	SE Diversion	0.5	100R	P	0.5	-	1	
P3	Watershed below Canal	3	100R	P	1.5	-	1	
L1	Canal Leakage		DY	M	.01-.025	-	3	
MINE DRAINAGE COLLECTION SYSTEM						24 hr Volume		Project at max size
S1	Houth Meadows Dump	-	10R	P		15	1	"
S2	Disturbed slide area runoff	100	10R	P	-	6	1	"
S3	Slide dewatering wells		DY	P	-	.044	2	"
S4	Runoff from Pit Surficials	335	10R	P	-	48	1	"
S5	Groundwater from Pit Surficials		DY	P	-	2	2	"
S6	North Valley Services area	200	10R	P	-	20	1	"
S7	Washdown water	-	DY	M	-	.090	1	"
S8	Medicine Creek Dump	-	10R	P	-	13	1	"
DISCHARGE OF TREATED DRAINAGE								
W1	North Valley Sed. Lagoons		10R	P	0.8	56	1	From Hydrograph
W2	Medicine Creek Sed. Lagoons		10R	P	0.2	13	1	" "
ZERO DISCHARGE SYSTEM						Est. Annual Volume		
Z1	Sanitary Effluent	-	DY	M	.0016	51	1	700 man shifts/day
Z2	Coal Blending Leachate	0.22	A	M	-	20	1	Project at Max size
Z3	Low Grade Coal Leachate	0.33	A	M	-	16	1	" "
Z4	Houth Dump Leachate	-	A	M	-	11	2	" "
Z5	Pit Coal & Rock Leachate	-	A	M	-	332	1	" "
Z6	Dust Control consumption	-	A	M	-	319	1	" "
Z7	Evaporative Disposal	-	A	M	-	129	1	" "
Z8	Medicine Dump Leachate	-	A	M	-	12	2	" "
WATER SUPPLY SYSTEM								
H1	Mine Services Area	-	Dy	M	.0041	101	1	700 Man shifts/day
H2	Reveg Nursery	-	A	M	-	75	1	10ha

Key to Symbols in Table:

100R - 100 year Av recurrence interval rainstorm flood
1000F - 1000 " Av " " rain-snowmelt flood
10R - 10 " Av " " rainstorm flood
PMF - Probable Maximum Flood
DY - Daily
A - Annual
P - Peak Discharge
M - Mean Discharge

Sources of Data:

1 CMJV Estimate
2 Golder Assoc. 1978, 79
3 BCH HEDD, 1978

NOTE:

- These data are based on Preliminary Mine Planning Data, Hydrological and Hydrogeological Studies. Surface water flows from small watersheds and seepage flows are estimates based on several assumptions as to runoff infiltration factors and hydraulic conductivities therefore they should be upgraded when further site specific data becomes available.
- Where a range of flow is shown this identifies the variability of flow in terms of the assumptions made.
- Areas used correspond to the estimated maximum effective area of natural watersheds, disturbed areas or mine facilities to be drained during the 35 year mining period.

In-Pit Surface Water Drainage

Surface water and seepage within the open pit will be collected in open bench drains alongside bench haul roads. Runoff and seepage from surficial material above the mouth of the mine (EL 895m) will flow by gravity to the north end of the pit where it will be collected and discharged to sedimentation lagoons to the north of the pit. Runoff from surficials below the mouth of the mine will be collected by bench drains, discharged to small pump sumps and raised to upper gravity bench drains by portable 100 mm and 150 mm pumps of capacities 40-70 l/s. Lining of major bench drains will probably be required especially in pervious surficials on the east pit benches.

Runoff and seepage from coal and bedrock strata in the base of the pit will drain via bench drains to sumps located near the main pit access. Temporary sumps and pumps will be located in low areas on the floor of the pit to collect and remove accumulations of water. A major system of lift pumps will be installed on the pit incline with a capacity of 200 l/s provided by a set of cascading electric vertical turbine pumps at 4-bench (60 m) vertical intervals. This system will discharge to a leachate storage lagoon located to the north of the pit. During summer, water tankers used for dust suppression on bench and haul roads will be filled directly from sumps within the pit.

Dewatering Wells

A staged program of groundwater withdrawal is planned for the open pit. The system is summarized below: (CMJV VOL.III 1978)

- Starting in Year -5 two systems of wells should be drilled and operated: 25 wells in selected locations inside the ultimate pit perimeter at 50-metre depths, and 10 to 15 regional or extra-perimeter wells averaging 300-metres in depth. All well holes should be drilled 150 mm diameter and cased.

- From Year 10 through Year 15 a final set of wells should be established beyond the projected perimeter of the 35-year pit. By Year 15 this system should increase to 75 pairs of wells - one shallow at 50-metres and one deep averaging 300-metres.

Total water yield from the system is expected to be low i.e. an average of .017 m^3/s or 1470 m^3/day (Golder 1979). Most of this water will come from wells in pit surficials and should be of suitable chemical quality for discharge to Hat Creek; it will therefore be drained to sedimentation lagoons together with runoff from surficials.

Water from wells in coal or clastic sedimentary rock may be unsuitable for direct discharge to Hat Creek so it will be collected in drainage sumps along with surface runoff and pumped up the North pit incline to leachate storage lagoons.

Temporary lagoons will be constructed near any wells sunk prior to completion of the major permanent lagoon systems in year -3.

322.2 South West Slide Area

Recent Geotechnical Studies of the surficial slide area to the south and southwest of the proposed pit have determined that stabilization measures will depend primarily on drainage (Golder 1979). Surface water drainage will be required to prevent recharge of the slide groundwater system and subsurface drainage will be required to dewater or depressurise the groundwater.

Perimeter Drainage

In order to minimize infiltration of surface runoff from small creeks and watersheds at the back of the slide two diversion drains will be constructed at the valley slope-slide debris contact zone.

The north slide diversion shown on Figure 3-8 will be a 1.5 m^3/s capacity open drain 1.7 km long originating at a small lake near Finney Lake and running north along the perimeter of an area described as a possible slide zone to discharge to the proposed West Perimeter drain near the southwest corner of the Houth Meadows Waste Dump.

The South Slide diversion will be an 0.75 m^3/s capacity open drain 1.2 km long originating near the same lake and running south across inactive slide debris to discharge to the north end of Finney Lake.

Should Finney Lake be drained during mining then this diversion would be extended around the western lake shore to discharge to Finney Creek at the lake outlet. Diversion drains will be either fully lined or lined on the downstream side with a compacted layer of impermeable soil to minimise seepage to the slide mass.

Surface Drainage within the Slide Area

The proposed layout of in-slide drainage is shown on Figure 3-8. The system will drain approximately 62 small lakes and ponds in the area by improving natural drainage channels and deepening lake and pond outlets. Drainage of lakes will be carried out in the years prior to coal production and the water will be discharged during the spring freshet to minimise enrichment of creeks.

The slide area uphill and to the west of the active slide area will be drained to the West Perimeter Drain via two secondary drains; one draining

cominco-monenco joint venture

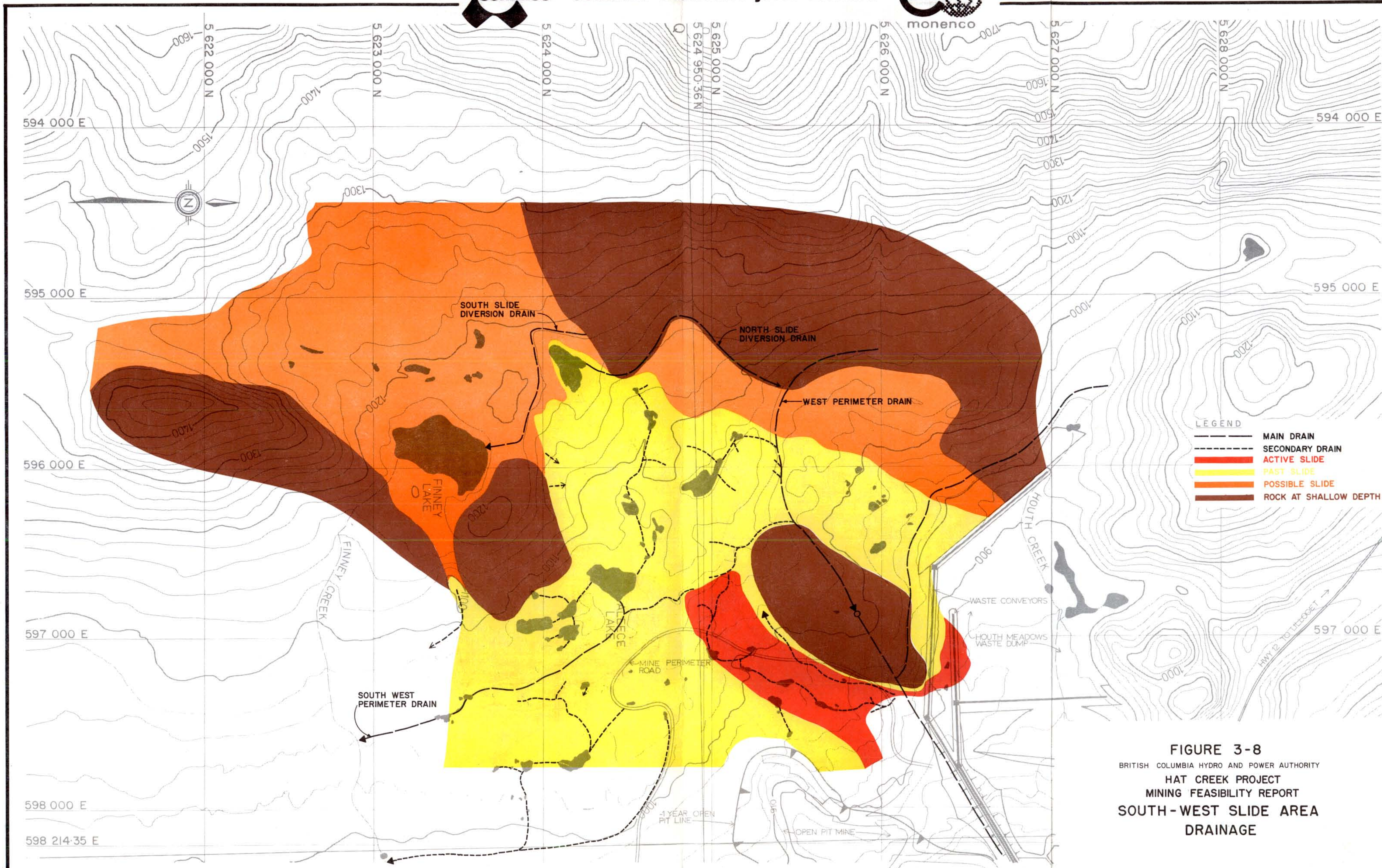


FIGURE 3-8
BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
SOUTH-WEST SLIDE AREA
DRAINAGE

the existing lake chain and one draining the series of hollows immediately above the active slide area.

Draining the active slide area itself will necessitate deepening and improving the existing channels down the slide. These channels will join together near the Houth Meadows conveyor causeway and drain to the surface water collection system at the north end of the upper pit benches. Provision has been made for drainage from this area to be discharged to the North Valley Sedimentation Lagoons.

The area to the south and southwest of the active slide area contains a discontinuous chain of lakes and hollows leading more or less towards Aleece Lake. The existing channels in this area will be deepened and improved and new channels excavated where necessary to drain all runoff through Aleece Lake to the Southwest Perimeter Drain, which will be constructed at the outset of the project in its "35 year pit" location. The southern end of this drain will now join Finney Creek approximately 750 metres upstream of the Finney Creek Diversion, requiring channel improvement for that stretch of creek bed.

The area downhill of the Southwest Perimeter Drain which will largely be removed by pit excavation during mining, will be dewatered and drained by a secondary drain system joining Finney Creek at its diversion point.

Well System

Provision has been made for the installation of a twenty well system and three kilometres of collector piping, however, as recommended by the geotechnical consultant, no layout has been attempted for this system at the present time. All piping has been assumed to be buried to allow use throughout the year, and flow rates are predicted to not exceed 16,000 m^3 per annum. (Golder 1979)

322.3 Houth Meadows Waste Dump

Perimeter Drainage

During waste dump construction in Houth Meadows surface water from the upper Houth Meadows watershed will be diverted around the dump via the West Perimeter Diversion as shown on Figure 3-7. This diversion consists of a 5 km long x 8 m wide open drain around the west and south perimeters of the dump, with discharge east to a buried pipe (approximately 2.2 km in length and 1.4 m to 2.1 m in diameter) in the conveyor causeway. This pipe will carry the flow northeast to rejoin Hat Creek north of the mine. The upper reach of the diversion will initially be constructed at elevation 950 m ASL in Year -2 and be relocated twice during the growth of the dump. The staged construction of the dump is illustrated on Figures 5-6, 5-7, 5-8, and 5-9 in CMJV Volume III.

The diversion is designed to carry the 1000 year spring freshet flood requiring 2 m^3/sec capacity in the upper reach and 5 m^3/sec capacity downstream of the confluence with the major tributaries of Houth Creek.

A typical cross-section of the open drain is shown on Figure 3-7. The channel will be unlined where minimum gradients i.e. less than 0.2% - 0.5% can be achieved, and the natural soil is relatively impervious. A compacted till lining will be placed in areas where pervious subsoil is encountered, and this layer would be later stabilized by revegetation with grasses. Where steeper gradients are encountered, a riprap lining will be placed to prevent scour. Icing of open drains may occur especially during early spring when there is late thawing during the daytime and freezing at night. To date, similar developments in the general region have not encountered icing problems in small drains or diversions serious enough to warrant special design configurations. Minor problems are presently dealt with by conventional winter maintenance operations.

Two further small perimeter drains will be constructed on the north slopes of Houth Meadows; these will discharge to the Marble Canyon watershed by way of level spreaders north of the waste dump saddle embankments.

Drainage of Lakes

Approximately 20 small lakes and ponds within Houth Meadows will be drained prior to dump construction.

Surface Water Collection

During construction of the dump it is expected that the top surface of the waste will be "undrainable" (as explained in section 334) and precipitation will be trapped and lost primarily to evaporation. Figure 3-9 illustrates the condition of the top surface of the dump during placement of waste. There may, however, be a small amount of drainage to be collected and disposed of from areas of prestripped land below perimeter diversion drains, areas of graded-off waste during progressive reclamation of the dump surface and from the final reclaimed dump surface which will have a 5% overall surface slope and be covered with a layer of glacial till to allow plant growth. An open-drain following the conveyorway on the south side of the dump will collect this drainage for discharge to the North Valley Sedimentation Lagoons by way of a buried pipe in the conveyor causeway. During operation of the waste dump this drain will dispose of surface water from the conveyorway and service roads. Drainage from the reclaimed dump surface will be channeled south across the dump surface to this drain by small diversion dykes or swales in the final dump surface relief.

When a stable ground cover is established on the dump surface and sediment load in drainage is reduced to acceptable levels the dump surface drains will be diverted to the west perimeter diversion drain, bypassing the sedimentation lagoons.

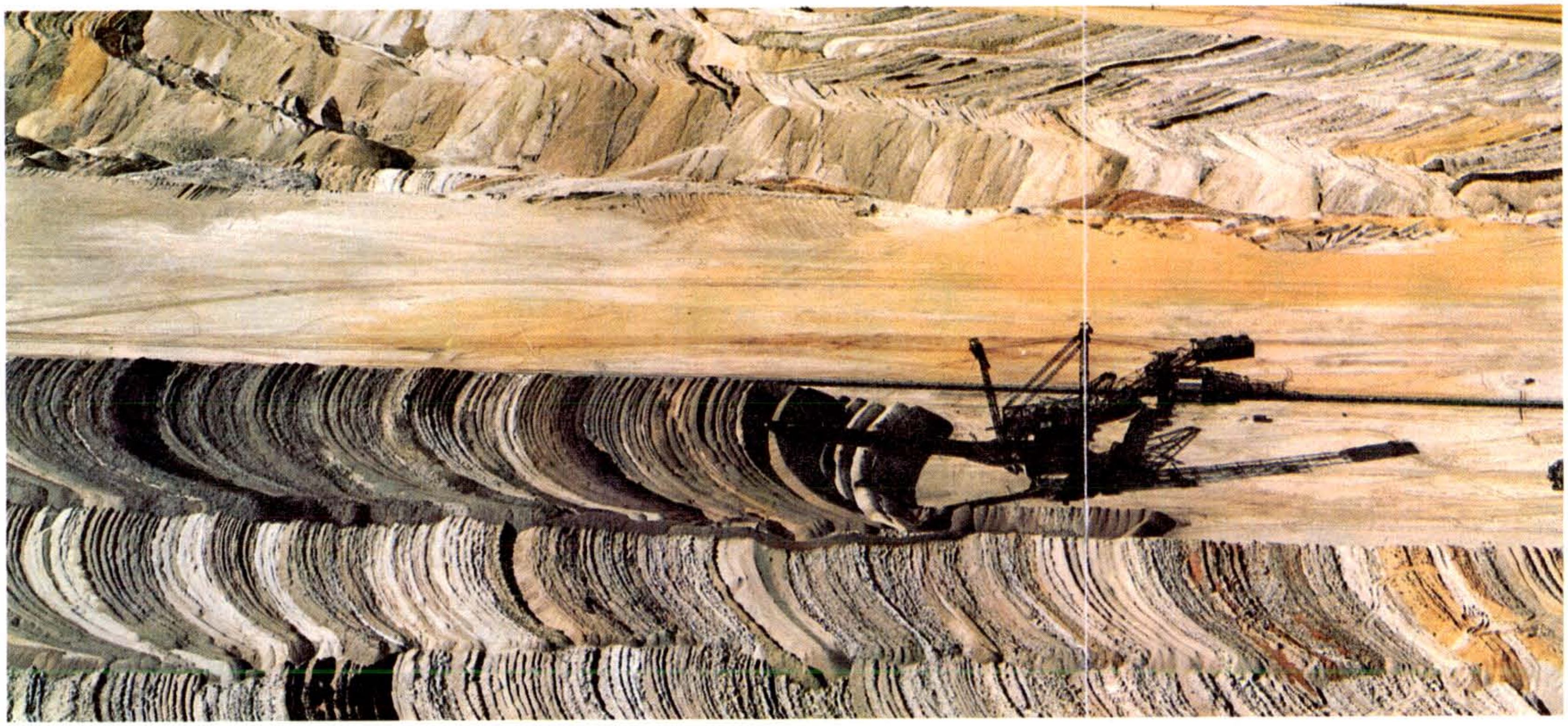


FIGURE 3-9

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT

TYPICAL WASTE DUMP OPERATION

Leachate Collection

Leachate from the toe of the main Houth Meadows waste embankment will be collected by a line of perforated subsoil drains and discharged to the leachate storage lagoon in the North Valley. It is further recommended that groundwater quality downstream of the two saddle embankments between the Houth Meadows Waste Dump and Marble Canyon watershed be monitored and should water quality deteriorate then dewatering wells could be installed to return leachate to the dump surface for disposal by evaporation.

322.4 Medicine Creek Waste Dump

Waste Dump Planning

Under the recently proposed "Dry Ash Disposal" (BCH Thermal Division 1978) waste management plan for Lower Medicine Creek valley both thermal power plant ash and mine waste will be placed separately in one valley - fill type dump. The power plant ash will be placed at the east end, i.e. head of the dump continuously from years 1 to 35 and the mine waste will be placed in the lower or west end of the dump during years 16 to 35.

Perimeter Drainage

At the outset of the project a power plant water supply reservoir will be constructed in Upper Medicine Creek Valley east of the proposed waste dump site. Two sidehill canals will collect runoff from the slopes above the upper part of the waste dump and discharge to the reservoir. The proposed location and design of the reservoir and canals is described in BCH HEDD Report DD122 "Design Memorandum on Alternative Wet and Dry Ash Disposal Schemes."

Prior to commencement of stripping and waste dumping operations in the lower valley two smaller sidehill drains will be constructed on the slopes above. These drains shown on Figure 3-7 will total 7 km in length and be designed to carry peak flows of 0.75 m^3/sec on the north slope and 3.5 m^3/sec on the south slope. The north drain will discharge to a level surface spreader above the Hat Creek diversion canal. The larger drain on the south slope will discharge to Ambusten Creek which will be stabilised with a riprap lining to prevent erosion.

Surface Drainage

During the first 15 years of power plant operation drainage from the ash disposal area will be collected at an earthfill berm in the lower valley and pumped to a holding pond for disposal by recycling. In later years when mine waste is dumped in the lower valley a berm of fairly impervious mine waste will be maintained downstream the toe of the ash pile to collect surface runoff and any leachate for pumping to the holding pond.

The top of the ash will be progressively reclaimed west from the head of the dump by capping the surface with a suitable soil material as a buffer and growth medium and by seeding to prevent erosion. During mining drainage from the reclaimed areas will be collected at the south perimeter of the dump and returned to the powerplant wastewater holding pond. In the decommissioning phase runoff from the reclaimed areas would be discharged to the south diversion drain and small temporary sedimentation basins would be constructed near the south perimeter to reduce sediment concentrations in runoff from areas yet to be stabilised by revegetation.

Runoff from prestripped areas and the progressively reclaimed mine waste in the lower valley will be collected at the dump perimeter and discharged to sedimentation lagoons at the mouth of Medicine Creek valley and then to the Pit Rim Reservoir. During dumping of waste negligible runoff is expected from the dump due to the continuation of level grade and rough surface illustrated on Figure 309. As sediment yield from the progressively reclaimed dump surface is reduced by revegetation the drainage will be diverted from the sedimentation lagoons to the south diversion drain to be directly discharged to the Hat Creek diversion canal via Ambusten Creek.

Leachate Collection

Leachate will be collected by a perforated subsoil drain at the toe of the waste embankment and discharged to a leachate storage lagoon for summer disposal by spray irrigation on the active dump surface.

322.5 Coal Blending Area

The proposed coal blending area will cover an area of 22 ha to the north of the mine and comprises four stockpiles of total area 15 ha. A compacted till blanket overlain by a pervious sand and gravel drainage layer would form the foundation for the stockpiles. Surface water and leachate will be drained to the west perimeter where it will be collected and piped to a leachate holding pond for temporary storage prior to disposal by recycling for dust control use within the mine.

322.6 Low-Grade Coal Stockpile

The proposed low-grade coal stockpile north of the mine, between the Houth Meadows conveyor ramp and the water treatment lagoons, should primarily consist fo claystone material with a varying percentage of coal. This material will be compacted as it is placed; therefore, the permeability of the proposed stockpile will be low. Non-active stockpile surfaces will be covered by a non-sodic buffer material and suitable surface soil for early re-establishment of vegetation. Runoff and leachate is to be collected in a sump at the north end and discharged to the leachate lagoon located immediately to the North.

322.7 Topsoil Storage Areas

Surface water will be diverted away from the upper perimeter of topsoil storage areas by small ditches to minimize erosion of piles. The stockpile surface is to be progressively revegetated, thus minimizing erosion of the pile and contamination of downstream surface water.

322.8 Mine Service Area

Surface runoff from the mine service area would originate from roofs of buildings and the open yard space used for storage of mine equipment and vehicles. Yards would be sloped to open drains at the perimeter and drainage around buildings would be handled in buried stormwater drains. Drainage from the service areas will be channelled west to the main sedimentation lagoons to remove any sediment and oil. Drainage from vehicle washdown facilities will be piped through an oil trap to the "Zero Discharge" system for leachate disposal.

322.9 Mine Roads

Surface water from haul roads within the pit will be collected in bench drains with runoff from pit slopes. Drainage from the upper benches will be discharged to sedimentation lagoons and that from the lower benches will be discharged to the "Zero Discharge" system. Drainage from roads on the northeast and northwest perimeter of the pit will be collected by open drains and discharged to the main sedimentation lagoons situated to the north of the pit.

Drainage from roads on the south perimeter of the pit will be drained to a small temporary lagoon in the valley south of the pit from where it will be pumped to the pit rim reservoir. Due to its close proximity to the pit this small lagoon would be lined to reduce seepage.

Roads within the two waste dump areas will drain to the sedimentation lagoons serving the dump developments.

3.3 WASTEWATER DISPOSAL

331 Water Quality Considerations

331.1 Discharge Objective

To ensure protection of the environment and compliance with present government regulations, the quality of water discharged from the Hat Creek Mine should be within the British Columbia Department of the Environment Pollution Control Board, Level 'A' effluent discharge guideline for the mining industry (B.C. Ministry of the Environment 1973).

The applicable discharge quality is given on Table IV of these guidelines, and objectives for receiving water quality are given on Table VI.

331.2 Projected Quality of Mine Drainage

Projections of water quality have been made using analytical data from well water, laboratory leachate studies on waste and coal; and from field samples taken during the Bulk Sample Program (Beak 1977,78,79). A summary table of natural surface water quality, projections of mine drainage quality and the corresponding present PCB Level A discharge standard are presented on Table 3-5.

Further data and assumptions used in projecting water quality can be found in "Impact Assessment of the Revised Project" Beak 1979.

Conclusions which have been drawn from these data are:

Open Pit

- Seepage and dewatering well flow from surficials should be chemically suitable for discharge. Sulphate concentrations may be slightly elevated but are comparable to natural levels in Hat Creek itself.

  Sedimentation may be required especially if joint groundwater and surface water collection systems are used.

- Seepage and dewatering well flow from bedrock will have higher concentrations of dissolved solids and would be unsuitable for direct discharge due to elevated Zinc and sulphate concentration.

- Surface water quality will depend on contact time with the parent material and on surface leaching rates which are presently not known. For planning purposes it has been assumed that these flows are inseparable and must be treated as for seepage.

TABLE 3-5

Projections of Water Quality of Mine Drainage

Hat Creek Mining Feasibility Study 1979

	Natural Surface Water				Mine Drainage							Discharge Guideline
Parameter (mg/1)	Hat(1) Creek	Medicine Creek Area	Finney Lake	Aleece Lake	Ash Leachate	Mine Waste(2) Leachate	Coal Leachate	Low Grade Coal Leachate	Slide Debris Groundwater	Mine Water (Bedrock)	Mine Water (Surficials)	PCB Level A Objectives
pH (units)	8.4	8.3	8.2	7.6	8.0-9.0	3.1	5.0*	4.6*	8.0	7.8	7.9	6.5-8.5
Filterable Residue	336	275	179	N.A.	4800-8900*	1125	8400*	5400*	1070	1950	350	< 2500
Non Filterable Residue	8	0-110	N.A.	N.A.	N.A.	N.A.	N.D.	N.D.	N.D.	N.D.	N.D.	< 50
BOD5	< 1	N.A.	N.A.	N.A.	< 35-195	137	N.D.	N.D.	N.A.	N.D.	N.D.	N.D.
TOC	8	19	18	N.A.	N.A.	N.A.	N.A.	N.D.	50	50	21	N.D.
Alkanity	212	221	123	217	1120-1260	123	27	0.5	570	1185	270	N.D.
Chloride	1.2	0.4	0.5	< 0.5	175-190	27	14	0.88	28	42	3	N.D.
Fluoride	.14	0.12	0.22	N.A.	3.3-4.9*	0.06	0.10	N.D.	0.16	0.2	0.2	2.5
Nitrate(as N)***	< .06	0.04	< 0.02	N.A.	2.4-3.3	4.4	N.D.	N.D.	< 0.14	< 0.06	< 0.2	10.0
Kjeldahl Nitrogen (as N)	.19	0.26	0.83	N.A.	N.A.	N.A.	N.A.	N.A.	< 11.0	14.0	< 0.2	N.D.
Ortho Phosphate (as P)	.038	0.01	0.025	N.A.	0.14-0.31	0.3	0.01	N.D.	< 0.03	< 0.03	< 0.03	2.0
Sulfate	50	20	5	52 *	1500-1580*	21	3700*	3800*	380*	< 321*	52*	50(3)
Arsenic	< .005	< 0.005	< 0.005	< N.A.	< 0.6-2.4 *	0.07*	0.005	0.005	< 0.005	0.006	< 0.005	0.05
Boron	< .01	< 0.1	< 0.1	N.A.	< 3.0-3.6	0.04	0.31	0.7	< 0.21	0.31	< 0.1	N.D.
Cadmium	< .005	< 0.005	< 0.005	N.A.	< 0.10	< 0.002	N.D.	N.D.	< 0.005	< 0.005	< 0.005	0.005
Calcium (as $CaCO_3$)	145	130	60	85	1050-1130	48	1900	1075	208	180	148	N.D.
Chromium	< .010	< 0.01	< 0.01	N.A.	< 0.12-0.20*	0.13*	0.01	0.010	< 0.01	< 0.01	< 0.01	0.05
Copper	< .005	< 0.005	< 0.005	N.A.	< 0.23-0.33*	1.5*	0.03	0.007	< 0.008	< 0.008	< 0.005	0.05
Iron	< .018	< 0.02	< 0.04	< 0.05	1.95-2.05*	1.25*	0.26	0.01	< 0.06	< 0.075	< 0.025	0.3
Lead	< .010	< 0.01	< 0.01	N.A.	< 0.05	0.02	N.D	N.D.	< 0.03	< 0.013	< 0.010	0.05
Magnesium (as $CaCO_3$)	74	85	33	100	220-230	33	2240*	1680*	118	124	66	150
Mercury	< .00038	< 0.0005	< 0.00033	N.A.	< 0.0013-0.0023*	0.0015*	0.0003	0.0003	< 0.0003	< 0.0003	< 0.0003	0.001
Sodium	20	11	15	38	325-335	63	190	150	230	412	39	N.D.
Vanadium	< .005	< 0.005	< 0.005	N.A.	< 0.18-0.22	0.01	0.04	0.006	< 0.006	< 0.007	< 0.005	N.D.
Zinc	.008	0.009	0.006	N.A.	0.82-2.5*	0.15	0.11	0.18	< 0.36	0.52*	< 0.03	0.5

SOURCE: Beak 1978, 1979 NOTE: (1) Mean of measurements taken Sept. 1976-1977 during a low flow year.
(2) Surface Runoff has been projected to be of this quality (Beak 1979).
(3) *Subject to review*

* indicates parameter is in excess of PCB Level A Objective.

Slide Area - Dewatering well flow from the slide area will have elevated sulphate concentrations. Surface water and dewatering well flow may require sedimentation if the slide debris is disturbed.

Waste Dumps - Runoff and leachate from Power Plant ash will be unsuitable for discharge due to elevated levels of BOD, suspended solids, total dissolved solids, Fluoride, Arsenic, Boron, Cadmium, Chromium, Copper, Iron, Mercury and Zinc.

- Leachate from Mine waste will be unsuitable for discharge due to elevated concentrations of Arsenic, Chromium, Copper, Iron and Mercury.

Coal Blending Stockpiles - Leachate will be unsuitable for discharge due to projected elevated concentrations of Total Dissolved Solids, Sulphate and Magnesium; and low pH.

- Runoff and leachate will be virtually inseparable due to the semi pervious nature of the stockpiles.

Low Grade Coal Stockpiles - Leachate will contain elevated levels of Total Dissolved Solids, Sulphate and Magnesium; and low pH.

- Runoff will probably be unsuitable for direct discharge.

Other projections which have been made on the basis of previous mining experience are:

Disturbed Land - Runoff from areas of stripped or disturbed land will contain elevated levels of suspended sediment. Average sediment yield may increase by a factor of 3 from 5.6 tonne/km^2/yr to 17 tonne km^2/yr. (Beak 1978) Assuming an average runoff of 50 mm for the mine area then mean sediment concentrations in incoming runoff may be in the order of 200-400 mg/l. Observations in North Dakota indicate that erosion rates may remain elevated after topsoiling and revegetation therefore sedimentation lagoons should be kept in service until acceptable sediment concentrations prevail.

Mine Service Area - Runoff and washdown water may contain elevated concentrations of oil, grease, coal fines, and suspended sediment.

- Sanitary effluent from the mine service area will probably be a medium strength waste of BOD_5 150-250 mg/1 and a Total Suspended Solids concentration of 200-300 mg/1.

331.3 Proposed Treatment to Meet Discharge Objectives

The following treatment and disposal systems are proposed to meet receiving water and effluent discharge quality objectives.

1) "Zero Discharge" System

- This system will store leachate and runoff which is not chemically fit to be discharged and dispose of it by recycling it to dust control and spray irrigation.

2) Sedimentation Lagoons

- This system will reduce projected elevated suspended solids concentrations in runoff from disturbed land which is otherwise fit for discharge. The treated effluent will be discharged to Hat Creek downstream of the mine.

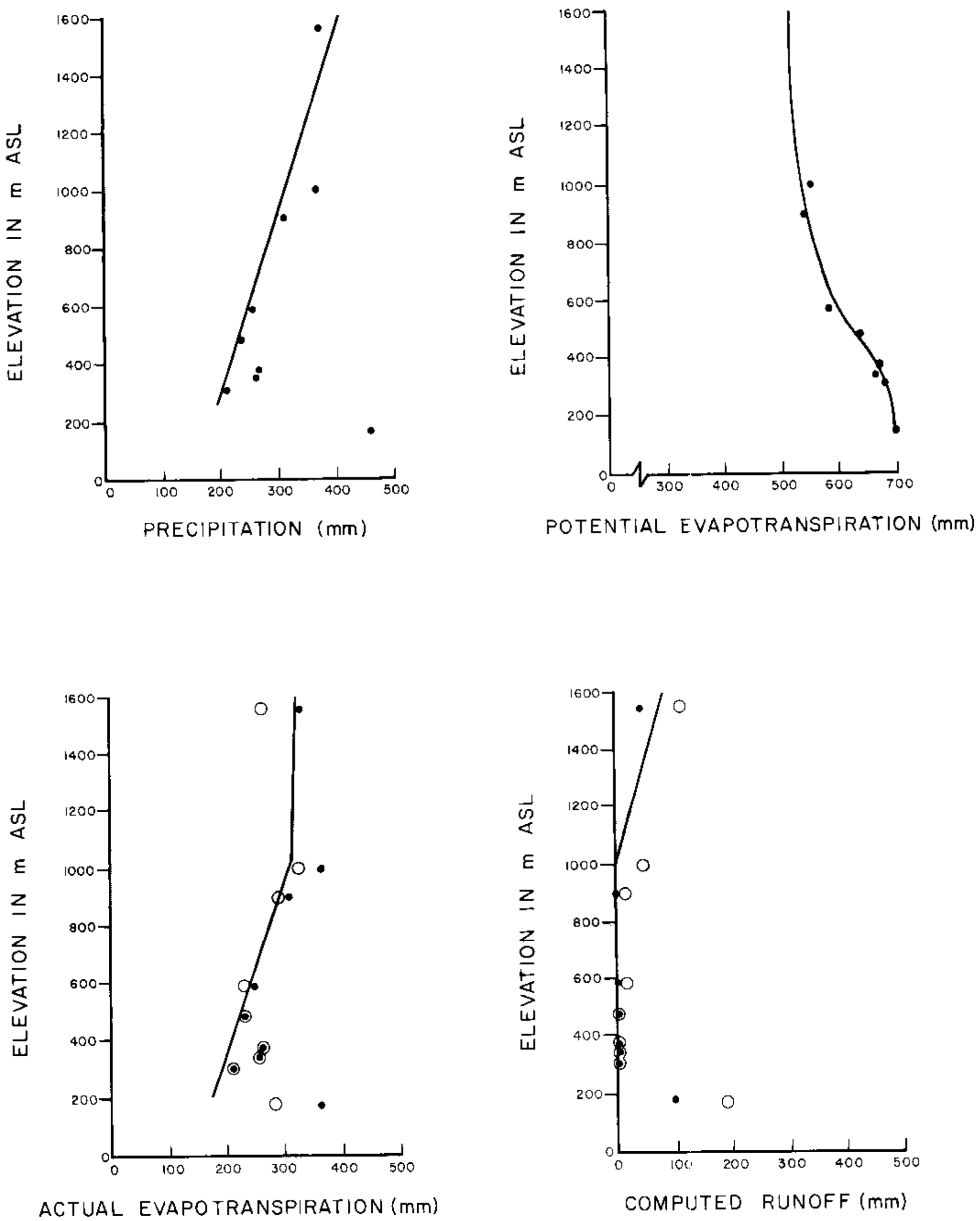
3) Sewage Treatment

- Sewage will be biologically pre-treated in an oxidation ditch system before being recycled to dust control in the mine.

332 "Zero Discharge" System

332.1 General

Leachate flow from the pit, waste dumps and coal stockpiles will be stored in a "Zero Discharge" lagoon system and evaporated in summer time by recycling the water to dust control operations on coal stockpiles and pit roads. The disposal of any surplus will be by spray irrivation on the active surfaces of waste dumps. Potential evapotranspiration, precipitation and watershed yield data are shown on Figure 3-10 and it can be seen by comparing the two upper graphs that the annual water deficit at the mine site varies from 350 mm at EL 640 m (pit floor level) to 170 mm at EL 1200 m (the highest point on the Medicine Creek waste dump).



LEGEND

○ 100 mm SOIL STORAGE
• 200 mm SOIL STORAGE
MINE SITE ELEVATION

Source. Beak 1978.

FIGURE 3-10
BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
WATERSHED YIELD

In order to utilise this deficit, which generally commences in April, reaches a maximum in July and tapers off again to zero in October, storage is required to hold back winter and spring leachate discharge. Discharge over this period will include the bulk of the runoff from the coal and bedrock strata in the lower pit. A large lagoon will be constructed in the bottom of Hat Creek Valley to the North of the pit to store leachage from the pit, Houth Meadows waste dump and the coal blending area. A smaller second lagoon will be constructed at the toe of the Medicine Creek waste dump to store leachate from the toe of the waste embankment.

332.2 Inflow, Outflow and Lagoon Capacity

The selection of the required lagoon capacity depends on:

- The acceptable risk of a leachate spill

- The quantity and time distribution of annual inflow

- The quantity and time distribution of annual outflow

In this feasibility study it was decided to allow sufficient lagoon capacity to store an "extreme" inflow equal to the maximum projected groundwater flow plus twice the projected mean inflow from surface runoff. The estimated inflow in a mean year and an extreme year is shown on Table 3-6. Analysis of runoff at the Hat Creek gauge 08LF061 indicates that the "extreme" event has an annual probability of occurrence of 0.1% or a 3.5% chance of occuring in the life of the mine (Monenco 1977), however, flow from small disturbed watersheds will be more variable than Hat Creek flow and an annual probability of 1% - 2% (corresponding to 30%-50% during the life of the mine) is probably representative of this risk.

Three additional safety factors which should also be considered are:

- The bulk of the climate dependent lagoon inflow is pumped from the lower pit therefore it is under the control of mine operations staff. In "extreme" inflow years it may be possible to temporarily store excess leachate in sumps in the bottom of the pit until capacity is available in the lagoon.

- In the unlikely event of a spill, flow would be discharged back to the open pit by an emergency spillway.

- The increasing volume of inflow over the mining period requires a system which grows.

TABLE 3-6

Annual Water Balance for Leachate System

Hat Creek Mining Feasibility Report 1979

	YEAR 5 $m^3 \times 10^3$		YEAR 15 $m^3 \times 10^3$		YEAR 35 $m^3 \times 10^3$	
	Mean	Extreme	Mean	Extreme	Mean	Extreme
INFLOW						
Pit Runoff & Seepage	101	202	202	404	332	664
Bedrock Groundwater	20	20	50	50	30	30
Houth Meadows Leachate	9	11	11	16	11	20
Coal Blending Drainage	18	36	18	36	20	40
Low Grade Coal Drainage	16	32	16	32	16	32
Sanitary Effluent	51	51	51	51	51	51
Medicine Creek Dump Leachate	0	0	4	4	12	12
	215	352	352	593	472	849
OUTFLOW						
DUST CONTROL						
Roads	158	158	158	158	158	158
Coal Blending Area	88	88	88	88	88	88
Low Grade Coal	38	38	38	38	38	38
Other	35	35	35	35	35	35
Net Pond Loss	12	12	12	12	12	12
	331	331	331	331	331	331
SPRAY IRRIGATION						
Houth Meadows Dump	0	21	17	258	129	506
Medicine Creek Dump	0	0	4	4	12	12
	0	21	21	262	141	518
BALANCE	0	0	0	0	0	0

NOTE: 1) Extreme flow case = 2 x mean annual flow from runoff plus maximum projected groundwater yield.

2) These data are based on preliminary estimates of water yield.

Provision can be made to bring forward planned increments in lagoon volume should operational experience indicate higher flows than predicted. Should the reverse happen and flow be lower than expected then expansion of these facilities could be deferred with savings in capital cost.

Taking these factors into consideration the chances of significant water pollution due to spillage are negligible.

Figures 3-11, 3-12, 3-13 show the hydrograph analysis of projected inflow and outflow data at mine development years 5, 15 and 35.

Conclusions which are drawn from these data are:

Year 5 - A total lagoon capacity of 200,000 m^3 is required. In mean years a water deficit for dust control of about 120,000 m^3 will exist which will require make up water from sedimentation lagoons. In an "extreme" year all inflow could be consumed by dust control operations within the mine in one year.

Year 15 - A total lagoon capacity of 360,000 m^3 is required. In a mean year inflow will exceed dust control outflow requiring spray irrigation on a dump area of about 5-10 ha. In an "extreme" year approximately 100 ha of spray irrigation would be required to empty the lagoon prior to the next season.

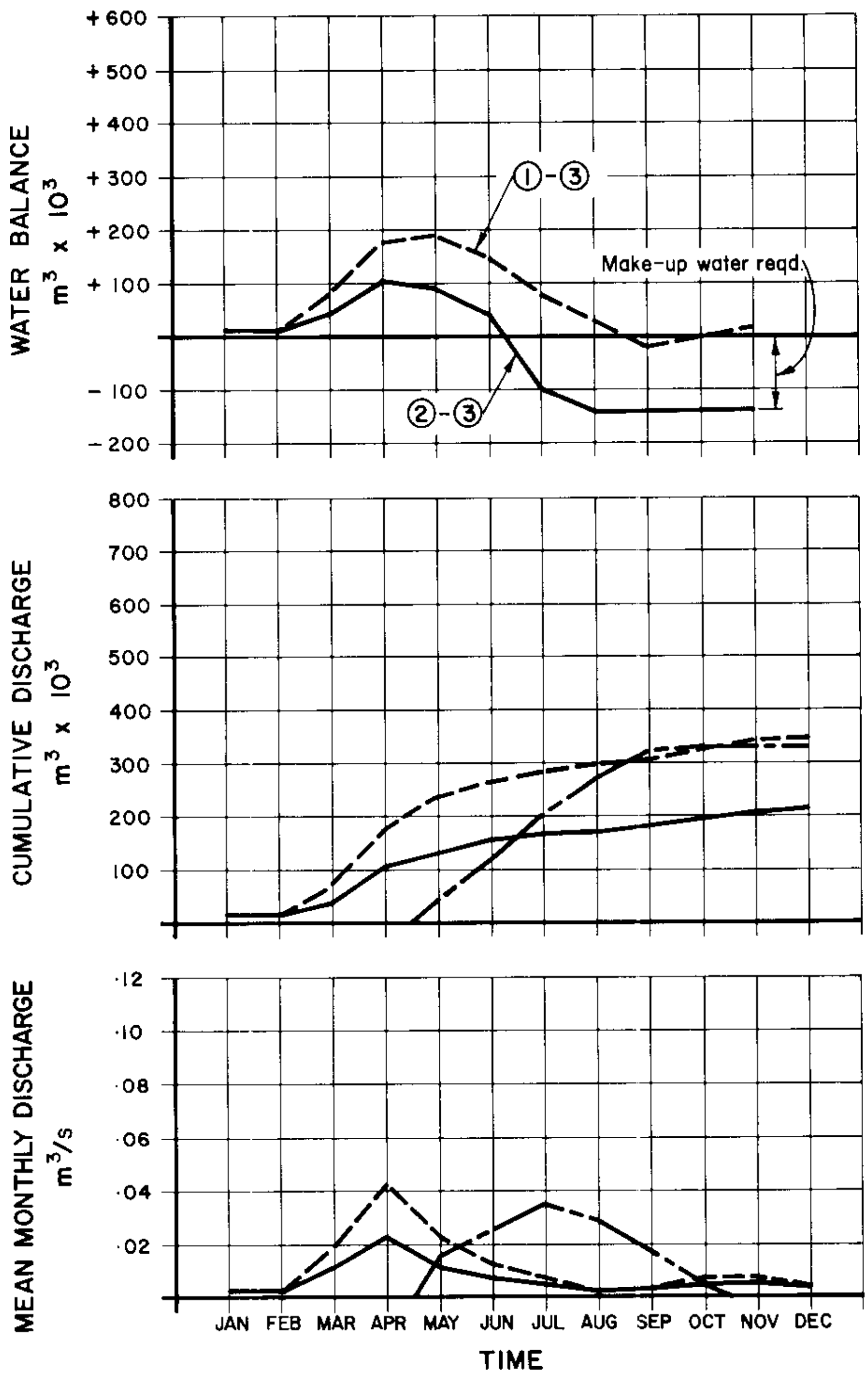
Year 35 - A total lagoon capacity of 560,000 m^3 is required. In a mean inflow year 50-60 hectares of spray irrigation will be required and in an extreme year 200-210 hectares would be required.

On the basis of these data it appears that such a scheme is both feasible and manageable at Hat Creek.

332.3 North Valley Lagoon and Disposal System

The North Valley Lagoon will cover an area of up to 9 ha and be constructed in the bottom of Hat Creek Valley near the confluence with Houth Creek. The proposed layout shown on Figure 3-7 features a zoned earthfill dam at the north and south end of the lagoon which can be raised in three 5m stages to elevation 845 m to provide a storage capacity of 700,000 m^3. A further 5 m increase in dam height to 850 m has been allowed for as an emergency measure to provide a total capacity of 1,100,000 m^3. Two metres of freeboard will be provided in both cases.

The east and west sides of the lagoon will be formed by the existing valley slopes which will be cut back to a grade of 3:1 to improve slope stability. The lagoon will be lined with a buried membrane lining consisting of an 0.8 mm thickness PVC membrane and up to two metres of zoned clay-till, sand and gravel.



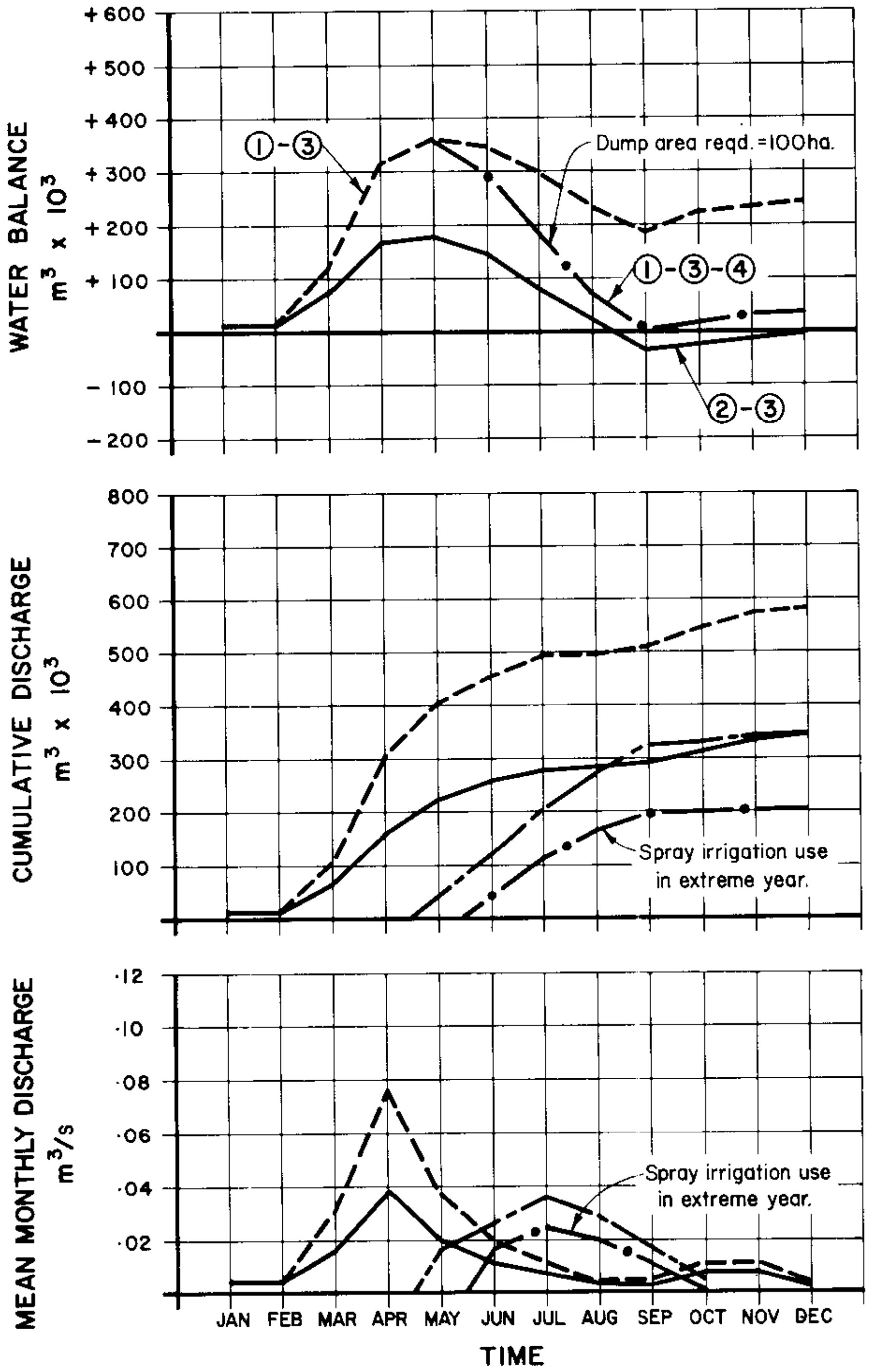
LEGEND

① EXTREME INFLOW
② MEAN INFLOW
③ DUST CONTROL OUTFLOW
④ SPRAY IRRIGATION OUTFLOW

FIGURE 3-11
BRITISH COLUMBIA HYDRO & POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT
ZERO DISCHARGE SYSTEM
HYDROGRAPHS-YEAR 5

cominco-monenco joint venture

monenco



LEGEND

① - - - - - EXTREME INFLOW

② ———— MEAN INFLOW

③ — - — DUST CONTROL OUTFLOW

④ — • — SPRAY IRRIGATION OUTFLOW

FIGURE 3-12

BRITISH COLUMBIA HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

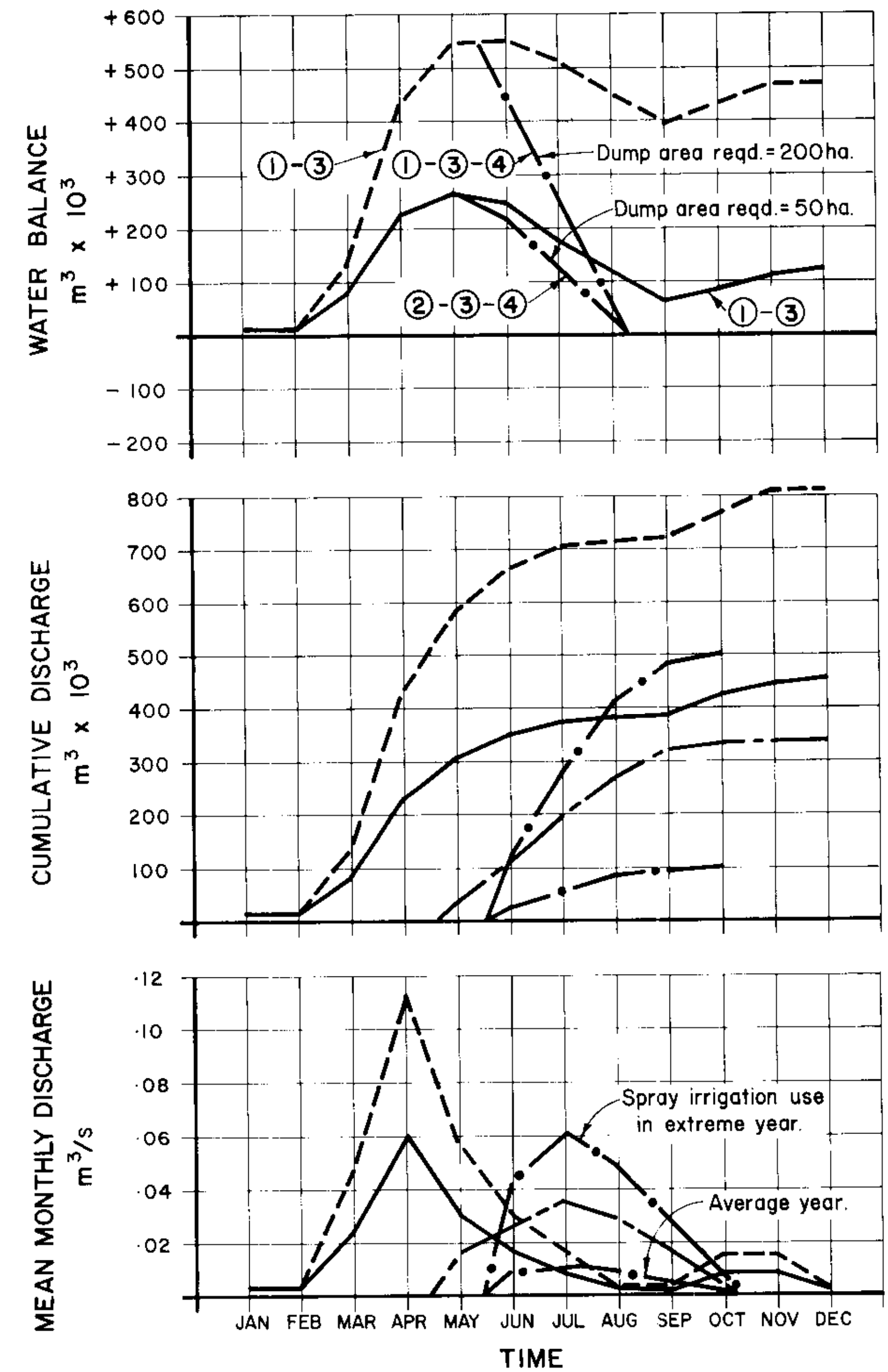
MINING FEASIBILITY REPORT

ZERO DISCHARGE SYSTEM

HYDROGRAPHS-YEAR 15

cominco-monenco joint venture

monenco



LEGEND

① EXTREME INFLOW

② MEAN INFLOW

③ DUST CONTROL OUTFLOW

④ SPRAY IRRIGATION OUTFLOW

FIGURE 3-13

BRITISH COLUMBIA HYDRO & POWER AUTHORITY

HAT CREEK PROJECT

MINING FEASIBILITY REPORT

ZERO DISCHARGE SYSTEM HYDROGRAPHS-YEAR 35

A series of drop manholes will be used to dissipate the energy of incoming flow and prevent scour of the pond lining. The pond outlet will consist of a concrete tower which will house leachate recycling pumps of total capacity 175 l/s. The buried discharge pipeline will supply pond effluent to:

- Sprinkler monitors at the Coal Blending Stockpiles.
- Water Tanker filling points on the north pit incline.
- A discharge point at the top of the low grade stockpile.
- A discharge point near the south abutment of the Houth Meadows waste embankment to service the spray irrigation system required in the latter part of the project.

Runoff drains will be constructed around the pond perimeter to divert surface inflow north to sedimentation lagoons and an emergency spillway of capacity equal to the 1,000 year return period flood will be located on the east abutment of the South Dam to protect the earthfill embankments.

332.4 Medicine Creek Valley Lagoon

Required leachate storage capacity at Medicine Creek is estimated at 12,000 m^3 which will be created in a small pond of area 0.7 ha downstream of the toe of the Medicine Creek waste embankment. This pond will be lined and will provide for expansion over and above projected storage requirements.

Inflow to the pond will stem from field drains at the base of the embankment and outflow will be pumped up the westerly face of the Medicine Creek waste embankment for disposal of by spray irrigation on the active dump surface.

An emergency spillway discharging to the pit and runoff diversion drains will be provided as for the North Valley System.

332.5 Operation

Once in operation, the "Zero Discharge" system will require minimum maintenance. Seasonal inspection of the pond lining should be done in late Autumn when the pond level will be at its lowest. Care will be required in the selection and maintenance of pump and piping systems due to the presence of sediment and potentially aggressive water.

Annual sediment accumulation in the large lagoon could be in the order of 65 to 250 m^3 a year which will have an insignificant affect on residual pond volume, (in the order of 200,000 to 600,000 m^3) therefore the sediment buildup in the pond will remain for the life of the project.

Spray irrigation on dump surfaces should be managed to avoid conflict with waste dumping operations. Geotechnical studies of dump stability have shown that it will be important to keep material near the transfer conveyor dry to improve stability of the bench on which it operates. (Golder 1978). Spray monitors should therefore be kept away from conveyor-spreader operations. Regarding overall dump stability it was found by the Geotechnical Consultant that even if the waste was fully saturated the material would be stable at the proposed final dump surface slope of 5%, therefore spray irrigation should not jeopardise overall dump stability. The assumed low surface irrigation rate of 250 mm per year plus the large storage capacity of the lagoon should give sufficient flexibility to the system to allow satisfactory operation.

In the post production period the mean annual lagoon inflow will decrease from 470,000 m^3 to 25,000 m^3 as pumping from the pit will have ceased, the coal blending area will be reclaimed and the mine service facilities will have been removed. The Medicine Creek system would abandon spray irrigation as a disposal system in this period and leachate would be disposed of by evaporation and/or overflow to the open pit via a buried pipeline. In the North Valley, natural evaporation from the leachate pond should be sufficient to dispose of the residual leachate from the Houth Meadows dump and low grade coal storage area.

333 Sedimentation Lagoon System

333.1 General

A sedimentation lagoon system is required to reduce projected elevated sediment concentrations in certain mine drainage which should otherwise be fit for discharge.

This runoff will come from:

- Natural rangeland within the mine development which is stripped of soil-cover during construction and operation of the mine.
- The area of pit surficials between the pit perimeter road and the rock interface.
- Stormwater drains in mine service areas.
- Regraded and reclaimed areas of waste dumps.

Two groups of lagoons are required and are shown on Figure 3-7. The first will be constructed (prior to mining operations) to the north of the pit at the junction of Hat Creek Valley and Marble Canyon and will consist of 3 lagoons. The second system of 2 lagoons will be constructed downstream of the the Medicine Creek Waste Dump prior to commencement of dumping operations in year 16.

333.2 Design Criteria

The PCB Level 'A' discharge objective for suspended sediment in drainage discharge is 50 mg/1. The theoretical sediment removal efficiency of a lagoon of given area depends on the overflow velocity at the design rate of pond discharge. The overflow velocity resulting from the 10 year 24 hour flood was selected as the design criteria for selection of pond size; this criteria has been proposed by the US Environmental Protection Agency. (EPA 1976).

During larger flood flows the efficiency of sediment removal will decrease with increased overflow rates. In such an event suspended sediment concentrations in Hat Creek itself may be elevated, (values of up to 300 mg/1 have been predicted during freshet) therefore, the net effect on receiving water quality should be low.

333.3 Inflow

An analysis was made of land use within the mine development area at years 5, 15 and 35 and these data, shown on Table 3-7, were used to evaluate the size of the watersheds to be drained to sedimentation lagoons. The 10 year 24 hour runoff from the watersheds was estimated using Figure 3-2 and summed to give total pond inflows. These data are shown on tables 3-8, 3-9 and 3-10. The resultant 10 year 24 hour volumes of runoff to be treated are 78,000 m^3 at years 5 and 15 and 91,000 m^3 at year 35. Annual mean discharges for the lagoons were also estimated and total 1,050,000 m^3 in year 5, 1,093,000 in year 15, and 1,181,000 m^3 in year 35.

333.4 Sedimentation Tests

Laboratory Jar and Settling Column tests were carried out on slurry samples from Hat Creek pit overburden, coal waste and waste rock, (B.C. Research 1978).

Preliminary tests aimed at investigating the natural sedimentation characteristics of the slurries (results are shown on table 3-11) determined that only runoff from Glacial-Fluvial sand and gravel (typical of the overburden on the east pit bench) could be expected to satisfy the less than 50 mg/1 discharge guideline without chemical treatment.

Tests carried out with Alum coagulant were successful in achieving satisfactory sediment concentrations in supernatant of all samples although high coagulant dosages were required, due to some extent, to the high initial suspended sediment concentrations used in the laboratory tests, i.e. in the range 2,000 - 20,000 mg/1. The results of these tests are given on Tables 3-12 and 3-13.

TABLE 3-7

Surface Condition of Mine Property Watershed

Hat Creek Project Mining Feasibility Report 1979

	Year 5	Year 15	Year 35
OPEN PIT MINE			
Total area of pit within perimeter road	450 ha	605 ha	750 ha
Exposed surface			
Coal	23%	22%	17%
Waste	5%	18%	38%
Surficials	72%	60%	45%
WASTE DUMPS			
Total area of Houth Meadows Dump	356 ha	455 ha	610 ha
Exposed surface			
Prestripped land	4%	2%	-
Dumped waste	96%	98%	69%
Reclaimed land	-	-	31%
Total area of Medicine Creek Dump	-	80 ha	410*
Exposed surface			
Prestripped land	-	100%	
Dumped waste	-	-	50%
Reclaimed land	-	-	50%
COAL STORAGE			
Coal Blending Stockpile	22 ha	22 ha	22 ha
Low Grade Coal Stockpile	15 ha	33 ha	33 ha
MINE SERVICE AREA			
Total area	200 ha	200 ha	200 ha
Exposed surface			
Yards	13%	13%	13%
Ponds	4%	4%	4%
Conveyorways	11%	11%	11%
Open Space	72%	72%	72%
SW SLIDE AREA			
Disturbed land Outside Mine Perimeter (Assumed)	100 ha	100 ha	100 ha
TOTAL	1,043 ha	1,495 ha	2,125 ha

Note Areas shown are plan areas.
*Area of upper surface of Medicine Creek Dump (Alternative B).
Total area including embankment is 427 ha.

TABLE 3-8

Estimated Sedimentation Lagoon Inflow - Year 5

Hat Creek Project Mining Feasibility Report - 1979

Source	Area (ha)	Runoff Curve Number CN	Mean Annual Runoff ($m^3 \times 10^3$)	10 yr 24 hr. Runoff ($m^3 \times 10^3$)
	NORTH VALLEY LAGOONS			
1. Open Pit Mine				
Runoff above EL 900	250	90	200	38
Runoff below EL 900	85	90	68	(13)10*
Dewatering flow	-	-	626**	2
2. North Valley				
Service areas, roads and open space	200	85	100	20
3. Slide Area				
Disturbed land	100	80	50	6
4. Houth Meadows Waste Dump				
Stripped land	10	90	5	2
Levelled waste	-	-	-	-
Reclaimed land	-	-	-	-
Total North Valley Lagoons	645	-	1049	78
	MEDICINE CREEK LAGOONS			
5. Medicine Creek Dump				
Stripped land	-	-	-	-
Levelled waste	-	-	-	-
Reclaimed land	-	-	-	-

NOTE:

It is assumed that maximum 24 hour inflows will occur during summer rainstorms. Curve numbers for soil cover complexes have been estimated from literature (USSCS 1964, 1975).

* Contribution to pond inflow limited by pump capacity.

** Includes 16,000 m^3 from slide area.

TABLE 3-9

Estimated Sedimentation Lagoon Inflow - Year 15

Hat Creek Project Mining Feasibility Report - 1979

Source	Area (ha)	Runoff Curve Number CN	Mean Annual Runoff ($m^3 \times 10^3$)	10 yr 24 hr. Runoff ($m^3 \times 10^3$)
		NORTH VALLEY LAGOONS		
1. Open Pit Mine				
Runoff above EL 900	250	90	200	38
Runoff below EL 900	102	90	82	(15)10*
Dewatering flow	-	-	656**	2
2. North Valley				
Service areas, roads and open space	200	85	100	20
3. Slide Area				
Disturbed land	100	80	50	6
4. Houth Meadows Waste Dump				
Stripped land	10	90	5	2
Levelled waste	-	-	-	-
Reclaimed land	-	-	-	-
Total North Valley Lagoons	661	-	1093	78
		MEDICINE CREEK LAGOONS		
5. Medicine Creek Dump				
Stripped land	80	90	40	12
Levelled waste	0	0	0	0
Reclaimed land				
Total Medicine Creek Lagoons	80	0	40	12

NOTE:

It is assumed that maximum 24 hour inflows will occur during summer rainstorms.
Curve numbers for soil cover complexes have been estimated from literature (USSCS 1964, 1975).

* Contribution to pond inflow limited by pump capacity.

** Includes 16,000 m^3 from slide area.

TABLE 3-10

Estimated Sedimentation Lagoon Inflow - Year 35

Hat Creek Project Mining Feasibility Report - 1979

Source	Area (ha)	Runoff Curve Number CN	Mean Annual Runoff ($m^3 \times 10^3$)	10 yr 24 hr. Runoff ($m^3 \times 10^3$)
NORTH VALLEY LAGOONS				
1. Open Pit Mine				
Runoff above EL 900	250	90	200	38
Runoff below EL 900	85	90	68	(38)10*
Dewatering flow			656**	2
2. North Valley				
Service areas, roads and open space	200	85	100	20
3. Slide Area				
Distrubed land	100	80	50	6
4. Houth Meadows Waste Dump				
Stripped land	-	-	-	-
Levelled waste	24	90	12	4
Reclaimed land	190	80	95	11
Total North Valley Lagoons	849	-	1181	91
MEDICINE CREEK LAGOONS				
5. Medicine Creek Dump				
Stripped land	-	-	-	-
Levelled waste	24	90	12	4
Reclaimed land	148	80	74	9
Total Medicine Creek Lagoons	172	-	86	13

NOTE:

It is assumed that maximum 24 hour inflows will occur during summer rainstorms. Curve numbers for soil cover complexes have been estimated from literature (USSCS 1964, 1965).

* Contribution to pond inflow limited by pump capacity.

** Includes 16,000 m^3 from slide area.

TABLE 3-11

Column Settling Tests in 2-1 Graduate Cylinders without Flocculant

Hat Creek Project Mining Feasibility Report 1979

Material	Time (hr)	Suspended Solids (mg/L) 0 cm	11 cm	28.5 cm	Particle Size (%) Clay + Silt (sample)*	Sand	pH
		---------depth---------					
Glaciofluvial sand/gravel	0.25	188	404	428	2	98	7.4
	4.5	120	132	132			
	24	76	56	60			
Glacial till	0.25	2,600	5,643	5,893	19	81	8.1
	4.5	510	1,980	2,670			
	24	45	1,040	1,360			
Slide Debris	0.25	5,798	10,049	11,218	36	64	8.2
	4.5	560	2,760	4,130			
	24	60	65	70			
Waste (1)	0.25	10,000	15,000	16,640	2	98	8.5
	4.5	840	9,480	10,160			
	24	133	5,800	7,020			
Waste (2)	0.25	12,500	17,080	19,160	6	94	8.3
	4.5	2,410	9,400	10,960			
	24	120	5,400	6,920			
Low-grade coal	0.25	13,280	17,080	19,060	n.a.	n.a.	6.9
	4.5	1,680	9,860	11,789			
	24	90	6,040	8,100			
Composite	0.25	7,700	10,820	12,260	n.a.	n.a.	8.1
	4.5	2,060	5,980	7,040			
	24	53	3,200	4,340			

Note: 50 g of original solids (coarse plus fine) per litre distilled water

* B.C. Research (1978)
Golder (1978)

(1) Golder Sample

(2) Acres Sample

TABLE 3-12

Column Settling Tests in 15 cm x 180 cm Cylinders

with Aluminum Sulphate (ALUM)

Hat Creek Project Mining Feasibility Report 1979

Material	Time (hr)	Suspended Solids (mg/L)	Turbidity NTU	Interface Depth (cm)	Sample Depth (cm)
Glacial till	0.3	44	21.0	61	48
	0.6	19	7.5	81	48
Slide debris	0.3	144	48.0	43	20
	0.6	68	29.0	67	36
	1.6	42	21.0	78	65
Waste (1)	0.9	105	32.0	8	6
	2.5	66	23.0	22	20
	5.3	5	3.2	48	37
	6.7	4	2.2	53	52
Waste (2)	0.7	28	11.0	7	5
	4.1	2	2.5	38	20
	4.2	21	7.5	38	36
	21.4	25	8.2	69	52
Low grade coal	0.6	11	7.2	8	5
	1.9	21	8.8	24	20
	4.7	8	5.2	51	36
	6.2	2	2.4	59	51
Composite	0.3	20	16.0	9	7
	0.9	9	6.5	28	22
	1.8	7	4.5	47	36
	3.7	3	4.2	67	53
	5.1	5	2.8	70	66

(1) Golder
(2) Acres

Note: Alum dosages are described in Table 3-13.

Source: B.C. Research (1978)

TABLE 3-13

Column Settling Tests in 15 cm x 180 cm Cylinders

with Aluminum Sulphate (ALUM)

Hat Creek Project Mining Feasibility Report 1979

	Alum Dosage mg/L	Free Interface Settling Rate cm/hr	Time to Achieve Suspended Solids $<$50 mg/L at 50 cm depth hours	SO_4 mg/L
Glacial till	100	253	<1	74
Slide debris	120	143	<2	138
Composite waste	206	30	4	106
Low grade coal	125	12	6	171
Waste (1)	206	9	6	152
Waste (2)	206	9	21	178

(1) Golder
(2) Acres

Source: B.C. Research (1978)

Based on these data an overflow velocity of 9cm/hr (2.5×10^{-5} m/sec) was selected for planning of pond size. It should be noted that in the present drainage scheme only runoff from overburden which has a substantially higher settling velocity than the design value is admitted to sedimentation lagoons. The more conservative value has been adopted in recognition of the need to minimise coagulant use because of observed increases in sulphate concentrations in supernatant and in recognition of the fact that absolute separation of runoff from pit overburden and bedrock cannot be 100% assured.

333.5 North Valley Sedimentation Lagoons

A three lagoon system will be constructed to the North of the pit near the mouth of Upper Hat Creek Valley. The system will consist of a primary sedimentation and flow balancing lagoon of area 2.5 ha and two secondary lagoons of total area 4.5 ha. The total storage volume of the system will be about 250,000 m^3. The primary lagoon will be formed in the bottom of Hat Creek Valley by the toe of the North Leachate lagoon dam and a second dam 120 m downstream. The pond will be operated between EL 824 m and EL 828 m and will regulate the inflow to the secondary lagoons. The secondary lagoons will be about 90 m x 250 m and will be created on valley bottomland by zoned earthfill retaining dykes of maximum height 10 m. Construction material for the core of the dykes will be excavated from till deposits in the mine area and sand and gravel for the outer shell of the dykes will be taken from the glacio-fluvial deposits on the east side of the valley. The Borelog from hole RH 77-46 which is near the lagoon site indicates that the near surface layers consist of silty and sandy gravel with a 0.6 m thick clay layer at 20 m depth. Should similar conditions be encountered at the lagoon site then a low permeability till lining may be required on the bottom of the lagoons. This lining should be continuous with the dyke core.

Inflow to the primary pond will be via a stilling basin and inlet manifold on the south side of the pond and outflow will be controlled by 2 decant towers on the opposite bank. Inflow to the secondary lagoons will enter via a pipe manifold at the south end and outflow will be via an overflow weir to the north.

When coagulation or pH adjustment is required, chemicals will be added at 2 mixing points, one in the inflow pipe to the primary lagoon and the other at the connection between the primary and secondary lagoons.

An emergency spillway channel will be constructed along the east flank of the lagoons to pass flows in excess of outlet capacity. The spillway will be designed to discharge the projected 1:1000 year return period flood.

333.6 Medicine Creek Sedimentation Lagoons

Two lagoons of total area 1.8 ha will be constructed downstream of the Medicine Creek dump prior to stripping operations in Year 15. The system will consist of a small primary and larger secondary lagoon created by dykes on the slopes of Hat Creek Valley just below the diversion canal alignment. The primary lagoon level will be operated between EL 946 m and EL 948 m to regulate incoming flows and the secondary lagoon level will remain constant at EL 945 m. An emergency spillway will also be provided.

333.7 Lagoon Discharge

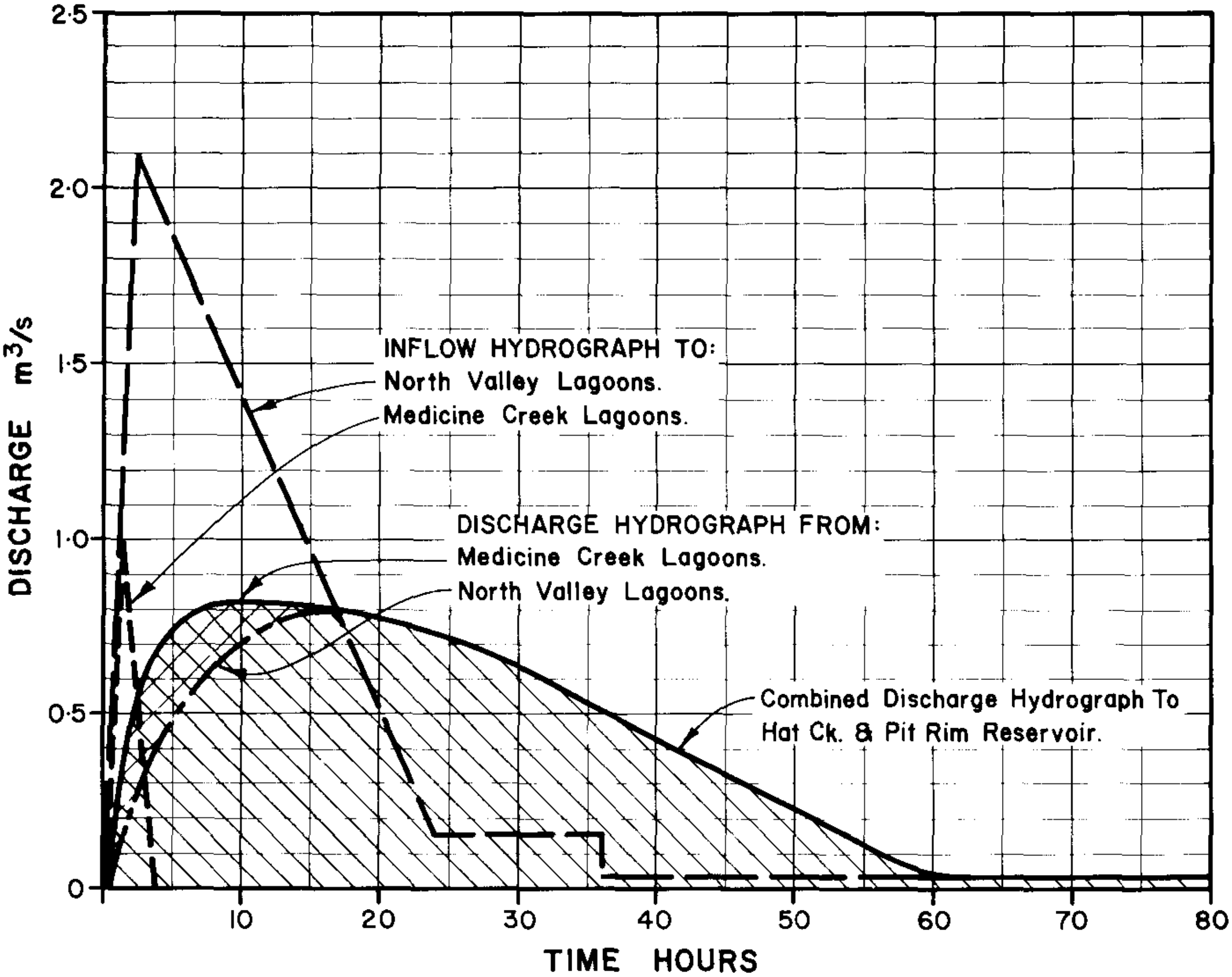
The 10 yr - 24 hr. storm discharge hydrographs from the proposed sedimentation lagoon system was determined using an inflow hydrograph of known volume and assumed shape and routing it through the pond system, taking account of changes of storage and the net smoothing affect of the system. These hydrographs are shown on Figure 3-14. The estimated mean annual discharge hydrograph from the lagoons shown on Figure 3-15 was constructed by assuming a relatively constant discharge of groundwater augmented by the estimated runoff yield in the lower valley in each month. Using these data and the water quality data on Table 3-5 projections were made by Beak Consultants of the future quality of lagoon effluent and the effects of lagoon discharge on receiving water quality in Hat Creek. Three cases were evaluated:

Case I - the dry weather condition when the predominant lagoon inflow would come from dewatering wells. Hat Creek flows would be at their lowest.

Case II - the spring runoff condition when the predominant lagoon inflow would come from surface water in the lower pit. Hat Creek flows would be elevated.

Case III - summer rainstorm condition when a proportionately larger amount of surface runoff may occur within the mine than the rest of Hat Creek Valley.

The projected water quality data are shown on tables 3-14, 3-15, 3-16 and indicate that:



NOTE

The lagoons are sized on the basis of these hydrographs. Emergency Spillways will be sized for the 1:1000 yr. return period flood.

FIGURE 3-14

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

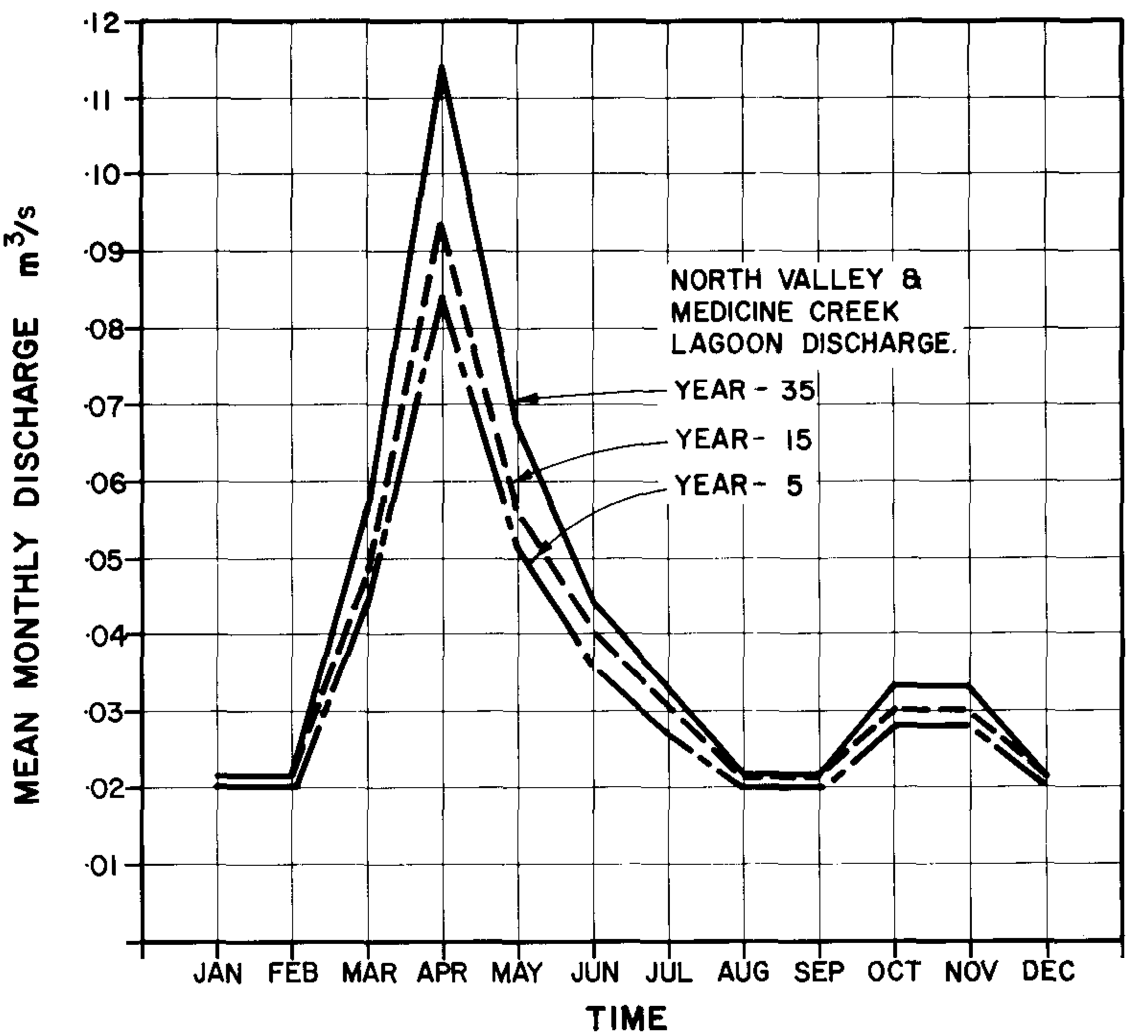
MINING FEASIBILITY REPORT

SEDIMENTATION LAGOONS

10 YEAR 24 HOUR

FLOOD DISCHARGE HYDROGRAPH

cominco-monenco joint venture



NOTE

Pond loss to seepage and evaporation plus dust control use early in mine development may reduce summer flows by ·010 – ·025 m^3/s

FIGURE 3-15

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT
MINING FEASIBILITY REPORT

SEDIMENTATION LAGOONS
ESTIMATED MEAN DISCHARGE
HYDROGRAPHS

TABLE 3-14

Projected Quality of Lagoon Discharge and Hat Creek - Case I *

Hat Creek Project Mining Feasibility Report 1979

Parameter (mg/1)	Projected North Lagoon Effluent	Existing Hat Creek	Projected Hat Creek
pH (units)	7.9	8.4	8.3
Filterable Residue	368	342	345
Non-Filterable Residue	< 50 mg/1	6	12
TOC	22	9	11
Total Hardness (as $CaCO_3$)	217	224	223
Alkalinity (as $CaCO_3$)	277	226	233
Chloride	4	1.1	1.6
Fluoride	0.2	0.16	0.17
Total Nitrogen (N)	< 0.56	0.24	< 0.26
Phosphorous (P)	< 0.03	0.043	< 0.04
Sulfate	60	54	55
Arsenic	< 0.005	< 0.005	< 0.005
Boron	< 0.10	< 0.10	< 0.10
Cadmium	< 0.005	< 0.005	< 0.005
Calcium (as $CaCO_3$)	149	143	144
Chromium	< 0.01	< 0.010	< 0.01
Copper	< 0.005	< 0.005	< 0.005
Iron	< 0.03	< 0.026	< 0.028
Lead	< 0.01	< 0.010	< 0.01
Magnesium (as $CaCO_3$)	67	77	76
Mercury	< 0.0003	< 0.0004	< 0.0004
Sodium	38	20	23
Vanadium	< 0.006	< 0.005	< 0.006
Zinc	< 0.04	< 0.007	< 0.01

*Dry Weather Condition (Year 35). The only discharge to Hat Creek via the sedimentation lagoon is the dewatering flows from the pit surficials and from the slide area. Refer Table 3-2. Hat Creek discharge assumed to be 0.12 m^3/sec.

(Source Beak 1979)

TABLE 3-15

Projected Quality of Lagoon Discharge and Hat Creek - Case II *

Hat Creek Project Mining Feasibility Report 1979

Parameter (mg/l)	Projected Effluent North Lagoon	Projected Effluent Med. Ck. Lagoon And Rim Reservoir	Existing Hat Creek	Projected Hat Creek After Mixing
pH (Units)	8.3	8.3	8.4	8.4
Filterable Residue	364	430	342	347
Non-Filterable Residue	< 50	< 50	12	< 18
TOC	13	25	9	20
Total Hardness (as $CaCo_3$)	216	190	224	222
Alkalinity (as $CaCO_3$)	235	203	226	227
Chloride	3	5	1.1	1.5
Fluoride	0.17	0.11	0.16	0.16
Total Nitrogen (N)	< 0.4	1.0	0.24	< 0.28
Phosphorus (P)	< 0.05	0.06	0.043	< 0.044
Sulfate	55	20	54	54
Arsenic	< 0.007	< 0.017	< 0.005	< 0.006
Boron	< 0.10	< 0.09	< 0.10	< 0.10
Cadmium	< 0.005	< 0.005	< 0.005	< 0.005
Calcium (as $CaCO_3$)	142	115	143	142
Chromium	< 0.013	< 0.04	< 0.010	< 0.011
Copper	< 0.04	< 0.28	< 0.005	< 0.016
Iron	< 0.06	< 0.25	< 0.026	< 0.036
Lead	< 0.01	< 0.012	< 0.010	< 0.01
Magnesium (as $CaCO_3$)	74	75	77	77
Mercury	< 0.0004	< 0.0007	< 0.0004	< 0.0004
Sodium	27	20	20	21
Vanadium	< 0.005	< 0.006	< 0.005	< 0.006
Zinc	< 0.017	< 0.035	< 0.007	< 0.009

*Spring Runoff Condition (Year 35). Discharges to Hat Creek via the sedimentation lagoon include prorated mean surface runoffs and the dewatering flows from the pit surficials and from the slide area. (Illustrated on Figure 3-15) Hat Creek discharge was assumed to be 0.48 m^3/sec. Surface runoff and dewatering rates are from CMJV estimates. Flow attenuation in the lagoons has been assumed as negligible.

(Source Beak 1979)

TABLE 3-16

Water Quality Projections - Case III*

Parameter (mg/l)	Projected Effluent North Lagoon	Projected Effluent Med. Ck. Lagoon	Projected Pit Rim Dam Discharge	Existing Hat Creek	Projected Hat Creek After Mixing
pH (Units)	8.4	8.2	8.3	8.4	8.4
Filterable Residue	376	536	450	342	357
Non-Filterable Residue	<50	<50	<50	95	79
TOC	11	29	20	9	10
Total Hardness (as $CaCO_3$)	220	174	196	224	222
Alkalinity (as $CaCO_3$)	223	191	200	226	224
Chloride	2.3	8.6	5.0	1.1	1.6
Fluoride	0.16	0.10	0.13	0.16	0.16
Total Nitrogen (N)	<0.43	1.6	0.60	0.24	<0.32
Phosphorus (P)	<0.05	0.10	<0.06	<0.043	<0.05
Sulfate	57	20	35	54	54
Arsenic	<0.008	<0.03	<0.019	<0.005	<0.007
Boron	<0.10	<0.08	<0.09	<0.10	<0.10
Cadmium	<0.005	<0.004	<0.005	<0.005	<0.005
Calcium (as $CaCO_3$)	140	105	122	143	141
Chromium	<0.015	<0.05	<0.03	<0.010	<0.013
Copper	<0.07	<0.47	<0.26	<0.005	<0.035
Iron	<0.08	<0.40	<0.23	<0.026	<0.05
Lead	<0.01	<0.014	<0.012	<0.010	<0.012
Magnesium (as $CaCO_3$)	76	69	73	77	77
Mercury	<0.0004	<0.0008	<0.0006	<0.0004	<0.0005
Sodium	24	27	24	20	21
Vanadium	<0.005	<0.007	<0.006	<0.005	<0.006
Zinc	<0.014	<0.052	<0.03	<0.007	<0.01

*Summer Rainstorm Condition (Year 35). Discharges to Hat Creek via sedimentation ponds include surface runoff caused by a 10 year 24 hour rainfall of 35mm, detwatering flows from pit surficials and from the slide area. Hat Creek discharge was assumed to be 1.68 m^3/sec. Surface runoff and dewatering rates are from CMJV estimates. Flow attenuation has been assumed to occur in the lagoons and the projected outflow hydrographs are shown on Figure 3-14. Discharge from Pit Rim Dam, into which the Medicine Creek sedimentation lagoon overflows, is assumed to be 0.12 m^3/sec. (pump capacity) into Hat Creek Canal.

(Source BEAK 1979)

Case I There could be a marginal increase in most water quality parameters in Hat Creek after mixing of the sedimentation lagoon effluent. The lagoon effluent meets all Pollution Control Branch Level A objectives excepting sulphate the criteria for which is under review by the agency.

Case II As in Case I, a marginal increase is indicated in most parameters of Hat Creek. Elevated levels of copper from the Medicine Creek sedimentation lagoon effluent may be possible. The predicted concentration remains below the Level B suggested in the Pollution Control Branch objectives.

Case III Marginal increases in most parameters can be expected for downstream Hat Creek water. Predictions indicate somewhat elevated levels of iron and copper could be expected from the Medicine Creek sedimentation lagoon discharge. However, once diluted with other runoff entering the Pit Rim reservoir, the levels of these parameters in the discharge to Hat Creek would be reduced significantly. The level of copper may still exceed Level A objectives.

It is concluded from this preliminary analysis that the sedimentation lagoon discharge should not substantially alter most water quality parameters in Hat Creek including those related to toxic chemicals. The projected maximum concentration of copper in discharges from the pit rim reservoir to Hat Creek (0.28 mg/l) is predicted to be above the PCB Level A discharge objective (0.05 mg/l), but below the Level B objective (0.3 mg/l). It falls within the acceptable limit defined in Canadian Drinking Water Standards 1968 i.e. 1 mg/l.

333.8 Operation

The sedimentation lagoon system will require careful operation during the life of the mine to achieve the required discharge water quality. Frequent sampling and chemical analysis of influent and effluent should be undertaken to decide rates of coagulant feed and whether or not pH control is required. Daily checks on pond inlet and outlets will be required during periods of high flow or at times when there is broken ice on the ponds. Annual inspection and maintenance should be carried out on dykes, inlets and outlets, and emergency spillways.

Sediment storage capacity in the North Lagoons will total 100,000 m^3 and 30,000 m^3 will be available at the Medicine Creek Lagoon. This storage is substantially greater than the projected total sediment yields during mine operations which total 10,000 m^3 and 500 m^3 respectively, therefore, no cleanout operations are anticipated.

Accumulations of oil on the pond surface will be collected by floating sorbent booms which will require replacement when near saturation.

In the post-production period the lagoon systems will remain in operation until land reclamation work in the valley has reduced sediment concentrations in runoff from disturbed areas to acceptable levels. During this period the lagoon systems will be maintained by reclamation staff and the stored water may be used for irrigation in the valley bottom.

334 Sewage Treatment System

334.1 Mine Services Area

Sanitary effluent from the mine service area will be biologically treated and recycled to dust control use in the mine. Provision has been made for treatment of up to 140 m^3/day of effluent containing up to 400 mg/1 BOD in a package oxidation ditch treatment system.

334.2 Environmental Services Complex

Sanitary effluent discharge from this area is estimated at 2 m^3/day which will be treated in a buried septic tank discharging to a field drain system downstream of the Pit Rim Dam.

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COMINCO-MONENCO JOINT VENTURE

TERMS OF REFERENCE

Objective

To prepare a revised mine drainage report utilizing where possible the Mine Drainage Section of CMJV's Mining Feasibility Report Volume IV. This Report should incorporate updated drainage data and provide a more complete description of drainage collection, waste water disposal and effluent control for the proposed Hat Creek Coal Mine.

Specific Tasks

1. Determine the most up-to-date information on the following for incorporation into the drainage scheme:

   a) Expected seepage flows and water quality from Houth Meadows dump (provided by Golder/Beak).

   b) Expected seepage flows and water quality from Medicine Creek dump. This data should include seepage to surface at the main embankments and for the Saddle Embankments at Houth Meadows. In addition seepage flows to ground water from both waste dumps should be confirmed (provided by Golder/Beak).

   c) Expected seepage flows and water quality into the open pit from surficials and coal/bedrock (provided by Golder/Beak).

   d) Review runoff data apropro HEDD comments on small water shed hydrology and confirm or alter the expected flows and determine seasonality effects. Comment on water quality (provided by Beak).

   e) Based on Golder's plan for drainage of the S & SW slide area determine water disposal flows and water quality from lake and slough draining and wells. (Input from Golder/Beak)

2. Using the data firm up the feasibility of operating the "contaminated" water cycle as a zero discharge system. Indicate the manner in which flows of "contaminated" water could be dealt with in the post-production phase of the project.

   a) Indicate a balance by simple hydrograph using most probable flows for Years 5, 15, 35.

   b) Determine a factor of safety.

   c) Provide a description of what would happen should system capacity be exceeded.

Specific Tasks (Cont'd)

d) Discuss more fully the disposal of excess water by spraying onto waste piles. Include geotechnical considerations if any.

e) Indicate more fully the manner in which the seepage flows from Medicine Creek dump embankment are disposed of.

f) Indicate the manner in which waste water from each location will be collected.

3. From the above data prepare typical discharge hydrographs for the average situation for Years 5, 15, 35. Using water quality data an estimate should be made of the quality of water discharged from sedimentation lagoons. (Input provided by Beak.)

a) Discuss the implications of an abnormal quantity of water in a typical year and possible solutions to an abnormal situation.

b) Discuss the operation of the sedimentation lagoon in as great a detail as possible. Include a brief description of post-production operation.

c) Indicate effect of sediment buildup.

d) Indicate manner in which surficial seepage would be collected and pumped from the openpit. Clarify how other inflows to the sedimentation ponds would be collected.

e) Indicate in detail how the Medicine Creek Sedimentation ponds would be operated.

All work required in Items 1, 2 and 3 will be based on current data. Where adequate data is not available necessary assumptions will be made and clearly stated in the report document.