BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

HAT CREEK PROJECT

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

VOLUME 4
APPENDICES

A Report for:

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

Prepared by:

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Vancouver, B.C.

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APPENDIX A

A1.0 GLOSSARY

The following glossary explains some of the terms used in the ground water sections of this report.

Aquifer — A lithologic unit (or combination of such units) which has appreciably greater transmissivity than adjacent units and which has capability to store and transmit water recoverable in economically usuable quantities.

Darcy Equation — The most basic equation used for estimation of seepage flow rates through a porous medium.

$$Q = k\ i\ A$$

where: Q = flow rate of water through the medium (L^3/T)
k = hydraulic conductivity (L/T)
i = hydraulic gradient (L/L)
A = cross sectional area of flow (L^2)

Base Flow — Portion of stream flow derived from ground water discharge.

Discharge area — Area in which ground water flow lines converge and are directed toward water table.

Equipotential line — Contour line which represents equal hydraulic head.

Evapotranspiration — Portion of the precipitation returned to the air through direct evaporation and/or by transpiration.

Flow system — A set of flow lines in which any two flow lines adjacent at one point in the flow region remain adjacent throughout the entire flow region, and that can be intersected anywhere by an uninterrupted surface across which flow occurs only in one direction.

Ground water — A body of subsurface water in which fluid pressure is greater than atmospheric.

Homogeneity — The physical properties of the porous medium do not vary from point to point in the medium.

Hydraulic conductivity — Ratio of flow velocity to driving force (hydraulic gradient) for viscous flow under saturated conditions of a specified liquid in a porous medium.

Hydraulic head	The sum of the pressure and elevation heads.
Hydraulic gradient	Increase in hydraulic head per unit length of flow path.
Infiltration	The inflow of water into earth materials.
Perched ground water	A lense of ground water separated from an underlying body of ground water by unsaturated earth material.
Permeability	A measure of the relative ease with which a porous medium can transmit a liquid under a hydraulic gradient. It is a property of the medium alone and is independent of the nature of the liquid and of the force field causing movement. It is a property of the medium that is dependent upon the shape and size of the pores.
pH	A measure of the acidity or alkalinity of water.
Piezometric surface	Imaginary surface defined by the level to which water will rise in wells tapping a confined aquifer.
Spring	Natural surface discharge of ground water having a concentrated flow.
Transmissivity	Rate of horizontal water flow in gallons per day through a vertical strip of aquifer 1 foot wide and extending full saturated thickness under hydraulic gradient of 1 foot per foot at prevailing water temperature.
Water table	Surface along which the fluid pressure is atmospheric and below which the fluid pressure is greater than atmospheric.

A2.0 WELL INVENTORY

The following summarises the data collected on domestic wells, developed springs and an industrial well in the Hat Creek Valley.

Well Designation:	DW-1*
Use:	B.C. Hydro Camp Supply
Location:	Approximately 3m from Hat Creek, directly behind camp.
Well Type:	In augered hole
Depth:	Approximately 5m
Yield:	Approximately $10m^3$/day
Description:	Galvanized pipe liner set in hole with boards covering top.
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Hole was originally drilled down to the coal below surficial sediments (approx. 5m thick). Most of the water infiltrates through surficial sands and gravel from Hat Creek.

Well Designation:	DW-2
Use:	Domestic supply for residence.
Location:	Located on western hillside
Well Type:	Developed spring
Depth:	Less than 1m
Yield:	Sufficient for small house $1.5m^3$/day.
Description:	Spring waters flow to a collection pool (approx. 1m x 2m x 0.5m)
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Shallow springs associated with seepage from Finney Creek

*DW-1 refers to Domestic Water Supply Source number 1. Note Nos. 6, 7, 11 and 12 are not wells as pump-pipe systems take water directly from Hat Creek.

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Well Designation:	DW-3
Use:	Domestic water supply for Residence
Location:	On west bench near Finney Creek. About 150m from residence
Well Type:	Developed spring
Depth:	Water flows to surface
Yield:	Not sufficient for house supply at mid summer
Description:	Spring is about 1m in diameter and the water depth about 10mm
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Shallow ground water associated with seepage from Finney Creek
Other Comments:	A sulphurous smell was noted when a water sample was collected. This spring used to supply two houses until about 4 years ago when, according to resident the supply almost dried up as a result of subsidence of part of the bench, west of the property.

Well Designation:	DW-4
Use:	Domestic supply for Residence. Some irrigation use.
Location:	About 20m west of Hat Creek
Well Type:	Dug well
Depth:	About 3m
Yield:	Good supply (approx. $2m^3$/day)
Description:	350mm diameter dug well collects seepage water from a bank about 15m away. Well is sealed and water is pumped into the house.
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Springs used to issue from the foot of the bank but the springs have now dried up and a dug well became necessary.

Well Designation:	DW-5
Use:	Domestic supply Ranch
Location:	Near house and close to a small creek
Well Type:	Dug well
Depth:	Estimate 5m
Yield:	Estimated $1.5m^3$/day
Description:	Well was dug with a back hoe and kept open with a well liner
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Well water is probably derived from a shallow ground water flow system and being only 15m from Hat Creek may also include some infiltrated creek water

Well Designation:	DW-8
Use:	Domestic supply Residence
Location:	Approx. 15m from Hat Creek
Well Type:	Dug well
Depth:	Approx. 8m
Yield:	Estimated $2m^3$/day
Description:	The well is completely boarded up and is not accessible. No construction details were available.
Water Type:	Ca - HCO_3, with high sodium chloride content
Hydrogeologic Setting:	Well dug into river alluvium and on pleistocene deposits.
Other Comments:	The high sodium chloride content is somewhat unusual for local ground waters and suggests that the well water may have been contaminated.

Well Designation:	DW-9
Use:	Domestic supply for Residence
Location:	Approx. 300m up hill, east of the residence
Well Type:	Developed Spring
Depth:	Surface flow
Yield:	Sufficient for household use ($1.5m^3$/day)
Description:	A small holding tank has been constructed to collect spring water
Water Type:	
Hydrogeologic Setting:	Water is derived from a marshy area. This water is probably a mixture of surface and shallow ground waters.

Well Designation:	DW-10
Use:	Domestic supply to Ranch house
Location:	Under the house and about 6m from Hat Creek
Well Type:	Dug well
Depth:	Estimated 5m
Yield:	Estimated $1.5m^3$/day
Description:	Top of well is sealed with a concrete slab and no construction details are available.
Water Type:	Ca - HCO_3
Hydrogeologic Setting:	Water derived from river alluvium and or pleistocene sediments.
Other Comments:	Water had a hydrogen sulphide smell and possible high dissolved iron content suggesting reducing conditions.

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Well Designation:	DW-13
Use:	Domestic water supply to a new house
Location:	Approx. 150m west of Hat Creek
Well Type:	Drilled
Depth:	36m
Yield:	1.6m^3/day (Note well is capable of producing approximately 230m^3/day).
Description:	150mm diameter steel cased well with 150mm stainless steel continuous wire wound screen with 1mm slot openings. Screen was set between 12 and 13 m depth.
Water Type:	No data available
Hydrogeologic Setting:	The well is located in the south end of the Hat Creek valley near Hat Creek. The water pumped from this well comes from a sand and gravel aquifer which extends from 11m to 13m. The unconsolidated sediments above this aquifer consist primarily of till with some alluvium near the ground surface. A soft steeply dipping bedrock was reported to have been encountered below the aquifer. No significant quantity of ground water was encountered in this bedrock material. The static water level in the completed well was 6m below ground which indicate that the sand and gravel is a confined aquifer.

Well Designation:	DW-14
Use:	Supplementary domestic water supply for Residence. (Supplements DW-3)
Location:	In front of house, between road and Hat Creek.
Well Type:	Dug hole
Depth:	Approx. 6m
Yield:	Unknown
Description:	Hole probably dug with a backhoe and then 1m diameter pipe liner installed.
Water Type:	no data
Hydrogeologic Setting:	Hole dug into unconsolidated silts, sands and gravel. Water probably infiltrates mainly from Hat Creek. Static water level about the same as Hat Creek.
Other Comments:	The well was only recently constructed and has not been used.

Well Designation:	DW-15
Use:	Domestic water supply
Location:	Off Highway 12 on Indian Reserve (see fig. 3-4)
Well Type:	Drilled
Depth:	Unknown
Yield:	Unknown (estimated 1m^3/day)
Description:	
Water Type:	
Hydrogeologic Setting:	Probably yielding water from unconsolidated sediments.
Other Comments:	Log of well was not available.

Well Designation:	DW-16
Use:	Domestic water supply
Location:	Off highway 12 on Indian Reserve (see fig. 3-4)
Well Type:	Drilled
Depth:	Unknown
Yield:	Unknown (estimated $1m^3$/day)
Description:	
Water Type:	
Hydrogeologic Setting:	Probably yielding water from unconsolidated sediments.
Other Comments:	Log of well was not available

Well Designation:	DW-17
Use:	Domestic water supply
Location:	Off highway 12 on Indian Reserve (see fig. 3-4)
Well Type:	Drilled
Depth:	Unknown
Yield:	Unknown (estimated $1m^3$/day)
Description:	
Water Type:	
Hydrogeologic Setting:	Probably yielding water from unconsolidated sediments.
Other Comments:	Log of well was not available.

Well Designation:	DW-18
Use:	Domestic water supply
Location:	Highway 12 at Caribou Highway
Well Type:	Dug well
Depth:	7.6m
Yield:	(estimated $1.5m^3$/day)
Description:	
Water Type:	(chloride 25 mg/l, pH 7.5)
Hydrogeologic Setting:	Flood plain sediment. Mostly silt.
Other Comments:	Data provided by B.C. Government Ground water Division.

Well Designation:	DW-19
Use:	Domestic water supply
Location:	Hwy. 12 at Caribou Hwy.
Well Type:	Dug well
Depth:	15m
Yield:	No data (estimated at $1.5m^3$/day)
Description:	
Water Type:	
Hydrogeologic Setting:	Located 5m south of Hat Creek. Probably yielding water from flood plain sediments.
Other Comments:	Data provided by B.C. Government Ground Water Division.

Well Designation:	Limestone Quarry Well
Use:	Supply of makeup and wash water for process plant.
Location:	Approximately 15m north of Hwy. 12 and 4km west of Upper Hat Creek Valley turnoff.
Well Type:	Drilled
Depth:	30m
Yield:	$525 m^3$/day (estimated)
Description:	175mm diameter drilled well with 150mm stainless steel screen set between 26 and 31m depth below ground.
Water Temperature:	$11^{\circ}C$
Water Type:	Ca - Mg - HCO_3
Hydrogeologic Setting:	The well is located in a narrow valley with limestone bedrock exposed on both sides of this valley. Water pumped from this well comes from a sand and gravel aquifer which is known to extend from a depth of 24m to the bottom of the well. The well only penetrates part of the aquifer and hence the total thickness of this aquifer is not known. A stoney clay material (probably till) was penetrated above the aquifer and probably acts as a confining layer. There are no records of static water levels in this well.

A3.0 SUMMARY OF GROUND WATER DRILLING PROGRAM

A3.1 INTRODUCTION

This appendix summarizes the results of a five hole drilling program supervised by Golder Associates to provide infill information on the environmental hydrogeology of the Hat Creek Valley area. The drilling and piezometer installation was performed by Ken's Drilling of Victoria, B.C. between August 2 and August 27, 1977.

A3.2 PURPOSE OF THE INVESTIGATION

The purpose of this field investigation was to supplement and correlate hydrogeologic data obtained from other studies in the Hat Creek Valley. Two areas of concern were the limestone bedrock exposed and underlying the northern portion of the Houth Meadows basin and the surficial and bedrock materials in the Medicine Creek Valley. Both areas are proposed waste rock and/or ash disposal sites. The geological properties, areal extent of the underlying bedrock and the ground water characteristics in both areas were of particular interest as the potential for contaminant transport with the ground water in these areas was unknown.

A3.3 DRILLING PROGRAM DETAILS

A total of 454 m of drilling was spread between five holes during the 26 day field program investigation. All holes were drilled 150 mm diameter and cased where necessary. Three of these holes are located in the Houth Meadows area and two in the Medicine Creek Valley (see locations Figure 3-4). All holes were drilled with a Chicago Pneumatic T-650 which was capable of drilling with the rotary air flush method and was also able to drive casing. A summary of all boreholes are given in the hydrogeologic logs presented in Appendix A4.0.

(a) Houth Meadows Program

(i) Borehole RH-77-45

The first hole drilled, RH-77-45, was started on August 6 and completed at a depth of 92.0 m on August 8, 1977. Four piezometers were installed at depths of 12.0, 35.2, 62.9 and 89.8 m (see Hydrogeologic Logs in Appendix A4.0). The shallow piezometer was a porous cup type lysimeter (see Figure A3-1) and was installed in the unsaturated silty gravel whereas the other piezometers were of the blow back sampling type (see Figure A3-2). The ground water table was encountered in the top of the limestone bedrock and the three lower piezometers were installed in potentially water bearing zones in this bedrock.

Water samples were taken and the rate of water return was measured as the drilling progressed. Each sample was tested in the field for temperature, electrical conductivity and pH. A Corning Model 3 pH Meter and a Beckman Solo-Bridge RB3 EC Meter were used to test the water samples, and these field data are shown on the Hydrogeologic Logs. Two soil samples were also taken at depths 6.8 m and 28.2 m and a grain size analysis for the 28.2 m sample is shown in Figure A3-3. Falling head permeability tests were carried out in all the piezometers in the limestone bedrock and hydraulic conductivities are summarized in Table A3-1.

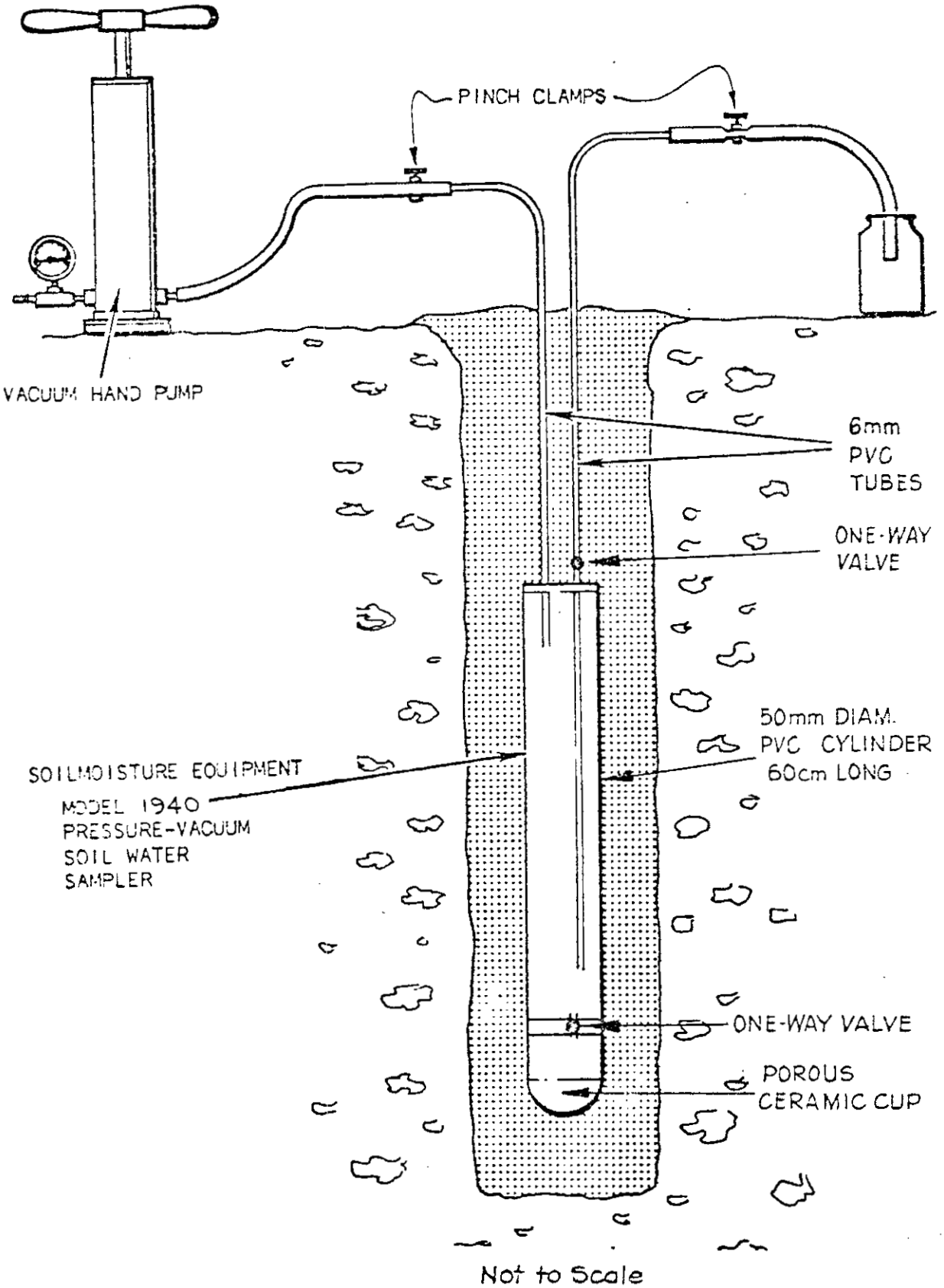
(ii) Borehole RH-77-46

The second hole drilled, RH-77-46, was started on August 9 and was completed at a depth of 92.0 m on August 11, 1977. Two blow back sampling piezometers were installed at depths of 36.0 and 89.8 m. The deep limestone bedrock piezometer was damaged during installation and is not operational. The shallow piezometer in the surficials was partially sealed by the casing and hence is only partially operational.

Water samples taken during drilling were tested in the field and results are shown on the Hydrogeologic Log. Five soil samples were taken at depths

SUCTION LYSIMETER AND WATER SAMPLING APPARATUS USED TO SAMPLE WATER FROM UNSATURATED SEDIMENTS.

Figure A3-1



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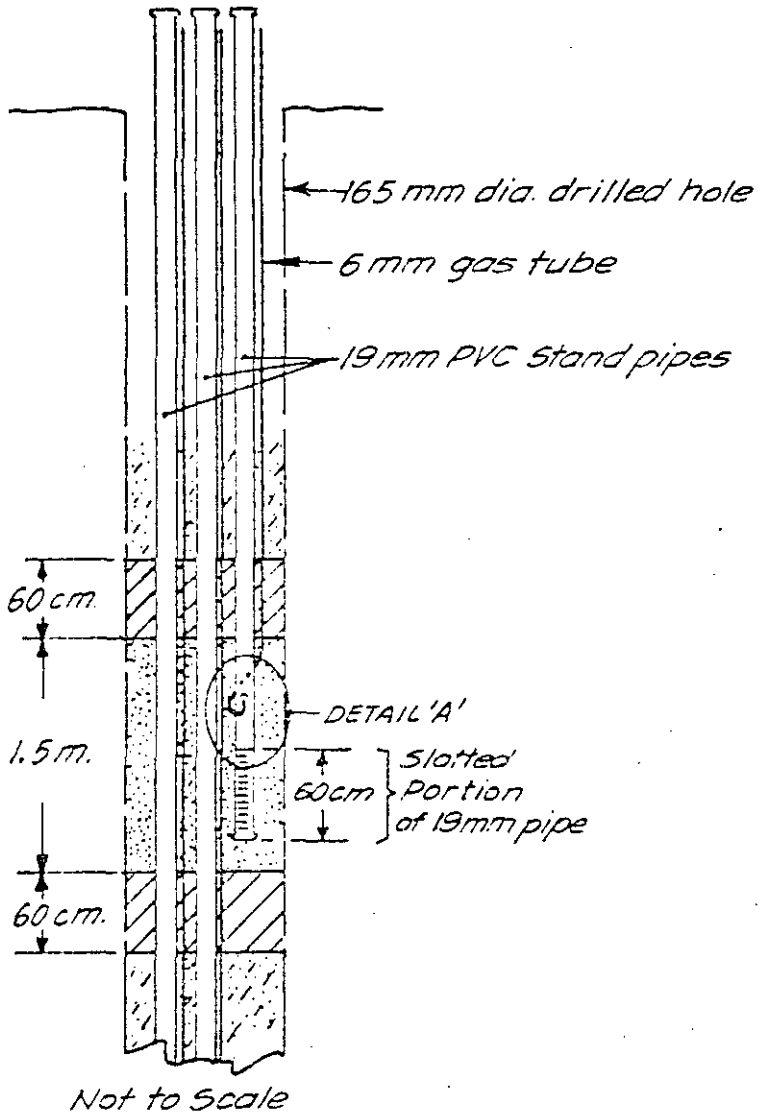
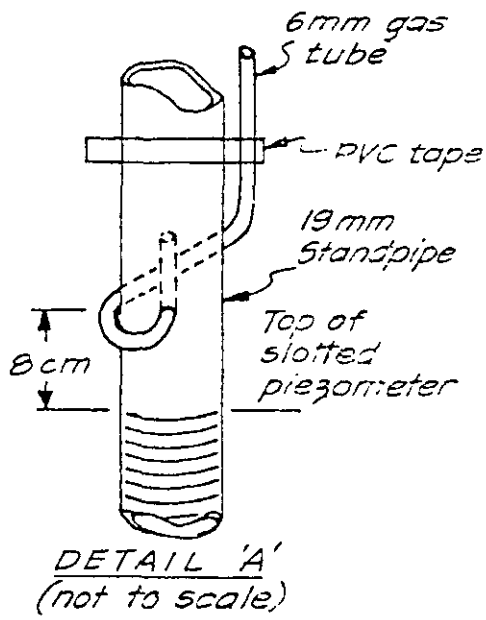
SKETCH SHOWING TYPICAL CONSTRUCTION OF A STANDPIPE PIEZOMETER TIP WITH GAS BLOW OUT TUBE FOR WATER SAMPLING

Figure A3-2





DETAIL 'A'
(not to scale)

Showing gas blow out tube used to raise water sample up to ground surface.

Notes:
1) Detail A shows the air/gas blow out tube that was used to raise water samples back to ground surface from the 19mm pvc standpipe.
2) See Appendix A4.0 for detailed information on instrumentation installed in boreholes.
3) The bentonite pellets and clean gravel were installed in an expandsible nylon mesh bag.

Backfill Materials

clean gravel

Not backfilled · sand and gravel will have collapsed into holes.

Sodium base, bentonite pellets.

Table A3-1

Summary of Logs of Boreholes Drilled for
Hat Creek Environmental Hydrogeological Study

Hole[1] Number	Piezo[1] Number	Piezo[2] Depth (m)	Lithology[2]	(2,3,5) Depth to Water (m)	(4) Hydraulic Conductivity (m/sec)	Comments
RH-77-45	1	89.8	blue LMST	19.2	1.7×10^{-6}	
	2	62.9	blue LMST	18.8	5.0×10^{-7}	
	3	35.2	buff LMST	17.3	1.3×10^{-6}	Weathered zone
RH-77-46	1	89.8	white LMST	-	-	Piezo. broken during construction
	2	36.0	sandy GRAVEL	-	-	Piezo sealed by casing
RH-77-47	1	32.0	silty CLAY	-	-	Piezo. broken during construction
RH-77-48	1	89.9	v. dark SHALE	20.0	5.0×10^{-7}	
	2	77.0	SANDSTONE	21.8	8.0×10^{-8}	Probably low due to plugging of formation
	3	58.1	grey SHALE	21.9	3.0×10^{-7}	
RH77-49	1	89.6	GREENSTONE	62.4	1.8×10^{-7}	
	2	71.5	GREENSTONE	64.8	5.0×10^{-7}	Fracture zone at 72 m.

Notes:

(1) see locations of boreholes in Figure 3-4.
(2) see a more detailed description of piezometer installation in Appendix A4.0.
(3) water levels recorded on September 20, 1977
(4) based on falling head tests
(5) water samples were taken for chemical and isotope analyses, see results given in Table 4-1.

7.7, 12.3, 14.3, 23.6 and 35.6 m and a grain size analysis for the 23.6 m sample is presented in Figures A3-3. No falling head permeability tests were carried out, however an estimate for the hydraulic conductivity of the gravel between 10^{-3} and 10^{-2} m/s. These estimates are based on calculations using the Hazen formula and grain size information provided in Figure A3-3.

(iii) RH-77-47

The last hole in the Houth Meadows area, RH-77-47, was started August 11 and completed August 13, 1977 at a depth of 86.0 m. One blow back type sampling piezometer was installed at a depth of 32.0 m in silty clay sediments. A deep piezometer could not be installed in the greenstone bedrock as this formation was too unstable.

The hole did not yield enough water for water samples to be taken, although 0.03 litres per second (l/s) did flow for a brief period at a depth of 24.5 m. Five soil samples were taken at depths 8.7, 8.8, 24.3, 24.6 and 28.2 m during the drilling. The grain size analyses of each sample are given in Figures A3-3 and A3-4, and cation exchange capacity test results are given in Table A3-2. The piezometer appears to have been severed during installation and no hydraulic conductivity and water level determinations could be made.

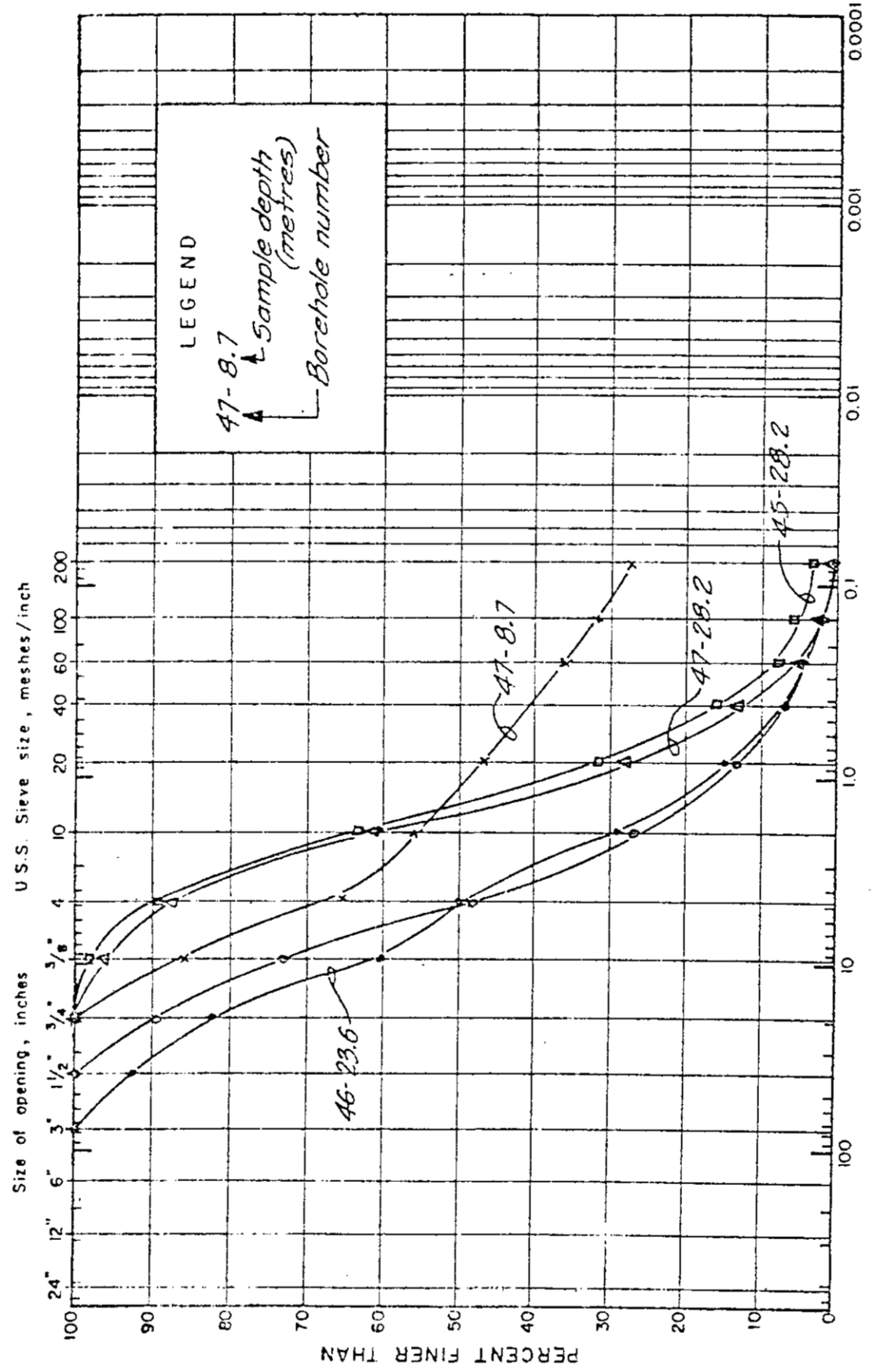
(b) Medicine Creek Program

(i) RH-77-48

The first hole in the Medicine Creek Valley, RH-77-48 was started August 14 and completed at a depth of 92.0 m on August 15, 1977. Three standard sampling type piezometers were installed in the bedrock at depths of 58.1, 77.0 and 89.9 m. The bedrock opposite each piezometer was respectively: grey shale, sandstone and dark shale.

GRAIN SIZE DISTRIBUTION OF SEDIMENTS SAMPLED FROM BOREHOLES

Figure A3-3



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GRAIN SIZE DISTRIBUTION OF SEDIMENTS SAMPLED FROM BOREHOLE RH77-47.

Figure A3-4

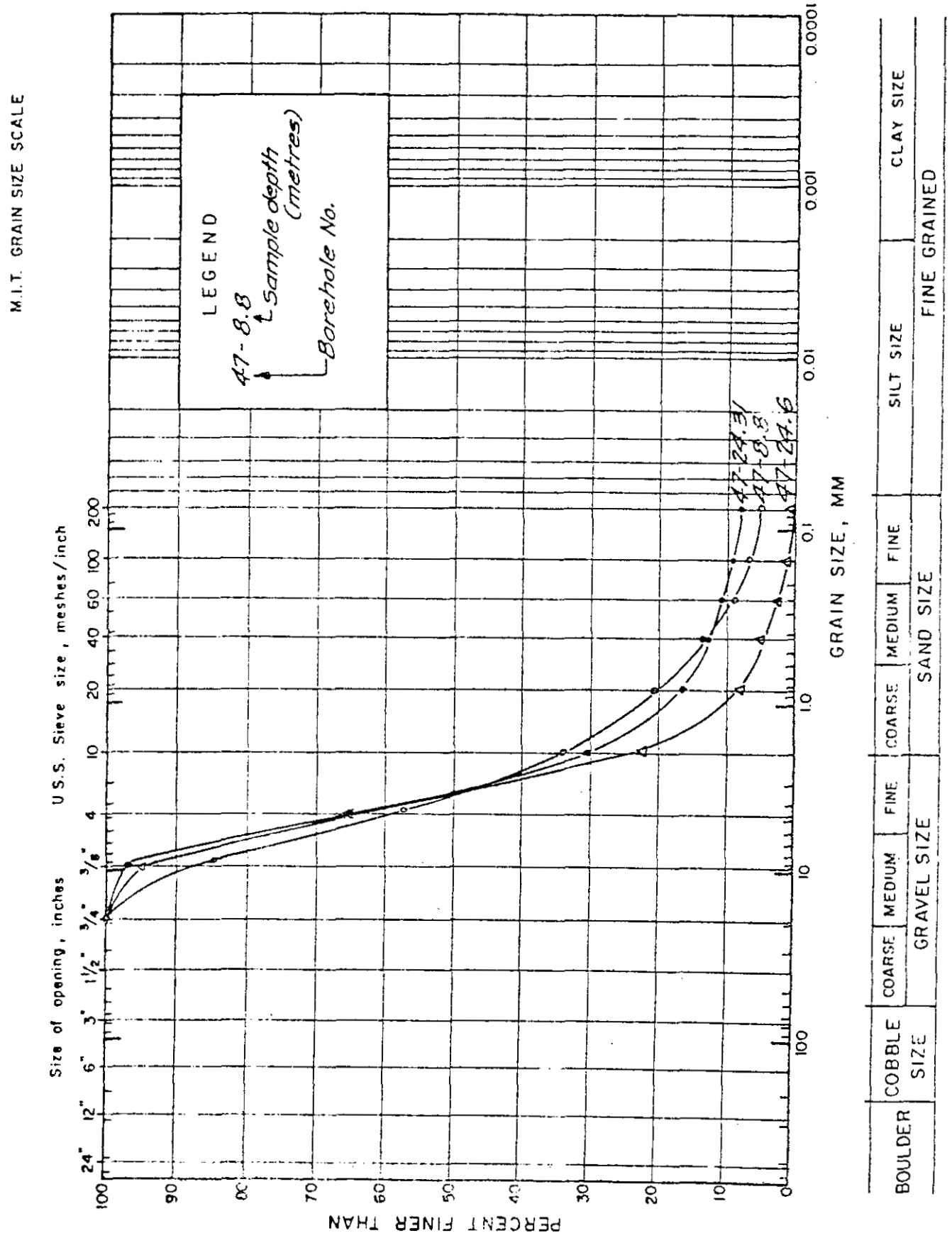

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Table A3-2

Summary of Cation-Exchange Capacity Values for Unconsolidated Sediments

Hole Number[1]	Sample Depth (m)	CEC[2] m.eq/100g
RH77-47	8.7	8.8
RH77-47	24.7	5.9
RH77-48	4.3-16.8	12.7
RH77-49	10.7-15.4	12.7

Notes: (1) See locations, Figure 3-4.

(2) The samples were tested for cation-exchange capacity by "Sodium Saturation" in accordance with procedures described in "Methods of Soil Analysis" purblished by the American Society of Agronomy.

Twelve water samples were taken, of which seven were field tested as was outlined for hole RH-77-45. The results of these tests are shown on the Hydrogeologic Log. One soil sample was obtained at a depth range of 4.3 - 16.8 m and a cation exchange capacity test was run on this soil sample (see results in Table A3-2).

Permeability tests were performed in all three piezometers and hydraulic conductivities are summarized in Table A3-1.

(ii) RH-77-49

The last hole drilled in the Medicine Creek Valley, RH-77-49, was started on August 16 and was completed at a depth of 92.0 m on August 19, 1977. Two standard piezometers were installed in the greenstone bedrock at depths of 71.5 and 89.6 m. Three water samples were field analyzed for temperature, electrical conductivity and pH. These results are given on the Hydrogeologic Log. Soil samples were taken at depths of 10.7 - 15.4, 29.6 - 36.0 and 57.0 - 59.4 m and one cation exchange capacity test was made on the first sample (see Table A3-2). Falling head permeability tests were performed in the two piezometers. Test results are found in Table A3-1.

A4.0 HYDROGEOLOGIC LOGS OF BOREHOLES

The following hydrogeologic logs summarize information on all boreholes that were drilled for the ground water study. The abbreviated lithology is based on data supplied from drillers logs, bag sample analyses and hydrogeologists' field notes.

In order to show all data in one compact log it was necessary to use a number of abbreviations and symbolic notation. The following notes explain these abbreviations. The note numbers correspond to the numbers shown in parenthesis at the head of each column in the following hydrologic logs:

1) Lithologic Terminology Used in Logs

Lithology determined from hydrogeologists' field description of rotary cuttings.

2) Datum

Unless otherwise stated all depth measurements are given in meters relative to present ground level.

T.D. = total depth drilled.

3) Construction

a) Type of Backfill

 sand, gravel and bentonite.

3) Cont'd

b) Hole

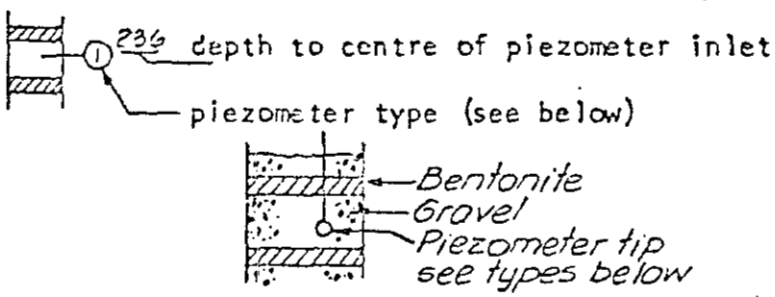
drilled hole casing removed

drilled hole casing left in place

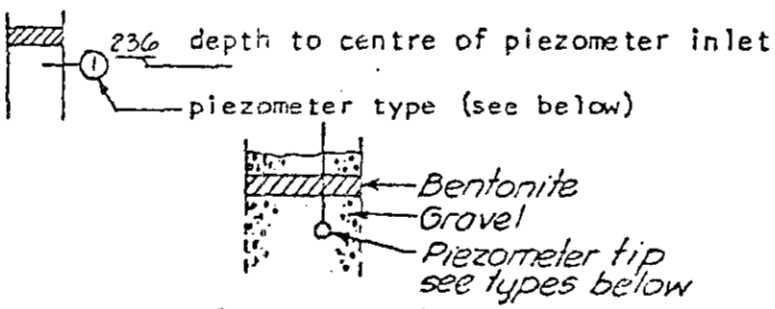
drilled open hole

drilled hole known to have squeezed in

Standard Double Seal Piezometer Arrangement



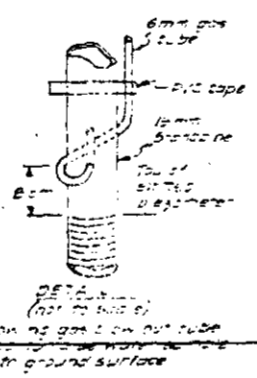
Standard Top Seal Piezometer Arrangement



Type of Piezometer Tip

Type 1: Standard Sampling Piezometer:

Slotted 19 mm (0.75 inch) diameter PVC pipe. Approx. 60 cm (2 feet) long. Has an air tube installed to enable water to be blown back to ground surface (see detail).



Type 2: Multiple Tip Sampling Piezometer:
6mm PVC tubing threaded through middle of 64mm PVC casing. End of tubes were exposed, covered with a cellulose filter cloth and taped to the 50mm casing.

Type 3: Porous Cup Type Lysimeter:
Used for water sampling purposes only (see details in Figure A3-1).

4) Water level measured in borehole when drilling had reached indicated depth (meters).

5) Water flows recorded while drilling was in progress. In hard rock drilling where the borehole stays open these flows normally represent cumulative flows since the water bearing zone was first encountered.

6) Other: fl = water flowing over top of casing
Lw = losing water
Mw = making water
EC = Electrical conductivity in micro mhos/cm
PH = Field pH measurement of water sample

7) Static water level in piezometer/well after the ground water has recovered from drilling operations (September, 1977). Positive values indicate artesian heads (i.e. above datum). These static water levels are equivalent to total piezometric heads in all piezometers.

8) D = Depth range for permeability test (meters)

K = Average formation permeability determined (cm/sec)

M = Method used to determine permeability

P = Packer test using head method

f = Falling head test in piezometer

w = Pumping test

HYDROGEOLOGIC LOG

Sheet 1 of 1

Job No. 763-59

Project: KAT CREEK ENVIRONMENTAL

Type of drilling: ROTARY

Rig: CHICAGO PNEUMATIC - T - 650

Drilling fluid: AIR

Coordinates: E 15486 N 89276

Angle from horizontal: 90°

Bearing: ____ *Azimuth

Reference elevation: 861.8

Elevation type: surveyed [X] altimeter [ ] from map [ ]

Purpose of hole: HYDROLOGIC DATA

(1) (2) * Lithology	(2) (3) Completed Construction	During Drilling: (2) Depth (m)	(2)(4) Water Level (m)	(5) Water Flow (l/s)	(6) Other	After Drilling: (2)(7) Water Level (m)	Permeability (8): (2) Depth (m)	Method	Value (cm/s)	Comments
Silty Gravel (0–24)		24		0.2	MW EC660 PH6.5					* A Type 3 piezometer was installed in a shallow hole at this site (Depth=12M)
Coarse sandy Gravel (24–30)		30		0.2	EC645 PH7.2					
buff. LMST. (weathered zone) (30–41)	33.2; ① 35.2; 36.7					17.3	33.2, 36.7	f	4.3×10^{-4}	Piezo 3
		38		0.21	EC560 PH7.0					
		43		0.3	EC700 PH7.2					
		49		0.5	EC650 PH7.1					Fracture Zone at 44m
										Fracture Zone at 62m
		56		0.6	EC655 PH7.3					Fracture Zone at 55m
blue limestone (41–90)	59.9; ① 62.9; 65.4	60		0.8	EC600 PH7.2					
						18.8	59.9, 69.4	f	5.0×10^{-5}	Piezo 2
		69		0.9	EC650 PH7.5					
		74		0.9	EC625 PH7.4					
	88; ① 89.8	88		2.0	EC610 PH7.4	19.2	88, 92	f	1.7×10^{-4}	Piezo 1
	TD 92									

Contractor: KEN'S DRILLING — Logged by: P.S.C.

Date started: 6/8/92 — Checked by:

Date finished: 8/8/92 — Date: 13/8/92

* NOTE Bracketed numbers refer to notes preceding the logs

Golder Associates

Scale 1:500

Job No. V76399

Project: MAT CREEK ENVIRONMENTAL

Type of drilling: ROTARY

Rig: CHICAGO PNEUMATIC - T-650

Drilling fluid: AIR

Coordinates: E 18381

N 88405

Angle from horizontal: 90°

Bearing: *Azimuth

Reference elevation: 822.7

Elevation type: surveyed [X] altimeter [ ] from map [ ]

Purpose of hole: HYDROLOGIC DATA

(1) (2) * Lithology	(2) (3) Completed Construction	During Drilling: (2) Depth (m)	During Drilling: (2)(4) Water Level (m)	During Drilling: (5) Water Flow (l/s)	During Drilling: (6) Other	After Drilling: (2)(7) Water Level (m)	After Drilling: Permeability (8) (2) Depth (m)	Permeability (8) Method	Permeability (8) Value (cm/s)	Comments
SILTY GRAVEL		5			MOIST MW					
		7.5		0.2	EC540 PH7.7					
9										
10 COARSE SAND AND GRAVEL 13.5		14		0.9	EC550 PH7.9					
SANDY COARSE GRAVEL		16		1.9	EC505 PH7.7					
18.2										
20 CLAY 20.5		20.5		0.3	EC450 PH8.0					
		21		1.3	EC470 PH8.0					
SANDY COARSE GRAVEL		24		2.8	EC440 PH7.9					
27.5										
30 GLACIAL SILTY CLAY 34.5										
SAND, GRAVEL INTERBEDDED WITH THIN CLAY SEAMS	1 36	35		1.9	EC510 PH8.1					Piezo No. 2: partly sealed by casing
		36.5		1.4	EC540 PH8.2					
40		41		0.9	EC530 PH8.3					
43		45		0.1						
50		51		0.1	EC445 PH8.7					
WHITE LIMESTONE		57		0.1	EC410 PH8.4					
60		62		0.1						
70		75		0.1	EC420 PH8.7					
80		85		0.1	EC350 PH8.0					
90	1 89.8 TD 92			0.1						Piezo No. 1: Tube was broken during construction

Contractor: KEN'S DRILLING

Date started: 9/8/77

Date finished: 10/8/77

Logged by: R.S.G.

Checked by: RAE

Date: 13/9/77

* NOTE Bracketed numbers refer to notes preceding the logs

Golder Associates

Scale: 1:500

Job No. 76359

Project: HAT CREEK ENVIRONMENTAL

Type of drilling: ROTARY

Rig: CHICAGO PNEUMATIC - T-650

Drilling fluid: AIR

Coordinates: E 18050

N 87108

Angle from horizontal: 90°

Bearing: *Azimuth

Reference elevation: 853.4

Elevation type: surveyed [X] altimeter [ ] from map [ ]

Purpose of hole: HYDROLOGIC DATA

(1) (2) * Lithology	(2) (3) Completed Construction	During Drilling: (2) Depth (m)	During Drilling: (2)(4) Water Level (m)	During Drilling: (5) Water Flow (l/s)	During Drilling: (6) Other	After Drilling: (2)(7) Water Level (m)	After Drilling: Permeability (8) (2) Depth (m)	Permeability: Method	Permeability: Value (cm/s)	Comments
SILTY GRAVEL										
16.5										
SILTY CLAY 18.5		18.5			Moist					
SANDY GRAVEL SOME SILT										
25.5		24.5		0.03	MW					
SILTY CLAY	30 / 32 / 35									Piezo No. 1
35.5										
GREENSTONE		49			Moist					
		TD 86			Moist					

Contractor: KEN'S DRILLING

Date started: 11/8/77

Date finished: 13/8/77

Logged by: R.S.G.

Checked by: AdC

Date: 13/9/77

* NOTE Bracketed numbers refer to notes preceding the logs

Golder Associates

Scale: 1:50

Job No. V76359

Sheet 1 of 1

Project: HAT CREEK ENVIRONMENTAL

Type of drilling: ROTARY

Rig: CHICAGO PNEUMATIC-T-650

Drilling fluid: AIR

Coordinates: E 42394 N 78115

Angle from horizontal:

Bearing: *Azimuth

Reference elevation: 1211.0

Elevation type: surveyed [x] altimeter [ ] from map [ ]

Purpose of hole: HYDROLOGIC DATA

(1) (2) * Lithology	(2) (3) Completed Construction	During Drilling: (2) Depth (m)	(2)(4) Water Level (m)	(5) Water Flow (l/s)	(6) Other	After Drilling: (2)(7) Water Level (m)	Permeability (8): (2) Depth (m)	Method	Value (cm/s)	Comments
CLAYEY TILL SOME PEBBLES 0–22.5		22.5								
		24		0.1	MW EC500 PH7.4					
FINE SANDSTONE 22.5–26.0										
GREENSTONE 26.0–35		32		0.2	EC540 PH7.4					
		35.5		0.9	EC545 PH7.4					
COARSE SANDSTONE 35–37.5		38		0.9	EC560 PH7.9					
		41		0.9	EC610 PH7.65					
GREENSTONE 37.5–55		45		1.9						
	55	56		1.9	EC600 PH7.6	21.9	55 60.1	f	3×10^{-5}	Piezo No. 3
	① 58.1 60.1									
GREY SHALE 55–76		62		1.9	EC620 PH7.9					
		69		1.9						
	75	75		1.9		21.8	75 78.8	f	8×10^{-6}	Piezo No. 2
	① 77 78.8									
SANDSTONE 76–81										
VERY DARK SHALE 81–92		87		1.9						
	87.7									
	① 89.9 TD	92				20.0	87.7 92	f	5×10^{-5}	Piezo No. 1

Contractor: KLEIN'S DRILLING Logged by P.S.G.

Date started: 11/8/77 Checked by [illegible]

Date finished: 15/8/77 Date 13/9/77

* NOTE Bracketed numbers refer to notes preceding the logs

Golder Associates

Scale 1:500

Job No. 77-1359

Sheet 1 of 1

Project: HAT CREEK ENVIRONMENTAL

Type of drilling: ROTARY

Rig: CHICAGO PNEUMATIC-T-650

Drilling fluid: AIR

Coordinates: E 35072 N 76397

Angle from horizontal: 90°

Bearing: *Azimuth

Reference elevation: 1147.5

Elevation type: surveyed [X] altimeter [ ] from map [ ]

Purpose of hole: HYDROLOGIC DATA

(1) (2) * Lithology	(2) (3) Completed Construction	During Drilling (2) Depth (m)	(2)(4) Water Level (m)	(5) Water Flow (l/s)	(6) Other	After Drilling (2)(7) Water Level (m)	Permeability (8) (2) Depth (m)	Method	Value (cm/s)	Comments
CLAYEY TILL SOME PEBBLES										
57										
GRAVELLY CLAY										
67		68			KW					
	70									
	70									
	① 71.5					64.8	70	f	5×10^{-5}	Piezo No. 2
	73						73			Fracture Zone at 72m
	73	75		0.2	EC950 PH7.4					
GREENSTONE		79		0.3	EC1000 PH7.6					
	88									
	① 89.6 TD	92		0.3	EC1050 PH7.6	62.4	88 92	f	8×10^{-5}	Piezo No. 1

Drilling contractor: NEN'S DRILLING — Logged by: R.S.G.

Date started: 10/8/77 — Checked by: RJB

Date finished: 12/8/77 — Date: 13/9/77

* NOTE Bracketed numbers refer to notes preceding the logs

Golder Associates

Scale 1:500

A5.0 ISOTOPES USED IN GROUND WATER STUDIES

A5.1 THEORY OF ISOTOPES APPLIED TO HYDROLOGY

The following is a brief review of the use of three selected isotopes for evaluation of hydrologic systems. Much of the information is summarized from Brown, R.H. et al.(1972)[1]

(a) Stable Isotopes of Hydrogen and Oxygen in Natural Waters

The stable isotopes of hydrogen and oxygen, which are the two elemental constituents of water, have mean abundances in natural compounds as follows:

Hydrogen (^{1}H) = 99.985%, Deuterium (^{2}H) or (D) = 0.015%
Oxygen-16 (^{16}O) = 99.76%, Oxygen-17 (^{17}O) = 0.04% and
Oxygen-18 (^{18}O) = 0.2%.

Among all the possible species of water, only the following are of practical interest for most studies:

$H_2{}^{16}O$, $HD^{16}O$, and $H_2{}^{18}O$

The variations of the isotopic ratios D/H and $^{18}O/^{16}O$ in water samples are expressed in terms of a per mil. difference (°/oo) with respect to the isotopic ratios of mean ocean water. This constitutes the reference standard called SMOW (Standard Mean Ocean Water), (Craig 1961)[2].

$$\delta\ ^{o}/_{oo} = \left(\frac{R\ sample}{R\ smow} - 1\right) \times 1{,}000$$

where R is the isotope ratio D/H or $^{18}O/^{16}O$.

Thus samples with + values are enriched, that is they have more of the heavier isotope than sea water. All oxygen-18 isotope data in this report is relative to the SMOW standard.

Many natural processes cause variations of the isotope compositions of natural waters. Among them, the most important are evaporation and condensation. During evaporation the lighter molecules of water ($H_2{}^{16}O$), are more volatile than those containing the heavier isotope, ($HD^{16}O$ or $H_2{}^{18}O$). Thus, the vapour which evaporates from the ocean is depleted by about 12-15°/oo in oxygen-18 and 80-120°/oo in deuterium, with respect to ocean water. Winter precipitation in general will be depleted in heavy isotopes (i.e. lighter) if compared to the summer precipitation and the variations of deuterium and oxygen-18 contents in precipitation are linearly correlated (Craig 1961) (2):

$$\delta D = 8\delta^{18}O + C$$

where C is a constant which varies from area to area.

Surface waters generally reflect the average isotopic composition of the local precipitation unless it is:

1) mixed with isotopically different waters, such as water from a different catchment basin, or ground water of a different isotopic composition.
2) allowed to re-evaporate from open waters (such as lake surfaces): If this evaporation occurs, the relationship between δD and $\delta^{18}O$ will deviate from the linear equation above, and will take on a flatter slope of the form:

$$\delta D = K\delta^{18}O - A$$

(Gat et al. 1968):(3)

where K = a constant falling value between 4 and 6
A = a second constant.

Ground water will tend to reflect the average composition of the recharge zone waters. Thus, if recharge took place from a lake which was highly

evaporitic, then these ground waters would have a heavier isotopic composition.

(b) *Tritium in Natural Waters: A Review*

Tritium is a radioactive isotope of hydrogen, having a mass of 3, and a half-life 12.26 years, (Brown et al 1972)[1]. It occurs in the environment as a result of both natural and man-made processes. Large amounts of man-made tritium were released to the atmosphere by thermonuclear tests in the period 1953-1962. The tritium content in natural waters is expressed in tritium units (T.U.). One tritium unit corresponds to a concentration of 1 tritium atom per 10^{18} hydrogen atoms.

In ground water studies, tritium measurements are useful to give information on the approximate time that has elapsed since recharge took place. If it can be assumed that the ground water enters a closed system and that no mixing takes place, then the age of the water can be determined by using a logarithmic decay formula.

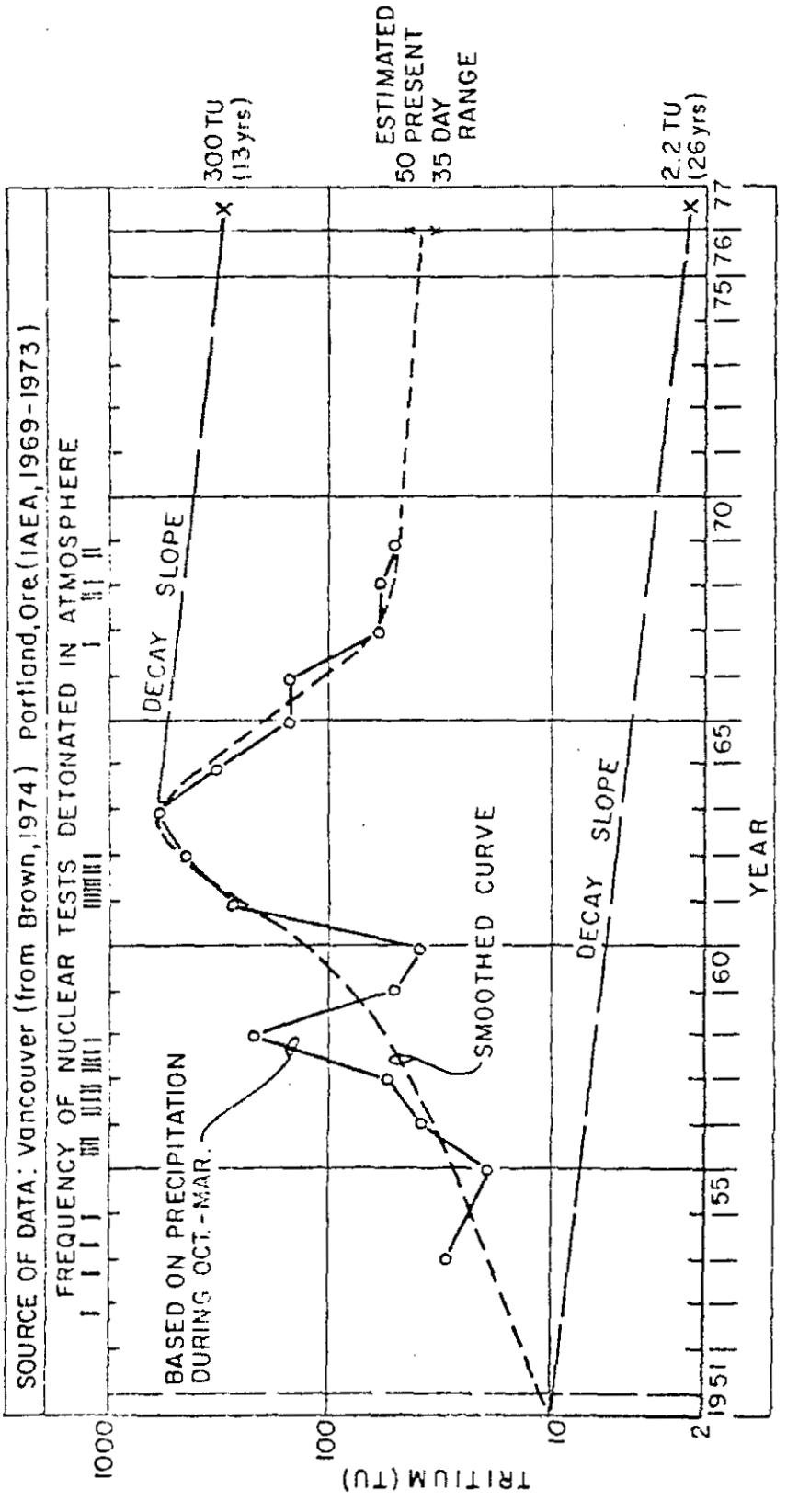
Estimated tritium concentrations for the precipitation in the Hat Creek area, are presented in Figure A5-1. As can be seen from this diagram the interpretation of the age of a particular ground water younger than 16 years is not very easy. This is due to the fact that for ground waters that have been in the ground for less than 16 years there are two age solutions for each tritium level obtained. However, if values are less than 30 tritium units the ground water can be interpreted as being over 16 years old.

A5.2 METHODS FOR ISOTOPE ANALYSIS

Samples of water collected in the field were analyzed using standard methods for isotopic analysis.

ESTIMATED TRITIUM CONCENTRATIONS IN RECHARGE WATERS ENTERING HAT CREEK GROUNDWATER AQUIFERS

Figure A5-1



(a) Deuterium

The water Samples (minimum 10 ml) were sent to the Environmental Research Branch of Atomic Energy of Canada Ltd. (A.E.C.L.) Chalk River Nuclear Laboratories for analysis. Water samples were fed continuously into an evaporator and the ensuing water vapour converted to hydrogen gas by the reaction with hot (750° C) uranium metal (Friedman and Woodcock 1957)[4]. The deuterium to hydrogen ratio in this gas is then analyzed by comparison with a standard gas using a specially constructed mass spectrometer with a double collector system. The results are accurate to $\pm$ 1°/oo for one standard deviation.

(b) Oxygen-18

The analysis of water samples was carried out at the University of Waterloo Geochemistry Laboratory. The field samples were collected and sealed with wax in 10 ml bottles. The method of analysis used is basically the same as that described by Epstein and Mayeda (1953)[5]. A 3 ml sample of the water was equilibrated with carbon dioxide gas at 25° C in a constant temperature bath with shaker, for a minimum of 24 hours. An aliquot of the gas was then analyzed for oxygen-18 content using a specially designed mass spectrometer (Varian-Mat GD-150). Corrections to the mass spectrometer analyses were carried out as described by Craig (1957)[6]. The oxygen-18 values for each group of 12 samples were checked against a standard water sample of known isotopic composition. The results are precise to a standard deviation of $\pm$ 0.1 per mil. (SMOW).

(c) Tritium

The analysis of tritium in the waters was carried out at the University of Waterloo laboratories. Analysis was carried out by first mixing 10 mls of

water sample with 15 mls of 'Instagel'. This mixture was then shaken up and the resulting emulsion allowed to gel. The sample was then placed in a Nuclear Chicago Liquid Scintillation Counter for radioactive counting. The temperature in the counter was 10° C and the average sample counting time was about 400 minutes.

REFERENCES FOR A5.0

1) Brown, R.H., Konoplyantsev, A.A., Ineson, J. and Kovalevsky, V.S. (Eds.), 1972. Ground water studies; an international guide for research and practice. Unesco, Paris, p. 10.1.1.

2) Craig, H., 1961. Standard for reporting concentrations of deuterium and oxygen-18 in natural waters; Science, Vol. 113, p. 1833-1824.

3) Gat, J.R., Gonfiantini, R. and Tongiorgi, E., 1968. Inter-relationships, atmosphere and surface waters; Chapter IV in Guidebook on Nuclear Techniques in Hydrology, Tech. Rept., No. 91, Int. Atomic Energy Agency, Vienna, 214 pp.

4) Epstein, S. and Mayeda, T., 1953. Variation of O-18 content of waters from natural sources; Geochem. Cosmochim. Acta. Vol. 4, p. 213-224.

5) Friedman, I. and Woodcock, A.H., 1957. Determination of deuterium hydrogen rations in Hawaiian waters; Tellus, Vol. 9, p. 553-556.

6) Craig, H., 1957. Isotopic standards for carbon and oxygen and correction factors for mass spectrometric analysis of carbon dioxide; Geochem. Cosmochim. Acta, Vol. 12, p. 133-149.

APPENDIX B

APPENDIX B SUPPLEMENTARY SURFACE HYDROLOGY INVENTORY TABLES AND FIGURES

B1.0 TABLES

B2.0 FIGURES

TABLE B1-1

STREAMGAUGING SITES IN THE REGIONAL ANALYSIS

No.	Station No.	Station Name	No. of Years of Records	Drainage Area (km^2)
1	08KE005	Cuisson Creek near Alexandria	11	162
2	08MC024	Hawks Creek above Lyne Creek	5	456
3	08MD026	Fountain Creek near Lillooet	12	52
4	08MF020	Cinquefoil Creek near Lillooet	10	57
5	08MF016	McGillivray Creek near Lillooet	12	52
6	08LA019	Boss Creek above Hendrix Creek	3	122
7	08LB059	Mann Creek near Blackpool	21	295
8	08LB020	Barriere River at the mouth	30	1,140
9	08LB075	Harper Creek near the mouth	3	168
10	08LB010	Louis Creek at boundary of railway belt	6	259
11	08LB072	Louis Creek at the mouth	5	663
12	08LB024	Fishtrap Creek near McLure	12	52
13	08LB004	Heffley Creek near Kamloops	12	168
14	08LB013	Paul Creek near Kamloops (Station A)	30	381
15	08LE031	South Thompson River at Chase	53	16,162
16	08LE069	South Thompson River at Monte Creek	13	16,602
17	08LD005	Hiuihill Creek near Squilax (lower Station)	8	106
18	08LE027	Seymour River Near Seymour Arm	24	805
19	08LE086	Ratchford Creek at 2,000 ft. contour	3	253
20	08LE024	Eagle River near Malakwa	18	904
21	08LC032	Shuswap River near Enderby	42	4,683
22	08LC034	Ferry Creek near Lumby	17	145
23	08LC005	Bessette Creek near Lumby	17	253
24	08LE065	Salmon River at Glenemma	6	1,173
25	08L[illegible]21	Salmon River near Salmon Arm	17	1,507
26	08L[illegible]01	Bolean Creek at Falkland	15	228
27	08LC005	Chase Creek near Chase	17	613
28	08LE013	Monte Creek near Monte Creek	20	184
29	08LE024	Tranquille River near Kamloops	13	596
30	08LE049	Watching Creek near Kamloops	15	80
31	08LE027	Deadman River above Criss Creek	23	862
32	08LE007	Criss Creek near Savona	25	490
33	08LE001	Barnes Creek near Ashcroft	17	104
34	08LE062	Bonaparte River near Bridge Lake	16	66
35	08LE060	Bonaparte River near Cache Creek	15	4,092
36	08LE002	Bonaparte River below Cache Creek	15	5,025

TABLE B1-1 Continued

No.	Station No.	Station Name	No. of Years of Records	Drainage Area (km^2)
37	08LF047	Fiftyseven Creek near Clinton	8	108
38	08LF021	Scottie Creek near Cache Creek	22	174
39	08LF013	Hat Creek near Ashcroft	12	73
40	08LF061	Hat Creek near Upper Hat Creek	16	350
41	08LF015	Hat Creek near Cache Creek	18	658
42	08LG049	Nicola River above Nicola Lake	13	1,500
43	08LG006	Nicola River near Spences Bridge	29	7,278
44	08LG048	Coldwater River near Brookmere	11	316
45	08LG010	Coldwater River near Merritt	24	914
46	08LG008	Spius Creek near Canford	15	906
47	08LF017	Murray Creek near Spences Bridge	15	149
48	08NN004	Kettle River at Kettle Valley	9	5,698
49	08NN013	Kettle River near Ferry	48	6,579
50	08NN015	West Kettle River near McCulloch	21	249
51	08NN007	Rock Creek near Rock Creek	6	280
52	08NN010	Myers Creek at International Boundary	36	207
53	08NN001	Boundary Creek at Greenwood	21	425
54	08NN002	Granby River at Grand Forks	18	2,331
55	08NM158	Trout Creek at the mouth	7	764
56	08NM159	Peachland Creek at the mouth	7	150
57	08NM155	Trepanier Creek at the mouth	7	254
58	08NM157	Powers Creek at the mouth	7	144
59	08NM003	Lambly Creek near the mouth	12	272
60	08NM151	Shorts Creek at the mouth	7	185
61	08NM179	Coldstream Creek above Kalavista diversion	6	207
62	08NM053	Kelowna Creek near Kelowna (lower station)	27	221
63	08NM118	Penticton Creek at the mouth	12	177
64	08NM135	Ellis Creek at Penticton	10	158
65	08NM015	Vaseux Creek above Dutton Creek	22	255
66	08NL007	Similkameen River at Princeton	41	1,852
67	08NL038	Similkameen River near Hedley	11	5,594
68	08NL005	Similkameen River near Keremeos	19	5,957
69	08NL036	Whipsaw Creek below Lamont Creek	11	185
70	08NL024	Tulameen River at Princeton	26	1,761
71	08NL023	Otter Creek at Tulameen	29	673
72	08NL015	Asp Creek near Princeton	10	52
73	08NL021	Granite Creek at the mouth	5	264

TABLE B1-1 Continued

No.	Station No.	Station Name	No. of Years of Records	Drainage Area (km^2)
74	08NL012	Allison Creek near Penticton	25	673
75	08NL013	Summers Creek at the mouth	8	249
76	08NL020	Hayes (five Mile) Creek near Princeton	8	751
77	08NL039	Siwash Creek near Princeton	9	174
78	08NL041	Wolfe Creek at the outlet of Issitz Lake	8	215
79	08NE050	Hedley Creek near the mouth	3	388
80	08NE004	Ashnola River near Keremeos	33	1,054
81	08NM138	Terrace Creek near Kelowna	11	31
82	08KH022	MacKay River at the mouth	5	144
83	08KH019	Moffat Creek near Horsefly	12	539
84	08KH021	Beaver Creek at outlet of Beaver Lake	5	852
85	08MC006	San Jose River near Lac la Hache	26	489

From Water Survey of Canada, Surface Water Data, Reference Index, 1975.

TABLE B1-2

THORNTHWAITE CLIMATIC WATER BALANCE (BASED ON CLIMATIC NORMALS FOR THE PERIOD 1941-1970)
[illegible] BRITISH COLUMBIA

50° 46 N 121° 35 W
809 METRES AES STATION # 1163340

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATIO IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
-11.0	-5.7	-1.8	3.7	9.1	12.3	15.1	14.2	10.5	4.1	-3.4	-8.3	3.2	Temperature, Deg. C.
0	0	0	35	71	104	125	105	65	28	0	0	532	Potential Evapotrans.
39	19	15	16	22	35	29	32	21	25	30	35	317	Precipitation
39	19	15	-18	-48	-68	-95	-72	-43	-2	30	35	-214	Precip. - Pot. Evapotrans
100	119	120	100	61	31	12	6	4	4	33	68		Storage
32	0	0	0	-38	-29	-18	-5	-1	0	30	35		Change in Storage
0	0	0	35	61	65	48	38	23	25	0	0	295	Actual Evapotrans.
0	0	0	0	10	38	77	67	42	3	0	0	238	Moisture Deficit
0	0	0	1	0	0	0	0	0	0	0	0	1	Moisture Surplus
0	0	0	1	0	0	0	0	0	0	0	0	1	Surplus Runoff
1	6	14	0	0	0	0	0	0	0	0	0	21	Snowmelt Runoff
1	6	14	1	0	0	0	0	0.	0	0	0	22	Total Runoff
9	25	41	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 100 MM

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATION IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
-11.0	-5.7	-1.8	3.7	9.1	12.3	15.1	14.2	10.5	4.1	-3.4	-8.3	3.2	Temperature Deg. C.
0	0	0	35	71	104	125	105	65	28	0	0	532	Potential Evapotrans.
39	19	15	16	22	35	29	32	21	25	30	35	317	Precipitation
39	19	15	-18	-48	-68	-95	-72	-43	-2	30	35	-214	Precip. - Pot. Evapotrans.
139	151	166	151	118	84	52	36	29	28	58	93		Storage
39	19	15	-14	-32	-33	-31	-15	-6	0	30	35		Change in Storage
0	0	0	31	55	69	61	48	28	26	0	0	317	Actual Evapotrans.
0	0	0	4	16	34	64	57	37	2	0	0	215	Moisture Deficit
0	0	0	0	0	0	0	0	0	0	0	0	0	Moisture Surplus
0	0	0	0	0	0	0	0	0	0	0	0	0	Surplus Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Snowmelt Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Total Runoff
0	0	0	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 200 MM

TABLE B1-3

THORNTHWAITE CLIMATIC WATER BALANCE (BASED ON CLIMATIC NORMALS FOR THE PERIOD 1941-1970)
ASHCROFT, BRITISH COLUMBIA

50° 43 N 121° 17 W
304 METRES AES STATION # 1160510

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATIO IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
-6.5	-1.2	3.6	9.4	15.0	18.5	21.4	20.4	15.7	8.8	1.8	-3.1	8.6	Temperature Deg. C.
0	0	16	53	91	124	146	124	81	25	6	0	675	Potential Evapotrans.
22	13	7	10	16	30	15	25	19	17	18	20	213	Precipitation
22	13	-7	-41	-74	-94	-130	-97	-61	-17	12	20	-462	Precip. - Pot. Evapotrans
54	68	62	41	19	7	2	1	0	0	13	32		Storage
22	13	-4	-20	-21	-11	-4	0	0	0	12	20		Change in Storage
0	0	13	32	37	41	21	27	19	17	6	0	213	Actual Evapotrans.
0	0	3	21	54	83	125	97	62	18	0	0	463	Moisture Deficit
0	0	0	0	0	0	0	0	0	0	0	0	0	Moisture Surplus
0	0	0	0	0	0	0	0	0	0	0	0	0	Surplus Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Snowmelt Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Total Runoff
0	0	0	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 100 MM

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATIO IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
-6.5	-1.2	3.6	9.4	15.0	18.5	21.4	20.4	15.7	8.8	1.8	-3.1	8.6	Temperature Deg. C.
0	0	16	53	91	124	146	124	81	35	6	0	675	Potential Evapotrans.
22	13	7	10	16	30	15	25	19	17	18	20	213	Precipitation
22	13	-7	-41	-74	-94	-130	-97	-61	-17	12	20	-462	Precip. - Pot. Evapotrans.
59	72	69	56	39	24	12	8	6	5	18	37		Storage
22	13	-2	-12	-17	-14	-11	-4	-1	0	12	20		Change in Storage
0	0	10	24	33	44	27	30	21	18	6	0	213	Actual Evapotrans.
0	0	5	29	58	80	119	94	60	18	0	0	463	Moisture Deficit
0	0	0	0	0	0	0	0	0	0	0	0	0	Moisture Surplus
0	0	0	0	0	0	0	0	0	0	0	0	0	Surplus Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Snowmelt Runoff
0	0	0	0	0	0	0	0	0	0	0	0	0	Total Runoff
0	0	0	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 200 MM

TABLE B1-4

THORNHILL CLIMATIC WATER BALANCE (BASED ON CLIMATIC NORMALS FOR THE PERIOD 1941-1970)
HOUSTON VALLEY, BRITISH COLUMBIA

54° 31' N 127° 1' W
1554 METRES ALS STATION #1123468

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATIO IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
-8.6	-3.8	-2.0	1.6	7.4	11.5	14.2	13.9	9.9	3.9	-2.3	-5.6	3.3	Temperature Deg. C.
0	0	0	18	71	93	115	105	73	28	0	0	502	Potential Evapotrans.
53	32	28	20	26	34	19	26	19	24	36	57	374	Precipitation
53	32	28	3	-44	-59	-95	-77	-53	-3	36	57	-127	Precip.-Pot. Evapotrans.
153	154	151	100	64	35	13	6	4	3	40	97		Storage
3	0	0	0	-35	-28	-21	-6	-2	0	36	57		Change in Storage
0	0	0	18	62	62	41	34	21	24	0	0	262	Actual Evapotrans.
0	0	0	0	9	31	74	71	52	4	0	0	240	Moisture Deficit
0	0	0	53	0	0	0	0	0	0	0	0	53	Moisture Surplus
0	0	0	27	13	7	3	2	1	0	0	0	53	Surplus Runoff
8	20	32	0	0	0	0	0	0	0	0	0	59	Snowmelt Runoff
8	20	32	27	13	7	3	2	1	0	0	0	112	Total Runoff
16	27	38	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 100 MM

ALL VALUES EXCEPT TEMPERATURE AND SNOWMELT RUNOFF RATIO IN MM

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
-8.6	-3.8	-2.0	1.6	7.4	11.5	14.2	13.9	9.9	3.9	-2.3	-5.6	3.3	Temperature Deg. C.
0	0	0	19	71	93	115	105	73	28	0	0	502	Potential Evapotrans.
53	32	28	20	26	34	19	26	19	24	36	57	374	Precipitation
53	32	28	3	-44	-59	-95	-77	-53	-3	36	57	-127	Precip.-Pot. Evapotrans.
153	211	223	200	159	118	73	50	38	37	73	131		Storage
53	17	0	0	-40	-40	-44	-23	-11	0	36	57		Change in Storage
0	0	0	18	66	75	64	50	30	25	0	0	328	Actual Evapotrans.
0	0	0	0	5	19	51	55	42	3	0	0	174	Moisture Deficit
0	0	0	26	0	0	0	0	0	0	0	0	26	Moisture Surplus
0	0	0	13	6	3	2	1	0	0	0	0	26	Surplus Runoff
0	4	16	0	0	0	0	0	0	0	0	0	20	Snowmelt Runoff
0	4	16	13	6	3	2	1	0	0	0	0	46	Total Runoff
0	28	40	0	0	0	0	0	0	0	0	0		Snowmelt Runoff Ratio (%)

ASSUMED WATER HOLDING CAPACITY 200 MM

FIGURE B2-1: (76-4-32) Streamgauging in Anderson Creek with Ott current meter, 16 Sept., 1976

FIGURE B2-2: (76-4-28) Ott propeller-type current meter, ready for streamgauging in Ambusten Creek, 16 Sept., 1976

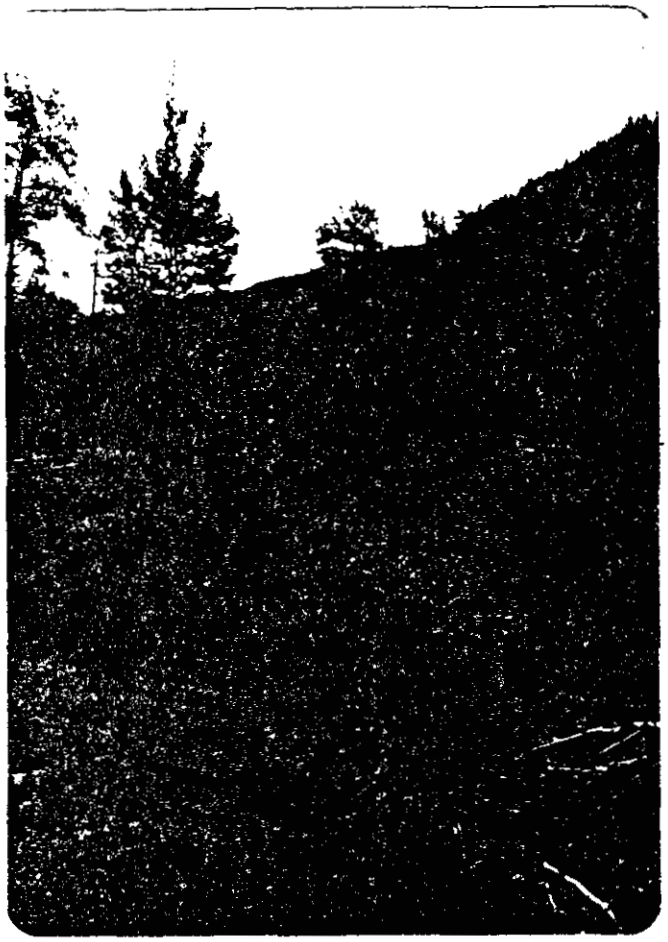


FIGURE B2-3: (76-1-15) View along the abandoned Hammond Diversion of Upper Hat Creek to Oregon Jack Creek, 19 July, 1976

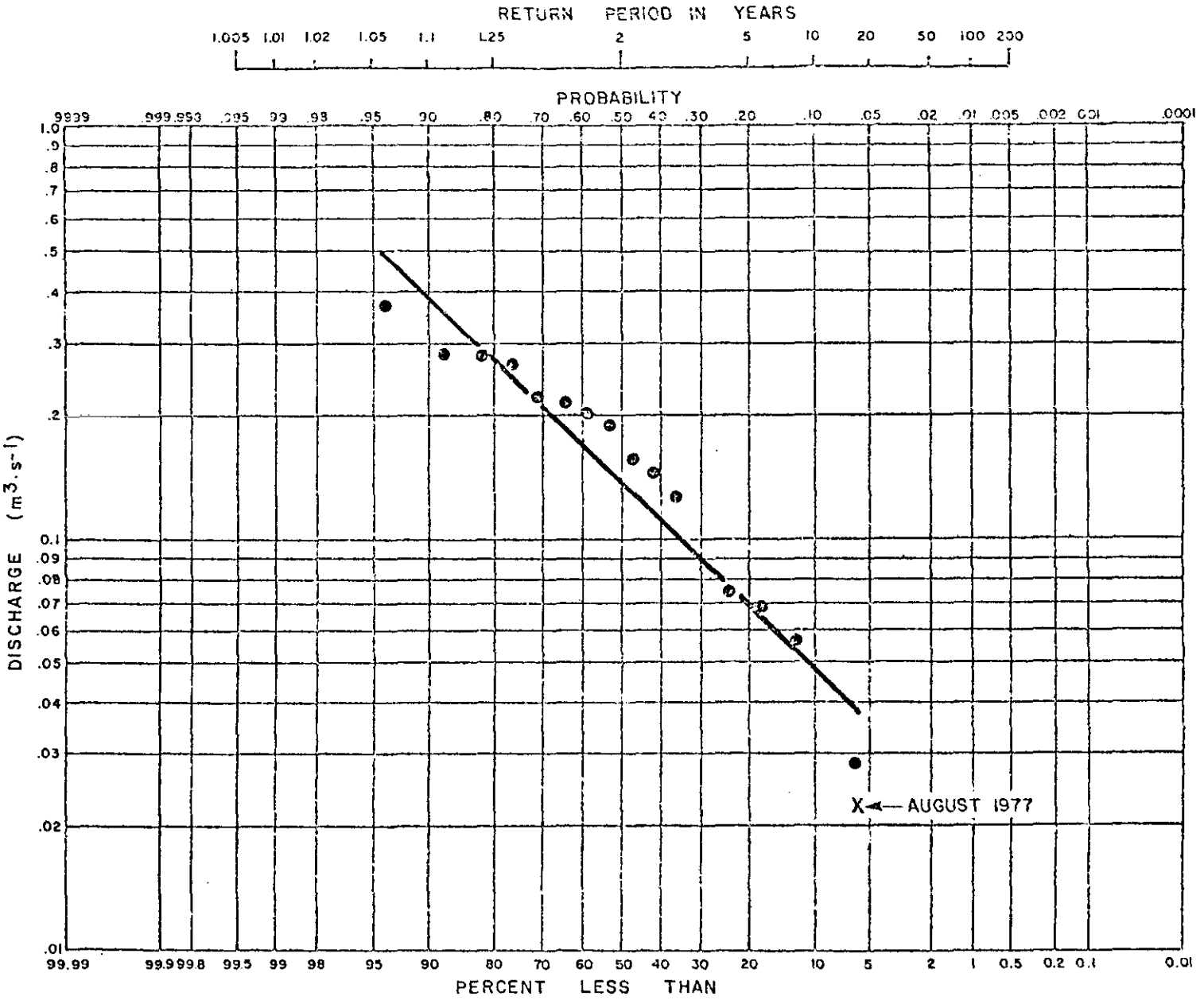


FIGURE B2-4: LATE SUMMER MINIMUM FLOW FREQUENCY CURVE FOR HAT CREEK NEAR UPPER HAT CREEK (08LF001)

DATE	Nov. 77 DF
PROJECT	K4242

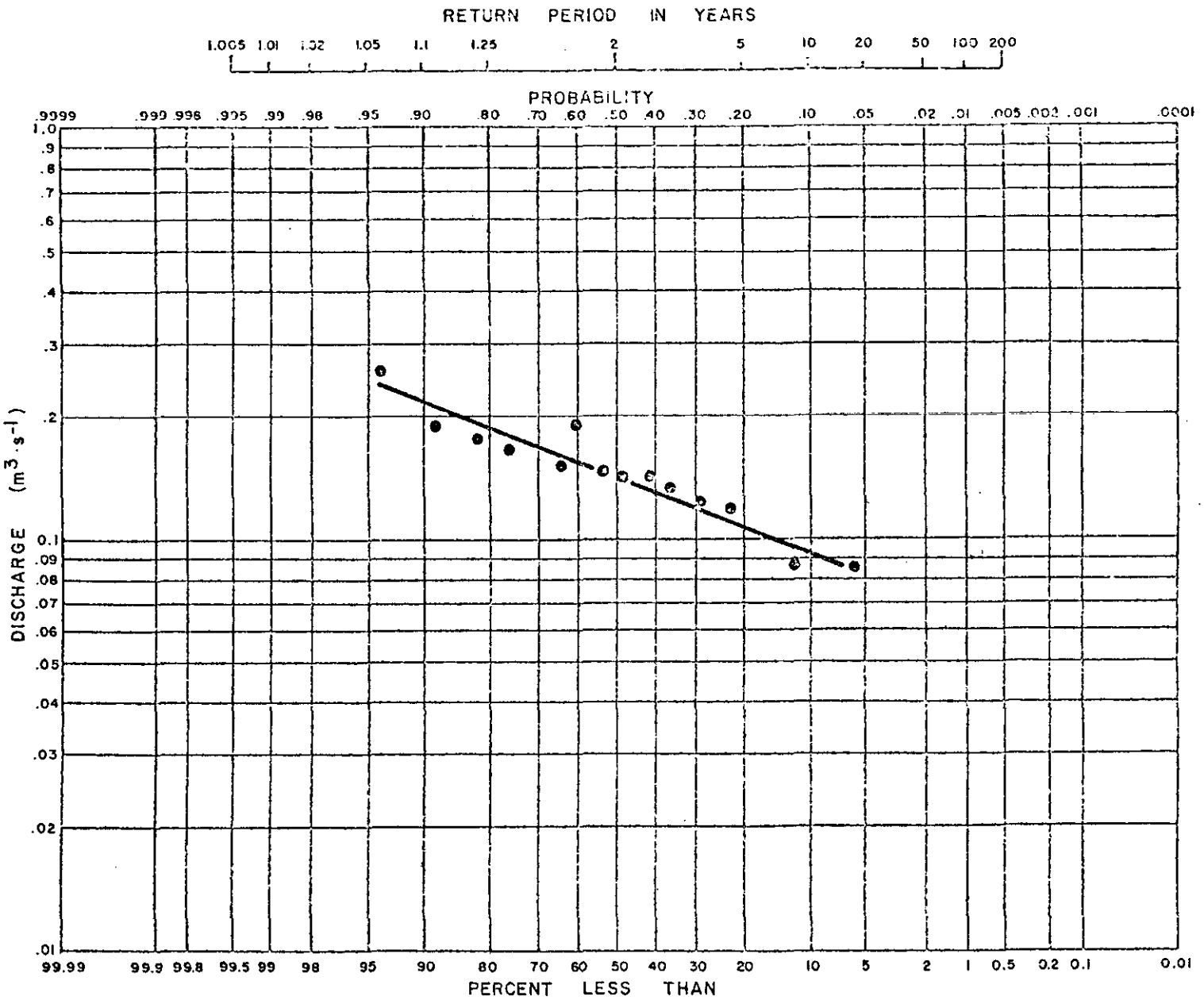


FIGURE B2-5: WINTER MINIMUM FLOW FREQUENCY CURVE FOR HAT CREEK NEAR UPPER HAT CREEK (08LF061)

DATE	Nov. 77 DF
PROJECT	K 4242
DWG NO	Rev 2 CAii-1

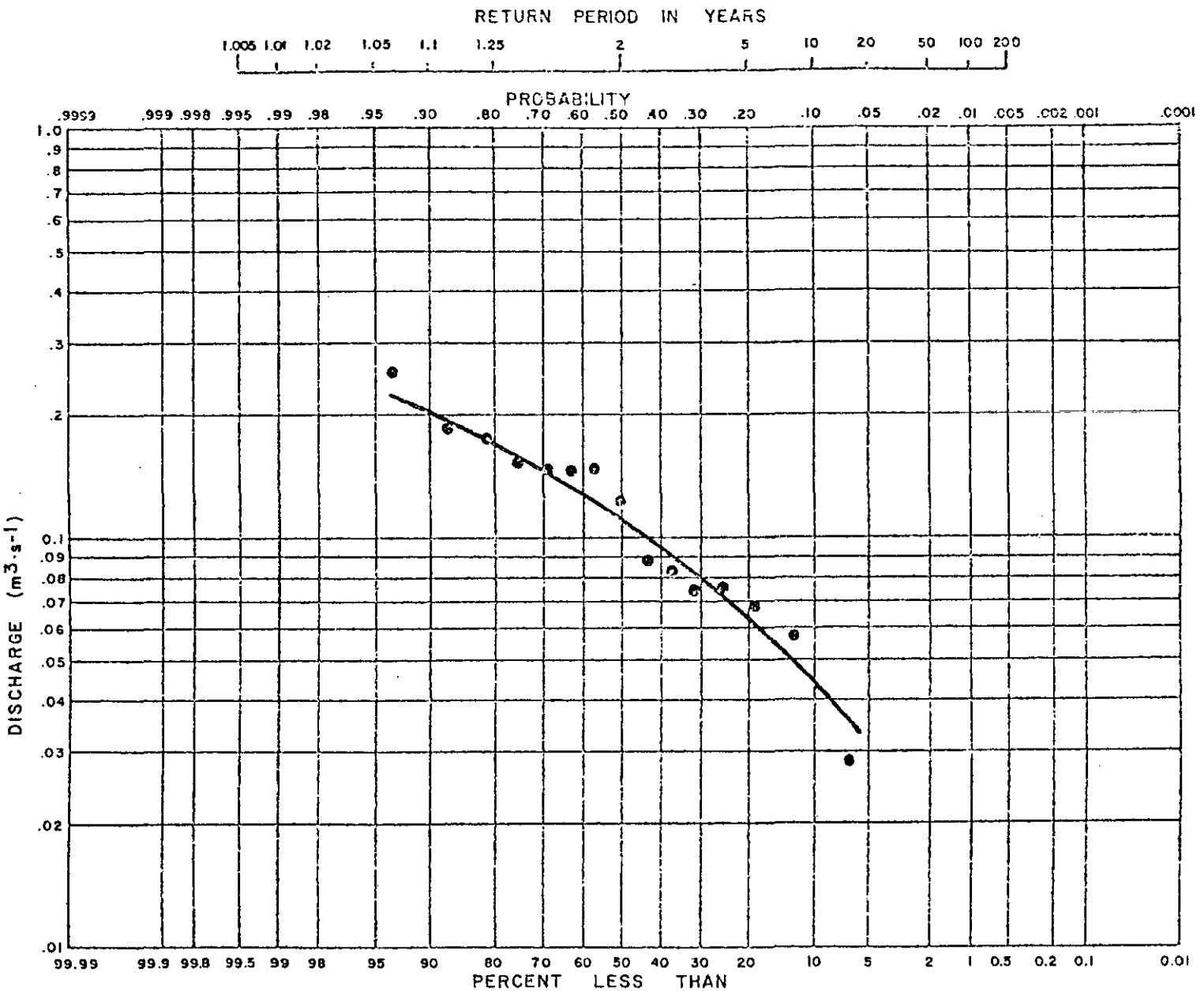


FIGURE B2-6: YEARLY MINIMUM FLOW FREQUENCY CURVE FOR HAT CREEK NEAR UPPER HAT CREEK (08LF061)

DATE	Nov 77 DF
PROJECT	K4242
DWG NO	Nov 2281-1

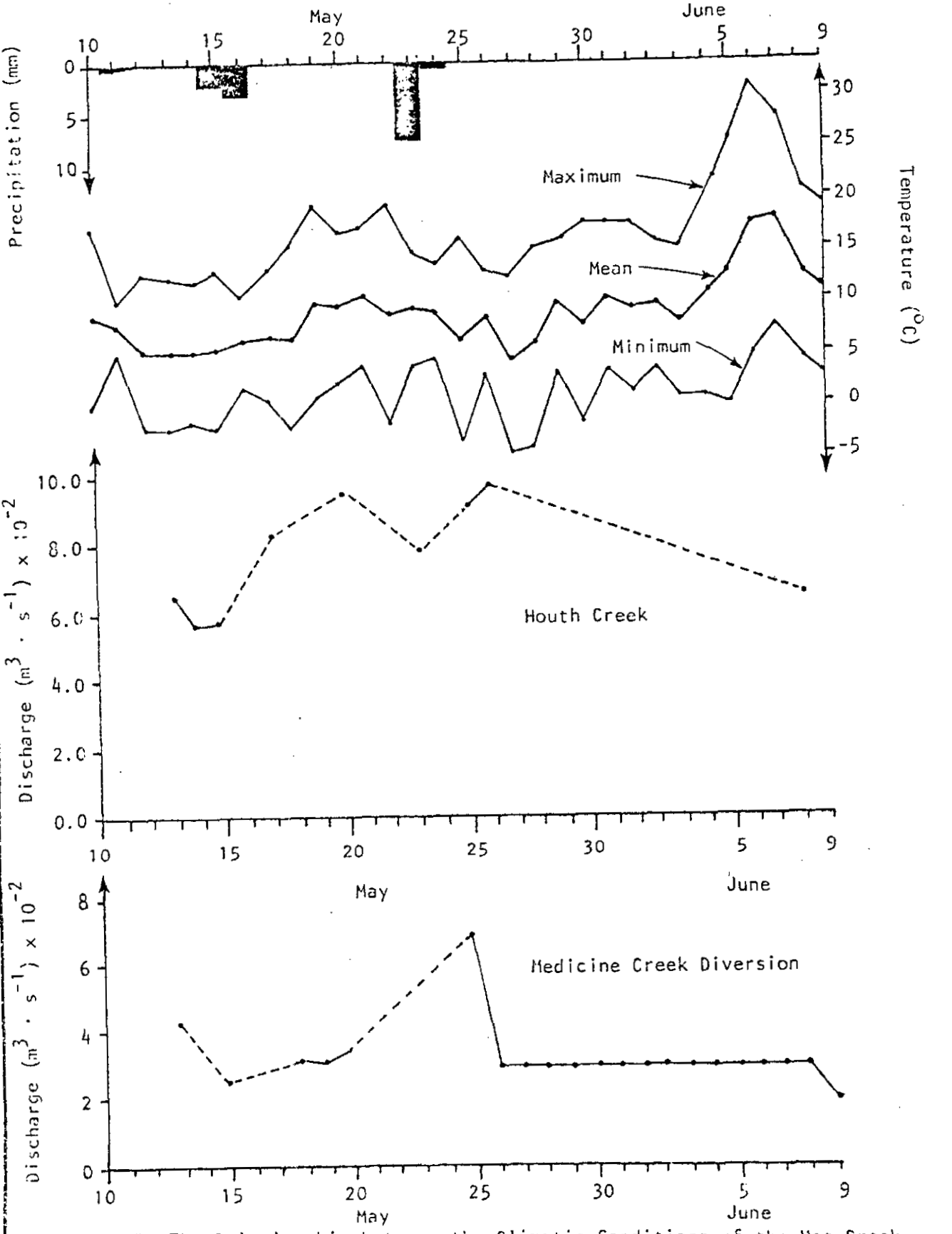


Figure B2-7: The Relationship between the Climatic Conditions of the Hat Creek Valley and the Discharges of the Houth Creek and Medicine Creek Diversion

DATE	7-77 IRM
PROJECT	K4242
DWG. NO.	

B2-7

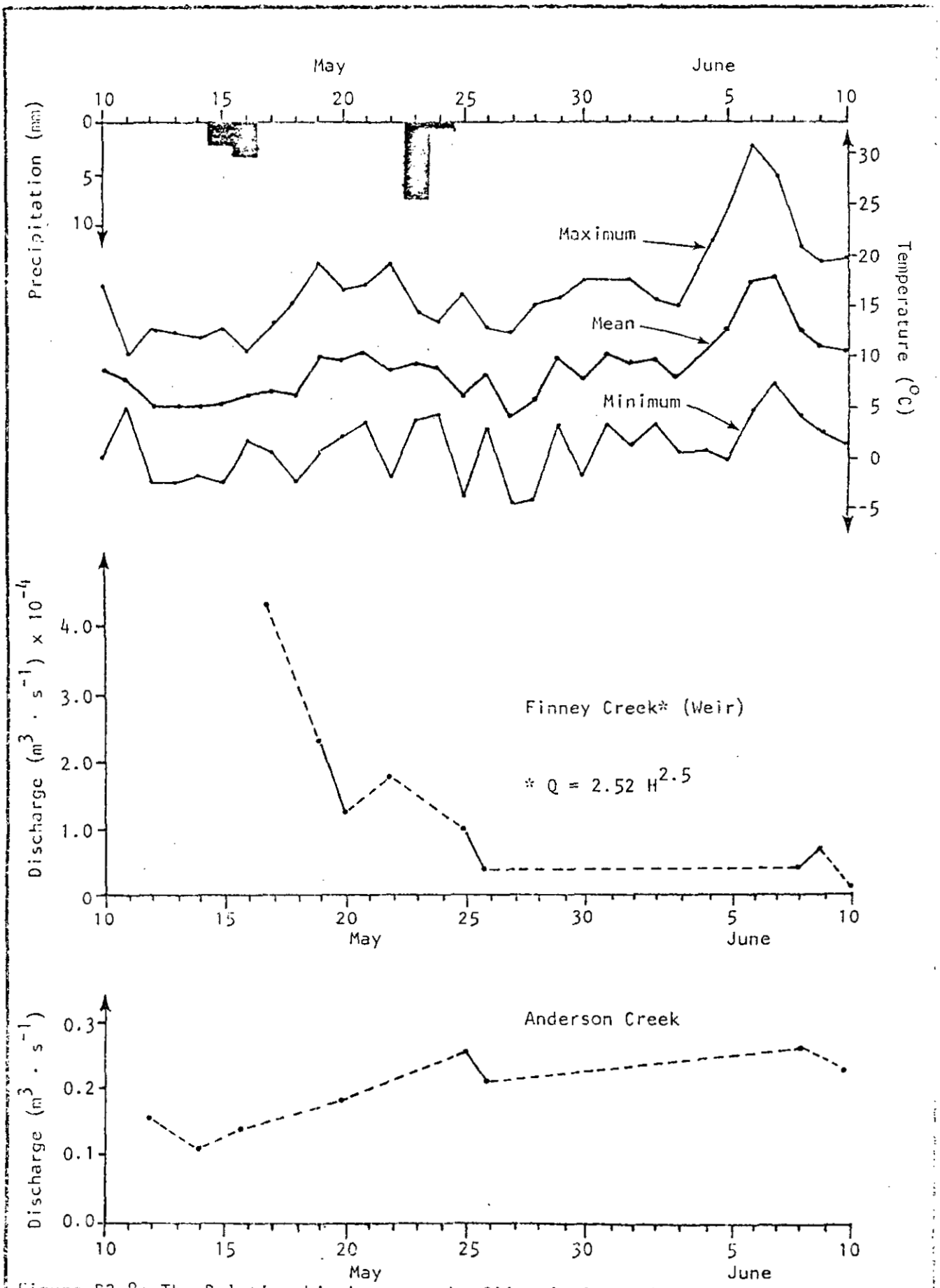


Figure B2-8: The Relationship between the Climatic Conditions of the Hat Creek Valley and the Discharges of Finney and Anderson Creeks

DATE	7-77	RM
PROJECT	K4242	
DWG NO		

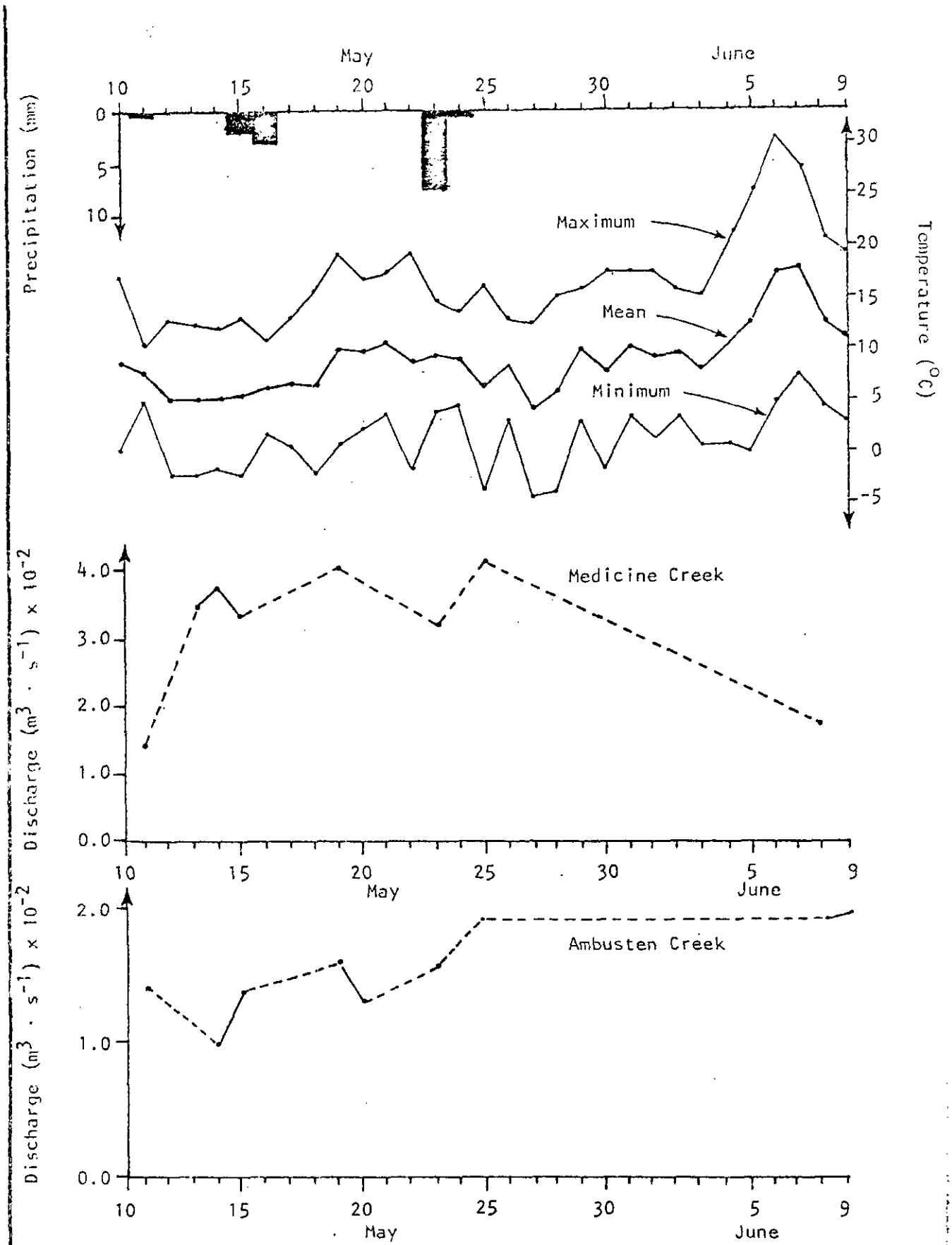


Figure B2-9: The Relationship between the Climatic Conditions of the Hat Creek Valley and the Discharges of Medicine and Ambusten Creeks.

DATE	7-77 IRM	B2-9
PROJECT	K4242	
DWG NO		

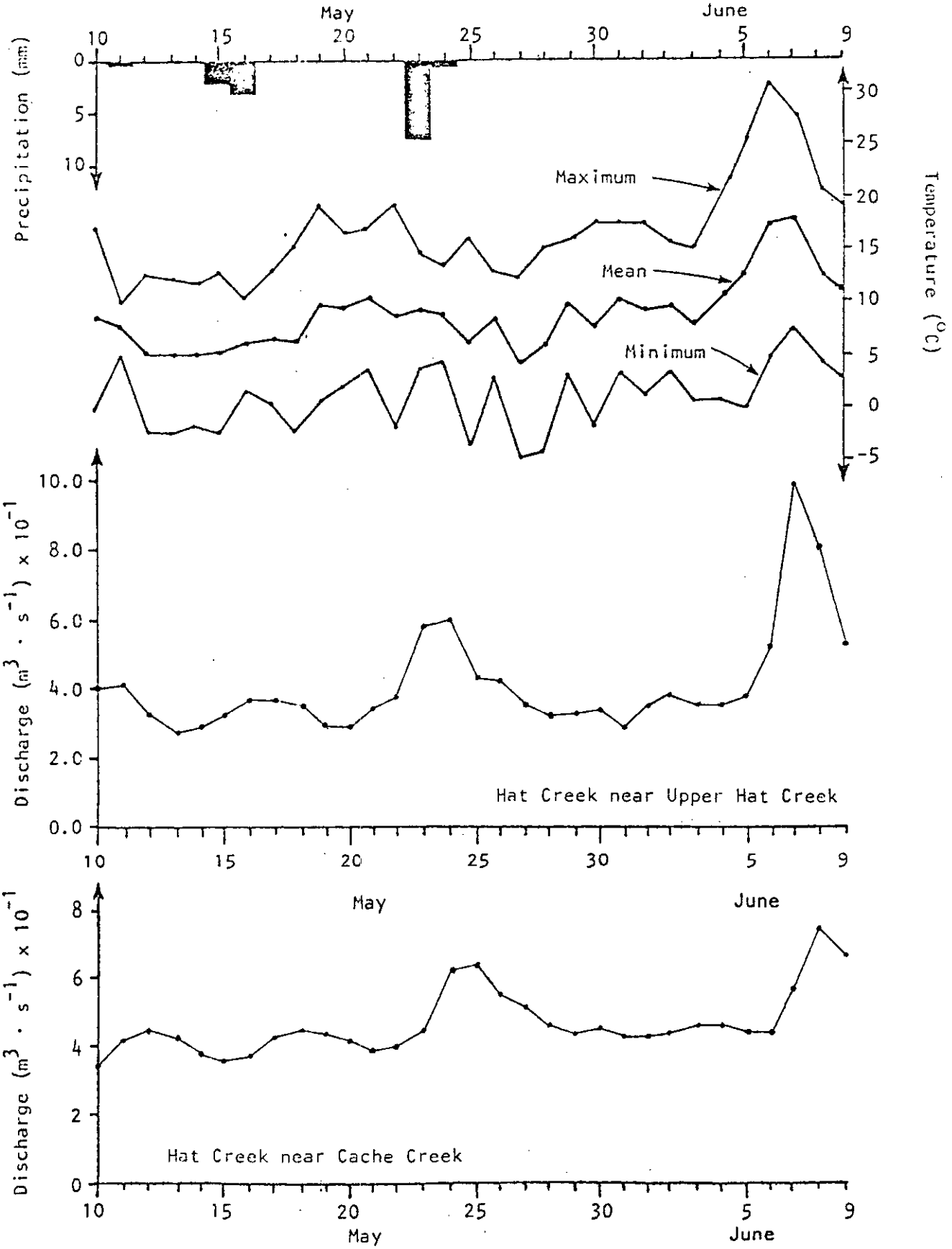
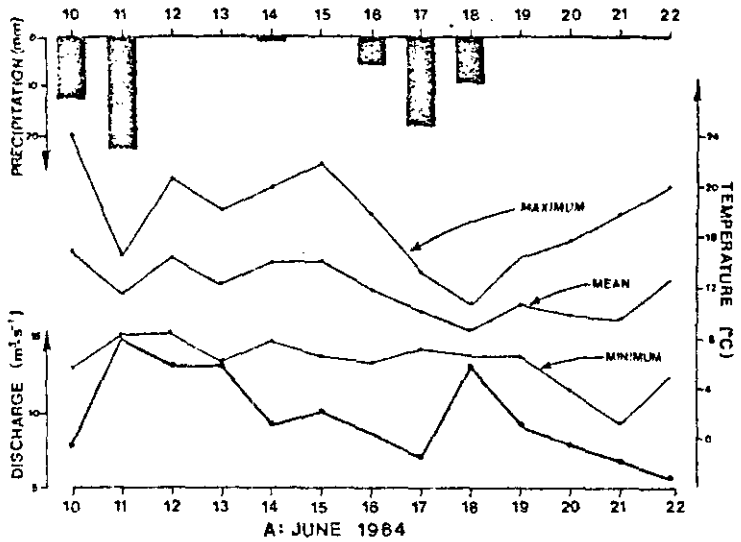


Figure B2-10: The Relationship between the Climatic Conditions of the Hat Creek Valley and the Discharges of the W.S.C. Stations on Hat Creek.

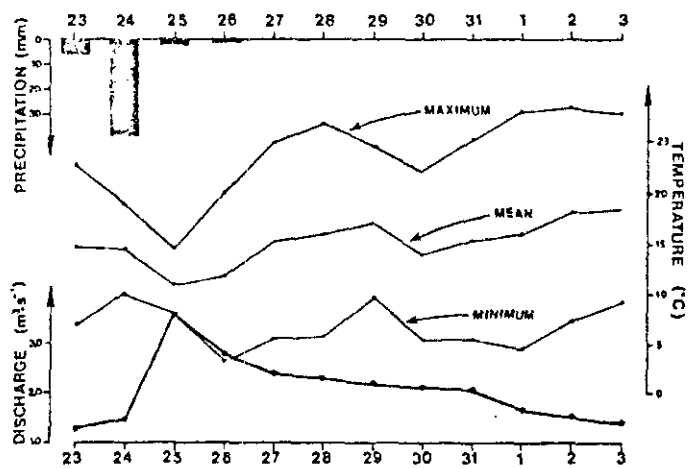
DATE	12-77 DF
PROJECT	K4242
DWG NO	

B2-10

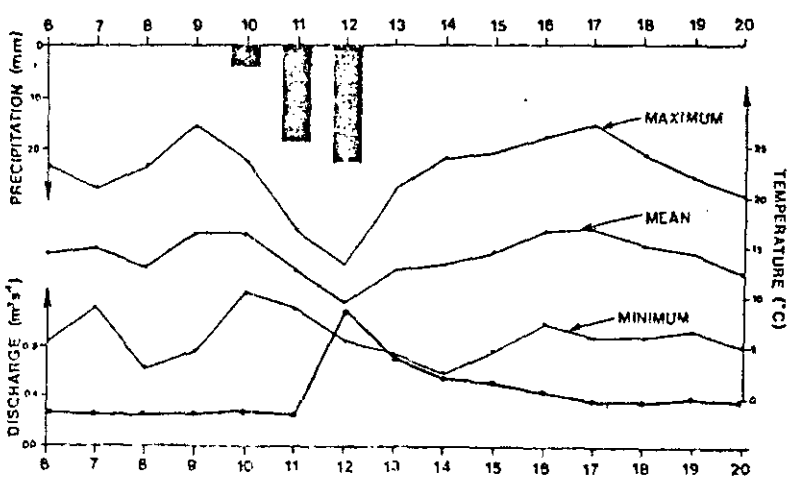
FIGURE B2-11: SOME TYPICAL RAINFALL - RUNOFF EVENTS IN HAT CREEK



A: JUNE 1964



B: JULY - AUGUST 1966



C: AUGUST 1974

DATE		B2-11
PROJECT	K42	
DWG. NO.		

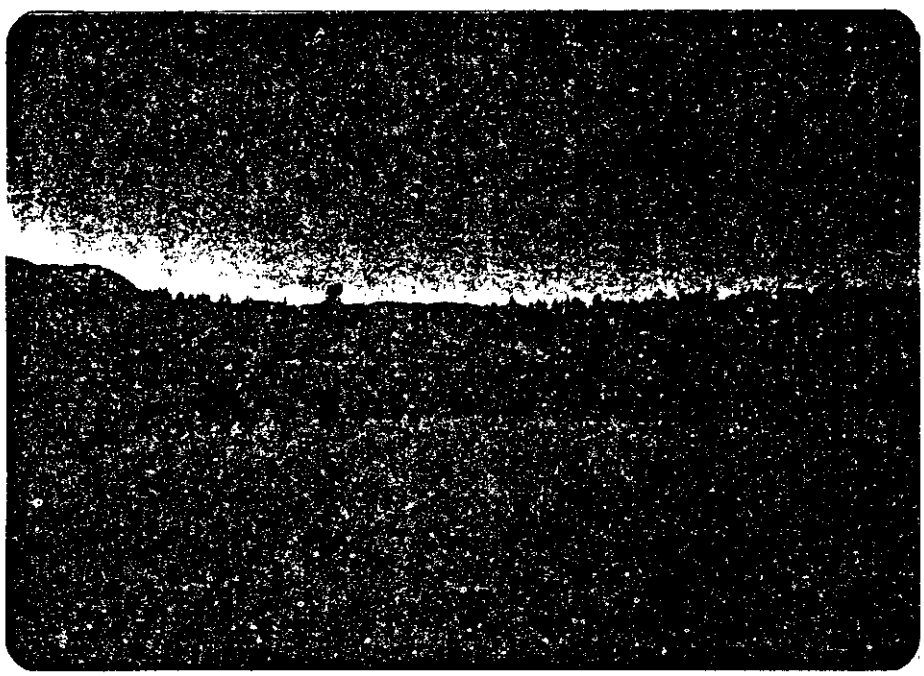


FIGURE B2-12: (76-4-35) Finney Lake, 16 Sept., 1976

FIGURE B2-13: (76-4-36) Dam and gate controlling outflow from Finney Lake, 16 Sept., 1976

FIGURE B2-14: (76-1-7) Deeply entrenched section of Hat Creek, immediately downstream of Indian Reservation No. 2, looking downstream, 18 July, 1976

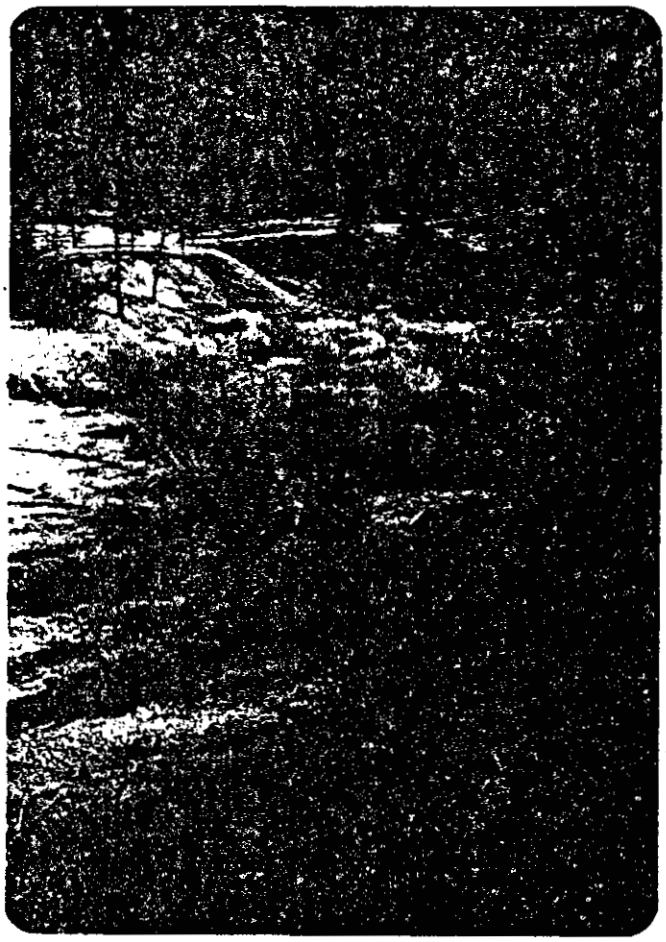


FIGURE B2-15: (76-5A-14) Meandering, partly entrenched and combined section of Hat Creek approximately 2 km downstream of Robertson Creek. A series of fragmentary terrace levels and a small genetic flood plain are prominent in the centre of the photo, 19 Oct., 1976

FIGURE B2-16: (76-5A-23) Hat Creek at Section 9-4, looking downstream. At this site, the stream flows across its fan in the Bonaparte Valley, 19 Oct., 1976

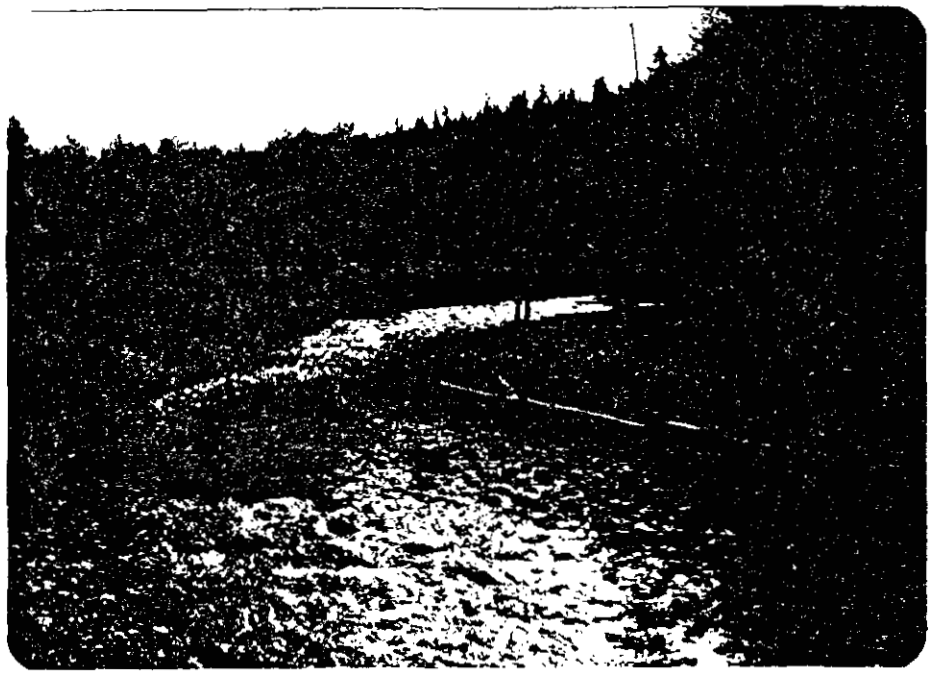
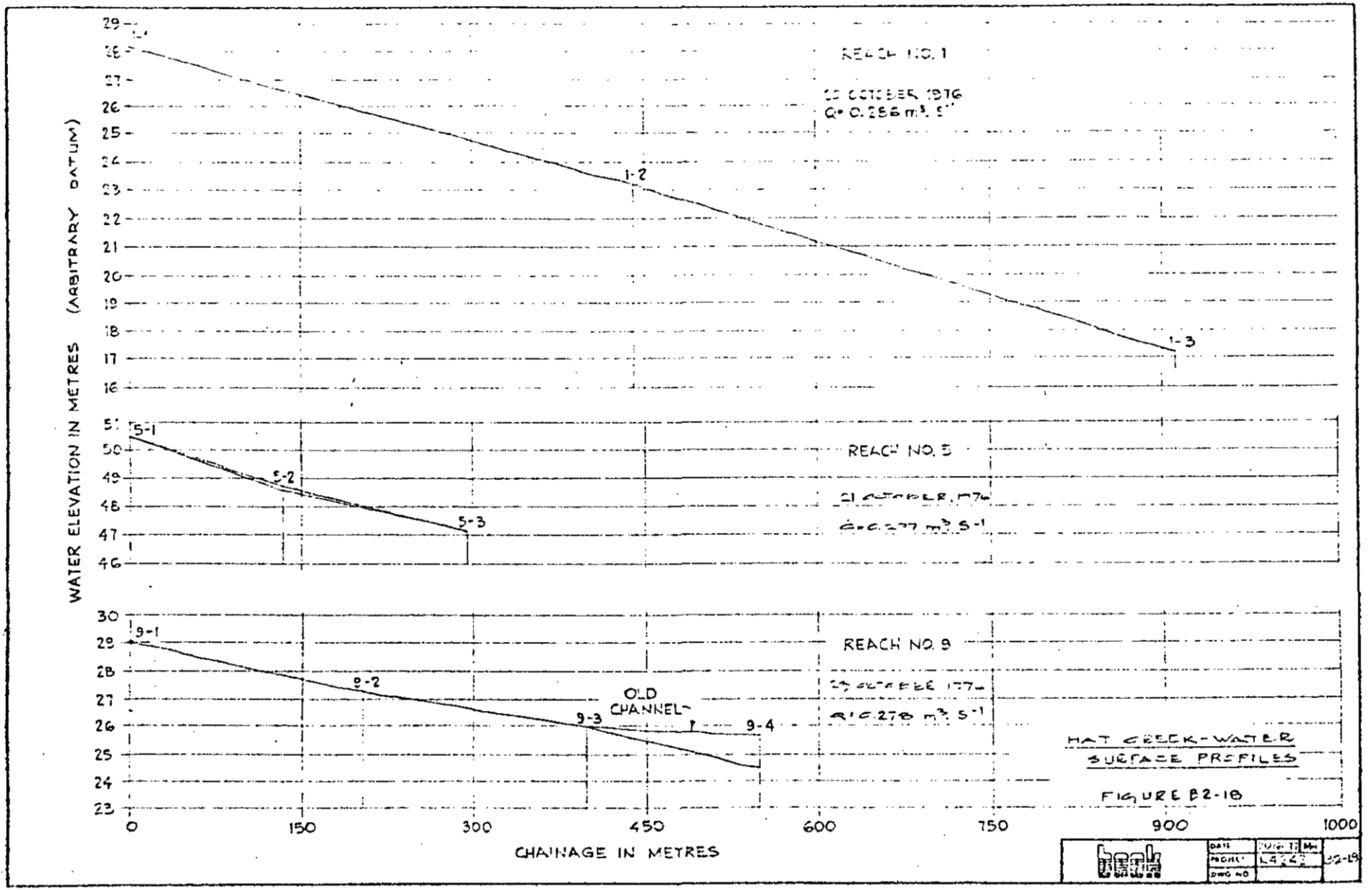


FIGURE B2-17: (76-5-29) Upstream view along Hat Creek from a site approximately 20 m below the line of Section 1-1, 18 Oct., 1976



HAT CREEK - WATER SURFACE PROFILES

FIGURE B2-18

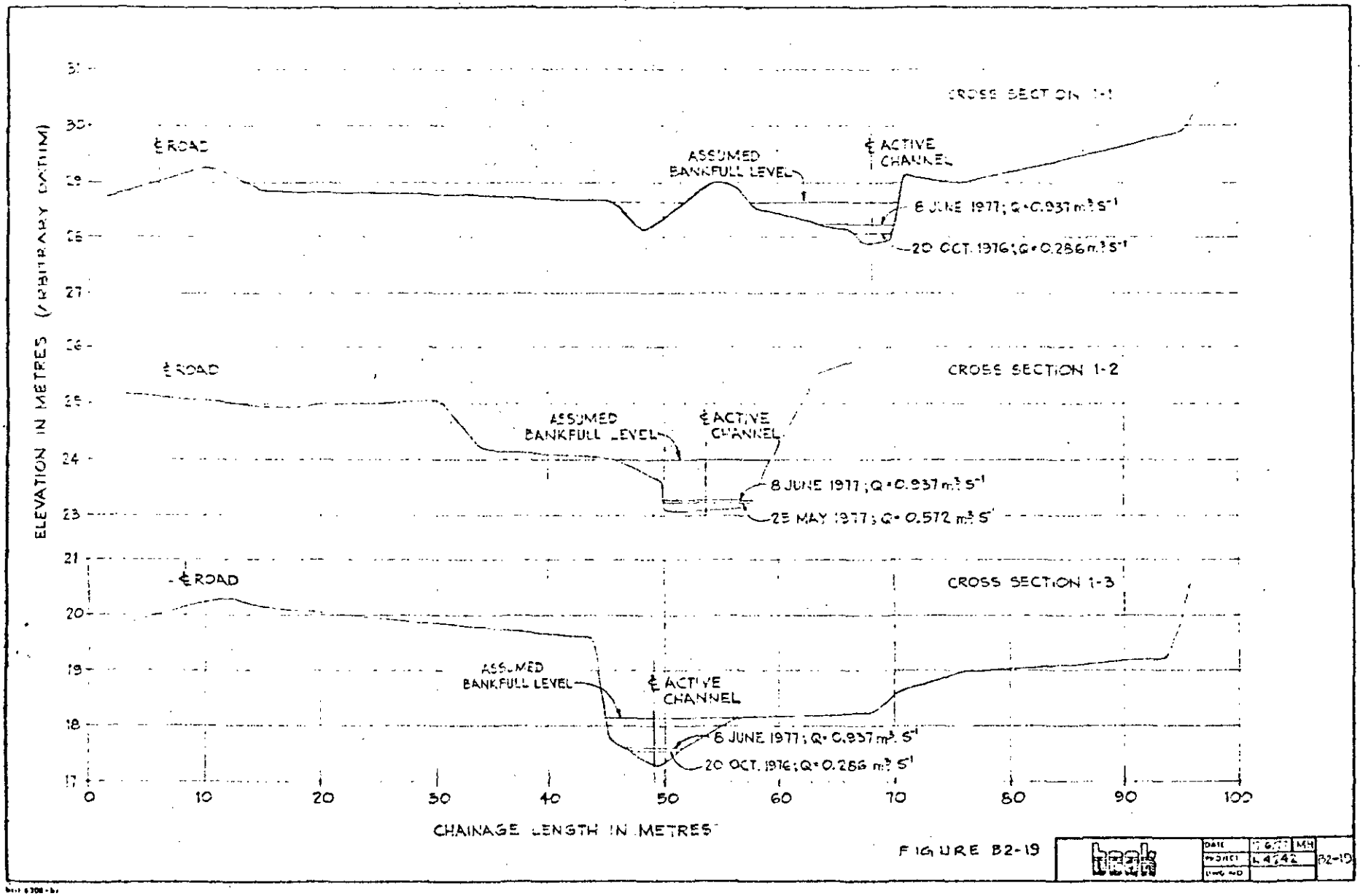

CROSS SECTION 1-1
℄ ROAD
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.937 m³ S⁻¹
20 OCT. 1976; Q = 0.286 m³ S⁻¹
CROSS SECTION 1-2
℄ ROAD
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.937 m³ S⁻¹
25 MAY 1977; Q = 0.572 m³ S⁻¹
CROSS SECTION 1-3
℄ ROAD
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.937 m³ S⁻¹
20 OCT. 1976; Q = 0.286 m³ S⁻¹
ELEVATION IN METRES (ARBITRARY DATUM)
CHAINAGE LENGTH IN METRES
0
10
20
30
40
50
60
70
80
90
100

FIGURE B2-19

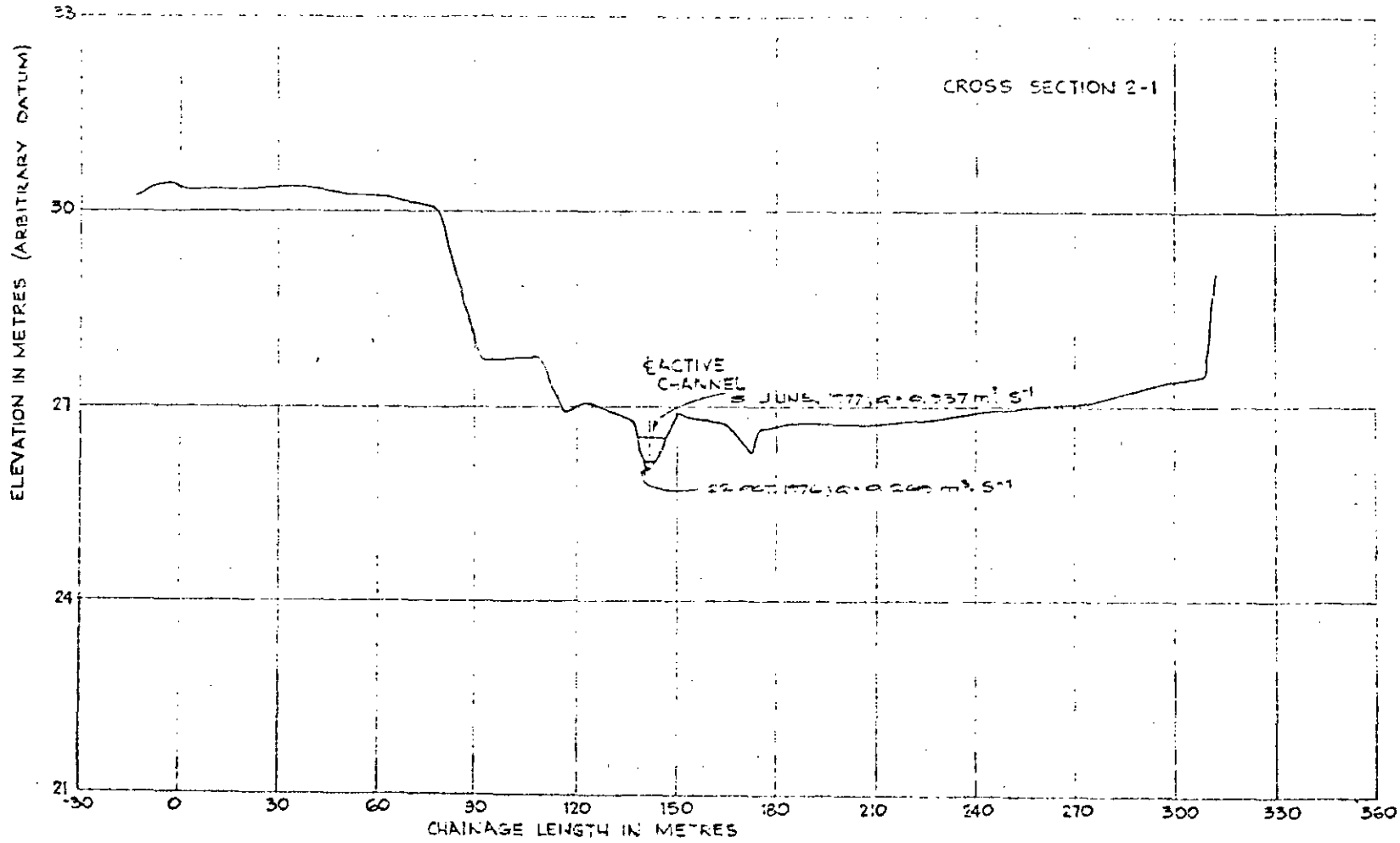

CROSS SECTION 2-1
ELEVATION IN METRES (ARBITRARY DATUM)
33
30
27
24
21
-30
0
30
60
90
120
150
180
210
240
270
300
330
360
CHAINAGE LENGTH IN METRES
ACTIVE CHANNEL

FIGURE B2-20

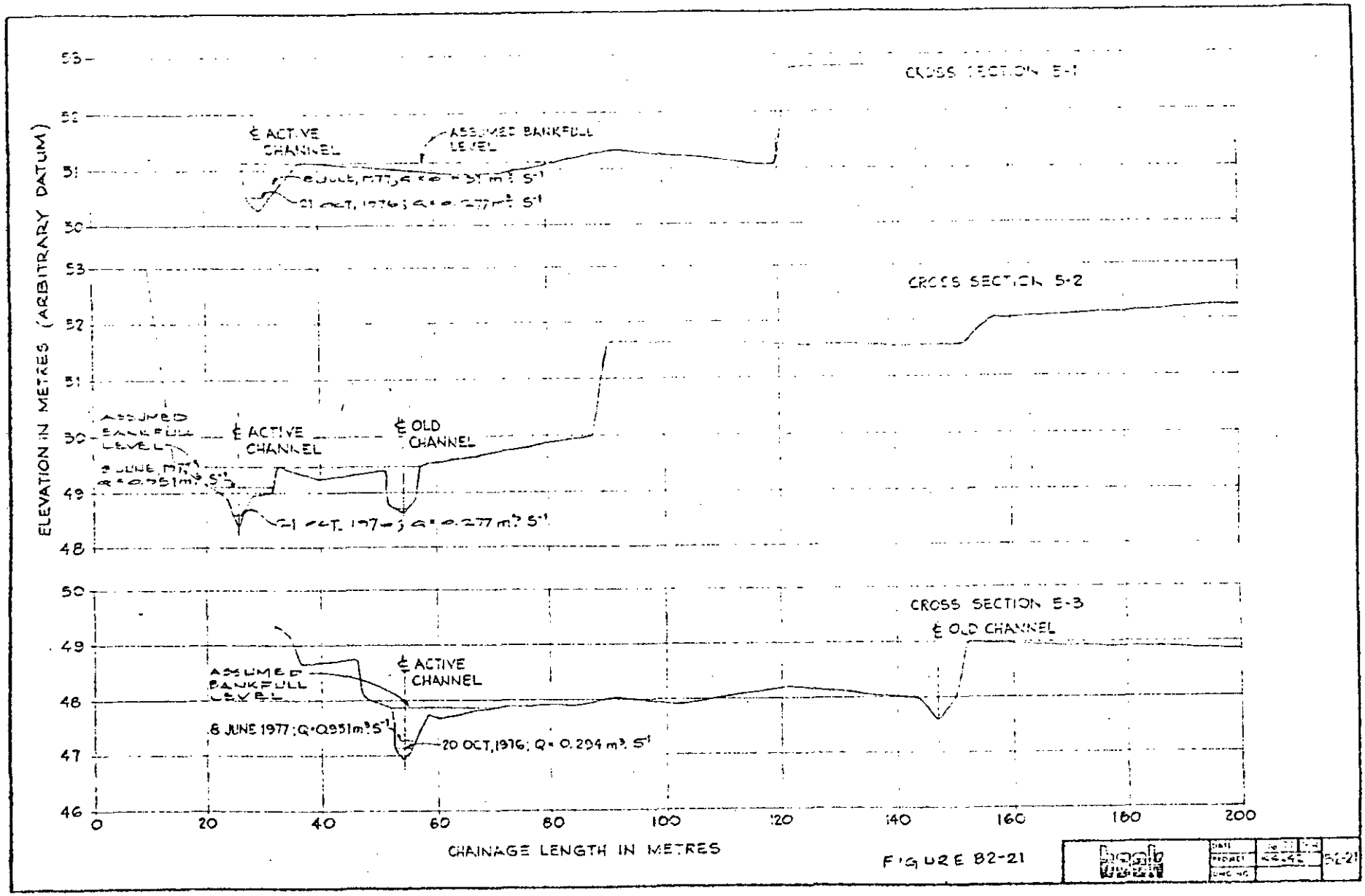

CROSS SECTION 5-1
℄ ACTIVE CHANNEL
ASSUMED BANKFULL LEVEL
CROSS SECTION 5-2
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
℄ OLD CHANNEL
CROSS SECTION 5-3
℄ OLD CHANNEL
℄ ACTIVE CHANNEL
ASSUMED BANKFULL LEVEL
8 JUNE 1977; Q=0.951m³S⁻¹
20 OCT, 1976; Q= 0.294 m³ S⁻¹
ELEVATION IN METRES (ARBITRARY DATUM)
CHAINAGE LENGTH IN METRES
0
20
40
60
80
100
120
140
160
180
200
46
47
48
49
50
51
52
53

FIGURE B2-21

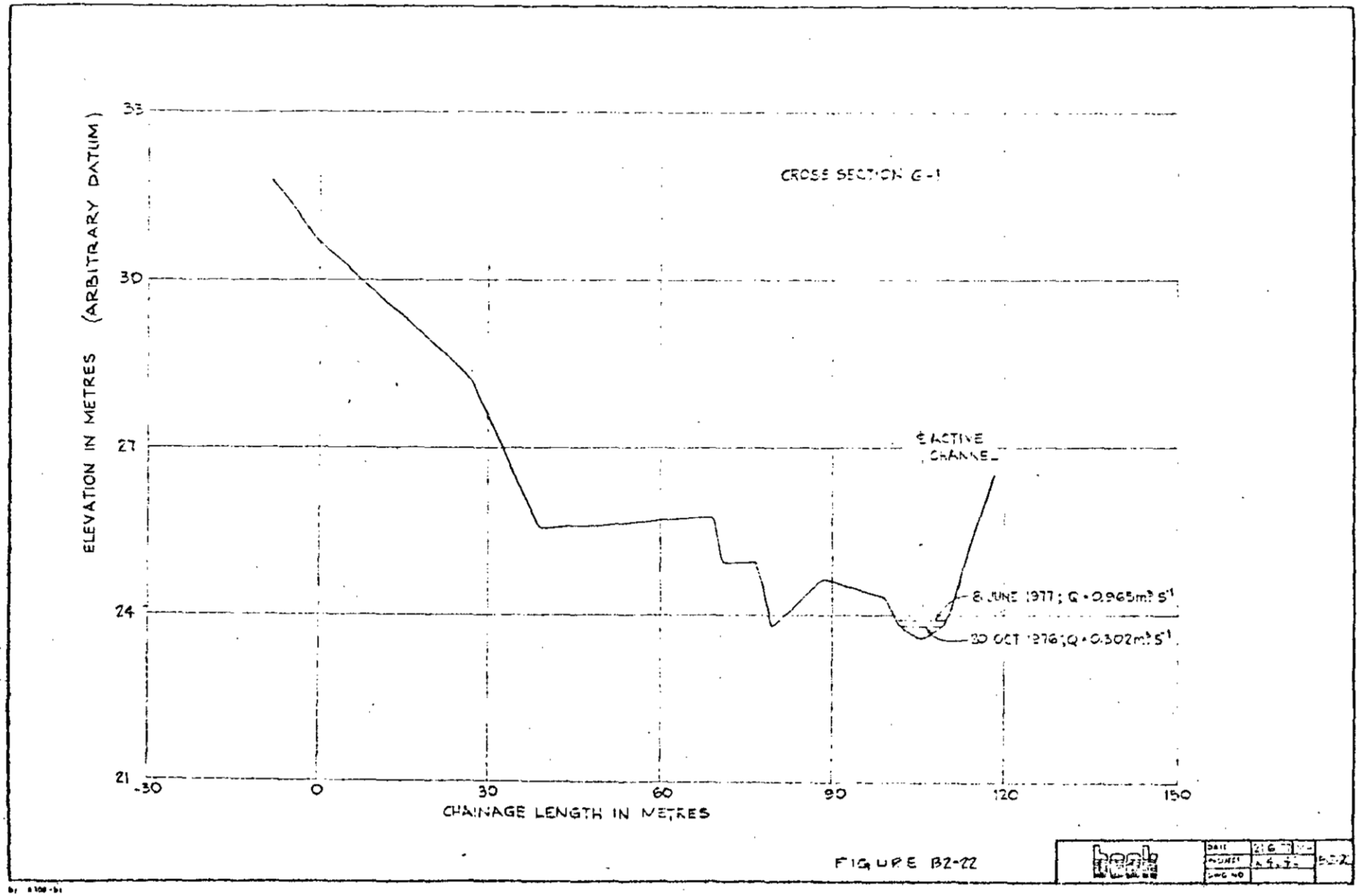

CROSS SECTION G-1
ELEVATION IN METRES (ARBITRARY DATUM)
33
30
27
24
21
-30
0
30
60
90
120
150
CHAINAGE LENGTH IN METRES
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.965m³ S⁻¹
30 OCT 1976; Q = 0.302m³ S⁻¹

FIGURE B2-22

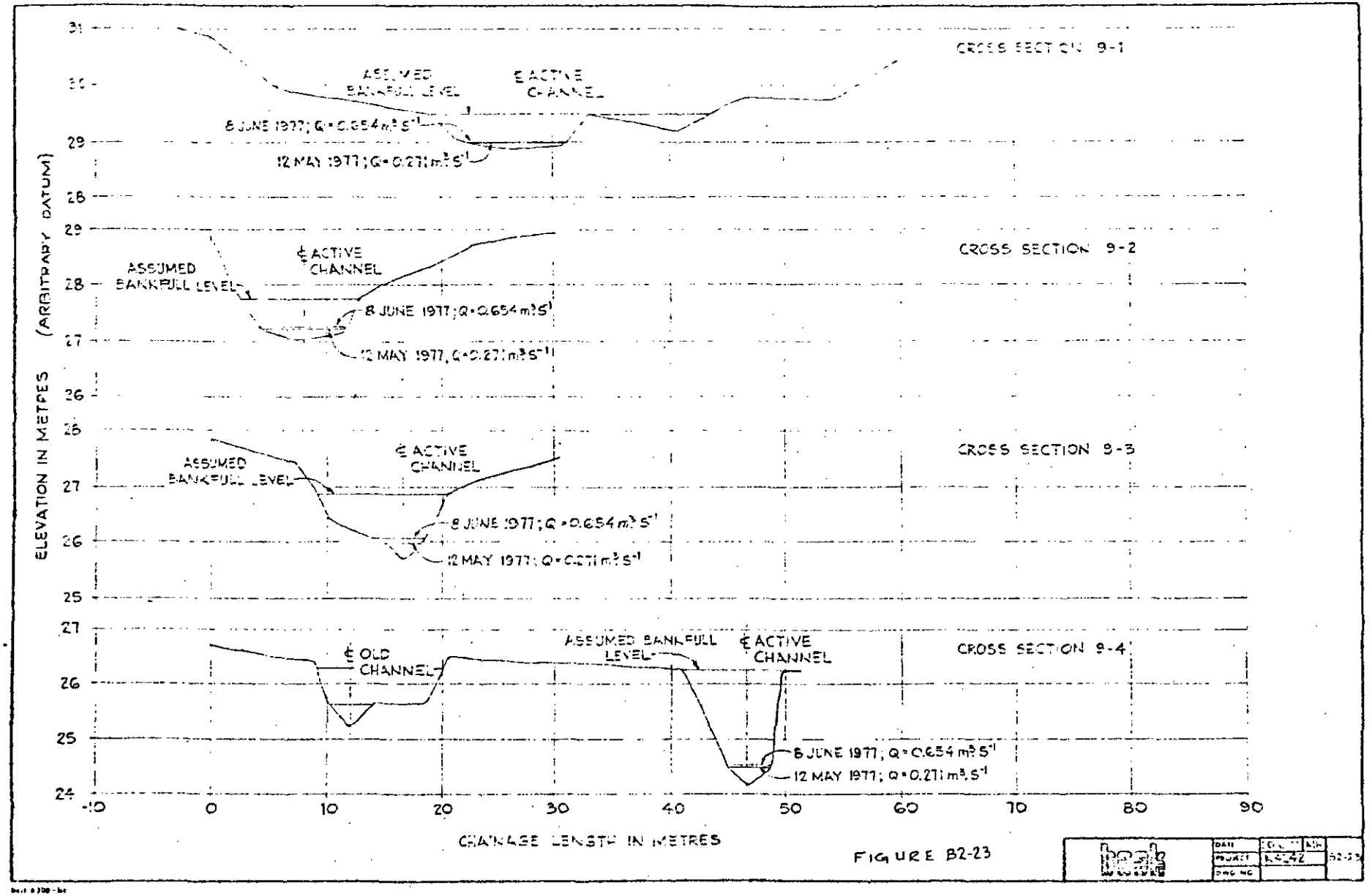

CROSS SECTION 9-1
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.654 m³ S⁻¹
12 MAY 1977; Q = 0.271 m³ S⁻¹
CROSS SECTION 9-2
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.654 m³ S⁻¹
12 MAY 1977; Q = 0.271 m³ S⁻¹
CROSS SECTION 9-3
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.654 m³ S⁻¹
12 MAY 1977; Q = 0.271 m³ S⁻¹
CROSS SECTION 9-4
℄ OLD CHANNEL
ASSUMED BANKFULL LEVEL
℄ ACTIVE CHANNEL
8 JUNE 1977; Q = 0.654 m³ S⁻¹
12 MAY 1977; Q = 0.271 m³ S⁻¹
ELEVATION IN METRES (ARBITRARY DATUM)
CHAINAGE LENGTH IN METRES

FIGURE B2-23

APPENDIX C

APPENDIX C SUPPLEMENTARY WATER QUALITY INVENTORY TABLES AND FIGURES

C1.0 TABLES

C2.0 FIGURES

TABLE C1-1

GROUNDWATER SAMPLE COLLECTION DATES

DOMESTIC WELLS (BASE)

DW 1	29 Nov./76	26 May/77
DW 2	1 Dec./76	29 May/77
DW 3	30 Nov./76	25 May/77
DW 4	1 Dec./76	29 May/77
DW 5	1 Dec./76	19 May/77
DW 8	1 Dec./76	28 May/77
DW 9	1 Dec./76	30 May/77
DW 10	2 Dec./76	28 May/77
DW 12	-	29 May/77
Steel Bros. Limestone Quarry Well		30 April/77

ARTESIAN SPRINGS

1	22 Nov./76	20 July 77
2	22 Nov./76	
3 (West)	22 Nov./76	
3 (East)	22 Nov./76	

BULK SAMPLE PROGRAM

	COLLECTION NUMBER				
	1	2	3	4	5
Well 1	7 June/77	-	-	-	-
Well 2	7 June/77	21 June/77	6 July/77	20 July/77	-
Well 3	7 June/77	21 June/77	6 July/77	20 July/77	4 Aug./77
Trench B	21 June/77	6 July/77	19 July/77	4 Aug./77	14 Sept./77

SPECIAL COLLECTIONS

Coal Seam 19 Sept. 1976

PIT HYDROLOGY STUDY

Well RH 76-19 14 October, 1976 (After Pumping)

" " " " 9 September, 1976 (Before Pumping)

TABLE C1-2

DETAILED PRESERVATION LIST AND REFERENCES

Analysis to be Performed	Sample Treatment
All parameters	Refrigerate at 4°C.
Biochemical Oxygen Demand	Refrigerate at 4°C. Take care to ensure that the container is filled to the brim and rid of air bubbles.
Chemical Oxygen Demand	Add 2 ml concentrated H_2SO_4 per litre.
Dissolved Oxygen	Analysis in the field. The procedure is described in "Standard Methods", 13th edition pp 477-479.
Mercury	Add 50 ml concentrated HNO_3, Aristar grade, and 5 ml of 10% $K_2Cr_2O_7$ per litre.
Metals - Total and Extractable (excluding Na, K, Ca, Mg, Al, As, B, Hexavalent Cr, and Hg)	Add 5 ml concentrated HNO_3, per litre to lower the pH to less than 2. Check with indicator paper that the stipulated pH has been attained.
Metals - Dissolved (excluding Al, As, B, Hexavalent Cr, and Hg)	The sample must be filtered at the time of sampling through 0.45 µm membrane filter paper before adding 5 ml concentrated HNO_3 per litre. A distilled water blank must also be run through the same apparatus using a similar filter paper.
Metals - Dissolved (Al, As, B, Hexavalent Cr, and Hg)	The sample must be filtered at the time of sampling through 0.45 µm membrane filter paper. A distilled water blank must also be run through the same apparatus using a similar filter paper.
Nitrogen - Ammonia, Kjeldahl	Add 2 ml of 2% $HgCl_2$ per litre. Refrigerate at 4°C.
Nitrogen, Nitrate, Nitrite	Add 2 ml of 2% $HgCl_2$ per litre. Refrigerate at 4°C.
Organic Carbon	Add 2 ml concentrated HCl per litre to lower the pH to less than 2. Check with indicator paper that the stipulated pH has been attained. Refrigerate at 4°C.
Phenol	Collect in 1 litre glass bottles. Add 10 ml of 10% $CuSO_4$ and 1 ml of concentrated H_3PO_4 to lower the pH to 4. Check with indicator paper that the stipulated pH has been attained. Biological degradation is inhibited by the $CuSO_4$. Acidification with H_3PO_4 assures the presence of copper ion in solution and eliminates any chemical changes caused by the presence of strong alkali conditions.
Phosphates	Add 2 ml of 2% $HgCl_2$ per litre. Refrigerate at 4°c. N.B.: If total phosphorus alone is to be determined, preservation is not necessary.

1. Standard Methods for the Examination of Water and Wastewater, 13th Edition. American Public Health Association, et al., Washington, D.C., 1971.

2. Instructions for Taking and Shipping Water Samples for Physical and Chemical Analyses, 2nd Edition. Inland Waters Directorate, Water Quality Branch, Ottawa, Canada, 1973.

3. Methods for Chemical Analysis of Water and Wastes. Environmental Protection Agency, Water Quality Office, Analytical Quality Control Laboratory, Cincinnati, Ohio, 1971.

4. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents: Plankton Chapter. Edited by Cornelius Weber, EPS-670/4-73-001, July, 1973.

5. Preservation of Dilute Mercury Solutions. Cyrus Feldman. Analytical Chemistry. Vol. 46, No. 1, January 1974.

TABLE C1-3

ANALYTICAL METHODOLOGY, REFERENCES & DETECTION LIMITS

PARAMETER (mg/ℓ)	Methodology	Method References	MDC
CATIONS - Trace Metals			
Aluminum (Al)	Eriochrome Cyanine R. Colorimetric	1,4	0.010
Arsenic (As)	Pyridine - AgDDC, Colorimetric	1,2,3,4,5	0.005
Cadmium (Cd)	AA	3,5,	0.005
Chromium (Cr)	AA	3,5	0.010
Copper (Cu)	AA	3,5	0.005
Iron (Fe)	AA	3,5	0.010
Lead (Pb)	AA	3,5	0.010
Mercury (Hg)	FAA	2	0.00025
Molybdenum (Mo)	Dithiol, Colorimetric	6	0.020
Selenium (Se)	Diaminobenzidine Colorimetric	4	0.003
Vanadium (V)	AA	3,5	0.005
Zinc (Zn)	AA	3,5	0.005
CATIONS - Alkali Earths & Metals			
Calcium (Ca)	AA	3	0.01
Lithium (Li)	AA	3	0.001
Magnesium (Mg)	AA	3	0.02
Potassium (K)	AA	3	0.1
Sodium (Na)	AA	3	0.1
Strontium (Sr)	AA	3,5	0.010
ANIONS - General			
Boron (B)	Curcumin, Colorimetric	1,2,3,4,5	0.1
Chloride (Cl)	$Hg(CNS)_2$, Colorimetric	1,2,3,4,7	0.1
Fluoride (F)	SPANS	3,4	0.05
Sulfate (SO_4)	Turbidimetric ($BaCl_2$)	1,3,4	1
ANIONS - Nutrients			
Total Kjeldahl Nitrogen (N)	Digestion, distillation & Nessler	1,4	0.02
Nitrate Nitrogen (NO_3 - N)	Brucine Colorimetric	3,4	0.02
Nitrite Nitrogen (NO_2 - N)	Diazotization Colorimetric	3,4	0.001
Total Orthophosphate Phosphorus (P)	Molybdate $SnCl_2 \cdot 2H_2O$ Colorimetric	1,2,4	0.003
ORGANIC, NONIONIC & CALCULATED VALUES			
COD	$K_2Cr_2O_7$ Digestion & FAS Titration	1,2,3,4,5	10
TOC	Carbon analyzer	1,4	1
Phenol	4 - Aminoantipyrine Colorimetric	1,3,4	0.002
Total Hardness ($CaCO_3$)	Calculation (Ca, Mg)	1,4,5	1
Total Alkalinity ($CaCO_3$)	Potentiometric	2,3,4	0.5
PHYSICAL DATA			
pH (units)	Potentiometric	1,2,3,4,5	0.1
Specific Conductance (μmhos/cm @ 25°)	Conductivity meter	1,2,3,4	0.2
True Color (Pt-Co units)	Centrifuge & Comparator	1,2,5	5
Temperature (°C)	Field	-	-
Turbidity (NTU)	Turbidimetric	1,2,3,4	0.1
PHYSICAL DATA - Residues			
Total Residue	Gravimetric	1,2,3,4	1
Filtrable Residue	Gravimetric	1,2,3,4	1
Nonfiltrable Residue	Gravimetric	1,2,3,4	1
Fixed Total Residue	Gravimetric	1,2,3,4	1
Fixed Filtrable Residue	Gravimetric	1,2,3,4	1
Fixed Nonfiltrable Residue	Gravimetric	1,2,3,4	1
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS			
BOD	Incubation & dissolved oxygen meter	1,2,3,4,5	1
D.O.	Field (Winkler & D.O. meter)	2,3,4,5	0.1
% Saturation	Calculation	-	-

REFERENCES FOR ANALYTICAL METHODS

1. A Laboratory Manual for the Chemical Analysis of Water, Wastewaters and Biological Tissues by Chemistry Laboratory, Water Resources Service, Dept. of Lands, Forests and Water Resources, Province of British Columbia. January 1973.
2. Methods for Chemical Analysis of Waters and Wastewaters by W.J. Traversy, Water Quality Division, Inland Waters Branch, Dept. of Fisheries and Forestry, Ottawa, Ontario. 1971.
3. Methods for Chemical Analysis of Water and Waters by U.S. Environmental Protection Agency, Methods Dev. & Quality Assurance Research Laboratory, National Environmental Research Centre, Cincinnati, Ohio 45268. 1974.
4. Standard Methods for the Examination of Water and Wastewater, 13th Edition by American Health Association American Water Works Association Water Pollution, Control Federation, Washington, D.C. 1971.
5. Environment Canada Analytical Methods Manual by Inland Waters Directorate, Water Quality Branch, Ottawa,
6. Colorimetric Determination of Traces of Metals, 3rd Edition by E.B. Sandell, Interscience Publishers, Inc. New York. 1959.
7. Water Analysis by Atomic Absorption Spectroscopy by C.R. Parker, Varian Techtron Pty. Limited, Sprinvale, Victoria, Australia. 1972.

TABLE C1-4

SURFACE WATER SAMPLE COLLECTION DATES

SURFACE WATERS	Sept. 76	Dec. 76	March 77	May 77
Station 1	18 Sept.	6 Dec.	16 March	20 May
Station 3	18 Sept.	5 Dec.	15 March	24 May
Station 4	16 Sept.	5 Dec.	16 March	25 May
Station 5	16 Sept.	5 Dec.	16 March	23 May
Station 6	16 Sept.	-	-	-
Station 7	16 Sept.	30 Nov.	15 March	22 May
Station 10	15 Sept.	-	-	26 May
Station 14	15 Sept.	30 Nov.	14 March	20 May
Station 16	17 Sept.	3 Dec.	14 March	24 May
Station 17	17 Sept.	3 Dec.	15 March	27 May
Station 18	18 Sept.	6 Dec.	17 March	23 May
Station 19	18 Sept.	6 Dec.	16 March	30 May

BULK SAMPLE PROGRAM

	COLLECTION NUMBER				
	1	2	3	4	5
Hat Creek Station 1	26 Apr. 77	11 May 77	24 May 77	8 June 77	22 June 77
Hat Creek Station 2	-	11 May 77	24 May 77	8 June 77	22 June 77
Hat Creek Station 3	26 Apr. 77	11 May 77	24 May 77	8 June 77	22 June 77

	6	7	8	9
Hat Creek Station 1	5 July 77	20 July 77	4 Aug. 77	14 Sept. 77
Hat Creek Station 2	5 July 77	20 July 77	4 Aug. 77	14 Sept. 77
Hat Creek Station 3	5 July 77	20 July 77	3 Aug. 77	14 Sept. 77

SPECIAL COLLECTIONS

Freshet (Turb., Cond., S.S.)

Station 1	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 3	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 4	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 5	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 6	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 7	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77
Station 14	19 May 77 to 28 May 77 Incl.	8, 9 & 10 June 77

PIT HYDROLOGY STUDY

Aleece Lake	9 September 1976
Hat Creek (Below Finney Creek)	9 September 1976

GENERATION SITE STUDY

	COLLECTION NUMBER			
	1	2	3	4
Medicine Creek	21 May 77	27 July 77	6 Aug. 77	13 Sept. 77
MacLaren Creek	27 July 77	6 Aug. 77		

PAVILION LAKE STUDY

Pavilion Lake	27 July 77	6 Aug. 77	13 Sept. 77	

TABLE C1-5

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 1

STATION: DW 1

PARAMETER (mg/l)	Dec. 1976	May 1977	$\bar{x}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	0.020	0.020	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	<0.00025	<0.00025	<0.00025
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.069	0.069	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	60	58	59	2
Lithium (Li)	-	0.004	0.004	-
Magnesium (Mg)	18	20	19	2
Potassium (K)	-	-	-	-
Sodium (Na)	18	23	21	5
Strontium (Sr)	0.35	0.30	.33	0.05
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	1.1	1.6	1.4	0.5
Fluoride (F)	0.54	0.113	0.33	0.427
Sulfate (SO_4)	53	61	57	8
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.11	0.36	0.24	0.25
Nitrate Nitrogen (NO_3 - N)	<0.020	0.06	<0.04	<0.040
Nitrite Nitrogen (NO_2 - N)	<0.0010	<0.0010	<0.0010	<0.0010
Total Orthophosphate Phosphorus (P)	0.035	0.043	0.039	0.008
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	45	45	-
TOC	-	24	24	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	224	227	226	3
Total Alkalinity ($CaCO_3$)	233	226	230	7
PHYSICAL DATA				
pH (units)	8.3	8.3	8.3	0
Specific Conductance (μmhos/cm @ 25°)	490	520	505	30
True Color (Pt-Co units)	10	20	15	10
Turbidity (NTU)	1.4	1.8	1.6	0.4
PHYSICAL DATA - Residues				
Total Residue	335	356	346	21
Filtrable Residue	331	347	339	16
Nonfiltrable Residue	4	9	7	5
Fixed Total Residue	273	271	272	2
Fixed Filtrable Residue	271	262	267	9
Fixed Nonfiltrable Residue	2	9	6	7

TABLE C1-6

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 2

STATION: DW 2

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{x}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	0.014	0.014	-
Arsenic (As)	-	<0.005	<0.005	
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	0.010	0.010	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	0.00026	<0.00025	<0.00025
Molybdenum (Mo)	-	*<0.020*	*<0.020*	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.008	0.008	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	84'	87	86	3
Lithium (Li)	-	0.003	0.003	-
Magnesium (Mg)	16	18	17	2
Potassium (K)	-	-	-	-
Sodium (Na)	15	14	15	1
Strontium (Sr)	0.33	0.26	.30	0.07
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	2.4	2.4	2.4	0
Fluoride (F)	0.56	0.082	0.32	0.478
Sulfate (SO_4)	49	57	53	8
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.05	0.08	0.07	0.03
Nitrate Nitrogen (NO_3-N)	0.13	0.15	0.14	0.02
Nitrite Nitrogen (NO_2-N)	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Orthophosphate Phosphorus (P)	0.016	0.004	0.010	0.012
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	31	31	-
TOC	-	17	17	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	276	291	284	15
Total Alkalinity ($CaCO_3$)	270	271	271	1
PHYSICAL DATA				
pH (units)	7.9	7.6	7.8	0.3
Specific Conductance (μmhos/cm @ 25°)	580	600	590	20
True Color (Pt-Co Units)	5	<5	<5	<5
Turbidity (NTU)	0.10	0.25	0.18	0.15
PHYSICAL DATA - Residues				
Total Residue	391	397	394	6
Filtrable Residue	389	395	392	6
Nonfiltrable Residue	2	2	2	0
Fixed Total Residue	389	346	368	43
Fixed Filtrable Residue	389	345	377	44
Fixed Nonfiltrable Residue	<1	1	<1	<1

TABLE C1-7

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 3

STATION: DW 3

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	0.015	0.015	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	<0.00025	<0.00025	<0.00025
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.025	0.025	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	73	81	77	8
Litnium (Li)	-	0.004	0.004	-
Magnesium (Mg)	15	17	16	2
Potassium (K)	-	-	-	-
Sodium (Na)	12	13	13	1
Strontium (Sr)	0.29	0.24	0.27	0.05
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	1.6	2.1	1.9	0.5
Fluoride (F)	0.55	0.084	0.32	0.46
Sulfate (SO_4)	28	37	33	9
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.06	0.38	0.22	0.32
Nitrate Nitrogen (NO_3-N)	0.28	0.32	0.30	0.04
Nitrite Nitrogen (NO_2-N)	<0.0010	0.0016	<0.0013	<0.0016
Total Orthophosphate Phosphorus (P)	0.011	0.022	0.017	0.011
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	38	38	-
TOC	-	16	16	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	244	272	258	28
Total Alkalinity ($CaCO_3$)	254	257	257	3
PHYSICAL DATA				
pH (units)	7.9	7.7	7.8	0.2
Specific Conductance (μmhos/cm @ 25°)	480	540	510	60
True Color (Pt-Co units)	5	5	5	0
Turbidity (NTU)	0.10	0.75	0.43	0.65
PHYSICAL DATA - Residues				
Total Residue	344	349	347	5
Filtrable Residue	341	342	342	1
Nonfiltrable Residue	3	7	5	4
Fixed Total Residue	309	295	302	14
Fixed Filtrable Residue	309	290	300	19
Fixed Nonfiltrable Residue	<1	5	3	<5

TABLE C1-8

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 4

STATION: DW 4

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	0.015	0.015	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	<0.00025	<0.00025	<0.00025
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.12	0.12	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	59	64	62	5
Lithium (Li)	-	0.004	0.004	-
Magnesium (Mg)	16	18	17	2
Potassium (K)	-	-	-	-
Sodium (Na)	16	23	20	7
Strontium (Sr)	0.35	0.29	0.32	0.06
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	0.98	1.4	1.2	0.4
Fluoride (F)	0.49	0.100	0.75	0.051
Sulfate (SO_4)	45	66	56	21
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.07	0.21	0.14	0.14
Nitrate Nitrogen (NO_3-N)	0.050	0.050	0.050	0.050
Nitrite Nitrogen (NO_2-N)	<0.0010	<0.0010	<0.0010	<0.0010
Total Orthophosphate Phosphorus (P)	0.045	0.050	0.048	0.005
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	38	38	-
TOC	-	22	22	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	213	234	224	21
Total Alkalinity ($CaCO_3$)	222	228	225	6
PHYSICAL DATA				
pH (units)	7.7	7.6	7.7	0.1
Specific Conductance (μmhos/cm @ 25°)	470	530	500	60
True Color (Pt-Co units)	5	5	5	0
Turbidity (NTU)	0.10	0.20	0.15	0.10
PHYSICAL DATA - Residues				
Total Residue	328	350	339	22
Filtrable Residue	326	348	337	22
Nonfiltrable Residue	2	2	2	0
Fixed Total Residue	301	302	302	1
Fixed Filtrable Residue	301	300	301	1
Fixed Nonfiltrable Residue	<1	2	<2	<2

TABLE C1-9

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 5

STATION: DW 5

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	0.069	0.069	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	<0.00025	<0.00025	<0.00025
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	0.014	0.014	-
Zinc (Zn)	-	0.013	0.013	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	54	54	54	0
Lithium (Li)	-	0.003	0.003	-
Magnesium (Mg)	14	14	14	0
Potassium (K)	-	-	-	-
Sodium (Na)	17	13	15	4
Strontium (Sr)	0.29	0.25	0.27	0.04
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	0.60	1.0	0.80	0.40
Fluoride (F)	0.56	0.085	0.32	0.47
Sulfate (SO_4)	37	34	36	3
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.09	0.11	0.10	0.02
Nitrate Nitrogen (NO_3-N)	0.020	0.13	0.08	0.11
Nitrite Nitrogen (NO_2-N)	<0.0010	<0.0010	<0.0010	<0.0010
Total Orthophosphate Phosphorus (P)	0.062	0.045	0.059	0.017
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	<10	<10	-
TOC	-	4	4	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	193	192	193	1
Total Alkalinity ($CaCO_3$)	193	188	191	5
PHYSICAL DATA				
pH (units)	7.7	7.7	7.7	0
Specific Conductance (μmhos/cm @ 25°)	400	420	410	20
True Color (Pt-Co units)	10	<5	<10	<10
Turbidity (NTU)	1.2	0.40	0.80	0.80
PHYSICAL DATA - Residues				
Total Residue	291	272	282	19
Filtrable Residue	290	269	280	21
Nonfiltrable Residue	1	3	2	2
Fixed Total Residue	268	226	247	42
Fixed Filtrable Residue	268	226	247	42
Fixed Nonfiltrable Residue	<1	<1	<1	<1

TABLE C1-10

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL B

STATION: DW B

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	0.015	0.015	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	0.022	0.022	-
Iron (Fe)	-	0.059	0.059	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	0.00032	0.00026	0.00029	0.00006
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.62	0.62	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	130	180	155	50
Lithium (Li)	-	0.012	0.012	-
Magnesium (Mg)	49	67	58	18
Potassium (K)	-	-	-	-
Sodium (Na)	95	120	108	25
Strontium (Sr)	1.0	1.0	1.0	0
ANIONS - General				
Boron (B)	-	1.3	1.3	-
Chloride (Cl)	55	79	67	24
Fluoride (F)	0.70	0.18	0.44	0.52
Sulfate (SO_4)	110	160	135	50
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.41	0.66	0.54	0.25
Nitrate Nitrogen (NO_3-N)	0.060	2.0	1.0	1.94
Nitrite Nitrogen (NO_2-N)	0.0020	0.0038	0.0029	0.0018
Total Orthophosphate Phosphorus (P)	0.045	0.033	0.039	0.012
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	55	55	-
TOC	-	67	67	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	527	725	626	198
Total Alkalinity ($CaCO_3$)	626	685	655	59
PHYSICAL DATA				
pH (units)	7.4	7.4	7.4	0
Specific Conductance (μmhos/cm @ 25°)	1400	1900	1750	500
True Color (Pt-Co units)	10	10	10	0
Turbidity (NTU)	2.7	2.3	2.5	0.4
PHYSICAL DATA - Residues				
Total Residue	929	1103	966	74
Filtrable Residue	926	1100	963	74
Nonfiltrable Residue	3	3	3	0
Fixed Total Residue	804	928	866	124
Fixed Filtrable Residue	804	925	865	121
Fixed Nonfiltrable Residue	<1	3	<2	<3

TABLE C1-11

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 9

STATION: DW 9

PARAMETER (mg/t)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	0.038	0.038	-
Iron (Fe)	-	0.016	0.016	-
Lead (Pb)	-	<0.010	<0.0 0	-
Mercury (Hg)	<0.00025	0.00035	<0.00035	<0.00035
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.28	0.28	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	72	70	71	2
Lithium (Li)	-	0.008	0.008	-
Magnesium (Mg)	37	32	35	5
Potassium (K)	-	-	-	-
Sodium (Na)	8.8	9.8	9.3	1.0
Strontium (Sr)	0.70	0.60	0.65	0.10
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	0.82	0.45	0.64	0.37
Fluoride (F)	0.91	0.078	0.49	0.83
Sulfate (SO_4)	78	75	77	3
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.06	0.08	0.07	0.02
Nitrate Nitrogen (NO_3-N)	0.065	0.07	0.07	0.005
Nitrite Nitrogen (NO_2-N)	<0.0010	<0.0010	<0.0010	<0.0010
Total Orthophosphate Phosphorus (P)	0.011	0.009	0.010	0.002
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	41	41	-
TOC	-	26	26	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	332	178	255	154
Total Alkalinity ($CaCO_3$)	286	268	277	18
PHYSICAL DATA				
pH (units)	8.1	7.9	8.0	0.2
Specific Conductance (µmhos/cm @ 25°)	630	360	495	270
True Color (Pt-Co units)	15	<5	<10	<15
Turbidity (NTU)	0.15	0.50	0.33	0.35
PHYSICAL DATA - Residues				
Total Residue	434	403	419	31
Filtrable Residue	432	400	416	32
Nonfiltrable Residue	2	3	3	1
Fixed Total Residue	381	332	357	49
Fixed Filtrable Residue	381	329	355	52
Fixed Nonfiltrable Residue	<1	3	<2	<3

TABLE C1-12

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 10

STATION: DW 10

PARAMETER (mg/ℓ)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	0.010	0.010	-
Arsenic (As)	-	<0.005	<0.005	-
Cadmium (Cd)	-	<0.005	<0.005	-
Chromium (Cr)	-	<0.010	<0.010	-
Copper (Cu)	-	<0.005	<0.005	-
Iron (Fe)	-	1.8	1.8	-
Lead (Pb)	-	<0.010	<0.010	-
Mercury (Hg)	<0.00025	0.00035	<0.00030	<0.00035
Molybdenum (Mo)	-	<0.020	<0.020	-
Selenium (Se)	-	<0.003	<0.003	-
Vanadium (V)	-	<0.005	<0.005	-
Zinc (Zn)	-	0.040	0.040	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	89	88	89	1
Lithium (Li)	-	0.005	0.005	-
Magnesium (Mg)	36	32	34	4
Potassium (K)	-	-	-	-
Sodium (Na)	16	16	16	0
Strontium (Sr)	0.48	0.35	0.42	0.13
ANIONS - General				
Boron (B)	-	<0.1	<0.1	-
Chloride (Cl)	2.6	4.6	3.6	2.0
Fluoride (F)	0.33	0.126	0.23	0.20
Sulfate (SO_4)	73	78	76	5
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.33	0.36	0.35	0.03
Nitrate Nitrogen (NO_3-N)	<0.020	0.14	<0.08	-
Nitrite Nitrogen (NO_2-N)	0.0010	<0.0010	<0.0010	<0.0010
Total Orthophosphate Phosphorus (P)	0.12	0.087	0.10	0.033
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	48	48	-
TOC	-	32	32	-
Phenol	-	<0.002	<0.002	-
Total Hardness ($CaCO_3$)	370	351	361	19
Total Alkalinity ($CaCO_3$)	354	310	332	44
PHYSICAL DATA				
pH (units)	7.3	7.2	7.3	0.1
Specific Conductance (μmhos/cm @ 25°)	740	820	785	90
True Color (Pt-Co units)	20	10	15	10
Turbidity (NTU)	36	12	24	24
PHYSICAL DATA - Residues				
Total Residue	527	478	503	49
Filtrable Residue	519	475	497	44
Nonfiltrable Residue	8	3	6	5
Fixed Total Residue	456	393	424	63
Fixed Filtrable Residue	450	390	420	60
Fixed Nonfiltrable Residue	6	3	5	3

TABLE C1-13

GROUNDWATER ANALYTICAL DATA - DOMESTIC WELL 12

STATION: DW 12

PARAMETER (mg/L)	Dec. 76	May 77	$\bar{X}$	R
CATIONS - Trace Metals				
Aluminum (Al)	-	<0.010	<0.010	
Arsenic (As)	-	<0.005	<0.005	
Cadmium (Cd)	-	<0.005	<0.005	
Chromium (Cr)	-	<0.010	<0.010	
Copper (Cu)	-	<0.005	<0.005	
Iron (Fe)	-	0.33	0.33	
Lead (Pb)	-	<0.010	<0.010	
Mercury (Hg)	-	0.00035	0.00035	
Molybdenum (Mo)	-	<0.020	<0.020	
Selenium (Se)	-	<0.003	<0.003	
Vanadium (V)	-	<0.005	<0.005	
Zinc (Zn)	-	0.040	0.040	
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	-	50	50	
Lithium (Li)	-	0.003	0.003	
Magnesium (Mg)	-	13	13	
Potassium (K)	-	-	-	
Sodium (Na)	-	9.1	9.1	
Strontium (Sr)	-	0.11	0.11	
ANIONS - General				
Boron (B)	-	<0.1	<0.1	
Chloride (Cl)	-	<0.10	<0.10	
Fluoride (F)	-	0.078	0.078	
Sulfate (SO_4)	-	13	13	
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	-	0.08	0.08	
Nitrate Nitrogen (NO_3-N)	-	0.07	0.07	
Nitrite Nitrogen (NO_2-N)	-	0.0011	0.0011	
Total Orthophosphate Phosphorus (P)	-	0.009	0.009	
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	41	41	
TOC	-	8	8	
Phenol	-	<0.002	<0.002	
Total Hardness ($CaCO_3$)	-	178	178	
Total Alkalinity ($CaCO_3$)	-	185	185	
PHYSICAL DATA				
pH (units)	-	7.9	7.9	
Specific Conductance (μmhos/cm @ 25°)	-	360	360	
True Color (Pt-Co units)	-	<5	<5	
Turbidity (NTU)	-	2.2	2.2	
PHYSICAL DATA - Residues				
Total Residue	-	222	222	
Filtrable Residue	-	219	219	
Nonfiltrable Residue	-	3	3	
Fixed Total Residue	-	196	196	
Fixed Filtrable Residue	-	194	194	
Fixed Nonfiltrable Residue	-	2	2	

TABLE C1-14

GROUNDWATER ANALYTICAL DATA - STEEL BROS. LIMESTONE QUARRY WELL

STATION: Steel Bros. Limestone Quarry

PARAMETER (mg/ℓ)	
CATIONS - Alkali Earths and Metals	
Calcium (Ca)	71.4
Magnesium (Mg)	45.4
Sodium (Na)	8.4
Potassium (K)	3.4
ANIONS - General	
Bicarbonate (HCO_3)	350
Sulfate	78
Chloride (Cl)	14.5
PHYSICAL DATA	
Specific Conductance (µmhos/cm 25°C)	666
pH	7.40

Sampled by Golder Brawner - Analyzed by Can-Test

TABLE C1-15

GROUNDWATER ANALYTICAL DATA - ARTESIAN SPRINGS

STATION:	AS-1		AS-2	AS-3 (West)	AS-3 (East)
PARAMETER (mg/ℓ)	Nov. 22 /76	July 20 /77	Nov. 22 /76	Nov. 22 /76	Nov. 22 /76
CATIONS - Trace Metals					
Aluminum (Al)	-	*	-	-	-
Arsenic (As)	-	*	-	-	-
Cadmium (Cd)	-	-	-	-	-
Chromium (Cr)	-	*	-	-	-
Copper (Cu)	-	0.15†	-	-	-
Iron (Fe)	-	0.12	-	-	-
Lead (Pb)	-	-	-	-	-
Mercury (Hg)	-	*	-	-	-
Molybdenum (Mo)	-	-	-	-	-
Selenium (Se)	-	*	-	-	-
Vanadium (V)	-	0.001	-	-	-
Zinc (Zn)	-	0.032	-	-	-
CATIONS - Alkali Earths & Metals					
Calcium (Ca)	74	72	72	62	140
Lithium (Li)	-	0.007	-	-	-
Magnesium (Mg)	14	16	33	15	66
Potassium (K)	-	-	-	-	-
Sodium (Na)	14	12	9.4	17	28
Strontium (Sr)	-	0.18	-	-	-
ANIONS - General					
Boron (B)	-	*	-	-	-
Chloride (Cl)	1.6	2.3	0.50	1.7	7.6
Fluoride (F)	-	0.017	-	-	-
Sulfate (SO_4)	35	37	76	44	250
ANIONS - Nutrients					
Total Kjeldahl Nitrogen (N)	-	-	-	-	-
Nitrate Nitrogen (NO_3-N)	-	-	-	-	-
Nitrite Nitrogen (NO_2-N)	-	-	-	-	-
Total Orthophosphate Phosphorus (P)	-	0.014	-	-	-
ORGANIC, NONIONIC & CALCULATED VALUES					
COD	-	*	-	-	-
TOC	-	30	-	-	-
Phenol	-	-	-	-	-
Total Hardness ($CaCO_3$)	-	246	-	-	-
Total Alkalinity ($CaCO_3$)	255	257	271	212	439
PHYSICAL DATA					
pH (units)	7.6	7.9	8.1	7.3	7.6
Specific Conductance (μmhos/cm @ 25°)	510	540	550	460	1100
True Color (Pt-Co units)	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-
PHYSICAL DATA - Residues					
Total Residue	-	349	-	-	-
Filtrable Residue	-	349	-	-	-
Nonfiltrable Residue	-	<1	-	-	-
Fixed Total Residue	-	-	-	-	-
Fixed Filtrable Residue	-	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-	-

* Denotes < MDC

† Contamination Suspected

Collected by Golder, Brawner personnel.

TABLE C1-16

GROUNDWATER ANALYTICAL DATA - PIT HYDROLOGY PROGRAM

STATION:	Station 1	Station 4	Station 6
PARAMETER (mg/L)	Aleece Creek	Well RH 76-19 (Before Pumping)	Well RH 76-19 (After 21 Day Pump)
CATIONS - Trace Metals			
Aluminum (Al)	-	-	0.004
Arsenic (As)	-	-	<0.005
Cadmium (Cd)	-	-	<0.001
Chromium (Cr)	-	-	<0.001
Copper (Cu)	-	-	0.007
Iron (Fe)	-	-	<0.05
Lead (Pb)	-	-	0.020
Mercury (Hg)	-	-	< 0.0002
Molybdenum (Mo)	-	-	-
Selenium (Se)	-	-	< 0.004
Vanadium (V)	-	-	< 0.10
Zinc (Zn)	-	-	1.97
CATIONS - Alkali Earths & Metals			
Calcium (Ca)	44.8	19.0	47.7
Lithium (Li)	-	-	0.05
Magnesium (Mg)	21.7	9.4	21.6
Potassium (K)	9.0	18.0	34.0
Sodium (Na)	33.0	110	330
Strontium (Sr)	-	-	0.06
ANIONS - General			
Boron (B)	-	-	<0.1
Chloride (Cl)	-	<0.5	<0.5
Fluoride (F)	-	-	0.067
Sulfate (SO_4)	-	47.7	17.3
ANIONS - Nutrients			
Total Kjeldahl Nitrogen (N)	-	-	22.2
Nitrate Nitrogen (NO_3-N)	-	-	<0.10
Nitrite Nitrogen (NO_2-N)	-	-	<0.001
Total Orthophosphate Phosphorus (P)	-	-	<0.01
ORGANIC, NONIONIC & CALCULATED VALUES			
COD	-	-	-
TOC	-	-	-
Phenol	-	-	-
Total Hardness ($CaCO_3$)	201	86	208
Total Alkalinity ($CaCO_3$)	-	213	943
PHYSICAL DATA			
pH (units)	7.85	7.6	7.6
Specific Conductance (µmhos/cm @ 25°)	508	677	1834
True Color (Pt-Co units)	-	-	-
Turbidity (NTU)	-	-	-
Temperature (°C)	-	-	-
PHYSICAL DATA - Residues			
Total Residue	-	-	-
Filtrable Residue	-	-	1600
Nonfiltrable Residue	-	-	-
Fixed Total Residue	-	-	-
Fixed Filtrable Residue	-	-	1400
Fixed Nonfiltrable Residue	-	-	-

NOTE: Field Collection conducted by Golder-Brawner and analysis by Cantest.

TABLE C1-17

GROUNDWATER ANALYTICAL DATA - BUCKET AUGER HOLE #7

STATION: Coal Seam Groundwater	Bucket Auger Hole 7	
PARAMETER (mg/ℓ)	Coal Seam 19 September 1976	
CATIONS - Trace Metals		
Aluminum (Al)	(0.030)	
Arsenic (As)	(0.012)	
Cadmium (Cd)	(*)	
Chromium (Cr)	(*)	
Copper (Cu)	(*)	
Iron (Fe)	(0.14)	0.11
Lead (Pb)		*
Mercury (Hg)	(0.00039)	
Molybdenum (Mo)		-
Selenium (Se)	(*)	
Vanadium (V)	(*)	
Zinc (Zn)	(0.009)	0.006
CATIONS - Alkali Earths & Metals		
Calcium (Ca)		48
Lithium (Li)	(0.015)	*
Magnesium (Mg)		41
Potassium (K)		27
Sodium (Na)		300
Strontium (Sr)	(0.20)	0.26
ANIONS - General		
Boron (B)	(*)	
Chloride (Cl)		8.2
Fluoride (F)		0.33
Sulfate (SO_4)		260
ANIONS - Nutrients		
Total Kjeldahl Nitrogen (N)		5.7
Nitrate Nitrogen (NO_3 - N)		0.02
Nitrite Nitrogen (NO_2 - N)		0.0010
Total Orthophosphate Phosphorus (P)		0.037
ORGANIC, NONIONIC & CALCULATED VALUES		
COD		-
TOC		21
Phenol		-
Total Hardness ($CaCO_3$)		289
Total Alkalinity ($CaCO_3$)		791
PHYSICAL DATA		
pH (units)		7.3
Specific Conductance (μmhos/cm @ 25°)		1700
True Color (Pt-Co Units)		20
Turbidity (NTU)		3.3
Temperature (°C)		10
PHYSICAL DATA - Residues		
Total Residue		1244
Filtrable Residue		1220
Nonfiltrable Residue		24
Fixed Total Residue		1068
Fixed Filtrable Residue		1060
Fixed Nonfiltrable Residue		8
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS		
BOD		7
O.D.		0.8
% Saturation		-

* Denotes <MDC
() Denotes Total Concentration

TABLE C1-18

GROUNDWATER ANALYTICAL DATA - POWER PLANT SITE PROGRAM

STATION: Drill Hole		RH - 77 - 45			RH - 77 - 48			RH-77-49
SAMPLE DEPTH: m		89.9	62.9	35.2	89.9	77.0	58.1	89.1
PARAMETER: (mg/ℓ)								
pH (Units)		7.75	8.00	8.15	8.10	8.10	8.35	8.00
Conductivity (μ mhos/cm)		626.	689.	729.	936.	1019.	872.	1326.
Total Hardness ($CaCO_3$)		281.	269.	258.	81.	97.	57.	682.
Dissolved Anions								
Alkalinity								
Bicarbonates	(HCO_3)	325.	330.	344.	407.	476.	408.	672.
Carbonates	(CO_3)	NIL	NIL	NIL	NIL	NIL	3.04	NIL
Chlorides	(Cl)	5.0	6.0	7.0	4.0	5.0	3.5	2.0
Sulfates	(SO_4)	62.4	91.2	96.0	115.2	139.2	81.6	196.8
Dissolved Cations								
Calcium	(Ca)	64.4	55.2	54.3	20.2	25.1	15.2	123.4
Magnesium	(Mg)	29.3	32.0	29.9	7.4	8.3	4.6	91.2
Potassium	(K)	4.33	4.62	4.74	3.95	4.12	3.47	4.74
Sodium	(Na)	23.0	43.7	57.5	172.5	203.6	170.2	32.2
Iron	(Fe)	0.049	L 0.03	0.043	L 0.03	0.044	L 0.03	0.073
Copper	(Cu)	L 0.001	0.002	0.002	0.005	0.004	0.003	L 0.001
Manganese	(Mn)	0.014	0.071	0.21	0.002	0.013	0.001	0.13
Lead	(Pb)	L 0.001	0.001	L 0.001	0.002	0.002	0.002	L 0.001
Zinc	(Zn)	0.010	0.009	0.005	0.037	0.006	L 0.001	L 0.001
Cadmium	(Cd)	L 0.001	0.002	L 0.001	L 0.001	L 0.001	L 0.001	L 0.001
Strontium	(Sr)	0.62	0.45	0.43	0.30	0.33	0.38	1.26
Barium	(Ba)	0.031	0.042	0.038	0.030	0.031	0.020	0.071
Vanadium	(V)	L 0.04	L 0.04	L 0.04	L 0.04	L 0.04	L 0.04	L 0.04

Note:- Field Collection by Golder, Brawner
- Analyses by Can Test Ltd.
- L Denotes Less Than

TABLE C1-19

GROUNDWATER ANALYTICAL DATA - BULK SAMPLING PROGRAM #1 WELL

STATION: 1, Well

PARAMETER (mg/ℓ)	7 June 1977	21 June 1977
CATIONS - Trace Metals		
Aluminum (Al)	*	-
Arsenic (As)	*	-
Cadmium (Cd)	-	-
Chromium (Cr)	*	-
Copper (Cu)	*	-
Iron (Fe)	0.043	-
Lead (Pb)	-	-
Mercury (Hg)	*	-
Molybdenum (Mo)	-	-
Selenium (Se)	*	-
Vanadium (V)	*	-
Zinc (Zn)	0.013	-
CATIONS - Alkali Earths & Metals		
Calcium (Ca)	74	-
Lithium (Li)	0.004	-
Magnesium (Mg)	16	-
Potassium (K)	-	-
Sodium (Na)	19	-
Strontium (Sr)	0.27	-
ANIONS - General		
Boron (B)	*	-
Chloride (Cl)	1.5	-
Fluoride (F)	0.091	-
Sulfate (SO_4)	48	-
ANIONS - Nutrients		
Total Kjeldahl Nitrogen (N)	-	-
Nitrate Nitrogen (NO_3 - N)	-	-
Nitrite Nitrogen (NO_2 - N)	-	-
Dissolved Phosphate Phosphorus (P)	0.024	-
ORGANIC, NONIONIC & CALCULATED VALUES		
COD	-	-
TOC	20	-
Phenol	-	-
Total Hardness ($CaCO_3$)	251	-
Total Alkalinity ($CaCO_3$)	230	-
PHYSICAL DATA		
pH (units)	7.8	-
Specific Conductance (μmhos/cm @ 25°)	520	-
True Color (Pt-Co Units)	-	-
Turbidity (NTU)	-	-
Temperature (°C)	-	-
PHYSICAL DATA - Residues		
Total Residue	382	-
Filtrable Residue	342	-
Nonfiltrable Residue	40	-
Fixed Total Residue	-	-
Fixed Filtrable Residue	-	-
Fixed Nonfiltrable Residue	-	-

* Denotes <MDC

TABLE C1-20

GROUNDWATER ANALYTICAL DATA - BULK SAMPLING PROGRAM #2 WELL

STATION: 2, Well

PARAMETER (mg/ℓ)	7 June /77	21 June /77	6 July /77	20 July /77
CATIONS - Trace Metals				
Aluminum (Al)	*	*	0.010	0.030
Arsenic (As)	*	*	*	*
Cadmium (Cd)	-	-	-	-
Chromium (Cr)	*	*	*	*
Copper (Cu)	*	*	*	*
Iron (Fe)	0.034	0.024	0.035	0.13
Lead (Pb)	-	-	-	-
Mercury (Hg)	*	-	*	*
Molybdenum (Mo)	-	-	-	-
Selenium (Se)	0.006	0.005	*	0.004
Vanadium (V)	*	*	*	0.001
Zinc (Zn)	*	0.014	0.008	0.041
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	64	75	65	66
Lithium (Li)	0.003	0.004	0.005	0.004
Magnesium (Mg)	15	15	16	16
Potassium (K)	-	-	-	-
Sodium (Na)	18	18	18	18
Strontium (Sr)	0.20	0.21	0.28	0.23
ANIONS - General				
Boron (B)	*	*	*	*
Chloride (Cl)	1.7	1.4	1.3	1.3
Fluoride (F)	0.104	0.128	0.135	0.146
Sulfate (SO_4)	38	45	54	48
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-	-	-	-
Dissolved Phosphate Phosphorus (P)	0.032	0.033	0.043	0.009
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	-	-	-	-
TOC	27	32	24	50
Phenol	-	-	-	-
Total Hardness ($CaCO_3$)	222	249	228	231
Total Alkalinity ($CaCO_3$)	229	232	231	241
PHYSICAL DATA				
pH (units)	7.6	7.4	7.4	7.6
Specific Conductance (µmhos/cm @ 25°)	510	520	531	540
True Color (Pt-Co Units)	-	-	-	-
Turbidity (NTU)	-	-	-	-
Temperature (°C)	-	-	-	-
PHYSICAL DATA - Residues				
Total Residue	354	370	409	387
Filtrable Residue	330	346	340	349
Nonfiltrable Residue	24	24	69	38
Fixed Total Residue	-	-	-	-
Fixed Filtrable Residue	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-

* Denotes <MDC

TABLE C1-21

GROUNDWATER ANALYTICAL DATA - BULK SAMPLING PROGRAM # 3 WELL

STATION: 3, Well

PARAMETER (Mg/l)	7 June /77	21 June /77	6 July /77	20 July /77	4 Aug. /77
CATIONS - Trace Metals					
Aluminum (Al)	*	*	*	0.057	*
Arsenic (As)	*	*	*	*	*
Cadmium (Cd)	-	-	-	-	-
Chromium (Cr)	*	*	*	*	*
Copper (Cu)	0.007	*	*	*	*
Iron (Fe)	0.060	0.081	0.23	0.25	0.19
Lead (Pb)	-	-	-	-	-
Mercury (Hg)	*	*	*	*	0.00063
Molybdenum (Mo)	-	-	-	-	-
Selenium (Se)	*	*	*	*	*
Vanadium (V)	*	*	0.008	*	0.003
Zinc (Zn)	0.024	0.016	0.012	0.13†	0.10
CATIONS - Alkali Earths & Metals					
Calcium (Ca)	260	260	230	250	230
Lithium (Li)	0.064	0.063	0.067	0.007	0.055
Magnesium (Mg)	81	83	85	88	65
Potassium (K)	-	-	-	-	-
Sodium (Na)	360	380	400	440	340
Strontium (Sr)	0.72	0.70	2.1	0.99	1.8
ANIONS - General					
Boron (B)	0.2	0.2	0.1	0.2	0.2
Chloride (Cl)	7.4	7.5	7.3	7.4	7.7
Fluoride (F)	0.105	0.134	0.134	0.133	0.135
Sulfate (SO_4)	1400	1300	1360	1280	1300
ANIONS - Nutrients					
Total Kjeldahl Nitrogen (N)	-	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-	-	-	-	-
Dissolved Phosphate Phosphorus (P)	0.038	0.035	0.046	0.034	0.048
ORGANIC, NONIONIC & CALCULATED VALUES					
COD	-	-	-	-	-
TOC	97	102	101	80	61
Phenol	-	-	-	-	-
Total Hardness ($CaCO_3$)	993	991	924	987	842
Total Alkalinity ($CaCO_3$)	464	506	538	572	586
PHYSICAL DATA					
pH (units)	7.8	7.3	7.2	7.3	7.3
Specific Conductance (µmhos/cm @ 25°)	3000	3000	2970	3030	3030
True Color (Pt-Co Units)	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-
Temperature (°C)	-	-	-	-	-
PHYSICAL DATA - Residues					
Total Residue	2871	2877	2845	2851	2846
Filtrable Residue	2710	2730	2700	2690	2740
Nonfiltrable Residue	161	147	132	161	106
Fixed Total Residue	-	-	-	-	-
Fixed Filtrable Residue	-	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-	-

* Denotes <MDC

† Contamination Suspected

TABLE C1-22

GROUNDWATER ANALYTICAL DATA - BULK SAMPLING PROGRAM - TRENCH B

STATION: Trench B Groundwater

PARAMETER (mg/ℓ)	21 June /77	6 July /77	19 July /77	4 Aug. /77	14 Sept./77
CATIONS - Trace Metals					
Aluminum (Al)	*	*	0.025	*	*
Arsenic (As)	*	*	*	*	*
Cadmium (Cd)	-	-	-	-	-
Chromium (Cr)	*	*	*	*	*
Copper (Cu)	*	*	*	*	*
Iron (Fe)	0.009	0.012	0.022	*	0.014
Lead (Pb)	-	-	-	-	-
Mercury (Hg)	-	-	*	0.0020	*
Molybdenum (Mo)	-	-	-	-	-
Selenium (Se)	0.003	*	0.003	*	0.004
Vanadium (V)	*	*	0.002	0.003	*
Zinc (Zn)	0.012	*	0.009	0.047	0.007
CATIONS - Alkali Earths & Metals					
Calcium (Ca)	71	56	60	59	67
Lithium (Li)	0.004	0.004	0.005	0.004	0.004
Magnesium (Mg)	16	16	17	16	19
Potassium (K)	-	-	-	-	-
Sodium (Na)	21	19	20	26	26
Strontium (Sr)	0.23	0.26	0.24	0.25	0.32
ANIONS - General					
Boron (B)	*	*	*	*	*
Chloride (Cl)	1.4	1.1	1.3	1.3	1.1
Fluoride (F)	0.142	0.099	0.102	0.143	0.112
Sulfate (SO_4)	44	56	48	46	58
ANIONS - Nutrients					
Total Kjeldahl Nitrogen (N)	-	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-	-	-	-	-
Dissolved Phosphate Phosphorus (P)	0.032	0.024	0.026	0.026	0.025
ORGANIC, NONIONIC & CALCULATED VALUES					
COD	-	-	-	-	-
TOC	31	83	95	11	4
Phenol	-	-	-	-	-
Total Hardness ($CaCO_3$)	243	206	220	213	246
Total Alkalinity ($CaCO_3$)	222	218	229	236	257
PHYSICAL DATA					
pH (units)	8.0	7.9	7.8	8.0	8.0
Specific Conductance (μmhos/cm @ 25°)	510	499	530	540	603
True Color (Pt-Co Units)	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-
Temperature (°C)	-	-	-	-	-
PHYSICAL DATA - Residues					
Total Residue	387	-	38846	361	380
Filtrable Residue	339	340	346	357	376
Nonfiltrable Residue	46	-	31500	4	4
Fixed Total Residue	-	-	-	-	-
Fixed Filtrable Residue	-	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-	-

* Denotes <MDC

TABLE C1-23

SURFACE WATER ANALYTICAL DATA - UPPER HAT CREEK

STATION: 14, Upper Hat Creek

PARAMETER (mg/ℓ)	Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_{1s}$	S_{1s}	R
CATIONS - Trace Metals							
Aluminum (Al)	(0.31)	-	-	*	<0.010	ø	-
Arsenic (As)	(*)	-	-	*	<0.005	ø	-
Cadmium (Cd)	(*)	-	-	*	<0.005	ø	-
Chromium (Cr)	(*)	-	-	*	<0.010	ø	-
Copper (Cu)	(*)	-	-	*	<0.005	ø	-
Iron (Fe)	(0.20) 0.059	-	-	0.036	0.048	0.016	0.023
Lead (Pb)	(*)	-	-	*	<0.01	ø	-
Mercury (Hg)	(*)	*	*	0.00030	<0.00027	0.00003	0.00005
Molybdenum (Mo)		-	-	*	<0.020	ø	-
Selenium (Se)	(*)	-	-	*	<0.003	ø	-
Vanadium (V)	(*)	-	-	*	<0.005	ø	-
Zinc (Zn)	(0.006)0.008	-	-	0.006	0.007	0.001	0.002
CATIONS - Alkali Earths & Metals							
Calcium (Ca)	58	56	52	30	49	13	28
Lithium (Li)	(0.010)*	-	-	0.004	<0.0025	0.0021	0.003
Magnesium (Mg)	16	14	14	19	16	2.6	5
Potassium (K)	4.9	-	-	-	4.9	-	-
Sodium (Na)	19	16	16	18	17	1.5	3
Strontium (Sr)	(0.28) 0.26	0.30	0.27	0.30	0.28	0.020	0.04
ANIONS - General							
Boron (B)	(*)	-	-	*	<0.1	ø	-
Chloride (Cl)	0.56	0.55	0.63	0.68	0.61	0.64	0.13
Fluoride (F)	0.23	0.20	0.074	0.097	0.15	0.076	0.133
Sulfate (SO_4)	50	41	41	66	50	12	25
ANIONS - Nutrients							
Total Kjeldahl Nitrogen (N)	0.23	0.10	0.18	0.25	0.19	0.67	0.15
Nitrate Nitrogen (NO_3 - N)	0.04	0.03	0.12	0.04	0.06	0.04	0.09
Nitrite Nitrogen (NO_2 - N)	*	0.003	0.0018	*	<0.0017	0.00094	0.002
Total Orthophosphate Phosphorus (P)	0.090	0.033	0.035	0.043	0.050	0.027	0.047
ORGANIC, NONIONIC & CALCULATED VALUES							
COD	-	-	-	45	45	ø	-
TOC	6	-	-	11	8.5	3.5	5
Phenol	-	-	-	*	<0.002	ø	-
Total Hardness ($CaCO_3$)	219	198	187	153	189	27.6	63
Total Alkalinity ($CaCO_3$)	220	198	162	215	199	36.2	58
PHYSICAL DATA							
pH (units)	8.3	8.0	8.1	8.2	8.1	0.13	3
Specific Conductance (μmhos/cm @ 25°)	470	420	410	500	450	42.4	80
True Color (Pt-Co Units)	20	10	5	15	12	6.4	15
Turbidity (NTU)	3.7	0.75	1.2	0.55	1.6	1.5	3.15
Temperature (°C)	10.5	0	0	8	4.6	5.4	10.5
PHYSICAL DATA - Residues							
Total Residue	360	290	290	343	321	36.2	70
Filtrable Residue	340	283	286	341	312	32.4	55
Nonfiltrable Residue	20	7	4	2	8	8.1	18
Fixed Total Residue	296	262	213	292	266	38.3	83
Fixed Filtrable Residue	281	257	213	292	261	35.0	79
Fixed Nonfiltrable Residue	15	5	*	*	<8	6.6	15
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS							
BOD	*	-	-	-	<1		-
D.O.	9.5	12.5	12.3	10.5	11.2	1.45	3
% Saturation	96.4	97.5	95.9	102			

/ Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-24

SURFACE WATER ANALYTICAL DATA - MID UPPER HAT CREEK

STATION: 10, Mid-Upper Hat Creek

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_{14}$	S_{14}	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.39)		-	-	*	<0.010	ø	-
Arsenic (As)	(*)		-	-	*	<0.005	ø	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ø	-
Chromium (Cr)	(*)		-	-	*	<0.010	ø	-
Copper (Cu)	(*)		-	-	*	<0.005	ø	-
Iron (Fe)	(0.29)	0.057	-	-	0.017	0.037	0.028	0.040
Lead (Pb)	(*)		-	-	*	<0.010	ø	-
Mercury (Hg)	(*)		-	-	0.0012	0.0012	ø	-
Molybdenum (Mo)		-	-	-	*	<0.020	ø	-
Selenium (Se)	(*)		-	-	*	<0.003	ø	-
Vanadium (V)	(*)		-	-	*	<0.005	ø	-
Zinc (Zn)	(*)	*	-	-	*	<0.005	ø	-
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		60	-	-	57	58	2.1	3
Lithium (Li)	(0.010)	*	-	-	0.004	<0.0025	0.0021	0.003
Magnesium (Mg)		19	-	-	20	20	0.71	1
Potassium (K)		4.5	-	-	-	4.5	ø	-
Sodium (Na)		24	-	-	25	24	0.71	1
Strontium (Sr)	(0.28)	0.40	-	-	0.29	0.34	0.078	0.11
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ø	-
Chloride (Cl)		0.65	-	-	1.4	1.0	0.53	0.75
Fluoride (F)		0.26	-	-	0.11	0.18	0.11	0.15
Sulfate (SO_4)		48	-	-	66	57	13	18
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.22	-	-	0.31	0.27	0.64	0.09
Nitrate Nitrogen (NO_3 - N)		0.04	-	-	0.04	0.04	0	0
Nitrite Nitrogen (NO_2 - N)		*	-	-	*	<0.001	0	0
		0.081	-	-	0.050	0.065	0.022	0.031
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	10	10	ø	-
TOC		7	-	-	24	16	12	17
Phenol		-	-	-	*	<0.002	ø	-
Total Hardness ($CaCO_3$)		228	-	-	225	226	2.12	3
Total Alkalinity ($CaCO_3$)		232	-	-	224	228	5.66	8
PHYSICAL DATA								
pH (units)		8.4	-	-	8.4	8.4	0	0
Specific Conductance (μmhos/cm @ 25°)		480	-	-	510	495	21.2	30
True Color (Pt-Co Units)		15	-	-	20	18	3.5	5
Turbidity (NTU)		1.4	-	-	1.4	1.4	ø	0
Temperature (°C)		9.7	-	-	10	9.8	0.21	0.3
PHYSICAL DATA - Residues								
Total Residue		360	-	-	351	356	6.36	9
Filtrable Residue		354	-	-	347	350	4.95	7
Nonfiltrable Residue		6	-	-	4	5	1	2
Fixed Total Residue		291	-	-	268	280	16.3	23
Fixed Filtrable Residue		288	-	-	264	276	17.0	24
Fixed Nonfiltrable Residue		3	-	-	4	4	1	1
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ø	-
DO		9.8	-	-	10.2	10	0.28	0.4
% Saturation		95.7	-	-	101			

ø Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-25

SURFACE WATER ANALYTICAL DATA - MID HAT CREEK

STATION: 7, Mid-Hat Creek

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_7$	S_7	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.31)		-	-	*	<0.010	ϕ	-
Arsenic (As)	(*)		-	-	*	<0.005	ϕ	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ϕ	-
Chromium (Cr)	(*)		-	-	*	<0.010	ϕ	-
Copper (Cu)	(*)		-	-	*	<0.005	ϕ	-
Iron (Fe)	(0.048)	*	-	-	0.026	<0.018	0.011	0.016
Lead (Pb)	(*)		-	-	*	<0.010	0	-
Mercury (Hg)	(*)		*	0.00048	0.00042	<0.00038	0.00012	0.00023
Molybdenum (Mo)		-	-	-	*	<0.020	ϕ	-
Selenium (Se)	(*)		-	-	*	<0.003	ϕ	-
Vanadium (V)	(*)		-	-	*	<0.005	ϕ	-
Zinc (Zn)	(0.013)	0.008	-	-	0.007	0.008	0.0007	0.001
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		59	59	56	56	58	1.7	3
Lithium (Li)	(*)	*	-	-	0.003	<0.002	0.001	0.002
Magnesium (Mg)		19	16	16	18	17	1.5	3
Potassium (K)		4.0	-	-	-	4.0	ϕ	-
Sodium (Na)		21	18	19	22	20	1.8	4
Strontium (Sr)	(0.30)	0.30	0.33	0.30	0.28	0.30	0.021	0.005
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ϕ	-
Chloride (Cl)		1.2	1.1	1.3	1.3	1.2	0.095	0.2
Fluoride (F)		0.16	0.22	0.080	0.10	0.14	0.063	0.14
Sulfate (SO_4)		46	46	50	59	50	6.1	4.0
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.24	0.10	0.12	0.28	0.19	0.090	0.18
Nitrate Nitrogen (NO_3 - N)		0.05	*	0.13	0.05	<0.06	0.04	0.08
Nitrite Nitrogen (NO_2 - N)		*	0.003	0.0022	*	<0.0018	0.00097	0.002
Total Orthophosphate Phosphorus (P)		0.040	0.024	0.043	0.045	0.038	0.009	0.021
ORGANIC, IONIONIC & CALCULATED VALUES								
COD		-	-	-	17	17	ϕ	-
TOC		6	-	-	10	8	2.8	4
Phenol		-	-	-	*	<0.002	ϕ	-
Total Hardness ($CaCO_3$)		226	213	206	214	215	8.30	20
Total Alkalinity ($CaCO_3$)		237	228	171	211	212	29.2	66
PHYSICAL DATA								
pH (units)		8.4	8.3	8.3	8.4	8.4	0.057	0.1
Specific Conductance (μmhos/cm @ 25°)		480	470	460	480	472	9.57	20
True Color (Pt-Co Units)		15	10	5	15	11	4.8	10
Turbidity (NTU)		6.3	0.80	1.7	1.3	2.5	2.5	5.5
Temperature (°C)		12	0.5	1	12	6.4	6.5	11.5
PHYSICAL DATA - Residues								
Total Residue		363	348	331	335	344	14.4	32
Filtrable Residue		346	346	327	327	336	11.0	19
Nonfiltrable Residue		17	2	4	8	8	6.6	15
Fixed Total Residue		283	301	231	282	274	30.1	79
Fixed Filtrable Residue		270	300	231	276	269	28.6	69
Fixed Nonfiltrable Residue		13	1	*	6	<5	5.7	12
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ϕ	-
D.O.		9.2	12.8	12.9	9.6	11.1	1.99	3.7
% Saturation		88.9	98.5	99.2	77.1			

* Single value, standard deviation not applicable
< Denotes <MDC
() Denotes Total Concentration

TABLE C1-26

SURFACE WATER ANALYTICAL DATA - MID LOWER HAT CREEK

STATION: 6, Mid-Lower Hat Creek

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_6$	S_6	R
CATIONS - Trace Metals								
Aluminum (Al)	(*)		-	-	-	-	-	-
Arsenic (As)	(*)		-	-	-	-	-	-
Cadmium (Cd)	(*)		-	-	-	-	-	-
Chromium (Cr)	(*)		-	-	-	-	-	-
Copper (Cu)	(*)		-	-	-	-	-	-
Iron (Fe)	(*)	*	-	-	-	<0.010	ϕ	-
Lead (Pb)	(*)		-	-	-	-	-	-
Mercury (Hg)	(0.0019)		-	-	-	-	-	-
Molybdenum (Mo)		-	-	-	-	-	-	-
Selenium (Se)	(*)		-	-	-	-	-	-
Vanadium (V)	(*)		-	-	-	-	-	-
Zinc (Zn)	(*)	*	-	-	-	<0.005		-
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		64	-	-	-	64	ϕ	-
Lithium (Li)	(*)	*	-	-	-	<0.001	ϕ	-
Magnesium (Mg)		20	-	-	-	20	ϕ	-
Potassium (K)		3.1	-	-	-	3.1	ϕ	-
Sodium (Na)		17	-	-	-	17	ϕ	-
Strontium (Sr)	(0.25)	0.28	-	-	-	0.28	ϕ	-
ANIONS - General								
Boron (B)	(*)		-	-	-	-	-	-
Chloride (Cl)		0.87	-	-	-	0.87	ϕ	-
Fluoride (F)		0.24	-	-	-	0.24	ϕ	-
Sulfate (SO_4)		41	-	-	-	41	ϕ	-
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.12	-	-	-	0.12	ϕ	-
Nitrate Nitrogen (NO_3 - N)		0.04	-	-	-	0.04	ϕ	-
Nitrite Nitrogen (NO_2 - N)		*	-	-	-	<0.001	ϕ	-
Total Orthophosphate Phosphorus (P)		0.059	-	-	-	0.059	ϕ	-
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	-	-	-	-
TOC		4	-	-	-	4	ϕ	-
Phenol		-	-	-	-	-	-	-
Total Hardness ($CaCO_3$)		242	-	-	-	242	ϕ	-
Total Alkalinity ($CaCO_3$)		247	-	-	-	247	ϕ	-
PHYSICAL DATA								
pH (units)		8.5	-	-	-	8.5	ϕ	-
Specific Conductance (μmhos/cm @ 25°)		470	-	-	-	470	ϕ	-
True Color (Pt-Co Units)		10	-	-	-	10	ϕ	-
Turbidity (NTU)		1.2	-	-	-	1.2	ϕ	-
Temperature (°C)		12.5	-	-	-	12.5	ϕ	-
PHYSICAL DATA - Residues								
Total Residue		337	-	-	-	337	ϕ	-
Filtrable Residue		333	-	-	-	333	ϕ	-
Nonfiltrable Residue		4	-	-	-	4	ϕ	-
Fixed Total Residue		259	-	-	-	259	ϕ	-
Fixed Filtrable Residue		259	-	-	-	259	ϕ	-
Fixed Nonfiltrable Residue		*	-	-	-	<1	ϕ	-
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ϕ	-
D.O.		9.5	-	-	-	9.5	ϕ	-
% Saturation		97.6	-	-	-			

ϕ Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-28

SURFACE WATER ANALYTICAL DATA - UPPER BONAPARTE RIVER

STATION: 4, Upper Bonaparte River

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_s$	S_s	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.15)		-	-	*	<0.010	ϕ	-
Arsenic (As)	(*)		-	-	*	<0.005	ϕ	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ϕ	-
Chromium (Cr)	(*)		-	-	*	<0.010	ϕ	-
Copper (Cu)	(*)		-	-	*	<0.005	ϕ	-
Iron (Fe)	(0.057)	0.046	-	-	0.058	0.052	0.0084	0.012
Lead (Pb)	(*)		-	-	*	<0.010	ϕ	-
Mercury (Hg)	(*)		*	*	0.00064	<0.00038	0.00023	0.00039
Molybdenum (Mo)		-	-	-	0.030	0.030	ϕ	-
Selenium (Se)	(*)		-	-	*	<0.003	ϕ	-
Vanadium (V)	(*)		-	-	*	<0.005	ϕ	-
Zinc (Zn)	(*)	*	-	-	0.032	<0.018	0.0191	0.027
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		22	33	27	22	26	5.2	11
Lithium (Li)	(*)	*	-	-	0.001	<0.001	0	0
Magnesium (Mg)		10	20	18	12	15	4.8	10
Potassium (K)		1.9	-	-	-	1.9	ϕ	-
Sodium (Na)		8.0	14	14	8.9	11	3.2	6
Strontium (Sr)	(0.13)	0.05	0.29	0.17	0.11	0.13	0.067	0.15
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ϕ	-
Chloride (Cl)		0.58	1.1	1.1	0.75	0.88	0.26	0.53
Fluoride (F)		0.20	0.28	0.088	0.089	0.16	0.093	0.192
Sulfate (SO_4)		10	26	18	5.8	15	8.9	20.2
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.25	0.16	0.20	0.40	0.25	0.10	0.24
Nitrate Nitrogen (NO_3 - N)		0.03	0.06	0.09	0.09	0.06	0.03	0.06
Nitrite Nitrogen (NO_2 - N)		*	0.002	0.0010	*	<0.0012	0.0005	0.001
Total Orthophosphate Phosphorus		0.042	0.027	0.027	0.038	0.034	0.008	0.015
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	27	27	ϕ	-
TOC		9	-	-	16	12	5.0	7
Phenol		-	-	-	*	<0.002	ϕ	-
Total Hardness ($CaCO_3$)		96	164	142	104	126	32.1	68
Total Alkalinity ($CaCO_3$)		106	181	163	113	141	36.9	75
PHYSICAL DATA								
pH (units)		8.1	8.3	8.2	8.1	8.2	0.082	0.2
Specific Conductance (μmhos/cm @ 25°)		210	360	320	230	280	71.6	150
True Color (Pt-Co Units)		20	10	5	30	16	11	25
Turbidity (NTU)		1.1	0.75	1.7	3.3	1.7	1.1	2.55
Temperature (°C)		11	0	0.5	13	6.1	6.8	13
PHYSICAL DATA - Residues								
Total Residue		162	245	249	192	212	42.3	87
Filtrable Residue		152	240	239	157	197	49.1	88
Nonfiltrable Residue		10	5	10	35	15	13.5	30
Fixed Total Residue		118	186	149	126	145	30.5	68
Fixed Filtrable Residue		110	184	149	94	134	40.4	90
Fixed Nonfiltrable Residue		8	2	8	32	12	13.3	30
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ϕ	-
D.O.		9.7	12.6	13.3	9.1	11.2	2.08	4.2
% Saturation		94.3	92.6	99.3	9.25			

† Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-29

SURFACE WATER ANALYTICAL DATA - MID BONAPARTE RIVER

STATION: 3, Mid-Bonaparte River

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_3$	S_3	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.11)		-	-	*	<0.010	ϕ	-
Arsenic (As)	(*)		-	-	*	<0.005	ϕ	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ϕ	-
Chromium (Cr)	(*)		-	-	*	<0.010	ϕ	-
Copper (Cu)	(*)		-	-	*	<0.005	ϕ	-
Iron (Fe)	(0.46)	0.049	-	-	0.050	0.050	0.00070	0.001
Lead (Pb)	(*)		-	-	*	<0.010	ϕ	-
Mercury (Hg)	(0.0027)		*	*	*	<0.00025	0	0
Molybdenum (Mo)		-	-	-	*	<0.020	ϕ	-
Selenium (Se)	(*)		-	-	*	<0.003	ϕ	-
Vanadium (V)	(*)		-	-	*	<0.005	ϕ	-
Zinc (Zn)	(*)	•	-	-	0.021	<0.013	0.011	0.016
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		22	35	33	22	28	7.0	13
Lithium (Li)	(*)	*	-	-	0.001	<0.001	0	0
Magnesium (Mg)		11	20	19	11	15	4.9	9
Potassium (K)		1.7	-	-	-	1.7	ϕ	-
Sodium (Na)		10	14	15	8.9	12	3.0	6.1
Strontium (Sr)	(0.13)	0.08	0.21	0.21	0.12	0.16	0.066	0.13
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ϕ	-
Chloride (Cl)		0.30	1.1	1.2	0.63	0.81	0.42	0.9
Fluoride (F)		0.20	0.28	0.086	0.081	0.16	0.096	0.199
Sulfate (SO_4)		12	26	30	8.0	19	11	22
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.24	0.17	0.24	0.50	0.29	0.14	0.33
Nitrate Nitrogen (NO_3 - N)		0.04	*	0.08	0.10	<0.06	0.04	0.08
Nitrite Nitrogen (NO_2 - N)		*	0.003	0.0014	*	<0.0016	0.0009	0.002
Total Orthophosphate Phosphorus (P)		0.041	0.032	0.021	0.044	0.034	0.010	0.023
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	21	21	ϕ	-
TOC		13	-	-	7	12	4.2	6
Phenol		-	-	-	*	<0.002	ϕ	-
Total Hardness ($CaCO_3$)		100	169	161	100	132	37.67	69
Total Alkalinity ($CaCO_3$)		113	188	174	110	146	40.6	78
PHYSICAL DATA								
pH (units)		8.2	8.3	8.2	8.0	8.2	0.13	0.3
Specific Conductance (μmhos/cm @ 25°)		220	370	350	220	290	81.2	150
True Color (Pt-Co Units)		20	10	10	30	18	9.6	20
Turbidity (NTU)		1.7	1.0	1.1	4.6	2.1	1.7	3.6
Temperature (°C)		12	0	1	13	6.5	7.0	12
PHYSICAL DATA - Residues								
Total Residue		186	253	257	205	225	35.2	71
Filtrable Residue		177	250	249	154	208	49.4	96
Nonfiltrable Residue		9	3	8	51	18	22	48
Fixed Total Residue		119	182	171	146	154	28.0	63
Fixed Filtrable Residue		113	180	171	103	142	39.4	77
Fixed Nonfiltrable Residue		6	2	8	43	15	19	41
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ϕ	-
D.O.		9.6	12.8	13.0	9.6	11.2	1.91	3.4
% Saturation		95.5	94.1	98.5	97.6			

* Single value, standard deviation not applicable
< Denotes <MDC
() Denotes Total Concentration

TABLE C1-30

SURFACE WATER ANALYTICAL DATA - LOWER BONAPARTE RIVER

STATION: 1, Lower Bonaparte River

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_t$	S_t	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.23)		-	-	*	<0.010	ø	-
Arsenic (As)	(*)		-	-	*	<0.005	ø	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ø	-
Chromium (Cr)	(*)		-	-	*	<0.010	ø	-
Copper (Cu)	(*)		-	-	0.005	0.005	ø	-
Iron (Fe)	(0.75)	0.042	-	-	0.042	0.042	0	0
Lead (Pb)	(*)		-	-	*	<0.010	ø	-
Mercury (Hg)	(0.00082)		*	*	*	<0.00025	0	0
Molybdenum (Mo)		-	-	-	*	<0.020	ø	-
Selenium (Se)	(*)		-	-	*	<0.003	ø	-
Vanadium (V)	(*)		-	-	*	<0.005	ø	-
Zinc (Zn)	(0.006)	0.065	-	-	0.007	0.036	0.041	0.058
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		24	38	35	26	31	6.8	14
Lithium (Li)	(*)	*	-	-	0.001	<0.001	0	0
Magnesium (Mg)		12	22	21	13	17	5.2	10
Potassium (K)		1.7	-	-	-	1.7	ø	-
Sodium (Na)		9.8	15	15	12	13	2.5	5.2
Strontium (Sr)	(0.15)	0.07	0.28	0.21	0.13	0.17	0.092	0.21
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ø	-
Chloride (Cl)		0.50	1.4	1.6	0.70	1.0	0.53	1.1
Fluoride (F)		0.20	0.34	0.090	0.086	0.18	0.12	0.254
Sulfate (SO_4)		13	33	30	8.7	21	12	24.3
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.25	0.15	0.27	0.41	0.26	0.11	0.26
Nitrate Nitrogen (NO_3 - N)		0.03	0.05	0.08	0.07	0.05	0.02	0.05
Nitrite Nitrogen (NO_2 - N)		0.004	0.004	0.0018	*	<0.0027	0.0015	0.0022
Total Orthophosphate Phosphorus (P)		0.036	0.062	0.054	0.047	0.049	0.011	0.026
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	*	<10	ø	-
TOC		8	-	-	9	8	0.7	1
Phenol		-	-	-	0.004	0.004	ø	-
Total Hardness ($CaCO_3$)		109	186	174	118	147	38.9	77
Total Alkalinity ($CaCO_3$)		120	196	183	122	155	39.9	76
PHYSICAL DATA								
pH (units)		8.3	8.4	8.3	8.1	8.3	0.13	0.3
Specific Conductance (μmhos/cm @ 25°)		240	390	370	250	312	78.5	130
True Color (Pt-Co Units)		20	10	10	20	15	5.8	10
Turbidity (NTU)		2.3	1.2	1.5	4.8	2.4	1.6	3.6
Temperature (°C)		14	0	3	12	7.2	6.8	11
PHYSICAL DATA - Residues								
Total Residue		184	280	266	199	232	47.8	81
Filtrable Residue		172	275	255	161	216	57.6	114
Nonfiltrable Residue		12	5	11	38	16	15	33
Fixed Total Residue		132	212	176	142	166	36.3	80
Fixed Filtrable Residue		124	209	176	109	154	46.3	100
Fixed Nonfiltrable Residue		8	3	5	33	12	14	30
BIOCHEMICAL, DISSOLVED GASES & RELATED PARAMETERS								
BOD		*	-	-	-	<1	ø	-
D.O.		9.5	13.3	12.4	9.9	11.3	1.86	3.8
% Saturation		96.9	96.4	97.3	96.6			

: Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-31

SURFACE WATER ANALYTICAL DATA - UPPER THOMPSON RIVER

STATION: 1B, Upper Thompson River

PARAMETER (mg/ℓ)		Sept. 76	Dec. 76	Mar. 77	May 77	$\bar{X}_{1s}$	S_{1s}	R
CATIONS - Trace Metals								
Aluminum (Al)	(*)		-	-	*	<0.010	ϕ	-
Arsenic (As)	(*)		-	-	*	<0.005	ϕ	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ϕ	-
Chromium (Cr)	(*)		-	-	*	<0.010	ϕ	-
Copper (Cu)	(*)		-	-	*	<0.005	ϕ	-
Iron (Fe)	(0.028)	*	-	-	0.025	<0.018	0.011	0.015
Lead (Pb)	(*)		-	-	*	<0.010	ϕ	-
Mercury (Hg)	(*)		*	0.00056	*	<0.00035	0.00017	0.00031
Molybdenum (Mo)		-	-	-	*	<0.020	ϕ	-
Selenium (Se)	(*)		-	-	*	<0.003	ϕ	-
Vanadium (V)	(*)		-	-	*	<0.005	ϕ	-
Zinc (Zn)	(0.011)	0.017	-	-	0.019	0.018	0.0014	0.002
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		8.7	13	13	11	11	2.0	4.3
Lithium (Li)	(*)	*	-	-	0.001	<0.001	0	0
Magnesium (Mg)		2.1	2.4	2.5	1.8	2.2	0.32	0.7
Potassium (K)		0.60	-	-	-	0.60	ϕ	-
Sodium (Na)		1.3	3.0	4.0	4.0	3.1	1.3	3.7
Strontium (Sr)	(0.03)	*	0.05	0.095	0.067	<0.055	0.035	0.045
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ϕ	-
Chloride (Cl)		0.45	2.0	2.9	1.3	1.7	1.0	2.45
Fluoride (F)		0.10	0.26	0.051	0.054	0.12	0.098	0.209
Sulfate (SO_4)		6	7	9.4	6.7	7.3	1.5	3.4
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.07	0.05	0.05	0.10	0.07	0.2	0.05
Nitrate Nitrogen (NO_3 - N)		0.05	0.05	0.11	0.10	0.08	0.03	0.06
Nitrite Nitrogen (NO_2 - N)		*	0.003	0.0011	0.0012	<0.0017	0.0011	0.002
Total Orthophosphate Phosphorus (P)		0.008	0.016	0.021	0.008	0.028	0.027	0.06
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	*	<10	ϕ	-
TOC		4	-	-	4	4	ϕ	0
Phenol		-	-	-	*	<0.002	ϕ	-
Total Hardness ($CaCO_3$)		30	42	43	35	38	6.1	13
Total Alkalinity ($CaCO_3$)		27	37	39	33	34	5.3	12
PHYSICAL DATA								
pH (units)		7.7	7.8	7.9	7.7	7.8	0.096	0.2
Specific Conductance (μmhos/cm @ 25°)		71	110	110	88	95	19	32
True Color (Pt-Co Units)		5	10	10	10	8.8	2.5	5
Turbidity (NTU)		0.80	0.55	0.55	1.4	0.82	0.40	0.85
Temperature (°C)		13	4.5	3	11	7.9	4.9	8
PHYSICAL DATA - Residues								
Total Residue		60	74	87	72	73	11	27
Filtrable Residue		58	73	84	68	71	11	26
Nonfiltrable Residue		2	1	3	4	2	1	3
Fixed Total Residue		46	64	44	52	52	9.0	20
Fixed Filtrable Residue		46	64	44	50	51	9.0	20
Fixed Nonfiltrable Residue		*	*	*	2	<1	0.5	1
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		1	-	-	-	1	ϕ	-
D.O.		9.8	11.1	13.2	10.0	11.0	1.56	3.4
% Saturation		96.1	88.9	101.6	93.6			

: Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-32

SURFACE WATER ANALYTICAL DATA - LOWER THOMPSON RIVER

STATION: 19, Lower Thompson River

PARAMETER (mg/L)		Sept. 76	Dec. 76	Mar. 77	May 77	$\overline{X}_{19}$	S_{19}	R
CATIONS - Trace Metals								
Aluminum (Al)	(0.010)		-	-	0.023	0.023	ϕ	-
Arsenic (As)	(*)		-	-	*	<0.005	ϕ	-
Cadmium (Cd)	(*)		-	-	*	<0.005	ϕ	-
Chromium (Cr)	(*)		-	-	*	<0.010	ϕ	-
Copper (Cu)	(*)		-	-	*	<0.005	ϕ	-
Iron (Fe)	(0.054)	*	-	-	0.043	0.026	0.0233	0.033
Lead (Pb)	(*)		-	-	*	<0.010	ϕ	-
Mercury (Hg)	(*)		*	*	0.00047	<0.00032	0.00013	0.00022
Molybdenum (Mo)		-	-	-	*	<0.020	ϕ	-
Selenium (Se)	(*)		-	-	*	<0.003	ϕ	-
Vanadium (V)	(*)		-	-	*	<0.005	ϕ	-
Zinc (Zn)	(0.057)	0.025	-	-	0.008	0.016	0.012	0.0077
CATIONS - Alkali Earths & Metals								
Calcium (Ca)		9.2	12	14	11	12	2.0	4.8
Lithium (Li)	(0.010)	*	-	-	0.001	<0.001	0	0
Magnesium (Mg)		2.2	2.6	2.8	2.1	2.4	0.33	0.7
Potassium (K)		0.65	-	-	-	0.65	ϕ	-
Sodium (Na)		1.3	4.0	6.8	2.0	3.5	2.5	5.3
Strontium (Sr)	(0.04)	*	0.05	0.095	0.063	<0.054	0.035	0.053
ANIONS - General								
Boron (B)	(*)		-	-	*	<0.1	ϕ	-
Chloride (Cl)		0.37	2.0	2.9	1.2	1.6	1.1	2.53
Fluoride (F)		*	0.28	0.059	0.057	<0.11	0.11	0.23
Sulfate (SO_4)		6	9	9.9	6.7	7.9	1.8	3.9
ANIONS - Nutrients								
Total Kjeldahl Nitrogen (N)		0.09	0.05	0.08	0.12	0.09	0.03	0.07
Nitrate Nitrogen (NO_3 - N)		*	0.06	0.10	0.10	<0.07	0.04	0.08
Nitrite Nitrogen (NO_2 - N)		*	0.004	0.0011	0.0011	<0.0018	0.0015	0.003
Total Orthophosphate Phosphorus (P)		0.015	0.012	0.016	0.004	0.012	0.005	0.011
ORGANIC, NONIONIC & CALCULATED VALUES								
COD		-	-	-	31	31	ϕ	-
TOC		2	-	-	1	2	0.7	1
Phenol		-	-	-	*	<0.002	ϕ	-
Total Hardness ($CaCO_3$)		32	41	46	36	39	6.1	14
Total Alkalinity ($CaCO_3$)		27	37	41	36	35	5.9	14
PHYSICAL DATA								
pH (units)		7.8	7.6	7.9	7.8	7.8	0.13	0.3
Specific Conductance (μmhos/cm @ 25°)		74	110	110	90	96	17	36
True Color (Pt-Co Units)		5	10	10	10	8.8	2.5	5
Turbidity (NTU)		0.90	0.50	0.40	1.4	0.80	0.45	1
Temperature (°C)		13	4.8	3	11.5	8.1	4.9	10
PHYSICAL DATA - Residues								
Total Residue		73	66	82	99	80	14	33
Filtrable Residue		70	66	80	94	78	12	28
Nonfiltrable Residue		3	*	2	5	<3	2	3
Fixed Total Residue		49	57	42	46	48	6.4	15
Fixed Filtrable Residue		49	57	42	41	47	7.4	16
Fixed Nonfiltrable Residue		*	*	*	5	<2	2	4
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS								
BOD		*	-	-	-	<1	ϕ	-
D.O.		9.7	11.6	13.3	9.9	11.1	1.68	3.6
% Saturation		95.1	93.5	102.4	94.0			

ϕ Single value, standard deviation not applicable
* Denotes <MDC
() Denotes Total Concentration

TABLE C1-33

SURFACE WATER ANALYTICAL DATA - HYDROLOGY PROGRAM

STATION:	Aleece Lake (Outlet)	Hat Creek Below Finney Creek Near RH-76-20
PARAMETER (mg/L)		
CATIONS - Trace Metals		
Aluminum (Al)	-	-
Arsenic (As)	-	-
Cadmium (Cd)	-	-
Chromium (Cr)	-	-
Copper (Cu)	-	-
Iron (Fe)	<0.05	-
Lead (Pb)	-	-
Mercury (Hg)	-	-
Molybdenum (Mo)	-	-
Selenium (Se)	-	-
Vanadium (V)	-	-
Zinc (Zn)	-	-
CATIONS - Alkali Earths & Metals		
Calcium (Ca)	33.9	58.0
Lithium (Li)	-	-
Magnesium (Mg)	25.2	17.1
Potassium (K)	11.5	4.0
Sodium (Na)	38.0	21.3
Strontium (Sr)	-	-
ANIONS - General		
Boron (B)	-	-
Chloride (Cl)	<0.5	-
Fluoride (F)	-	-
Sulfate (SO_4)	52.2	-
ANIONS - Nutrients		
Total Kjeldahl Nitrogen (N)	-	-
Nitrate Nitrogen (NO_3 - N)	-	-
Nitrite Nitrogen (NO_2 - N)	-	-
Total Orthophosphate Phosphorus (P)	-	-
ORGANIC, NONIONIC & CALCULATED VALUES		
COD	-	-
TOC	-	-
Phenol	-	-
Total Hardness ($CaCO_3$)	188	214
Total Alkalinity ($CaCO_3$)	217	-
PHYSICAL DATA		
pH (units)	7.6	8.0
Specific Conductance (µmhos/cm @ 25°)	508	462
True Color (Pt-Co Units)	-	-
Turbidity (NTU)	-	-
Temperature (°C)	-	-
PHYSICAL DATA - Residues		
Total Residue	-	-
Filtrable Residue	-	-
Nonfiltrable Residue	-	-
Fixed Total Residue	-	-
Fixed Filtrable Residue	-	-
Fixed Nonfiltrable Residue	-	-

Note: Field Collection conducted by Golder, Brawner and Analysis by Cantest.

TABLE C1-34

SURFACE WATER ANALYTICAL DATA - POWER PLANT SITE PROGRAM - MEDICINE CREEK

STATION: Medicine Creek

PARAMETER (PPM)	21st May 1977	27 July 1977	6 Aug. 1977	13 Sept. 1977
CATIONS - Trace Metals				
Aluminum (Al)	<0.010	-	-	-
Arsenic (As)	<0.005	-	-	-
Cadmium (Cd)	<0.005	-	-	-
Chromium (Cr)	<0.010	-	-	-
Copper (Cu)	<0.005	-	-	-
Iron (Fe)	0.021	-	-	-
Lead (Pb)	<0.010	-	-	-
Mercury (Hg)	0.00050	-	-	-
Molybdenum (Mo)	<0.020	-	-	-
Selenium (Se)	<0.003	-	-	-
Vanadium (V)	<0.005	-	-	-
Zinc (Zn)	0.009	-	-	-
CATIONS - Alkali Earths & Metals				
Calcium (Ca)	61	57	61	58
Lithium (Li)	0.003	-	-	-
Magnesium (Mg)	29	20	21	24
Potassium (K)	-	2.5	2.2	2.3
Sodium (Na)	14	12	12	11
Strontium (Sr)	0.44	-	-	-
ANIONS - General				
Boron (B)	<0.1	-	-	-
Chloride (Cl)	0.50	0.35	0.20	0.26
Fluoride (F)	0.122	-	-	-
Sulfate (SO_4)	40	20	18	15
Total Silica (SiO_2)	-	0.5	2.0	5.2
ANIONS - Nutrients				
Total Kjeldahl Nitrogen (N)	0.26	-	-	-
Nitrate Nitrogen (NO_3 N)	0.04	-	-	-
Nitrite Nitrogen (NO_2 N)	<0.0010	-	-	-
Total Orthophosphate Phosphorus (P)	0.010	-	-	-
ORGANIC, NONIONIC & CALCULATED VALUES				
COD	10	-	-	-
TOC	27	-	-	-
Phenol	<0.002	-	-	-
Total Hardness ($CaCO_3$)	272			
Total Alkalinity ($CaCO_3$)	188	255	263	262
Phenolphthalein Alkalinity ($CaCO_3$)	-	5.9	4.9	7.3
PHYSICAL DATA				
PH (units)	8.4	8.5	8.5	8.5
Specific Conductance (µmhos/	550	470	500	482
True Color (Pt-Co units)	10	-	-	-
Turbidity (NTU)	0.30	-	-	-
Temperature (°C)	7	-	-	-
PHYSICAL DATA - Residues				
Total Residue	361	-	-	-
Filtrable Residue	359	304	322	318
Nonfiltrable Residue	2	-	-	-
Fixed Total Residue	261	-	-	-
Fixed Filtrable Residue	260	-	-	-
Fixed Nonfiltrable Residue	1	-	-	-
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS				
D.O.	10.1	-	-	-

TABLE C1-35

SURFACE WATER ANALYTICAL DATA - POWER PLANT SITE PROGRAM

MACLAREN CREEK

STATION: MacLaren Creek PARAMETER (mg/ℓ)	27 July/77	6 Aug./77	13 Sept./77
CATIONS - Alkali Earths and Metals			
Calcium (Ca)	52	56	-
Magnesium (Mg)	17	19	-
Potassium (K)	1.8	2.4	-
Sodium (Na)	4.4	5.6	-
ANIONS - General			
Chloride (Cl)	<0.1	30.0	-
Sulfate (SO_4)	9.6	11	-
Total Silica (SiO_2)	1.8	1.4	-
NONIONIC VALUES			
Phenolphthalein Alkalinity ($CaCO_3$)	0	0	-
Total Alkalinity ($CaCO_3$)	220	240	-
PHYSICAL DATA			
pH (Units)	8.3	8.2	-
Specific Conductance (µmhos/cm @ 25°C)	400	450	-
PHYSICAL DATA - Residues			
Filtrable Residue	257	284	-

TABLE C1-36

SURFACE WATER ANALYTICAL DATA - PAVILION LAKE PROGRAM

STATION: Pavillion Lake	27 July/77	6 Aug./77	13 Sept./77
PARAMETER (mg/ℓ)			
CATIONS - Alkali Earths and Metals			
Calcium (Ca)	37	37	40
Magnesium (Mg)	16	16	18
Potassium (K)	4.1	4.4	3.5
Sodium (Na)	6.2	7.7	6.7
ANIONS - General			
Chloride (Cl)	0.53	0.50	0.40
Sulfate (SO_4)	52	53	50
Total Silica (SiO_2)	1.6	1.1	6.5
NONIONIC VALUES			
Phenolphthalein Alkalinity ($CaCO_3$)	2.0	3.0	4.9
Total Alkalinity ($CaCO_3$)	141	139	138
PHYSICAL DATA			
pH (Units)	8.5	8.5	8.5
Specific Conductance (μmhos/cm @ 25°C)	360	360	359
PHYSICAL DATA - Residues			
Filtrable Residue	239	241	238

TABLE C1-37

SURFACE WATER ANALYTICAL DATA BULK SAMPLE PROGRAM - HAT CREEK

STATION 1

STATION: 1 HAT CREEK

PARAMETER (Mg/l)	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	4/8/77	14/9/77
CATIONS - Trace Metals									
Aluminum (Al)	*	*	*	*	*	*	*	*	*
Arsenic (As)	*	*	*	*	*	*	*	*	*
Cadmium (Cd)	-	-	-	-	-	-	-	-	-
Chromium (Cr)	*	*	*	*	*	*	*	*	*
Copper (Cu)	*	*	*	*	*	*	*	*	*
Iron (Fe)	0.018	0.019	*	0.029	0.022	0.020	0.014	0.015	0.030
Lead (Pb)	-	-	-	-	-	-	-	-	-
Mercury (Hg)	*	*	*	*	-	*	*	0.00025	*
Molybdenum (Mo)	-	-	-	-	-	-	-	-	-
Selenium (Se)	*	*	0.005	*	0.003	*	*	*	*
Vanadium (V)	*	0.002	0.011	*	*	0.001	0.001	0.006	0.006
Zinc (Zn)	0.008	0.005	*	0.010	*	*	0.024	0.036	0.006
CATIONS - Alkali Earths & Metals									
Calcium (Ca)	42	59	60	37	57	60	60	56	58
Lithium (Li)	0.010	0.005	0.004	0.003	0.004	0.004	0.005	0.004	0.002
Magnesium (Mg)	13	21	21	12	15	22	19	17	19
Potassium (K)	-	-	-	-	-	-	-	-	-
Sodium (Na)	14	24	25	15	21	20	22	23	22
Strontium (Sr)	0.24	0.30	0.30	0.13	0.18	0.31	0.24	0.25	0.29
ANIONS - General									
Boron (B)	*	0.2	*	*	0.1	*	*	*	*
Chloride (Cl)	0.78	1.2	1.0	0.63	0.88	0.99	1.0	1.3	1.2
Fluoride (F)	0.088	0.120	0.107	0.090	0.107	0.112	0.118	0.118	0.101
Sulfate (SO_4)	41	56	65	34	44	68	52	45	41
ANIONS - Nutrients									
Total Kjeldahl Nitrogen (N)	-	-	-	-	-	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-	-	-	-	-	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-	-	-	-	-	-	-	-	-
Dissolved Phosphate Phosphorus (P)	0.030	0.056	0.054	0.051	0.083	0.049	0.032	0.045	0.049
ORGANIC, NONIONIC & CALCULATED VALUES									
COD	-	-	-	-	-	-	-	-	-
TOC	15	10	17	19	24	34	26	17	6
Phenol	-	-	-	-	-	-	-	-	-
Total Hardness ($CaCO_3$)	158	234	236	142	204	240	228	210	223
Total Alkalinity ($CaCO_3$)	149	220	230	149	198	236	243	250	234
PHYSICAL DATA									
pH (units)	7.9	8.5	8.4	8.3	8.4	8.4	8.5	8.6	8.4
Specific Conductance (µmhos/cm @ 25°)	370	490	520	350	440	547	520	520	508
True Color (Pt-Co Units)	-	-	-	-	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-	-	-	-	-
Temperature (°C)	-	-	-	-	-	-	-	-	-
PHYSICAL DATA - Residues									
Total Residue	323	362	383	288	313	383	351	353	359
Filtrable Residue	253	360	367	253	306	378	349	353	346
Nonfiltrable Residue	70	2	16	35	7	5	2	<1	13
Fixed Total Residue	-	-	-	-	-	-	-	-	-
Fixed Filtrable Residue	-	-	-	-	-	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-	-	-	-	-	-
BIOCHEMICAL, DISSOLVED GASES & RELATED MEASUREMENTS									
BOD									
D.O.									

* Denotes <MDC

TABLE C1-38

SURFACE WATER ANALYTICAL DATA - BULK SAMPLING PROGRAM - HAT CREEK

STATION 2

STATION: 2 HAT CREEK

PARAMETER (mg/ℓ)		26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/8/77	20/8/77	4/8/77	14/9/77
CATIONS - Trace Metals										
Aluminum (Al)	-		*	*	*	*	*	0.015	*	*
Arsenic (As)	-		*	*	*	*	*	*	*	*
Cadmium (Cd)	-		-	-	-	-	-	-	-	-
Chromium (Cr)	-		*	*	*	*	*	*	*	*
Copper (Cu)	-		*	*	*	*	*	*	*	*
Iron (Fe)	-		0.025	0.026	0.029	0.026	0.020	0.012	0.014	0.025
Lead (Pb)	-		-	-	-	-	-	-	-	-
Mercury (Hg)	-		*	*	*	*	*	*	0.0038	*
Molybdenum (Mo)	-		-	-	-	-	-	-	-	-
Selenium (Se)	-		*	0.004	0.006	*	*	*	0.003	0.006
Vanadium (V)	-		0.002	*	*	*	0.002	0.001	0.003	*
Zinc (Zn)	-		0.009	0.024	*	0.010	*	0.018	0.010	0.014
CATIONS - Alkali Earths & Metals										
Calcium (Ca)	-		59	60	45	57	61	60	57	61
Lithium (Li)	-		0.005	0.004	0.004	0.004	0.004	0.005	0.005	0.003
Magnesium (Mg)	-		20	21	12	15	22	19	17	18
Potassium (K)	-		-	-	-	-	-	-	-	-
Sodium (Na)	-		24	24	16	19	20	20	22	22
Strontium (Sr)	-		0.29	0.30	0.20	0.18	0.32	0.24	0.30	0.30
ANIONS - General										
Boron (B)	-		*	*	*	0.1	*	0.1	*	*
Chloride (Cl)	-		1.3	1.2	0.70	0.94	1.1	0.90	1.1	1.0
Fluoride (F)	-		0.110	0.110	0.081	0.110	0.111	0.120	0.120	0.098
Sulfate (SO_4)	-		56	61	35	49	62	46	43	44
ANIONS - Nutrients										
Total Kjeldahl Nitrogen (N)	-		-	-	-	-	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-		-	-	-	-	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-		-	-	-	-	-	-	-	-
Dissolved Phosphate Phosphorus (P)	-		*0.050*	*0.064*	*0.060*	*0.066*	*0.046*	*0.033*	*0.049*	*0.032*
ORGANIC, NONIONIC & CALCULATED VALUES										
COD	-		-	-	-	-	-	-	-	-
TOC	-		6	22	22	24	22	30	17	4
Phenol	-		-	-	-	-	-	-	-	-
Total Hardness ($CaCO_3$)	-		230	236	162	204	240	228	212	226
Total Alkalinity ($CaCO_3$)	-		222	228	157	196	237	246	251	241
PHYSICAL DATA										
pH (units)	-		8.5	8.4	8.3	8.4	8.5	8.5	8.5	8.4
Specific Conductance (µmhos/cm @ 25°)	-		460	520	360	440	546	530	520	515
True Color (Pt-Co Units)	-		-	-	-	-	-	-	-	-
Turbidity (NTU)	-		-	-	-	-	-	-	-	-
Temperature (°C)	-		-	-	-	-	-	-	-	-
PHYSICAL DATA - Residues										
Total Residue	-		359	381	275	308	380	355	362	353
Filtrable Residue	-		357	369	255	302	372	351	362	343
Nonfiltrable Residue	-		2	12	20	6	8	4	<1	10
Fixed Total Residue	-		-	-	-	-	-	-	-	-
Fixed Filtrable Residue	-		-	-	-	-	-	-	-	-
Fixed Nonfiltrable Residue	-		-	-	-	-	-	-	-	-

* Denotes <MDC

TABLE C1-39

SURFACE WATER ANALYTICAL DATA - BULK SAMPLING PROGRAM - HAT CREEK

STATION 3

STATION: 3 HAT CREEK

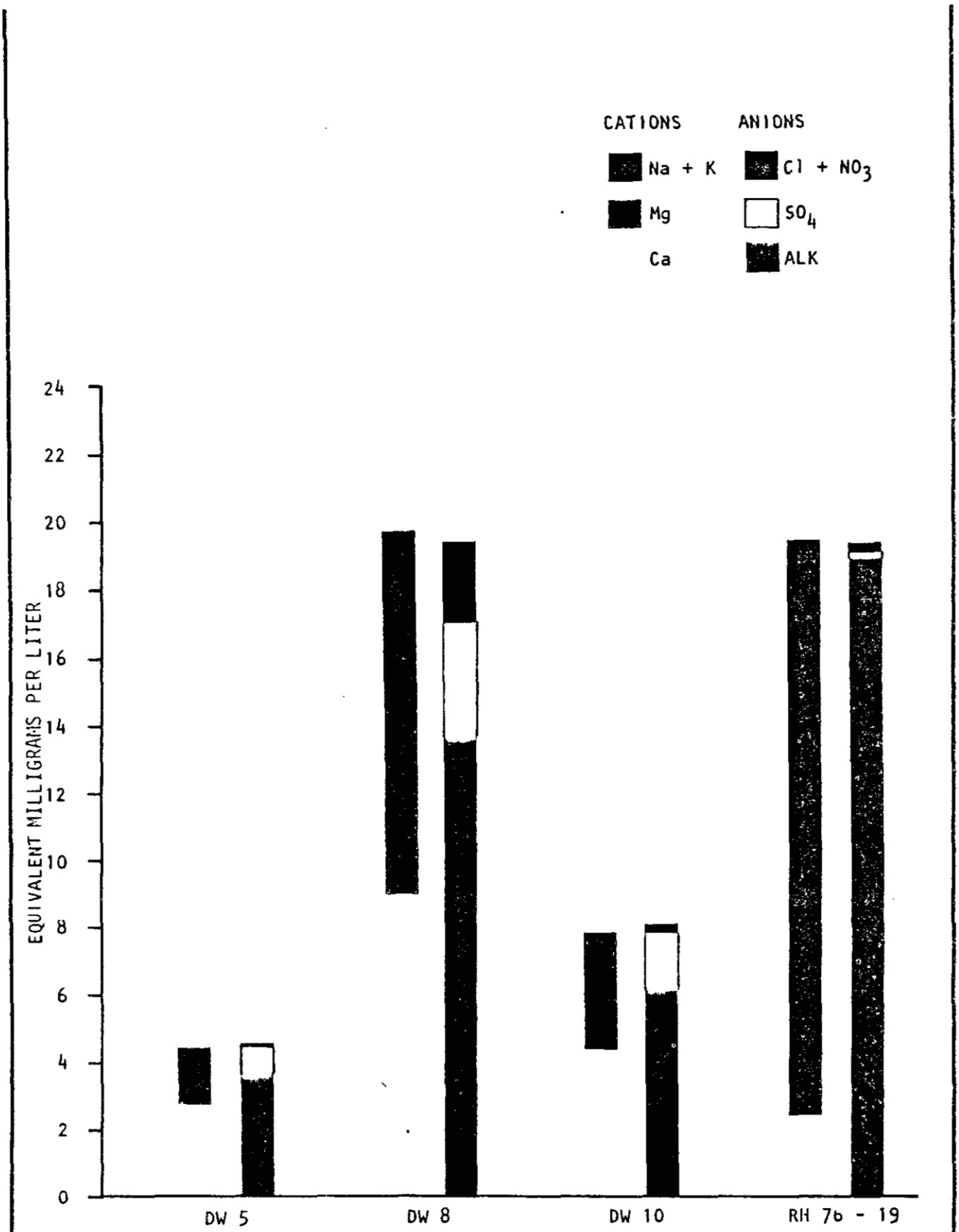
PARAMETER (mg/L)	26/4/77	11/5/77	24/5/77	8/6/77	22/6/77	5/7/77	20/7/77	3/8/77	14/9/77
CATIONS - Trace Metals									
Aluminum (Al)	*	*	*	*	*	*	0.015	0.25	*
Arsenic (As)	*	*	*	*	*	*	*	*	*
Cadmium (Cd)	-	-	-	-	-	-	-	-	-
Chromium (Cr)	*	*	*	*	*	*	*	*	*
Copper (Cu)	*	*	*	*	*	*	*	*	*
Iron (Fe)	0.012	0.032	0.032	0.021	0.028	0.018	0.010	0.010	0.026
Lead (Pb)	-	-	-	-	-	-	-	-	-
Mercury (Hg)	*	*	*	*	*	*	*	*	*
Molybdenum (Mo)	-	-	-	-	-	-	-	-	-
Selenium (Se)	0.004	0.004	*	*	0.003	*	*	*	0.005
Vanadium (V)	*	0.001	*	*	*	0.003	*	0.004	*
Zinc (Zn)	*	0.008	0.011	0.005	0.021	*	0.084	0.010	0.007
CATIONS - Alkali Earths & Metals									
Calcium (Ca)	45	60	59	39	57	61	60	57	57
Lithium (Li)	0.001	0.005	0.004	0.004	0.004	0.005	0.005	0.005	0.003
Magnesium (Mg)	15	20	21	12	15	21	19	17	18
Potassium (K)	-	-	-	-	-	-	-	-	-
Sodium (Na)	14	24	25	14	19	20	21	23	22
Strontium (Sr)	0.26	0.29	0.31	0.20	0.18	0.34	0.24	0.26	0.30
ANIONS - General									
Boron (B)	*	*	*	*	*	*	*	*	*
Chloride (Cl)	0.95	1.3	1.3	0.70	0.85	0.94	0.85	1.1	0.88
Fluoride (F)	0.088	0.107	0.113	0.082	0.117	0.108	0.120	0.122	0.091
Sulfate (SO_4)	35	56	64	34	42	66	50	41	41
ANIONS - Nutrients									
Total Kjeldahl Nitrogen (N)	-	-	-	-	-	-	-	-	-
Nitrate Nitrogen (NO_3 - N)	-	-	-	-	-	-	-	-	-
Nitrite Nitrogen (NO_2 - N)	-	-	-	-	-	-	-	-	-
Dissolved Phosphate Phosphorus (P)	0.030	0.045	0.062	0.052	0.078	0.055	0.038	0.048	0.042
ORGANIC, NONIONIC & CALCULATED VALUES									
COD	-	-	-	-	-	-	-	-	-
TOC	19	6	16	20	32	28	28	12	5
Phenol	-	-	-	-	-	-	-	-	-
Total Hardness ($CaCO_3$)	174	232	234	147	204	239	228	212	216
Total Alkalinity ($CaCO_3$)	158	219	230	153	196	237	247	248	229
PHYSICAL DATA									
pH (units)	7.9	8.5	8.4	8.3	8.4	8.6	8.5	8.6	8.4
Specific Conductance (µmhos/cm @ 25°)	380	410	530	360	446	540	530	520	498
True Color (Pt-Co Units)	-	-	-	-	-	-	-	-	-
Turbidity (NTU)	-	-	-	-	-	-	-	-	-
Temperature (°C)	-	-	-	-	-	-	-	-	-
PHYSICAL DATA - Residues									
Total Residue	336	355	385	270	308	378	352	362	337
Filtrable Residue	258	350	367	236	300	371	349	360	328
Nonfiltrable Residue	78	5	18	34	8	7	3	2	9
Fixed Total Residue	-	-	-	-	-	-	-	-	-
Fixed Filtrable Residue	-	-	-	-	-	-	-	-	-
Fixed Nonfiltrable Residue	-	-	-	-	-	-	-	-	-

* Denotes <MDC

TABLE C1-40

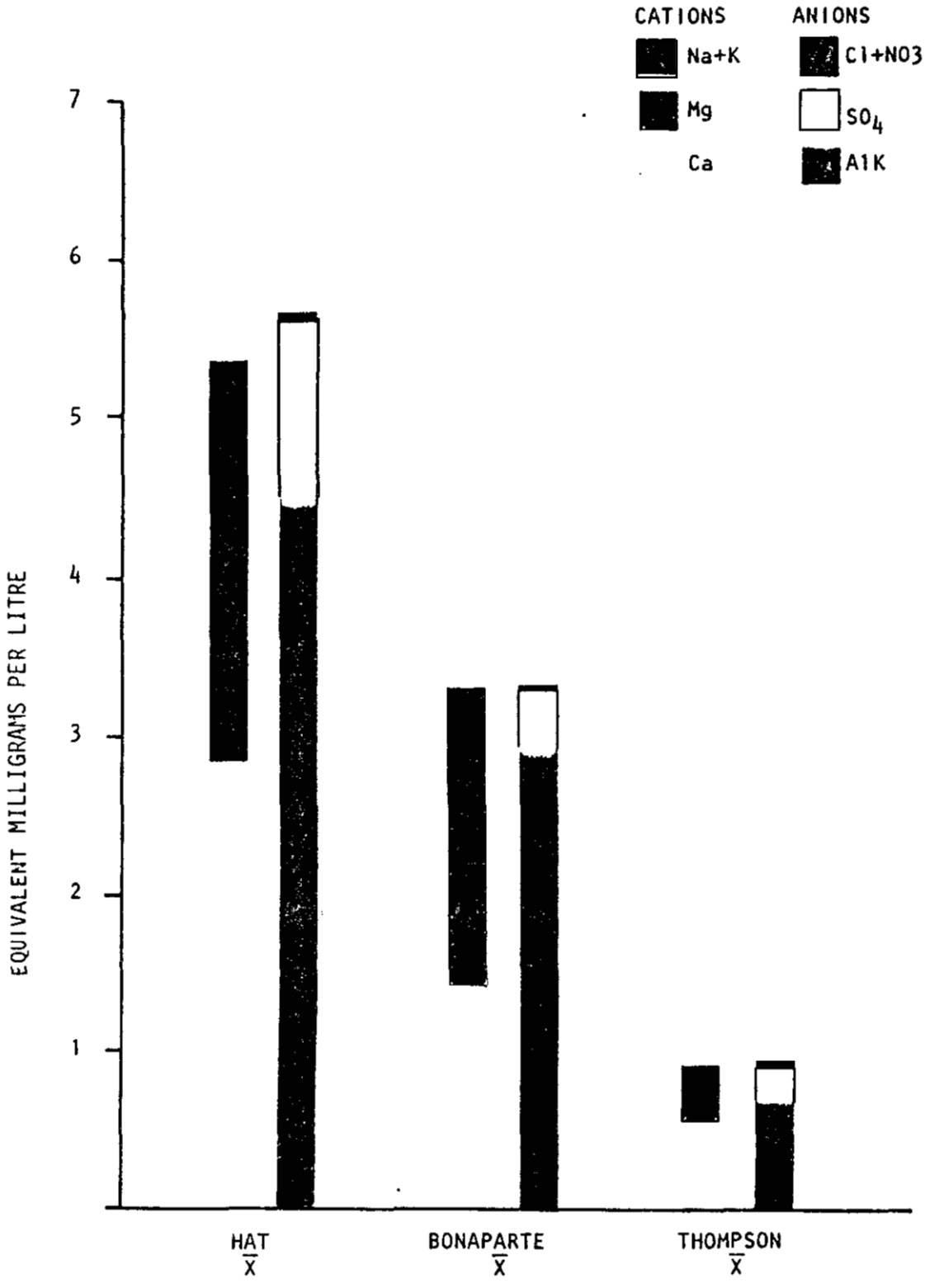
CALGON STUDY - THOMPSON RIVER - MEANS

PARAMETER (mg/ℓ)	Thompson River Dec.74 - Oct. 75
CATIONS - Trace Metals	
Aluminum (Al)	0.2
Arsenic (As)	-
Cadmium (Cd)	-
Chromium (Cr)	-
Copper (Cu)	0.07
Iron (Fe)	0.2
Manganese (Mn)	<0.05
Mercury (Hg)	-
Molybdenum (Mo)	-
Selenium (Se)	-
Vanadium (V)	-
Zinc (Zn)	
CATIONS - Alkali Earths & Metals	
Calcium (Ca)	11
Lithium (Li)	-
Magnesium (Mg)	2
Potassium (K)	-
Sodium (Na)	9
Strontium (Sr)	-
ANIONS - General	
Boron (B)	-
Chloride (Cl)	2.3
Fluoride (F)	-
Sulfate (SO_4)	10
ANIONS - Nutrients	
Total Kjeldahl Nitrogen (N)	-
Nitrate Nitrogen (NO_3 - N)	0.1
Nitrite Nitrogen (NO_2 - N)	-
Phosphate Phosphorus (P)	0.0
ORGANIC, NONIONIC & CALCULATED VALUES	
TOC	5
Silica (SiO_2)	4.5
Colloidal Silica	1.0
Total Hardness ($CaCO_3$)	35
Total Alkalinity ($CaCO_3$)	41
PHYSICAL DATA	
pH (units)	7.4
Specific Conductance (µmhos/cm @ 25°)	96
APHA Color (Pt-Co Units)	8
Turbidity (NTU)	5
Temperature (°C)	-
PHYSICAL DATA - Residues	
Total Residue	93
Filtrable Residue	89
Nonfiltrable Residue	4
Fixed Total Residue	-
Fixed Filtrable Residue	-
Fixed Nonfiltrable Residue	-



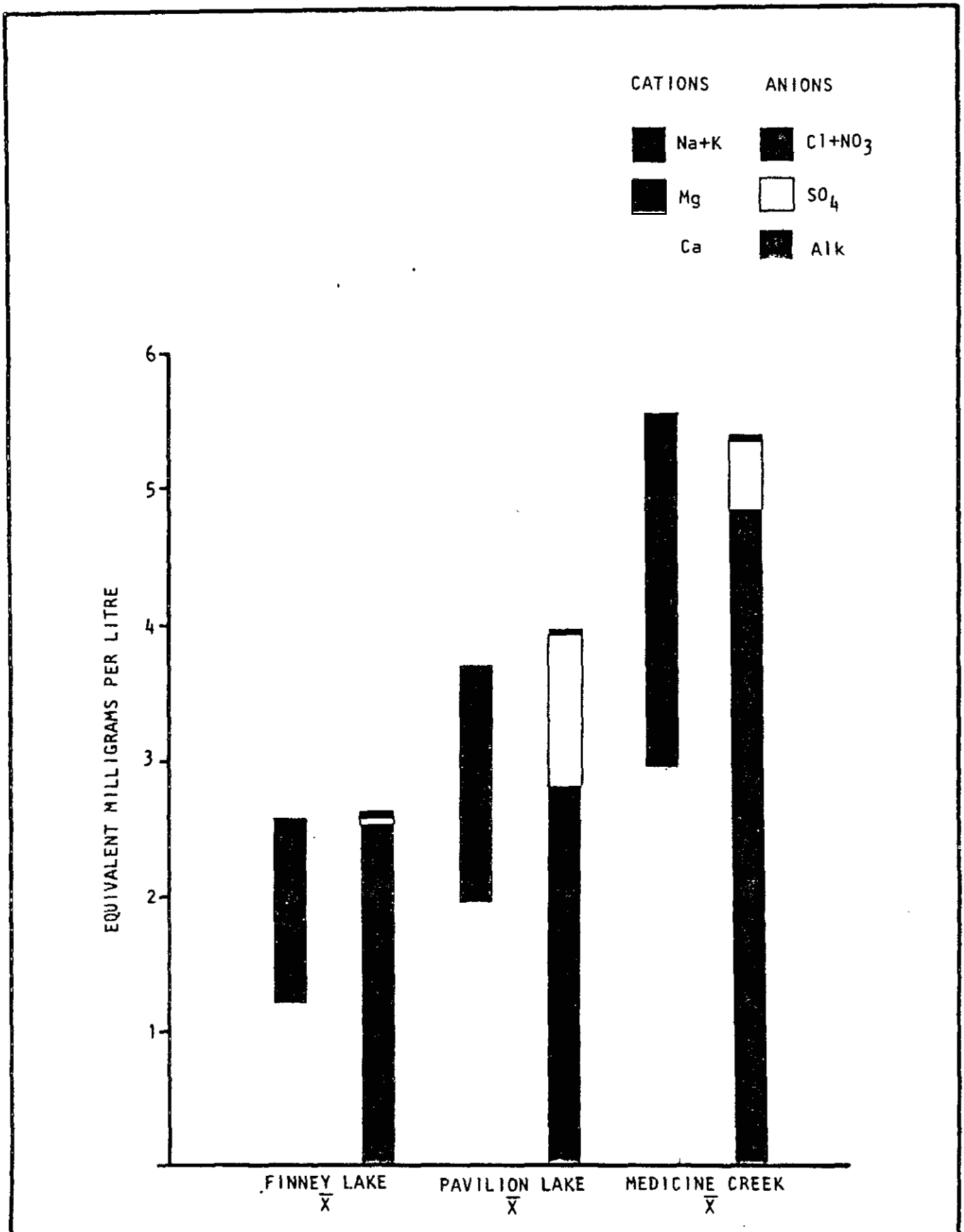
ANALYSES OF HAT CREEK VALLEY GROUNDWATERS

DATE	7-77	RM	C2-1
PROJECT	K4242		
DWG NO			



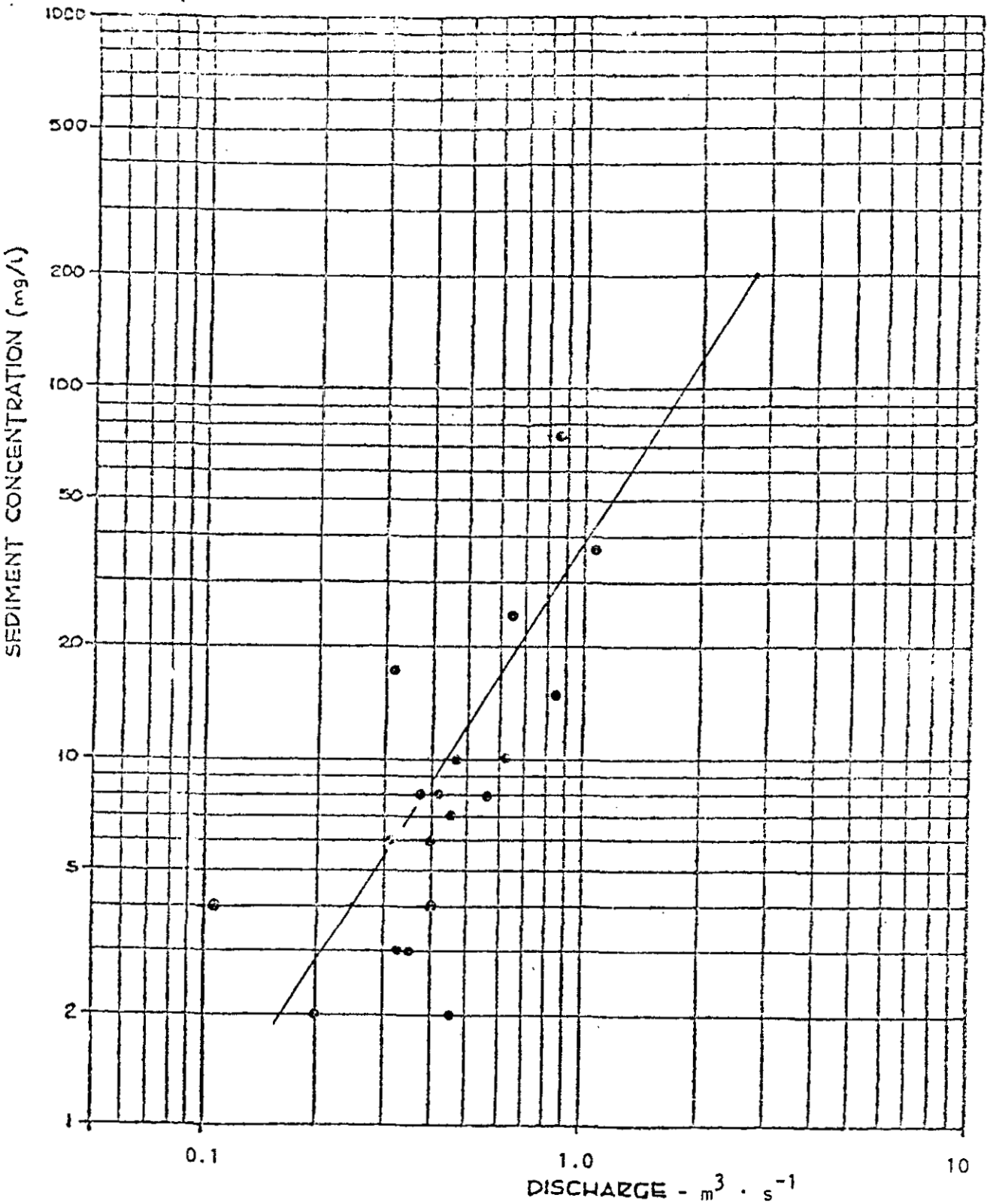
MEAN CONCENTRATIONS OF SURFACE WATERS

DATE	7-77	RM	C2-2
PROJECT	K4242		
DWG NO			



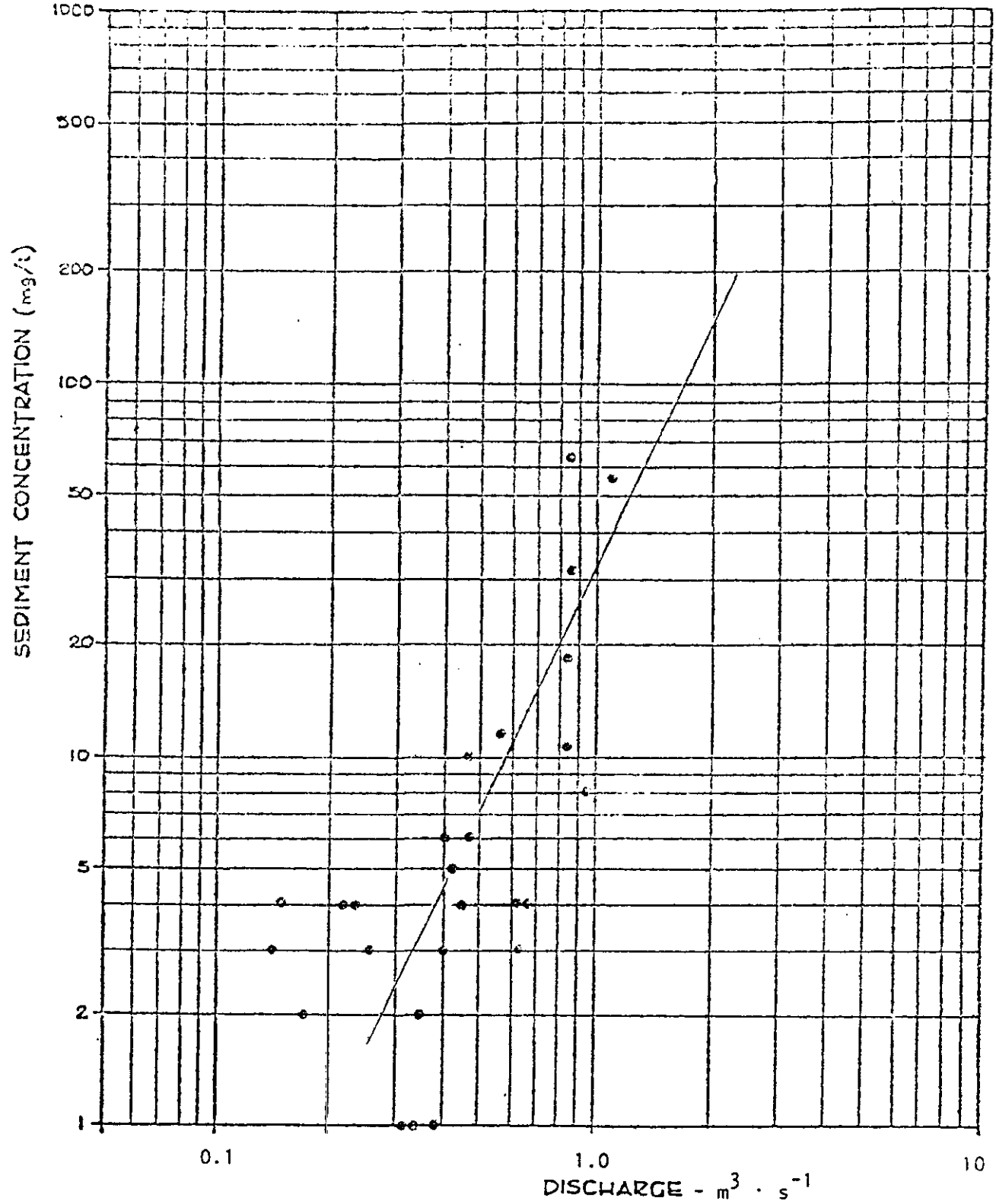
MEAN CONCENTRATIONS OF GENERATION SITE SURFACE WATERS

DATE	Dec 77 DF	C2-3
PROJECT	K4242	
DWG NO		



SEDIMENT CONCENTRATION VS DISCHARGE
HAT CREEK - NEAR UPPER HAT CREEK

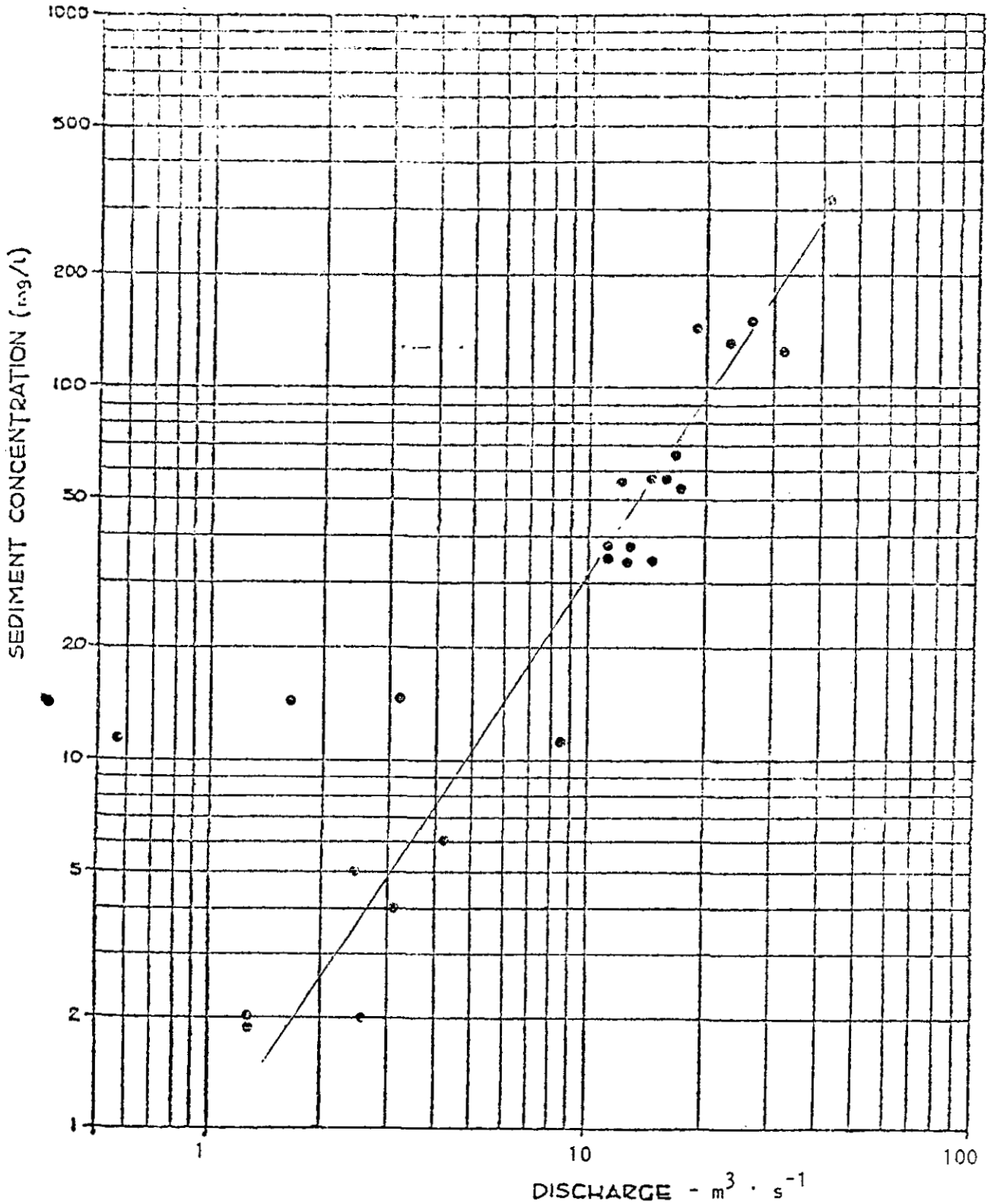
DATE		G.N.
PROJECT	K4242	C2-4
DWG NO		



SEDIMENT CONCENTRATION VS DISCHARGE
HAT CREEK - NEAR CACHE CREEK

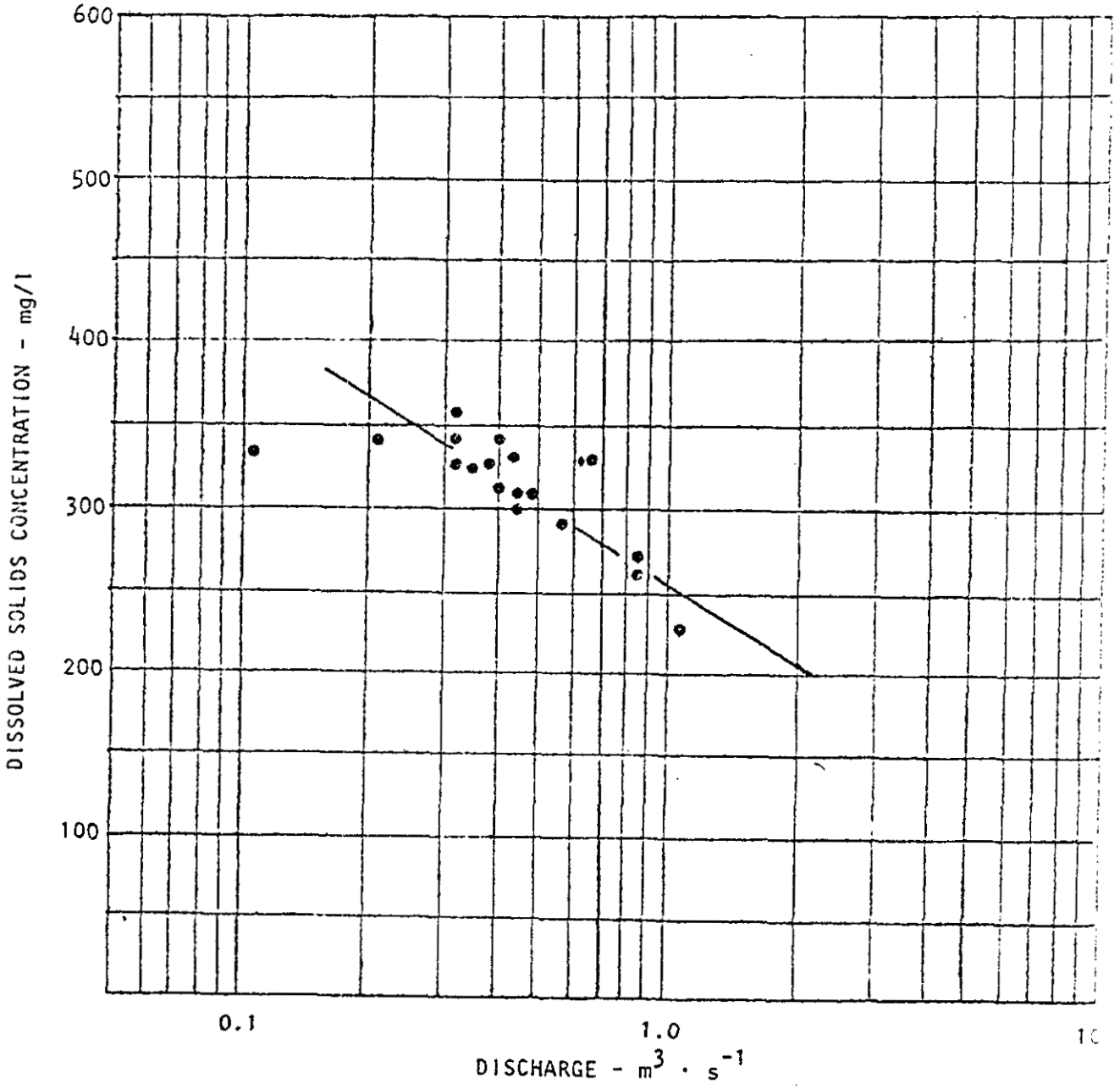
DATE	
PROJECT	4242
DWG NO	

C2-5



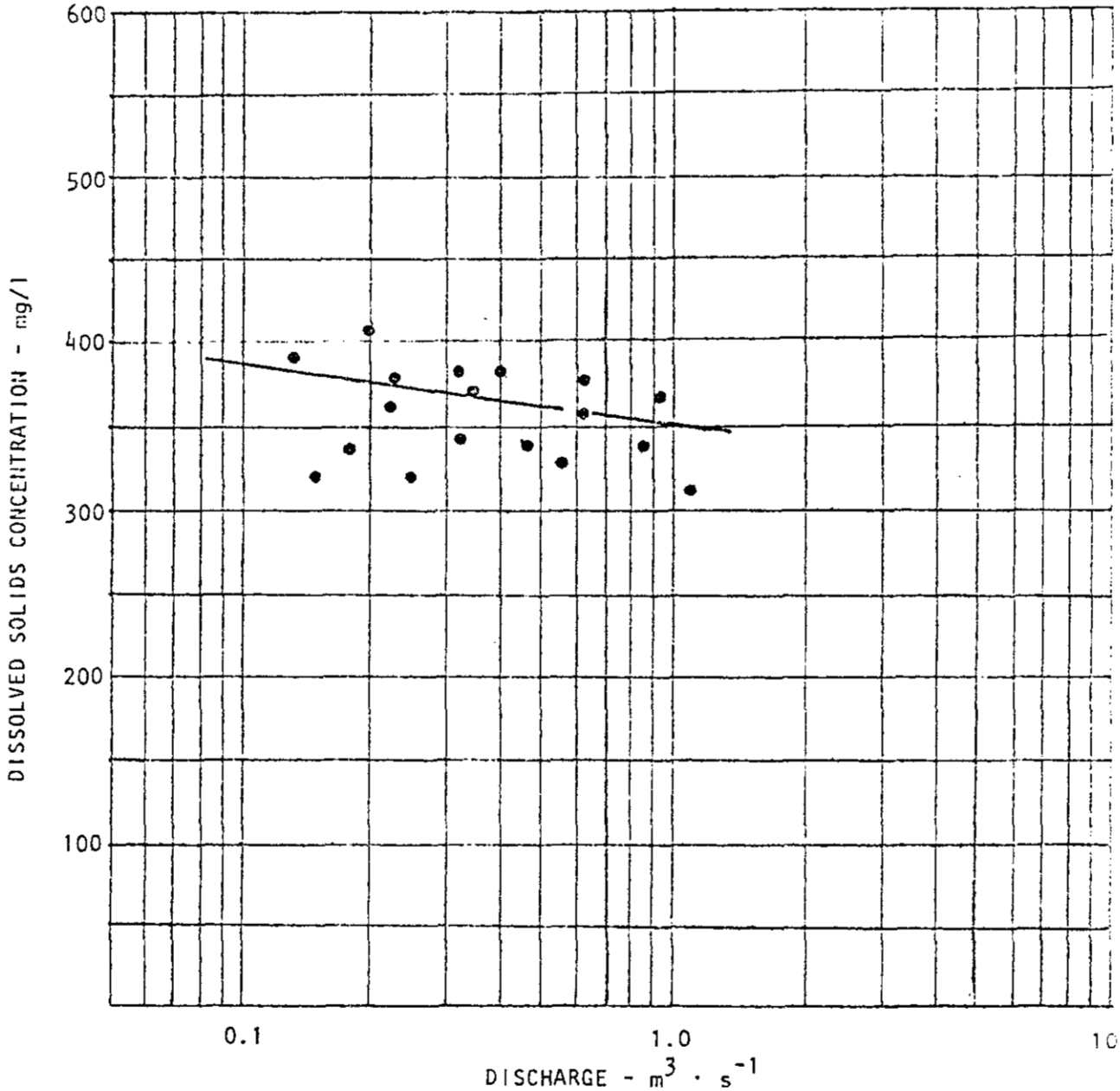
SEDIMENT CONCENTRATION VS DISCHARGE
BONAPARTE RIVER - BELOW CACHE CREEK

DATE		
PROJECT	K4242	C2-6
DWG NO		



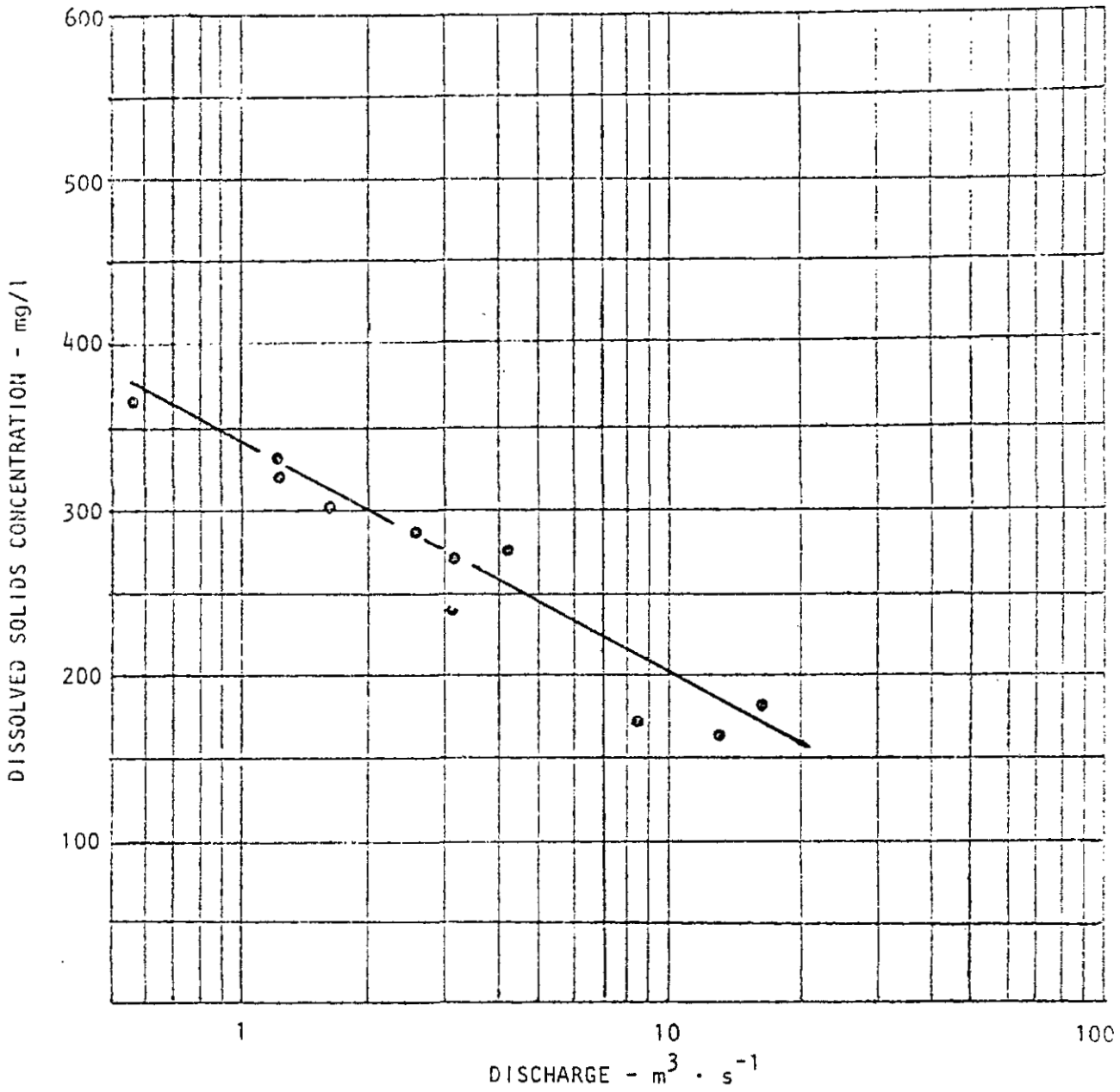
DISSOLVED SOLIDS CONC. VS DISCHARGE
HAT CREEK - NEAR UPPER HAT CREEK

DATE		G.N.
PROJECT	K4242	C2-7
DWG NO		



DISSOLVED SOLIDS CONC. VS DISCHARGE
HAT CREEK - NEAR CACHE CREEK

DATE		G.N.
PROJECT	K4242	C2-8
DWG NO		



DISSOLVED SOLIDS CONC. VS DISCHARGE
BONAPARTE RIVER - BELOW CACHE CREEK

DATE		G.N.
PROJECT	K4242	C2-9
DWG NO		

APPENDIX D

APPENDIX D SUPPLEMENTARY WATER USE INVENTORY TABLE

D1.0 TABLES

Table D1-1 : Domestic, Municipal, and Industrial Use Water Licences

TABLE D1-1

DOMESTIC MUNICIPAL AND INDUSTRIAL USE WATER LICENCES

	Location	Water Source	Date	Volume ($l \cdot day^{-1}$)
HAT CREEK VALLEY				
1. Indian Affairs	I.R. #1	Hat Creek	Sept. 26, 1888	6810
2. J.B. Jackson	L.279	Hat Creek	Mar. 19, 1894	2270
3. Indian Affairs	I.R. #2	Hat Creek	Sept. 26, 1888	6810
4. J.B. Jackson	L.94 & 93	Hat Creek	Jan. 9, 1871	6810
5. Ashcroft Estates	via Cornwall Cr.	Medicine Cr.	Nov. 19, 1877	4540
6. A. Cameron	Hat Creek Basin	Hat Creek	May 25, 1892	4540
7. Indian Affairs	via Oregon Jack Cr.	Hat Creek	Jun. 1, 1883	13620
8. J.B. Jackson	Hat Creek Basin	Robertson Cr.	Nov. 4, 1883	9080
9. A. Cameron	Hat Creek Basin	McDonald Cr.	Oct. 19, 1885	4540
10. Ridge Investments	Hat Creek Basin	Hat Creek	Mar. 9, 1894	4540
11. A. Cameron	Hat Creek Basin	McCormick Cr.	Sept. 1, 1894	2270
12. A. Cameron	Hat Creek Basin	Hat Creek	Oct. 9, 1894	2270
13. G. Parke	Hat Creek Basin	Hat Creek	Feb. 16, 1897	2270
14. A. Cameron	Hat Creek Basin	Anderson Cr.	Mar. 2, 1903	2270
15. J.B. Jackson	Hat Creek Basin	Ambusten Cr.	Apr. 10, 1905	2270
16. D.E. Goff	Hat Creek Basin	Yet Cr.	Sept. 15, 1911	2270
17. G. Parke	Hat Creek Basin	McDonald Cr.	May 14, 1918	2270
18. J.B. Jackson	Hat Creek Basin	Cashmere Cr.	Dec. 14, 1922	2270
19. B.C.H.P.	Hat Creek Basin	Finney Cr.	Aug. 22, 1958	2270
BONAPARTE RIVER-HAT CREEK TO THOMPSON RIVER				
A.A. Parke	L.102	Bonaparte R.	Dec. 5, 1871	2270
J.B. Jackson	L.90,91,92	Bonaparte R.	Apr. 6, 1872	4540

TABLE D1-1 CONT'D

DOMESTIC MUNICIPAL AND INDUSTRIAL USE WATER LICENCES

	Location	Water Source	Date	Volume ($l \cdot day^{-1}$)
Est. of J. Fergusson	L.95	Bonaparte R.	Dec. 23, 1896	2270
J.B. Jackson	L.95	Bonaparte R.	Dec. 23, 1896	2270
J.B. Jackson	L.93	Bonparate R.	June 16, 1905	22700
A.H. Woodburn	S.18, Tp21, R.24	Bonaparte R.	Dec. 29, 1908	2270
A.H. Woodburn	S.8, S.17, Tp21, R.24	Bonaparte R.	Jan. 5, 1909	2270
Chevron Canada Ltd.	L.5189	Bonaparte R.	Dec. 1, 1950	4540
Circle 7 Ranch Ltd.	S.33, Tp20, R.24	Bonaparte R.	Jul. 13, 1954	9080
Emter & Sons Invest. Ltd.	L.377, & S.7, Tp21, R.24	Bonaparte R.	Jun. 27, 1962	2270
A. Stohlman	S.33, Tp22, R.24	Walker Brook	Apr. 25, 1962	2270
Indian Affairs	I.R. #3	Bonaparte R.	Jul. 15, 1963	11350
O.M. Hagen	L.377	Bonaparte R.	Nov. 20, 1964	11350
Village of Cache Cr.	Cache Creek	Bonaparte R.	Jul. 11, 1968	3178000 (wwks)
O.M., NO., & K.A. Hagen	L.377, S.8, Tp21, R.24	Bonaparte R.	Oct. 23, 1972	177060 (ind)
O.M., N.O., & K.A. Hagen	L.377	Bonaparte R.	Oct. 23, 1972	726500 (wwks)
Bonaparte Cr. Holdings Ltd.	L.3832, L.1657	Bonaparte R.	May 16, 1973	170250 (ind)
Village of Cache Cr.	Cache Creek	Bonaparte R.	Aug. 15, 1973	4894120 (wwks)
Emter & Sons Invest. Ltd.	L.377, S.7, Tp21, R.24	Bonaparte R.	Dec. 30, 1976 (appl.)	N.A. (ind)
CORNWALL CREEK				
Ashcroft Est. Ltd.	L.15,16,17,18,19	Cornwall Cr.	Apr. 27, 1865	4540

TABLE D1-1 CONT'D

DOMESTIC MUNICIPAL AND INDUSTRIAL USE WATER LICENCES

	Location	Water Source	Date	Volume ($l \cdot day^{-1}$)
Ashcroft Est. Ltd.	L.19	Lone Tree Cr.	Apr. 27, 1865	4540
Indian Affairs	IR#4 (Ashcroft Tribe)	Cornwall Cr.	May 19, 1942	4540
Burford Mgmt. Services Ltd.	L.16	Cornwall Cr.	Nov. 26, 1943	11350
Shell Canada Ltd.	L.16	Cornwall Cr.	Dec. 21, 1973	1135 + 12300 (ind)
T.C. & P.V. Fisk	L.16,17	Cornwall Cr.	Dec. 21, 1944	1135
T.C. & P.V. Fisk	L.16,17	Cornwall Cr.	Dec. 21, 1944	3405
Indian Affairs	I.R.#4	Cornwall Cr.	May 18, 1966	18160 (wwks)
OREGON JACK CREEK				
Indian Affairs	L.17	Oregon Jack Creek	Apr. 6, 1863	2270
Indian Affairs	L.18, L.374	Oregon Jack Creek	Mar. 8, 1867	4540
Indian Affairs	Lower Oregon Jack I.R.#3	Oregon Jack Creek	Sept. 26, 1888	4540
Indian Affairs	Upper Oregon Jack I.R.#2	North Oregon Jack Creek	Sept. 26, 1888	2270
M.A. Landels	S.28, Tp19, R.24	Oregon Jack Creek	Aug. 27, 1965	2270

TABLE D1-1 CONT'D

DOMESTIC MUNICIPAL AND INDUSTRIAL USE WATER LICENCES

THOMPSON RIVER (Between Wallachin and Lytton, B.C.)[1]

Water Source	Date	Volume ($l \cdot day^{-1}$)	
Thompson River	April 20, 1898	464900	
Thompson River	July 17, 1915	46490	(Ind)
Thompson River	July 3, 1962	1810775	(wwks)
Thompson River	May 2, 1964	9790	
Thompson River	March 8, 1968	2446	
Thompson River	August 13, 1968	68271076	(mining)
*Thompson River	November 18, 1968	N.A.	(mining)
*Thompson River	September 21, 1970	97880	(mining)
*Thompson River	April 21, 1975	73410	(Ind)
*Thompson River	April 21, 1975	18409080	(Ind)

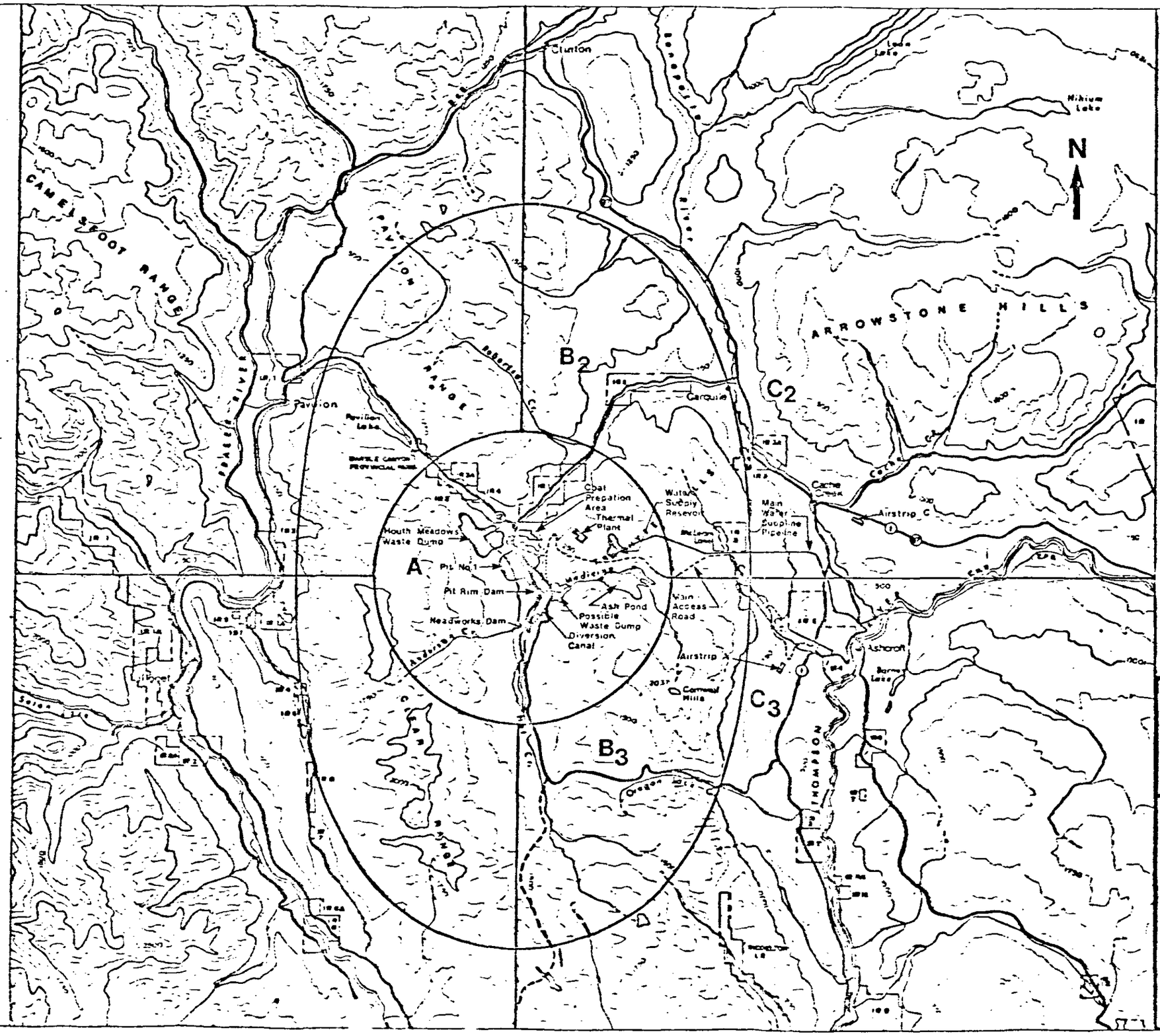
* Denotes water application only, not a licence

[1] Integ-Ebasco, Hat Creek Project - Site Evaluation Study, October 1976

APPENDIX E

APPENDIX E QUALITATIVE IMPACT ASSESSMENT MATRICES

E1.0 FIGURES



BRITISH COLUMBIA
HYDRO AND POWER AUTHORITY
HAT CREEK PROJECT

DETAILED ENVIRONMENTAL STUDIES

IMPACT ZONES FOR QUALITATIVE ASSESSMENT MATRICES

Figure E1-1

BEAK CONSULTANTS LIMITED

QUALITATIVE MATRIX

IMPACT ZONE A

Negative Impact
- major
- minor

Beneficial Impact
- major
- minor

Ambivalent

No Impact

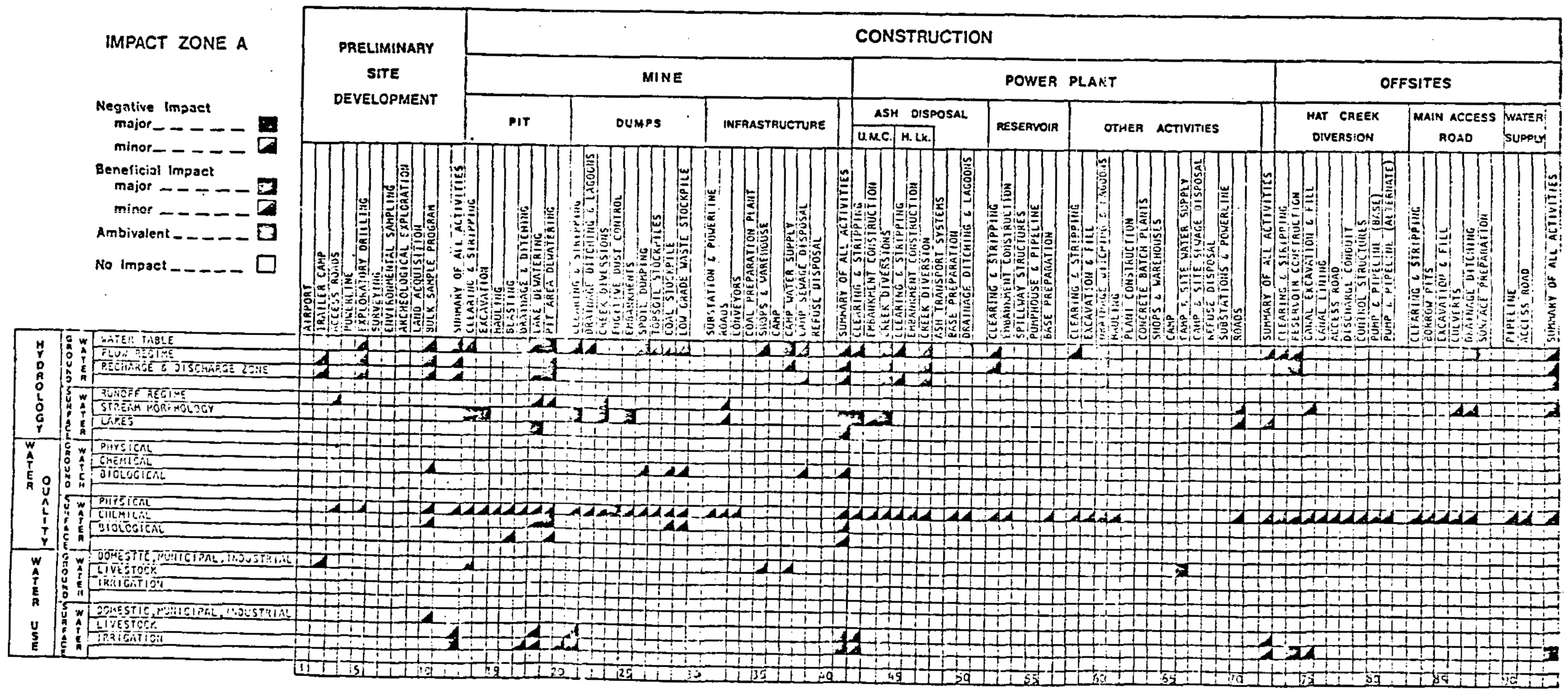
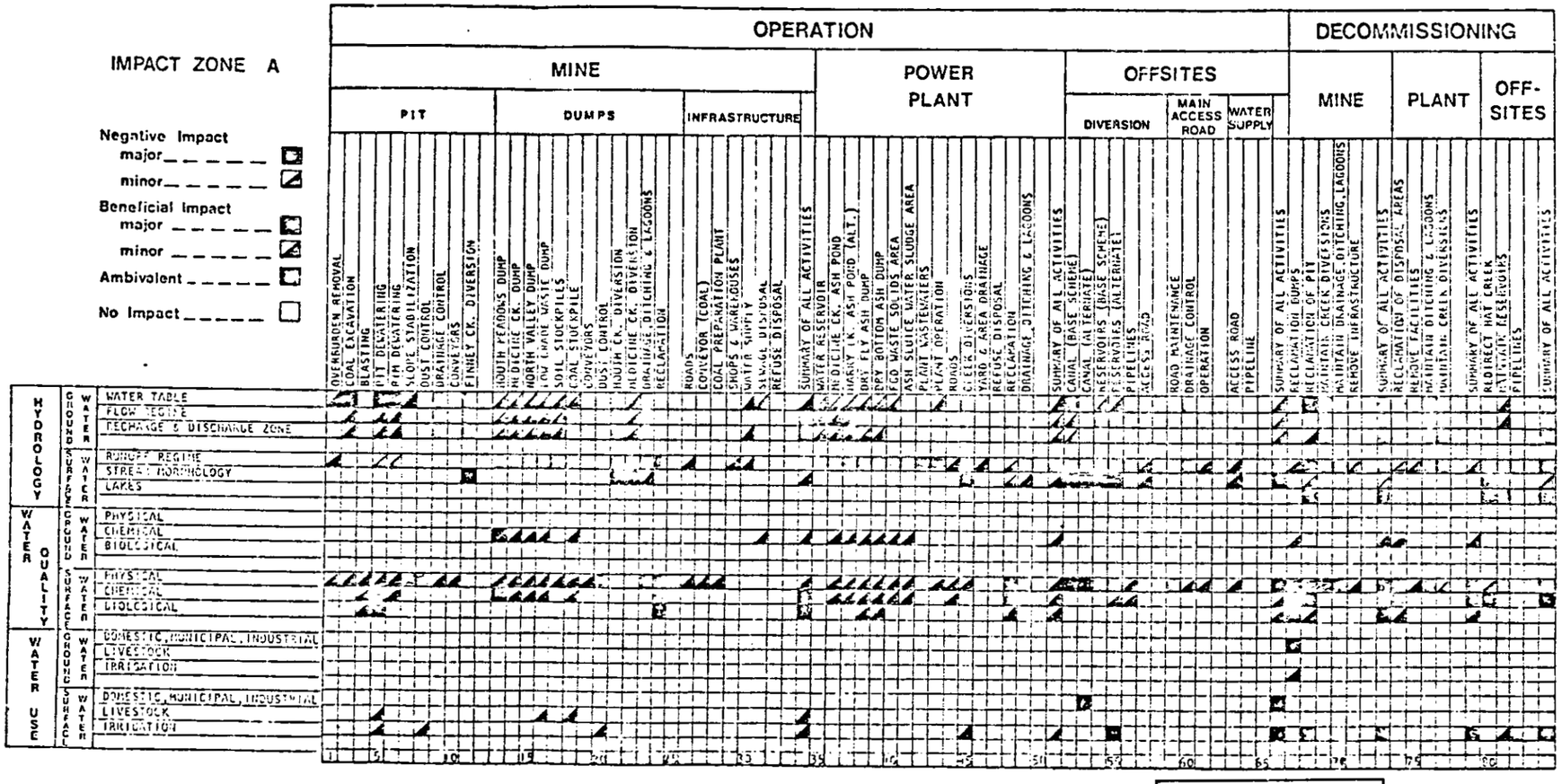


Figure E1-2
May 78

QUALITATIVE MATRIX

IMPACT ZONE A

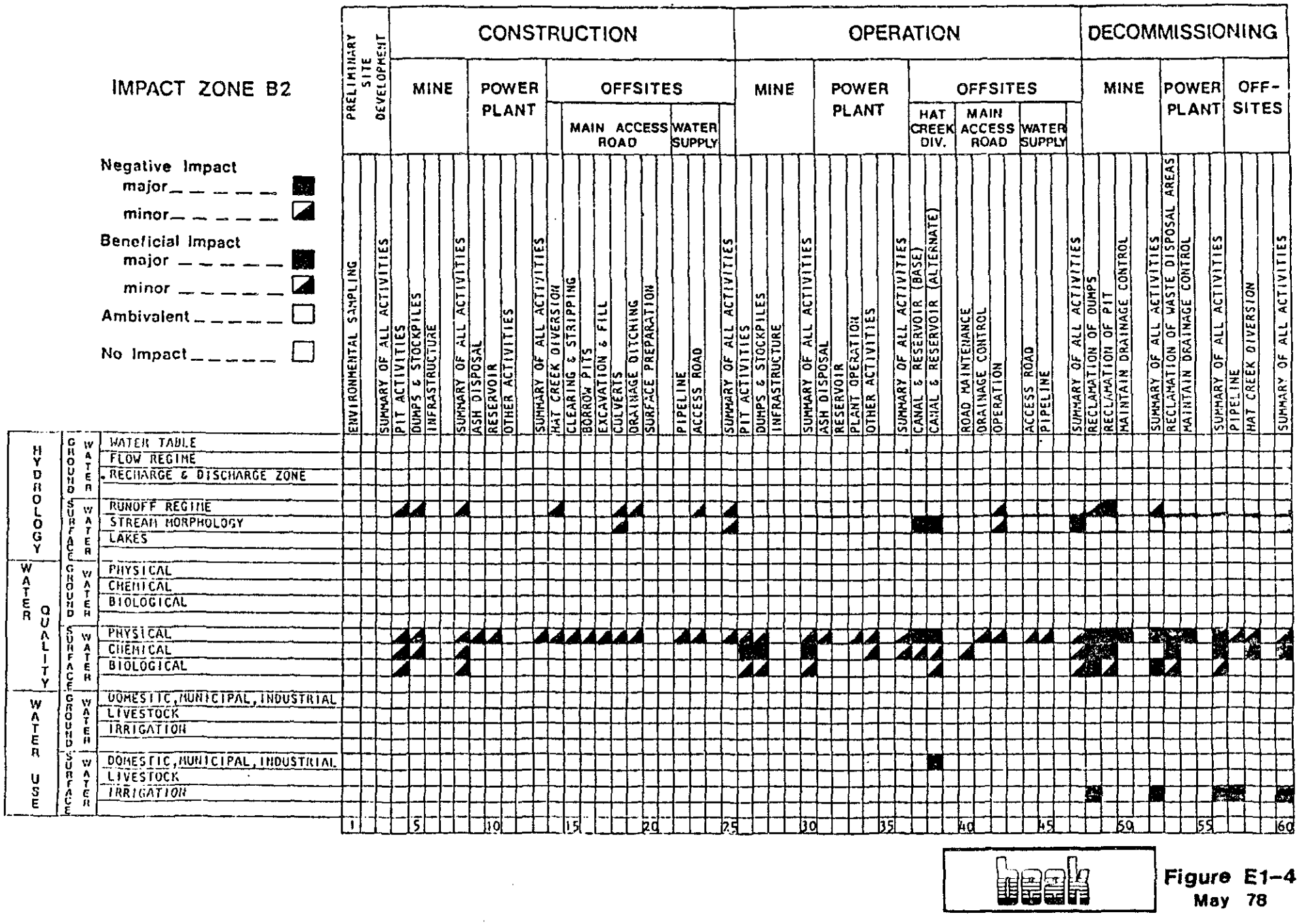
Negative Impact
major
minor
Beneficial Impact
major
minor
Ambivalent
No Impact



back

Figure E1-3
May 78

QUALITATIVE MATRIX



back

Figure E1-4
May 78

QUALITATIVE MATRIX

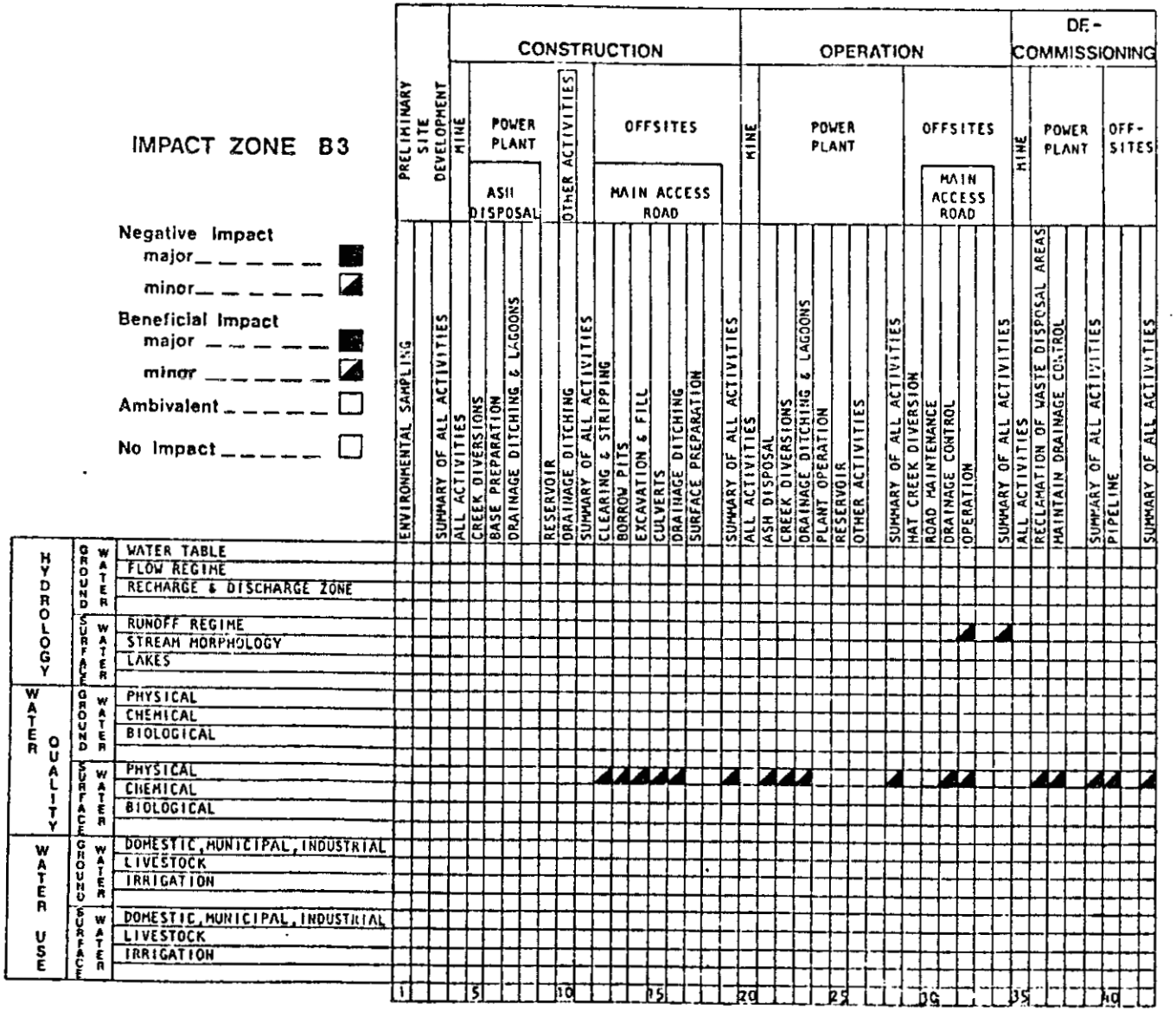


Figure E1-5

May 78

QUALITATIVE MATRIX

IMPACT ZONE C2

Negative Impact
major
minor
Beneficial Impact
major
minor
Ambivalent
No impact

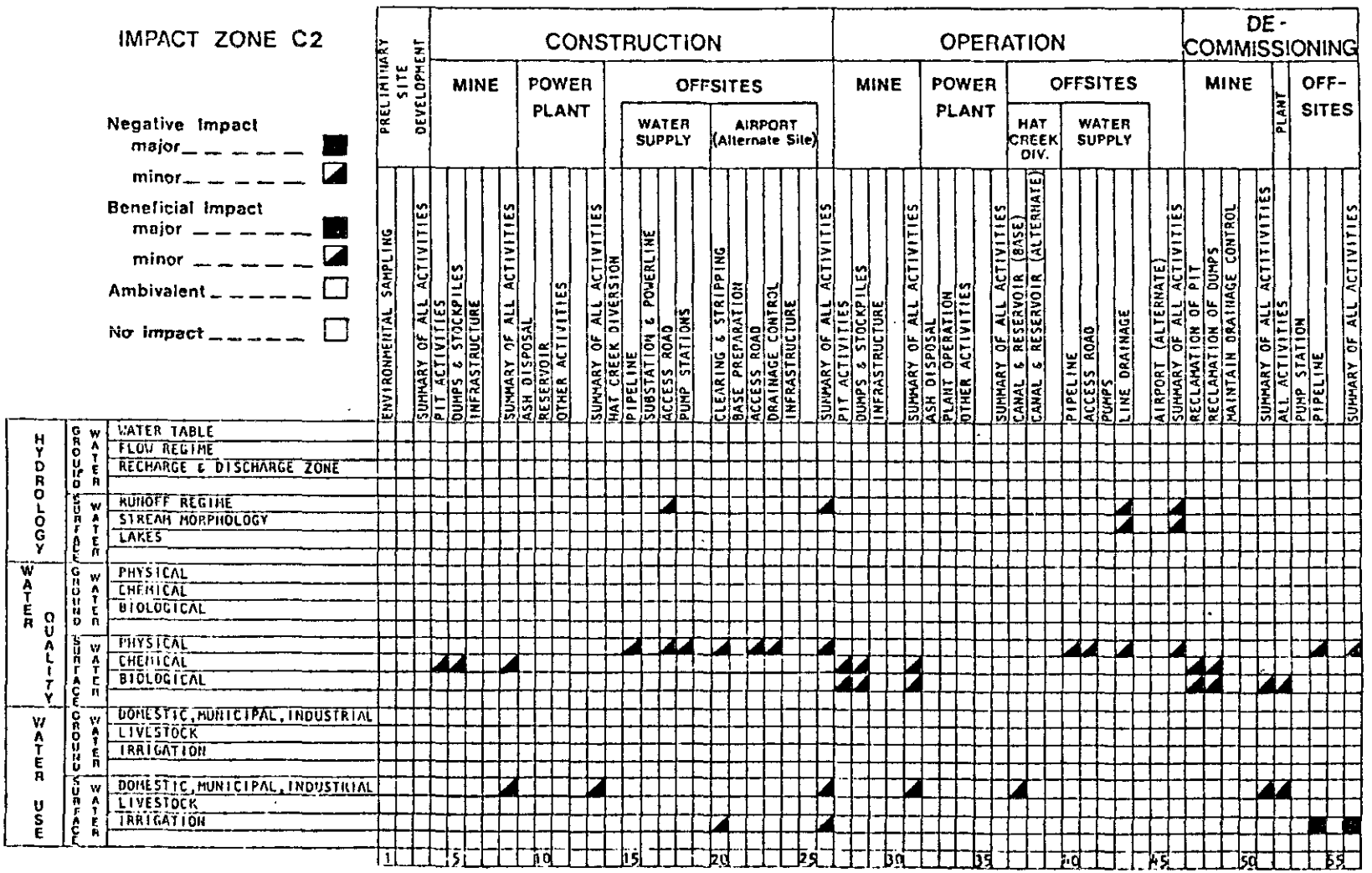


Figure E1-6
May 78

QUALITATIVE MATRIX

IMPACT ZONE C3

- Negative Impact
  - major
  - minor
- Beneficial Impact
  - major
  - minor
- Ambivalent
- No Impact

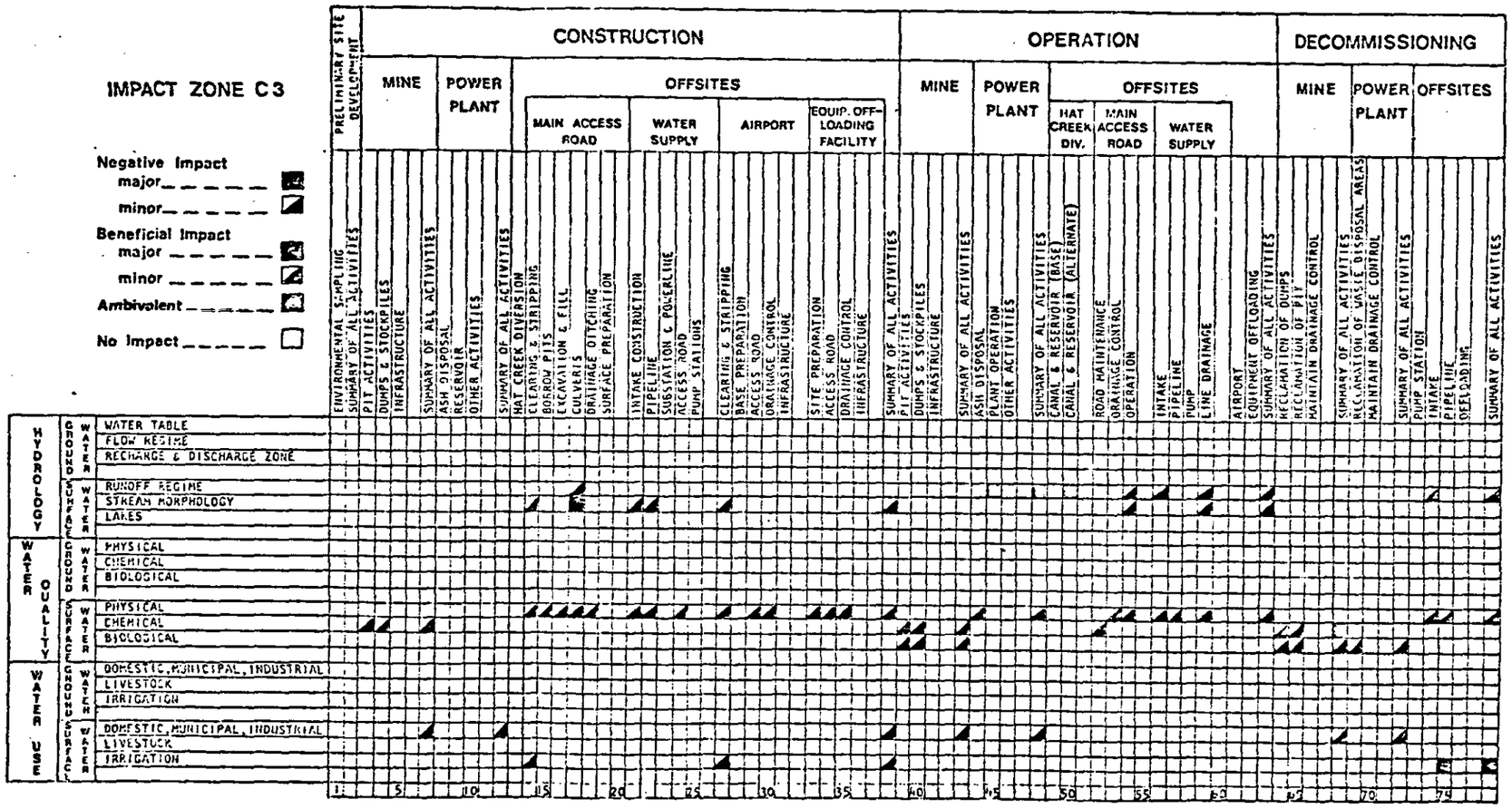


Figure E1-7
May 78

Qualitative Impact Assessment Matrices

Notes on Qualitative Matrices:

1) The assessments on Ground Water in the Qualitative Matrices refer only to activities in the Hat Creek Valley (Zone A). Activities outside the Hat Creek Valley are beyond the scope of this study and therefore impacts on the ground water resources of these areas (Zones B and C) are not assessed.

APPENDIX F

APPENDIX F QUANTITATIVE IMPACT ASSESSMENT MATRICES

APPENDIX F1.0

Matrices, Notes and M-1 Forms for Ground Water Hydrology and Surface Water Hydrology

TABLE F1-1
Quantitative Impact Matrix
Ground Water Hydrology
Hat Creek Area

Note: All values are flows given in m^3/d (see Note 1)

Activity / Resource		Construction				Operation				Decommissioning
		Mine	Plant		Off Site	Mine		Plant	Offsite Diversions	Filling of Pit
			Water Supply	Other Activities		Dewatering	Other Activities			
Valley Alluvial Aquifer	Amt (1)	1250	-	85	-	2000	250	-	1000	100
	Qual (2)	G	-	G	-	G	G	-	G	G
	Impact (3)	-H	-	+L	-	-H	+M	-	-H	+M
Buried Bedrock Aquifer	Amt	300	1350	-	-	300	115	20	300	400
	Qual	F	F	-	-	F	F	F	F	F
	Impact	-I	-M	-	-	-M	+L	+I	+M	+M
Marble Canyon Aquifer	Amt	-	-	5	-	-	700	-	-	-
	Qual	-	-	G	-	-	G	-	-	-
	Impact	-	-	+I	-	-	+M	-	-	-

Notes: (1) Values given are based on averages of ranges given in M-1 form.

(2) Quality of Resource: explanatory note No. 7 given at end of M-1 form (this appendix).

(3) Impact Significance: see explanatory note No. 8 given at end of M-1 form (this appendix).

TABLE FI - 2 QUANTITATIVE IMPACT MATRIX - SURFACE WATER HYDROLOGY
HAT CREEK AREA
(NOTE 1)

RESOURCE \ ACTIVITY		CONSTRUCTION				OPERATION					DECOMMISSIONING	
		MINE	PLANT		OFF SITE	MINE		PLANT	OFF SITE		Filling of Pit	Other Activities
			Water Supply	Other Activities		Dewatering	Other Activities		Diversions	Other Activities		
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
RUNOFF VOLUME (Note 2)	Amt.	+330	+225	+130	+(<100)	0	+1500	-240	+(<100)	+(<100)	-500	-1800
	Qual.	P	P	P	P		P	P	P	P	P	P
	Impact	+I	+I	+I	+I		+L	-I	+I	+I	-L	-L
RUNOFF DISTRIBUTION (Note 8)	Amt.											
	Qual.	F	F	F	F	F	F	F	F	F	F	F
	Impact	-L	+I	-L	-L	+I	-M	-L	I	-L	+H	+M
STREAM MORPHOLOGY	Amt.	-5	0	-5	-(<1)	0	21	0	-4	-(<1)	+28	+1
	Qual.	G		F	F		G		G	F	G	F
	Impact	-H		-M	-L		±L		-M	-L	+N	+L
LAKES	Amt.	-20	0	0	0	0	0	0	+14	0	+225	0
	Qual.	F							F		F	
	Impact	-H							+M		+H	

FORM M1

HAT CREEK PROJECT

RESOURCE: GROUND WATER AREA: HAT CREEK VALLEY

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTER	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)
Preliminary site development	Water supply and disposal	Coal pit	VAA	2	m^3/d	R	0.1	G	-I	a, b
Preliminary site development	Exploratory drilling	Coal pit	VAA	16	m^3/d	M	1	G	-I	c
Preliminary site development	Bulk sample program	Coal pit	VAA	2,000	m^3/d	M	3	G	-I	d
Construction	Pit dewatering	Coal pit	VAA BBCA	1,000 → 2,000	m^3/d	P	32	F	-H	
Construction	Water supply to offices and warehouses	North of coal pit	VAA MCA	23 → 167	m^3/d	R	6	G	-L	e
Construction	Coal stocking and blending	North of coal pit	VAA BBCA	20 → 100	m^3/d	M	2.5	F	+L	f
Construction	Water supply for mine and plant camps	North of coal pit	BBCA	300 → 400	m^3/d	P	8	F	-L	-
Construction	Sewage disposal for mine camp	North of coal pit	BBCA	200 → 300	m^3/d	P	6	F	-L	-
Construction	Water supply to plant offices, warehouse, etc.	North of coal pit	BBCA	1,000 → 1,200	m^3/d	R	24	F	-M	g
										h

Note: For an explanation of the above values and symbols, see attached notes under appropiate note given at the head of each column.

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTER	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)
Construction (Continued)	Diversions and embankment construction	Houth dump	VAA MCA	5→20	m^3/d	O	<1	G	±I	
Construction	Diversions and embankment construction	Medicine dump	VAA	5→10	m^3/d	O	<1	G	+I	
Construction	Soil and vegetation removal	North of Medicine Creek	VAA	5→10	m^3/d	O	<1	G	+I	
Operation	Dewatering	Coal pit	VAA BBCA	1,000 → 3,000	m^3/d	P	40	G	-M	e
Operation	Canal base scheme	South and east of pit	BBCA	500 → 700	m^3/d	M	13	F	+M	
Operation	Reservoir	South of pit	VAA	1,300	m^3/d	M	57	G	-H	
Operation	Stocking and blending coal	North of pit	VAA	26 → 130	m^3/d	M	2.5	G	+L	
Operation	Dumping of durficials	North valley dump	VAA	30 → 70	m^3/d	M	2.2	G	+L	
Operation	Dumping of waste rock	Houth meadows	MCA	200→600	m^3/d	M	30	G	+M	J

HAT CREEK PROJECT

RESOURCE: GROUND WATER AREA: HAT CREEK VALLEY

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTER	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)
Operation (Continued)	Dumping of waste rock	Mouth Meadows	MCA	10 → 50	m^3/d	M	2	G	+I	j
Operation	Creek diversion	Marble Canyon	MCA	300	m^3/d	M	15	G	+M	k
Operation	Creek diversion and dumping of waste rock	Medicine Creek	VAA	10 → 50	m^3/d	M	2	G	+I	j
Operation	Storing low grade coal	North of Medicine Creek	VAA BBCA	50→150	m^3/d	M	1.5	F G	+I	
Operation	Dumping top soil	Coal pit	VAA BBCA	15 → 50	m^3/d	M	1	F G	+I	
Operation	Store water in reservoir	Upper Medicine Creek	VAA	10	m^3/d	M	<1	G	+I	l
Operation	Ash pond	Upper Medicine Creek	VAA	20	m^3/d	M	<1	G	+I	
Operation	Store bottom ash (Alt. I)	Harry Lake	BBCA	40→120	m^3/d	M	1.5	F	+I	m
Operation	Store fly ash (Alt. I)	Upper Medicine Creek	BBCA	15	m^3/d	M	<1	G	+I	
Operation	Store ash (Alt. IIa)	Harry Lake	BBCA	55→155	m^3/d	M	2	F	+I	m

HAT CREEK PROJECT

RESOURCE: GROUND WATER AREA: HAT CREEK VALLEY

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTER	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(12)
Operation (Continued)	Store ash (Alt. IIb)	Harry Lake	BBCA	55→155	m^3/d	M	2	F	+I	m
Decommissioning	Maintain creek diversion	South and east of pit	BBCA	500→700	m^3/d	M	13	F	+M	

DATE
PROJECT
DWG NO

NOTES ON MATRIX GIVEN ON M-1 FORM

1. Phase: The phase of development for Hat Creek Coal Project proposed.

2. Activity: Activity that causes the impact that has been quantified.

3. General Areas: These are the same as given in the matrix sheets.

4. Resource Character: These refer to the major ground water aquifers outlined in the Inventory Report (Section 4.1 (a)).

   VAA = Valley Alluvial aquifer

   BBCA = Buried bedrock channel aquifer

   MCA = Marble Canyon aquifer

5. Absolute Amount: This is the amount of ground water, measured in terms of changing water table and/or flow regime, that could be affected by development in the given area.

6. Units: Units of measurement are flows. Changing water levels were not easy to quantify in a matrix form.

7. Accuracy: The limits of accuracy are specified as follows:-

   D - Determined: A precise value is given based on calculation or measurement.

   R - Range: No exact single value can be provided but the limits of the range within which the value will fall can be precisely stated.

   P - Predicted: Neither an exact value nor exact limits can be stated but a value can be provided based on limited knowledge, known relationships, or any other measure

that will provide a value within a level of accuracy acceptable to the profession or discipline under which the resource is categorized.

M - Limited information is available and a value is provided for a scenario representative of an assumed set of conditions.

O - Opinion: A value is provided for which supporting data is unavailable. However, the value represents the best judgment of the professional assigned to study the resource.

In cases where no data on the amount of resource affected can be provided, the lack of numerical data is specified as follows:-

I - Indeterminant: An amount cannot be determined.

U - Undetermined: An amount has not been determined.

8. *Percentage of Resource:* The percentage of the total resource within the general area that will be affected by the development. The total resource is generally restricted to the local aquifer and/or ground water flow system.

9. Resource Quality: Levels of quality have been assigned to the affected resource using the following letter designations:-

O - Outstanding; unique;scarce, rare, endangered

H - High; much above average quality

G - Good; average quality

F - Fair; somewhat below average quality

P - Poor; substantially below average quality

I - Indeterminant; quality cannot be determined

U - Undetermined; the quality of the resource has not been determined.

10. Impact Significance: The impact significance is an indication of the net effect of the project on the resource. Beginning with the existing amount and quality, a determination has been made of resource amount and resource quality following project actions.

Letter designations have been used to designate impact levels so as to avoid the inherent difficulties in numerical value scaling. The impact significance is indicated in five levels as follows:-

E - Extreme

H - High

M - Moderate

L - Low

I - Insignificant

Note: The sign prefixing each letter is - ve if water is lost and + ve if there is a gain to the ground water resource.

12. Comments:

a) the alluvial aquifer is hydraulically connected to Hat Creek and hence a minor reduction in the flow in the creek would occur.

b) the water supply would require about 10 m^3/d. However, about 8 m^3/d is retained in another part of the same aquifer and hence net impact is a loss of about 2 m^3/d.

c) the quantity of water pumped was about 320 m^3/d of this total flow, 95 per cent would return to the ground water. Only 16 m^3/d is lost.

d) Bulk sample Trench "B" was very close to Hat Creek and the so most of this water would have come indirectly from the creek.

e) The per cent of resource is determined by calculating a weighted average impact on each of the two aquifers affected.

f) The values given assume that a well near the offices would supply the water.

g) This assumes that the seepage from the sewage disposal facility reaches the ground water table in the buried channel aquifer.

h) The project description proposes that a well be drilled at a point southeast of the plantsite. As there are no significant aquifers in this area, it is highly unlikely that a ground water source capable of 1800 m^3/d could be developed. The nearest potential aquifer is the buried bedrock channel aquifer and we have assumed that the water would come from this source.

i) The estimated seepage losses from the ditch range between 50 and 150 $m^3/d/km$. However, this seepage loss only occurs while there is water in the diversion ditch. About 400 m^3/d could be expected to be lost on average throughout the year.

j) This estimate is for ground water seepage only and does not include seepage losses through the embankments which would be picked up on the surface water collection system.

k) This seepage is likely to be very variable depending on the season. 300 m^3/d is the maximum average monthly discharge. However, there would generally be no flow in this channel for at least six months of the year.

l) This seepage would flow toward the Medicine Creek Valley and then westward to the Hat Creek Valley where it would enter the alluvial aquifer.

m) These values include both ground water flows and surface waters which have come through the retaining embankments and/or the ash piles but not entered the ground water table. These surface water flows are included here as much of the low flow in Harry Creek seeps down to the Buried Bedrock Valley Aquifer.

ITEM NO. HAT CREEK PROJECT

RESOURCE: Surface Water Hydrology AREA: Hat Creek

PHASE	ACTIVITY	GENERAL AREA (Note 1)	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICAN.	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Construction	Mine	Hat Creek	Runoff Volume	+330	$10^3 m^3 \cdot yr^{-1}$	M	+2	P	+I	Note 2 and 3.
Construction	Plant Water Supply	Hat Creek	Runoff Volume	+225	$10^3 m^3 \cdot yr^{-1}$	D	+1	P	+I	Construction water supply. Note 4
Construction	Plant - Other Activities	Hat Creek	Runoff Volume	+130	$10^3 m^3 \cdot yr^{-1}$	M	+1	P	+I	Storm runoff only. Notes 2 and 3.
Construction	Offsite	Hat Creek	Runoff Volume	+(<100)	$10^3 m^3 \cdot yr^{-1}$	M	+(<1)	P	+I	Facilities are dispersed and of small areal extent.
Operation	Mine - Dewatering	Hat Creek	Runoff Volume	0	$10^3 m^3 \cdot yr^{-1}$	M	0	P		Flow from dewatering wells and mine seepage would reach Hat Creek without mine.
Operation	Other Mine Activities	Hat Creek	Runoff Volume	+1500	$10^3 m^3 \cdot yr^{-1}$	M	+7	P	+L	Note 5
Operation	Plant	Hat Creek	Runoff Volume	-240	$10^3 m^3 \cdot yr^{-1}$	M	-1	P	-I	Note 6
Operation	Offsite Diversions	Hat Creek	Runoff Volume	+(<100)	$10^3 m^3 \cdot yr^{-1}$	M	+(<1)	P	+I	Note 7
Operation	Offsite - Other Activities	Hat Creek	Runoff Volume	+(<100)	$10^3 m^3 \cdot yr^{-1}$	M	+(<1)	P	+I	Facilities are dispersed and of small areal extent

FORM M1

HAT CREEK PROJECT

RESOURCE: Surface Water Hydrology AREA: Hat Creek

PHASE	ACTIVITY	GENERAL AREA (Note 1)	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Decommissioning	Filling of Pit	Hat Creek	Runoff Volume	-500	$10^3 m^3 yr^{-1}$	M	-2	P	-L	Evaporation from lake
Decommissioning	Other Activities	Hat Creek	Runoff Volume	-1260	$10^3 m^3 yr^{-1}$	M	-6	P	-L	Revegetation, return of plant-site and reservoir drainage to Hat Creek
Construction	Mine	Hat Creek	Stream Morphology	-5	km	D	-11	G	-M	Destruction of 5 km of Medicine Creek channel, out of 55 km of comp. channel
Construction	Plant, Water Supply	Hat Creek	Stream Morphology	0	km					Flow too small to cause detectable changes.
Construction	Plant, Other Activities	Hat Creek	Stream Morphology	-5	km	D	-9	F	-M	Destruction of 5 km of Medicine Creek channel, out of 55 km of comp. channel
Construction	Offsite	Hat Creek	Stream Morphology	-(<1)	km	D	-(<1)	F	-L	Only local interferences with stream channels for dams, culverts etc.

FORM NI

HAT CREEK PROJECT

RESOURCE: Surface Water Hydrology AREA: Hat Creek

PHASE	ACTIVITY	GENERAL AREA (Note 1)	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Operation	Mine Dewatering	Hat Creek	Stream Morphology	0						No flows are added
Operation	Other Mine Activities	Hat Creek	Stream Morphology	± 21	km	D	± 47	G	± L	The mine affects 21 km of Hat Creek in minor way through flow modifications and siltation.
Operation	Plant	Hat Creek	Stream Morphology	0						No discharges from the plant. Note 10
Operation	Offsite Diversions	Hat Creek	Stream Morphology	-4	km	D	-9	G	-M	The diversion eliminates a further 4 km of Hat Creek, beyond the 5 km eliminated by the mine.
Operation	Offsite, Other Activities	Hat Creek	Stream Morphology	-(<1)	km	D	-(<1)	F	-L	Only local interference with some stream channels (dams, culverts, etc.)
Decommissioning	Filling of Pit	Hat Creek	Stream Morphology	+28	km	D	+60	G	+M	7 km of Hat Creek re-established, 23 km fully regulated
Decommissioning	Other Activities	Hat Creek	Stream Morphology	+1	km	D	+2	F	+L	Other diversions to remain in place but 1 km of Medicine Creek re-established

FORM N1

HAT CREEK PROJECT

RESOURCE: Surface Water Hydrology AREA: Hat Creek

PHASE	ACTIVITY	GENERAL AREA (Note 1)	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Construction	Mine	Hat Creek	Lakes Note 11	-20	ha	D	-38	F	-H	Draining Finney and Aleece Lake Note 11.
Construction	Plant, Water Supply	Hat Creek	Lakes Note 11	0						
Construction		Hat Creek	Lakes Note 11	0						
Construction		Hat Creek	Lakes Note 11	0						
Operation	Mine Dewatering	Hat Creek	Lakes Note 11	0						
Operation	Other Mine Activities	Hat Creek	Lakes Note 11	0						The lagoons are not considered to be lakes.
Operation	Plant	Hat Creek	Lakes Note 11	0						The makeup water reservoir and ash pond are not lakes.

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FORM M1 HAT CREEK PROJECT

RESOURCE: Surface Water Hydrology AREA: Hat Creek PAGE: 5 of 5

PHASE	ACTIVITY	GENERAL AREA (Note 1)	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICAN	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Operation	Offsite Diversions	Hat Creek	Lakes Note 11	+14	ha	D	+27	F	+M	The two reservoirs of the Hat Creek diversion are permanent and might be considered lakes.
Operation	Offsite, Other Activities	Hat Creek	Lakes Note 11	0						
Decommissioning	Filling of Pit	Hat Creek	Lakes Note 11	+225	ha	D	+433	F	+H	Filling of pit
Decommission-ing	Other Activities	Hat Creek	Lakes Note 11	0						Finney and Aleece Lake are assumed to be permanently drained

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NOTES: SURFACE WATER HYDROLOGY

1. The "Hat Creek Area" is assumed to include the entire Hat Creek drainage basin to the confluence with the Bonaparte River.

2. Only mean annual runoff is considered, assuming that more runoff constitutes a positive impact.

3. Absolute values are estimates of the increased runoff, assuming 22 mm for disturbed surfaces, based on the differences between water balances for 100 mm and 200 mm soil storage (Table B1-2).

4. It is assumed that the construction water supply is derived from deep wells or from surface waters outside of the Hat Creek basin and that 75 percent of the flow eventually becomes an addition to Hat Creek flows.

5. This refers to the time near completion of mining, with 1370 ha in the pit and in the Houth Meadow dump contributing at 100 mm and 800 ha of other disturbed ground contributing at 22 mm.

6. With the plant area, make-up water reservoir, and ash pond, 570 ha will be withdrawn from the drainage area contributing to Hat Creek. Runoff at El. 1300 is approximately 42 mm according to Fig. 4 - 39. Medicine Creek is assumed to be diverted around the ash pond, not to McLaren Creek.

7. The prime diversion scheme does not affect runoff significantly but the alternate scheme with storage would have a major impact on the time distribution of Hat Creek flows.

8. The time distribution of runoff cannot be reduced to one or a few numbers yet it needs to be considered in the quantitative matrix. If only "runoff volume" is shown, because it happens to be quantifyable, the erroneous picture of a generally beneficial impact of the project on the resource "surface runoff" appears.

9. A major portion of Medicine Creek is also being destroyed, but since the tributaries to Hat Creek cannot readily be lumped with Hat Creek and are of less significance, this is ignored here.

10. The internal drainage of the plant site, reservoir/and ash pond does not significantly reduce flows in Hat Creek and there is no natural Medicine Creek channel left below the ash pond.

11. The main lakes in the Hat Creek drainage (and their areas in ha) are Blue Earth (6), Parke (4), Fish Hook (6), Finney (16), Aleece (4) and Gallagher (6). Several other, unnamed lakes of one to two hectares in area have a combined area of approximately 10 ha, for a total of 52 ha. The resource is of relatively low significance because several much larger lakes are situated within a few kilometers of the Hat Creek basin perimeter, in particular Pavilion, McLean and Bedard Lakes. Lake area given here are rough estimates only as there is considerable conflict between different maps. The large-scale maps tend to indicate larger lake areas but only a few lakes are included in the larger-scale mapping.

APPENDIX F2.0

Matrices, Notes, and M-1 Forms for Ground Water and Surface Water Quality

TABLE F2-1 QUANTITATIVE IMPACT MATRIX - GROUND WATER QUALITY
HAT CREEK AREA

RESOURCE / ACTIVITY		OPERATION		DECOMIS-SIONING
		MINE		MINE
		HOUTH MEA-DOWS DUMP	MEDI-CINE CREEK DUMP	RECLAMA-TION
CHEMICAL	AMOUNT	400	40	500 to 700
	QUALITY	G	G	U
	IMPACT	- H	-I	-

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TABLE F2-2 QUANTITATIVE IMPACT MATRIX - SURFACE WATER QUALITY

HAT CREEK AREA

RESOURCE / ACTIVITY		CONSTRUCTION						OPERATION								
		MINE				PLANT	OFF-SITES	MINE						PLANT	OFF-SITES	MINE
		LAND DISTURBANCE	DEWATERING	COAL STOCKPILE	LOW GRADE WASTE STOCKPILE	LAND DISTURBANCE	LAND DISTURBANCE	DEWATERING	OVERBURDEN DUMPS	LAND DISTURBANCE	COAL STOCKPILE	LOW GRADE WASTE STOCKPILE	RECLAMATION	ASH DISPOSAL	HAT CREEK DIVERSION	RECLAMATION
PHYSICAL	AMOUNT	U	0.018			U	U	0.03	0.087	U				0.21	0.12	
	QUALITY	G	G			G	G	G	G	G				G	G	
	IMPACT	-M	-L			-M	-M	-L	-L	-M				-I	-E	
CHEMICAL	AMOUNT		0.018	0.03	0.04			0.03	0.087		0.09	0.42		0.21		
	QUALITY		G	G	G			G	G		G	G		G		
	IMPACT		-H	-I	-I			-H	-H		-I	-I		-I		
BIOLOGICAL	AMOUNT		0.018					0.03					U			
	QUALITY		G					G					G			G
	IMPACT		-L					-H					-E			-E

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TABLE F2-3 QUANTITATIVE IMPACT MATRIX - SURFACE WATER QUALITY
BONAPARTE RIVER

ACTIVITY / RESOURCE		CONSTRUCTION				OPERATION					DECOMIS-SIONING
		MINE		PLANT	OFFSITES	MINE				OFFSITES	MINE
		DEWATERING	LAND DISTURBANCE	LAND DISTURBANCE	LAND DISTURBANCE	DEWATERING	LAND DISTURBANCE	OVERBURDEN DUMPS	RECLAMATION	HAT CREEK DIVERSION	RECLAMATION
PHYSICAL	AMOUNT QUALITY IMPACT		0.12-4.0 G -I	0.12-4.0 G -I	0.12-4.0 G -I		0.24-4.0 G -L			0.24-4.0 G -M	
CHEMICAL	AMOUNT QUALITY IMPACT	0.12-4.0 G -L				0.24-4.0 G -M		0.24-4.0 G -L			
BIOLOGICAL	AMOUNT QUALITY IMPACT								0.24-4.0 G -L		0.24-4.0 G -L

TABLE F2-4 QUANTITATIVE IMPACT MATRIX - SURFACE WATER QUALITY

THOMPSON RIVER

RESOURCE / ACTIVITY		CONSTRUCTION	OPERATION	DECOMISSIONING
PHYSICAL	AMOUNT QUALITY IMPACT	2.0-16.0 G -I	2.0-16.0 G -I	
CHEMICAL	AMOUNT QUALITY IMPACT	2.0-16.0 G -I	2.0-16.0 G -I	
BIOLOGICAL	AMOUNT QUALITY IMPACT			2.0-16.0 G -I

FORM M1

RESOURCE: Ground Water Quality AREA: Hat Creek

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Part	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Operation	Mine-Mouth Meadow Dump	Marble Canyon Aquifer	Chemical	400	$m^3 d^{-1}$	P	100	G	-H	Note 1
Operation	Mine-Medicine Creek Dump	Valley Alluvium Aquifer	Chemical	40	$m^3 d^{-1}$	P	100	G	-I	Note 2
Decommissioning	Mint-Pit Reclamation	Valley Alluvium and Burried Bedrock Channel Aquifers	Chemical	500 to 700	$m^3 d^{-1}$	P	100	U	Note 3	

NOTES: GROUND WATER QUALITY

1. Parameters of leachate quality that exceeded PCB Guidelines or were unusually high include aresenic, chromium, copper, iron, dissolved solids, and pH. These were considered in the impact assessment.

   The leachate flow perecent of the total aquifer was assumed to be 20% as determined by Golder.

   The leachate and existing acquifer quality were used to estimate the final acquifer water quality. These values were compared to the Canadian Drinking Water Standards in evaluating the impact.

2. The quality and quantity of seepage to the ground water from the Medicine Creek dump will produce insignificant impact.

3. Quality of pit water and buried Bedrock Channel Aquifer unknown and therefore impact indeterminant.

FORM 81 — LAT-SITE IMPACTS

RESOURCE: SURFACE WATER QUALITY — AREA: HAT CREEK —

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONSTRUCTION	MINE-LAND DISTURBANCE	HAT CREEK	PHYSICAL	U	-	-	100	G	-M	Increased suspended solids in Hat Creek due to mine construction activities.
CONSTRUCTION	MINE-PIT DEWATERING	HAT CREEK	PHYSICAL	0.018	$m^3.s^{-1}$	P	100	G	-L	Impact due to increased total suspended solids in Hat Creek.
CONSTRUCTION	MINE-PIT DEWATERING	HAT CREEK	CHEMICAL	0.018	$m^3.s^{-1}$	P	100	G	-H	Impact due to increased total dissolved solids in Hat Creek.
CONSTRUCTION	MINE-PIT DEWATERING	HAT CREEK	BILOGICAL	0.018	$m^3.s^{-1}$	P	100	G	-L	Impact due to increased ammonia and BOD_5 in Hat Creek from blasting.
CONSTRUCTION	MINE-COAL STOCKPILE	HAT CREEK	CHEMICAL	0.03	$m^3.s^{-1}$	P	100	G	-I	Assume no discharge to Hat Creek.
CONSTRUCTION	MINE-LOW GRADE WASTE STOCKPILE	HAT CREEK	CHEMICAL	0.04	$m^3.s^{-1}$	P	100	G	-I	Assume no discharge to Hat Creek.
CONSTRUCTION	PLANT-LAND DISTURBANCE	HAT CREEK	PHYSICAL	U	-	-	100	G	-M	Increased suspended solids in Hat Creek due to plant construction activities.
CONSTRUCTION	OFFSITES - LAND DISTURBANCE	HAT CREEK	PHYSICAL	U	-	-	100	G	-M	Increased suspended solids in Hat Creek due to offsite construction activities, especially the Hat Creek Diversion.

FORM R1 HAT CREEK PROJECT

RESOURCE: SURFACE WATER QUALITY AREA: HAT CREEK PAGE: 2 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
OPERATION	MINE DEWATERING	HAT CREEK	PHYSICAL	0.030	$m^3.s^{-1}$	P	100	G	-L	Elevated levels of suspended solids in Hat Creek.
OPERATION	MINE DEWATERING	HAT CREEK	CHEMICAL	0.030	$m^3.s^{-1}$	P	100	G	-H	Increased levels of total dissolved solids in Hat Creek.
OPERATION	MINE DEWATERING	HAT CREEK	BIOLOGICAL	0.030	$m^3.s^{-1}$	P	100	G	-H	Reduced dissolved oxygen concentration in Hat Creek due to increased BOD_5 and ammonia
OPERATION	MINE - OVERBURDEN DUMPS	HAT CREEK	PHYSICAL	0.087	$m^3.s^{-1}$	M	100	G	-L	Increased levels of suspended solids in Hat Creek.
OPERATION	MINE - OVERBURDEN DUMPS	HAT CREEK	CHEMICAL	0.087	$m^3.s^{-1}$	P	100	G	-H	Increased levels of Cr, Cu, Fe, and total dissolved solids in Hat Creek.
OPERATION	MINE - LAND DISTURBANCE	HAT CREEK	PHYSICAL	U	-	-	100	G	-M	Increased suspended solids in Hat Creek due to mine construction activities.
OPERATION	MINE - COAL STOCKPILE	HAT CREEK	CHEMICAL	0.09	$m^3.s^{-1}$	P	100	G	-I	Assume no discharge to Hat Creek.
OPERATION	MINE - LOW GRADE WASTE STOCKPILE	HAT CREEK	CHEMICAL	0.42	$m^3.s^{-1}$	P	100	G	-I	Assume no discharge to Hat Creek.

FORM M1 HAT CREEK PROJECT

RESOURCE: SURFACE WATER QUALITY AREA: HAT CREEK PAGE: 3 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
OPERATION	PLANT - ASH DISPOSAL	HAT CREEK	PHYSICAL CHEMICAL	0.21	$m^3.s^{-1}$	P	100	G	-I	Assume no discharge to Hat Creek.
OPERATION	OFFSITES - HAT CREEK DIVISION	HAT CREEK	PHYSICAL	< 0.12	$m^3.s^{-1}$	P	100	G	-E	Impact due to substantial Hat Creek temperature increase.
OPERATION & DECOMMISSIONING	MINE - RECLAMATION	HAT CREEK	BIOLOGICAL	U	-	P	100	G	-E	Increased nutrient load due to fertilizers.

FORM NO. MAT CREEK PROJECT

RESOURCE: SURFACE WATER QUALITY AREA: BONAPARTE RIVER PAGE: 4 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONSTRUCTION	MINE - PIT DEWATERING	BONAPARTE RIVER	CHEMICAL	0.12 - 4.0	$m^3.s^{-1}$	R	100	G	-L	Impact due mostly to increased total dissolved solids.
CONSTRUCTION	MINE, PLANT, OFFSITES-LAND DISTURBANCE	BONAPARTE RIVER	PHYSICAL	0.12 - 4.0	$m^3.s^{-1}$	R	100	G	-I	Impact due to increased suspended solids.
OPERATION	MINE - LAND DISTURBANCE	BONAPARTE RIVER	PHYSICAL	0.24 - 4.0	$m^3.s^{-1}$	R	100	G	-L	Impact due to increased suspended solids.
OPERATION	MINE - PIT DEWATERING	BONAPARTE RIVER	CHEMICAL	0.24 - 4.0	$m^3.s^{-1}$	R	100	G	-M	Impact due mostly to increased dissolved solids.
OPERATION	MINE - OVER-BURDEN	BONAPARTE RIVER	CHEMICAL	0.24 - 4.0	$m^3.s^{-1}$	R	100	G	-L	Impact due to increased metals and dissolved solids.
OPERATION	OFFSITES - MAT CREEK DIVERSION	BONAPARTE RIVER	PHYSICAL	0.24 - 4.0	$m^3.s^{-1}$	R	100	G	-M	Impact due to increased temperature.
OPERATION & DECOMMISSIONING	MINE - RECLAMATION	BONAPARTE RIVER	BIOLOGICAL	0.24 - 4.0	$m^3.s^{-1}$	R	100	G	-H	Increased nutrient load due to fertilizers.

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RESOURCE: SURFACE WATER QUALITY AREA: THOMPSON RIVER PAGE: 5 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANC	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CONSTRUCTION	ALL	THOMPSON RIVER	CHEMICAL PHYSICAL	2.0 - 16.0	$m^3.s^{-1}$	R	100	G	-I	
OPERATION	ALL	THOMPSON RIVER	CHEMICAL PHYSICAL	2.0 - 16.0	$m^3.s^{-1}$	R	100	G	-I	
DECOMMISSION-ING	ALL	THOMPSON RIVER	BIOLOGICAL	2.0 - 16.0	$m^3.s^{-1}$	R	100	G	-I	

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APPENDIX F3.0

Matrix, Notes, and M-1 Forms for Surface Water Use

TABLE F3-1 QUANTITATIVE MATRIX - SURFACE WATER USE

ACTIVITY / RESOURCE		CONSTRUCTION																	
		ALL STUDY AREAS				BONAPARTE, CORNWALL AND OREGON JACK					HAT CREEK DRAINAGE								
											SUB-REGION II								III
		MINE		PLANT	OFF-SITES						MINE			PLANT	OFFSITES				
		LAND ALIENATION	FINNEY & ALEESE LAKE DEWATERING	LAND ALIENATION	LAND ALIENATION	MAIN ACCESS ROAD	AIRPORT SITE A	MAIN PUMP STATION I	BOOSTER PUMP STATION I	AIRPORT SITE C (ALTERNATE ACTIVITIES)	PIT	DUMPS	FINNEY LAKE DEWATERING	UPPER MEDICINE CREEK ASH DISPOSAL	HAT CREEK DIVERSION (LAND ALIENATION)	HAT CREEK DIVERSION (CONVEYANCE DISRUPTION)	FINNEY CREEK DIVERSION	PIT RIM RESERVOIR	HAT CREEK WATER SUPPLY RESERVOIR (ALTERNATE ACTIVITIES)
LIVESTOCK	AMOUNT	2384	-	827	156														
	QUALITY	G	G	G	G														
	IMPACT	-L	-L	-L	-I														
IRRIGATION	AMOUNT					17	39	2	2	33	85	29	12	11	3	16	12	7	45
	QUALITY					G	G	G	G	G	G	G	G	G	G	G	G	G	G
	IMPACT					-L	-L	-I	-I	-L	-M	-L	-L	-L	-I	-L	-L	-L	-L

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TABLE F3-1 QUANTITATIVE MATRIX - SURFACE WATER USE

RESOURCE / ACTIVITY		OPERATION											DECOMMISSIONING							
		HAT CREEK DRAINAGE																		
		SUB-REGIONS I & II									II		ALL STUDY AREAS							
		DUST CONTROL	PIT RIM RESERVOIR	HEADWORKS RESERVOIR	MINE PIT SEEPAGE EVAPORATION & QUALITY	PIT RIM DEWATERING DIVERSION	COAL STOCKPILES DRAINAGE WATER QUALITY	MEDICINE CREEK DIVERSION (ALTERNATE ACTIVITY)	MEDICINE CREEK WATER SUPPLY (ALTERNATE ACTIVITY)	HAT CREEK WATER SUPPLY (ALTERNATE ACTIVITY)	MINE		PIT RIM RESERVOIR	PIT LAKE	DUST CONTROL CEASES	PIT RIM DEWATERING CEASES	PLANT RESERVOIR	SUPPLY PIPELINE	MEDICINE CREEK WATER SUPPLY (ALTERNATE ACTIVITY)	HAT CREEK WATER SUPPLY RESERVOIR (ALTERNATE ACTIVITY)
											COAL STOCKPILE LEACHATE	MINE DRAINAGE								
LIVESTOCK	AMOUNT										-	-								
	QUALITY										G	G								
	IMPACT										-L	-L								
IRRIGATION	AMOUNT	10	3	3	0-21	0-21	-	-	-	-			25	1035	10	21	830	650	-	213
	QUALITY	G	G	G	G	G	G	G	G	G			G	G	G	G	G	G	G	G
	IMPACT	-L	-I	-I	-L	-I	-L	-M	-M	-H			-L	-H	-L	-L	-H	-H	-M	-H

FORM 81 — LAND USE IMPACT

RESOURCE: Surface Water Use — AREA: All Study Areas — PAGE: 1 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Construction	Mine - Land Alienation	All Study Areas	Livestock	2384	ha	D	4 Note 1	G	-L	Loss of Watering Sites
Construction	Finney & Aleece Lake Dewatering	All Study Areas	Livestock	—	—	U	—	G	-L	Loss of Watering Sites
Construction	Plant - Land Alienation	All Study Areas	Livestock	827	ha	D	1 Note 1	G	-L	Loss of Watering Sites
Construction	Offsites - Land Alienation	All Study Areas	Livestock	156	ha	D	<1 Note 1	G	-L	Loss of Watering Sites
Operation	Mine - Coal Stockpile Leachate	Sub Region II	Livestock	Note 2	—	U	—	G	-L	Potential Unsuitable Drinking Water
Operation	Mine - Drainage	Sub Region II	Livestock	Note 2	—	U	—	G	-L	Potential Unsuitable Drinking Water

FORM M1 HAT CREEK PROJECT

RESOURCE: Surface Water Use AREA: Hat Creek Drainage PAGE: 2 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Construction	Mine-Pit	Sub-Region II	Irrigation	85	$ha \cdot m \cdot yr^{-1}$	D	31 Note 3	G	-M	Alienation of Irrigable Land
Construction	Mine-Dumps	Sub Region II	Irrigation	29	$ha \cdot m \cdot yr^{-1}$	D	10 Note 3	G	-L	Alienation of Irrigable Land
Construction	Finney Lake Dewatering	Sub-Region II	Irrigation	12	$ha \cdot m \cdot yr^{-1}$	D	4 Note 3	G	-L	Storage Loss
Construction	Plant-Upper Medicine Creek Ash Disposal	Sub Region II	Irrigation	11	$ha \cdot m \cdot yr^{-1}$	D	4 Note 3	G	-L	Alienation of Irrigable Land
Construction	Off sites-Hat Creek Diversion	Sub Region II	Irrigation	3	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	-I	Alienation of Irrigable Land
Construction	Off sites-Hat Creek Diversion	Sub Region II	Irrigation	23 Note 2	$ha \cdot m \cdot yr^{-1}$	D	6 Note 3	G	-L	Conveyance Disruption
Construction	Finney Creek Diversion	Sub Region II	Irrigation	12 Note 2	$ha \cdot m \cdot yr^{-1}$	D	4 Note 3	G	-L	Conveyance Disruption (Excludes 12 $ha \cdot m \cdot yr^{-1}$ also alienated by Finney Lake dewatering)
Construction	Pit Rim Reservoir	Sub Region II	Irrigation	7	$ha \cdot m \cdot yr^{-1}$	D	3 Note 3	G	-L	Alienation of Irrigable Land
Construction	Hat Creek Water Supply Reservoir (Alternate)	Sub Region III	Irrigation	45	$ha \cdot m \cdot yr^{-1}$	D	12 Note 3	G	-L	Alienation of Irrigable Land

FORM M1

RESOURCE: Surface Water Use AREA: As noted

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERIST	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Construction	Main Access Road	Bonaparte, Cornwall And Oregon Jack Study Areas	Irrigation	17	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	-L	Alienation of Irrigable Land
Construction	Airport Site A	Bonaparte, Cornwall And Oregon Jack Study Areas	Irrigation	39	$ha \cdot m \cdot yr^{-1}$	D	2 Note 3	G	-L	Alienation of Irrigable Land
Construction	Main Pump Station 1	Bonaparte, Cornwall And Oregon Jack Study Areas	Irrigation	2	$ha \cdot m \cdot yr^{-1}$	D	<1 Note 3	G	-I	Alienation of Irrigable Land
Construction	Booster Pump Station 1	Bonaparte, Cornwall And Oregon Jack Study Areas	Irrigation	2	$ha \cdot m \cdot yr^{-1}$	D	<1 Note 3	G	-I	Alienation of Irrigable Land
Construction	Airport Site C	Bonaparte, Cornwall And Oregon Jack Study Areas	Irrigation	33	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	-L	Alienation of Irrigable Land
Operation	Dust Control	Sub-Regions I & II	Irrigation	10	$ha \cdot m \cdot yr^{-1}$	D	2 Note 3	G	-L	Project Use Evaporation
Operation	Pit River Reservoir	Sub-Regions I & II	Irrigation	3	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	-I	Surface Evaporation
Operation	Headworks Reservoir	Sub-Regions I & II	Irrigation	3	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	-I	Surface Evaporation
Operation	Mine Pit Seepage Evaporation & Quality	Sub-Regions I & II	Irrigation	0-21	$ha \cdot m \cdot yr^{-1}$	R	≤4 Note 3	G	-L	Based on Maximum Pump Capacity Specification

FORM M1

RESOURCE: Surface Water Use AREA: Hat Creek Drainage PAGE: 4 of 5

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Operation	Pit Rim Dewatering Diversion	Sub Regions I & II	Irrigation	0-21	$ha \cdot m \cdot yr^{-1}$	R	≤ 4 Note 3	G	-I	Based on Maximum Pump Capacity Specification
Operation	Coal Stock-pile Drainage Water Quality	Sub-Regions I & II	Irrigation	—	—	U	—	G	-L	—
Operation	Medicine Crk. Diversion (Alternate)	Sub-Regions I & II	Irrigation	—	—	U	—	G	-M	—
Operation	Medicine Crk. Water Supply (Alternate)	Sub-Regions I & II	Irrigation	—	—	U	—	G	-M	—
Operation	Hat Creek Water Supply Alternate Note 4	Sub-Regions I & II	Irrigation	—	—	U	—	G	-H	—

FORM #1

HAT CREEK PROJECT

RESOURCE: Surface Water Use AREA: All Study Areas

PHASE	ACTIVITY	GENERAL AREA	RESOURCE CHARACTERISTIC	AMOUNT				RESOURCE QUALITY	IMPACT SIGNIFICANCE	COMMENT
				Absolute	Unit	Accuracy	% Resource			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Decommissioning	Pit Rim Reservoir	All Study Areas	Irrigation	25 Max.	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	+L	Available Storage
Decommissioning	Pit Lake	All Study Areas	Irrigation	1035 Max.	$ha \cdot m \cdot yr^{-1}$	D	30 Note 3	G	+H	Available Storage
Decommissioning	Dust Control Ceases	All Study Areas	Irrigation	10 Max.	$ha \cdot m \cdot yr^{-1}$	D	<1 Note 3	G	+L	Project Use Stops
Decommissioning	Pit Rim Dewatering Ceases	All Study Areas	Irrigation	21 Max.	$ha \cdot m \cdot yr^{-1}$	D	1 Note 3	G	+L	Project Use Stops
Decommissioning	Plant Reservoir	All Study Areas	Irrigation	830 Max.	$ha \cdot m \cdot yr^{-1}$	D	24 Note 3	G	+H	Available Storage
Decommissioning	Supply Pipeline	All Study Areas	Irrigation	650 Max.	$ha \cdot m \cdot yr^{-1}$	D	19 Note 3	G	+H	Available Supply
Decommissioning	Medicine Crk. Water Supply (Alternate)	All Study Areas	Irrigation	—	—	U	—	G	+M	Available Storage
Decommissioning	Hat Creek Water Supply Reservoir (Alternate)	All Study Areas	Irrigation	213 Max.	$ha \cdot m \cdot yr^{-1}$	D	6 Note 3	G	+M	Available Storage

NOTES: SURFACE WATER USE

1. Based on "Probable Use" Case Grazing Land without Project, Hat Creek drainage only.

2. Appears to be easily mitigated.

3. Based on "Probable Use" case without the project.

4. Would also affect Sub-Region III.