BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

# HAT CREEK PROJECT

Beak Consultants Limited - Hat Creek Project - Detailed Environmental Studies - <u>Hydrology, Drainage, Water Quality and Use</u> - <u>Impact Assessment of the Revised Project - Volume 3A</u> - July 1979

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# HAT CREEK PROJECT
# DETAILED ENVIRONMENTAL STUDIES
# WATER RESOURCES SUBGROUP
# HYDROLOGY, DRAINAGE, WATER QUALITY AND USE

## VOLUME 3A
## IMPACT ASSESSMENT OF THE REVISED PROJECT

A Report for:

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY
Vancouver, B.C.

Prepared by:

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A MEMBER OF THE SANDWELL GROUP

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## PREFACE

As a result of several major changes in the design of the proposed Hat Creek development since the completion of Beak Consultants Limited's report on Impact Assessment on Hydrology, Drainage, Water Quality and Use issued in June 1978, this volume has been prepared addressing the impacts of the revised project.

The following project documents completed in the interim period, contain the descriptions of the revised project which were used in updating the assessment:

British Columbia Hydro & Power Authority. August, 1978. Hat Creek Project Water Supply and Ash Disposal Study: Design Memorandum on Alternative Wet and Dry Ash Disposal Schemes.

Cominco-Monenco Joint Venture. February, 1979. Hat Creek Project. Mine Feasibility Report. Volume IV and Volume V.

Integ-Ebasco. November, 1978. Alternative "B" Ash Disposal Study. Report submitted to British Columbia Hydro and Power Authority.

British Columbia Hydro and Power Authority. March, 1978. Hat Creek Project: Diversion of Hat and Finney Creeks Preliminary Design Report.

The major changes in the project development plans include:

- Relocation of the plant water supply reservoir and incorporation of Medicine Creek runoff in the water supply;
- Adoption of a dry ash disposal scheme to be located in the Medicine Creek valley;
- Revisions to the mine drainage plans including adoption of a zero discharge system for low quality drainages;
- Both major waste dumps would contain a mix of overburden and waste rock. The Medicine Creek waste dump would begin operation about year 16 of the development;

- Hat Creek diversion would be maintained in service after completion of mining;
- The open pit would remain a void after completion of mining.

# 9.0 IMPACTS OF THE REVISED PROJECT

## 9.1 HYDROLOGY

### (a) Groundwater

The following assessment of impacts is based on the revised site development plans described in two reports[96, 97]. These reports describe the revised plans for the mine waste dumps and ash disposal.

In making the following assessment of potential impacts on hydrogeology, the following considerations were examined for each area and phase of development:

1. Changes in Groundwater Level: Higher groundwater tables were generally considered as a beneficial impact. However, this did not include areas where the high water table could cause either water logging of the plant root zone or soil slope instability.

2. Changes in Groundwater Flow: Increased groundwater flows were considered to be beneficial impacts provided that no side effects would develop. These side effects could include deterioration of water quality and/or adverse effects caused by an accompanying rise of the groundwater table. Water quality aspects are addressed in Section 9.2 (a).

#### (i) Preliminary Site Development

The impacts caused by preliminary site development would be the same as described in BEAK 1978.[98]

(ii) Construction

The basis for evaluation of the impact on groundwater resources and the development plan are the same as outlined in Section 6.1 (a) (i) A.[98] Construction activities have been subdivided into three main categories: Mine (including the pit, waste dumps and infrastructure); power plant (including ash disposal areas, water reservoir and construction camp); and offsites (including creek diversions, water supply and access roads).

A. Mine

Clearing and Stripping in Pit Area

The groundwater table is generally deeper than 20 m over most of the pit, and the only exception occurs in the valley bottom where the groundwater table is close to the ground surface. The clearing and stripping operations proposed would remove top soil, surficial sediments and claystone bedrock from part of the upland recharge areas. This removal would reduce groundwater recharge and increase surface water run-off in these areas. The result would be a minor negative impact on recharge to the alluvial aquifer.

Drainage Ditching in Pit Area

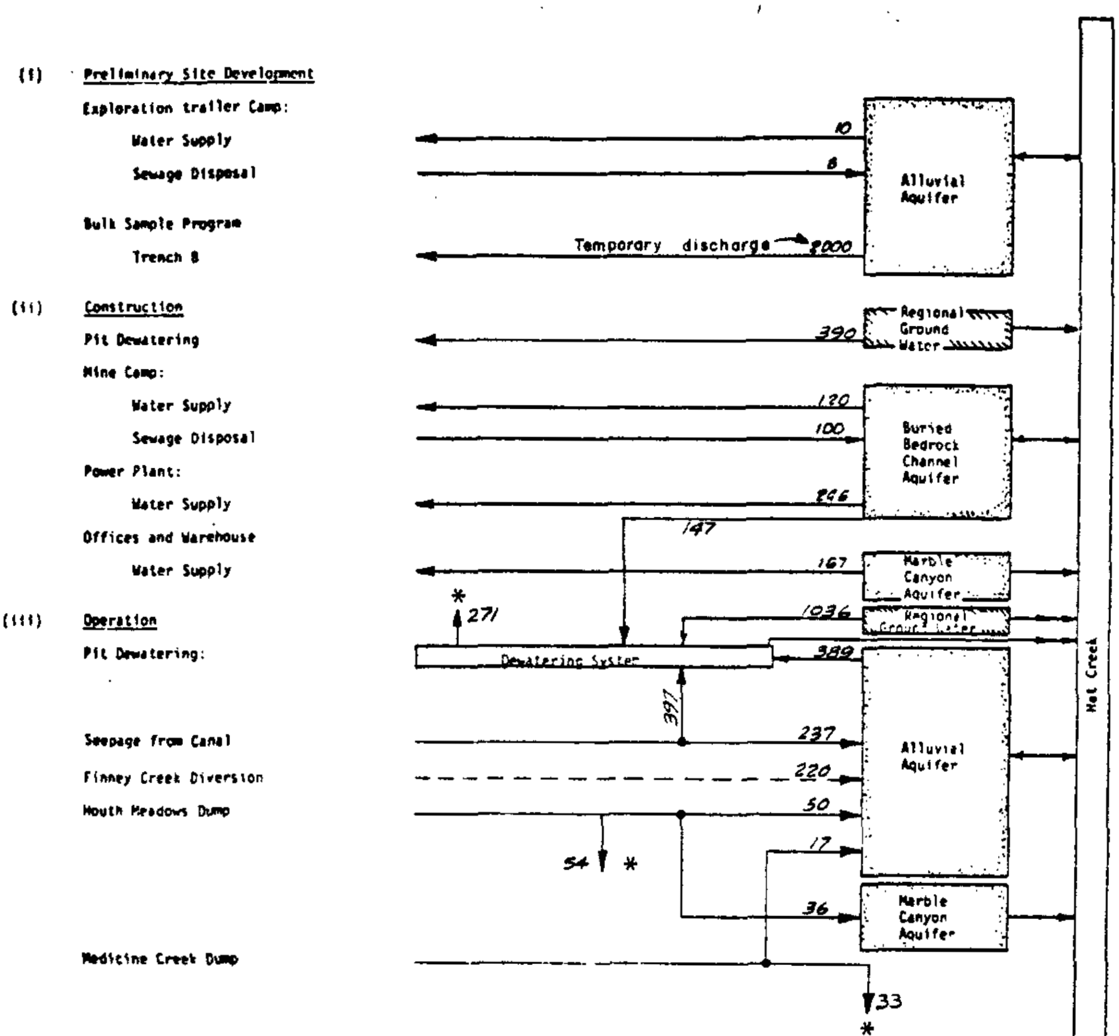
A system of surface ditching is proposed for the pit perimeter. Most of this ditching would be constructed on the west side of the pit where surface water run-off is more significant. Most of the surficial sediments in the vicinity of the coal pit are classified as glacial till and hydraulic conductivities are expected to be low.

The surface water collection system proposed by CMJV[97] would consist of open perimeter drainage ditches which lie near the major access roads which are located beyond the 35-year pit perimeter. These diversion ditches would

TABLE 9-1

SUMMARY OF APPROXIMATE QUANTITIES OF TRANSFERRED GROUND WATER
RESULTING FROM PROPOSED COAL PROJECT

(for explanation of notation see below)




Notes: 1) Seepage quantities are estimates only and can be regarded as probable maximum values.

2) The seepage quantities do not necessarily apply to the same time period and hence may not always balance with recharge.

3) Evapo-transpiration losses include zero discharge system.

Notation:

600 → arrow showing direction of ground water transfer. The number denotes estimated average flow in cubic metres per day (i.e. 500 m³/d) Note all disposal of water shown in this diagram is, unless otherwise indicated, to the ground water table and then eventually discharged to a surface water body as indicated.

600 ⇢ arrow showing direction of seasonal ground water transfers. The number denotes (ie 500 m³/d) estimated peak seasonal flow in cubic metres per day.

T → "T" indicates that the discharge is temporary (ie. lasting for less than 3 months.)

major ground water aquifer

Perennial surface water flow.

Ephemeral surface water flow.

* Water loss at ground surface by evapo-transpiration (See note 3)

normally be lined with rip-rap, however, in areas where the surface soils are pervious, the ditch invert would be lined with between 0.25 and 0.50 m of compacted till.

Some minor recharge to the water table could be expected in areas where the soil is moderately permeable, but does not warrant the cost of installing a till liner. The overall impact of these diversion ditches would be negligible, as the total recharge to the groundwater table is likely to be the same as with the present undeveloped area.

Lake Dewatering

The proposed development plan includes the dewatering of Aleece Lake, and approximately 62 small lakes and ponds, most of which are in the slide area west of the pit. When water levels are high, these lakes and ponds could contribute significant quantities of seepage water to the local groundwater table. However, based on an evaluation of natural isotopes in the lake water (see Section 4.1 (a) (iii) B)[98] these lakes were found to loose most water by evaporation from the lake surface. Only a small portion of the lake water appears to be lost as seepage through the lake bottom. Most of this seepage would be through the upper metres around the wetted perimeter of the water surface. Thus, the complete dewatering of the lakes and ponds would have little or no impact on the groundwater resources of the area.

Aleece Lake is located relatively close to the projected 35-year pit perimeter and from geotechnical considerations this lake must be drained in order to minimize the influence that this lake could have on the stability of the pit slope. The present plans are for the monitoring of groundwater conditions around Finney Lake and to delay a decision on the drainage of this lake until it can be shown that seepage from the lake is likely to be detrimental to pit stability.

## Pit Area Dewatering

The dewatering of the coal pit would be achieved by means of vertical wells drilled both in the pit and around the pit perimeter. A proposed schedule of well installation is given in Table 9-2. This table shows that at least 17 wells would be installed one year prior to the start of mine operations. The initial total discharge of groundwater from the coal pit has been estimated to be 1123 $m^3$/d. During the construction phase, most of the wells would be installed and would pump water from the surficial sediments in and around the pit perimeter.

The surficial sediments around the pit perimeter generally consist of glacial and glacio-fluvial sediments and slide debris. These sediments have higher hydraulic conductivities than the underlying claystones, however, saturated thicknesses are not very great. Estimated average hydraulic conductivities for the surficial sediments range between $10^{-8}$ to $10^{-5}$ m/sec and saturated thicknesses along the western side of the pit average 20 m. Assuming maximum hydraulic conductivities, the calculated maximum radius of influence caused by pit dewatering could extend about 1 km beyond the pit perimeter (i.e. extending to a maximum radius of 2.5 km from the center of the final pit) (see Figure 6-2).[98] However, if average hydraulic conductivities were lower than $10^{-6}$ m/sec, the radius of influence would be in the order of a few hundred metres beyond the pit perimeter at any stage. During the construction stage, it is anticipated that wells would be located in the west side of the pit only. Hence, there would be no groundwater withdrawal from the Hat Creek alluvium.

Some wells would be drilled and completed in the low permeability claystone, siltstone and coal bedrock materials. In addition, there would be a few wells installed in the low permeability slide area sediments west of the proposed pit. The locations of these wells have not been finalized and will be determined during the design stage. It is anticipated that they would yield little water, but would be effective in achieving depressurization. The estimated annual yield from a typical well is not likely to exceed 800 cubic metres (2.2 $m^3$/d). This rate of withdrawal from low permeability materials will result in a very minor impact on the groundwater in and around the pit.

TABLE 9-2

ESTIMATES OF GROUND WATER SEEPAGE CONTROL METHODS

| YEAR BY WHICH WELLS MUST BE INSTALLED | CUMULATIVE(1) TOTAL OF INSTALLED WELLS | ESTIMATED(2) TOTAL QUANTITY PUMPED lps | m³/d | NUMBER OF 40 m WELLS IN SURFICIALS INSTALLED | NUMBER OF 60 m WELLS IN SURFICIALS INSTALLED | NUMBER OF 160 m WELLS IN SURFICIALS INSTALLED | NUMBER OF 300 m WELLS IN COAL INSTALLED | NUMBER OF 80 m OBSERVATION WELLS INSTALLED |
|---|---|---|---|---|---|---|---|---|
| -1 | 17 | 13 | 1123 | 4 | 2 | 6 | | 5 |
| 0 | 27 | 20 | 1728 | 2 | 1 | 2 | 5 | |
| 5 | 53 | 17 | 1469 | 10 | 2 | 4 | 5 | 5 |
| 10 | 68 | 17 | 1469 | 10 | | | 5 | |
| 15 | 79 | 17 | 1469 | 6 | | | 5 | |
| 20 | 83 | 17 | 1469 | 4 | | | | |
| 25 | 87 | 17 | 1469 | 4 | | | | |
| 30 | 91 | 17 | 1469 | 4 | | | | |
| 35 | 91 | 17 | 1469 | | | | | |
| TOTALS | 91 | | | 44 | 5 | 12 | 20 | 10 |

Modified from Golder Associates[99].

(1) These numbers represent estimated numbers of wells. Actual number of wells may be substantially less if major in-pit seepage collection systems are installed.

(2) These figures should be taken as a very approximate guide to the expected pumpage rates.

The overall impact on groundwater would be an estimated steady state withdrawal of up to 1000 $m^3/d$ from the surficial sediments along the west side of the pit. These sediments would gradually be dewatered in areas close to the wells and a cone of depression in the water table would expand toward the west.

Clearing and Stripping in Dump Areas

Creek Diversions Around Dumps

Embankment and Spoil Dumping

Stock Piles

Mine Camp Water Supply

Office and Warehouse Water Supply

The impacts of the above activities on the groundwater, as described in BEAK[98], would all apply for the construction phase of the revised mine plan.

B. Plant

Ash Disposal Facilities

The revised project description[96] describes a proposed scheme where both fly and bottom ash would be placed dry in an area downstream of the water supply reservoir in Medicine Creek (see area in Figure 9-1).

Reservoir Outlet Conduit and Run-off Canals

Medicine Creek would be dammed at a point about two-thirds of the way up the valley from Hat Creek (see Figure 9-1). Run-off from the sides of the Medicine Creek valley would be collected in a canal that directs the run-off water toward the reservoir. A buried 1650 mm (66 inch) diameter pipe is proposed to carry the overflow from the reservoir.

The canals are to be lined with a 0.6 m thick till layer in areas where the surficial sediments are reasonably permeable. Where there is low permeability till or bedrock at the ground surface, the canals would be unlined and in areas where the bedrock slope is steep, a concrete lined flume would be constructed. The groundwater table is at least 2 m below ground surface along the alignment of the proposed canals and hence, the construction of these works would not affect the local groundwater regime.

Clearing and Stripping for the Reservoir

Activities at the Power Plant Site

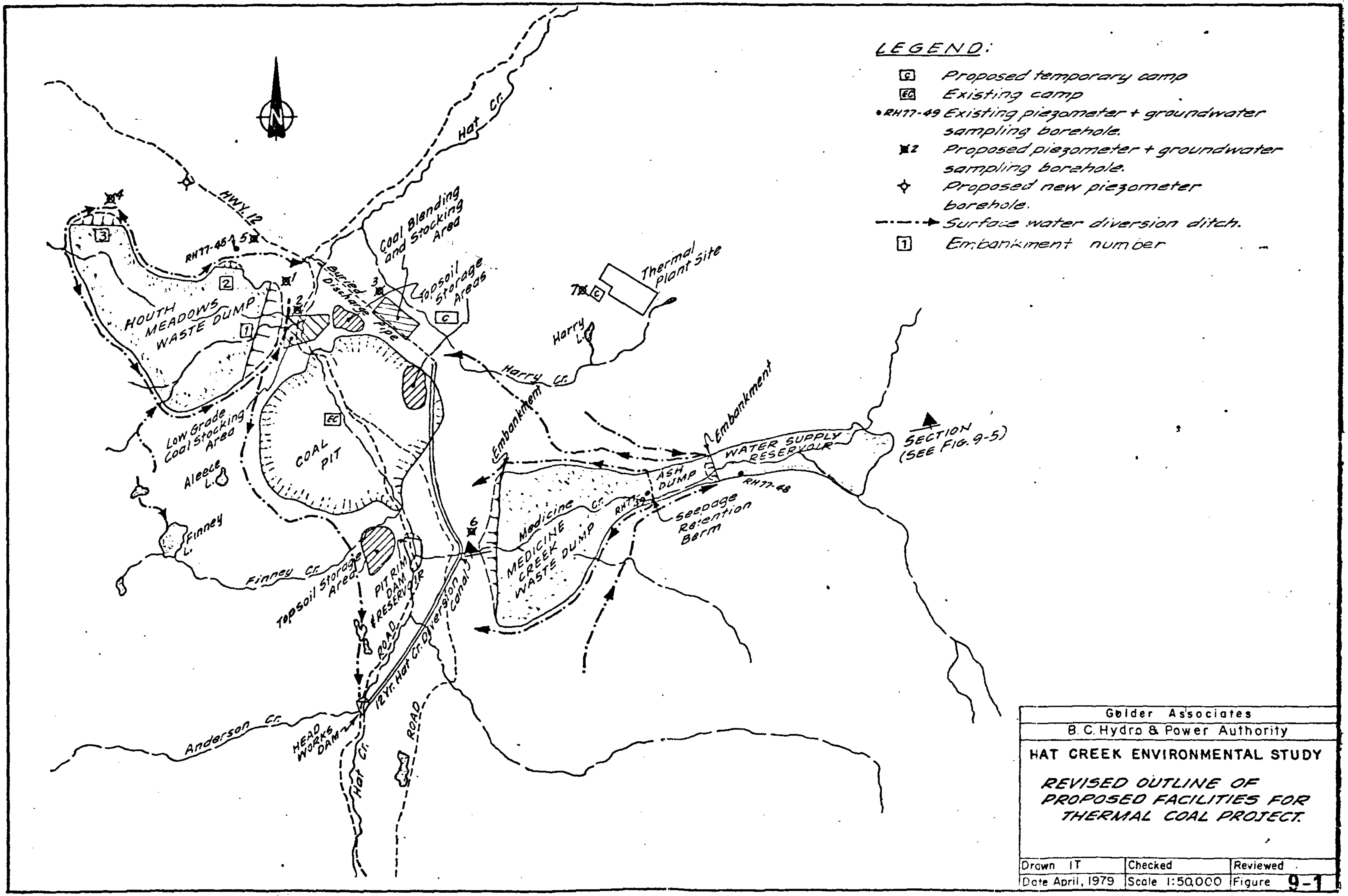
The impact of above activities on the groundwater would be the same as described previously, BEAK[98].

C. Offsites

The comments given in BEAK[98] would apply.

(iii) Operation

A. Mine




| | | |
|---|---|---|
| Golder Associates | | |
| B.C. Hydro & Power Authority | | |
| HAT CREEK ENVIRONMENTAL STUDY | | |
| REVISED OUTLINE OF PROPOSED FACILITIES FOR THERMAL COAL PROJECT. | | |
| Drawn IT | Checked | Reviewed |
| Date April, 1979 | Scale 1:50,000 | Figure 9-1 |

## Overburden Removal in Pit Area

The comments given in BEAK[98] would apply.

## Pit Area Dewatering and Depressurization

The dewatering and depressurization systems in and around the pit would include the following installations:

- low yield wells in the west slide area: approximately 20 wells with an estimated maximum yield from one well of 5 $m^3/d$.
- moderate yield wells around the pit periphery: approximately 33 wells in surficial sediments; the maximum anticipated steady state yield per well is 80 $m^3/d$.
- depressurization wells, drains and horizontal drain holes in the low permeability bedrock sediments in the pit: the maximum steady state seepage rate from bedrock is estimated to be 147 $m^3/d$.
- drains and sumps in surficial sediments within the pit perimeter: This represents the total seepage that bypasses the perimeter dewatering wells.

The estimated annual and peak seasonal pumpage rates from the mine dewatering systems are summarized in Table 9-3 for the period 5, 15 and 35 years after mining operations have started. In addition, a mine seepage and dewatering flow chart is given in Figure 9-2.

The influence on the groundwater regime due to the dewatering of the surficial sediments around the pit and the depressurization of slide area sediments was described in the dewatering section for the construction phase.

The coal deposits are encapsulated within low permeability claystone and siltstone units. Hydraulic conductivities of these massive claystone units are around $10^{-10}$ m/sec (see Section 4.1 (a) (i) B)[98] and hence the radius of influence of the dewatered bedrock around the coal pit would be restricted to distances less than 100 m beyond the pit face at any stage. As the final radius

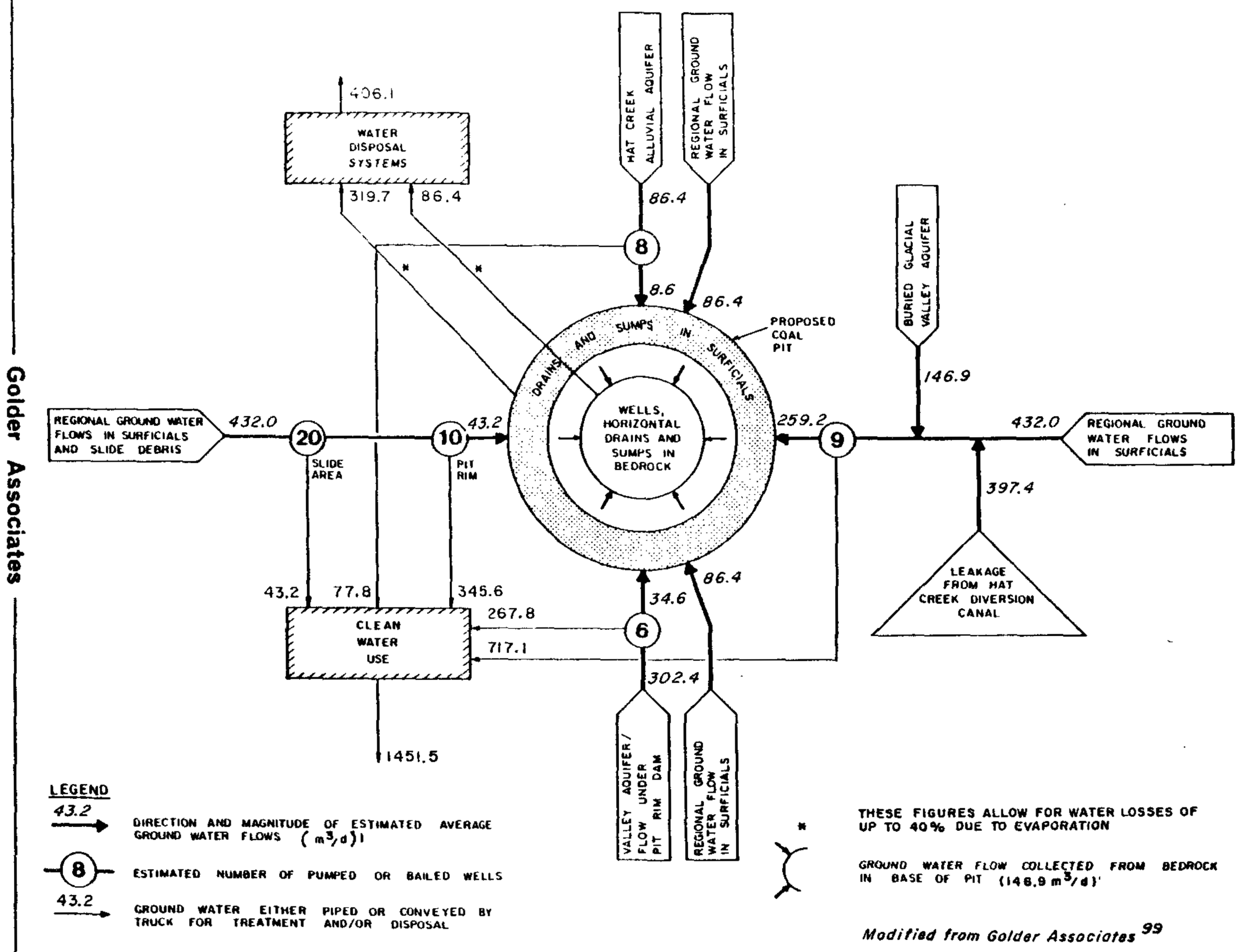
TABLE 9-3

ESTIMATED ANNUAL PUMPAGE AND PEAK SEASONAL PUMPING RATES FOR PIT DEWATERING SYSTEM

| Year | Annual Pumpage ($10^{+6}$ $m^3$/yr) | | | Peak Seasonal Pumping Rates ($10^{-3}$ $m^3$/d) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Late Spring | | | Late Summer | | | |
| | Periferal Wells | In-Pit Systems | | Periferal Wells | In-Pit Systems | | Periferal Wells | In-Pit Systems | | |
| | | Surficials | Bedrock | | Surficials | Bedrock | | Surficials | Bedrock | |
| 5 | 0.52 | 0.09 | 0.02 | 1555.2 | 518.4 | 112.3 | 1261.4 | 172.8 | 43.2 | |
| 15 | 0.52 | 0.12 | 0.05 | 1555.2 | 691.2 | 259.2 | 1261.4 | 259.2 | 112.3 | |
| 35 | 0.52 | 0.12 | 0.03 | 1555.2 | 691.2 | 172.8 | 1261.4 | 259.2 | 69.1 | |

Note: (1) Values exclude pumpage from slide area dewatering wells.

792-1430 … Apr '79




MINE SEEPAGE AND DEWATERING FLOW CHART

Figure 9-2

of the proposed coal pit is approximately 1.5 km, the maximum distance to the edge of the zone of groundwater influenced in bedrock would be about 1.6 km from the center of the pit (see Figure 6-2).[98]

The overall impact on groundwater would be very significant in the areas close to the pit, but there would be no influence beyond a distance of 2.5 km from the center of the proposed pit. The estimated steady state annual discharge from the pit and all peripheral wells is 1425.6 $m^3/d$ (218 Igpm).

Drainage Control in Pit Area

Finney Creek Diversion

Impacts on groundwater caused by the above activities would be as described in BEAK[98].

Houth Meadows Dump

The hydrogeology of the existing dump area is described in Section 4.1 (a) (ii) B)[98]. When dumping commences in this area some major changes in groundwater flow patterns are likely to occur particularly in the limestone bedrock at the north of the dump. The placement of waste rock in the groundwater discharge areas in the northern part of the valley would cause a progressive restriction of these groundwater flows from the limestone and consequently the water table in the limestone would start to rise.

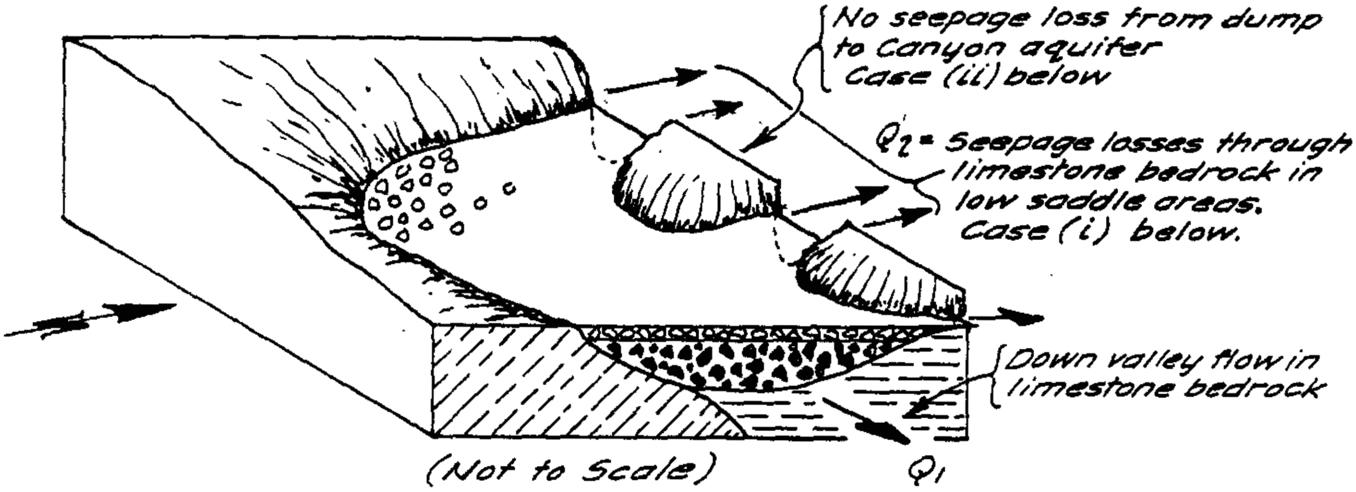
Hydraulic conductivities are estimated to be between $10^{-5}$ and $10^{-3}$ m/s for loose dumped waste rock and these values would be reduced to about $10^{-11}$ m/s as the waste rock consolidated under its own weight at the bottom of the dump. Data on hydraulic conductivities of Hat Creek waste rock materials are limited. The lower range values assumed above are based on laboratory tests of Hat Creek samples and some field data from other coal mine areas (see Table 6-3)[98]. The upper range values are estimated hydraulic conductivities and are assumed to apply to the upper 5 m of the waste dump only. Due to the wide range of expected hydraulic conductivities, predictions on seepage losses to the groundwater table are difficult to make as much would depend on dump operation techniques used.

The siltstone and claystone rock waste materials in the dump are likely to break down as the result of weathering. In zones where this weathered rock is not compacted, and where there is a substantial flow of water, piping channels in the waste rock could result as the claystones are highly dispersive. The most serious zones where this piping could occur, would be up against the sand and gravel embankments and against the more permeable bedrock zones around the small northern embankments. In order to prevent this piping and to minimize seepage a 1.5 m thick till layer would be placed against the inside face of all embankments and against any significantly fractured limestone rock zones near the embankments.

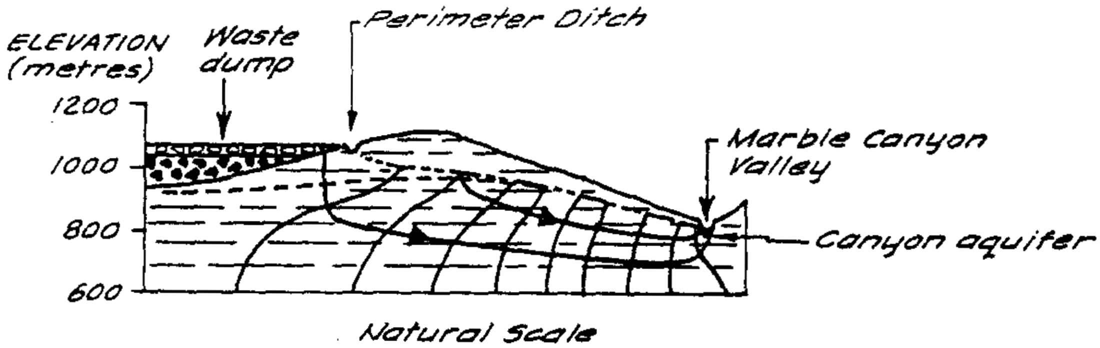
The following summarizes some of the probable impacts:

- initially when the waste rock is dumped it would be loose and seepage water would easily pass through.
- as the dump height increases the material in the bottom of the dump would become more compact and would tend to seal off the seepage flow through the base of the dump.
- the water table in the limestone bedrock immediately adjacent to the dump would rise at about the same rate that the dump surface rises.
- groundwater seepage and surface run-off from the limestone bedrock would flow toward the dump until the water table in the dump became higher than the groundwater divide in the bedrock. At this point seepage from the dump would flow into the bedrock (see illustrations in Figure 9-3).
- the major seepage losses to the groundwater table would occur in the northeastern corner, around the saddle embankments and beneath the east embankment (see illustration in Figure 9-3). Estimated seepages from the

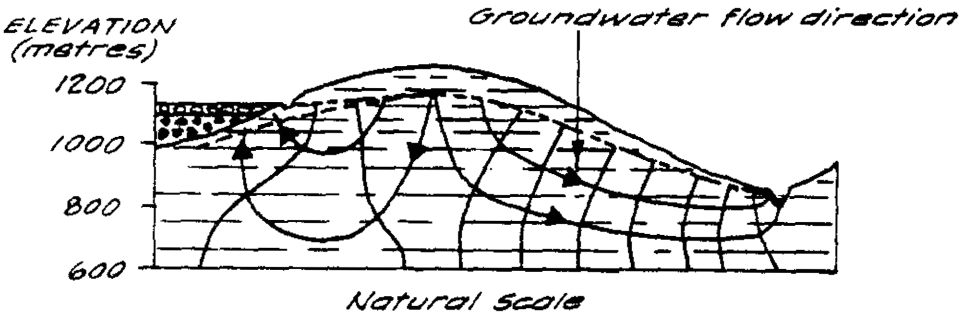
MAJOR GROUNDWATER FLOWS FROM AND INTO BEDROCK AROUND THE HOUTH MEADOWS WASTE DUMP AT FULL HEIGHT. **Figure 9 - 3**




ISOMETRIC VIEW OF WASTE DUMP




CASE (i) SEEPAGE FROM WASTE DUMP ENTERS LIMESTONE BEDROCK.




CASE (ii) GROUNDWATER FLOWS FROM LIMESTONE BEDROCK TOWARDS WASTE DUMP AND CANYON AQUIFER.

LEGEND:

- Compacted waste rock.
- Uncompacted waste rock.
- ------ Existing groundwater table.
- -·-·-·- New water table after dump is in operation.
- Limestone bedrock.
- Claystone bedrock.
- → Minor groundwater seepage from dump.

Golder Associates

dump through the limestone bedrock have been made assuming a hydraulic conductivity of bedrock equal to $10^{-7}$ m/s. These estimates at Year 35, as shown in Figure 9-3 are:

Q1 under the east embankment 50 $m^3$/d. This is only 20 percent of the estimated natural groundwater seepage, see Section 4.1 (a) (ii) B[98]. As shown on Table 9-4, approximately 25 percent of this seepage would be intercepted by the pit dewatering system.

Q2 northward around the saddle embankments 36 $m^3$/d (note: these figures do not include seepages through the embankments themselves as this seepage does not reach the groundwater table).

These estimated seepage flows would replace the natural predevelopment groundwater flow (see discussion in Section 4.0 (a) (ii) B).

The dump would have a moderate impact on groundwater tables and flow directions in the limestone bedrock north of the Houth Meadows. This would result in a diversion of an estimated additional water flow of 36 $m^3$/d toward the surficial aquifer in Marble Canyon. This represents about a 5 percent increase in groundwater flow in the limestone bedrock on the south side of the canyon. The groundwater level in the canyon aquifer, which flows eastwards, would rise by less than 1 m and would not reach the ground surface. The result would be a inor beneficial impact on the canyon aquifer. This assumes that the seepage ater quality would be satisfactory.

is additional groundwater flow in the Marble Canyon aquifer would supplement e flows in the Hat Creek Alluvial Aquifer in the vicinity of the road juncon. This additional water would not cause a significant rise in the water le and would eventually supplement the low flows in Hat Creek. Thus the dump ld reroute near surface groundwater flows which presently discharge as base w into Houth Creek. Ultimately however these waters would still discharge to Creek. Hence, the overall impact of the dump on the ground water flowing Hat Creek would be ambivalent.

The estimated seepage flows through the embankment structures at Year 35, while not strictly groundwater flows, have been estimated to be about 54 $m^3$/d. Approximate values for each embankment are given in Table 9-4. The actual seepage would depend on embankment and dump construction procedures used, and on the hydraulic conductivity of the loose upper materials in the dump.

Medicine Creek Dump

Present plans are to start using this dump at approximately Year 15. The dump would gradually fill up and be merged with the ash dump in the central part of the Medicine Creek Valley. The proposed construction sequence and estimated seepage values are illustrated in Figure 9-5.

The depth to groundwater table below the base of the dump is about 30 m below ground surface and hydraulic conductivities of underlying bedrock and surficial sediments are low ($10^{-8}$ to $10^{-7}$ m/s). When the waste rock dumping commences there would be some seepage down to the water table and laterally into the side walls. This would result in a rise of the water table by 10 to 20 m and possibly to the ground surface. Eventually the steeper hydraulic gradient toward the Hat Creek Valley would dominate and groundwater seepage would become greatest in this direction (see Figure 9-4). The estimated down valley seepage of Year 35 is estimated to be about 17 $m^3$/d (see summary in Table 9-4). The fate of this seepage is difficult to assess. Some of the seepage would reach the pit rim reservoir and some (possibly 20% of the seepage) would reach the pit dewatering system. The estimated down valley seepage flow is considerably less than the pre-dump seepage of 350 $m^3$/d given in Section 4.0 (a)(ii) D.

The estimated seepage flow through the embankment structures, while strictly not groundwater flows, have been estimated to be about 33 $m^3$/d. Most of this seepage would come to the ground surface and would discharge to the surface water collection and treatment systems. As with the Houth Meadows dump, this value would depend on dump construction procedures used and on the in place hydraulic conductivity of the liner till material and the loose upper dump materials.

TABLE 9-4

ESTIMATED SEEPAGE RATES FROM HOUTH MEADOWS AND MEDICINE CREEK WASTE DUMPS

Houth Meadows Dump

| Seepage ($m^3/d$) (4) | | | | | | |
|---|---|---|---|---|---|---|
| Through Embankments (1)(2)(3) | | | | To Regional Ground Water (5) | | |
| No. 1 | No. 2 | No. 3 | Total | Range of Totals | Estimated Maximum(6) Q1 (7) | Estimated Maximum(6) Q2 |
| 25.9 | 4.3 | 0 | 30.2 | 0.97 - 8.6 | 7.6 | 1.0 |
| 30.2 | 8.6 | 5.2 | 44.0 | 4.30 - 43.2 | 25.1 | 18.1 |
| 30.2 | 11.2 | 13.0 | 54.4 | 17.30 - 86.4 | 50.1 | 36.3 |

Medicine Creek Dump

| Seepage ($m^3/d$) Through Embankments | Seepage ($m^3/d$) To Regional Ground Water |
|---|---|
| 0 | 0 |
| 11.2 | 0.9 - 8.6 |
| 32.8 | 2.6 - 17.3 |

(1) For embankment locations see Figure 9-4 attached.

(2) These values are for those seepages that could be collected in shallow ditches or drains at the downstream toe of each embankment.

(3) The values are considered to be maximum values and if favourable conditions prevail, then the seepages could be much less.

(4) The seepage from the dumps will be relatively steady during each year. The annual fluctuations in flow due to precipitation will be less than 10 per cent, and the only significant changes in flow rate will result from the expansion of the dump as indicated.

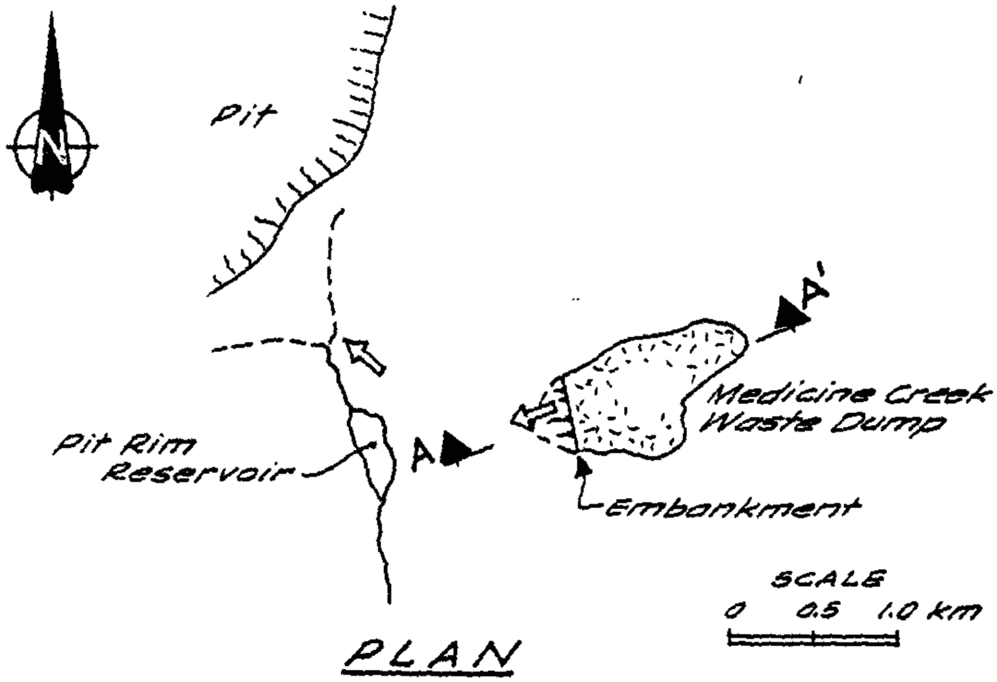
(5) The rate of seepage from the waste dumps to the regional ground water system will depend on the permeability of the near surface formations around the dumps (maximum depth 5 m). Based on data that is available, estimated seepages were calculated by assuming the probable lowest and highest hydraulic conductivity values for the near-surface formations.

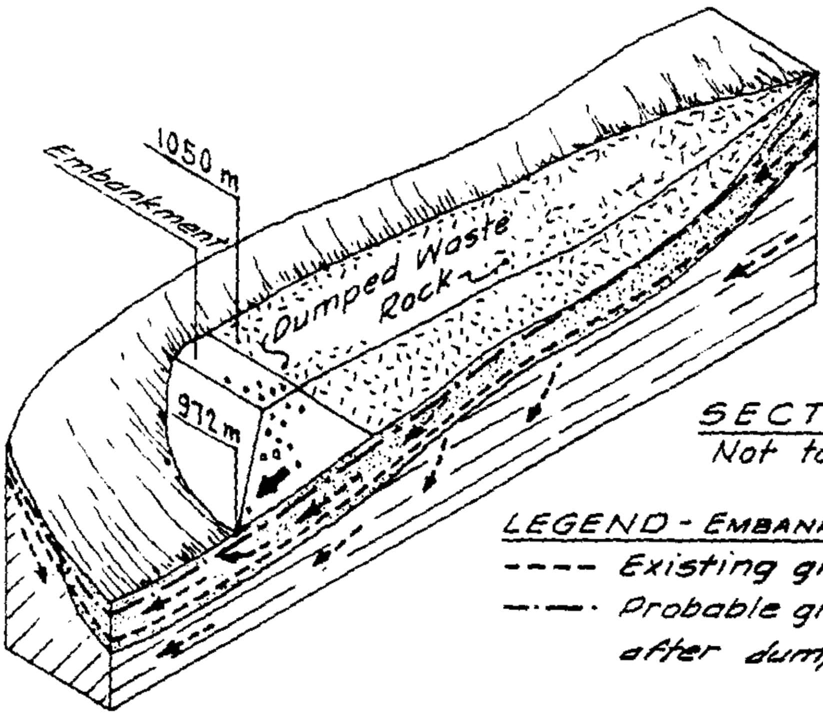
(6) These symbols refer to Q1 and Q2, shown in Figure 9-3.

(7) Note approximately 25 per cent of the 35-year seepage Q1 (i.e. 12.5 $m^3/d$) would reach the pit dewatering system. Most of this flow is in the surficial sediments and would thus be collected by the wells and sumps installed in these sediments.

SKETCH OF PROBABLE GROUNDWATER SEEPAGE AROUND AND THROUGH MEDICINE CREEK WASTE DUMP AT YEAR 15.

**Figure 9 - 4**




SECTION A - A'
Not to Scale

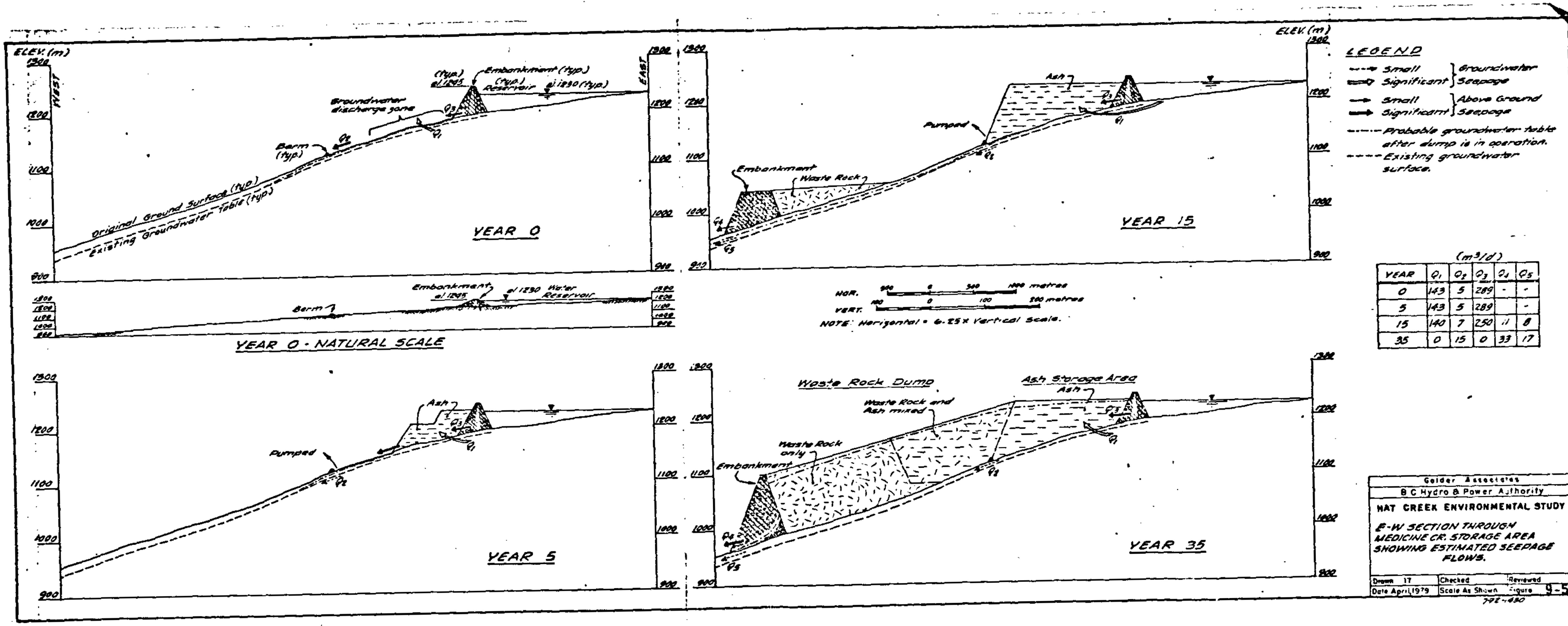
LEGEND - EMBANKMENT STRUCTURE:

- ---- Existing groundwater table.
- —·—· Probable groundwater table after dump is in operation.

- Small } Groundwater seepage
- Significant } Groundwater seepage
- Small } Above ground seepage
- Significant } Above ground seepage

Till with hydraulic conductivities between $10^{-8}$ and $10^{-7}$ m/s.

Volcanic and sedimentary bedrock with hydraulic conductivities between $10^{-8}$ and $10^{-7}$ m/s




($m^3/d$)

| YEAR | $Q_1$ | $Q_2$ | $Q_3$ | $Q_4$ | $Q_5$ |
|---|---|---|---|---|---|
| 0 | 143 | 5 | 289 | - | - |
| 5 | 143 | 5 | 289 | | - |
| 15 | 140 | 7 | 250 | 11 | 8 |
| 35 | 0 | 15 | 0 | 33 | 17 |

Golder Associates

B C Hydro & Power Authority

**HAT CREEK ENVIRONMENTAL STUDY**

E-W SECTION THROUGH MEDICINE CR. STORAGE AREA SHOWING ESTIMATED SEEPAGE FLOWS.

| Drawn 17 | Checked | Reviewed |
|---|---|---|
| Date April 1979 | Scale As Shown | Figure 9-5 |

792-430

### Ash Disposal Facilities

The revised plans [96,100] for the ash disposal indicate that the fly ash would be placed in layers alternating with bottom ash. This method of placement would ensure proper drainage of the ash as it is being placed.

Seepage estimates indicate that the ash piles would be largely free-draining for the first 15 years. Later when the low permeability waste rock material is placed in the valley immediately west of the ash dump there is a likelihood that the ash dump would become progressively saturated.

Seepage from the ash dump to the water table would be relatively minor. Installations and estimated values of the seepage to the groundwater table and through the embankments are given in Figure 9-5.

The overall impact on the groundwater resource would be a rise in the water table and a reduction in the down-valley seepage. This reduction in seepage would result from the removal of permeable alluvium and compaction of loose till sediments underneath the ash dump.

### Flue Gas Desulphurization Waste Solids Areas

### Creek Diversions

The same comments as given in BEAK[98] apply.

## C. Offsites

### Hat Creek Diversion

The comments given in BEAK[98] still apply, however, a modified Base Scheme has been adopted where the proposed canal, at an elevation of about 980 m, would initially be along the same alignment. However, after about fifteen years of plant operation, the mine pit would have grown to a size that would require realignment of about 1400 m of the canal. The affected length of the canal would be replaced by a tunnel or some sort of a conduit located further to the west of the initial alignment.

Initially some seepage would find its way into the pit dewatering system as illustrated in Figure 9-2. The seepage from the canal would result in a minor temporary benefit to the buried channel aquifer.

After fifteen years, the amount of seepage would be reduced as the proposed tunnel is likely to be located in a low permeability rock. However, as there are no detailed plans for this tunnel or a conduit, no allowance has been made for this realignment in the seepage estimates for flows to the pit as given in Table 9-3.

Drainage Control Along Main Access Road

Same comments as in BEAK[98].

(iv) Decommissioning

A. Mine

Reclamation of Dumps

Same comments as in BEAK[98].

Reclamation of Pit

The revised mine plans are to maintain a low water level in the bottom of the pit. Some slope instability could be expected and the resultant slumping would help fill in the base of the pit. The groundwater table around the pit would remain depressed for a considerable number of years until the water levels rose above the base of the surficial sediments. The result would be a major long-term impact on the groundwater resources within a maximum 1.5 km radius of the pit, however, there would be no impact on groundwater beyond a 2.5 km radius of the centre of the pit.

Maintain Creek Diversions Around the Pit

The flow of Hat Creek through the low permeability volcanic rock tunnel would have a negligible impact on groundwater resources in the area.

Maintain Drainage Diversions

Same comment as in BEAK[98].

B. Plant

Reclamation of Ash Disposal Area

The placement of soil and vegetation on the surface of the ash dump would not have a significant impact on the groundwater regime.

Maintain Ditching Lagoons and Creek Diversions

Same comments as in BEAK[98].

C. Offsites

There would be no impacts caused by offsite facilities during the decomissioning phase.

(v) Overall Impact Assessment

The total groundwater resource in the area would not be seriously affected by the proposed Hat Creek Project. However, most of the mitigating beneficial impacts are contingent on satisfactory water quality at the point of recharge. Most of the groundwater supply abstractions apply to the construction period only and would not apply when Thompson River water is made available.

The pit dewatering system would pump up to 1,860 $m^3/d$ of groundwater at peak periods. This dewatering and the pit excavation would cut the alluvial aquifer in half and significantly reduce groundwater flow in the northern end of this aquifer. However, even this peak flow represents only 20 percent of the total groundwater available for development in the northern part of the valley. Most of this water would be returned to Hat Creek and only a small percentage would be lost in evaporation from the pit walls.

The upper parts of the waste dumps would act as large "sponges" that would retain precipitation and surface water runoff during wet periods and would gradually release this water during the rest of the year, along with expelled soil water resulting from consolidation. As the bottom of the dumps would be well sealed, most of the seepage would be directed into the valley walls and to surface water channels. The total seepages from these dumps, both directly to these channels and to groundwater, would not be significant as the rock is expected to compact under its own weight.

The total estimated maximum groundwater seepage from the Houth Meadows Dump is 86 $m^3/d$ made up as follows: 36 $m^3/d$ towards Marble Canyon and 50 $m^3/d$ towards Hat Creek under the main embankment. This seepage flow would go principally into surficial sediments in both the Alluvial and Marble Canyon Aquifers. Some of this flow (approximately 12 $m^3/d$) would end up in the pit and the remainder would eventually discharge to Hat Creek. The point of discharge to Hat Creek cannot be precisely determined as the groundwater interchange between creek and groundwaters is complex. However, the groundwater flow beneath the creek east of the road junction, is estimated to be about 2,000 $m^3/d$ and would include only a small proportion of water that would have originated from the Houth Waste Dump.

As with the waste dump, the seepage from the ash dump and water reservoir would have only a minor impact on groundwater. The restraint of this seepage is largely a result of placing low permeability waste rock down gradient of the ash dump. Some reverse seepage from the ash dump to the reservoir might occur if the water level in the reservoir is lowered (i.e. due to irrigation). Estimates of seepage rates are difficult to make since it is dependent on the amount of lowering of the water level. However, the actual amount of seepage is likely to be insignificant due to the relatively small gradient and low permeability of the materials involved.

Most diversion canals and ditches would redistribute the surface water and slightly increase recharge to the groundwater aquifers. Seepage from the Hat Creek diversion canal and tunnel would be small and would not affect the stability of the pit walls.

All impacts on the groundwater resources would be restricted to an area within 1.5 km from the limits of the proposed waste dumps and coal pit. Within this area of influence there would be many minor negative impacts, however, these impacts would be mitigated by an equal number of beneficial impacts and the net impact would be ambivalent.

(b) Surface Water

Neither the revised mine drainage scheme[97] nor the new arrangement of the plant make-up water reservoir and ash disposal area[100] change the basic types of impact on surface water hydrology discussed in the introduction to Section 6.1 (b). The areas affected and the magnitude and timing of some impacts are altered, but the only two entirely new impacts appear to be the need to dispose of surplus blow-down water and the consumptive use of Medicine Creek water. The quantity of blow-down water to be disposed of is so small (0.6 to 21.1 l/s) that, whatever disposal method is finally adopted (none has been proposed so far), impacts on surface waters, exclusive of water quality impacts, are likely to be negligible. Under natural conditions, Medicine Creek contributes 10 to 20 percent of Hat Creek flows at the mine site. Some of this flow is presently being diverted to MacLaren Creek, but the proposed new water supply reservoir arrangement would divert most of it.

By not draining Finney Lake, the revised mine drainage scheme avoids a significant impact.

(i) Preliminary Site Development

The revised designs do not appear to modify the impacts discussed in Section 6.1 (b) (i) in any significant way.

(ii) Construction

A. Mine

The earlier discussion of potential impacts remains valid in most respects, however, the concern about draining of Finney Lake is now redundant as the revised and refined drainage studies have concluded that it does not need to be drained. Erosion and sedimentation problems during construction depend almost entirely on detailed construction procedures and scheduling. Sedimentation ponds should be completed and operational before any ditches draining into them are excavated. It is recommended that extreme care be used in planning the construction of drainage and diversion works.

With most of Medicine Creek being used in the plant, the diversion of Medicine Creek around the combined ash-mine dump is simplified. With proper scheduling it should be possible to construct the diversion entirely in the dry seasons (see Section C below).

B. Plant

The powerplant itself remains essentially unchanged, but the revised make-up water and ash disposal schemes reduce the affected land area by approximately 40 percent and concentrate construction activities into fewer sites (the former make-up water reservoir area is no longer needed). Both these factors should reduce impacts, but it is impossible to be specific without construction details.

Storm drainage of the plant site was assumed to be released into Harry Creek with the previous plant arrangement. With the new designs, this water would drain to a holding pond and be used for dust control on the ash pile. Overflow from the holding pond would drain to the make-up water reservoir, but this is expected to occur only infrequently. This new plant drainage scheme would eliminate potential sedimentation and water quality problems along Harry Creek. The surplus blow-down water is to be disposed of on-site but no designs are available yet.

C. Offsite

The comments of the earlier corresponding section remain almost entirely valid, except for the Medicine Creek diversion. The "Design memorandum on alternative wet and dry ash disposal schemes"[96] does not comment on the construction sequencing for the make-up water reservoir. Medicine Creek will either have to be diverted temporarily, or the dam and the outlet works discharging to the Hat Creek diversion will have to be built on a carefully timed, rigid schedule to assure completion before the reservoir could possibly fill.

(iii) Operation

A. Mine

The CMJV Mine Drainage Report of February 1979 gives much more detail about the design of the mine drainage works than earlier reports. Although no drastic design changes have occurred since Section 6 was written, many of the preliminary assumptions made there can now be firmed up, and more definite impact predictions become possible.

Contrary to earlier assumptions, seepage from bedrock into the mine or into dewatering wells will now be separated from other drainage flows and used in the mining operation for dust control, together with treated sanitary sewage. The average leachate flow to be disposed of in this manner ranges from 7 l/s in Year 5 to 15 l/s in Year 35, with a possible high of 27 l/s in Year 35. As only 10 l/s can be used for dust control, the remainder is to be disposed of by spray irrigation on the waste dumps. This disposal does not appear to create any environmental impacts in the field of surface water hydrology.

To what degree the leachate flow constitutes a consumptive use of Hat Creek water is unknown. Even if all of it would, under natural conditions, have shown up in Hat Creek (a most unlikely assumption), it would only represent a significant consumptive use (in excess of 20 percent) once every three years for periods of a few weeks.

The new drainage plan incorporates two major sedimentation lagoons, one servicing the mine and Houth Meadow dump areas, while the other one services the Medicine Creek ash disposal and mine waste dump. The new storm flow volumes are considerably smaller than those assumed in Section 6, e.g. the combined 10-year storm flow volume from the Houth meadows and mine areas is now computed as 91,000 $m^3$, while Section 6 had assumed a corresponding value of 280,000 $m^3$. Much depends on the assumed configuration of the dump surface. CMJV assumes a very rough surface with ample storage in small depressions and therefore practically no runoff. Being based on more recent design information, the CMJV storm runoff values should be more realistic.

Lagoon outflows are now considerably larger than assumed in Section 6, but of shorter duration. The ten-year rain storm now results in a lagoon outflow between 0.7 and 0.8 $m^3/s$ for 20 hours, which compares with the 0.35 $m^3/s$ lasting 20 days assumed before any lagoon designs were available. These new, larger flows are still an order of magnitude smaller than the morphologically significant flows in Hat Creek and impacts on channel morphology will be negligible. The frequency and severity of flooding along downstream reaches of Hat Creek should also not be affected by these lagoon outflows. The conditions that could cause large lagoon outflows are somewhat different (more rain-dependent) than the snowmelt-dominated conditions that cause most major floods in Hat Creek (see Section (iii)C, below).

All major drainage works, such as the embankments and spillways of the sedimentation lagoons, are designed for a 1,000-year flood condition, which implies a 3 percent probability of exceeding design conditions during the life of the mine. Exceeding design conditions does not necessarily mean failure, but, assuming it did, failure of a sedimentation pond would have serious but relatively short-lived environmental consequences. Highly sediment laden flows would damage Hat Creek for several kilometres below the mine, but new vegetation and a new stream channel would likely be established within two to three years from the date of the failure. The Kaiser Resources sedimentation pond on Harmer Creek near Sparwood, B.C. failed in the early seventies. Little damage was apparent when the writer inspected the downstream reaches of Harmer Creek in April 1978. The 1000-year design criterion adopted by B.C. Hydro appears to be reasonably consistent with generally accepted design practice for intermediate-size embankments and moderate hazard potential.[102]

B. Plant

As predicted in Section 6, economic considerations have now led to the proposed consumptive use of Medicine Creek flows in the plant. It is felt that considerable further benefits could be obtained by using the South Runoff Canal of the new make-up water and ash disposal scheme to divert runoff from the headwaters of Ambusten Creek into the make-up water reservoir.

The main difference between the design alternatives discussed in Section 6 and the new make-up water reservoir and ash disposal scheme is the consumptive use of most Medicine Creek flows and the elimination of the former make-up water reservoir. This will reduce the drainage area of Hat Creek downstream of the mine by 51.6 $km^2$ or approximately 12 percent. It is rather difficult to estimate what the corresponding reduction in flows is likely to be because a significant proportion of the Medicine Creek runoff has in the past been diverted to MacLaren Creek (approx. $2.2 \times 10^6 m^3$), and because the Medicine Creek basin has a considerably higher unit runoff than the Hat Creek basin due to its higher mean elevation. B.C. Hydro assumes that in an average year $4 \times 10^6 m^3$ of Medicine Creek water will be available for consumptive use in the plant, which compares to a mean annual runoff in Hat Creek of $21 \times 10^6 m^3$. Combining these various factors, an average 10 percent reduction in downstream flows appears most likely. This could aggravate present low-flow problems during dry summers and it will naturally also aggravate the temperature-rise problem of the Hat Creek diversion canal.

C. Offsites

The environmental effects discussed in Section 6 remain valid, except that some design alternatives have now been eliminated. The alternate Hat Creek diversion scheme with significant upstream storage is no longer being considered. Winter diversion flows in the Medicine Creek South Runoff Canal will likely be handled by means of a buried pipe to prevent icing.

Flooding has not been a significant problem along the downstream reaches of Hat Creek but it should be pointed out that both the make-up water reservoir on Medicine Creek and the limited capacity of the Hat Creek diversion (with overflow into the mine pit) provide protection against extreme floods along Hat Creek downstream of the mine.

(iv) Decommissioning

The details of decommissioning remain somewhat unresolved, but there are several significant changes. Medicine Creek will now continue to pass through the make-up water reservoir and then along the discharge conduit to the Hat Creek diversion canal or to Hat Creek. Both the dam and the discharge conduit are facilities that would require regular inspection and maintenance.

The essence of the earlier concern about the diversion of Medicine Creek around the ash pond remains valid with respect to any drainage ditch traversing slopes, such as the South Runoff Ditch above the Medicine Creek waste dump or similar ditches above the Houth Meadow Dump. Any such ditch requires continuing maintenance, even though designed for PMF conditions, to avoid slides into the ditch, debris jams, log jams, or other obstructions which could cause failure. A decommissioning scheme which places all drainage courses into stable positions on the gradient of land surfaces or along valley floors is recommended.

The most significant change in decommissioning plans is the new plan of diverting Hat Creek around the pit in perpetuity. The earlier plan of letting the pit fill up as soon as possible and then diverting Hat Creek through the pit would have resulted in major changes to the hydrological regime of Hat Creek. The new Proposals avoid these changes but would require continued maintenance of the Hat Creek diversion works.

(v) Overall Impact Assessment

The basic types of impacts on surface water hydrology identified previously in Section 6.1 (b) will still remain with the revised project and mine drainage scheme. The consumptive use of Medicine Creek water appears to be the most significant new impact. Three major impacts have been eliminated by not draining Finney Lake, by disposing of mine drainage and by maintaining the Hat Creek diversion around the pit after completion of mining. The most recent mine drainage report has permitted much more definite impact predictions than were previously possible.

## 9.2 WATER QUALITY

### (a) Groundwater

#### (i) Preliminary Site Development

Although some preliminary site development activities have continued (environmental sampling, reclamation test plots etc.) none of these activities will have affected ground water quality.

#### (ii) Construction

##### A. Mine

Coal and Low Grade Waste Stockpiles

Leachate from a stockpile at the mouth of the mine would be handled by collecting and storing in the main leachate storage lagoon.[97] No significant pollution of groundwater will occur as the lagoon will be provided with a plastic liner and a 2-metre layer of impermeable till material to mitigate seepage.

Area Dewatering

The estimates of quantities of water requiring disposal from dewatering activities are 1728 $m^3$/d (0.02 $m^3$/sec) from pit surficials and about 43 $m^3$/d (0.0005 $m^3$/sec) from the southwest slide area dewatering activities. Extraction of groundwater should not affect the quality of the remaining or surrounding groundwater. The impact of disposal of the extracted water on surface water quality is discussed in Section 9.2 (b) (ii) A.

Overburden Dump Construction

The most recent mine plan indicates mine waste would not be segregated. Houth Meadows dump would contain mixed waste (claystone and surficials). Medicine Creek Dump would not begin operation until after Year 15 and when completed will consist of mine waste on the west end and on the east power plant ash. Both dumps would be constructed with perforated subsoil drains for collection of seepage and leachates. Except for seepages from the north saddle embankments on the Houth Meadows Dump, all leachates collected will be disposed to storage lagoons with no discharge to surface waters. Quality of these seepages which become surface water are discussed in Section 9.2 (b) (iii) A. Groundwater seepages from the saddle embankments would be monitored and if necessary collected by wells for disposal onto the dump.

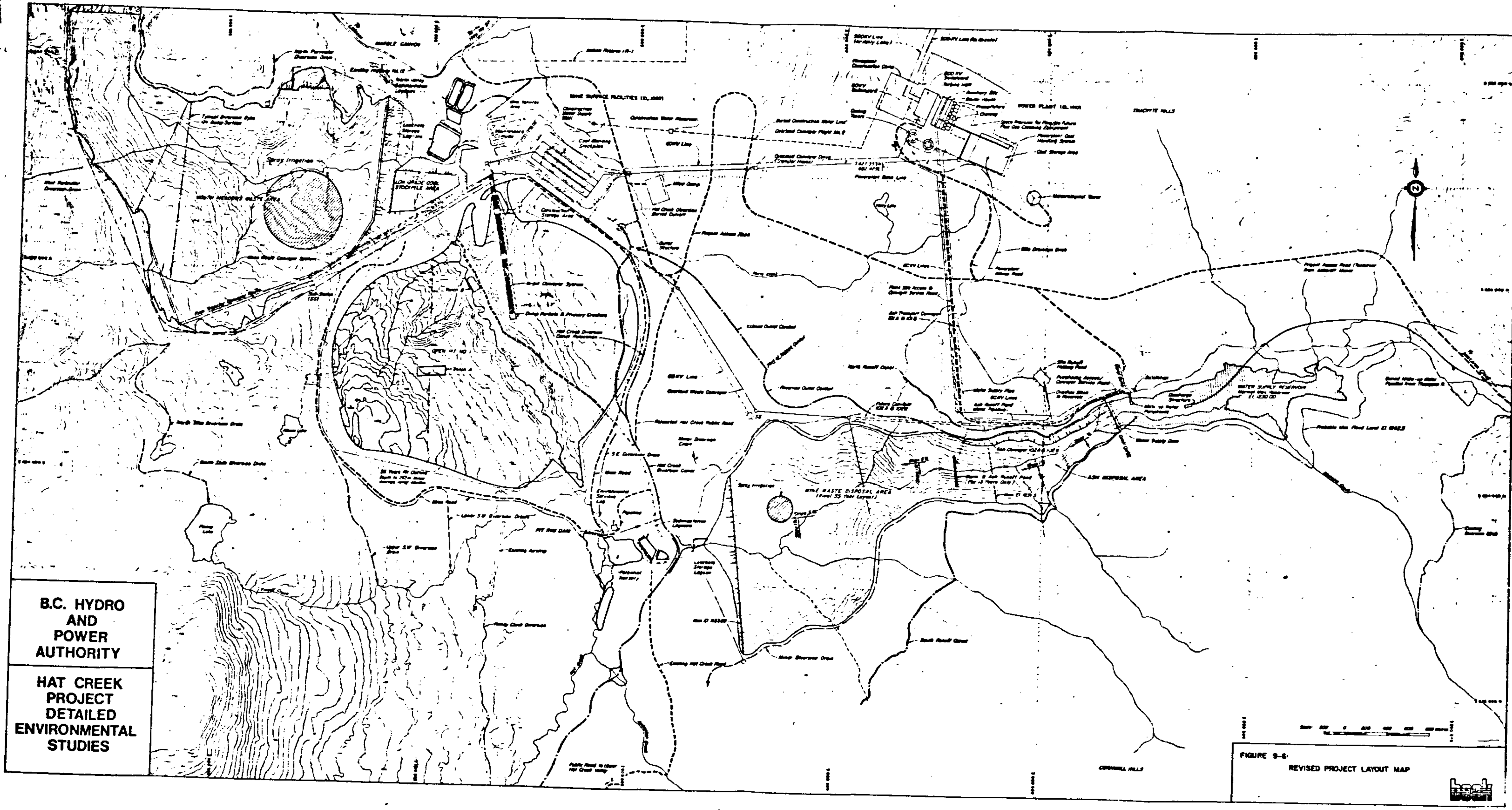
B. Plant

Ash Disposal Facilities

The ash disposal scheme adopted based on more recent studies is a dry ash scheme in which both conditioned flyash and dump bottom ash will be disposed to Mid Medicine Creek Valley west of the new water supply reservoir location (Upper Medicine Creek). Construction operations involved in preparing this site should not affect groundwater quality. Figure 9-6 shows the proposed ash disposal area.

Water Supply Reservoir

Construction of a water supply reservoir and associated facilities in Upper Medicine Creek should not affect groundwater quality. Figure 9-6 shows the reservoir location.



B.C. HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT DETAILED ENVIRONMENTAL STUDIES

FIGURE 9-6

REVISED PROJECT LAYOUT MAP

C. Offsites

Hat Creek Diversion

The diversion scheme construction activities should not affect groundwater quality. The most recent design[101] calls for a 6.4 km canal and a 2.0 km discharge conduit together with a headworks reservoir; pit rim reservoir and pump station.

(iii) Operation

A. Mine

Mine Area Dewatering

The mine drainage plan[97] indicates quantities of water extracted for mine stability includes 1468 $m^3$/d (0.017 $m^3$/s) from surficials near the pit, 43 $m^3$/d (0.0005 $m^3$/s) from the slide area and between 52 and 130 $m^3$/d (0.0006 and 0.0015 $m^3$/sec) from bedrock in the pit. In addition, a total of between 1036 and 1642 $m^3$/d (0.012 and 0.019 $m^3$/sec), on an average annual basis, of runoff and seepage to the pit will have to be handled. Since all of these waters become surface water, assessment of their disposal is discussed in Section 9.2 (b) (iii) A. The dewatering activity in itself is not expected to affect quality of the remainder of the groundwater resources.

Overburden Dumps

The estimates of seepage loss to regional groundwater from the Houth Meadows Dump range from 0.86 $m^3$/d to 86 $m^3$/day. Approximately 58 percent or 50 $m^3$/d will enter the Houth Meadows groundwater regime with the remainder entering the Marble Canyon regime.

TABLE 9-5

PROJECTED WASTE DUMP LEACHATE CHARACTERISTICS*

| Parameters (mg/l) | Combined Waste |
|---|---|
| pH (units) | 8.1 |
| Filterable Residue (105°C) | 1125 |
| $BOD_5$** | 137 |
| Alkalinity (as $CaCO_3$) | 123 |
| Chloride | 27 |
| Fluoride | 0.06 |
| Nitrate (as N) | 4.4 |
| Ortho-phosphate (as P) | 0.3 |
| Sulfate | 21 |
| Arsenic | 0.07 |
| Boron | 0.04 |
| Cadmium | <0.002 |
| Calcium (as $CaCO_3$) | 48 |
| Chromium | 0.13 |
| Copper | 1.5 |
| Iron | 1.25 |
| Lead | 0.02 |
| Magnesium (as $CaCO_3$) | 33 |
| Mercury | 0.0015 |
| Sodium | 63 |
| Vanadium | 0.01 |
| Zinc | 0.15 |

Raw data from Acres Consulting Services Limited leachate tests on overburden and waste rock.

**Estimated by BEAK utilizing $BOD_5$ from Total Extractable Tests and multiplying by ratio of filterable residue extracted in 24 hours to Total Extractable Filterable Residue.

*At low pore volume displacement (see example calculation)

Leachate Characteristic in mg/l =

$$\frac{(\text{Extractable Component at Day 1 in mg.kg}^{-1}) \times (\text{Weight of Sample in kg})}{(\text{Volume of Extract at Day 1 in liters})}$$

Approximately 25 percent of this water or 12.5 $m^3$/d will be intercepted by the open pit surficials dewatering system. The remainder will flow into the alluvial aquifer downstream of the pit. The quality of this seepage water is estimated in Table 9-5 based on averaging the projections of leachate quality of overburden and waste rock as given in Table 6-9 Volume 3.

The impact on groundwater quality should be minor since the available information indicates the seepage should not contain high levels of contaminants. Dissolved solids could be expected to increase somewhat in this area because there will be little dilution potential available.

The seepage through the north saddle embankments which does not evaporate may eventually enter the Marble Canyon groundwater regime since the plans are to not collect this water. The total quantity in this direction, including loss to regional groundwater through the base of the dump, is estimated at Year 35 to be 60 $m^3$/d. The natural groundwater flow in the Marble Canyon as estimated in Section 4.1 (a) (ii) C is 2053 $m^3$/d. Thus a large dilution potential is available indicating the impact on groundwater quality will be insignificant. Based on the flow and quality estimates available an increase in dissolved solids of less than 5 percent would be expected.

During the latter part of the operation phase, the majority of flow in the valley alluvial aquifer well downstream of the development will be made up of groundwater from the Marble Canyon aquifer since the open pit will intercept the majority of the flow in the upper Hat Creek alluvial aquifer. The makeup of the aquifer would include an estimated flow of 100 $m^3$/d from the upper Hat creek alluvium aquifer including the groundwater seepage loss from Houth Meadows Dump of 38 $m^3$/day together with the Marble Canyon aquifer flow of 2,053 $m^3$/d which would include 60 $m^3$/d maximum from the Houth Meadows Dump. Given this flow distribution and estimates of the respective water qualities, the maximum change in groundwater quality downstream of the development based on dissolved solids would be a 15-20 percent increase. This estimate is considered to be conservatively high since the mean flow path of seepage from the Houth Meadows Dump is not necessarily through the middle of the dump and thus the mean quality of the seepage may be better than predicted. A considerable portion of the change would be due to the alluvial aquifer shifting to conveying a greater portion of water from the Marble Canyon area which according to available data has a somewhat higher dissolved solids level. From this assessment it is concluded that the groundwater in the alluvial aquifer downstream of the development will remain acceptable for human consumption and agricultural use.

The current estimate of quantities of seepage from the Medicine Creek overburden dump as given in Section 9.1 (a) (iii) A are between 11 and 32 $m^3/d$ through the embankment and between 1.0 and 2.0 $m^3/d$ to the regional groundwater regime, the larger quantities being at Year 35 of the development.

The quality of drainage from the overburden dump is best estimated as being similar to Houth Meadows waste dump leachate (Table 9-5). This seepage to regional groundwater combines with other down valley seepage from the ash disposal area. The impact on groundwater quality of these seepages are discussed in Section 9.2 (a) (iii) B. Ash Disposal. Surface water seepage through embankment is discussed in Section 9.2 (b) (iii).

Reclamation

The most recent plans are for a combined waste/ash dump in Medicine Creek area. The waste dumping would not begin until Year 16 in the lower valley. The dry ash dump will have covered upwards of 100 ha of area most of which will have been reclaimed according to project descriptions[100]. A subsequent project report [97] indicates reclamation will have occurred on about 150 ha of the mine waste dump by Year 35. Thus in total by Year 35 over 60 percent of the total Medicine Creek Dump (410 ha) should have been reclaimed.

By Year 15, the size of the Houth Meadows dump will be about 455 ha with little reclaimed area. By Year 35, 190 ha or 31% of the dump area (610 ha) will have been reclaimed[97].

Nutrient loss from revegetation and reclamation activities may cause an impact to surface water quality as discussed in Section 9.2 (b) (iii) A.

B. Plant

Ash Disposal

The most recent proposal is for ash disposal (Alternate B) to Mid Medicine Creek in dry form. Since the ash will be a mixture of conditioned fly ash and damp bottom ash, some seepage will eminate from the dump. Leachate surfacing at the toe of the dump will be returned to a power plant waste disposal pond whereas seepage to the substrata will enter the Medicine Creek regional groundwater regime. The seepage quantities will vary as the dump expands. Surface reclamation which will proceed on the finished dump surface throughout the dump development will minimize infiltration of precipitation. The estimated maximum seepage to groundwater from the ash disposal area is 7.0 to 15 $m^3$/d. The estimated quality of this seepage is shown in Table 9-6. This seepage together with the seepage from the overburden dump has the potential to contaminate the groundwater in Medicine Creek Valley. Based on the flow and quality estimates of these seepages the theoretical dissolved solids level in the groundwater of Lower Medicine Creek valley could reach 6,200 mg/l. This estimate is considered to be conservatively high since the mean path of the down valley flow is not necessarily through the center of the overburden and ash dumps and thus the pick-up of contaminants may be considerably less. In addition, the attenuation effect of flowing through several kilometres of till may be substantial. No groundwater users will remain near the dump area after development begins. The groundwater resource in Lower Medicine Creek Valley will be reduced to less than 5 percent of the estimated original quantity. The impact from a water quality standpoint is considered minor in comparison to the total Hat Creek Valley groundwater resource considering these factors plus the fact that the majority of the potentially contaminated groundwater would end up in the pit dewatering system where it can be disposed to the zero discharge system if required. In order to reduce impact on groundwaters consideration should be given to placing the most impervious ash component next to the base till in order to further reduce seepage from the ash dump.

Plant Wastewaters

The combination of a dry ash disposal scheme together with the inclusion of Medicine Creek in the plant water supply scheme results in excess power plant

TABLE 9-6

PROJECTED COMBINED ASH LEACHATE QUALITY*

| Parameter (mg/l) | Range |
|---|---|
| pH (units) | 8.0-9.0 |
| Filterable Residue (105°C) | 4800-8900 |
| $BOD_5$ | < 35-195 |
| Alkalinity (as $CaCO_3$) | 1120-1260 |
| Chloride | 175-190 |
| Fluoride | 3.3-4.9 |
| Nitrate (as N) | 2.4-3.3 |
| Ortho-phosphate (as P) | 0.14-0.31 |
| Sulfate | 1500-1580 |
| Arsenic | < 0.6-2.4 |
| Boron | < 3.0-3.6 |
| Cadmium | < 0.10 |
| Calcium (as $CaCO_3$) | 1050-1130 |
| Chromium | < 0.12-0.20 |
| Copper | < 0.23-0.33 |
| Iron | 1.95-2.05 |
| Lead | < 0.05 |
| Magnesium (as $CaCO_3$) | 220-230 |
| Mercury | < 0.0013-0.0023 |
| Sodium | 325-335 |
| Vanadium | < 0.18-0.22 |
| Zinc | 0.82-2.5 |

*Based on Fly Ash to Bottom Ash ratio of 75/25, conditioned and wetted with recycled power plant wastewaters to 20% and 40% moisture respectively.

cooling water of 6.1 l/s (at 65% capacity factor and average annual conditions). At present no scheme has been adopted for disposal of this wastewater which will have a quality as shown in Table 9-7. One option for disposal would be an evaporation lagoon. In this case it would be necessary to provide an impermeable liner on the basin to prevent migration of highly saline water into the groundwater of the area. Should this be done impact should be minor.

C. Offsites

Significant changes have not occurred in the design and operation concepts of offsite facilities.

(iv) Decommissioning

A & B. Mine and Plant

According to recent project reports[97] considerable reclamation of waste dumps will remain to be completed after the end of the mine operation phase. Application of fertilizers during vegetation may cause surficial groundwaters to carry undesirable nutrient loads to the surface water regime as discussed in Section 9.2 (b) (iii) A.

Adoption of the dry ash scheme will allow reclamation of the disposal area on an ongoing basis which is a definite advantage over the alternate wet ash disposal method. Thus reclamation will reduce infiltration of precipitation and ultimate seepage of contaminated leachates.

The latest plan for reclamation of the pit is to leave it as a void. This proposal should not result in any groundwater quality impairment.

(v) Overall Impact Assessment

Since all low quality seepages of surface or groundwaters which are extracted will be collected and stored in leachate storage lagoons lined with impervious materials, no significant groundwater quality impairment should result.

TABLE 9-7

ESTIMATED COOLING TOWER BLOWDOWN WATER QUALITY

| Parameter (mg/l) | Value |
|---|---|
| Total Dissolved Solids | 2034 |
| Conductivity ( mho/cm) | 3297 |
| Calcium | 326 |
| Magnesium | 80 |
| Potassium | 19.2 |
| Sodium | 62 |
| Chloride | 26.4 |
| Sulphate | 1239 |
| Total Silica (as $SiO_2$) | 106 |
| Alkalinity (as $CaCO_2$) | 17 |
| TOC | 122 |
| pH (units) | 8.0 |

Notes:

- All parameters expressed in mg/l unless otherwise noted.
- Includes effect on Total Dissolved Solids, Conductivity and Sulphate concentrations due to Sulphuric Acid ($H_2SO_4$) dosing.

(Source: Integ Ebasco Nov. 1978 Alt. "B" Ash Disposal Study)

The groundwater quality downstream of the development in the valley alluvial aquifer could change slightly with the most noticeable effect being a minor increase in dissolved solids level.

The ash disposal to Mid Medicine Creek area between the more impervious Lower Medicine Creek Valley mine waste dump and the upper Medicine Creek water supply reservoir could cause groundwater quality deterioration. Drainage from the ash itself plus seepage from the water supply reservoir into the ash will migrate into the substrata groundwater below the ash disposal area. This potentially contaminated groundwater will proceed down valley picking up some seepage from the waste dump and will then be intercepted by the pit dewatering system. After decommissioning however, this groundwater will enter the pit. Mitigation measures such as utilizing an impervious ash liner should be considered in the design stage to further reduce this potential discharge of low quality groundwater.

(b) Surface Water

(i) Preliminary Site Development

The previous discussion in Section 6.2 (b) (i) Volume 3 remains valid.

(ii) Construction

A. Mine

Dewatering Activities

The most recent project report outlining dewatering activities indicates that in addition to pit area dewatering, a considerable amount of dewatering of the southwest slide area will occur. This will include draining of surface waters from Aleece Lake and 62 other lakes and ponds plus subsurface dewatering using wells in the area. Finney Lake is in a more stable area and at this point is not considered essential for draining at the outset of the project.

The quantity of surface water to be drained from the lakes and ponds is not available. Project descriptions[97] indicates that this would be done during spring freshet to minimize enrichment of creeks and thus impact on water quality. The quantity of well water from the slide area has been estimated to be 44 $m^3$/d. The quality of this based on best available information as shown in Table 9-8 is considered acceptable for disposal through sedimentation lagoon to the Hat Creek system once diluted with other discharges being directed through these lagoons.

The groundwaters extracted from the pit area will be segregated into those from surficials and those from bedrock and coal strata the estimated quality of which are shown in Table 9-9. Waters from surficials are considered acceptable for disposal to Hat Creek after sedimentation, whereas bedrock/coal waters of lower quality will be collected and stored in a storage pond together with other low quality leachates and contaminated pit waters and used for dust control.

The quantities of groundwater from surficials has been estimated to be 1728 $m^3$/day maximum in the early years while the quantity from bedrock will be minimal until well into pit development and coal production stage. Since this water is combined with various other discharges in the sedimentation pond discussion of the impact on receiving water of Hat Creek is reserved for Section 9.2 (b) (v).

Coal and Low Grade Waste Stockpiles

Runoff and leachates from these stockpiles will be collected and stored in a leachate storage pond thus there will be no impact on surface water quality. The quality estimates of this water are shown in Table 9-10 and are based on actual samples collected from B.C. Hydro's bulk sample program on site stockpiles. New data are somewhat different than previously projected (Section 6.2 (b) (ii) A. Volume 3) however they confirm the need to contain these wastewaters throughout construction and operation of the mine development.

## TABLE 9-8
## PROJECTED S.W. AREA WATER QUALITY

| Parameter (mg/1) | Slide* Debris | Finney Lake | Aleece Lake |
|---|---|---|---|
| pH (units) | 8.0 | 8.2 | 7.6 |
| Filterable Residue | 1070 | 17 9 | N.A. |
| TOC | 50 | 18 | N.A. |
| Alkalinity | 570 | 123 | 217 |
| Chloride | 28 | 0.5 | <0.5 |
| Fluoride | 0.16 | 0.22 | N.A. |
| Nitrate (as N) | <0.14 | <0.02 | N.A. |
| Kjeldahl Nitrogen (as N) | <11.0 | 0.83 | N.A. |
| Ortho Phosphate (as P) | <0.03 | 0.025 | N.A. |
| Sulfate | 380 | 5 | 52 |
| Arsenic | <0.005 | <0.005 | N.A. |
| Boron | <0.21 | <0.1 | N.A. |
| Cadmium | <0.005 | <0.005 | N.A. |
| Calcium (as $CaCO_3$) | 208 | 60 | 85 |
| Chromium | <0.01 | <0.01 | N.A. |
| Copper | <0.008 | <0.005 | N.A. |
| Iron | <0.06 | <0.04 | <0.05 |
| Lead | <0.03 | <0.01 | N.A. |
| Magnesium (as $CaCO_3$) | 118 | 33 | 100 |
| Mercury | <0.0003 | <0.00033 | N.A. |
| Sodium | 230 | 15 | 38 |
| Vanadium | <0.006 | <0.005 | N.A. |
| Zinc | <0.36 | <0.006 | N.A. |

*Based on averaging the water quality projections for surficials and bedrock (not including coal strata waters) in the mine area.

TABLE 9-9
PROJECTED MINE WATER QUALITY

| Parameter (mg/l) | From Surficials* | From Bedrock** |
|---|---|---|
| pH (units) | 7.9 | 7.8 |
| Filterable Residue | 350 | 1950 |
| TOC | 21 | 50 |
| Alkalinity | 270 | 1185 |
| Chloride | 3 | 42 |
| Fluoride | 0.2 | 0.2 |
| Nitrate (as N)*** | <0.2 | <0.06 |
| Kjeldahl Nitrogen (as N)*** | <0.2 | 14.0 |
| Ortho Phosphate (as P) | <0.03 | <0.03 |
| Sulfate | 52 | 321 |
| Arsenic | <0.005 | <0.006 |
| Boron | <0.1 | 0.31 |
| Cadmium | <0.005 | <0.005 |
| Calcium (as $CaCO_3$) | 148 | 180 |
| Chromium | <0.01 | <0.01 |
| Copper | <0.005 | <0.008 |
| Iron | <0.025 | <0.075 |
| Lead | <0.010 | <0.013 |
| Magnesium (as $CaCO_3$) | 66 | 124 |
| Mercury | <0.0003 | <0.0003 |
| Sodium | 39 | 412 |
| Vanadium | <0.005 | <0.007 |
| Zinc | <0.03 | 0.52 |

*Based on the average of Wells 77-54A; 77-58; 78-68A; Bulk Sample Wells #1 and 2; Trench B; and Domestic Wells DW1, 2 & 3.

**Based on the average of Wells RH76-19; 78-67; 78-70; 78-75; 78-77; Bulk Sample Well #3; and Bucket Auger Hole #7.

***Not including any contribution from blasting residuals.

TABLE 9-10

PROJECTED LOW GRADE COAL AND COAL LEACHATE CHARACTERISTICS

| Parameters (mg/1) | Low Grade Coal* | Coal** |
|---|---|---|
| pH (units) | 4.6 | 5.0 |
| Filterable Residue (105°C) | 5400 | 8400 |
| $BOD_5$ | N.D. | N.D. |
| Alkalinity (as $CaCO_3$) | 0.5 | 27 |
| Chloride | 0.88 | 14 |
| Fluoride | N.D. | 0.10 |
| Nitrate - N | N.D. | N.D. |
| Ortho-phosphate - P | N.D. | 0.01 |
| Sulfate | 3800 | 3700 |
| Arsenic | 0.005 | 0.005 |
| Boron | 0.7 | 0.31 |
| Cadmium | N.D. | N.D. |
| Calcium (as $CaCO_3$) | 1075 | 1900 |
| Chromium | 0.010 | 0.01 |
| Copper | 0.007 | 0.04 |
| Iron | 0.01 | 0.26 |
| Lead | N.D. | N.D. |
| Magnesium (as $CaCO_3$) | 1680 | 2240 |
| Mercury | 0.0003 | 0.0003 |
| Sodium | 150 | 190 |
| Vanadium | 0.006 | 0.04 |
| Zinc | 0.18 | 0.11 |

N.D. Not Determined

* Based on one sampling of leachate collected from storage pile constructed as part of the bulk sample program. Data supplied by B.C. Hydro. Sampling data 28/4/78.

** Based on three (3) samplings of leachate collected from coal storage pile constructed as part of the bulk sample program. Raw data supplied by B.C. Hydro.

### Drainage System

The proposed mine drainage plan[97] calls for numerous minor diversion canals and perimeter drains around the proposed pit, slide area and waste dumps to keep upper valley uncontaminated surface runoff segregated, to control slope stability and to keep the active areas (dumps, pit etc.) dry enough to allow continuous operation. New construction sediment loss could pose a significant hazard and thus temporary sediment control facilities may be required. Alternatively this drainage could be temporarily directed through the proposed main sedimentation lagoons until such time as construction is completed and drains and ditches have stabilized and first flush sediment loss diminishes to acceptable levels for direct discharge to Hat Creek as is proposed. Should these precautions be undertaken, construction impact on water quality of Hat Creek should be minimal.

B. & C. Plant and Offsites

The discussion presented previously in Section 6.2 (b) (ii) B Volume 3 in general remains valid except that the newly adopted schemes for dry ash disposal and water supply reservoir are in Medicine Creek Valley. Construction of drainage ditching, embankments and base preparations will require close control to avoid impact on Medicine Creek water quality during this period.

(iii) Operation

A. Mine

### Blasting

The original concern expressed in Section 6.2 (b) (iii) Volume 3 regarding nutrient discharge in mine waters due to blasting residuals is now considered insignificant. The mine waters from the coal bedrock levels will not be discharged to Hat Creek. Instead these waters will be stored in a leachate lagoon for disposal by evaporation and use in dust control programs.

### Dewatering

As indicated previously groundwater extracted from surficials (reasonable quality) will be segregated from that extracted from bedrock/coal zones. The quantities estimated throughout the life of the mine are shown in Table 9-11 as given in a recent mine drainage report[97].

TABLE 9-11
QUANTITIES OF WATER FROM DEWATERING ACTIVITIES

| Source ($m^3/d$) | Year 5 | Year 15 | Year 35 |
|---|---|---|---|
| Surficials | | | |
| Pit Area | 1671 | 1753 | 1753 |
| Slide Area | 44 | 44 | 44 |
| Bedrock | | | |
| Pit Area | 55 | 137 | 82 |

The best estimate of the quality of these waters are as previously listed in Tables 9-8 and 9-9. Since the proposed plan is to contain the low quality bedrock water, there will be no impact on water quality of creeks and streams in the valley negating previous concerns expressed in Section 6.2 (b) (iii) A. The projected impact of the surficials waters to be discharged to Hat Creek after treatment in sedimentation lagoons along with other surface runoffs is discussed in 9.2 (b) (v) C.

### Overburden Dumps

Concerns expressed previously regarding the undesirable approach of combining dump runoff with runoff from undisturbed areas are much reduced since the segregated approach is now proposed[97]. Runoff from the waste dumps (Houth

Meadows and Medicine Creek) will be directed through sedimentation ponds prior to entering Hat Creek. As presently conceived ash disposal area runoff would not be allowed to mix with Medicine Creek waste dump runoff. Ash area runoff would be collected and returned to the power plant waste water disposal system, whereas mine waste runoff would be directed through a dedicated sedimentation lagoon. In Year 35 the estimated runoff from a 10 year-24 hour rainstorm is now 15,000 $m^3$ from the contributing area of Houth Meadows dump (214 ha) and 13,000 from the mine waste in Medicine Creek Dump (172 ha) based on the mine drainage report[97]. These values are apparently based on the premise that the remainder of the dump area are "undrainable" due to trapped precipitation in the un-levelled waste and thus will not be contributing areas to the storm runoff. Since the peak runoff will occur when the entire dumps are reclaimed, the lagoon may have to be expanded. For instance if the lagoon is initially designed for an inflow of 13,000 $m^3$/day at Year 35 it would require expansion to handle the 25,000 $m^3$/day to be expected from the totally reclaimed dump (410 ha including mine waste and ash dump).

The quality of the dump runoff depends on contact time of the precipitation. The best estimate for runoff from the levelled areas would be similar to that of Table 9-5. Runoff from reclaimed areas of the dumps should be similar to natural Medicine Creek water Table 9-12 for the Medicine Creek reclaimed area and could be assumed to be not worse than Hat Creek water for the Houth Meadows dump reclaimed area (since no water quality data is available from natural runoff in Houth Creek).

The impact of treated dump runoff along with other disturbed area runoffs and dewatering discharges which pass through the North Valley lagoon are discussed further in Section 9.2 (b) (v) C.

Coal and Low Grade Waste Stockpiles

Since the plan is to retain runoff from these stockpiles in a storage pond there will now be no impact on surface water quality.

TABLE 9-12

PROJECTED QUALITY OF INTERCEPTED SURFACE WATER-MEDICINE CREEK AREA*

| Parameter (Mg/1) | Value |
|---|---|
| pH (units) | 8.3 |
| Filterable Residue | 275 |
| Non-Filterable Residue | 0-110 |
| TOC | 19 |
| Alkalinity | 221 |
| Chloride | 0.4 |
| Fluoride | 0.12 |
| Nitrate (as N) | 0.04 |
| Kjeldahl Nitrogen (as N) | 0.26 |
| Ortho Phosphate (as P) | 0.01 |
| Sulfate | 20 |
| Arsenic | <0.005 |
| Boron | <0.1 |
| Cadmium | <0.005 |
| Calcium (as $CaCO_3$) | 130 |
| Chromium | <0.01 |
| Copper | <0.005 |
| Iron | <0.02 |
| Lead | <0.01 |
| Magnesium (as $CaCO_3$) | 85 |
| Mercury | <0.0005 |
| Sodium | 11 |
| Vanadium | <0.005 |
| Zinc | 0.009 |

*Based on average of available Medicine Creek water quality data 21/5/77 to 21/8/78.

### Reclamation

Previous information regarding reclamation schedule indicated both major waste dumps would have been reclaimed by the end of mining. More recent information contained in the mine drainage report[97] indicates 31 percent of the 610 ha Houth meadows dump and 36 percent of the mine waste area of the 410 ha Medicine Creek Dump will have been reclaimed by Year 35. Thus a considerable amount of the dump reclamation effort shifts to the decommissioning phase.

### Infrastructure

The discussion presented previously remains valid concerning potential dust fallout effects in Harry Creek watershed near the coal piles and processing plants. It is therefore reemphasized that consideration should be given to placing a settling basin on Harry Creek.

Those streams from the mine service area vehicle washdown area that have potential to carry oil, will be segregated for disposal to the leachate storage lagoon.

## B. Plant

### Ash Disposal

Surface runoff from the ash disposal area in Mid Medicine Creek will be contained during the first 15 years of operation by an embankment across the valley below the fill. Collected runoff and dump seepage will be returned via pump station and pipeline to the power plant wastewater retention pond. In subsequent years, ash pond runoff will be prevented from mixing with lower Medicine Creek mine waste dump runoff by means of maintaining a till berm across the lower perimeter of the ash disposal fill. Ash runoff will then be pumped back up to the power plant wastewater retention pond. The most recent project report[100] indicates that this pond will be sized to hold the runoff from a 10 year - 24 hour rainfall event. Based on the current plans, there will be no direct discharge of runoff from the ash area to surface waters or creeks and thus during operation, phase, impact will be zero. Care will be necessary however to ensure the integrity of the till berm to avoid washout and resultant comtamination of mine waste dump runoff and potentially deleterious discharge to Hat Creek from the Medicine Creek sedimentation ponds.

The dry ash disposal scheme eliminates the need for ash sluice water treatment system and the requirement for associated sludge disposal.

## Coal Pile Storage and Yard Drainage

These wastewaters will be directed to a plant wastewater retention pond and subsequently used for dust control. Since there will be no positive discharge there will be no impact on quality of natural surface waters.

## Plant Operation

The most recent project report[100] indicates under normal plant operation, an excess of cooling water blowdown will be generated in the amount of 6.1 $l \cdot s^{-1}$ The quality of this water will generally be as shown in Table 9-7. Potential means of disposal include in-plant evaporator trains, out-plant evaporation ponds, or discharge to a suitable receiving water. Because of the quantity involved, discharge to the Thompson River via a pipeline parallel to the water supply line, concern would be environmentally inconsequential from a dissolved solids point of view, however, the cost would be considerable. Discharge to Hat Creek may also be feasible at times when available dilution would reduce the increase in dissolved solids to acceptable levels. Assuming a maximum desirable increase of 10 percent in dissolved solids levels, the discharge would have to be suspended whenever Hat Creek flow dropped below about 0.3 $m^3s^{-1}$.

Since a scheme is not proposed, further evaluation has not been conducted. Any proposal to discharge this excess cooling tower blowdown to a receiving water should also be thoroughly evaluated for potential impact from possible residual constituents such as zinc, chromium, phosphorus, other corrosion inhibitors and free available chlorine. These parameters are currently regulated in thermal power plant cooling tower blowdown in the U.S.A. to the extent that residual chlorine must be less than 0.2 mg/l average for not longer than two hours per day. All other parameters mentioned must be nondetectable in discharges from new plants.

C. Offsites

Hat Creek Diversion

The mid-summer water temperature increase resulting from the diversion of Hat Creek was reestimated for the most recently proposed diversion design[101]. In this design, the diversion canal has an invert width of 1.2 m, sides with a slope of 0.4 and a gradient of 0.02 percent.

The flow used for the calculation was 0.2 $m^3$/sec, which represents the average 3-day low flow in August. At this flow, the water depth in the canal was estimated as 0.4 m. The estimated time required for the water to travel the 6375 m distance of the canal is 7.8 hours. Atmospheric conditions assumed for the calculations are shown in Table 9-13; other assumptions used were as stated previously (Section 6.2 (iii) C, Volume 3).

The mid-summer water temperature at the beginning of the canal was not estimated, but surface temperature data taken in the interior of British Columbia (Environment Canada, 1977) suggest that it would likely be between 15°C and 20°C. Accordingly, two sets of calculations were made for the diversion channel, one using an initial temperature of 15°C, the other using 20°C. For these initial temperatures, the estimated water temperatures at the end of the canal are 30°C and 31°C, respectively.

The most important factor in causing the temperature increase is the rate of solar insolation. However, at high water temperatures, the rate of evaporation of water vapour from the water surface becomes significant in moderating the

TABLE 9-13

ATMOSPHERIC CONDITIONS USED FOR ESTIMATION
OF WATER TEMPERATURE INCREASE IN DIVERSION CANAL

| Time Period | Wind Speed $km \cdot hr^{-1}$ | Air Temperature $^oC$ | Absolute Humidity mmHg | Incident Radiation* $MJ \cdot hr^{-1} \cdot m^{-2}$ |
|---|---|---|---|---|
| 9 a.m. - 10 a.m. | 6.4 | 15.5 | 12 | 3314 |
| 10-11 | 4.8 | 21.1 | 11 | 3616 |
| 11-12 | 3.2 | 26.7 | 10 | 3805 |
| 12-1 | 1.6 | 29.4 | 9 | 3805 |
| 1-2 | 1.6 | 32.2 | 8 | 3616 |
| 2-3 | 1.6 | 35.0 | 8 | 3314 |
| 3-4 | 3.2 | 32.2 | 8 | 2696 |
| 4-5 | 3.2 | 29.4 | 8 | 2015 |

* It was assumed that 90% of incident radiation is absorbed by the water.

temperature increase. The rate of evaporation is governed by wind speed, atmospheric humidity and water temperature. To test the sensitivity of the estimated water temperature to assumed atmospheric humidity, a calculation was made using a humidity of 13.5 mm Hg throughout the 8-hour period; using an initial water temperature of 15°C, the final water temperature was estimated as 31°C, only 1°C higher than calculated using the humidity data in Table 9-13.

The calculations indicate that the potential mid-summer temperature increase in the diversion canal is a serious concern. Therefore, it is recommended that a detailed study be conducted to investigate methods to minimize water temperature increases in lower Hat Creek. For example, a relatively high, steep, rock-lined waterfall should be considered at the end of the diversion canal. Evaporative cooling that would occur in the waterfall could significantly reduce the temperature of the water before it entered lower Hat Creek. Also, consideration should be given to redesigning the channel to minimize the water surface area and/or minimize the time of travel from the beginning to the end of the canal.

It is also recommended that in any detailed studies, the procedure used to predict the temperature increase be refined to improve the reliability of temperature predictions. Such refinement should include added consideration of heat transfer between the water and the channel bed and consideration of site specific details such as possible shading.

(iv) Decommissioning

A. Mine

Reclamation of Disturbed Areas

Although the schedule of dump surface reclamation appears to have shifted a larger fraction of this activity into the post mining phase[97], overall area to be eventually reclaimed probably remains similar to earlier estimates. The need for fertilization is being investigated. Although progressive reclamation will be practiced, some increase in nutrient levels in surface waters could be expected.

Reclamation of the Pit

The discussions of concern in Section 6.2 (b) (iv), Volume 3 is no longer valid as new information regarding reclamation plans for the pit indicate it will be left as a void. A further concern centers on the quality of groundwater discharge to the pit from the Medicine Creek waste and ash disposal areas. During the operating phase groundwater flows from this area will be picked up by the dewatering program and that which enters the pit will be collected and discharged to the leachate storage pond. Upon decommissioning of the dewatering wells and flooding of the pit, however, this groundwater will discharge to the pit void. As discussed in Section 9.2 (a) (iii) B., there is the potential that this groundwater could contain residual levels of constituents from the ash dump leachate. These residuals will depend on the degree of attenuation achieved by precipitation and adsorption in travel through the till substrata. The new pit reclamation plans indicate positive discharge to surface waters from the pit would be unlikely to occur for many centuries, thus having no impact on the water quality of the remaining surface water resources within this time frame. The quality of the water collecting in the pit void is unlikely to be suitable for any consumptive use. The waterbody may however have some habitat value for aquatic birds and mamals.

B. Plant and Offsites

Previous discussion concerning decommissioning of the plant facilities remains valid (Section 6.2 (b) (iv) B., Volume 3). Hat Creek diversion together with the headworks reservoir will be maintained in perpetuity. The potential for elevated temperatures in the diversion canal during low flow conditions will thus continue as a significant negative impact. The previous comments regarding the cooling water supply and other offsite activities remains valid.

(v) Overall Impact Assessment

A. Preliminary Site Development

Previous discussion remains valid (Section 6.2 (b) (v) A Volume 3).

B. Construction

The main potential impact results from construction sediment loss. Provided this is controlled by means of settling ponds impacts will be minimal. Since groundwaters extracted from bedrock and coal strata will be contained, potential impacts on water quality from high dissolved solids, nutrients and colour should be minimal.

C. Operation

With adoption of the zero discharge approach for all low quality waters (leachates, seepages, mine water and coal pile runoff), many of the previous concerns and potential impact sources are now non-existent Those that remain are as follows:

1. Increased temperature in Hat Creek within the diversion canal during summer periods of low flow.
2. Potential for fugitive dust precipitation washout particularily in the Harry Creek area.
3. Some nutrient loss from fertilization activities can be expected.

In order to project the probable change in quality of Hat Creek water during the operation phase, a water quality balance (as previously in Section 6.2 (b) (v) C Volume 3) was made of those remaining discharges to Hat Creek. Three case situations have been evaluated:

<u>Case I</u> Dry weather condition when the predominant sedimentation lagoon inflow and outflow will be water from dewatering wells. Hat Creek will be at low flow.

Case II Spring runoff condition when the predominant lagoon inflow and outflow will be surface runoff, and dewatering activities. Hat Creek flows will be elevated.

Case III Summer rainstorm condition (a 10 year, 24 hour rainfall) when surface runoff to lagoons will be large. Hat Creek flows will be elevated.

The basis of the water balances are listed in Table 9-14.

The resulting water quality derived from these balances is given in Table 9-15 to 9-17. The results of the excercise in comparison with the Pollution Control Branch objectives listed in Table 9-18 indicates the following:

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 sulfate 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.

# TABLE 9-14

## BASIS OF WATER QUALITY BALANCE PROJECTIONS

### CASE I: DRY WEATHER (Year 35)

#### North Valley Sedimentation Lagoon

Dewatering Discharge from Pit to Lagoon - 0.02 $m^3$/sec[97]
Quality - as per Table 9-9

Dewatering Discharge from Slide Area to Lagoon- 0.0005 $m^3$/sec[97]
Quality - as per Table 9-8

Lagoon Discharge - 0.0205 $m^3$/sec

Hat Creek Discharge (summer low flow) - 0.12 $m^3$/sec
(BEAK Inventory Report Vol. 2)
Quality - Table 4-16 (BEAK Inventory Report, Volume 2)

#### Medicine Creek Sedimentation Lagoon

No Discharge

### CASE II: SPRING RUNOFF (Year 35)

#### North Valley Sedimentation Lagoon

Dewatering Discharge from Pit to Lagoon - 0.02 $m^3$/sec[97]
Quality - as per Table 9-9

Dewatering Discharge from Slide Area to Lagoon - 0.0005 $m^3$/sec[97]
Quality - as per Table 9-8

Runoff - Houth Meadows Waste to Lagoon - 0.002 $m^3$/sec[97]
Quality - as per Table 9-5

Runoff - All Others to Lagoon - 0.065 $m^3$/sec[97]
Quality - not worse than Hat Creek - Table 4-16
BEAK Inventory Report, Vol.2)

Lagoon Discharge -0.0875 $m^3$/sec

#### Medicine Creek Sedimentation Lagoon

Runoff - Medicine Creek Waste to Lagoon - 0.002 $m^3$/sec[97]
Quality - as per Table 9-5

Runoff - Reclaimed Land to Lagoon - 0.009 $m^3$/sec[97]
Quality - not worse than Medicine Creek - Table 9-12

Lagoon Discharge 0.011 $m^3$/sec

Discharge - Pit Rim Reservoir to Hat Creek - 0.011 $m^3$/sec

#### Hat Creek

Discharge (Mean April) - 0.48 $m^3$/sec
BEAK Inventory Report, Vol. 2)

Quality - as per Table 4-16 and Figure C2-4
BEAK Inventory Report, Vol. 2)

### CASE III: SUMMER RAINSTORM (Year 35)

#### North Valley Sedimentation Lagoon

Dewatering Discharge from Pit to Lagoon - 0.023 $m^3$/sec[97]
Quality - as per Table 9-9

Dewatering discharge from Slide Area to Lagoon - 0.0005 $m^3$/sec[97]
Quality - as per Table 9-3

Runoff - Houth Meadows Waste to Lagoon - 0.046 $m^3$/sec[97]
Quality - as per Table 9-5

Runoff - All Others to Lagoon - 0.982 $m^3$/sec[97]
Quality - not worse than Hat Creek - Table 4-16
(BEAK Inventory Report, Vol. 2)

Attenuated Discharge Rate from Lagoon to Hat Creek -0.8 $m^3$/sec[97]

#### Medicine Creek Sedimentation Lagoon

Runoff - Medicine Creek Waste to Lagoon - 0.046 $m^3$/sec[97]
Quality - as per Table 9-5

Runoff - Reclaimed Land to Lagoon - 0.104 $m^3$/sec[97]
Quality - not worse than Medicine Creek - Table 9-12

Discharge from Lagoon to Pit Rim Reservoir - 13,000 $m^3$[97]

Discharge from Lower SW Diversion, SE Diversion and Watershed Below Canal - 10,400 $m^3$ [97]
Quality - not worse than Hat Creek - Table 4-16 (BEAK Inventory Report, Vol. 2)

Discharge Rate from Pit Rim Reservoir to Hat Creek - 0.12 $m^3$/sec (pump station capacity)[101]

#### Hat Creek

Discharge (Base flow plus incremental due to rainstorm)- 1.68 $m^3$/sec (BEAK Estimate Based on Aug. 1965 and July 1966 Hydrographs)
Quality - as per Table 4-16 and Figure C2-4 (BEAK Inventory Report, Vol. 2)

TABLE 9-15

WATER QUALITY PROJECTIONS - CASE I*

| Parameter (mg/l) | Projected North Lagoon Effluent | Average Existing Hat Creek | Projected Hat Creek |
|---|---|---|---|
| pH (units) | 7.9 | 8.4 | 8.3 |
| Filterable Residue | 368 | 342 | 345 |
| Non-Filterable Residue | ≤50 mg/l | 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 | <0.01 | <0.01 |
| Copper | <0.005 | <0.005 | <0.005 |
| Iron | <0.03 | <0.026 | <0.028 |
| Lead | <0.01 | <0.01 | <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. Hat Creek discharge assumed to be 0.12 $m^3$/sec.

TABLE 9-16

WATER QUALITY PROJECTIONS - CASE II*

| Parameter(mg/1) | Projected Effluent North Lagoon | Projected Effluent Med. Ck. Lagoon and Rim Reservoir | Average 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 | 10 |
| 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 | <0.01 | <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 | <0.01 | <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. 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.

TABLE 9-17

WATER QUALITY PROJECTIONS - CASE III*

| Parameter (mg/1) | 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 | < 0.008 | <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, dewatering 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. 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.

## TABLE 9-18

### *Objectives for Effluent Discharges*

| Characteristics | Description | Unit of Measurement | Fresh-water Discharge | | |
|---|---|---|---|---|---|
| | | | Level A | Level B | Level C |
| Total suspended solids (non-filterable residue) | That portion of the effluent, as discharged which is retained by an approved filter | mg/l | 50[1] | 150[1] | ([2]) |
| Total dissolved solids (filterable residue) | That portion of the effluent as discharged which passes through an approved 0.45-micron pore-sized filter | mg/l | <2,500 | <3,500 | <5,000 |
| Colour[3] | Colour of the effluent, at the point of discharge | Approved units | — | — | — |
| pH[2] | The pH of the effluent at the point of discharge | pH units | 6.5–8.5[4] | 6.5–9.5 | 6.0–10 |
| Specific elements and compounds[1] | Material contained in the effluent, at the point of discharge, which passes an approved 0.45-micron pore-sized filter (except where total values are required) | — | — | — | — |
| Aluminum (Al) | Dissolved in the effluent | mg/l | 0.50 | 1.00 | 10.00 |
| Ammonia (as N) | Dissolved in the effluent | mg/l | 0.50[4] | 1.00 | 10.00 |
| Antimony (Sb) | Dissolved in the effluent | mg/l | 0.05 | 0.25 | 1.00 |
| Arsenic (As) | Dissolved in the effluent | mg/l | 0.05 | 0.25 | 1.00 |
| Cadmium (Cd)[5] | Dissolved in the effluent | mg/l | 0.005 | 0.01 | 0.02 |
| Chromium (Cr) | Dissolved in the effluent | mg/l | 0.05 | 0.30 | 0.50 |
| Cobalt (Co) | Dissolved in the effluent | mg/l | 0.10 | 0.50 | 1.00 |
| Copper (Cu) | Dissolved in the effluent | mg/l | 0.05 | 0.30 | 1.00 |
| Cyanide (CN) | Total cyanide in the effluent | mg/l | 0.10 | 0.50 | 2.00 |
| Fluoride (F) | Dissolved in the effluent | mg/l | 2.50 | 5.00 | 15.00 |
| Iron (Fe) | Dissolved in the effluent | mg/l | 0.30 | 1.00 | 5.00 |
| Lead (Pb) | Dissolved in the effluent | mg/l | 0.05 | 0.10 | 0.50 |
| Manganese (Mn) | Dissolved in the effluent | mg/l | 0.05 | 0.50 | 1.50 |
| Magnesium (Mg) | Dissolved in the effluent | mg/l | 150 | 300 | 500 |
| Mercury (Hg) | Total in the effluent | mg/l | 0.001[4] | 0.003 | 0.01 |
| Molybdenum (Mo) | Dissolved in the effluent | mg/l | 0.50[4] | 1.00 | 10.00 |
| Nickel (Ni) | Dissolved in the effluent | mg/l | 0.30 | 0.50 | 1.00 |
| Nitrates/Nitrites (as N) | Dissolved in the effluent | mg/l | 10.00 | 25.00 | 50.00 |
| Phosphate (as P) | Total in the effluent | mg/l | 2.00 | 5.00 | 10.00 |
| Selenium (Se) | Dissolved in the effluent | mg/l | 0.05 | 0.10 | 1.00 |
| Silver (Ag) | Dissolved in the effluent | mg/l | 0.10 | 0.50 | 1.00 |
| Sulphate ($SO_4$) | Dissolved in the effluent | mg/l | 50[4] | 250 | 1,000 |
| Uranyl ($UO_2$) | Dissolved in the effluent | mg/l | 2.00 | 5.00 | 10.00 |
| Zinc (Zn) | Dissolved in the effluent | mg/l | 0.50 | 5.00 | 10.00 |
| Oil and Grease | Total in the effluent | mg/l | 15.00 | 15.00 | 15.00 |

NOTE—Acceptable concentrations for characteristics not appearing in this list are to be determined as required. When all liquids are totally recycled, the applicability of the above objectives will be assessed.

1 Initially, semiquarterly sampling on effluents and at control and test stations in receiving-waters; quarterly sampling on effluent discharged to closed systems.

2 Daily sampling.

3 To be reviewed.

4 Tentative, subject to review.

5 Subject to review where applied to smelters.

The levels of nutrients projected does not include any contribution from losses from reclamation fertilization. The need for fertilization is being assessed by B.C. Hydro. Indications are that progressive reclamation will be practiced. Nevertheless some increase in nutrient levels could be expected.

The new mine drainage plan based on containing all low quality wastewater, leachates and seepages results in a substantially reduced increase in dissolved solids of lower Hat Creek. The projections indicate an increase of between 1-4 percent as compared with earlier predictions of 90 percent.

The calculated projections of changes in suspended solids levels in Hat Creek range from a maximum increase of 6 mg/l or 50 percent (during dry weather and spring runoff) to a decrease during a rainstorm condition. On an average annual basis, experience elsewhere as previously reported (Section 6.2 (b) (v) C Volume 3) indicates the sediment yield may be expected to increase by 11 percent. On an average annual basis this is considered to be a minor negative impact.

D. Decommissioning

The potential significant impacts projected during the decommissioning phase are as follows:

1. Nutrient loss to Hat Creek resulting in possible fostering of algae and eutrophication effect.

2. Continued elevated temperatures in Hat Creek diversion canal during summer low flow conditions.

3. Beneficial impact of reduced sediment and dissolved solids losses from disturbed areas due to completion of reclamation.

## 9.3 WATER USE

### (a) Ground Water

The same comments given in BEAK[98] apply.

### (b) Surface Water

#### (ii) Construction

##### A. Mine, Plant and Offsites

Irrigation

The impacts on irrigation water use due to construction of the project according to the revised project description [96, 97, 100] would differ from that previously reported (BEAK 1978) in three areas. Firstly, the potential nursery sited next to the Pit Rim Reservoir[96], which was not identified in the previous project description, would take the place of about 10 ha (24 ac) of presently irrigated land. The quantity of irrigation water associated with this land is 7.5 ha-m-yr$^{-1}$ (61 ac-ft). Secondly, the revised location of the project acccess road, depending on the exact location, may infringe more on the land projected to be irrigated in the future for corn production. However, optimum placement of this road with respect to this potential corn land could afford better access and therefore encourage possible development. Thirdly, according to the present proposal not to drain Finney Lake, the 12 ha-m-yr$^{-1}$ present storage use would not be affected. These impacts would occur in Subregion II of the Hat Creek Drainage Basin (Figure 4-48 BEAK, Volume 2).

Table 9-19 presented as a revision of Table 6-29 (Volume 3), summarizes all impacts that would be associated with the revised proposal and identifies differences to the earlier report.

In summary, the revised project construction activities would impact about 20 percent more presently irrigated land and 4 percent more of the total land projected to be irrigated in the future (without mine and power plant development) than the old project description. However, this is offset by the plans not to drain Finney Lake, with the net effect being little change from the earlier impact estimates.

### Livestock Use

According to the revised project description, Finney Lake will now remain, while the small lakes and ponds in the area would be drained. Although this could have some effect on grazing patterns, the impact is not clear.

In the Medicine Creek area, the Alternative "B" ash disposal scheme and adjacent plant water supply reservoir[96,100] together would take up roughly 400 ha (988 ac) less rangeland than the previous project proposal and therefore eliminate fewer livestock watering sites in that area.

In summary, the impacts on cattle water use are not expected to be very great.

### Domestic, Municipal, and Industrial

There is no significant change to the previously reported impact discussion.

TABLE 9-19

REVISED IRRIGATION WATER USE IMPACTS

DUE TO PROJECT CONSTRUCTION

Impact of Alienation

| Project Activity | Water Use Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Presently Irrigated | | Projected Irrigated Corn | | Projected Irrigated Spring Pasture | | Total Projected Use | |
| | Land (ha) | Water ($ha\text{-}m\text{-}yr^{-1}$) | Land (ha) | Water ($ha\text{-}m\text{-}yr^{-1}$) | Land (ha) | Water ($ha\text{-}m\text{-}yr^{-1}$) | Land (ha) | ($ha\text{-}m\text{-}yr^{-1}$) |
| Mine | 12 | 8 | 113 | 75 | 48 | 8 | 173 | 91 |
| Plant | 16 | 11 | - | - | - | - | 16 | 11 |
| Offsites | 27* | 21* | 62 | 41 | 6 | 1 | 95 | 63 |
| Total | 55 | 40 | 175 | 116 | 54 | 9 | 284 | 165 |

Other Impacts

| Project Activity | Water Use Category | Water Quantities ($ha\text{-}m\text{-}yr^{-1}$) |
|---|---|---|
| Finney Creek Diversion | Conveyance Disruption | 12 |
| Hat Creek Diversion | Conveyance Disruption | 23 |
| Total | | 35* |

* change of impact due to revised project character

(iii) Operation

A. Mine, Plant and Offsites

Irrigation

Except for one item, the differences in impact of the revised project description compared to the parallel section in the previous report (BEAK, Volume 3) would be minor. Table 9-20, presented as a revision of Table 6-31 (Volume 3), summarizes all impacts that would be associated with the revised proposal and identifies significant and minor differences to the earlier report.

The significant difference is that the new proposal considers a power plant water supply reservoir in the Medicine Creek valley. Water users in Hat Creek Valley could be affected due to the project use of present and potential irrigation water.

B.C. Hydro [96] estimates that natural drainage to the Medicine Creek reservoir on an average annual basis would be about 400 ha-m (3241 ac-ft). An average quantity of about 20 $ha\text{-}m\text{-}yr^{-1}$ (162 ac-ft) from plant yard drainage would also be collected in a holding pond and used for ash wetting. Two present irrigation licences of 6 $ha\text{-}m\text{-}yr^{-1}$ (49 $ac\text{-}ft\text{-}yr^{-1}$) each in the lower Medicine Creek area would be displaced. A major licence of up to 216 $ha\text{-}m\text{-}yr^{-1}$ (1750 $ac\text{-}ft\text{-}yr^{-1}$) for the diversion from the Medicine Creek watershed to McLean Lake would not be displaced and hence would remain available for irrigation of about 270 ha (667 ac) south of Cache Creek near the junction of Cornwall Creek and Highway One. As well as the impact on present irrigation use, project use of Medicine Creek water could hinder the possible development during project life of irrigated corn land in Subregion II which requires, for full development, storage and use of, about 220 $ha\text{-}m\text{-}yr^{-1}$ (1783 $ac\text{-}ft\text{-}yr^{-1}$). In summary, the potential impact of the Medicine Creek reservoir on irrigation water use would be about 232 $ha\text{-}m\text{-}yr^{-1}$ (1880 $ac\text{-}ft\text{-}yr^{-1}$).

TABLE 9-20

IMPACT ON IRRIGATION WATER USE
DUE TO PROJECT OPERATION

| Project Activity | Annual Impact |
|---|---|
| Mine Dust Control* | - Evaporation of up to a maximum of 12 ha-m of Hat Creek basin water collected in sedimentation ponds and used during the early years for dust control. |
| Pit Rim Reservoir | - Evaporation of approximately 3 ha-m from reservoir surface during irrigation season. |
| Headworks Reservoir | - Evaporation of approximately 3 ha-m from reservoir surface during irrigation season. |
| Sedimentation Lagoons | - Evaporation of approximately 4 ha-m from lagoon surfaces during irrigation season. |
| Mine Pit Seepage* | - Evaporation from pit surfaces of approximately 6 ha-m of seepage during irrigation season (using seepage rate of 0.0047 $m^3$-$s^{-1}$).<br>- No impact due to unsuitable quality if kept within "zero discharge system". |
| Mine and Slide Area Dewatering* | - Collection of approximately 27 ha-m of ground water (slightly less during early years) and diversion to Hat Creek canal during irrigation season (possible small net benefit to irrigation users). |
| Coal Stockpiles* | - No impact due to unsuitable quality if leachate kept within "zero discharge system". |
| Plant and Ash Wetting Water Supply Reservoirs** | - Storage and use of up to 232 ha-m of Medicine Creek irrigation water. |
| Zero Discharge System* | - Evaporation from project surfaces of up to 8 ha-m of water that would have entered Hat Creek during irrigation season.<br>- Possible, but doubtful use of about 23 ha-m for crop irrigation. |

*minor change of impact due to revised project character

**significant change of impact due to revised project character

It should be pointed out that the revised project description considers a "zero discharge system" for disposal of liquid wastes (including the leachates from the mine pit and coal stockpiles) and thus the previous concerns with possible water quality impacts due to the use of this water for crop irrigation have been alleviated. Under the new scheme waste waters of this type would be collected, used for seasonal dust control and any remaining quantity irrigated onto active project dump surfaces for disposal. Although doubtful, due to suspect water quality (sulfates and total dissolved solids), there may be a possible benefit by using part of the collected seepage and waste waters for crop irrigation. After dust control use, there would be up to 23 ha-m-yr$^{-1}$ (186 ac-ft-yr$^{-1}$) of water available at full stage development of the collection reservoir. Water quality monitoring and perhaps crop experimentation during initial project years would be necessary to substantiate the potential use of this water for crop irrigation.

The impacts within the operation section could be modified somewhat by considering that the amounts stated would each contain a fraction resulting from the reduced consumptive use of previously unimproved areas.

Livestock Use

There is no significant change to the previously reported impact.

Domestic, Municipal, and Industrial

There is no significant change to the previously reported impact discussion.

(iv) Decommissioning

A. Mine, Plant, and Offsites

## Irrigation

As most of the impacts of decommissioning are closely interrelated, the following section completely replaces the parallel section in Volume 3. The impacts of decommissioning are perceived to be beneficial. This assumes that any irrigation use of water developed during and as a result of the project and depending on it will be protected (e.g., maintenance of flow in the canal or maintenance of creek and dewatering diversions to provide water required of irrigation uses developed with the project). Table 9-20 summarizes the project activities, causes, and water quantities associated with benefits of decommissioning. The economic feasibility of potential benefits identified has not been addressed in this study.

The water supply pipeline from the Thompson River with a capacity of 1.6 $m^3 s^{-1}$ (25,000 USGPM) could supply irrigation water for 700 - 1100 ha (1730 - 2720 ac) assuming a daily peak demand double the July peak demand shown in Table 4-24 (Volume 2). These quantities of land are available in the study area but no attempt was made to assess specific irrigation feasibility. On a seasonal basis, about 650 ha-m (5267 ac-ft) could be supplied by the Thompson River pipeline for irrigation use.

A large potential benefit occurring at decommissioning is that of irrigation water being made available through storage provided by project reservoirs. As shown in Table 5-4 (Volume 2), almost 1600 ha-m (12,970 ac-ft) of water are potentially available for storage in the Hat Creek drainage basin. Subtracting 84 ha-m (680 ac-ft) of additional probable use (see Section 5.3, Probable Use, Volume 2) of stream flow for spring pasture irrigation, leaves almost 1516 ha-m (12,285 ac-ft). Also possibly available, depending on the economics of pumping, is the 1.6 $m^3 s^{-1}$ (25,000 USGPM) capacity of the supply pipeline less the amount that might be used directly during the irrigation season as referred to in the preceding paragraph; which leaves 4330 ha-m-$yr^{-1}$ (35,089 ac-ft-$yr^{-1}$) or, together with water of the Hat Creek watershed, 5930 ha-m-$yr^{-1}$ (48,055 ac-ft-$yr^{-1}$).

TABLE 9-21

BENEFICIAL IMPACTS ON IRRIGATION WATER USE DUE TO PROJECT DECOMMISSIONING

| Project Activity | Cause of Benefit | Water Quantity ($ha\text{-}m\text{-}yr^{-1}$) |
|---|---|---|
| Base Scheme: | | |
| Supply Pipeline | - Capacity ($1.6\ m^3\text{-}s^{-1}$) | 650 |
| Plant Water Supply Reservoir | - Storage becomes available | 202-2122* |
| Pit Rim Reservoir | - Storage becomes available | 22 |
| | - Pump becomes available | - |
| | - Evaporation of Summer flow stops | 3 |
| Zero Discharge Reservoir | - Storage becomes available | 56 |
| Mine and Slide Area Dewatering | - Diversion stops | 27** |

*the larger quantity depends on supply from Thompson River and assuming optimum control of outlet works to utilize full reservoir capacity.

**possible negative impact if irrigation dependence on this water is developed during the life of the project.

Assuming an eventual surface area of about 100 ha (247 ac) for all reservoirs and a potential evaporation rate of 0.48 $m\text{-}yr^{-1}$ (Table 4-24, Volume 2) evaporation loss would be about 48 $ha\text{-}m\text{-}yr^{-1}$ (622 $ac\text{-}ft\text{-}yr^{-1}$).

This leaves 5882 ha-m (47,666 ac-ft) of water that could be stored in project reservoirs, if the large capacity of Pit Lake is included. However, this reservoir has been considered not available for this purpose [97]. The total quantity allocated to the remaining reservoirs is 280 - 2200 $ha\text{-}m\text{-}yr^{-1}$ (2269 - 17,828 $ac\text{-}ft\text{-}yr^{-1}$) where the smaller figure assumes no availability of Thompson River water.

In this case the Medicine Creek watershed would yield a gross amount of about 250 $ha\text{-}m\text{-}yr^{-1}$ (2026 $ac\text{-}ft\text{-}yr^{-1}$) assuming 150 $ha\text{-}m\text{-}yr^{-1}$ (1216 $ac\text{-}ft\text{-}yr^{-1}$) diversion to McLean Lake.[96] Allowing for evaporation losses, 202 $ha\text{-}m\text{-}yr^{-1}$ (1637 $ac\text{-}ft\text{-}yr^{-1}$) remain for irrigation use.

Assuming a conservative irrigation application rate of 0.91 m (3 ft), 308 ha (760 ac) could be irrigated using the stored water of the Hat Creek watershed, while a total of 2418 ha (5,974 ac) could be irrigated if using the Thompson River water as well. Since this latter quantity is a considerable portion of the maximum potential irrigation use identified in the Inventory section (Volume 2), it is doubtful that much land would be within efficient reach of the reservoir locations for individual farm systems and a regional water supply network (water district) would need to be considered. The extent and feasibility of a water district of this nature was not determined in this study.

Other decommissioning impacts of the mine are comparatively minor. A number of operation impacts causing reduced summer flow would cease or at least be compensated for by storage of other water. These include the effect of the Pit Rim Reservoir evaporation on summer flow and the diversion of water due to Pit Rim dewatering would cease. A total of about 30 $ha\text{-}m\text{-}yr^{-1}$ (243 $ac\text{-}ft\text{-}yr^{-1}$) are involved.

Livestock Use

Use of water by livestock during and after decommissioning depends on the agricultural use of lands at that time. Projections of this use are not available.

Domestic, Municipal, and Industrial

There is no significant change to the previously reported discussion.

(v) Overall Impact Assessment

Irrigation

The main differences in the overall impact assessment of the revised project from that previously reported (Volume 3) results from the new location and capacity of the proposed plant water supply reservoir and the unavailability of Pit Lake as a storage reservoir in decommissioning. In addition to the previously identified overall impacts, in the operation phase, the Medicine Creek reservoir is expected to have significant interference with present and probable irrigation use amounting up to 232 $ha\text{-}m\text{-}yr^{-1}$ (1880 $ac\text{-}ft\text{-}yr^{-1}$). There are, however, additional benefits possible during the decommissioning stage due to the new reservoir scheme, but accounting for the unavailability of Pit Lake storage, the total benefits reported are about the same magnitude in terms of water quantity as in Volume 3. However, since the storage is at a higher elevation the actual potential benefits are probably greater.

Livestock Use

The losses or benefits from the project on livestock water use would appear to be minor in nature, especially in view of the fact that the magnitude of this use is small in comparison to other water uses.

Domestic, Municipal, and Industrial

There is no significant change to the previously reported discussion.

# 10.0 OPPORTUNITIES FOR MITIGATION, COMPENSATION AND ENHANCEMENT

## 10.1 HYDROLOGY

### (a) Groundwater Hydrology Impacts

Same comments as given in BEAK[98] will apply, with the exception of opportunities (iii) and (iv) which should be deleted.

### (b) Surface Water Hydrology Impacts

The general comments of Section 7.1 (b) remain entirely valid. It should be noted however, that all three specific recommendations are now incorporated in the latest designs.

- Finney Lake is not to be drained
- The sedimentation lagoons are large enough to keep outflows below morphologically significant values, and
- The highly negative water balance of the Hat Creek valley floor is being used to dispose of leachates.

## 10.2 WATER QUALITY

### (a) Groundwater Quality Impacts

It is noted that four of the previous recommendations in Section 7.2 (a) are generally included in the most recent project design.

- Ponds or lagoons receiving low quality effluents, seepages and leachates will be constructed to minimize loss of contaminated water to the groundwater regime.
- Storage areas for coal and low grade waste will be prepared in a manner to minimize leachate loss to the groundwater.
- Progressive reclamation is to be utilized.
- Overburden and stock piled materials will not be placed over thick snow in order to minimize leachate drainage.

The following point is suggested for further consideration:

1. Further study and investigation may uncover methods to reduce potential groundwater contamination from the ash disposal area in Medicine Creek Valley.

### (b) Surface Water Quality Impacts

The general suggestions made previously in Section 7.2 (b) remain valid and many have now been incorporated into the project design.

- Fertilization requirements are being investigated and progressive reclamation is being adopted.
- Leachates and runoff from the coal pile will be collected and disposed to the zero discharge system.
- Sedimentation lagoons have been designed to minimize inclusion of runoff from undisturbed areas.
- Small lakes would be drained during high flow in Hat Creek.

The following suggestions are offered in reference to the new project descriptions:

1. Further study of the Hat Creek diversion may uncover options to reduce the potentially high water temperatures during low flow.
2. Further study would be necessary of any proposal to discharge excess power plant cooling tower blowdown to surface streams or rivers.
3. Consideration should be given to the need for a settling basin on lower Harry Creek to control potential precipitation washout of fugitive dust from nearby coal preparation operations.

## 10.3 WATER USE

### (a) Groundwater Use Impacts

The discussion as given in BEAK[98] will apply.

### (b) Surface Water Use Impacts

#### Irrigation

The suggestions for mitigation and compensation made earlier in Volume 3 remain valid except for minor changes in the amounts stated.

An additional suggestion has to do with the proposed design of the make-up reservoir outlet works. As currently proposed there would be available storage above the outlet works but this would have to be strictly regulated to be prepared for the probable maximum flood. It would seem quite advantageous to construct the outlet works with an additional outlet at a lower elevation, perhaps around 1225 meters. This outlet could then be used after decommissioning to provide gravity flow of local runoff water stored in the reservoir while providing unregulated flood protection. An even lower outlet may be worthwhile if Thompson River water would also be available. A number of factors would need to be considered in making a cost comparison between this outlet scheme and the one proposed by B.C. Hydro. Besides a small amount of additional piping at the dam site the pipe under the ash disposal area would need to be stronger because of greater fill depths. However, additional costs may be offset by the fact that, with a steeper energy gradient at the lower elevation, a smaller diameter pipe could be used to handle the design flows.

# 11.0 RESEARCH AND MONITORING PROGRAM RECOMMENDATIONS

## 11.1 HYDROLOGY

### (a) Groundwater

#### (i) Hydraulic Conductivity of Waste Materials

Same comments as given in BEAK[98].

#### (ii) Installation of Piezometers and Water Sampling Stations

Combination water sampling and groundwater level monitoring piezometers should be installed in boreholes located around the ash and rock waste dump areas. These piezometers would supplement the three operating monitoring piezometer stations in the valley. The locations of the three existing and seven proposed boreholes are shown in Figure 9-1. At least three piezometers should be installed at different depths in each borehole. Where appropriate, suction lysimeters should also be installed to sample water from the unsaturated zones (see typical details in Figure A3-1 BEAK[98]).

All three existing piezometer boreholes, RH77-45, 77-48 and 77-49 should be preserved. Special provisions would have to be made to protect these installations particularly RH-49 which is inside the ash dump and RH-48 which is inside the reservoir.

The water levels in existing piezometers are being read once a month. When the new piezometers are installed the monitoring program should be extended to include these piezometers. Samples of water should be taken for chemical analysis from these piezometers once a year for three years prior to the commencement of mining and dumping activities. A more regular monitoring program could be instituted when mining activities commence.

Numerous piezometers have already been installed in the vicinity of the coal pit and water levels in these piezometers are being monitored once a month. In addition, one borehole with a minimum of three piezometers should be installed and monitored alongside Highway No. 12 just west of Indian Reserve No. 4 in the Marble Canyon. This station would monitor the effects of recharge and/or withdrawals from the Marble Canyon aquifer (see locations Figure 9-1).

(b) Surface Water

All of the earlier (Section 8.1 (b)) recommendations remain valid, except that MacLaren and Cornwall Creeks no longer require investigation since Medicine Creek will not be diverted into them.

## 11.2 WATER QUALITY

### (a) Groundwater

#### (i) Research Recommendations

The recommendations for research stated previously regarding further water quality data needs in the pit area have largely been accommodated. The requirement for additional data needs in the Harry Lake area is no longer required. Site specific data for disposal sites impoundments and lagoons will still be required in the detail design stage.

#### (ii) Monitoring Program Recommendations

The recommendations outlined previously remain valid.

### (b) Surface Water

#### (i) Research Recommendations

The previously reported recommendations Nos. 3, 4, 5 remain valid while the others suggested have generally been accommodated in development of the most recent project description and design. In addition it is recommended that:

1. Information be gathered on nutrient, dissolved solids and sediment loss from any groundwater or surface water runoff from the test reclamation plots being studied in the Hat Creek Valley.

#### (ii) Monitoring Program Recommendations

The recommendations reported previously in Section 8.2 (b) (ii) remain valid.

## 11.3 WATER USE

### (a) Groundwater

#### (i) Potable Water Supply from Wells

Comments given in BEAK[98] will apply.

### (b) Surface Water

#### (i) Irrigation

The discharge to natural waters of potentially unsuitable project waste waters should be routinely monitored and strictly controlled to ensure acceptable water quality for irrigation use. If the PCB criteria for the "zero discharge system" are adhered to, there should be no problems.

Surface waters should be monitored throughout the project and evaluated relative to irrigation use.

It may be worthwhile to experiment with the "zero discharge waters" to determine in actual fact whether or not any beneficial irrigation use could be made with them.

#### (ii) Livestock Use

There is no change to the previous report of this section.

#### (iii) Domestic, Municipal and Industrial

There is no significant change to the previously reported discussion.

# REFERENCES

## SECTION 9


96. British Columbia Hydro & Power Authority. August, 1978. Hat Creek Project: Water Supply and Ash Disposal Study: Design Memorandum on Alternative Wet and Dry Ash Disposal Schemes. Unpublished report No. DD122 by the Hydro-electric Design Division.

97. Cominco-Monenco Joint Venture. February, 1979. Hat Creek Project: Mine Feasibility Report. Volume IV, Section 3 (Draft) and Volume V.

98. Beak Consultants Limited. June, 1978. Hat Creek Project: Detailed Environmental Studies: Water resources Sub-group on Hydrology, Drainage, Water Quality and Use. Volumes 1 to 4 of a report prepared for British Columbia Hydro and Power Authority.

99. Golder Associates. 1979. Hat Creek Project: Preliminary Engineering Work - Geotechnical Study 1977-78. Final report submitted to British Columbia Hydro and Power Authority.

100. Integ-Ebasco. November, 1978. Alternative "B" Ash Disposal Study. Report submitted to British Columbia Hydro and Power Authority.

101. British Columbia Hydro and Power Authority. March, 1978. Hat Creek Project: Diversion of Hat and Finney Creeks Preliminary Design Report. No. 913. Hydroelectric Design Division.

102. U.S. Dept. of the Interior. Mining Enforcement and Safety Administration. Engineering and Design Mannual, Coal Refuse Disposal Facilities. Report prepared by E. D'Appolonia Consulting Engineers Inc. no date.