B. C. HYDRO

THERMAL GENERATION PROJECTS DIVISION

HAT CREEK PROJECT

PROPOSED

MINING FIELD PROGRAM - 1982

FEBRUARY 1982

MINING DEPARTMENT

DRAFT

HAT CREEK PROJECT

MINING FIELD PROGRAM - 1982

TABLE OF CONTENTS

Figures

Tables

Appendices

HAT CREEK PROJECT

MINING FIELD PROGRAM 1982

1.0 INTRODUCTION

1.1 B. C. Hydro owns 36 coal licenses situated in the Hat Creek Valley south of Highway 12 between Lillooet and Cache Creek. Annual exploration work on these coal licences is carried out in terms of the Coal Mines Act and the Coal Mines Regulation Act to determine feasibility information for the development and production of coal from these licenses. The cost of this work can be applied against the assessments for extending the term of licenses for further terms of one year each up to a maximum of 10 years protection (Coal Act Section 19).

These 36 "old" licenses have protection of 10 years as at May 1981 but reduces to 9 years as at May 1982 until we submit the annual renewal and declaration of assessment work done.

New coal licenses totalling 18 and 4387 hectares have been registered as of 15 March 1982 lying east of the old licenses and covering the powerplant and Medicine Creek waste disposal sites. These must have protection work done on them in 1982 and the excess amounts will provide protection for additional years beyond 1983.

1.2 Six programs of work have been planned for the 1982 Mine Exploration Program on these coal licenses under Reclamation Permit #103.

"Notice of Work" on the coal licenses is being submitted to the Chief Inspector of Mines and the District Inspector of Mines on the coal exploration Form 7, and the "Proposed Reclamation Program" on Form 8, in terms of Section 9 of the Coal Mine Regulation Act.

1.3 Six programs of work have been planned to provide important information and conclusions for the design evaluation in the two main areas of concern for the development and operation of the mine. These two areas are:

a) Geotechnical and hydrological control factors for pit slope stability and the Hat Creek Diversion Tunnel around the pit;

b) coal quality control factors for production, material handling and supply of coal to the powerplant at fuel specification grade and estimated characteristics.

1.4 The objectives and need for the work to be done on these areas of design investigation has been supported and recommended by the Hat Creek Board of Review at its last meeting in 1981.

1.5 The scope and cost of the total planned programs was initially found to exceed $3 million and require preliminary site selection work. In view of the economic situation, which requires constraint and under the extended project schedule it seems propitious to schedule the total work required over two years, 1982 and 1983. The budget for 1982 is consequently reduced to less than $2 million. The budget estimate, Figure 5-1, indicates those parts of the programs that have been postponed to 1983. The two programs that have been almost entirely deferred to next year are:

The Claystone Excavation Trench "F"
The Infill Drilling - Waste Dumps, Geotechnical.

Also the major part of a third program, the "C" Zone Coal Trench E excavation, has been deferred to 1983, although sufficient excavation will be done at the site to get one of its objectives accomplished. This is to get a representative bulk sample (20 tons) of the coal to go with that of A zone coal Trench D to Homer City for the coal washing test at the EPRI there. This 20-ton sample will confirm whether the C Zone coal has the same washing characteristics as the A Zone coal.

1.6 The schedule, Figure 4-1, shows that the duration of all the work for 1982, engineering study and fieldwork, will take most of the year. The fieldwork on the several programs is planned to be done at the same time from June to September with catering and site accommodation provided for contractors, consultants, and B. C. Hydro supervision. Manpower - workforce on site during the fieldwork period is expected to peak at 55 persons.

2.0 SUMMARY

The 1982 Mining field programs summarized below in 2.1 through 2.6 are explained in detail in the Appendices 1-7. They have been planned to examine certain aspects identified as requiring further studies by the B. C. Hydro Mining Department and its consultants.

These studies, endorsed by the eighth meeting of the Board of Review in October 1981, are primarily concerned with geotechnical, hydrological and coal quality considerations and are necessary to assist in determining or updating design parameters for the planning and development of the open pit, associated mine offsite facilities and possibly of a pilot preparation plant.

These parameters would consider such aspects as pit slope stability, drainage systems, creek diversions, the design and sizing in coal handling and other equipment, in both the mine and powerplant, waste handling equipment in the mine, as well as the concept for flowsheet processes and equipment of a pilot preparation plant.

Information gathered would also assist in identifying what further studies are required.

2.1 Hat Creek Diversion Tunnel Investigation Program

The present plan for the diversion of the creek comprises a headworks dam to reroute Hat Creek into a 4 m deep lined canal, about 6.5 km long around the eastern limits of the 35-year pit, and a 2.1 km long buried conduit running under the mine services area and which discharges into the Hat Creek stream bed to the north of the pit limits.

Sometime after Year 12 it is proposed to either realign this open canal, or replace it with a tunnel to protect the pit slopes. Golder Associates pointed out in 1981 that because of the weak claystones

which underlie the surficials in the area, any movement in these could cause failures in the canal causing seepage or even flooding in the pit. Therefore, it was decided to investigate the use of a tunnel at the start of mining operations and other alternative. A detailed proposal of Golder Associates dated February 1982 (see Appendix 7) explains their methodological approach to reduce certain divertion alternatives for field investigations under hydrological aspects.

The field program will consist of a geophysical survey, geotechnical/ geological mapping and the drilling of up to 1200 m of boreholes. The total field program, engineered and supervised by Golder Associates, has a total estimated cost of $534,115 and would begin in June with a September 1982 completion date.

2.2 Groundwater and Geotechnical Update Program

Further consideration is being given to the quantities of water that may be encountered in the mine. The investigations would require:

a) geophysical survey;

b) drilling of exploration wells and pump testing (approximately 200 m);

c) installation of piezometers to test permeability, water flows, etc.

The information gathered from this program will assist in the reassessment of potential water flows into the pit. This will lead to recommendations in drainage and dewatering system planning.

The program coordinates with other field programs (i.e. 2.1, 2.5, 2.6) in providing information on pit slope stability, etc.

The program will be engineered and supervised by Golder Associates. Estimated cost for the program is $201,411 not including the geophysical survey which has been estimated at a total of $72,500.

2.3 A and C Zone Bulk Sample Program

While in previous years B and D Zone coal has been investigated, the objectives of the Bulk Sample Program are to: confirm the stratigraphy, coal quality and coal preparation characteristics of A zone coals as well as gather information on selective mining and handling properties; and confirm stratigraphy and coal quality of "C" zone coals. Two trenches are proposed to the program, Trench D to extract a bulk sample of A zone coal for detailed testing and handling studies, and Trench E to gather a sample of C zone coal for bench scale testing.

Overburden will be removed and stockpiled prior to coal extraction, average overburden depth is 7 m. Coal mining will be carried out using a hydraulic shovel using "selective mining" techniques as a means of quality control. Various technical control procedures such as geophysics and sampling will be employed prior to mining to predict coal quality and run-of-mine samples will be taken to enable a comparison to be made of actual vs predicted quality. The run-of-mine coal will be handled through a handling plant to prepare samples. The data obtained will be required to accurately define mine design criteria as a basis for detailed mine planning and tender work to be undertaken in 1983.

A program of tests will be carried out in various laboratories to determine various physical and chemical properties of the coal and pilot scale tests will be employed to confirm or establish design criteria for possible flowsheets, equipment, processes etc. The results of all testing (including Homer City and Batac) will be used to establish design criteria for a pilot plant in accordance with recommendations of B. C. Hydro's Review Board.

The field program would be scheduled between May and September 1982 employing up to 49 people during the peak activities. Total estimated cost for both trenches and testing is $736,000.

Coal and waste piles will be located and constructed to provide environmental test programs and will be in accordance with all regulations imposed by the Coal Mines Regulation Act.

2.4 Coal Characteristics Evaluation Program

The proposed bulk sample programs offer an opportunity to test simulated run-of-mine coal for several combustion related chemical characteristics. Basic research programs will be conducted in conjunction with university and commercial laboratories in the following study areas:

(i) Establishment of analytical procedures for measuring the presence and distribution of active and fixed sodium in coal;

(ii) Analysis of the distribution of iron in the deposit and its impact on ash fusion temperatures;

(iii) Mineralogy of non-combustibles in the coal to aid in correlation studies;

(iv) Petrographic analyses for rank determination and combustion efficiency predictions;

(v) Trace element analyses in relation to selective mining practices.

Proximate, sulphur and calorific value determinations will be conducted in the on site laboratory. Summer students will be employed under the guidance of a reputable coal laboratory consultant to operate the facility.

A budget estimate of $50,000 is included to carry out these studies.

2.5 Claystone Investigation

Golder Associates recommended further studies into the nature and characteristics of saturated claystones and suggested that a trench be excavated in the Medicine Creek Formation.

The objectives of the trench would be to examine the structure of the claystones and also to gain experience in the mining and handling of these materials as well as to test the depressurization by excavation concept. This latter point would give more information for pit slope design criteria and stability.

The proposed trench, near to the Lehman Ranch, would require large volumes to be excavated to be of any value and consequently high costs, therefore, this task has been delayed until 1983. However, exploratory holes will be drilled and piezometers installed to provide information on overburden permeability and water flows.

It will also be possible to test some claystone materials in Trench D outlined above in 2.3. Although these materials are above water table, and therefore not saturated, in this location it will be possible to carry out some tests for handling characteristics.

The total estimated cost of this limited program supervised by Golder Associates is $30,000.

2.6 Geological Investigation Program

The objective of this program is to ensure that all the planned summer programs are coordinated with respect to geological, geotechnical, geophysical and hydrological requirements. The information will be gathered and together with the information from the SIP 81 studies will be input into the B. C. Hydro data file.

The main areas for study or review are:

1) Regional Geology - updating the Regional Geology Map;

2) Surficial Material Study - to update and produce revised surficials maps;

3) Tunnel Diversion Study - correlation and verification of data and field supervision;

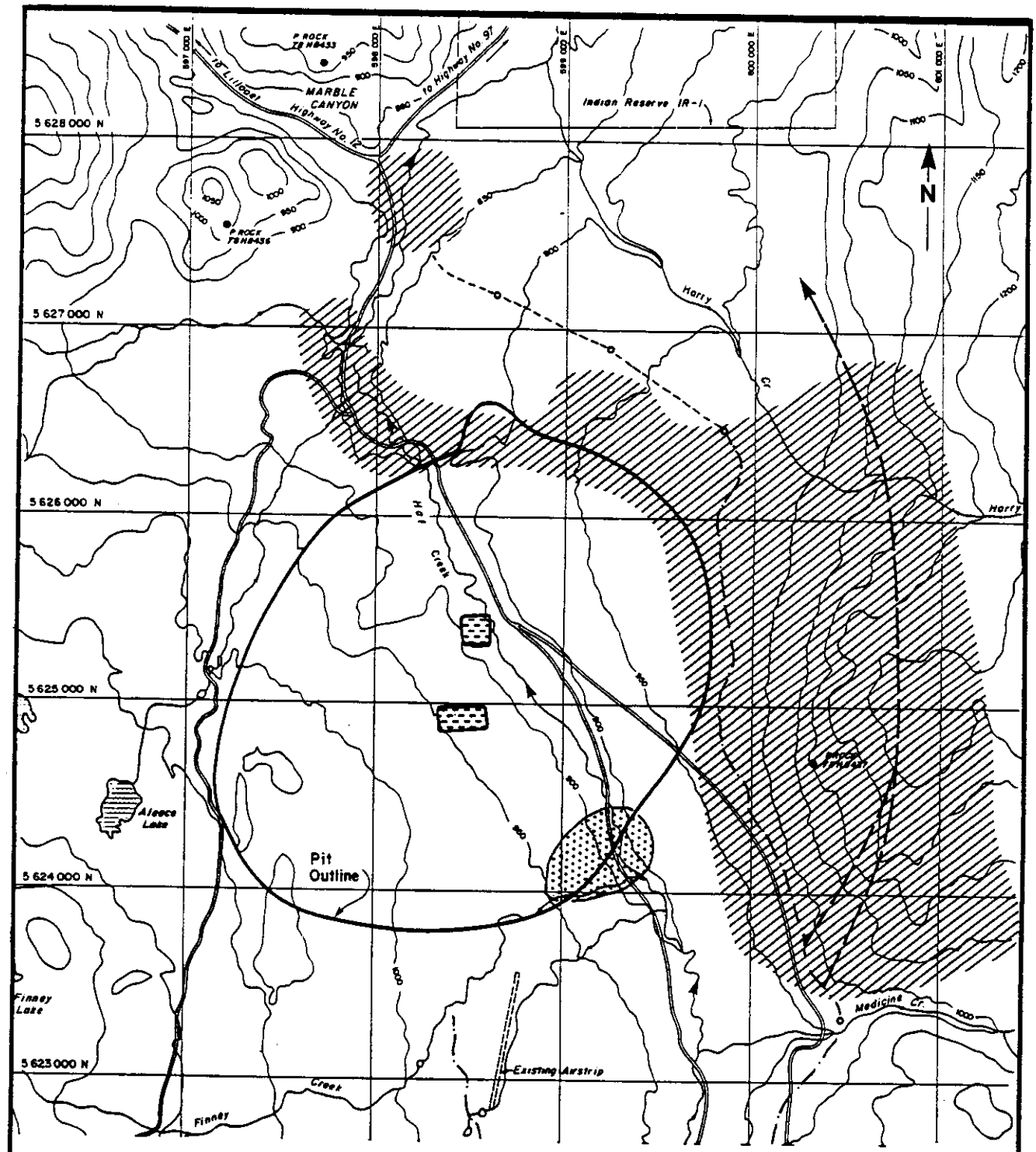
4) Groundwater Studies - correlation and compilation of data;

5) Bulk Sample Program - detailed mapping of surficials and coal units in Trench D and E. Geophysical studies of the materials and sampling and monitoring of coal quality.

6) Geophysical Studies - assist Golder Associates and Geo-Physi-Con in conducting geophysical surveys.

7) Gravity Survey - investigate application to extend existing survey information south to include No. 2 Deposit.

Provision has been made to take on additional student help to assist in compiling data. Further assistance may be required later in the program. It has been estimated that a total of 330 man-days of B. C. Hydro manpower will be required. Golder Associates will provide limited assistance in this area. A budget estimate of $11,802 has been allowed for this.



LEGEND

- Hat Creek Diversion Tunnel Program.
- Groundwater & Geotechnical Program.
- Geological & Geophysical Program.

A & C Zone Bulk Sample Program & Coal Characteristics Program. (Trenches 'D' & 'E')

Claystone Investigation Program. (Trench 'F')

Proposed Hat Creek Diversion Tunnel. (Montreal Engineering - 1976)

Proposed Hat Creek Diversion Canal

500 0 500 1000

Scale in Metre : 1:20000

Figure 2-1

MINING FIELD PROGRAM 1982
PROGRAM LOCATION MAP

3.0 FIELD SERVICES

The following provides information on field services and conditions for the Mining Field Programs - 1982.

3.1 Accommodation

A catering contract will provide for operation of the on-site bunkhouses and kitchen-diner. For this contract to be economic it is essential that all contractors, consultants and B. C. Hydro workers who do not have permission to live out must register for board and lodging at this site camp. No payments will be made for accommodation elsewhere without prior approval of the Site Manager.

Permission to live out will include certain B. C. Hydro employees or consultant services persons who have been on full-time long-term assignment on site at Hat Creek. In these cases a daily living out allowance of $35.00 per day is provided. These persons were hired away from site, and have established accommodation in Cache Creek or Ashcroft. If meals are taken at the camp caterers, the cost of these will be deducted from the daily allowance. Once the camp is in operation these individuals will report to the job site and no payment will be made for travel to the site.

Persons registered as camp occupants must check out in advance if they leave camp for more than 24 hours.

3.2 First Aid

A first aid station and an ambulance, along with qualified attendants, will be provided on site. The hospital in Ashcroft is within one hour travel time.

3.3 Protective Clothing

Hard hats will be provided to B. C. Hydro and consultant persons working on site. These must be worn at work sites and in travel on site. Contractors must provide their own protective clothing.

3.4 Offices and Telephones

Office space and access to existing telephones (there are only three lines available), will be provided to consultants and contractors at the on-site facilities. Long distance calls must be paid if not chargeable to B. C. Hydro. Contractors may bring in their own site office trailer for installation at the work site of their program if so required.

3.5 Vehicles, Gasoline and Maintenance

A number (approximately 10) of 4 x 4 pickup trucks will be leased and kept in a pool on site where maintenance servicing and fueling will be carried out. These vehicles have lease terms which call for mileage payments and restoration of body damage to as new conditions, so controls must be exercised. No vehicles will be leased without B. C. Hydro Site Manager's approval.

Vehicles will be issued to consultants and B. C. Hydro supervisors for use on site on contract work. They are not to be used for outside highway travel unless trips are authorized. In some cases bus trips to public carrier depots (including PWA at Kamloops Airport, Greyhound Bus in Cache Creek, or B. C. Rail Station at Pavilion Lake or Lillooet, etc.) will be arranged.

3.6 Fuel - Diesel and Gasoline

Supply tanks on site may be used by contractors and consultants to fuel up equipment and vehicles being used on the contract. Contractors will deduct the cost of fuel taken from their monthly invoices. Consultants will utilize fuel from B. C. Hydro tanks and will sign for fuel taken.

3.7 Hours of Work

The contractors work schedules are based on 10 hours per day and seven days per week for the short periods of individual programs when the contractor or subcontractor is actually active on site. It is also probable that consultant services such as trail location, surveying, geological mapping and other contingent work will require 10 hour days.

All consultant persons will daily report their working hours, place of work and nature of work done. This will be reported at the Site Management Office and such records will be the basis of authorized overtime, as well as providing information for the reporting of work progress on the many programs.

B. C. Hydro staff reports are on a two-week basis and actual days worked will be recorded as well as overtime for B. C. Hydro staff which will be considered as daily in excess of 7.5 hours. Consultants' invoices should reflect the hours worked and overtime claimed for their on-site personnel.

3.8 Travel Allowances

Expenses may be claimed for the initial trip in and last trip out on demobilization. An allowance will be paid for one trip home each three weeks. B. C. Hydro will bear the cost of travel expenses for regular employees only. Time involved and weekend allowances will not be paid for the period of absence.

On-site leased vehicles may not be used for trips in lieu of public carrier unless authorized.

4.0 SCHEDULE

The schedule of the field activities for the six programs summarized in Section 2.0 are shown on Figure 4.1.

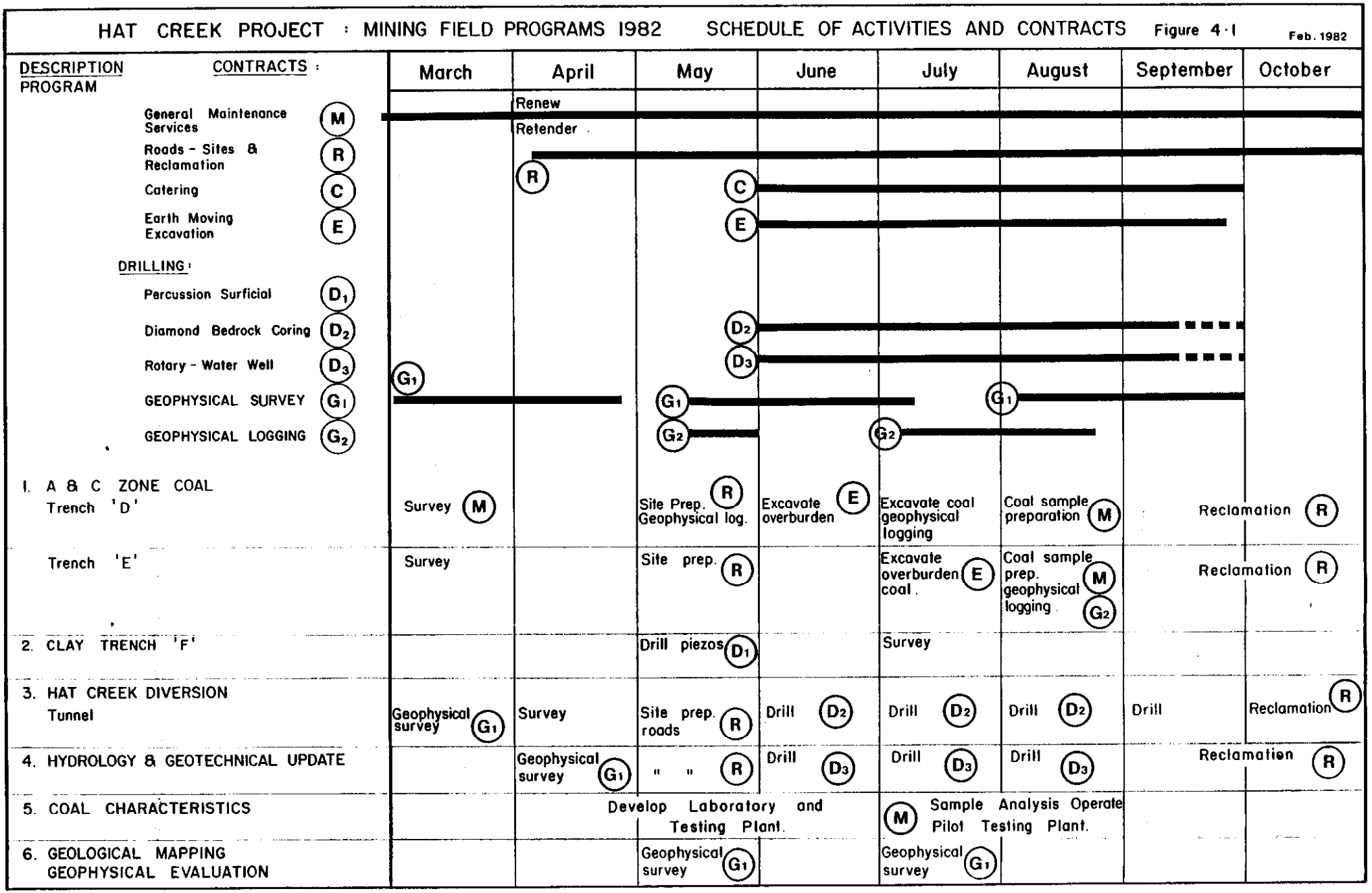
The schedule covers activities required for the pre-planning of some programs, i.e. geophysical surveys and land surveys.

The main work activities are due to commence in May 1982 with the maximum activity during June, July and August 1982.

HAT CREEK PROJECT : MINING FIELD PROGRAMS 1982 SCHEDULE OF ACTIVITIES AND CONTRACTS

Figure 4-1

Feb. 1982



5.0 BUDGET ESTIMATES

Budget estimates have been prepared for the various programs by either B. C. Hydro Mining Department and/or the consultants for the respective programs. These estimates are shown in Figure 5-1 Budget Summary. As can be seen the original estimate of the planned program was in excess of $3.0 million, not including contingencies. A review of the scope of work of the programs and the establishing priorities and by deferring certain programs it was possible to reduce the estimate to $1.77 million, not including contingencies. By allowing a contingency of 10% the budget estimate was established at $1.949 million. It is not expected that this figure would be subject to increase after the contract tendering procedures are completed and contracts have been awarded.

It should be noted that some pre-planning and engineering activities are being carried out prior to the start of the programs. This is to help better define the scope of work in some programs, i.e. Tunnel Diversion Study.

Cost control procedures with monthly reporting on cost and progress control will be followed in the field using daily field reports and invoices to closely monitor progress and budget compliances of the field programs.

Figure 5-1

DRAFT

ITEM	MARCH 1982	BUDGET ESTIMATES 1982 ORIGINAL	REVISED 25 FEB. 1982	REVISED 10 MARCH 1982
FIELD SERVICES				
BUILDING MAINTENANCE/SECURITY		60,000	60,000	60,000
SURVEYING/FIRST AID		24,000	24,000	24,000
ROADS, DRILL SITES		40,000	40,000	40,000
RECLAMATION		60,000	60,000	60,000
CATERING		135,000	100,000	100,000
VEHICLES		24,000	24,000	24,000
FUEL		15,000	15,000	15,000
SERVICES $22,000 IN COST CENTRE				
		358,000	323,000	323,000
PROGRAMS IN ORDER OF PRIORITY				
1. HAT CREEK DIVERSION TUNNEL INVESTIGATION				
GEOPHYSICAL	48,000			
ENGINEERING	66,815	255,110	182,000	182,000
FIELD		345,264	237,300	237,300
	114,815	600,374	419,300	419,300
2. GROUNDWATER EXPLORATION AND GEOTECHNICAL UPDATE				
ENGINEERING	21,185	77,673	64,726	64,726
FIELD		181,260	116,000	116,000
	21,185	258,933	180,726	180,726
3. FINAL REPORT - GOLDER	-	31,231	21,000	21,000
4. "A" ZONE BULK SAMPLE PROGRAM				
TRENCH "D" EXCAVATION		562,500	391,000	361,172
SAMPLING, HANDLING		50,000	50,000	50,000
SHIPPING, WASH TEST		75,000	150,000	150,000
GEOPHYSICAL		15,000	15,000	15,000
PLANT EQUIPMENT		66,000	40,000	40,000
MATERIAL HANDLING TESTS		20,000	20,000	20,000
BATAC JIG TEST		25,000	25,000	25,000
SITE LABORATORY		20,000	10,000	10,000
		833,500	701,000	671,172
5. COAL CHARACTERISTIC EVALUATION PROGRAM		50,000	50,000	50,000
6. CLAYSTONE INVESTIGATIONS				
TRENCH "F" EXCAVATION		320,000	-	
DRILLING AND PIEZOMETERS		-	20,000	
ENGINEERING, SUPERVISION, LABORATORY		40,000	10,000	
		360,000	30,000	-
7. "C" ZONE BULK SAMPLE PROGRAM				
TRENCH "E" EXCAVATION		98,000	20,000	
DRILLING AND PIEZOMETERS		20,000	-	
SAMPLING AND HANDLING		50,000	5,000	
SHIPPING AND WASH TEST		75,000	-	
OTHER TESTS		25,000	5,000	
LABORATORY ANALYSIS		20,000	5,000	
		288,000	35,000	-
8. GEOLOGICAL REASSESSMENT		51,262	11,802	11,802
9. INFILL DRILLING - WASTE DUMPS				
ENGINEERING		55,633	-	
FIELD		109,950	-	
		165,583	-	-
10. GEOLOGICAL MAPPING, GEOPHYSICAL		42,000	-	-
TOTAL	136,000	3,038,883	1,771,828	1,677,000
CONTINGENCY			177,183	-
GRAND TOTAL	136,000	3,038,883	1,949,011	1,677,000

6.0 FINAL REPORT

At the completion of the field activities and ensuing studies a final report on the six programs will be issued.

The report would contain the findings and recommendations of the B. C. Hydro Mining Department and consultants.

The recommendations would detail what future studies should be undertaken and outline the suggested Mining Field Program for 1983.

APPENDIX 1

HAT CREEK PROJECT

MINING FIELD PROGRAM - 1982

HAT CREEK DIVERSION TUNNEL INVESTIGATION PROGRAM

TABLE OF CONTENTS

FIGURES

SUMMARY

There has recently been some concern about the risks involved in the geohydrologic conditions and the general stability of the glacio-fluvial deposits on the east perimeter of the Hat Creek 35-year open pit. In conjunction with this, it would be worthwhile to note that there have been cases of canal failure damaging up to $40 million in recent years (Elbe-Seitenkanal near Luneberg in 1976, Kircheim reservoir plastic liner in 1977, Nuremberg Canal in 1979, etc.). The Elbe-Seiten canal failure has been discussed at a seminar in Aachen in 1977. It was then stated: "It must be made clear that apparently, under certain conditions, possible seepages that occur over an extended length of time and in some cases only appear at certain times, can have catastrohic results, even with a very small excess water pressure" (translation). The present Hat Creek diversion canal system requires about 1.5 km of canal rerouting in a tunnel after the 12th year of mine operation. In view of the risk involved in a canal diversion, a consideration might be given to diverting Hat Creek in a tunnel at the start of the mining operation or in several plastic pipelines. To date the feasibility of diverting Hat Creek in a tunnel has not been investigated from a geotechnical standpoint.

A detailed proposal of Golder Associates dated February 1982 (see Appendix 7) explores their methodological approach to reduce certain divertion alternatives for field investigations under hydrological aspects.

Field work for the proposed Hat Creek diversion tunnel investigation program consists of a geophysical survey, geological/geotechnical mapping and drilling. The geophysical survey will be carried out by Geo-Physi-Con Ltd. in March or April to cover the area between the Hat Creek junction office on Highway 12 and the pit rim. In addition the survey will be extended to cover part of the groundwater investigation area. The diamond drilling for tunnel investigation will commence in June and finish in September 1982. The total field program could employ up to 15 people during peak periods and would entail the cost of $534,115.00

1.0 INTRODUCTION

This report outlines the Hat Creek Diversion Tunnel study proposed for the 1982 field season. The program will investigate the potential of various Hat Creek Diversion Tunnel schemes.

The present creek diversion system comprises a 16 m high headworks dam to divert Hat Creek into a 4 m deep lined canal, about 6.5 km long around the easterly outer limits of the 35-year pit outline and a buried conduit nearly 2.1 km long to divert the flows of Hat Creek. A pit rim dam located between the headworks dam and the pit would intercept local inflows, surface and subsurface water as well as seepage loss from the upstream facilities. The proposed canal on the east perimeter of the pit is on the high bench of glacio-fluvial sands, gravels and till. After Year 12 the mine pit would have grown to a size requiring realignment, or replacement by a tunnel, of 1.5 km of the Hat Creek Diversion Canal. In the early years of mining, the troublesome weak clay rocks are not exposed, and the pit slopes are in layered glacial outwash materials consisting of silts, sands, and gravels. If leakage out of the canal did occur, it is quite possible that failures in the sands and gravels could take place as a result of erosion by piping of fine grained silt materials along preferred layers within that deposit. Furthermore, as mining progresses deeper into the pit, stress relief and creep of the underlying claystones might cause shear movements along the canal which could aggravate such leakages.

Golder Associates pointed out in their letter to Dr. G. F. Lange, November 1981 that "there is a risk involved in diverting Hat Creek in a canal around the perimeter of the pit above ongoing mining operations involving men and equipment at the base of the pit. For security, therefore, consideration might be given to diverting Hat Creek at the start of operations in a tunnel. The question of the feasibility of diverting Hat Creek in a tunnel has not been investigated from a geotechnical standpoint."

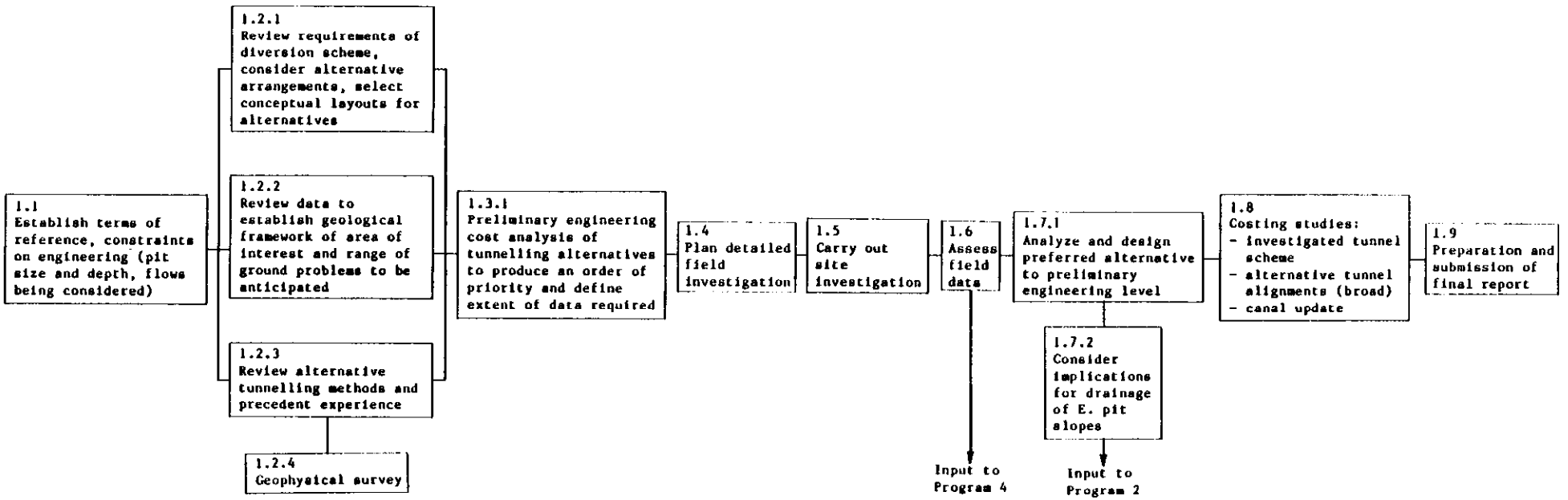
Recent concerns for the groundwater conditions and the general stability of the surficial materials on the east site of the proposed open pit in connection with possible leakages of the diversion canal indicated that further investigation is warranted. The area of concern includes the canal section of the diversion system between Medicine Creek and Harry Creek at approximately El. 975. It is the task of the Hat Creek Project Team to check whether an alternative system can be shown to be more secure and economically attractive under a renewed geotechnical risk evaluation.

In particular there may be some advantages in constructing a deep tunnel (El. ≃ 825) to act as both creek diversion and dewatering system for the surficial materials and weak rocks.

Figure 1 (prepared by Golder Associates) shows the sequence of the activities proposed for the study and the various responsibilities involved.

FIGURE 1

PROPOSED PROGRAM 1 ACTIVITIES, HAT CREEK/FINNEY CREEK DIVERSION SYSTEMS



Involvement								
BCH/GA	GA,BCH Specialist input A.A. Mathews Robins, Lovat (Machine manufacturers)	Geophysical contractor, GA, BCH	GA/BCH	GA, Drilling contractor	GA	Specialist input (soft-ground tunnelling) Z. Eisenstein	GA/BCH	GA or GA/BCH

2.0 ACTIVITIES PRIOR TO DRILLING PROGRAM

2.1 Geological Reassessment

The available surface and subsurface geologic data should be reassessed in the light of the present consideration of a tunnel for the creek diversion and dewatering the eastern pit slopes.

Existing data from about 30 diamond and percussion holes drilled for the investigation of the waste dump embankment and coal exploration should be carefully rechecked and assembled along with the recent bedrock mapping, to establish a preliminary stratigraphic sequence and the tectonic elements related to the diversion tunnel scheme.

2.2 Geophysical Survey

It is necessary to define the geology and structure within the area of the alternative tunnel schemes as early as possible in the program. Golder Associates recommended that a geophysical survey be conducted to support and refine the present geological interpretation. The geophysical survey will be augmented by further fieldwork after the Spring breakup.

It is proposed that the geophysical survey, which would be carried out by Geo-Physi-Con in April and which would cover part of the area of groundwater interest during the tunnel investigations, should be extended to cover the area between the recently drilled well (PW1) and the pit rim. Results from this survey should define the geometry of any aquifers present and permit the assessment of the potential extent of any inflow problem. The geophysical survey for this program comprises magnetics, resistivity and transient EM. Applicability of the geophysics for deduction of the bedrock geology will be monitored by the Mining Department of B. C. Hydro.

2.3 Contract Specification

The drilling contract specification will be jointly prepared by the B. C. Hydro Mining Department and Golder Associates. After the completion of the contract specification, a tender document will be released to prospective contractors. The various bids will be evaluated by B. C. Hydro and Golder Associates and the preferred bid will be selected.

It has been already decided that the drilling contract will be let on a cost per metre rather than a cost per hour basis.

The contract specifications for the geophysical survey will be prepared initially by Golder Associates and reviewed by B. C. Hydro for approval.

2.4 Layout of Proposed Program

A detailed drilling plan cannot be proposed until an evaluation of the geophysical ground surveys and the bedrock mapping is completed.

The geophysical surveys in the tunnel scheme area are scheduled to be completed in March. After completion of the transient EM, magnetics and resistivity surveys, the general bedrock stratigraphy and structure will be determined. This interpretation along with the surface mapping will dictate the drilling program layouts.

3.0 FIELD DRILLING PROGRAM

3.1 Organization of Drilling

The extent of the drilling along the tunnel line would be much dependent on the alignment chosen. Estimates indicate that the drilling requirements could vary in the following way:

Low level tunnel in rock	1,000 m
Low level tunnel in claystone	800 m
High level tunnel in glacials	200 m
High level tunnel in rock	400 m

The budget should be based on the low level tunnel in rock; any other scheme would lie within that budget.

In addition, some drilling would be required at the headworks and pit rim dam sites. An allowance of 200 m has been made for this.

The tunnel drilling would include three deep holes, 250 m in length, along the proposed tunnel line between Harry Creek and Medicine Creek. Three additional holes ranging from 40 to 60 metres in length would be drilled along the tunnel discharge route between the tunnel discharge conduit and the Hat Creek road junction.

3.2 Technical Supervision

It is proposed that a study of the various design alternatives for the Hat Creek/Finney Creek diversion would be carried out by an in-house Golder Associates team augmented by specialists to provide input to specific areas. There would be a close liaison with the B. C. Hydro Mining Department in the selection of conceptual layouts, acquisition of geological data and costing studies. The hydrological/ hydraulic aspects

would be carried out under the direction of Dr. Dennis Russell of Sigma Resource Consultants Ltd. with whom Golder Associates work in close contact. H. Kim of B. C. Hydro would be responsible for the overall field coordination and supervision. Golder Associates would be responsible for drill inspection and core logging.

3.3 Drilling Techniques

The drilling would be done by skid mounted diamond drills using HQ size coring equipment and with the capability of reducing down to NQ if drilling difficulties arise. The overburden would be triconed and the bedrock would be cored. Cutting samples should be taken when triconing through overburden.

3.4 Site Preparation and Reclamation

The drill hole access roads and site preparation would be done by a private contractor at the site. The access roads and drill sites would be cleaned up and reseeded on completion of the drilling program.

4.0 MANPOWER

The proposed operating schedule will be one 10-hour shift per day with a 7-day work week. This results in the following personnel requirements:

	B. C. Hydro	Contractor	Consultant
Supervisors	1	1	-
Drillers	-	2	-
Driller's Helper	-	2	-
Shiftboss	-	1	-
Geologists	2	-	1
Junior Geologist	-	-	1
	3	6	2

5.0 COSTS & BUDGET

Total drilling in connection with the diversion studies should not exceed 1,200 m.

Mobilization and demobilization of three rigs	$ 6,000
Estimated cost of drilling	
1,200 m @ $150/m	180,000
Consumables - say	22,000
Piezometer installation say 10 rig hrs/hole in the tunnel line holes, 5 rig hrs/hole in say 7 sam site holes = 105 rig hrs. @ $85/rig hr	$ 7,225
	$213,225

*Contingency particularly related to a possible extension of the tunnel to the south of Medicine Creek, if required.

Schedule

Tunnel line drilling	169 shifts
Piezometer installation	11 shifts
	180 shifts for 2 rigs = 90 days

*169 shifts of drilling is based on 7 m/rig/shift.

6.0 PRODUCTION OF REPORT

6.1 Progress Report

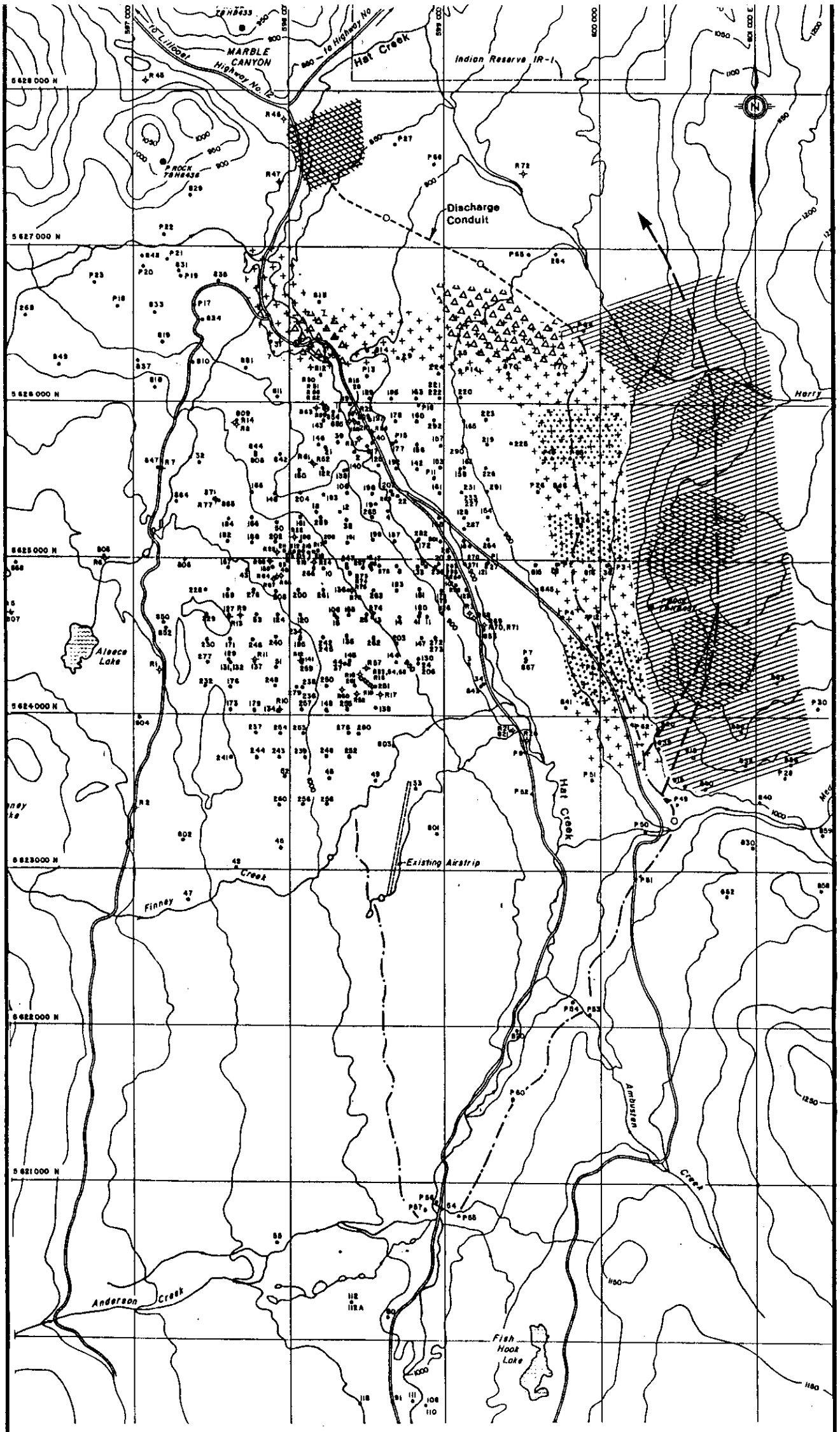
A tunnel investigation drilling progress report will be submitted by Golder Associates to B. C. Hydro on a weekly basis. This report will be included in the Site Manager's weekly report of all field activities. The tunnel investigation progress report will include drilling progress and all technical data including drill hole logs, drill shift reports, etc.

6.2 Geophysical Report

Magnetics, resistivity, transient EM and seismic refraction geophysical survey will be performed by Geo-Physi-Con with Golder Associates' supervision. On completion of the above work, Golder Associates will submit to B. C. Hydro a complete and thorough geophysical report. A geophysical interpretation should outline all geological features which can be deduced from the geophysics.

6.3 Final Report

On completion of the tunnel investigation program a final report will be produced by Golder Associates. The report will describe the diversion study and recommend an alternative solution.



LEGEND

Proposed Hat Creek Diversion Tunnel.
(Montreal Engineering - 1976)

Proposed Hat Creek Diversion Canal.

Area of Geo-Physi-Con.
EM Survey (February - March)

Areas of Potential Drilling
(Soft ground or Claystone Tunnel)

Area of Magnetic / Seismic
Refraction Survey (May)

Areas of Potential Drilling
(Rock Tunnel)

Areas of Groundwater Exploration

Figure 2

1982 HAT CREEK DIVERSION TUNNEL INVESTIGATION PROGRAM

FEB. 1982

APPENDIX 2

HAT CREEK PROJECT

MINING FIELD PROGRAMS 1982

GROUNDWATER EXPLORATION AND GEOTECHNICAL UPDATE PROGRAM

TABLE OF CONTENTS

TABLES AND FIGURES

HAT CREEK SITE PROGRAM - 1982

THE GROUNDWATER AND GEOTECHNICAL UPDATE PROGRAM

SUMMARY

Further consideration is being given to the quantities of water that may be encountered in the mine. It is recognized that the estimated inflow into the pit could be subject to fairly wide variations in quantity largely due to stored water in the coal.

Consideration must be given to the disposal of this water. Because of the implications of the zero discharge system a check must be made on the maximum quantities that may be handled.

Fieldwork by drilling tests wells and carrying out pumping tests on them will be the main activity of a groundwater exploration program and hydrological study to be carried out on site over three months of summer 1982.

A geophysical survey to be carried out early in the program will integrate with the geological mapping other techniques which can provide data for the groundwater investigations needed in the North-East of the pit.

Results of the geophysical survey, geological mapping, and drilling program will be used to update the geotechnical assessments for future pit stability and slope angles in a final report.

Cost of the program are estimated at:

Engineering	$ 85,000
Drilling and Tests	116,000
Geological/Geotechnical	11,800
Final Report	21,000
	$233,800

1.0 INTRODUCTION

In order to achieve a comprehensive update of the geohydrological and geotechnical assessment of the Hat Creek No. 1 coal deposit prior to final engineering design and planning for development and construction of the mine the following interacting programs of work are proposed for 1982 and 1983.

1) Groundwater Exploration
2) Groundwater Monitoring Wells (Environmental Department)
3) Geophysical Surveying
4) Geological, Hydrological and Geotechnical Reassessment
5) Clay Trench Excavation (Trench F)

The objectives of this Groundwater Program are:

- reassessment of the dewatering aspects of the pit including a risk analysis of potential inflows (Program 2);

- assessment of the movements which might develop in the E pit slopes and the potential risk to diversion structures sited close to the pit (Programs 1, 2 and 3);

- planning for the future location of a trench (F) into the Medicine Creek Formation claystone (Program 3);

- assembly of the geological and geotechnical data collected to date for slope and embankment stability purposes and consideration of the role of structure in slope stability (Program 4).

The details of the programs recommended to achieve these objectives and the range of activities proposed are shown on Figure 2 and 3.

2.0 INTERACTION OF THE PROPOSED PROGRAMS

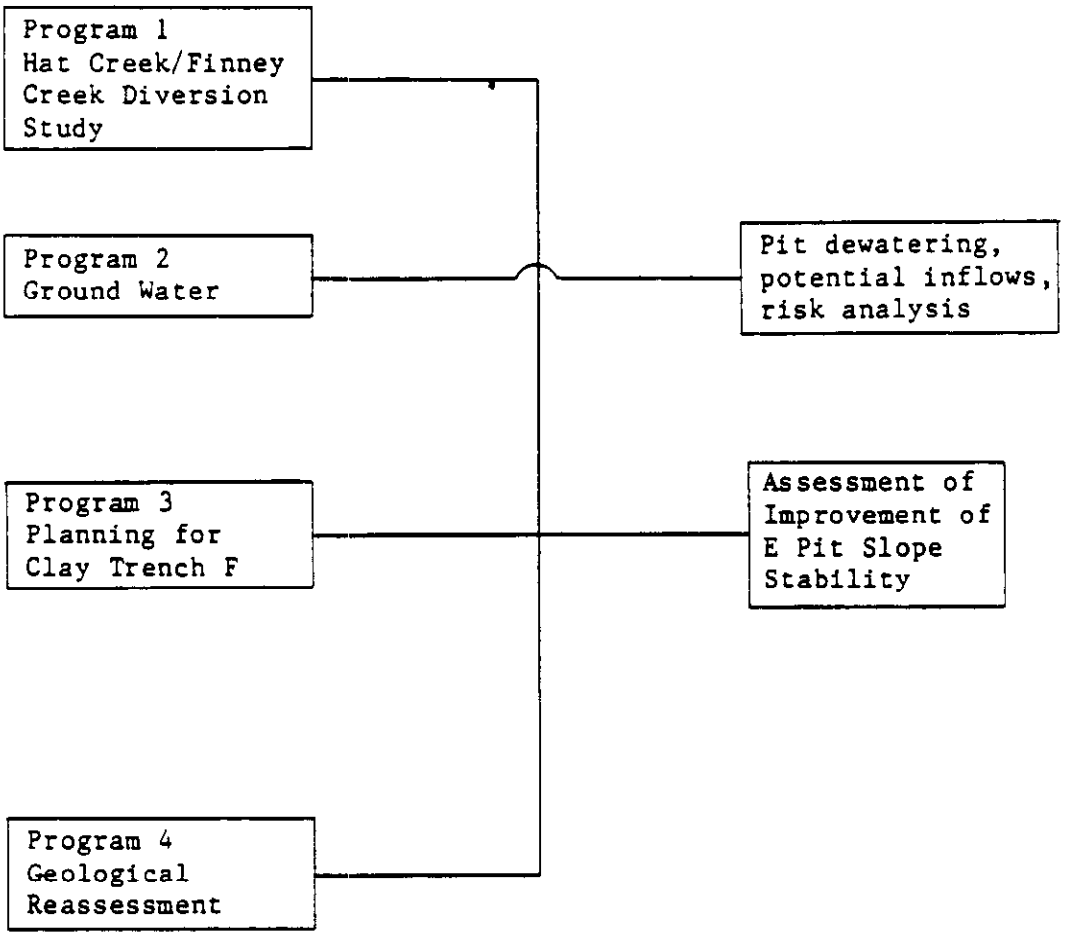
In addition to the groundwater programs and geotechnical update there are interlinking and interacting programs proposed for which separate technical reports and objectives are written.

The largest and most intensive program that interacts is the Hat Creek Diversion Study which will be given priority for action in 1982 along with the Groundwater Program.

Other programs such as the Medicine Creek Clay Trench excavation and the waste dumps infill drilling (Houth Meadows and Medicine Creek) will be planned and site investigated in 1982 and probably carried out in 1983.

The interaction of the proposed programs is illustrated in Figure 1 of the Golder Associates' report.

FIGURE 1
INTERACTION OF PROPOSED PROGRAMS



3.0 THE GROUNDWATER PROGRAM

3.1 The planning of the activities of the proposed programs to achieve these objectives is illustrated in Figure 3 by Golder Associates.

The work starts with reassessment of existing data and definition of the future information required.

This leads into planning the steps of the investigations and fieldwork which are:

(a) a geophysical survey,

(b) drilling exploration wells and pump testing,

(c) drill groundwater monitoring wells,

(d) field tests of permeability, water pressures, and piezometer installations (some of which will be in the Hat Creek Diversion drill program holes).

3.2 Golder Associates have described this work as follows on Pages 6 and 7 of their report (attached).

3.3 The last step of the Groundwater Program is then to determine or rework the estimates of the quantities of water likely to be intercepted by pit excavations, and the location or sources of these flows.

Recommendations must be made regarding pit dewatering methods such as pumping wells, drainage pipes in the benches, and water disposal from pit pumping.

Studies of the possible effects of such dewatering on the stability of the pit slopes and perimeter ground have to provide recommended parameters for design and layout of the mine service facilites.

3.2 Ground Water

To reconsider the quantity of drainage into the pit as planned, it would be necessary not only to acquire some further data in the NE. of the pit but also to critically review the data already obtained.

Re-analysis of some of the ground water data acquired between 1976-78 has shown that stabilisation of piezometric levels over that period has taken longer than anticipated. In consequence, it is necessary to rework some of the permeability test and pumping test calculations. The revised data, together with the results of the recommended exploration program below, would provide a secure data base for further inflow calculations.

Golder Associates currently input all piezometric data supplied by BCH on a 2-monthly basis. This data goes onto punch-cards. A period exists in the early phases of the study when this was not being carried out. It is recommended that this back-log of data be processed in a similar format to the current data and that it should all be transferred to magnetic tape so that piezometer hydrographs can be plotted directly from the stored data as and when needed. All hydrographs are currently plotted manually.

Recent ground water investigations have shown that deep permeable gravels could exist close to the pit rim in the north and northeast of the pit. It is possible that significant seepage into the pit could result and therefore further definition of the ground water system in that vicinity is required.

It is proposed that the geophysical survey, which would be carried out by Geo-Physi-Con in February/March and which would cover part of the area of ground water interest during the tunnel investigations, should be extended to cover the area between the recently drilled well (PW1) and the pit rim. Results from this survey should define the

geometry of any aquifers present and permit the assessment of the potential extent of any inflow problem. On the basis of that assessment a program of air-flush exploratory rotary drilling would be undertaken to obtain data on the ground water regime and pumping tests would be carried out, as necessary, to measure aquifer characteristics. It is planned that the exploration holes would be screened if potential aquifers were identified and that the wells would be test pumped. It might also be necessary to install some further observation wells at this stage. The results of this work would then be used to estimate the quantity of inflow into the pit from that section of the slope.

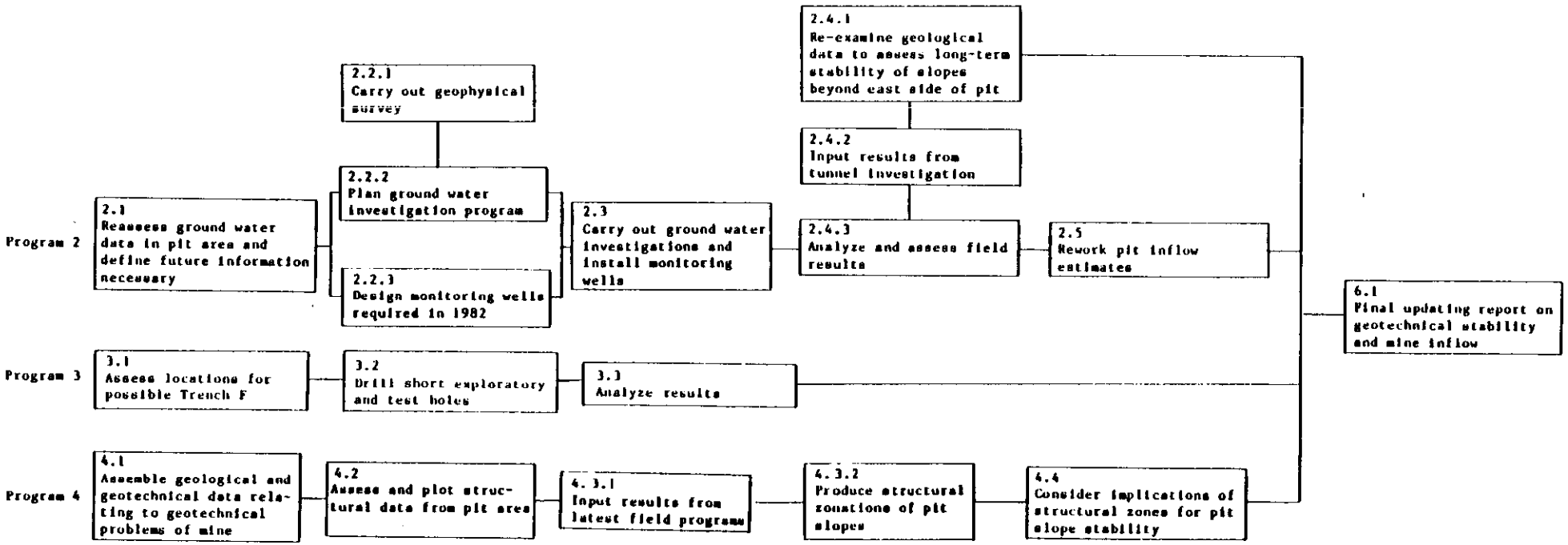
As a final exercise, the assessment of pit inflows throughout the pit made during the 1978 study by Golder Associates, using the latest data, would be updated and risk analyses undertaken to determine the confidence levels for various quantity of inflow.

The extent of the field work is difficult to estimate until the results of the geophysical survey are available. However, it has been provisionally estimated that 4 exploratory drill holes (3 deep, 1 shallow) would be put down. Screens would only be installed if a potential problem were shown to exist and that potential high inflows would be possible. Pumping tests might therefore be carried out to the north and northeast of the pit rim. An allowance has been made for the tests in the estimates although it is possible that it might not be necessary to carry out this work. If screens are installed, it is hoped that the wells could be left as permanent dewatering installations if necessary.

The ground water program could also encompass the installation of the baseline monitoring wells required under the environmental program and agreed with Dr. Hawthorn. It is recommended that this be supervised by the GA ground water field staff who would be supervising the exploration program but that it should be let as a separate drilling contract because of the difficulty of any one contractor being able to cope with the full program of work. The details of the work required and the budget for it form the subject of a separate proposal.

FIGURE 3

PROPOSED PROGRAM 2 - 4 ACTIVITIES, GEOTECHNICAL/HYDROGEOLOGICAL STUDIES, 1982



4.0 THE GEOLOGICAL AND GEOTECHNICAL REASSESSMENT OR UPDATE PROGRAMS

4.1 The chart (Figure 3) by Golder Associates illustrates the steps leading up to the final updating report on the geotechnical stability and mine inflow.

The sequence is seen to be:

4.1 Assemble geological and geotechnical data relating to geotechnical problems of the mine.

4.2 Assess and plot structural data from pit areas.

4.3.1 Input results from latest field programs.

4.3.2 Produce structural zonations of pit slopes.

4.4 Consider implications of structural zones for pit stability.

6.1 Final updating report.

5.0 FIELD ACTIVITIES

5.1 Technical Control and Direction

Golder Associates will provide the full technical control and field supervision for the grounwater drilling program and the geotechnical update.

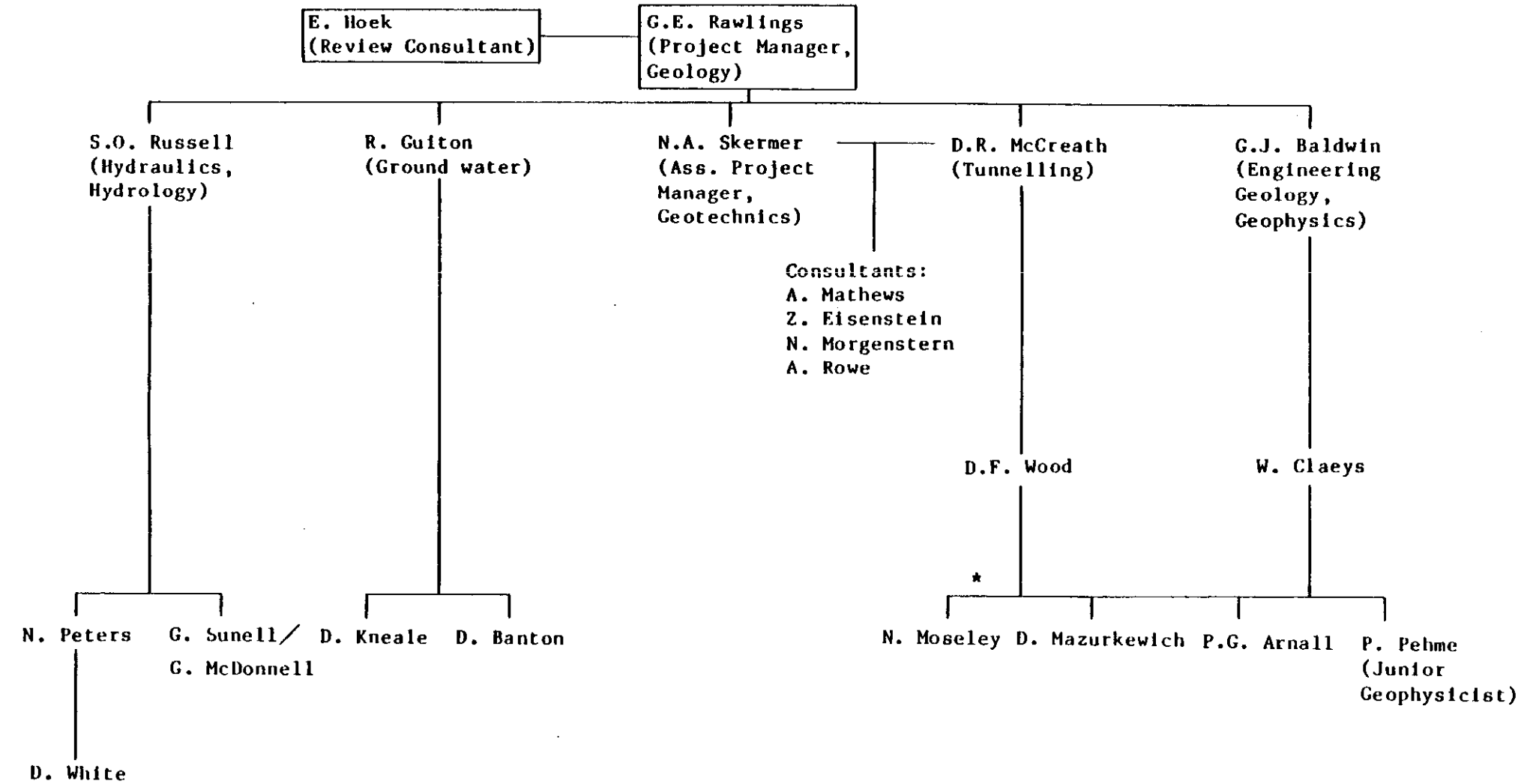
Golder's Figure 4 outlines the schedule for the work.

It is apparent that in order to get the bulk of the field work carried out during June, July and August a timely start must be made on the diversion and groundwater studies. (This assumes that B. C. Hydro needs some two months for the preparation of contract documents, calling tenders, comparing bids and letting contracts.) It will be necessary to identify the preferred diversion alternative (activity 1.3.1) before contract documents are written. It is recommended, therefore, that the transient EM geophysical survey be undertaken by Geo-Physi-Con as soon as possible to explore the groundwater problem, define the buried glacial channel and establish the position of the eastern boundary of the Medicine Creek Formation. Likewise, the preliminary hydrological and tunnelling studies for the diversion should begin as soon as possible. The geophysical survey to be carried out by Golder Associates could be delayed until the spring breakup so that it could be coordinated with the geological/geotechnical field mapping along the preferred alignment.

Figure 5 shows the proposed Golder Associate's consultant team assigned to the various programs.

It is to be noted that: 1. Golder Associates will provide the Drill Inspectors for full time attendance at the contractor's rig - probably drilling will be done five days per week for a 10-hour shift; 2. B. C. Hydro Mining Department geologists will provide coordination and control for all core logging, numbering, storage and sampling recording.

FIGURE 5
PROPOSED PROJECT TEAM



* Extra junior staff to be provided as necessitated by program

5.2 Surveying

The area of activity is adequately covered with existing survey monuments and all old drill holes have been accurately located. All new drill sites and investigation targets can be easily located by a field survey party who will be on site for the duration of the program.

5.3 Road Access and Site Preparation

A contractor will be hired by tender for providing the road and trail access to drill sites and the preparation of drill sites.

At the time of completion of the drilling all sites and roads will be reclaimed by this contractor.

Sufficient equipment and labour will be provided by the general maintenance contractor to assist with the hydrology tests and installations.

5.4 Drilling Contracts

B. C. Hydro - Thermal Generation Projects Division will assemble and prepare the contract documents for tendering. Golder Associates will prepare the specifications section. B. C. Hydro Purchasing will call the tenders in April and award the contract.

Mobilization and start of drilling should be timed for early in June when the camp catering is in force.

B. C. Hydro site management will be responsible for field contract administration and drill inspectors will supply Daily Field Reports of work done.

5.5 Pump Tests, Monitoring and Environment Control

The proposal is to carry out a seven-day pump test in each of the exploration holes.

The contractor provides the crew to install the pump, equipment and carry out the test. It is assumed that Golder Associates hydrology drill inspectors will monitor and supervise most of the duration of each pump test after it has started so as to reduce contractors costs for such work.

B. C. Hydro Environment Department will direct and monitor the disposal of water pumped from these tests.

5.6 Safety, Inspection and Permits

B. C. Hydro site management will be directly responsible under terms of the Coal Mine Regulation Act for all activities on the coal licences.

The District Inspector of Mines from Kamloops will be notified of our proposed work and reclamation program on the prescribed coal exploration Forms 7 & 8 under our Permit #103.

All the proposed groundwater exploration drill sites are on coal licences.

6.0 MANPOWER, CAMP FACILITIES AND SCHEDULING

The groundwater drilling program will be carried out with one drill rig and one pump test crew on a five-day week and one 10-hour shift per day.

6.1 Manpower List

	B. C. Hydro	Contractor	Consultant
Supervisors	1	-	1
Hydrologist-Drill Inspector	-	-	2
Drillers	-	2	-
Pump Test Crew	-	2	-
Geotechnical Assessment	-	-	1
Geological	1	-	1
Environment Inspector	1	-	-
	3	4	5

6.2 Camp Facilities

1. Accommodation and camp catering provided on site.
2. 4 X 4 vehicles available on site.
3. Office trailer with telephone.
4. First aid and ambulance.

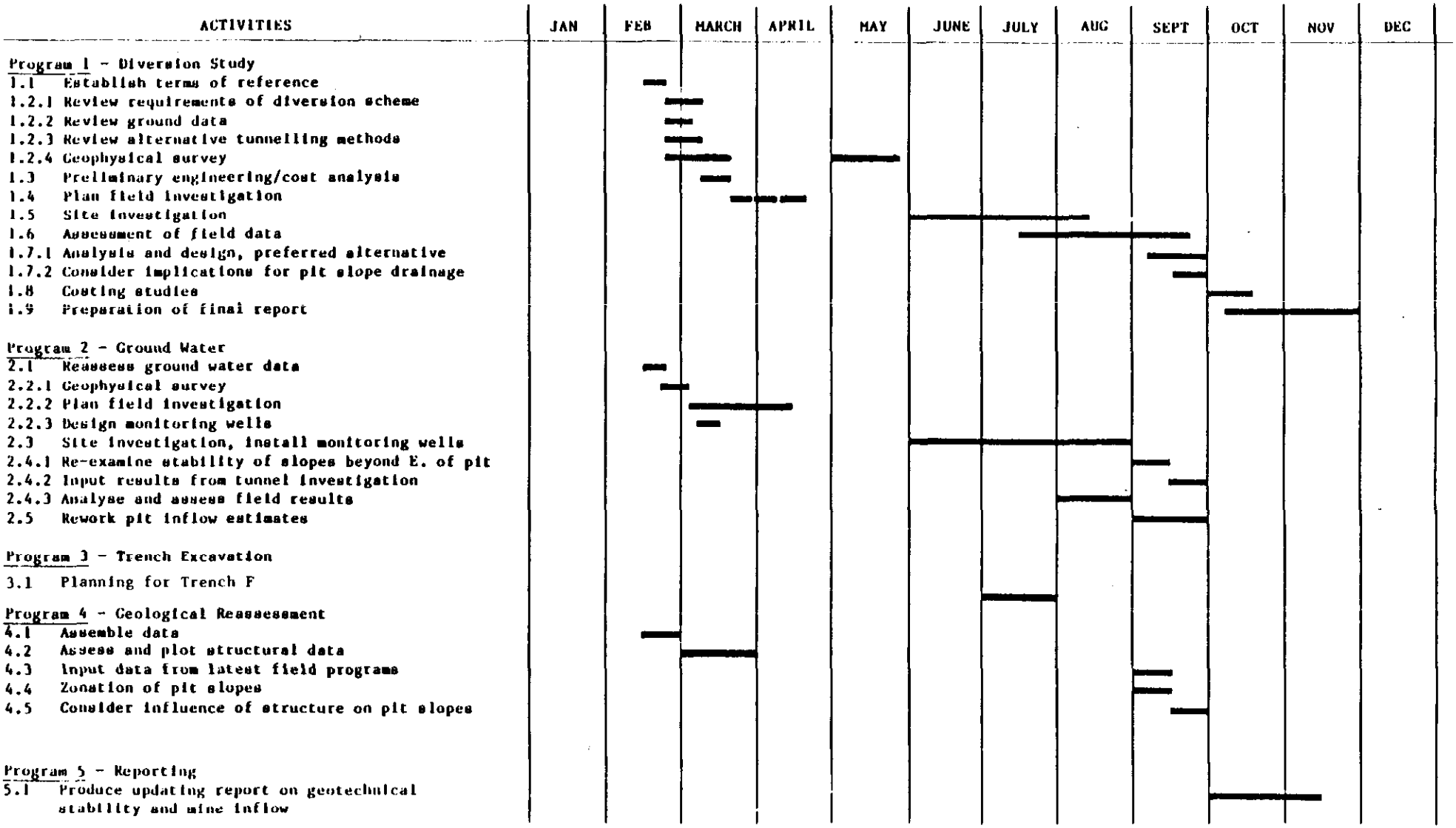
6.3 Scheduling

Figure 4 by Golder Associates indicates their proposed schedule of activities for the several programs.

The drilling program may take three months.

FIGURE 4

SCHEDULE OF ACTIVITIES (PROGRAMS 2 to 5), 1982 SEASON



7.0 COST ESTIMATES AND BUDGET CONTROL

7.1 From Table 3 - Cash Flow by Golder Associates the following budgets are included:

	Pre-March 31/82	Post-April 1/82	Total
Geophysical Survey with Program 1 Hat Creek Diversion	$ 48,000	$ 24,500	$ 72,500
Program 2 - Engineering	21,185	64,226	85,411
Groundwater Drilling		116,000	116,000
Program 3 - Engineering	-	10,000	10,000
Clay Trench Planning - Drilling		20,000	20,000
Program 4 Geological Reassessment	-	11,802	11,802
Program 5 Final Report	-	21,000	21,000

7.2 Program 2 - Groundwater - Details

Program 2 - Groundwater (excluding monitoring well installation)

Activity 2.1	Preparation of proposal, assess and reprocess existing data.	$ 16,334
2.2.2	Planning, contract document preparation	3,272
2.2.3	Design monitoring wells	1,579
2.3.1	Supervision monitoring wells (separate budget)	
2.3.2	Supervision, exploration	17,617
2.3.3	Pump testing	10,811
2.3.4	Data reduction	8,467

2.4.1	Reexamine E. pit slope stability	$ 4,200
2.4.2	Input field results	1,376
2.4.3	Analyze groundwater results	1,683
2.5	Rework pit inflow estimates	13,072
Disbursements		7,000
	Total Engineering	$ 85,411
	Total Contracting (see Appendix A2)	116,000
		$201,411

APPENDIX A

2. Rotary Drilling - Ground Water Exploration Cost Estimate

The cost estimate for the ground water exploration program for the southeast pit area is based on the following assumptions:

(1) Drill four 200 mm diameter exploration boreholes to bedrock. The depth to bedrock is estimated to be 170 m for 3 holes and 30 m for the remaining hole. Water levels in the deep holes are expected to be 90 m below ground surface and near ground surface in the shallow hole.

(2) The results from geophysics to be carried out will be used to determine the exact location of the exploration holes. Information obtained from the geophysics may be used to alter the initial program.

(3) It is anticipated to complete 2 deep holes and 1 shallow hole with well screens. Information from the results of drilling will be used to determine the holes to be screened and the position of the screens.

(4) It is proposed to carry out a 7 day pump test in each of the three exploration holes.

(5) Since the exploration area is relatively large, the spread of information obtained from this program will be limited. Budget constraints do not allow observation holes to be completed at chosen intervals to the pump wells.

(6) The estimated costs can only be maintained by drilling the exploration wells with the larger model air/rotary drills. Drilling with the smaller model air/rotary drill

could only be carried out by starting the hole at a larger diameter and reducing the hole size with depth. This would result in higher costs.

Contractor's Exploration Drilling and Completion Costs	
Mobilization and demobilization	$ 5,000
Deep Well Sites	
Drill and case surficials at 200 mm Ø 170 m @ $120/m	20,400
Hourly work including standby without crew and rig moves	1,600
Consumables, well screens and fittings	2,800
Pump Test and Exploration Wells	
Mobilization and demobilization	1,000
Install pump, pump test for 7 days, breakdown equipment and monitor recovery	13,000
Shallow Well Site	
Drill and case surficials at 200 mm Ø 30 m @ $120/m	3,600
Install screens and develop by air/surge method 20 hrs @ $175/hr	3,500
Hourly work - standby without crew 10 hrs @ $125/hr	1,250
Consumables, screens and fittings	2,650
Pump testing	
Install pump, pump test for 7 days, breakdown equipment and monitor recovery	5,500
Summary of Costs	
Drilling and completion	
Drill 3 deep exploration holes	$ 61,200
Drill 1 shallow exploration hole	3,600
Complete 2 deep exploration wells	19,300
Complete 1 shallow exploration well	7,400
Mobilization and demobilization	5,000
Total	$ 96,500
Pump Testing	
Pump test 2 deep exploration wells	$ 13,000
Pump test 1 shallow exploration well	5,500
Mobilization and demobilization	1,000
Total	$ 19,500
Grand Total - Drilling and Pump Testing	$116,000

APPENDIX A

3 Geophysical Survey

1. Magnetics and Resistivity - to define structure and stratigraphy in volcanics/volcaniclastic sequences.

Field work duration	6 days		
Personnel cost	120 hrs	@ $40/hr	$ 4,800
Equipment	6 days	@ $100/day	600
Interpretation	6 days	@ $500/day	3,000
Total			$ 8,400

2. Transient EM - to define buried glacial channel, nature of glacial materials and to boundary fault.

Field work duration	11 days		
Personnel cost	11 days	@ $1,100/day	$12,100
Equipment cost	11 days	@ $800/day	8,800
Interpretation	11 days	@ $500/day	5,500
Total			$26,400

(Note: Golder Associates representative to be one of the above team).

3. Seismic Refraction - to further define structure and stratigraphy in volcanic/volclanistic sequence.

Field work duration	5 days		
Personnel cost	5 days	@ $1,500/day	$ 7,500
Equipment cost	5 days	@ $200/day	1,000
Interpretation	5 days	@ $500/day	2,500
Total			$11,000

4. Seismic Reflection - experimental techniques to be performed by GSC at no charge

GA supervision	5 days	@ $500/day	$ 2,500
Equipment	5 days	@ $300/day	1,500
Total			$ 4,000

5. Mobilization costs

Personnel - Golder Associates	$ 4,000
Geo-Physi-Con	3,000
Equipment GA (EC)	1,000
Total	$ 8,000

Summary of Estimated Contracting Costs

1.	Magnetics and Resistivity	$ 8,400
2.	Transient EM	26,400
3.	Seismic Refraction	11,000
4.	Seismic Reflection	4,000
5.	Moblization/demobilization costs	8,000
		$57,800

Geo-Physi-Con survey (February/March)	$29,400
Golder Associates survey (May)	24,400
GSC	4,000
Disbursements, contingencies, etc	14,700
Total	$72,500

Note: This work is covered in the budget by $48,000 for the February/March program and $24,500 for the May program.

Program 3 - Trench F Planning

Activity 3.1	Planning field work supervision and assessment of data	$ 10,000
	Contracting	20,000
		$ 30,000

Program 4 - Geological Re-assessment

Activity 4.1	Assemble data	$ 1,010
4.2	Assess and plot structural data	1,662
4.3.1	Input data from field programs	808
4.3.2	Zone pit slopes	2,277
4.4	Consider influence of structure on slopes	4,225
Disbursements		1,000
	Total	$ 11,802

Program 5 - Final report $ 21,000

TABLE 3 - CASH FLOW

	Pre-March 31st 1982	Post April 1st 1982	Total
Program 1			
Engineering and Disbursements	$ 66,815	$182,000	$248,815
Geophysical survey (including engineering supervision)	48,000	24,500	72,500
Drilling, etc.	---	212,800	212,800
Program 2			
Engineering and Disbursements	21,185	64,226	85,411
Exploration drilling	---	116,000	116,000
Program 3			
Engineering and Disbursements	---	10,000	10,000
Drilling	---	20,000	20,000
Program 4			
Engineering and Disbursements	---	11,802	11,802
Program 5			
Engineering and Disbursements	---	21,000	21,000
TOTALS	$136,000	$662,328	$798,328
	Consulting	$383,380	
	Contracting	$445,722	

8.0 FINAL REPORTING

The work recommended would result in the production of three reports:

-a report on the Groundwater Exploration Program.

-a report which addresses the results of all the geotechnical work carried out with particular reference to the potential for improving the currently recommended pit slope angles. The same report would contain the results of the re-analysis of the pit inflows.

-the third report would put on record the design and installation of the monitoring wells and the baseline readings from them.

APPENDIX 3

HAT CREEK PROJECT

MINING FIELD PROGRAM 1982

A AND C ZONE BULK SAMPLE PROPOSAL

(TRENCHES D AND E)

TABLE OF CONTENTS

SUMMARY

Field work for the proposed Trench D and E bulk sample programs, respectively, A zone and C zone coals, will commence in May and finish in September of 1982 and could employ up to 49 people during peak activity periods. Two sites have been chosen, Trench D near section Q above the water table and Trench E on section M, below the water table (see Fig. No. 1 location map entitled Hat Creek Project - Map of Pit Area - No. 1 Deposit).

Site preparation including clearing, road upgrading and overburden removal will start as soon as ground conditions permit. While this is underway, geophysical techniques for predicting R.O.M. quality will be tested in existing Trench A.

Once the coal has been exposed in D and E trenches geophysical logs and channel samples will be obtained. The majority of the bulk sampling is planned for Trench D, and this years effort for Trench E will merely be to confirm that the proposed location is correct. Coal extraction in Trench D will be carried out using a hydraulic shovel. Selective mining techniques will be tested during the excavation of the upper benches and representative Run-of-Mine samples will be produced from the lower-most bench. Coal and waste piles will be located and constructed to meet various environmental test requirements.

The Run-of-Mine coal will be handled through a portable conveying and crushing system, and systematically sampled for various test purposes. An on-site laboratory will be commissioned to analyze samples for mining control purposes. Various offsite laboratories will be employed for special testing.

TRENCH 'B'

TRENCH 'E'

TRENCH 'C'

TRENCH 'A'

TRENCH 'D'

Hat Creek

5625500 N

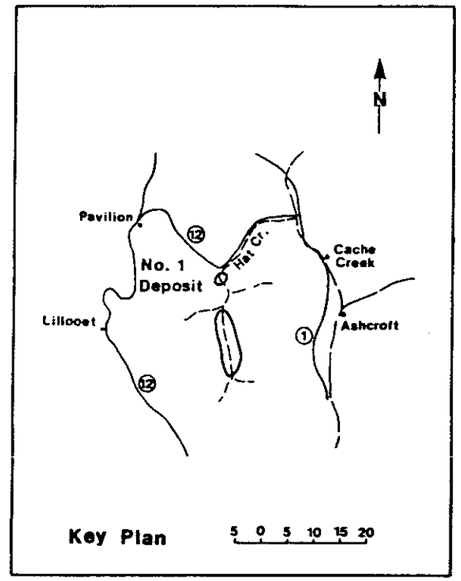
5625000 N

597500 E

598000 E

598500 E

599000 E



LEGEND

- Coal Dump
- Low Grade Coal Dump
- Coaly Waste Dump
- Overburden Dump
- Topsoil Dump

B. C. HYDRO
HAT CREEK PROJECT

TRENCHES LOCATION MAP
No. 1 DEPOSIT

Feb. 1982

Figure 1

Bulk samples will be forwarded to several different pilot plants for coal preparation and material handling studies.

Final reclamation will be completed at the end of the field program. Various monitoring stations will be established and operated in future years to collect environmental data.

SECTION 1.0 - INTRODUCTION

The primary objectives for the D Trench program are to confirm design information for selective mining and material handling and to confirm the stratigraphy, coal quality and the coal preparation characteristics of A zone coals. Numerous other technical study objectives are included in the proposed scope of work. The objectives for the E Trench program are to confirm the stratigraphy and coal quality at the proposed Trench site. Bulk sample extraction and coal preparation testwork will be deferred until 1983.

The majority of the information available to date for the Hat Creek Project comes from core samples. Extensive exploration was performed from 1974 to 1978 to bring the drill hole spacing to 150 m centres. Several bulk samples were collected in the past including large diameter bucket-auger samples and samples from the two previous trenches, A and B. The auger samples provided some coal preparation data but it could not be related to any mining scheme. The previous trenches proved that selective mining was possible and provided further washability data, but the information confined to B and D zone coals.

The proposed D trench will sample the A zone coal in such a manner that the resulting data can be related to future full scale mining practices. Design criteria for selective mining will be developed so that computer models can be constructed to determine the R.O.M. coal quality and variability. Geotechnical environmental impact and material handling information will be generated as the coal is uncovered and mined. The reclamation program will be geared towards yielding environmental impact data.

Bulk samples collected during the program will be tested both in bench scale tests and pilot scale tests for:

- washability
- material handling and crushing
- tailings handling
- chemical and physical characteristics
- combustion characteristics
- environment.

SECTION 2.0 - FIELD ACTIVITIES PRIOR TO MINING

(Note: The proposed trench for the A zone coal will be referred to as "D".
The proposed trench for the C zone coal will be referred to as "E".)

2.1 SURVEY

Three control points were established from the 1981 photogrammetry at selected positions at Trench D.

Coordinates of existing bore holes in the trench areas were already determined by photogrammetry in 1979. DDH 76-198 will be used for control at Trench E.

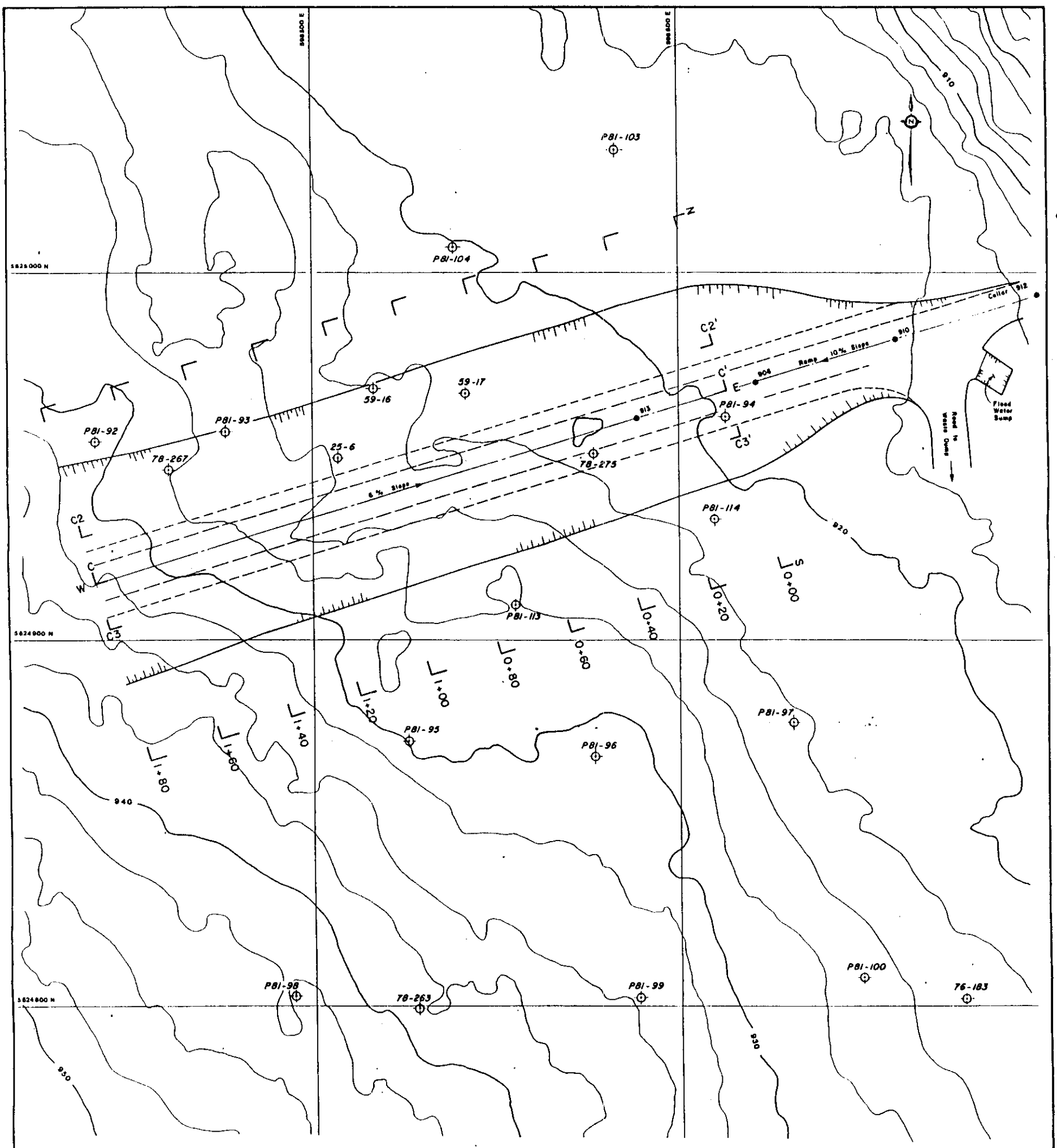
It is proposed to survey in additional control stations on the cross-section lines indicated on Fig. Nos. 2 and 3. (Note: Fig. No. 3 shows the excavation work proposed for the 1983 program).

Geological and geometrical determinations of the field excavations will be surveyed from these stations.

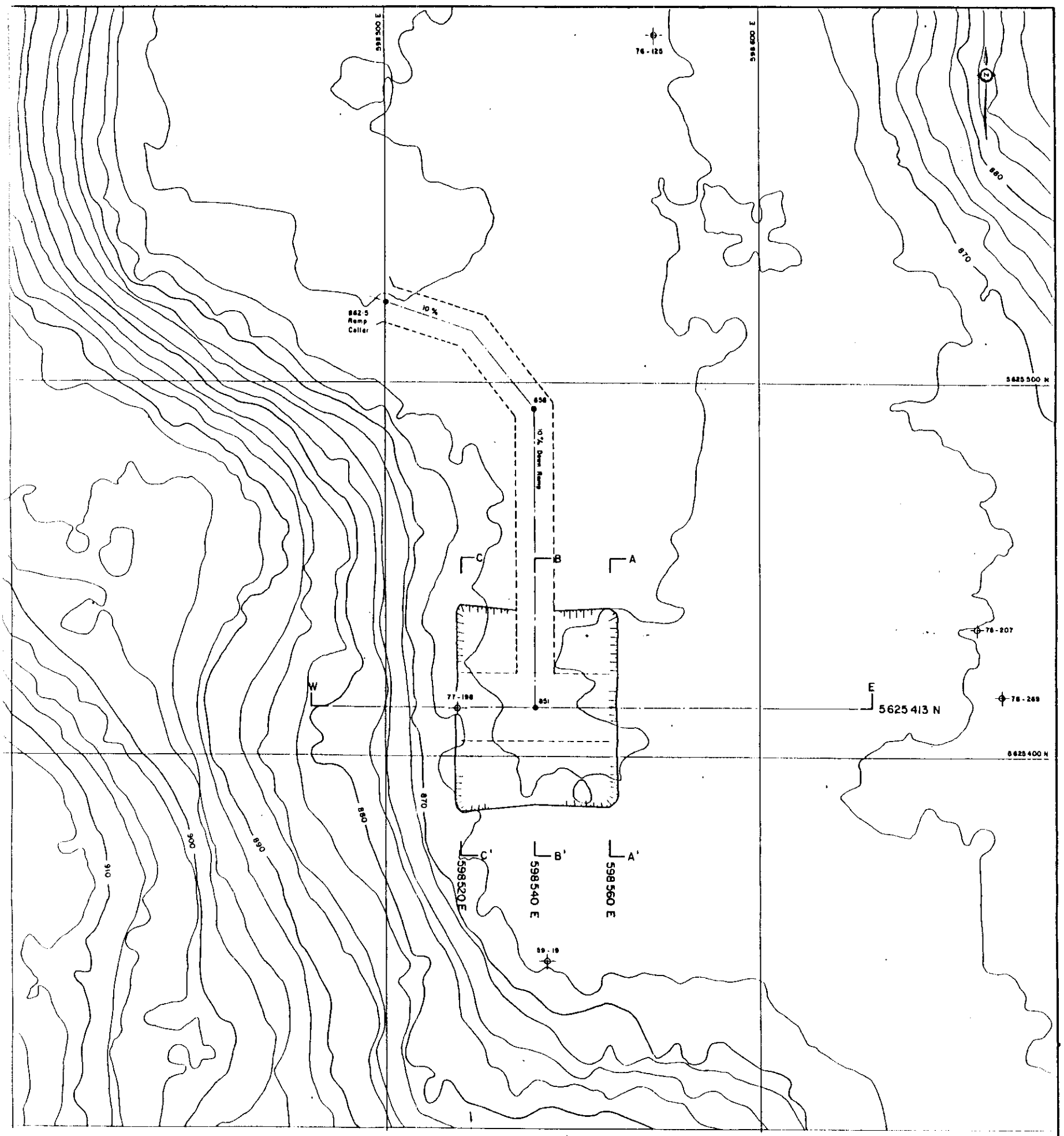
2.2 SITE PREPARATION

Locations of the two proposed trenches have been investigated and selected from the drill program in October 1981. Existing main access roads to the two areas will require upgrading with some new alignment to improve gradients. Additional surfacing materials will be required on all the road lengths.

It is planned to use the same coal storage yard with its drainage controls as was used in 1977 for the bulk sample. The old coal dumps



		B.C. HYDRO HAY CREEK PROJECT	
Design	W.C.F	PROPOSED TRENCH 'D' PLAN No. 1 DEPOSIT	
Drawn	B.W.		
Checked			
Approved			
Date	JAN. 1982	DWG. No.: Figure 2	R



		B C HYDRO HAT CREEK PROJECT
Design	WCF	PROPOSED TRENCH 'E' PLAN No. 1 DEPOSIT
Drawn	BW	
Checked		
Approved		
Date	FEB. 1982	DWG No Figure 3 A

will have to be moved and stockpiled at one end of the yard into a single large pile. Haulage distances from the new trenches to the coal storage yard are relatively short.

It is proposed to use "Dry Lake" as the tailings pond for holding water pumped from the trenches during excavation and testing. This natural storage dam proved to be a satisfactory water impoundment site in 1977 for large quantities pumped from Trench B. Environmental considerations require isolating the water to be pumped out of the trench excavations from the Hat Creek River flow.

A large diesel pump capable of 200 gpm is available on site (owned by B.C. Hydro). Additional 3-inch plastic piping will have to be purchased to cover the longer distances to Dry Lake. Approximately 0.5 km is required.

The bridge over Hat Creek to Dry Lake north of Trench B was repaired and renovated in October 1981. The deck has to be placed in position after the high water spring runoff. This bridge is strong enough to allow light dozers and truck crossing.

A foot bridge across Hat Creek will be constructed at the old coal mine site near the bunkhouse.

The contractors equipment maintenance yard will be the same site as was used for the 1977 bulk sample program. However, the bulk storage tank for diesel fuel supply (Red Star) to contractors will remain in its present location near the core sheds.

Waste dump stockpile areas as indicated on the area plan will be cleared and will have access roads, drainage ditches prepared as soon as ground conditions permit after spring thaw.

2.3 OVERBURDEN

Fig. No. 4 and 5 Geological Cross Sections of Proposed D and E Trenches indicates the amount of overburden material required to be removed in order to expose the in-place top of the coal beds. Maximum depth of overburden to be excavated is expected to be 10 m while the average will be approximately 7 m. The types of material that will be encountered in the overburden are:

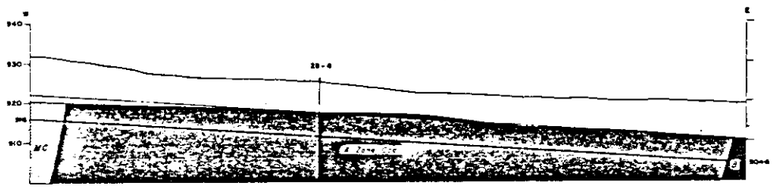
- top soil and some vegetation
- gravel and sand
- clay beds - glacio-lacustrine
- hardpan - basal till.

All materials will be easy to dig except the hardpan till which may require the use of hydraulic shovel or backhoe. The contractor will be allowed to select the equipment for overburden removal. Motor scrapers will be the preferred method of overburden removal and waste dump placement. As was successfully carried out for the previous bulk sample trenches separate terraces for different waste materials will be prepared so that reclamation re-vegetation experiments can be continued. In particular the coaly waste (carbonaceous clay) will be separated into a special stockpile dump so that run off leachates can be collected and analysed.

2.4 PRE-MINING SAMPLING AND TESTING

Experimental sampling and testing procedures for the proposed Trenches "D" and "E" will be tested on the B zone coal in Trench A. These tests will not only provide information on the B zone coal but will also provide information for refining the procedures for Trench D.

A "Ditch-Witcher" will be used to dig a 300 mm deep trough across the bedding along the base of the Trench A. Geophysical tools will then be



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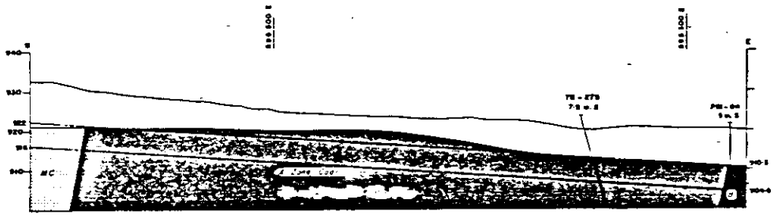
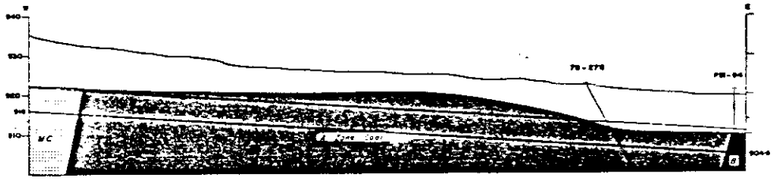
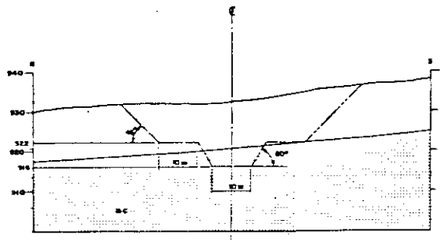


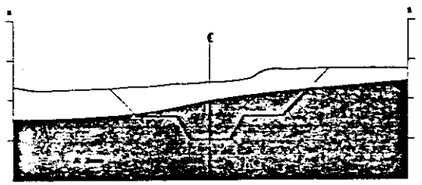
SECTION C - C'



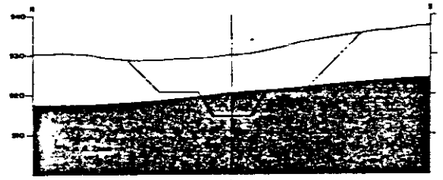
SECTION C3 - C3'



SECTION 1+80



SECTION 1+00



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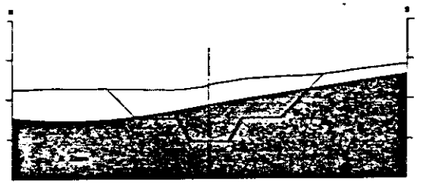

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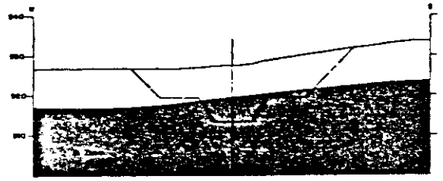

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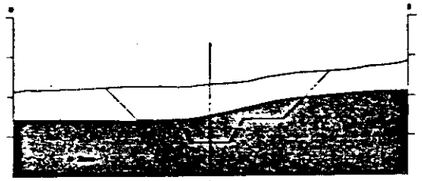

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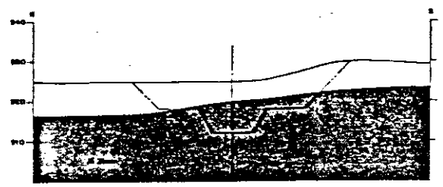

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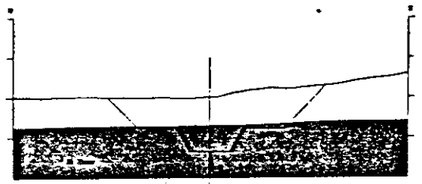
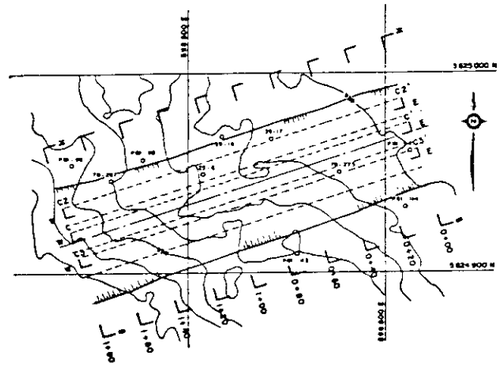
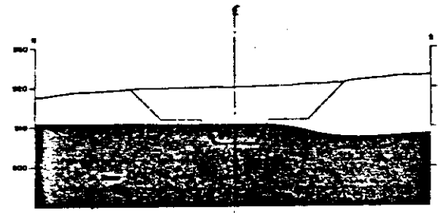


SECTION 0+40



KEY PLAN



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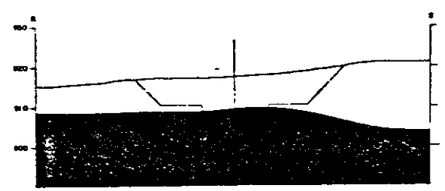


SECTION 0+00

LEGEND

- OVERBURDEN
- MEDICINE CREEK FORMATION - Claystone
- A COAL - Interbedded coal and claystone
- B COAL - Mainly coal

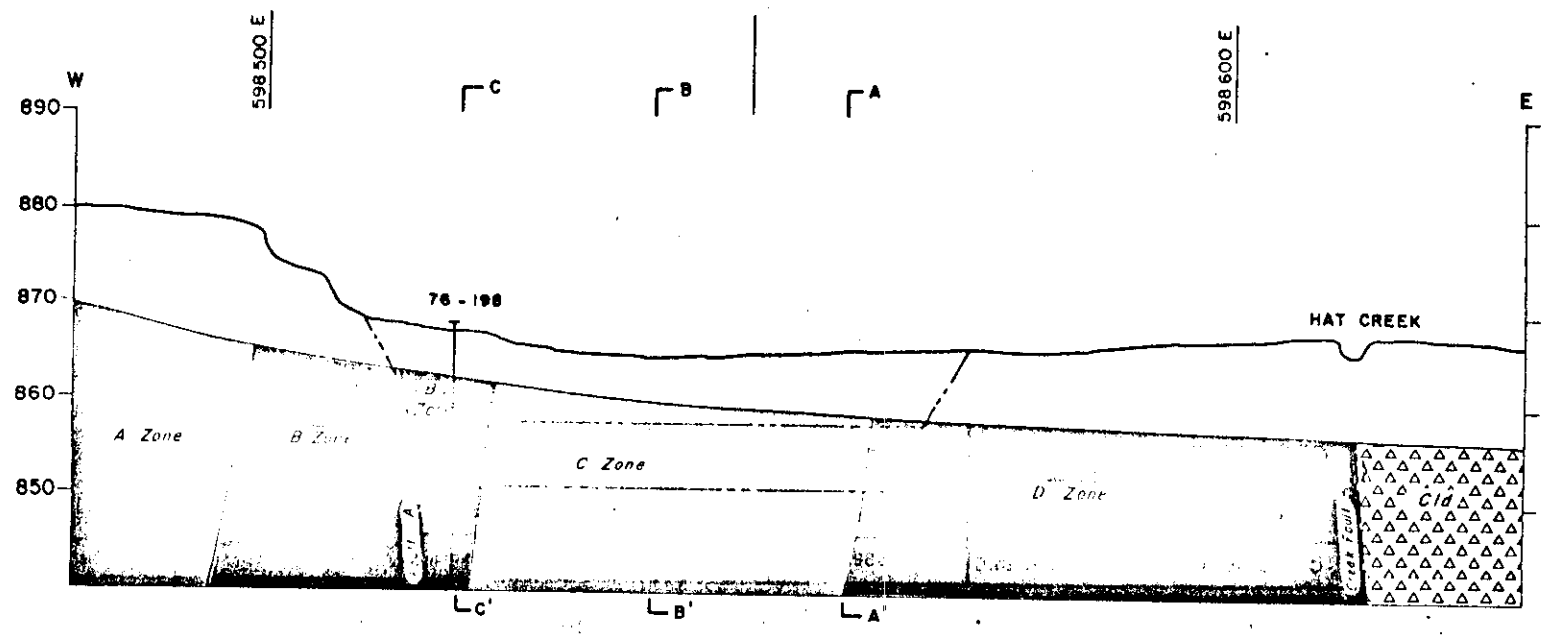
SCALE 1 : 500

B.C. HYDRO
HAT CREEK PROJECT

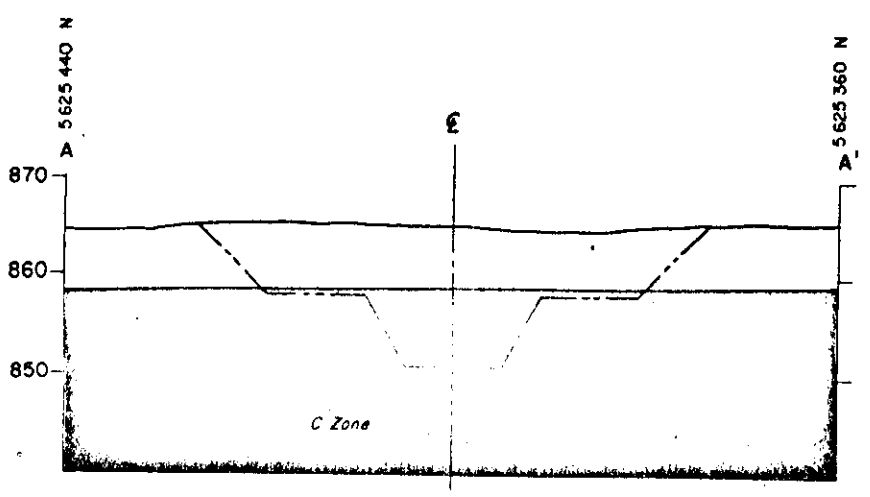
GEOLOGICAL CROSS SECTIONS
of
PROPOSED TRENCH 'D'
No. 1 DEPOSIT

Design	A.W.P. / W.C.F.
Drawn	S.W.
Checked	-
Approved	-
Date	12 - 2 - 82

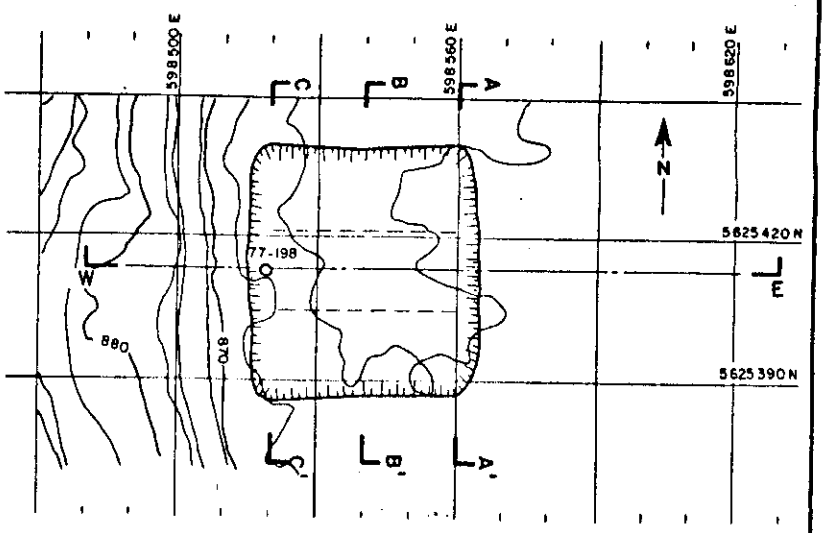
Drawing No. Figure 4



SECTION 5625 413 N

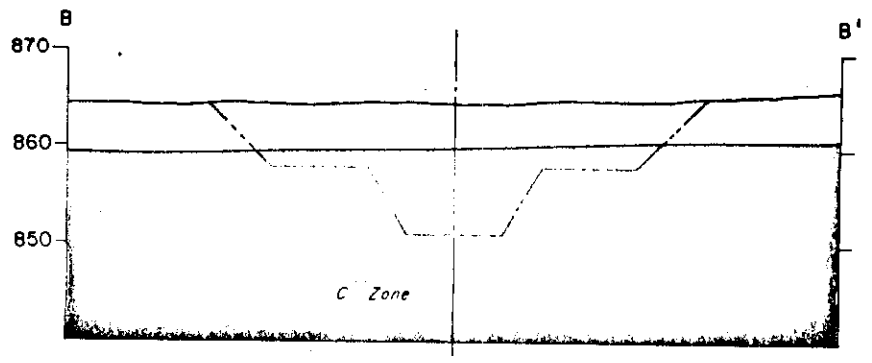


SECTION 598 560 E

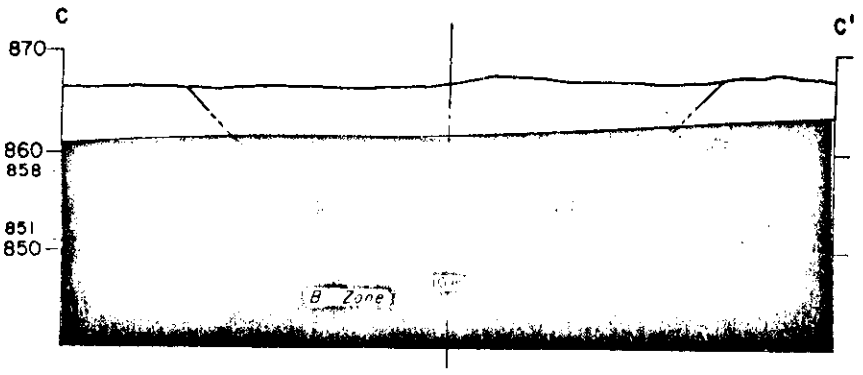


KEY PLAN

10 0 10 20 30 40 50



SECTION 598 540 E



SECTION 598 520 E

LEGEND

- Overburden
- A & C Coal - Interbedded coal and claystone
- B & D Coal - Mainly coal
- Coldwater (Cld)

10 0 10 20 30 40 50m

Scale in Metre : 1 : 500

Design	A.W.P / W.C.F	Drawn	S.W
Checked			
Approved		Date	FEB. 1982

B C HYDRO
HAT CREEK PROJECT

GEOLOGICAL CROSS SECTIONS of PROPOSED TRENCH 'E' No. 1 DEPOSIT

DWG. No.: Figure 5 R

winched along the base of the trough to provide various geophysical responses from the exposed beds. A channel sample will be cut along the side of the trough with the rotary coal cutting saw available at the site (see sampling procedure diagram Fig. No. 6). The geophysical logs will be used to aid in channel sampling to relate the geophysical breaks to the sample intervals. This will allow correlation of the analytical data to the geophysics, and will provide a base for comparing this geophysical logging technique with previous downhole techniques.

The methods which prove successful in Trench A will be employed in the sampling and testing of trenches "D" and "E". Some variations in techniques will probably be required for Trench E because the coal exposures could be below the water table.

The testing and sampling in Trench A will be done in May while the coal is being exposed in the proposed Trench D site. (Note: This is contingent on the timing of spring break-up and dry ground conditions.) The overburden will be removed from the Trench D site in June and channel sampling will follow the overburden removal. A second channel sample will be taken at the base of Trench D after bulk sample excavations are completed.

The Trench E will be located very close to the old Hat Creek coal mine. Underground workings dating back to 1932 to 1937 are now all collapsed. Test drill probing will be carried out to verify the safety of the site, and confirm that the C zone coal is not already mined out. This is the only location that the C zone has a subcrop close to surface and below the water table. It is proposed also to dig a narrow backhoe pit down to the coal and water table as a preliminary test.

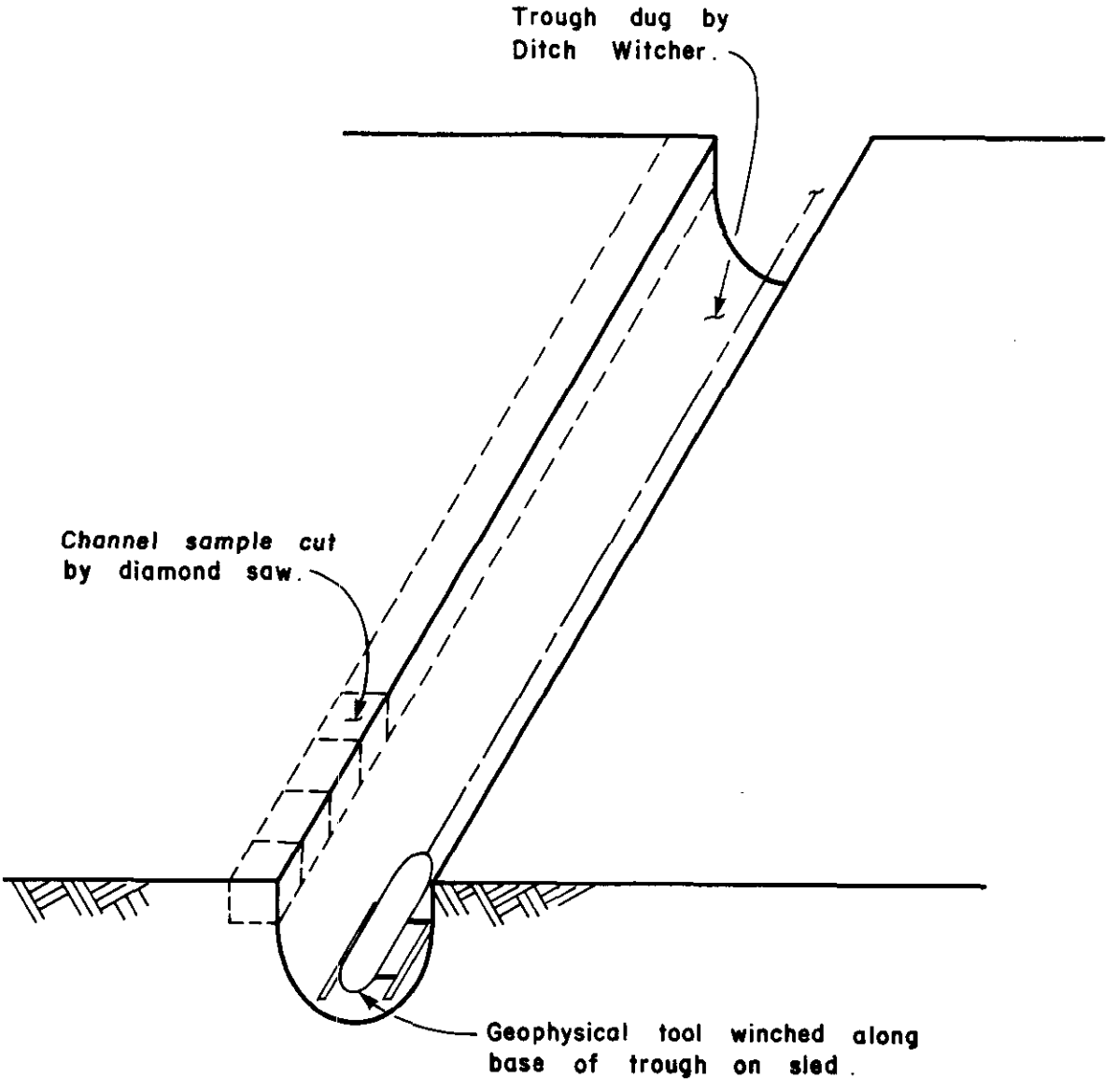


Figure 6

PRE - MINING
SAMPLING & TESTING
PROCEDURE

SECTION 3.0 - MINING PLAN

3.1 GEOLOGICAL DESCRIPTION

(a) Trench D

The proposed Trench D is located on the east limb of the Hat Creek Syncline between the Syncline's axis and the Creek Fault near section Q (see Fig. No. 1 Hat Creek Project Map of Pit Area - No. 1 Deposit). The beds in the area of the trench location are striking N17°E and dip at 70° to 90° to the west. The proposed trench will be cut perpendicular to the strike of the beds at N73°W exposing the true thickness of the strata. Development will progress from the upper section of B zone to the top of A zone and on into the Medicine Creek Claystone. This will result in exposure of the entire 165 m of A zone coal (see Fig. No. 4 Geological Cross Section of Proposed D and E Trenches).

The surficial cover in the area of Trench D consists of glacial tills and glacio-lacustrine clay. There is an upper layer of glacial till, 1 to 4 m thick, which consists of loose to dense, silty, gravelly clays with included cobbles and boulders. Beneath the till is a layer of glacio-lacustrine clay, 2 to 7 m thick, which is loose to compact, silty, and includes some pebbles and cobbles. Beneath this clay is a glacial basal till, a dense gravelly clay of 0.5 to 3 m thick overlying bedrock. The total thickness of the surficial material varies from about 10 m at the ends of the proposed trench down to about 4 m in the middle of the trench (see Fig. No. 4).

(b) Trench E

The proposed Trench E is located on the east limb of the Hat Creek Syncline, between the Syncline's axis and the Creek Fault, on section M (see location map Fig. No. 1). The general strike in this area is north south and dips are 75° to 90° to the west. The trench will be cut perpendicular to the strike in the east west direction to expose the true thickness (approximately 35 m in total) of the C zone coal (see Fig. No. 4). (Note: Fig. No. 5 shows the excavation plans for the proposed 1983 program).

Surficial materials are not well defined in this area because of the nature of the drill hole information that is available. Chip samples received from tricone drilling indicated the presence of sand and gravel.

3.2 GEOTECHNICAL DESCRIPTION

Due to the synclinal folding the beds and strata of the A and C zone coal at the selected sites will be almost vertical. The proposed new trenches will be excavated with the bench face advancing at approximate 90° to strike cutting through successive beds with a bench height of about 6 m. The strength of the coal and clay partings will be assessed and bench failures recorded.

At the west end of the proposed D trench it is planned to expose a high wall of the Medicine Creek claystone. This will be opened up on strike similar to the way in which the claystone parting (C1 subzone) was excavated at the west end of Trench A. Geotechnical assessment of the strength of this Medicine Creek claystone can then be done.

The C zone coal Trench E is located to expose the coal and waste partings below the water table i.e. well saturated. The D zone coal in the Trench B excavated in 1977 did not have any appreciable waste

partings in the coal. It is important to know the strength of the various waste partings in the active working of a bench face below the water table.

3.3 MINING EQUIPMENT - Methods, Cost and Efficiencies.

(a) Excavating Overburden - top bench to expose top of coal beds.

Unit Costs:	Per Hr. ($)		($)
1 - D8 Dozer Skipper	80	-	80
2 - D8 Dozer-Pusher	70	-	70
2 - 20 m^3 Motor Scraper	75	-	150
1 - Front End Loader (4 yd^3)	65	-	60
2 - End Dump Truck (12 yd^3)	50	-	100
Supervision	40	-	40
			500
Unit costs at 300 m^3/hr $\frac{500}{300}$ =	$1.67		
+50 percent indirect cost	.83		
+30 percent profit margin	.80		
TOTAL ESTIMATED UNIT COST	$3.30/$m^3$		

The front end loader, dozer and trucks will carry out the grubbing, cleaning and removal of vegetation ahead of the scraper loading operation. Dozer ripping will have to be done in hard material areas (the glacial basal till). Benches will be sloped to 45° angle and the top bench height will vary from 5 to 10 m. Haulage distance for waste averages 0.25 km. Large boulders and petrified wood will be loaded and trucked to a separate pile.

(b) Excavating Benches in Coal - Methods, Cost and Efficiencies.

No drilling or blasting is anticipated. Digging will be by hydraulic excavator (front or backhoe) with 3 - 5 m^3 bucket on horizontal floor with approximately 60° slope angle bench walls. Two to twenty-five-tonne haul trucks or 4 - 9 m^3 end dump trucks will be used for clean up assisted by a front end loader and a dozer. Waste dump will be levelled using a dozer.

Haul distance for coal to the coal storage yard will average 0.5 km from either trench. Trench E will have a steep uphill gradient (approximately 100 m elevation change) to get the coal to the storage yard so only the coal required for sample purposes will be hauled; the balance will go into a coal stockpile adjacent to the trench.

Unit costs are:

		Per Hr. ($)		($)
1	Hydraulic Shovel (3.5 m^3)	160	-	160
2 - 25 t	Haul Trucks	70		
or			-	140
4 - 9 m^3	Haul Trucks	35		
1	F.E. Loader (2.5 m^3)	65	-	65
1	Dozer D8	70	-	70
1	Grader	50	-	50
Supervision		40/hr	-	40
	SUBTOTAL			525

Unit cost at 200 m^3/hr $\frac{525}{200}$ = $2.62

+50 percent indirect $1.31

+30 percent profit margin $1.00

TOTAL UNIT COST $4.93/$m^3$

(c) Other Work in the Trenches (By the Contractor)

- Pumping and drainage
- Road maintenance - grading, ditching, etc.

Cost for these are included in the 50 percent "indirect" above.

3.4 SELECTIVE MINING TECHNIQUES AND QUALITY CONTROL

Experience in excavating Trench A confirmed the fact that "selective mining" could be successfully carried out using hydraulic shovels. The results of the mining tests in Trench D will be used to establish practical mine design criteria for the selective removal of waste material during the digging operation. Various technical control systems including coal sampling and analysis and geophysics will be employed to predict the coal quality prior to mining. Attempts will be made to separate coal and waste using different separation criteria and different methods of on-site supervision. Regular samples will be taken and analyzed by the on-site laboratory to enable comparison of the predicted quality to the actual R.O.M. quality.

The main excavator will be a hydraulic shovel, with front-end loaders and end dump trucks for secondary handling. A backhoe will supplement the front bucket shovel for digging. Selective mining and testing will be emphasized to the contractor during the excavation of coal rather than speed or rate of mining.

Contracting strategy will obviously have to be modified from the normal "price per cubic yard" bid because of this experimental work in digging and materials handling. The cost of the work to be done will be tied to utilizing machines and operators by the hour. The ideal will be to have an equipment pool with flexibility of operators and several work phases at different trench locations. (This includes the clay trench excavation (Trench F).)

Payment would not involve surveying of excavated quantities (although survey control will be maintained) but would be done by daily time control of equipment and manpower. Consumables other than equipment repairs and maintenance would be largely procured and supplied by B.C. Hydro.

3.5 COAL HANDLING STOCKPILING AND SAMPLING

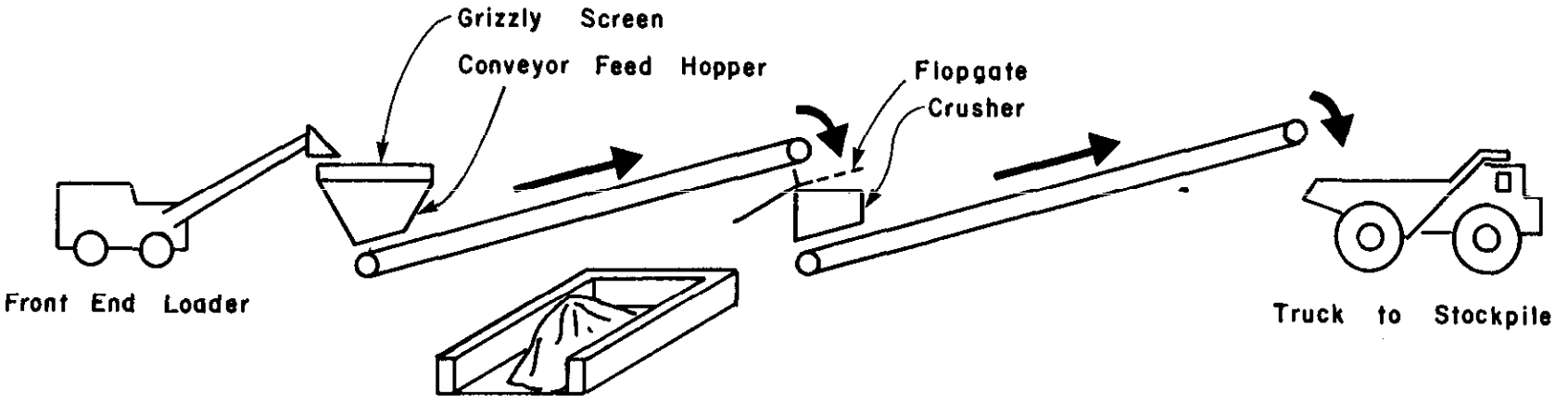
The coal produced during the excavation of the trenches will be handled, stockpiled and sampled to meet the study objectives of the various test programs. Different mining techniques will be attempted in the upper benches to gain experience with the mining equipment. Specific selective mining practices will be carried out in the lower most bench to produce approximately 2000 t of coal for pilot plant washing tests, washability tests, physical/mechanical tests etc.

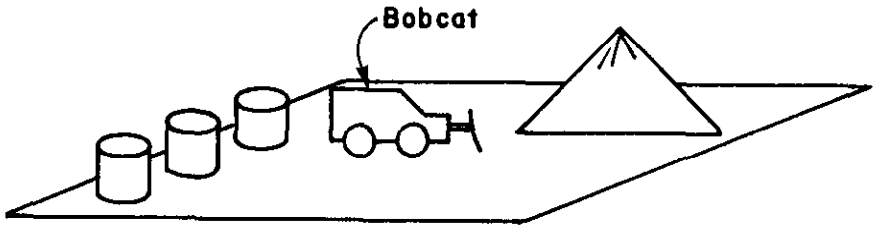
Coal will be trucked from the face directly to the conveyor feed hopper in order to facilitate sample identification. One of the major objectives of the overall field program is to relate R.O.M. coal quality to in situ coal quality. This can only be accomplished in a handling system (see Fig. No. 7 Coal Handling Plant) where belt conveyor samples can be identified according to their stratigraphic origin.

Each "seam" identified by the geophysics and channel sampling methods outlined in Section 2.4 of this report will be handled separately. The R.O.M. coal will be trucked from each trench and dumped in a designated area near the conveyor feed hopper. A front end loader will be used to systematically reclaim this coal and feed it into the conveyor feed hopper. A stationary grizzly screen located above the feed hopper will be used to scalp out the plus 12-inch material. This oversize material will either be crushed and returned to the feed hopper if it is obviously coaly material or be rejected if it is obviously waste material. A flopgate installed at the transfer point between the

Figure 7

Coal Handling Plant





conveyor and the crusher will be used to sample the minus 300 mm R.O.M. coal at regular timed intervals. The flopgate will divert sample increments onto a specially prepared pad for coning and quartering with a "Bobcat" mini loader.

Individual samples will be analyzed at the on-site laboratory in order to monitor the mining operation as the shovel progresses from hanging wall to footwall in each "seam" and composite samples will be prepared for each seam. Samples of crushed coal will also be taken at regular intervals to monitor the effects of the crusher on different qualities of coal. Crushed coal will be transported to a stockpile area and stored in separate compacted piles according to its quality.

Coal produced from the lowest bench in the test pit will be used to produce the representative bulk samples. This coal will be handled and stored separately under very carefully controlled conditions. Individual control samples will be analyzed on-site, but composite samples for each seam and eventually for each zone, will be used for various offsite test (see Fig. No. 8 Bulk Sample Flowsheet).

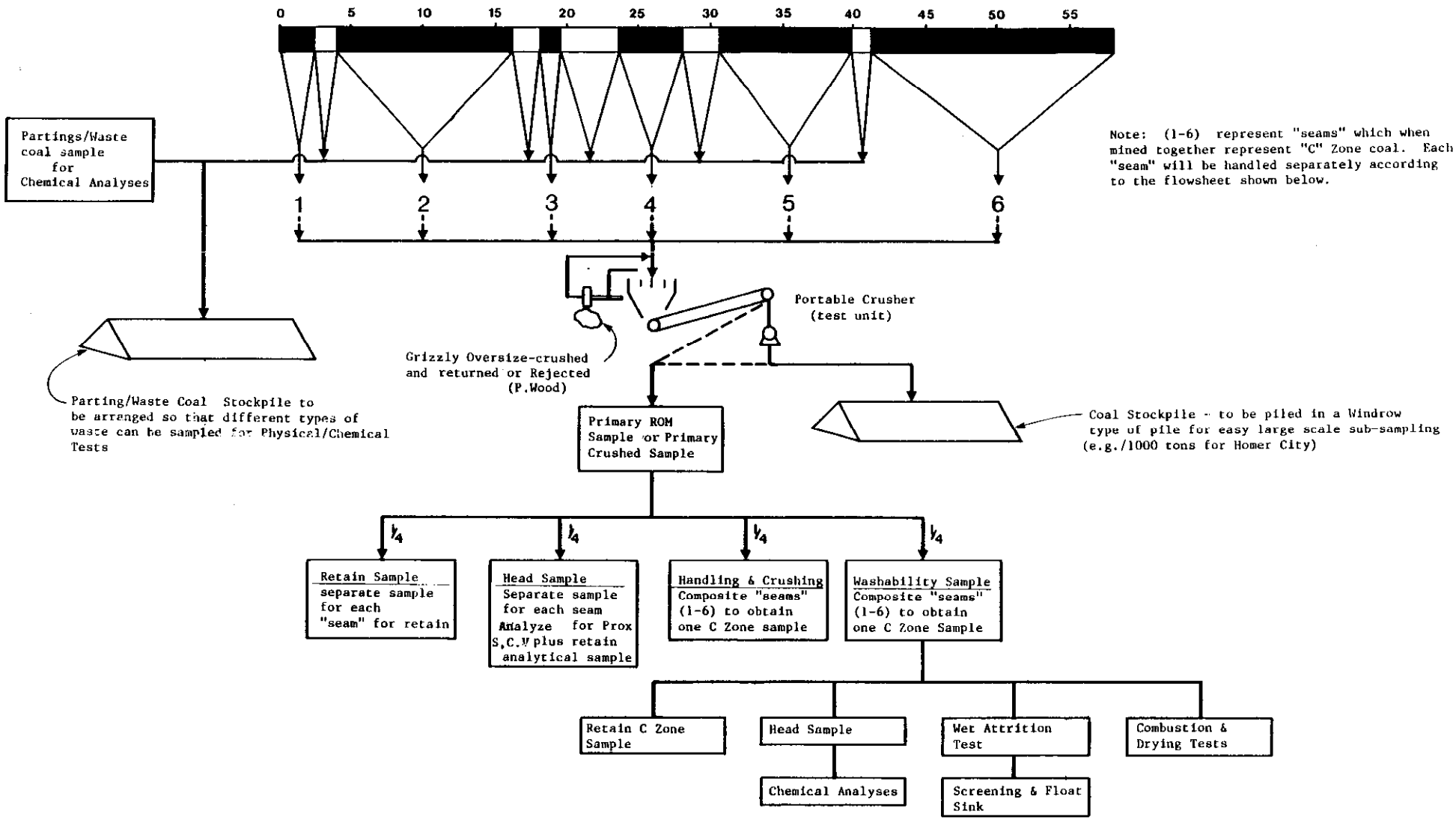
3.6 WASTE HANDLING, STOCKPILING AND SAMPLING

As is shown on the site location plan Fig. No. 1 the waste dump terraces will be laid down moving south on contour but building up gradient for drainage between terraces. Initially dump faces will be at angle of repose but later can be dozed to experimental slope angles as required.

Dozer levelling of waste dump top surfaces will compact the material and in the case of the waste coal reduce spontaneous combustion hazards.

Figure 8

Bulk Sample Flowsheet



The various types of materials will be hauled to separate dump terraces if testing and sampling work is to be done on them for engineering or environmental reasons.

3.7 RECLAMATION PLAN

The reclamation plan will conform with the requirements of the B.C. Coal Mines Reg. Act and follow the same procedures as were successfully carried out on site following the 1977 bulk sample program. This reclamation work has received very favourable commendation by the various government officials who have inspected our progress. We must continue the same high standard of work for this 1982 mining program.

Permit No. 103 issued by the Ministry of E.M. & R. B.C. government in terms of the Coal Mines Act is valid for this program, and Forms 7 and 8 will be submitted by 31 April 1982 detailing the work to be done and the reclamation proposed. Approval of this will be the permit for all the work on the Hat Creek coal licenses subject to inspection by the District Inspector of Mines.

Suggested improvements and variations to the reclamation field work for D and E Trench program have been prepared by F.G. Hathorn and are attached.

Estimated costs for the reclamation work of this program are mainly concerned with providing for costs of physical material moving after mining excavation (top soil and special test plots) plus the vegetation seeding.

3.8 MANPOWER - 1 shift per day x 10 hr

The proposed operating schedule will be one 10-hour shift per day with a 5-day work week. This results in the following personnel requirements:

	BCH	Contractor	Consultant	
Supervisors	1	1	-	
Shiftboss	-	1	-	
Geologists	2	-	-	
Coal Quality Control	1	-	1	
Clerical and First Aid	1	1	-	
Surveyor's Helper	-	1	1	
Supplies - Pickup Driver	-	1	-	
Operators - Shovel & Backhoe	-	2	-	
Scraper & F.S. Loader	-	3	-	
Truck Drivers	-	4	-	
Drill (Auger)	-	2	-	
Maintenance - Mechanical	-	2	-	
Electrical	-	1	-	
Labour	-	4	-	
	5	23	2	
2. Coal Preparation and Sampling				
Operators - Loader, Dozer	-	1	-	
Crusher Foreman	-	1	-	
Crusher Helpers	-	2	-	
Maintenance - Mechanical	-	1	-	
Electrical	-	1	-	
Sampling	1	2	1	
Laboratory	-	2	1	
Labour - Utility	-	2	-	
Other - Supervisors	1	1	2	
Subtotal	2	13	4	
TOTAL ALL PROGRAMS	7	38	6	= 49

SECTION 4.0 - BULK SAMPLE TEST PROGRAMS

4.1 INTRODUCTION

Bulk sample collected during the mining programs will be analyzed as extensively as possible to gain engineering design information for all facets of the project. Bench scale tests will be employed to determine the basic chemical and physical properties of the coal and pilot scale tests will be used to confirm various design criteria. Detailed washability results will be carefully examined prior to finalizing the selection of pilot plant processes to be used.

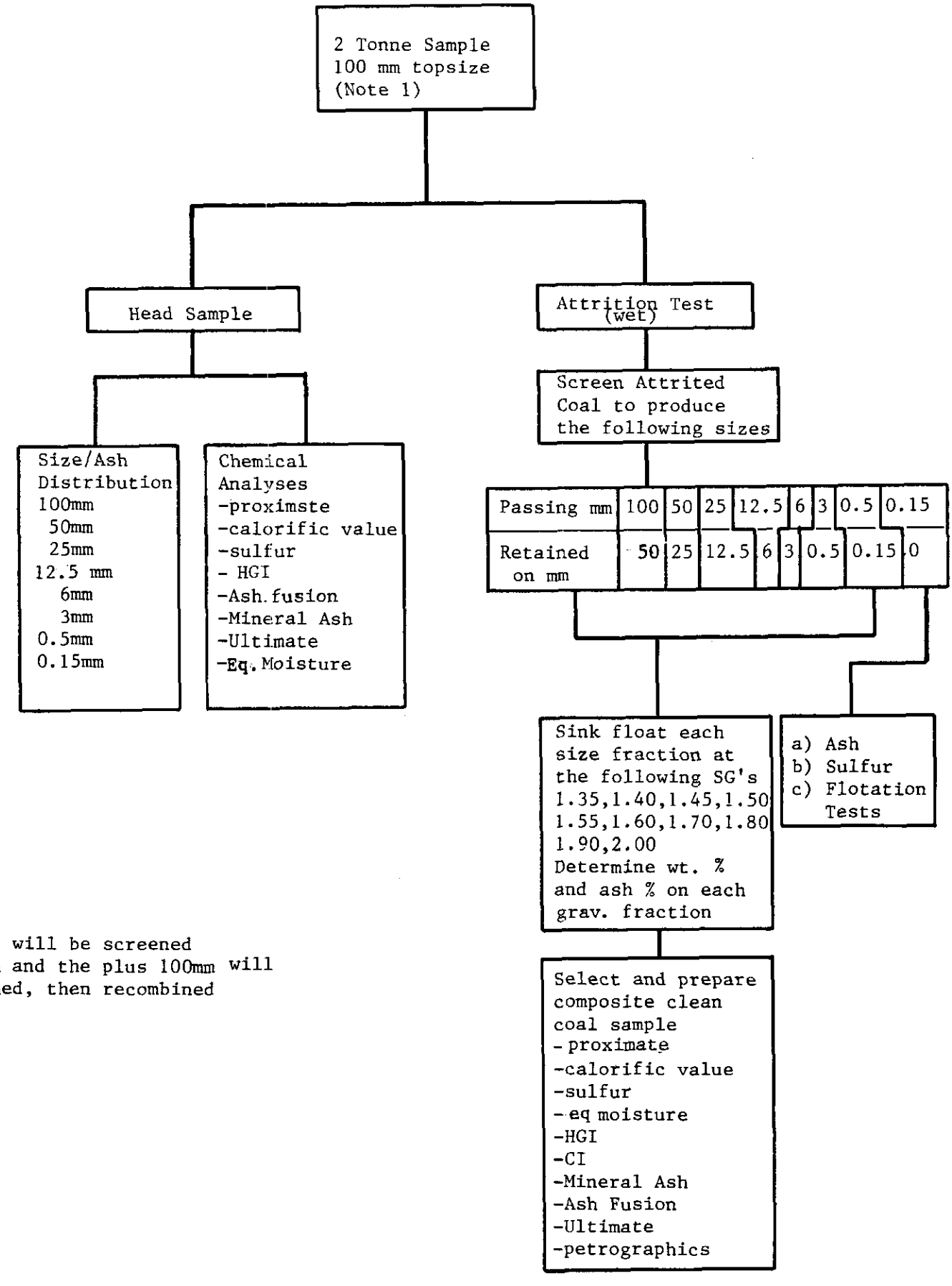
The results of all testing, including the various pilot plant tests, will be used to establish design criteria for a pilot wet washing facility which could be installed in the early years of mine development. A separate follow-up report will include flowsheet design, equipment selection and a detailed cost estimate for an on-site pilot preparation plant.

4.2 BENCH SCALE TESTS

The size-ash distribution of the Run-of-Mine (ROM) coal and the crushed (minus 100 mm) coal will be determined by various screening and attrition tests. Attrited coal will be float/sunk at various gravities (see Fig. No. 9, Standard Washability Tests) to obtain washability curves and preparation plant yield predictions. Complete analytical tests will be performed on both the raw coal and the selected clean coal composites.

Figure 9

Standard Washability Tests



Note. 1

ROM coal will be screened at 100mm and the plus 100mm will be crushed, then recombined

4.3 PILOT SCALE TESTS

Several different pilot plants are currently being investigated by members of the project team to determine their applicability to the Hat Creek Project.

The pilot facilities currently being considered are:

1. Coal Preparation

   a. EPRI's Homer City Test Facility (300 tonne sample).
   Homer City, Pa.
   Owned by the Electric Power Research Institute and operated under contract by Kaiser Engineers of Oakland.

   - heavy media cyclones, large diameter water cyclones, deister, tables, froth flotation,
   - excellent automatic samplers throughout the plant,
   - no experience with low rank coals.

   b. Birtley Coal Mineral Testing (10 tonne sample).
   Calgary, Alberta

   - very familiar with Western Canadian coals,
   - heavy media cyclone, large diameter cyclone, compound water cyclone and froth floation,
   - poor access to some critical sample points.

   c. Humboldt Wedag (10 tonne sample).
   Bochum, West Germany.

   - Batac Jig,
   - offer a variety of handling tests including tailings handling.

d. Western Research Laboratory (10 tonne sample).
Edmonton, Alberta.

- Batac Jig test unit,
- very limited experience with the test unit,
- familiar with Hat Creek coal.

2. Material Handling

- Hazemag, Montreal.
- Pennsylvania Crusher, Pa.
- FMC, Toronto.
- H. Colijn, Monroeville, Pa.
- Allis Chalmers, Vancouver.

SECTION 5.0 - COST ESTIMATE

The cost summary is based on the following assumptions:

1. Field services including building maintenance, security, surveying, first aid, road upgrading, reclamation, catering, B.C. Hydro staff supervisors and service vehicles are provided for elsewhere.

2. The Trench E proposal (which would cost a total of $293,000 if it were selected instead of D Trench) includes only a small backhoe trench to confirm that the stratigraphy and coal quality at the proposed site. The full program as shown on Fig. Nos. 3 and 7 has been deferred to 1983.

3. The overburden removal will be done on a price per cubic metre basis and the coal excavations will be on an hourly equipment rate.

4. The "Plant Equipment" will be leased or rented but not purchased.

5. The major coal preparation pilot plant work will be done on a 300 ton sample at Homer City, Pennsylvania.

The major costs for the program have been identified as follows:

Trench D

Excavation		391,000
Sample Handling on Site		50,000
Shipping and Testing at Homer City, Pa.		150,000
Geophysical Tests		15,000
Plant Equipment		40,000
Material Handling Tests		20,000
Batac Jig Tests		25,000
Site Laboratory		10,000
	Trench D Total	701,000

Trench E

Excavation		20,000
Sample Handling		5,000
Sample Testing		10,000
	Trench E Total	35,000
	Total Proposed	$736,000

APPENDIX 4

HAT CREEK PROJECT

MINING FIELD PROGRAM 1982

COAL CHARACTERISTIC EVALUATION PROGRAM

TABLE OF CONTENTS

1.0 INTRODUCTION

In the development of fuel specification for the powerplant the statistical approach did not take into account the anomalous values of several parameters nor establish their geological and stratigraphical association.

The purpose of this program is to identify these anomalies and their stratigraphical distribution and establish combustion characteristics so critical for the powerplant.

It is also intended to evaluate these characteristics and possible improvement in fuel spec using selective mining, where the undesirable elements have been identified and removed from the overall run-of-mine coal.

2.0 SODIUM IN HAT CREEK COAL

The "Total Sodium in Ash" is determined by ASTM (D 2795-69 and D-3682-78) which required the coal to be ashed at 700-750^{o}C. When Paul Weir were reviewing the analytical data they introduced the two stage determination - water soluble sodium and remaining sodium in coal. Unfortunately this method does not provide practical correlation of "active" alkalies vis a vis "fouling action" on boilers, nor does it recognize the organic or inorganic character of sodium.

To augment this basic need of identifying the forms of Na present in coal, their mineralogical character and their behaviour at temperatures up to 1400^{o}C, Dr. Samia Fadl of Simon Fraser University in discussion with Mining and Thermal Engineering Staff has developed the following program:

1. Verification of Paul Weir's sodium analytical procedure and data.

2. Development of an analytical procedure to account for the variation in sodium values using ASTM method.

3. Classification of active and fixed sodium using various organic solvents and acids as suggested by Combustion Engineering.

4. Presence and distribution of sodium in coal using this method (3).

5. Identification of sodium associated minerals and their behaviour at high temperatures.

The above study will be conducted with the assistance of Simon Fraser University, British Columbia Institute of Technology and University of British Columbia staff as a research project.

3.0 PRESENCE AND DISTRIBUTION OF Fe_2O_3 IN COAL SECTION AND ITS EFFECT ON ASH FUSION TEMPERATURES

A brief review of existing data indicates that the low ash fusion temperatures recorded are related to high iron content. This higher iron content is associated with ferruginous petrified wood which forms discreet bands at the junction of the major zones. It may be possible to remove these bands by selective mining.

The following scope of study has been developed:

1. Correlation of Fe_2O_3 content in ash with ash fusion temperature.

2. Ash fusion temperatures of blended coal samples of a given Fe_2O_3 content will be compared with the same Fe_2O_3 content in individual unblended coal samples.

This study will provide a guideline for predicting ash fusion temperatures based on their Fe_2O_3 content.

4.0 MINERALOGY OF NON-COMUBSTIBLE CONSTITUENTS IN COAL

The mineral content of non-combustible matters in coal determine the behaviour of ash especially their slagging, fusion temperatures and corrosion characteristics. Some of these minerals are syngentic, related to the depositional environmentl while the others are secondary.

These minerals will be studied using X-ray diffraction, electron microprobe and scanning electromicroscope to determine the qualitative and quantitative values of the elements present in the minerals. The University of British Columbia has facilities for these tests.

5.0 COAL PETROLOGICAL STUDIES

For the evaluation of coal characteristics, its rank, mineral content, coal petrology has been a universally accepted practice. Very little work has been done in this area.

Samples from Trenches D and E, representing coals from A Zone and C Zone will be studied both under reflected and refracted lights.

EMR Ottawa, and UBC have facilities for petrographical studies. Some of the consultants offer these services -

i) David Pearson and Associates, Victoria, B. C.;

ii) Cascade Petrography, Calgary, Alberta

6.0 TRACE ELEMENT STUDIES

The impact of trace elements on environment studies as provided in the EIS reports requires reassessment due to the fact that mining plans have been developed since then and the possibility of selective

mining is under review. The earlier studies were based on the "total 35-year pit" concept instead of shorter increments which are more critical from the sensitive environmental viewpoint.

A detailed review of the old database has been initiated, based on which future scope of work will be developed jointly with the Environmental Department.

7.0 ASH ANALYSIS AND ASH FUSION TEMPERATURES ON GRAVITY FRACTIONS

The standard ASTM ash fusion temperature determinations treats the ash from a sample as a homogeneous mass. In actuality, the mineral matter within a coal consists of several discreet minerals, the combustion behaviour of which is not represented by the usual SiO_2/Al_2O_3 base/acid ratios. Use of the coal-ash fusibility values and the coal/ash ratios does not explain the selective deposition of ash constituents noted on furnace walls.

It is proposed that these minerals will be separated by gravity methods and fusion-temperature determined on individual gravity fractions with the corresponding mineral determination using methods mentioned in Section III. This work has been developed with the concurrence of Thermal Engineering Department.

8.0 SITE COAL TESTING LABORATORY

B. C. Hydro's coal testing laboratory at site is fully equipped to handle proximate, sulphur and thermal value determinations. Sample preparation facilities are able to handle up to 40-50 samples at one time. Sieve analyses and large-opening screens are already available.

Sink and float facilities can be added without any major capital expenditure - less than $250.00.

The advantages of having a site laboratory are:

i) quality control and direct supervision;
ii) promptness in obtaining analytical data;
iii) economical to operate.

8.1 Operation and Control

Two or three BCIT graduates and/or students in the Chemical Technology program will be hired for four months. One of these will be a Graduate Technologist. A chemical consultant with extensive coal lab experience will be retained to train the personnel, provide supervision and guarantee the accuracy of analyses following ASTM procedures. Comparative tests will be run at other laboratories to confirm the analytical data.

9.0 COST ESTIMATES

The cost estimates for this study is presented below:

	Cost Estimate
Sodium in Hat Creek Coal	$ 20,000
Presence and Distribution of Fe_2O_3 in coal section and its effect on ash fusion temperatures.	5,000
Mineralogy of Non-Combustible Constituents in coal	10,000
Coal Petrological Studies	10,000
Trace Element Studies	(covered under Environmental Department's budget)
Ash Analysis and Ash Fusion Temperatures on Gravity Fractions	5,000
Site Coal Testing Laboratory Operation and Control	40,000
Total Estimate	$90,000

APPENDIX 5

HAT CREEK PROJECT

MINING FIELD PROGRAM 1982

CLAYSTONE INVESTIGATION PROGRAM

TABLE OF CONTENTS

1.0 INTRODUCTION

As a result of their studies of the Hat Creek No. 1 Deposit, Golder Associates recommended an average slope angle of 20^{0} for the slopes in the open pit. This value was considered as being flexible with respect to mine planning and would vary depending upon location within the pit boundaries, and would be subject to continual review as mining develops.

Although Golder Associates do not recommend further extensive drilling programs for slope stability studies, a trench excavation into saturated Medicine Creek claystones is recommended.

The objectives of a claystone trench would be to examine the physical texture and structure of the claystones and to gain experience in the actual mining and handling characteristics of the saturated materials. In addition, a trench will test the depressurization by excavation concept described in the Golder Associates December 1978 Report, Volume 1, Figure 14. This concept proposes that as the surficial materials are removed from the underlying saturated claystones, the inherent pore pressures are decreased, giving rise to an improved slope stability in the exposed Medicine Creek claystones.

In order to test this concept it would be necessary to drill exploratory holes into these claystones for piezometer installation to monitor the water conditions before and after removing the overburden materials. This would measure the pore pressure response and monitor any changes over time. This would allow estimates of slope stabilities to be reviewed and revised accordingly.

2.0 FIELD PROGRAM

Two possible sites have been identified for access to the Medicine Creek Formation: one is on the west side of Hat Creek opposite the Lehman Ranch and would entail the excavation of a fairly large trench (Trench F); the other location would be at the western end of the proposed coal Trench D which would also require a fairly large excavation to gain access to saturated materials.

Due to other priorities and budgetary restraints it was decided that the 1982 investigations should be limited to the following programs which would aid in the future planning of Trench F possible in 1983:

2.1 Exploratory Drilling

Golder Associates proposed that four rotary air flush holes (100 m total) be drilled in the area of the planned Trench F. These holes would be drilled through the surficial materials to reach the bedrock of the Medicine Creek claystones. This drilling will provide the necessary data in an aid to design the trench excavation and to obtain information on the permeability of the overburden and on water flows. The piezometers would be installed in these holes for this purpose.

All drill sites would be reclaimed as part of the overall reclamation program.

2.2 Excavation

As described in Section 3 of the A and C Zone Bulk Sample Program, the Medicine Creek Claystone Formation is exposed at the west end of the proposed Trench D. The claystones at this location and elevation are above the water table and therefore will not be saturated; access to materials below the water table would require the excavation

of significant extra volumes of material. However, some experience will be gained in the mining and handling of these claystones which will assist in future planning and equipment selection.

The mining plan and equipment is described in the above Bulk Sample Program.

3.0 TEST WORK

Samples of claystone materials would be tested with respect to geotechnical design criteria and for materials handling tests.

The materials handling tests would include flowability, screening and crushing of the claystones. Some of these tests could be carried out in the field using the equipment for the coal bulk sample program, however, samples would be sent to equipment manufacturers for detailed testing, e.g. Hazemag, Pennsylvania Crusher Co., Allis Chalmers etc.

4.0 SCHEDULE AND COSTS

4.1 Schedule

The planning for the proposed exploratory drilling for Trench F will be carried out during the summer months. The drilling would be carried out toward the end of the groundwater drilling program when a drill rig becomes available. Golder Associates together with B. C. Hydro will plan and monitor this drilling and install the piezometers.

4.2 Costs

Planning, supervision, testing and data assessment	$ 10,000
Contracting - rotary drilling 4 holes at 25 m each	$ 20,000
TOTAL	$ 30,000

APPENDIX 6

HAT CREEK PROJECT

MINING FIELD PROGRAM 1982

GEOLOGICAL & GEOPHYSICAL INVESTIGATION PROGRAM

TABLE OF CONTENTS

GEOLOGICAL & GEOPHYSICAL INVESTIGATION PROGRAM

1.0 INTRODUCTION

The geological and geophysical program outlined here is integrated with the proposed Hat Creek Diversion Tunnel Investigation Program, A and C Zone Trenches, Hydrology - Geotechnical Update and other related studies. The purpose of this section is to identify and coordinate the geological commitment of the Mining Department into the various programs.

2.0 GEOLOGICAL INVESTIGATIONS

2.1 Regional Geological Mapping

The current Geological Map, scale 1:20,000 produced by the Mining Department in 1981 covers No. 1 and No. 2 Deposit, in the Hat Creek Valley. The present work will be an extension of the Regional Mapping Program, initiated in 1980-1981, to cover the southern part of the Hat Creek Valley.

2.2 Detailed Geological Mapping

Detailed mapping will be conducted in the eastern side of No. 1 Deposit to form the base map for the Geotechnical Investigation by Golder Associates.

Mapping will be further extended to the southern and western areas, including the Dry Lake and the areas associated with Pit Rim Dam and Finney Creek Diversion. Reports submitted by the consultants for the 1981 Site Investigations Program will be reviewed and the data from them incorporated into the Mining Department's "Regional Geology Map".

2.3 Surficial Material Study

The surficial materials studies in the past were based on borehole data, where the overburden have been triconed and only fine cuttings were available for examination. SIP-1981 program provided information on actual exposures in test pits and cores. This data, together with Trench D and E overburden information will be utilized to provide surficial material maps.

Preparation of the Regional Surficial Map (scale 1:20,000) will be based on mapping and compilation of data from consultants' reports.

Updating the present Surficial Map (scale 1:5000) for the 35-year pit area and reserve estimation of the various materials during various stages of production using geological mapping and compilation of data from trenches, test pits, boreholes, etc.

3.0 TUNNEL DIVERSION STUDY

Detailed description is presented in the program description in section 2.1.

Mining Department will be involved in supervision, data verification and confirmation of drilling data for the duration of Golder's program.

4.0 GROUNDWATER STUDY

The potential inflows of groundwater and reassessment of the dewatering aspects of the pit are being investigated by Golder Associates.

The Mining Department will be providing close liaison with respect to geological, geophysical surveys and field investigations, including well drilling and monitoring.

5.0 TRENCH D AND E PROGRAM

This program is discussed in detail in Appendix 3.

5.1 Overburden

This study entails detailed mapping of the sidewalls and description of the surficial material, their physical and mechanical handling properties, etc.

5.2 Coal Section

The following work will be performed in the coal section of the trench:

- Detailed mapping of the sidewalls for each bench with material description as to their physical, chemical and mechanical properties.

- Sampling of each lithological unit, together with mineable unit to obtain a run-of-mine bulk sample.

- Application of Roke's Surface Geophysics.

Geophysics as a tool for identifying and sampling the lithologic units for future application in mining. The experimental work will be conducted in Trench A, and followed up in Trench D and E.

6.0 GEOPHYSICAL INVESTIGATIONS

6.1 Geo-Physi-Con

As proposed by Golder Associates a geophysical survey will be conducted by Geo-Physi-Con and themselves using seismic refraction and reflection methods. The Mining Department will be coordinating, monitoring and evaluating their applicability.

The objectives of the various geophysical applications are as follows:

- magnetics and resistivity to define structure and stratigraphy in volcanics/volcanoclastics sequences (6-day program) in the Hat Creek Tunnel Diversion area.

- transient EM to define buried glacial channels, nature of glacial material and location of the boundary fault east of No. 1 Deposit (11-day program).

6.2 Seismic Refraction and Reflection Methods (Golder Associates)

These applications will further define the structure and stratigraphy in the volcanic rocks (10-day program).

6.3 Practical Application of the Above Methods

These will be applied in the No. 1 Deposit (Section Q) to evaluate the potential for lithologic differentiation (2-day program), and in the "E" Trench area to outline the old underground mine workings (2-day program).

6.4 Gravity Survey of Hat Creek Valley

The anomalies identified by gravity survey conducted in 1975-1976 by C. A. Ager & Associates (now Ager, Berretta & Associates) for No. 1 Deposit were not extended in same detail south of No. 1 Deposit.

It is necessary to identify the disposition of coal sequences, its depth of burial and structure for proper evaluation and its impact on the Pit Rim Dam Headworks Dam.

The structure of No. 2 Deposit is based on relatively few boreholes and moderately detailed gravity profiles.

This program will provide better understanding of No. 2 Deposit and assist in proper selection of borehole sites in future development.

The priority of this work is subject to review. No work is scheduled on the No. 2 Deposit area for 1982.

7.0 COMPUTER DATA INPUT

The geological information has to be input into B. C. Hydro's data file. A summer student will assist in this work at the end phase of the field program.

8.0 MANPOWER

In the above geological and geophysical programs the estimated manpower requirement is 260 man-days as shown in the table below.

		Estimated Man-days
GEOLOGICAL INVESTIGATIONS:		
Regional Geological Mapping	1 x 30	30
Detailed Geological Mapping	1 x 20	20
Surficial Material Study	2 x 20	40
TUNNEL DIVERSION STUDY	1 x 45	45
GROUNDWATER STUDY	1 x 15	15
TRENCH D & E PROGRAM Overburden Coal Section	2 x 45	90

GEOPHYSICAL INVESTIGATIONS		
Geo-Physi-Con	1 x 11	11
Seismic Refraction and Reflection Method (Golder Associates)	1 x 5	5
Practical Application of the Above Methods	1 x 4	4
Gravity Survey of Hat Creek Valley	(2 x 25)	
	Total Man-days	260

APPENDIX 7

GOLDER ASSOCIATES PROPOSAL TO B. C. HYDRO FOR MINING GEOTECHNICAL STUDIES 1982 PROGRAM

HAT CREEK PROJECT

TABLE OF CONTENTS

Golder Associates
CONSULTING GEOTECHNICAL AND MINING ENGINEERS

PROPOSAL TO B.C. HYDRO & POWER AUTHORITY FOR MINING GEOTECHNICAL STUDIES 1982 PROGRAM ON THE HAT CREEK PROJECT

BRITISH COLUMBIA

DISTRIBUTION:

3 copies - B.C. Hydro & Power Authority
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1 copy - Sigma Resource Consultants Ltd.
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Vancouver, British Columbia

February, 1982

822-1508

HAT CREEK PROJECT

PROPOSED MINING GEOTECHNICAL STUDIES, 1982 SEASON

1.0 INTRODUCTION

This proposal sets out the mining geotechnical work which Golder Associates recommend should be carried out during 1982. It is desirable to integrate this work with the other activites planned on site by BCH for the 1982 season.

The geotechnical work has been divided up into five programs, namely:

(1) Hat Creek/Finney Creek Diversion Study
(2) Ground water
(3) Trench F planning
(4) Geological re-assessment
(5) Production of final report

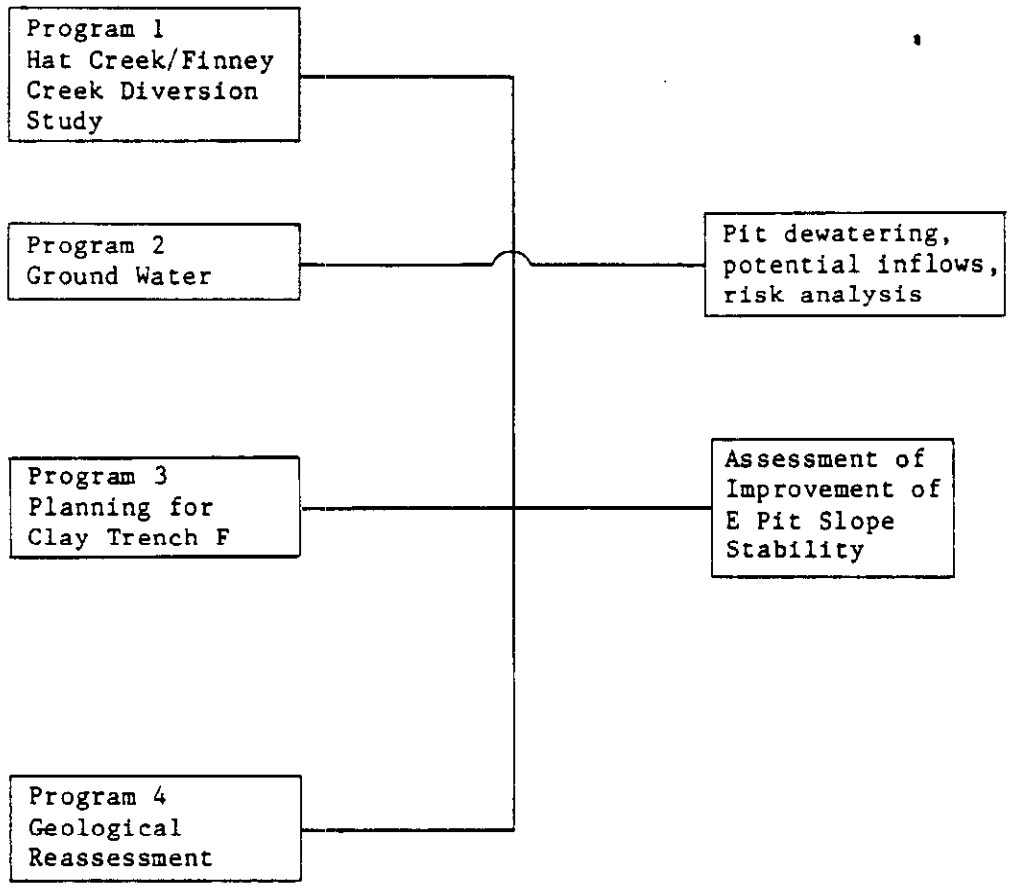
Figure 1 shows the inter-relationships of the various proposed programs.

2.0 OBJECTIVES

The major objectives of the 1982 work are considered to be as follows:

- consideration of the various methods of diverting Hat Creek/Finney Creek around the pit with particular emphasis on the extent to which a deep-level tunnel could achieve drainage of the E. pit slopes and hence improve slope stability (Program 1).
- re-assessment of the dewatering aspects of the pit including a risk analysis of potential inflows (Program 2)

FIGURE 1
INTERACTION OF PROPOSED PROGRAMS



- assessment of the movements which might develop in the E. pit slopes and the potential risk to diversion structures sited close to the pit (Programs 1, 2, and 3)
- planning for the future location of a trench (F) into the Medicine Creek Formation claystone (Program 3)
- assembly of the geological and geotechnical data collected to date for slope and embankment stability purposes and consideration of the role of structure in slope stability (Program 4)

The details of the programs recommended to achieve these objectives and the range of activities proposed are shown on Figures 2 and 3.

3.0 METHODS OF WORK

3.1 Hat Creek/Finney Creek Diversion Study

The main elements of this study have been presented to BCH at the two meetings on January 15th and 25th, 1982. The interrelation of the proposed activities in the study is shown on Figure 2.

The question of the Hat Creek diversion has already been studied by others and the presently recommended scheme involves a diversion canal around the pit during the early stages of pit development with a tunnel at later stages. However, the studies were made several years ago and since then conditions and mining plans have changed. A review of the alternatives in the light of present information is required particularly with respect to the imporvement of the stability of the E. pit slopes by drainage.

It is proposed that a study of the various design alternatives for the Hat Creek/Finney Creek diversion would be carried out by an in-house Golder Associates team augmented by specialists to provide input to specific areas. We would anticipate close liaison with the BCH Mining Department in the selection of conceptual layouts, acquisition of

FIGURE 2

PROPOSED PROGRAM 1 ACTIVITIES, HAT CREEK/FINNEY CREEK DIVERSION SYSTEMS

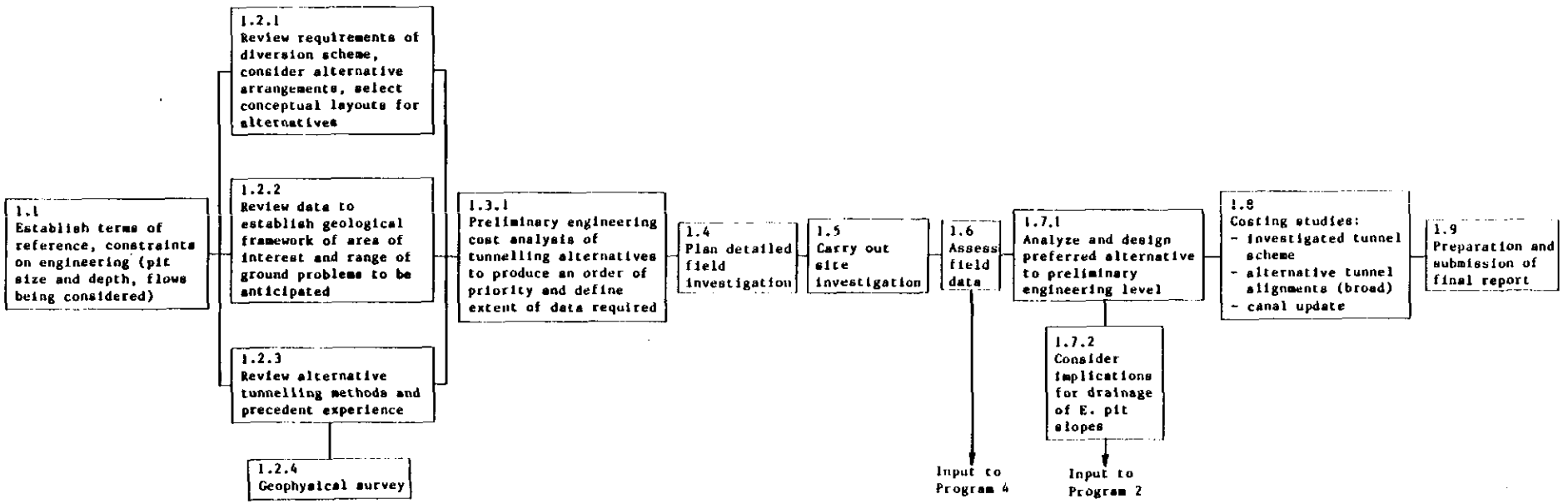
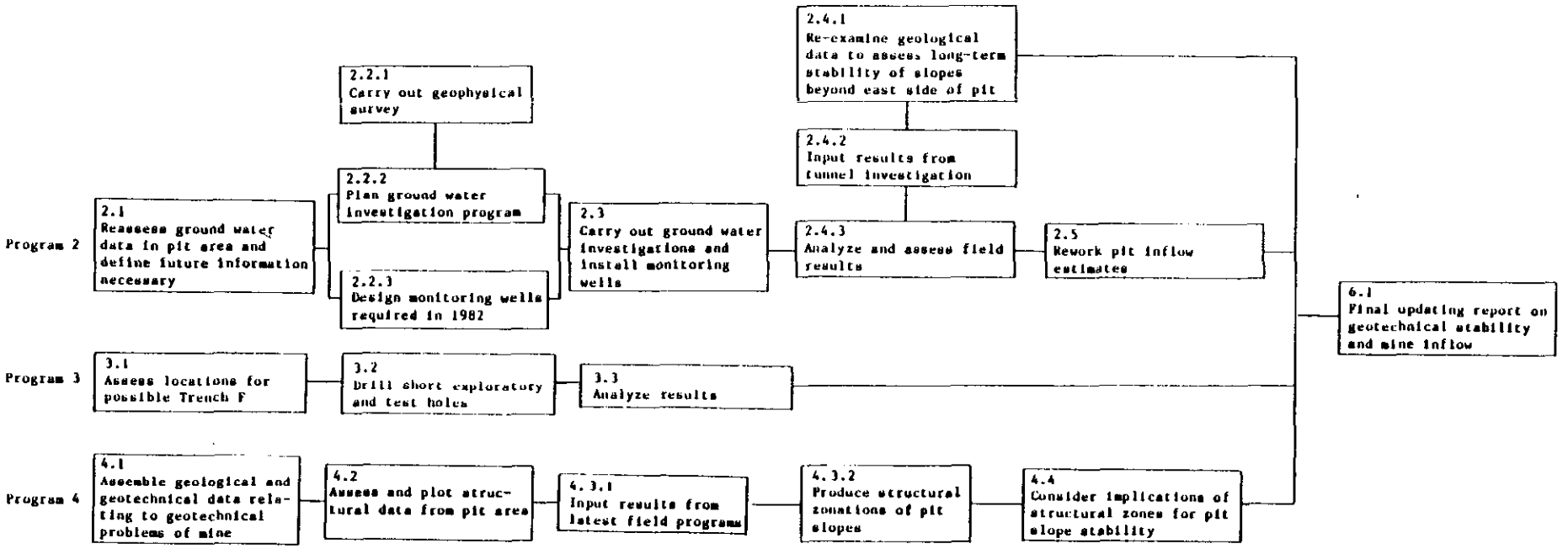


FIGURE 3

PROPOSED PROGRAM 2 - 4 ACTIVITIES, GEOTECHNICAL/HYDROGEOLOGICAL STUDIES, 1982



geological data and costing studies. The hydrological/hydraulic aspects would be carried out under the direction of Dr. Dennis Russell of Sigma Resource Consultants Ltd. with whom Golder Associates work in close contact.

It would be necessary to define the geology within the zone covered by the alternative schemes as early as possible in the program. It is recommended, therefore, that a geophysical survey be let which would integrate with the geological mapping already carried out and which would be augmented by further field work after the Spring break-up. Discussions with a geophysical consultant (Geo-Physi-Con) have indicated that techniques are available which could provide data concurrently for both this study and the ground water investigations needed in the northeast of the pit. We propose that the field work which is necessary for planning purposes and which should be carried out as soon as possible (EM transient and seismic reflection methods) should be completed by Geo-Physi-Con and the remaining geophysical work (magnetic and seismic refraction) should be undertaken by Golder Associates during the period in May when drilling tenders are being called.

Our initial appraisal of the diversion alternatives indicates that there could be six:

- through the volcaniclastic sequence at a high level
- through the volcaniclastic sequence at a lower level
- through the Quaternary deposits
- through the Medicine Creek Formation at a low level
- below the pit as a pressurized system
- plastic pipe on surface to replace canal diversion.

Some of these alternatives would be discarded early in the preliminary engineering analysis.

The approach proposed is what is formally known as a "Branch and Bound" procedure. It involves attempting to identify all potentially feasible alternatives and sub-alternatives and then eliminating the less

promising alternatives as quickly as possible. An alternative or sub-alternative is eliminated from further active consideration as soon as it can be clearly demonstrated to be inferior to another alternative. This is an efficient process in that engineering effort is progressively concentrated on the more promising alternatives and if it is combined with regular meetings of all those involved (including the client), it keeps everyone informed of the progress of the study and helps to ensure that nothing is overlooked.

The initial hydrological review of the alternatives for the Hat Creek diversion would be made on the basis of the existing hydrology studies and recommended design flows. There would be liaison with the previous surface water consultants. Required tunnel sizes would be calculated for various alternative tunnel alignments and profiles; the presently proposed diversion canal scheme would be briefly reviewed; and various pipeline alternatives would be developed.

Conceptual layouts for the alternative diversion schemes within constraints of pit geometry, hydrology and acceptable hydraulic characteristics would be developed. Alternatives might include pipeline, tunnel, shaft/tunnel and canal arrangements. Consideration would be given to the siting of the head works and pit rim dams. Benefits and drawbacks of alternatives would be identified. The results would be reviewed with BCH staff.

For the alternative schemes developed above, geological data along tunnel and shaft centreline sections would be reviewed and geological sections prepared. Field and laboratory data would be assessed to provide the basis for anticipated tunnel/shaft performance within various geological regimes encountered. Layouts of alternative schemes would be modified as appropriate. Specific or suspected tunnelling problems would be identified for various alternatives. Where possible, the magnitude of problem (e.g. water inflows; squeezing ground; range of lining pressures, etc) would be quantified. Portal conditions would be assessed and the priority of alternatives established.

For conditions identified along various tunnel alternatives, tunnnel construction (including lining) methods appropriate to the nature of the ground anticipated would be reviewed. From precedent data comparative unit cost and schedule ranges for various tunnelling conditions would be assembled.

Utilizing data derived from the previous activities, conceptual level analysis of tunnel and pipeline alternatives would be undertaken to provide cost/schedule/technical feasibility/risk ranking alternatives and to consider the ability of the tunnel to achieve drainge of the pit slopes. This review of alternatives would be a continuous process with the aim of closing in on the one, or possibly two, most promising alternatives for detailed investigation. If it were decided by BCH that a pipeline and not a tunnel should be investigated from this point on, the scale of field work and engineering studies would be much reduced. Areas where further data is required for the preferred scheme would be defined and a field drilling program planned if a tunnel is preferred.

The results of the geophysical survey, geological/geotechnical mapping and drilling program would be assessed to refine the geological model of the preferred alternative alignment.

Assuming that a tunnel is selected as the preferred alternative, preliminary engineering of the tunnel including lining and support would be carried out to level necessary to provide basis for cost estimates. Any special measures required such as dewatering, pressure grouting, portals, etc., would be included.

Feasibility level cost estimates of the preferred alternatives would be undertaken in conjunction with a costing specialist for input to a final report. No recommendation is made at this time for a consultant to fill this role as the choice would be dependent on the particular selected alternative (soft ground/hard rock tunnel, pipeline).

3.2 Ground Water

To reconsider the quantity of drainage into the pit as planned, it would be necessary not only to acquire some further data in the NE. of the pit but also to critically review the data already obtained.

Re-analysis of some of the ground water data acquired between 1976-78 has shown that stabilisation of piezometric levels over that period has taken longer than anticipated. In consequence, it is necessary to rework some of the permeability test and pumping test calculations. The revised data, together with the results of the recommended exploration program below, would provide a secure data base for further inflow calculations.

Golder Associates currently input all piezometric data supplied by BCH on a 2-monthly basis. This data goes onto punch-cards. A period exists in the early phases of the study when this was not being carried out. It is recommended that this back-log of data be processed in a similar format to the current data and that it should all be transferred to magnetic tape so that piezometer hydrographs can be plotted directly from the stored data as and when needed. All hydrographs are currently plotted manually.

Recent ground water investigations have shown that deep permeable gravels could exist close to the pit rim in the north and northeast of the pit. It is possible that significant seepage into the pit could result and therefore further definition of the ground water system in that vicinity is required.

It is proposed that the geophysical survey, which would be carried out by Geo-Physi-Con in February/March and which would cover part of the area of ground water interest during the tunnel investigations, should be extended to cover the area between the recently drilled well (PW1) and the pit rim. Results from this survey should define the

geometry of any aquifers present and permit the assessment of the potential extent of any inflow problem. On the basis of that assessment a program of air-flush exploratory rotary drilling would be undertaken to obtain data on the ground water regime and pumping tests would be carried out, as necessary, to measure aquifer characteristics. It is planned that the exploration holes would be screened if potential aquifers were identified and that the wells would be test pumped. It might also be necessary to install some further observation wells at this stage. The results of this work would then be used to estimate the quantity of inflow into the pit from that section of the slope.

As a final exercise, the assessment of pit inflows throughout the pit made during the 1978 study by Golder Associates, using the latest data, would be updated and risk analyses undertaken to determine the confidence levels for various quantity of inflow.

The extent of the field work is difficult to estimate until the results of the geophysical survey are available. However, it has been provisionally estimated that 4 exploratory drill holes (3 deep, 1 shallow) would be put down. Screens would only be installed if a potential problem were shown to exist and that potential high inflows would be possible. Pumping tests might therefore be carried out to the north and northeast of the pit rim. An allowance has been made for the tests in the estimates although it is possible that it might not be necessary to carry out this work. If screens are installed, it is hoped that the wells could be left as permanent dewatering installations if necessary.

The ground water program could also encompass the installation of the baseline monitoring wells required under the environmental program and agreed with Dr. Hawthorn. It is recommended that this be supervised by the GA ground water field staff who would be supervising the exploration program but that it should be let as a separate drilling contract because of the difficulty of any one contractor being able to cope with the full program of work. The details of the work required and the budget for it form the subject of a separate proposal.

The ground water exploration and monitoring well installation programs should be run concurrently to make most efficient use of the field personnel (see Section 4).

3.3 Geological Reassessment

Much of the work recommended in this proposal necessitates reviewing and assessing existing geological and geotechnical data collected outside the coal body. Further data will be continually acquired up to and during mining. Of the data collected so far, the information on the structure within the beds above and below the coal has been assembled only to a limited extent. It is recommended therefore that this data should be put together to produce a structural zonation of the pit. Such zonation would be integrated in conjunction with other geotechnical parameters to check on possible correlations and the implications, if any, for pit slope stability.

3.4 Final Reporting

The work recommended above would result in the production of three reports:

- a report describing the diversion study and the recommended alternative solution
- a report which addresses the results of all the geotechnical work carried out with particular reference to the potential for improving the currently recommended pit slope angles. The same report would contain the results of the re-analysis of the pit inflows.
- the third report would put on record the design and installation of the monitoring wells and the baseline readings from them.

4.0 SCHEDULE

Figure 4 outlines the schedule for the above work (excluding Program 3).

It is apparent that in order to get the bulk of the field work carried out during June, July, and August a timely start must be made on the diversion and ground water studies. (This assumes that BCH need some two months for the preparation of contract documents, calling tenders, comparing bids and letting contracts.) It will be necessary to identify the preferred diversion alternative (activity 1.3.1) before contract documents are written. It is recommended, therefore, that the transient EM geophysical survey be undertaken by Geo-Physi-Con as soon as possible to explore the ground water problem, define the buried glacial channel and establish the position of the eastern boundary of the Medicine Creek Formation. Likewise, the preliminary hydrological and tunnelling studies for the diversion should begin as soon as possible. The geophysical survey to be carried out by Golder Associates could be delayed until the spring break-up so that it could be coordinated with the geological/geotechnical field mapping along the preferred alignment.

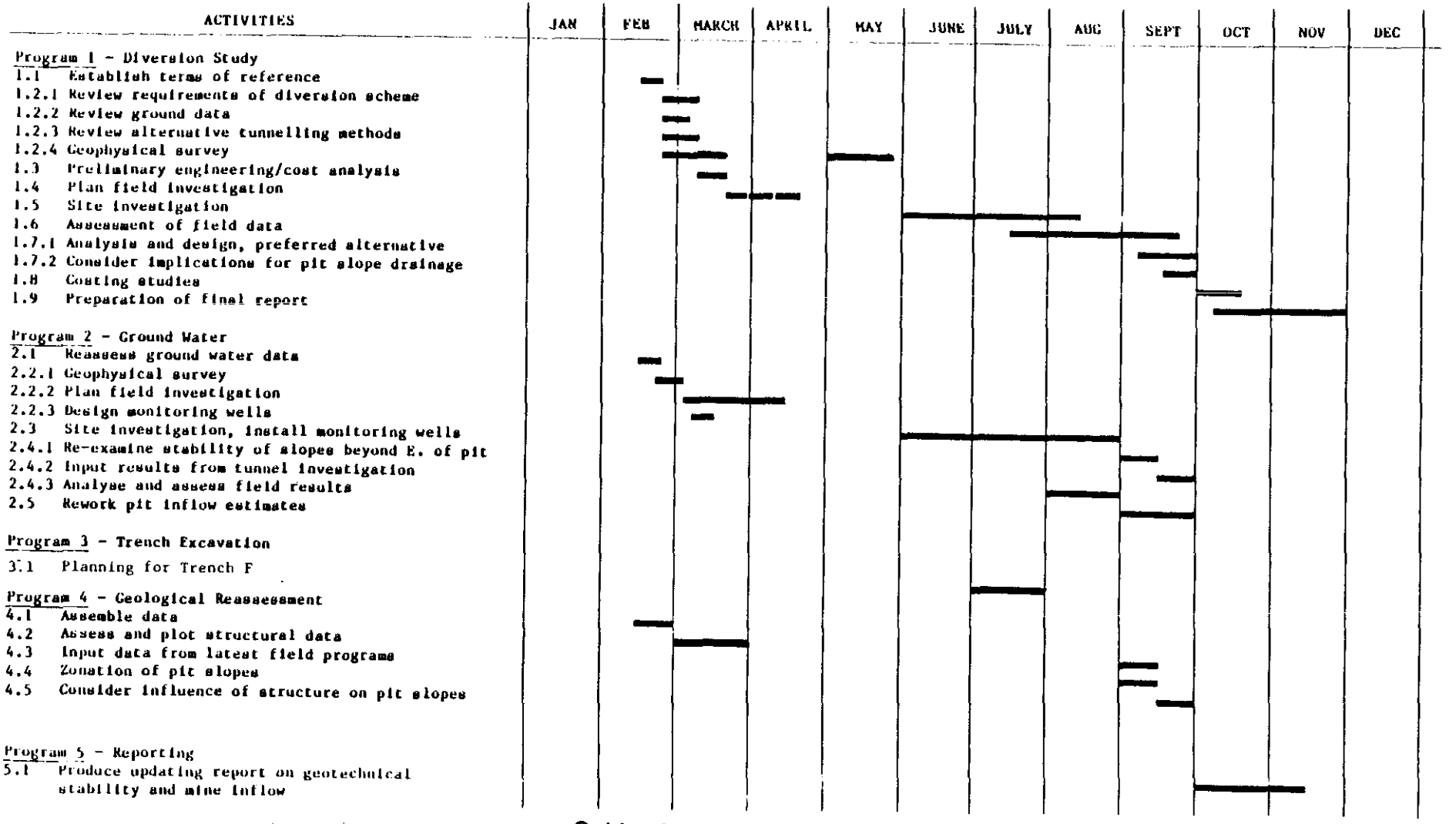
5.0 PERSONNEL

Figure 5 shows the proposed project team for all six programs. The extent of junior staff required cannot yet be assessed but the personnel shown could be augmented as needed. Curricula vitae have already been supplied.

In addition to the named Golder Associates and Sigma Resource Consultants Ltd. staff, we would propose the use, on a strictly limited basis, of outside specialist consultants. Dr. N. Morgenstern and Dr. Z. Eisenstein of the University of Alberta and Mr. A. Mathews would be consulted regarding pit slope stability and tunnel designs respectively. In addition, Professor P.W. Rowe of Manchester University, England, who

FIGURE 4

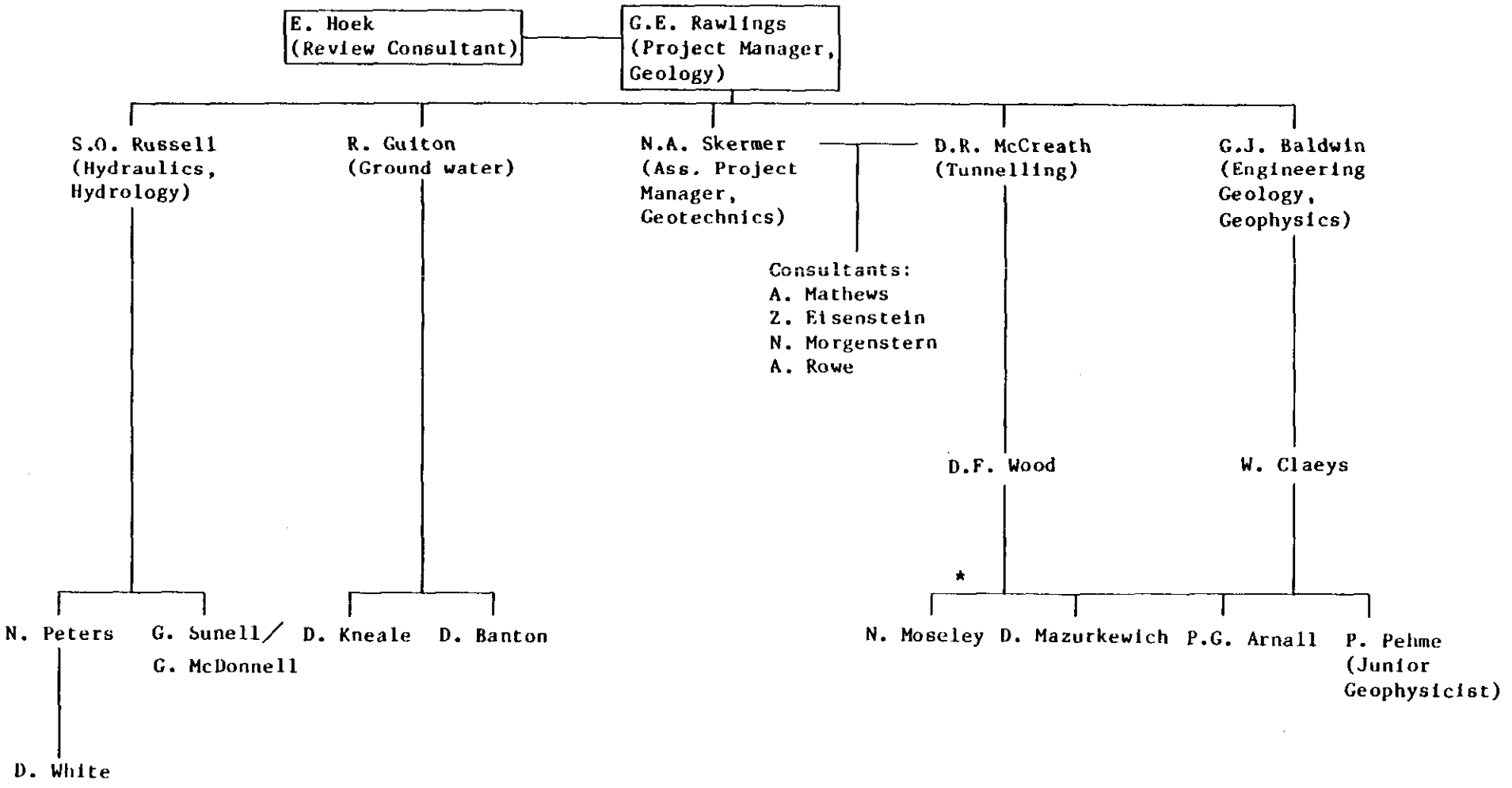
SCHEDULE OF ACTIVITIES (PROGRAMS 2 to 5), 1982 SEASON



Golder Associates

Golder Associates

FIGURE 5
PROPOSED PROJECT TEAM



* Extra junior staff to be provided as necessitated by program

will be in Calgary periodically in conjunction with another project in which we are involved, would be consulted in regards to determination of strength characteristics of the clay shale pit slope materials.

6.0 ENGINEERING COSTS

The estimated engineering costs to carry out the recommended program are shown below. The estimated contract costs for the geotechanical drilling, ground water work and geophysical survey are included as Appendix A.

All time is billed on the basis of time actually worked according to the revised Schedule of Rates shown in Table 1. These rates will be applicable on the project throughout 1982. Disbursements are billed at cost without handling charges. It is assumed that the terms and conditions specified in BCH Form GP-5 are still applicable.

The assumptions made in the planning of the field programs are shown in Table 2. The cash flow in relation to the financial years 1981-82, and 1982-83 is shown in Table 3.

TABLE 2

Assumptions Made In Planning of the Field Programs

1. All accommodation during main field programs provided by BCH.
2. Vehicles for site work (except geophysics) supplied under contract by BCH.
3. Surveying to be carried out by BCH.
4. Drilling to be undertaken on 2 x 10 hr shifts/6 days/week except for the ground water programs.
5. Drilling contracts directly with BCH. Geophysics contracted by GA.

TABLE 1

HAT CREEK PROJECT - MINING GEOTECHNICAL STUDIES
1982 CHARGE-OUT RATES

Engineering Staff	
M. Adler	50.66
P.G. Arnall	34.62
G. Baldwin	51.28
D. Banton	37.18
R. Butler	70.00
D. Campbell	75.00
W. Claeys	40.38
J. Clark	80.00
S. Cochrane	38.46
T. Cook	32.06
J. Currie	39.76
B. Fletcher	70.00
B. Gohl	43.90
R. Guiton	60.00
T. Fitzell	50.00
R. Hammett	70.00
E. Hii	32.70
W. Hodge	70.00
E. Hoek	80.00
J. Hull	55.12
A. Kent	45.52
D. Mazurkewich	31.40
N. McCammon	75.00
D. McCreath	75.00
G.S. McDonnell (Sigma)	53.00
C. O'Boy	46.80
P. Pehme	32.06
N.J. Peters (Sigma)	50.00
G. Rawlings	70.00
I. Rozier	56.40
S.O. Russell (Sigma)	75.00
F. Salgado	33.98
D. Shirley	38.46
N. Skermer	70.00
C. Soto	50.66
p. Stacey	75.00
B. Stewart	50.00
G.J. Sunell (Sigma)	53.00
R. van Ryswyk	49.36
N. Wedge	46.16
D.L. White (Sigma)	35.00
K. Wong	46.16
D. Wood	51.28

Technicians, Draftsmen and Support Staff	
W. Carney	28.20
B. Davidson	16,02
R. Dick	31.10
B. Drozdiak	24.62
T. Evans	20.77
W. Gilmer	44.88
S. Horvath	36.25
B. Howe	18.46
K. Inouye	41.02
S. Kerber	25.38
D. Kneale	34.30
L. Lee	37.82
L. Ling	15.38
D. Lyon	29.48
D. McKenzie	21.48
K. McKenzie	21.56
K. Merken	18.46
M. Odaka	31.40
D. Parks	30.78
W. Takasaki	46.16
I. Templeman	36.88
L. Theriault	27.58
P. Vendrasco	13.78
I. Watanabe	37.18

TABLE 3 - CASH FLOW

	Pre-March 31st 1982	Post April 1st 1982	Total
Program 1			
Engineering and Disbursements	$ 66,815	$182,000	$248,815
Geophysical survey (including engineering supervision)	48,000	24,500	72,500
Drilling, etc.	---	212,800	212,800
Program 2			
Engineering and Disbursements	21,185	64,726	85,911
Exploration drilling	---	116,000	116,000
Program 3			
Engineering and Disbursements	---	10,000	10,000
Drilling	---	20,000	20,000
Program 4			
Engineering and Disbursements	---	11,802	11,802
Program 5			
Engineering and Disbursements	---	21,000	21,000
TOTALS	$136,000	$663,102	$799,102
	Consulting	$383,380	
	Contracting	$445,722	

6.1 Program 1 - Diversion Study

Activity	1.1	Terms of reference/Preparation of proposal	$ 15,450
	1.2.1	Review requirements	18,900
	1.2.2	Review geological data	9,900
	1.2.3	Tunnelling methods and experience	12,430
	1.2.4	Geophysical survey supervision included in contract cost (see letter dated February 9th, 1982)	(48,000)
	1.3	Preliminary cost analysis	18,496
	1.4	Plan investigation	2,426
	1.5	Supervision site work, testing geological mapping	90,160
	1.6	Assess field data	8,646
	1.7.1	Engineer alternative scheme	20,059
	1.7.2	Consider implications of E. pit slope drainage	2,520
	1.8	Costing	say 13,500
	1.9	Final reporting	20,328
Disbursements			16,000
		Total Engineering	$248,815
		Total Contracting (see Appendix A1 & A3)	285,300
			$534,115

It should be noted that this estimate relates to the most expensive alternative, i.e. a deep tunnel in rock. If it transpires that the preferred scheme is other than this, engineering and contracting costs would be reduced. Moreover, if a pipeline were selected for detailed study, the contracting and supervision costs would be minimized but item 1.7.1 would increase.

Program 2 - Ground Water (excluding monitoring well installation)

Activity	2.1	Preparation of proposal, assess and re-process existing data	$ 16,334
	2.2.2	Planning, contract document preparation	3,272
	2.2.3	Design monitoring wells	1,579
	2.3.1	Supervision monitoring wells (separate budget)	
	2.3.2	Supervision, exploration	17,617
	2.3.3	Pump testing	10,811
	2.3.4	Data reduction	8,467
	2.4.1	Re-examine E. pit slope stability	4,200
	2.4.2	Input field results	1,376
	2.4.3	Analyze ground water results	1,683
	2.5	Rework pit inflow estimates	13,072
Disbursements			7,000
		Total Engineering	$ 85,411
		Total Contracting (see Appendix A2)	116,000
			$201,411

Program 3 - Trench F Planning

Activity 3.1	Planning field work supervision and assessment of data	$ 10,000
	Contracting	20,000
		$ 30,000

Program 4 - Geological Re-assessment

Activity 4.1	Assemble data	$ 1,010
4.2	Assess and plot structural data	1,662
4.3.1	Input data from field programs	808
4.3.2	Zone pit slopes	2,277
4.4	Consider influence of structure on slopes	4,225
Disbursements		1,000
	Total	$ 11,802

Program 5 - Final report $ 21,000

If there are any queries in relation to this work we should be glad to discuss them with you.

Yours very truly,

GOLDER ASSOCIATES

G.E. Rawlings, P. Eng.

GER/bjh
822-1508

APPENDIX A

ESTIMATED CONTRACT COSTS

1. Diamond Drilling

2. Rotary Drilling (Ground Water)
   a. Exploration

3. Geophysical Survey

APPENDIX A

1. Diversion Study

The extent of the drilling along the tunnel line would be much dependent on the alignment chosen. Estimates indicate that the drilling requirements could vary in the following way:

Low level tunnel in rock	1,400 m
Low level tunnel in claystone	800 m
High level tunnel in glacials	200 m
High level tunnel in rock	400 m

The budget should preferably be based on the low level tunnel in rock; any other scheme would lie within that budget. However in the light of the constraints on the budget for the program, it has been assumed that there would be a limit of approximately 1,000 m of the drilling along the tunnel alignment. In addition, some drilling would be required at the headworks and pit rim dam sites. An allowance of 200 m has been made for this.

Total drilling in connection with the diversion studies should not exceed 1,200 m but with the finite budget it will be much dependent on the rates bid by the contractors.

Mobilisation and demobilisation of 3 rigs		$ 6,000
Estimated cost of drilling 1200 m @ $150/m		180,000
Consumables	say	22,000
Piezometer installation say 10 rig hrs/hole in the tunnel line holes, 5 rig hrs/hole in say 7 dam site holes = 105 rig hrs @ $85/rig hr		7,225
		$213,225

2.0 Schedule

Tunnel line drilling 400 shifts
Piezometer installation 11 shifts
411 shifts for 3 rigs = 137 dys/single shift
or 69 dys/double shift
(assuming 3 men/shift overall)

The assumed rate of progress might be able to be improved by triconing sections of the hole although this is unlikely to affect the overall costs.

APPENDIX A

2. Rotary Drilling - Ground Water Exploration Cost Estimate

The cost estimate for the ground water exploration program for the southeast pit area is based on the following assumptions:

(1) Drill four 200 mm diameter exploration boreholes to bedrock. The depth to bedrock is estimated to be 170 m for 3 holes and 30 m for the remaining hole. Water levels in the deep holes are expected to be 90 m below ground surface and near ground surface in the shallow hole.

(2) The results from geophysics to be carried out will be used to determine the exact location of the exploration holes. Information obtained from the geophysics may be used to alter the initial program.

(3) It is anticipated to complete 2 deep holes and 1 shallow hole with well screens. Information from the results of drilling will be used to determine the holes to be screened and the position of the screens.

(4) It is proposed to carry out a 7 day pump test in each of the three exploration holes.

(5) Since the exploration area is relatively large, the spread of information obtained from this program will be limited. Budget constraints do not allow observation holes to be completed at chosen intervals to the pump wells.

(6) The estimated costs can only be maintained by drilling the exploration wells with the larger model air/rotary drills. Drilling with the smaller model air/rotary drill

could only be carried out by starting the hole at a larger diameter and reducing the hole size with depth. This would result in higher costs.

Contractor's Exploration Drilling and Completion Costs	
Mobilization and demobilization	$ 5,000
Deep Well Sites	
Drill and case surficials at 200 mm Ø 170 m @ $120/m	20,400
Hourly work including standby without crew and rig moves	1,600
Consumables, well screens and fittings	2,800
Pump Test and Exploration Wells	
Mobilization and demobilization	1,000
Install pump, pump test for 7 days, breakdown equipment and monitor recovery	13,000
Shallow Well Site	
Drill and case surficials at 200 mm Ø 30 m @ $120/m	3,600
Install screens and develop by air/surge method 20 hrs @ $175/hr	3,500
Hourly work - standby without crew 10 hrs @ $125/hr	1,250
Consumables, screens and fittings	2,650
Pump testing	
Install pump, pump test for 7 days, breakdown equipment and monitor recovery	5,500
Summary of Costs	
Drilling and completion	
Drill 3 deep exploration holes	$ 61,200
Drill 1 shallow exploration hole	3,600
Complete 2 deep exploration wells	19,300
Complete 1 shallow exploration well	7,400
Mobilization and demobilization	5,000
Total	$ 96,500
Pump Testing	
Pump test 2 deep exploration wells	$ 13,000
Pump test 1 shallow exploration well	5,500
Mobilization and demobilization	1,000
Total	$ 19,500
Grand Total - Drilling and Pump Testing	$116,000

APPENDIX A

3 Geophysical Survey

1. Magnetics and Resistivity - to define structure and stratigraphy in volcanics/volcaniclastic sequences.

Field work duration	6 days		
Personnel cost	120 hrs	@ $40/hr	$ 4,800
Equipment	6 days	@ $100/day	600
Interpretation	6 days	@ $500/day	3,000
Total			$ 8,400

2. Transient EM - to define buried glacial channel, nature of glacial materials and to boundary fault.

Field work duration	11 days		
Personnel cost	11 days	@ $1,100/day	$12,100
Equipment cost	11 days	@ $800/day	8,800
Interpretation	11 days	@ $500/day	5,500
Total			$26,400

(Note: Golder Associates representative to be one of the above team).

3. Seismic Refraction - to further define structure and stratigraphy in volcanic/volclanistic sequence.

Field work duration	5 days		
Personnel cost	5 days	@ $1,500/day	$ 7,500
Equipment cost	5 days	@ $200/day	1,000
Interpretation	5 days	@ $500/day	2,500
Total			$11,000

4. Seismic Reflection - experimental techniques to be performed by GSC at no charge

GA supervision	5 days	@ $500/day	$ 2,500
Equipment	5 days	@ $300/day	1,500
Total			$ 4,000

5. Mobilization costs

Personnel - Golder Associates	$ 4,000
Geo-Physi-Con	3,000
Equipment GA (EC)	1,000
Total	$ 8,000

Summary of Estimated Contracting Costs

1.	Magnetics and Resistivity	$ 8,400
2.	Transient EM	26,400
3.	Seismic Refraction	11,000
4.	Seismic Reflection	4,000
5.	Moblization/demobilization costs	8,000
		$57,800

Geo-Physi-Con survey (February/March)	$29,400
Golder Associates survey (May)	24,400
GSC	4,000
Disbursements, contingencies, etc	14,700
Total	$72,500

Note: This work is covered in the budget by $48,000 for the February/March program and $24,500 for the May program.

Golder Associates

P.G. Arnall

EDUCATION B.Sc. Civil Engineering, University of Manchester, U.K., 1977.

AFFILIATIONS Associate Member, Institute of Civil Engineers, U.K.

EXPERIENCE

1981 to date Geotechnical Engineer, Golder Associates, Vancouver, B.C.

1977 - 1981 Geotechnical Engineer, Foundation Engineering Ltd., London. Involved on diversified subsurface investigations in U.K., South Yemen and Saudi Arabia, including studies for a major main drainage project (Weymouth Main Drainage Scheme), a waterfront development (Jeddah Ship Repair Yard) and site preparation projects (Yanbu and Jubail Site Preparation).

03/81

Golder Associates

G.J. Baldwin

EDUCATION

B.Sc. Engineering Geology and Geotechnics, Portsmouth Polytechnic, U.K. 1971.
M.Sc. Engineering Rock Mechanics, Imperial College, U.K., 1978.

AFFILIATIONS

Chartered Engineer, U.K.
Member, Institution of Civil Engineers, London.
Member, Institution of Mining and Metallurgy, London.
Member, Association of Engineering Geologists.
Member, Institution of Geologists, London.
Fellow of the Geological Society of London.

EXPERIENCE

1980 to date — Senior Geotechnical Engineer, Golder Associates, Vancouver, B.C., with responsibility for engineering geology projects, including geothermal project in the U.K; underground mining of Western Canadian oil sands.

1978 - 1980 — Head, Engineering Geology Section, Hunting Surveys Ltd., London. Project Manager for beach crossing survey in Scotland, involving onshore and offshore geotechnics and geophysics. Supervisory Geologist for inshore geotechnical investigations for a proposed gas pipeline, Thailand. Business development in Europe, Middle East and Far East. Geotechnical Specialist on port development project, Thailand. Also assumed responsibility for Engineering Geophysics section.

1974 - 1977 — Geotechnical Engineer, Binnie and Partners, U.K. Responsibilities included Landslip Study for Hong Kong Government; work on slope stability and safety investigations; Project Engineer on stability investigations of private sites, Hong Kong; ground water investigations for the Mass Transit Railway Corp., Hong Kong; Tuen Mun Road Project for Hong Kong Government; remedial measures to slopes (Tsuen Wan), for Hong Kong Government.

1971 - 1974 — Geophysicist, Hunting Surveys Ltd., U.K. Projects included resistivity surveys for sand and gravel in Essex and Kent, U.K.; seismic refraction surveys for motorways in U.K. and proposed sugar plantation irrigation scheme, Sudan; marine geophysical site investigations for proposed drilling platform sites and sewage outfalls in Ireland, Wales and the North Sea; electromagnetic (V.L.F.) survey for copper, Morocco; site investigations for highways and pipeline routes in Yorkshire and Wales, U.K; major irrigation project in Greece, including geotechnical mapping, geophysics, soil and rock testing; seismic refraction and resistivity surveys for a proposed dam site, Greece.

03/81

Golder Associates

D. Banton

EDUCATION B.A., (Dual Hons.), Geography and Geology, University of Sheffield, England, 1979
M.Sc., Hydrogeology, University of Birmingham, England, 1980

AFFLIATIONS Fellow, Geological Society of London

EXPERIENCE

1981 to date Hydrogeologist, Golder Associates, Vancouver, B.C. Involved in hydrogeological investigations related to groundwater supply, including supervision of drilling, pump testing, water sampling, and installation of monitoring equipment. Also involved with geotechnical studies related to engineering geological assessment of proposed port and mine facilities in British Columbia.

1979 - 1980 Studies for Masters Degree. Research topic on the groundwater balance of the Triassic Sandstones aquifer in South West England.

Summer Employment

1978 Geotechnical Assistant, Building Research Station, England

1980 Geophysical Assistant, Applied Geophysics Unit, Birmingham, England

08/81

Golder Associates

W.D. Claeys

EDUCATION

"Candidate of Science", (B.Sc. equivalent), Geology Option, State University of Ghent, Ghent, Belgium, 1974

"Licensee of Science" (M.Sc. equivalent), Geology Option, State University of Ghent, Ghent, Belgium, 1977

EXPERIENCE

1981 to date — Intermediate Engineering Geologist, Golder Associates, Calgary, Alberta
Involved with geotechnical consultation and investigation for municipal work, concerning industrial, residential and office development.

1980 - 1979 — Intermediate Engineering Geologist, Geotechnical Department, Montreal Engineering Company Ltd., Calgary, Alberta.
Involved with planning and supervision of site investigation studies and geotechnical design for hydro-electric and open-pit coal mining projects.

1979 - 1980 — Engineering Geologist, Belgian Army Corps of Engineers, Buildings Division, Brussels, Belgium (military service).
Involved with review and analysis of site investigation data and preparation of contracting specifications for foundations of S.H.A.P.E. command nuclear shelter, Casteau, Belgium.

1978 - 1979 — Involved with geotechnical investigation and geotechnical design for Sissiboo Hydro-electric Development, Nova Scotia.

Performance of finite element analyses for evaluation of dam foundation stresses and deformations for Jebba hydro-electric development, Nigeria.

Supervision of site investigation program, involving extensive drilling, in situ testing and surface geological mapping for Andekaleka Hydro-electric Development, Madagascar.

Planning and supervision of geotechnical route investigation for Trans Canada Pipeline, Quebec extension.

1977 - 1978 — Junior Geologist, Terratech Ltee and Geocon (1975) Ltd., Montreal, Quebec.
Involved with site investigation for Guy-Favreau Office Complex. Site investigation for Pulp and Paper Mill diffuser pipeline.

03/81

T. P. Fitzell

EDUCATION

B.A., Civil Engineer, Trinity College, Dublin, Ireland, 1973.
M.Sc., Soil Mechanics and D.I.C. in Seismology, Imperial College of Science and Technology, London, England, 1978.

AFFILIATIONS

Registered Professional Engineer, British Columbia.
Member, Vancouver Geotechnical Society

EXPERIENCE

1978 to date and 1974 to 1977

Soils Engineer with Golder Associates, Vancouver, British Columbia.
Responsible for field investigations, analysis, design and construction supervision on a wide range of geotechnical engineering projects, including:

- Industrial and residential structures, bridges, harbour facilities, and general development projects.
- Highway, railway, sewer and other service installations.
- Landslide and slope stability studies.
- Earth and rockfill dams and embankments.

Typical projects include:

- Geotechnical investigation and design for mine plant facilities and tailings dam near Hope, British Columbia.
- Site supervision on earth dam construction near Salmo, British Columbia.
- Geotechnical investigation and design of major railway cut in soft swampy soils where electro-osmosis was used to improve stability (near Revelstoke, British Columbia).
- Embankment design and stability study for sewage lagoons on soft clay near Terrace, British Columbia.
- Analysis of slope stability for an open pit coal mine in Australia.
- Geotechnical investigation and design for numerous residential developments in British Columbia.
- Development of a site in North Vancouver where dynamic consolidation techniques were used to improve stability under seismic loading.
- Development of lowlying, swampy areas in Burnaby, British Columbia, for commercial use.
- Measurement and analysis of vibrations caused by traffic and heavy construction equipment.

1977 to 1978

Full time post graduate studies at Imperial College of Science and Technology, London, England.
Dissertation on "Seismic Risk in the Lower Mainland Area of British Columbia, Canada".

Golder Associates

R.S. Guiton

EDUCATION B.Sc. (Honours), Geology, University of Waterloo, 1974.
M.Sc., Hydrogeology, University of Waterloo, 1977.

AFFILIATIONS Member, International Association of Hydrogeologists.

Member, National Water Well Association.

Member, Canadian Geotechnical Society.

EXPERIENCE

1977 to date Hydrogeologist, Golder Associates, Vancouver, British Columbia. Responsible for hydrogeologic and hydrogeochemical investigations for geotechnical and environmental projects. Responsibilities have included management and supervision of major ground water investigations related to mining projects, carrying out and analysis of numerous aquifer tests, design of mine dewatering systems and domestic and municipal water supply problems.

Specific assignments have included:

Hat Creek Coal Development, Central British Columbia. Hydrogeologist responsible for the extensive geotechnical study to assess mine feasibility, and the Stage I and II environmental impact assessments relating to ground water.

Key Lake Project, N. Saskatchewan. Hydrogeologist responsible for the design of peripheral and in-pit dewatering systems.

Cantung Mines, South-Western N.W.T. Hydrogeologist responsible for computer modelling of aquifer systems and contaminant migration related to tailings disposal.

Elco Coal Project, S-E British Columbia. Hydrogeologist responsible for geotechnical ground water investigation to assess footwall stability and mine dewatering requirements. Design of dewatering systems.

Monkman Pass Coal Project, North-East Coal Block, British Columbia. Project manager responsible for a Stage II Environmental Impact Assessment relating to ground water for a proposed open pit mining operation.

1976 - 1977 Research Student, University of Waterloo Research Institute, Waterloo, Ontario. Work involved computer modelling of ground water regimes.

1974 - 1975 Assistant Geologist, British Newfoundland Exploration Ltd. Provided field and office assistance for geological work relating to a uranium prospect in Labrador.

04/81

Golder Associates

E. Hoek

EDUCATION	B.Sc., Mechanical Engineering, University of Cape Town, 1955. M.Sc., Mechanical Engineering, University of Cape Town, 1958. Ph.D., Rock Mechanics, University of Cape Town, 1965. D.Sc., Engineering, University of London, 1975.
AFFILIATIONS	Registered Professional Engineer, British Columbia. Chartered Engineer, U.K. Fellow, The Institution of Mining and Metallurgy, London. Fellow, Geological Society of London. Member, Canadian Institute of Mining and Metallurgy.
EXPERIENCE	
1975 to date	Principal, Golder Associates, Vancouver, British Columbia.
1973 - 1975	Principal, Golder Associates, Maidenhead, England.
1966 - 1975	Reader and then, in 1970, London University Professor of Rock Mechanics at the Royal School of Mines, Imperial College of Science and Technology, London. Responsible for establishing an inter-departmental centre for post-graduate teaching and research in rock mechanics.
1958 - 1966	Research Officer through to Senior Chief Research Officer and Head of the Rock Mechanics Division, National Mechanical Engineering Research Institute, South African Council for Scientific and Industrial Research, Pretoria, South Africa. Consulting experience includes rock slope stability for; Open-pit mines in Spain, New Guinea, South Africa, Zambia, Indonesia, Ireland and the United Kingdom. Quarries in the United Kingdom, Hong Kong and Colombia. Highways in the United Kingdom and Hong Kong. Dam foundations in Tunisia and SRI Lanka. Rock foundation studies in Turkey. In addition, work has been carried out in underground mines in South Africa, Zambia, Ireland, Spain and Canada and in underground hydro-electric projects in South Africa, the United Kingdom and Argentina.
PUBLICATIONS	Author of approximately 50 papers on experimental stress analysis, brittle fracture of rock, rock mechanics laboratory equipment, stability of rock slopes and underground excavations. Co-author of two text books - "Rock Slope Engineering" (with J.W. Bray) and "Underground Excavations in Rock" (with E.T. Brown).

03/81

Golder Associates

D.E. Kneale

EDUCATION

First year geology, University of Windsor, 1972.
Petroleum geology course, S.A.I.T. Calgary, 1973.
Hydrology course, B.C.I.T., 1978.
Soil Mechanics, B.C.I.T., 1978-79.
Water Well Technology course, N.W.W.A, 1980.
Commercial Explosives course, B.C.I.T., 1980.
Water well Completion, Testing and Modelling course, University of Alberta, 1980.
Ground Water Hydrology course, U.B.C., 1980.
Sedimentology course, U.B.C., 1981.
Ground Water Contamination course, U.B.C., 1981.

AFFILIATIONS

Member, National Water Well Association.

EXPERIENCE

1978 to date — Senior Technician, Golder Associates, Vancouver, B.C.
Monkman Coal Project, Monkman Pass, B.C. Field supervisor of 1980 Ground Water Impact Study including supervision of Hydrogeological/Geotechnical drilling, field instrumentation installation, pump testing and water sampling.
Elk River Coal Project, Elk River, B.C. Hydrogeologic Data analysis and dewatering requirements.
Climax Molybdenum Mine, Kitsault, B.C. Town water supply.
Hat Creek Coal Project, Hat Creek, B.C. 1978 Pump testing program.
Supervision of geotechnical drilling operations of various projects in British Columbia and materials testing.

1975 - 1978 — Took Engineering Services Inc., Surrey, B.C.
Drilling operation for Willen Estates Slope Stability Project - Abbotsford, B.C.
Materials testing.

1973 - 1975 — Spratt Bailey Laboratories Ltd., Vancouver, B.C.
Materials testing.

1972 - 1973 — R.M. Hardy & Associates, Calgary, Alberta.
Drilling operations for various projects in Alberta.
Pile load testing - Calgary Air Terminal and Stampede Fair Grounds - Calgary, Alberta.

1970 - 1972 — H.Q. Golder & Associates, Windsor, Ontario.
Drilling program for sanitary sewer line, Belle River, Ontario.
Drilling for limestone quarry, Essex County, Ontario.
Field and laboratory materials testing.

03/81

Golder Associates

D.J. Mazurkewich

EDUCATION B.A. Sc., Geologic Engineering, University of British Columbia, 1981.

EXPERIENCE

1981 to date Junior Engineer; Golder Associates, Vancouver, B.C.

SUMMER EMPLOYMENT

1980 Golder Associates, Vancouver, B.C.
Elk River Coal Project, Elk River, B.C. Supervision of Hydrogeologic/Geotechnical drilling and field instrumentation installation.

1979 Bethlehem Copper Corporation, Vancouver, B.C.
Geologic Field Assistant. Geological mapping and geochemical soil and rock sampling at various locations in British Columbia.

1978 Bethlehem Copper Corporation, Vancouver, B.C.
Geologic Field Assistant. Geological mapping and geochemical soil and rock sampling at various locations in British Columbia.

Golder Associates

D.R. McCreath

EDUCATION

B.Sc. Civil Engineering, University of Manitoba, 1964.
D.I.C. Concrete Structures & Technology, Imperial College, 1968.
Ph.D The Fracture Mechanics of Concrete, University of London, 1968.
M. Eng. Geotechnical Engineering, University of Alberta, 1980.

AFFILIATIONS

Registered Professional Engineer, Ontario.
International Society for Soil Mechanics and Foundation Engineering.
International Society for Rock Mechanics.
Canadian Geotechnial Society.
American Society of Civil Engineers.
Underground Construction Research Council.

EXPERIENCE

1980 to date — Principal, Golder Associates, Vancouver, B.C.

1976 to 1979 — Head, Geotechnical Department; Member of Board of Directors 1977-1979, Acres Consulting Services Ltd. Responsible for administration of the department and coordination and review of geotechnical work (geology, geohydrology, soil and rock mechanics) on all projects in progress, including:
Coal-fired thermal station at Atikokan, Ontario.
Tailings retention dam at Marietta, Ohio.
Hydroelectric developments at Karun River, Iran; Spanish River, St. Marys River, and Arnprior, Ontario; Volta River, Ghana.
Irrigation development at Yaguaron, Brazil.
Radioactive waste storage studies in Canada, Sweden and U.S.A.
Oil storage, compressed air storage, and underground pumped storage programs, U.S.A.
Tidal power studies and field investigations at Bay of Fundy, Canada.

1968 to 1976 — Senior Engineer, then Staff Engineer Rock Mechanics. Consultant to the company on projects and studies involving rock mechanics, including:
Machine bored spillway tunnel, American Electric Power.
Seismicity of geographic regions and dynamic response of structures.
Ground water investigations for open pit and subsurface mining.
Underground siting of nuclear power plants, U.S.A.
Underground pumped storage concepts for North American and European utilities.
Potrerillos pumped storage development near Mendoza, Argentina.
Pressure relief tunnels, Nilo Pecanha powerhouse and Henry Borden plants, Brazil.
Geotechnical design aspects of Alto Anchicaya hydroelectric project, Colombia.
Preparation of a geotechnical report on physical characteristics of rock and soil at the site of the proposed Gull Island power project, Labrador.
Responsible for rock mechanics engineering and its project coordination for Churchill Falls hydroelectric project, Labrador, Newfoundland.

03/81

GLENN S McDONNELL

PROJECT ENGINEER

B A Sc (Honours - Civil Engineering) UBC 1976
Member of Association of Professional Engineers of British Columbia

Glenn McDonnell has several years experience in water resource and civil engineering covering hydro power development, flood control, river engineering, stormwater control, and municipal engineering.

HYDRO POWER DEVELOPMENT

- Project Engineer for the regional study of potential sites for small hydro power development leading to the selection of one site for development as a pilot project in a mixed hydro/diesel system

- Design, coordination during construction and commissioning of the Klemtu Hydro Power Project, a 300 kw plant to serve a small isolated community in British Columbia

- Design and preparation of tender documents for the Kingcome Hydro Power Project, a 75 kw plant serving a small community in a mixed hydro/diesel system

MUNICIPAL ENGINEERING

- Planning and design of a road and water distribution system for a new townsite near Bella Coola, B C

- Design and site supervision for the construction of a water storage tank and supply line at Bella Coola, B C

- Preparation of a report for the upgrading of an existing water supply and distribution system serving the town of Bella Coola

STORMWATER MANAGEMENT AND DESIGN

- Design Engineer on the master drainage programming for the District of Surrey, B C covering data collection and analysis at a network of recording rain gauges and streamflow recorders, assistance with the preparation of a drainage design manual, and design and planning of the drainage system based on stormwater detention and use of the natural watercourses

- Preliminary design and layout of the stormwater collection system for a 2½ sq km development zone in the District of Surrey

- Design of watercourse improvements including hydraulic design of culverts, sediment traps and energy dissipators and design of watercourse concrete headwalls and related structures. Contract documents and related reports were also prepared.

GLENN S McDONNELL (Continued)

UNDERGROUND EFFLUENT DISPOSAL

- Field surveys, design and report for a subdivision on Bowen Island with independent sewage disposal systems
- Field reconnaissance, air photo analysis and mapping for a soil-effluent capability study for 6 sq km of the Pender Harbour region
- Preliminary investigation and feasibility of wastewater evaporation and infiltration system near Vernon, B C
- Field investigation, design and report preparation on numerous small wastewater disposal systems (including evapotranspiration) in the Lower Mainland, Vancouver Island, Sunshine Coast and Whistler regions

RIVER ENGINEERING

- Design of stream training and embankment protection for 375 m of Seton River, Lillooet, B C
- Preliminary design of erosion control works for North Thompson River near Barriere, B C
- Site engineer for Watercourse Improvement Program - 1978, Surrey, B C
- Site engineer for Seton River - Stream Training and Embankment Protection Program, Lillooet, B C

COST ESTIMATING

- Quantity take-offs for excavation and rockwork, first phase of Coquihalla Highway, Hope, B C
- Quantity take-offs for all concrete work in powerhouse - Revelstoke Dam, B C
- Cost estimate for required improvements to drainage in Surrey, B C and approtioning to future developers and the District

Golder Associates

N.G. Mosley

EDUCATION

B.Sc., Geology, University of Sheffield, Sheffield, England, 1976.
M.Sc. Engineering Geology, Imperial College of Science and Technology, University of London, England, 1981.

AFFILIATIONS

Fellow, Geological Society of London, England.

EXPERIENCE

1981 to date

Intermediate Engineering Geologist, Golder Associates, Calgary, Alberta. Primarily involved in geotechnical data acquisition and evaluation for resource development projects.

1977 - 1980

Geologist/Soils Engineer, Pynford Geotechnical Division, London, England. Experience related to geotechnical investigations, investigation management, testing and report preparation concerning:

- the inspection of failed foundations prior to the design of remedial construction works, and for litigation purposes
- the design and construction of foundations for domestic and light industrial structures, sewers and roads
- the location of construction aggregate sources
- the stability of a small retaining wall
- the delineation of collapsed swallow-hole features in chalk, and back-filled borrow pits

Involved in the project management of site investigations, testing, and writing of factual geotechnical reports.

12/81

Golder Associates

C. A. O'Boy

EDUCATION
B.Sc. (Honours), Geology, University of Southampton, UK, 1972
M.Sc., Hydrogeology, University of Birmingham, UK, 1973
Diploma in Management and Administration, University of Bradford, UK, 1977

AFFILIATIONS
Member, Institution of Geologists, UK
Member, National Water Well Association
Fellow, Geological Society, London
Associate Member, Institution of Civil Engineers, UK

EXPERIENCE

1981 to date — Senior Hydrogeologist, Golder Associates, Vancouver, B.C. with responsibility for the groundwater aspects of mining and civil engineering projects in Western Canada.

1978 - 1981 — Hydrogeologist, Babtie Shaw and Morton, Consulting Engineers, Glasgow, Scotland. Responsible for hydrogeological and geotechnical aspects of civil and mining engineering schemes. Typical projects included:

- Kielder Dams, Northumbria, England. Interpretation of foundation geology.
- Strand Lough, Northern Ireland. Site investigation planning, laboratory testing and seepage analysis for tidal embankment.
- A9 Highway Upgrading, Scotland. Groundwater aspects of environmental impact study.
- Girvan Valley Pollution, Scotland. Investigation of surface water pollution by abandoned mine workings.
- Plenmeller Coal Open Pit, England. Surface and groundwater aspects of environmental impact study of proposed pit.
- Kerman City Water Supply, Iran. Feasibility studies for water well field location.
- Construction Industry Research and Information Association, England. Site management for drill rig instrumentation research for tunnelling machinability.
- Ayrshire Refuse Landfill, Scotland. Hydrogeological studies of leachate migration potential for domestic and industrial landfill sites.

1973 - 1976 — Assistant Hydrogeologist, Sir William Halcrow and Partners, London, England. Responsible for hydrogeological aspects of civil engineering projects. Typical schemes included:

- Stabilization of Coal Waste Dumps, South Wales. Groundwater aspects of dump stability including use of tracer techniques.
- Regional Ground Water Investigation and Development, Sultanate of Oman. Surface geophysical surveys, deep and shallow well drilling, geological and geophysical logging, test pumping and hydrometeorological data collection.

09/81

Golder Associates

P. Pehme

EDUCATION	B.Sc. (Hons), Earth Science, University of Waterloo, 1981
EXPERIENCE	
1981 to date	Junior Engineer, Golder Associates, Vancouver, B.C. Recently involved in Arctic shallow marine seismics, and drilling as well as general drill supervision.
1980 Jan - Sept	Geophysicist, Golder Associates, Toronto, Ontario. Supervising and interpretation of refraction seismic, magnetometer, bathymetric and groundwater contamination detection surveys.
1979 May - Aug	Geological Assistant, Hudson Bay Mining and Smelting, Snow Lake, Manitoba. Base metal exploration by reconnaissance and detail mapping.
1978 Sept - Dec	Geological Assistant, Hudson Bay Mining and Smelting, Snow Lake, Manitoba. Assistant geologist and supervised drilling.
Jan - April	Gravity Observer, Department of Energy, Mines and Resources, Ottawa, Ontario. Conducted gravity and bathymetry survey in the Canadian Arctic.
1977	Junior Assistant, Canadian Occidental Petroleum. Conducting Alphameter and scintillometer surveys as well as soil sampling in the process of uranium exploration.

09/81

NEIL J PETERS

DESIGN ENGINEER

M A Sc, Water Resources, UBC 1978
B A Sc, Geological Engineering, UBC 1973

Neil Peters has experience in many aspects of hydrology, river engineering, water supply and environmental studies.

RIVER ENGINEERING AND HYDROLOGY

- design and construction inspection of a 400 m long riprapped diversion channel - Carpenter Creek near Sandon, B C
- study of streamflow records of small streams in the Okanagan Valley for the purpose of estimating the quantity of water available - Silver Star Mountain near Vernon, B C
- coordination of a flow gauging program to develop a hydrologic data base for two open pit coal mine properties - Northeastern B C
- hydrology and preliminary design of a 600 m long diversion channel and associated bank protection works - Flat River near Tungsten, B C
- preliminary design of a multiplate arch culvert river crossing capable of fish passage - Flat River near Tungsten, NWT
- preliminary design of a rock weir fishway to allow upstream migration of arctic grayling over a water supply diversion weir
- Master thesis on the effects of extreme river flows and channel modifications on the productivity of natural spawning areas

WATER SUPPLY

- preparation of a pre-design cost estimate for an iron removal treatment plant - Salmon hatchery near Kitimat, B C
- evaluation of an existing water spply and rapid sand filter system - Salmon hatchery near Bella Coola, B C
- preparation of a report outling aeration principles and methods as applied to treatment of hatchery water supplies
- compilation of a water quality requirement and criteria handbook, used to evaluate new salmon hatchery water supplies
- Conducting of water quality analysis of wells at potential hatchery site - Bowron River and at Kemano, B C

NEIL J PETERS (Continued)

WASTE TREATMENT AND DISPOSAL

- cost estimation and preliminary design of an underdrained sand filter for disposal of domestic waste - Silver Star Mountain
- design of piping connections to and from an aerated lagoon - gas plant waste treatment facility, Fort Nelson, B C
- report on water use and waste treatment in the Yukon placer mining industry, Department of Indian and Northern Affairs
- bench scale testing of chemical coagulants and flocculants for treatment of placer mining effluents
- preliminary design of settling ponds for treatment of process plant effluent and surface drainage for placer mines - Dublic Gulch and Clear Creek, Yukon Territory

ENVIRONMENTAL IMPACT

- estimation of supersaturation levels of dissolved gases - Upper Nechako River, B C
- coordination of water quality and aquatic biology data collection at two open pit coal mine properties - Northeastern B C
- preparation of a preliminary environmental impact report for a placer dredging operation - Clear Creek, Yukon Territory

GEOTECHNICAL

- concrete mix design and inspection, gravel exploration, foundation investigations and air photo interpretation - Engineering Aide, two summers
- field permeability measurements and observations of seepage flows from tailings ponds - Tungsten, NWT
- field and airphoto evaluation of landforms, soils and geologic hazards affecting subdivision development - Sites on Duncan and Mica Reservoirs

January 1981

Golder Associates

G.E. Rawlings

EDUCATION B.Sc. (Honours), Geology, University of Sheffield, England, 1960.

AFFILIATIONS Registered Professional Engineer, British Columbia.
Chartered Engineer, U.K.
Member, Institution of Civil Engineers, London.
Fellow, Geological Society of London.
Member, Association of Engineering Geologists.

EXPERIENCE

1975 to date Associate, Golder Associates, Vancouver, B.C. Responsible for engineering geological aspects of civil and mining engineering projects, and administration of ground water group. Selected projects include:
Project Manager, Hat Creek Coal Development, B.C., geotechnical and ground water studies for the No. 1 Coal Deposit feasibility assessment and open pit design; pre-feasibility studies for the No. 2 Deposit.
North Point Rock Slope Study, Hong Kong. Field studies for the stability assessment of existing slopes in an urban area.
Athabasca Oil Sands, Alberta. Desk study to investigate access to the oil sands through the underlying limestones.
Sucre Project, Bolivia. Advice on stability of rock cuts for 600 km of road in the Andes.
Nuclear Waste Repository Siting, U.S.A. Formulation of guidelines for evaluation of geotechnical parameters, radioactive waste storage in salt.

1968 - 1975 Senior Geologist, Binnie and Partners, London, U.K. Responsible for geological aspects of water supply, hydro-electric/ thermal power development and irrigation schemes. Specific projects:
Dinorwic Pumped Storage Hydro-Electric Scheme, N. Wales. Geotechnical feasibility and dam design studies for alternative pumped storage schemes.
Lima Water Transfer Scheme, Peru. Feasibility studies for the water diversion across the continental divide for Lima water supply.
Mosul Dam, Iraq. Appraisal of Karstic foundation problems.
River Towy Scheme, Wales. Resident Geologist for construction of 100 m rockfill dam and 4-mile tunnel.
Kathmandu Water Supply and Sewerage Scheme, Nepal. Resident Geologist.

1963 - 1967 Geologist, Hydro-Electric Commission, Hobart, Tasmania. Responsible for geological aspects of hydro-electric development schemes including:
Mersey-Forth Power Development Scheme; Gordon River Scheme and Olga River Scheme.

1961 - 1963 Period spent in Industrial Management, U.K.

1960 - 1961 Research Student, Shell International Petroleum Company, Bristol University.

03/81

S. O. (Denis) Russell

Specialist Consultant

B.Sc., 1953; M.Sc., 1954; Ph.D., 1975, Queen's, Belfast, N.I.

Member of Association of Professional Engineers of B.C.

Member of Canadian Society for Civil Engineers

Member of American Society of Civil Engineers

Member of International Association for Hydraulic Research

EXPERIENCE

Denis Russell has more than 25 years experience in civil engineering and water resource projects including construction, design, planning, research and teaching. Presently engaged in teaching and research in water resources including the application of systems engineering, optimization techniques, decision analysis and evaluation methods to the planning, design and operation of water related projects. Recently interests have expanded to general resource planning and the environmental and social effects of engineering projects.

1968 ● Research includes:

- Development of optimization techniques
- Application of decision analysis to reservoir operation, hydraulic design and assessment of effects of uncertainty in engineering design

● Consulting and contract research have included:

- Participation in interdisciplinary studies
- Hydrologic network planning
- Hydrologic computer models
- Energy system studies
- Hydro system optimization
- River basin planning
- Reservoir operating procedures
- Drainage system studies
- Environmental impact studies

1961 - 1968 ● Caseco Consultants Ltd

● Responsible for hydrologic and system studies of the Canadian portion of the Columbia Basin

● Design and preparation of specifications for hydraulic structures for Mica Dam

1957 - 1961 ● Design Engineer on hydro electric projects; hydrology river engineering and powerhouse design

1954 - 1957 ● Junior Engineer on various construction projects

June, 1979

Golder Associates

N.A. Skermer

EDUCATION B.Sc., Civil Engineering, University of Manchester, England, 1960.
M.Sc., Soil Mechanics Research, University of Manchester, 1963.

AFFILIATIONS Registered Professional Engineer, British Columbia.
Member, Engineering Institute of Canada.
Member, Institution of Civil Engineers, London, England.
Member, Canadian Geotechnical Society.
Member, International Association of Engineering Geology.

EXPERIENCE

1974 to date Golder Associates, Vancouver, B.C. Concerned with the geotechnics of landslides, mine tailings disposal, and earthwork design and construction. Recent work includes:
Evaluation of a number of sites for land development in mountainous terrain in B.C.
Research on landslides in the Alps of Europe, documenting historical data on debris flow slides and rock slides.
Feasibility studies of open pit mining, waste disposal and water supply at Hat Creek coal deposit, B.C.
Feasibility studies for tailings disposal at Mactung and Cantung tungsten properties, NWT.
Investigation of large culvert collapses on Mackenzie Highway, NWT.

1972 - 1974 Crippen Engineering - CASECO Consultants Ltd. Investigation and design of pile foundations and approach fills for new Pitt River Bridge, B.C. Design and construction control of tailrace cofferdam for Mica Powerhouse. Finite element stress analyses, instrumentation and earthquake studies of completed Mica Dam embankment. Geotechnical aspects of feasibility studies for various water resources projects in Canada and overseas.

1970 - 1972 Lecturer in Geotechnics at Teesside Polytechnic, England, and part-time private practice in site investigations and foundation engineering in U.K.

1965 - 1970 CASECO Consultants Ltd. Design of various aspects of Mica Dam, an 800 ft. high earth dam on the Columbia River in B.C., specifically:
Design studies and preparation of specifications and construction drawings, including instrumentation.
Development of finite element stress-strain analyses of the embankment.
Analysis of laboratory testing of embankment materials, including high pressure triaxial compression tests on rockfill carried out in conjunction with the Comision Federal de Electricidad in Mexico.

1962 - 1965 Soils engineer in U.K. with site investigation contractors responsible for drilling, soil testing, and foundation design and construction.

03/81

GREG J SUNELL

PROJECT ENGINEER

B A Sc (Civil Engineering) University of British Columbia, 1975
Member of Association of Professional Engineers of B C

Greg Sunell's experience includes hydrology studies, the design of hydraulic structures, municipal services and construction administration.

STORMWATER MANAGEMENT AND FLOOD CONTROL

- Master Drainage Program, District of Surrey, B C - development of a computerized hydrology model, assistance with preparation of the drainage design manual and planning of the drainage system based on stormwater detention methods

- Stormwater Detention Study, Township of Langley, B C - participation in the drainage study for a mixed commercial / residential development using stormwater detention

- Stormwater / Flood Control Study, Fauquier, B C - analysis of an existing drainage system including design for remedial works

- Watercourse Improvement Program, District of Surrey, B C - design of watercourse improvements including hydraulic structures, culverts and related works

- Ocean Park Washout, District of Surrey, B C - Project Engineer - analysis to determine surface and subsurface water runoff which caused a bank slippage

- Stormwater Management Study, Simon Fraser University, B C - analysis of the existing drainage system for an undeveloped section of SFU

CONSTRUCTION ENGINEERING

- Birkenhead River Bridge, Mount Currie, B C - Resident Engineer - site supervision of three separate contracts let for the construction of a concrete bridge including the piles, pre-cast deck and approaches

- Sewage Collection / Drainage / Water Supply, Salmon Arm, B C - Site Engineer (5 months) - field supervision and layout for the installation of gravity and forcemain piping

- Four Mile Subdivision, Bella Coola, B C - Site Engineer - completion of water supply, roads and drainage works

GREG J SUNELL

CONSTRUCTION ENGINEERING (Continued)

- Townsite Preparation and Municipal Services, Kitsault, B C - Contractor's Resident Engineer (7 months) - responsible for the site office and survey personnel, payroll, scheduling, correspondence, material procurement and some work supervision for $8 million project

- 600 kw Hydro-Electric Plant, Klemtu, B C - Resident Engineer - survey and site engineering duties during construction of the hydro plant

WATER RESOURCE DEVELOPMENT AND MUNICIPAL SERVICES

- Brent-Snow Mountain, Okanagan, B C - determination of available surface runoffs for a winter ski resort water supply which included long-term storage

- Yelohed Mountain, North Central, B C - determination of available surface runoff for a winter ski resort which included some water storage

- 600 kw Hydro-Electric Plant, Klemtu, B C - Design Engineer - participation in the design of a hydro-electric power plant that includes an intake, penstock, powerhouse and transmission line

- Sewage Collection System, Phase II, Salmon Arm, B C - design of sewage collection system

- Watermain Improvements, Salmon Arm, B C - design of a replacement watermain and a booster pumping station

- Small Concrete Structures, Salmon Arm, Richmond and others - design of miscellaneous small concrete structures such as retaining walls and a small pump station

DONALD L WHITE

DESIGN ENGINEER

BASc, Civil Engineering, Waterloo 1981

Donald White has 4 years experience in Engineering and Structural detailing.

WATER RESOURCE DEVELOPMENT

- Thorsen Creek Hydro Study, Vancouver - layout and design of a 2500 m penstock. Preparation of preliminary cost estimates of the powerhouse, turbine, generator, penstock etc.
- Iskut Water Supply System, Vancouver - design of storage tank and water line and preparation of cost estimates.
- Barnes Lake, Ashcroft - survey and layout of an irrigation water line.
- MacTung Mining Development, NWT - layout and preliminary design of tailings dam.

LAND DEVELOPMENT

- Lands Development (Residential), Scarborough, Assistant Surveyor -layout of storm and sanitary sewers, water services, etc.
- Baxter Subdivision, Whistler - temporary site engineer. Preparation of as-built drawings.

STRUCTURAL ENGINEERING

- Verifying Computer Data, Toronto - Stress Analyst, summarized computer results from a finite element modelling of a small jet aircraft, Canadair Challenger.
- Seismic Qualifications, Toronto - Stress Analyst, prepared reports which verified the structural integrity of pumps, located in nuclear power stations, to withstand earthquake forces.
- Illinois Power Station, Scarborough - Structural Steel Detailer, prepared fabrication drawings of structural steel members.
- Thunder Bay Coal Terminal, Toronto - Structural Steel Draftsman, prepared drawings of the dumper house, positioner building and thaw shed.
- Prince Rupert Grain Terminal Proposal, Toronto - Draftsman, prepared proposal drawings for two shiploaders.

Golder Associates

D.F. Wood

EDUCATION

B.Sc., (Honours) Physical Geology, University of Exeter, 1973.
M.Sc., Engineering Rock Mechanics, University of London, 1978.
D.I.C., Royal School of Mines, 1978.

AFFILIATIONS

Fellow, Geological Society of London.
Member, American Institute of Mining, Metallurgical and Petroleum Engineers.
Member, Vancouver Geotechnical Society.

EXPERIENCE

1978 to date — Rock Mechanics Engineer, Golder Associates, Vancouver, B.C. Major involvements include: slope, tunnel and bridge abutment stability assessment, stabilization design, construction supervision and contract handling for Canadian railway company. On site excavation stability assessment, rock support design and general geotechnical studies for underground hydroelectric pumped storage scheme in Argentina; duration one year.

1977 - 1978 — Full time post graduate studies at Imperial College, London University. Dissertation on case history and analysis of major highwall failure in a Canadian open pit iron ore mine.

1973 - 1977 — Geological Engineer, Golder Associates, Vancouver, B.C. Involved in field programs and analytical processes for slope stability, open pit design, underground mine design and foundation engineering for projects in Canada, U.S.A. and Zambia.
Slope stability studies include: geotechnical mapping, structural core logging and data reduction; analysis and slope design; design and installations of slope and ground water monitoring programs, and associated data collection, handling, analysis and interpretation; supervision of geotechnical drilling contracts for exploration and development projects include: instruction and supervision of data collection; detailed geological data collection, reduction and interpretation for mine design analyses; model studies investigating mechanistic response to various mining methods following geological interpretation of structural data. Field programs for civil engineering including: site investigation with core drilling, petrographic analysis, geophysical surveying and materials testing for foundation engineering and major highway construction.