



PITEAU ASSOCIATES
GEOTECHNICAL AND
HYDROGEOLOGICAL CONSULTANTS

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Our file: 89-193

October 3, 1989

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003169

Curragh Resources Inc.
P.O. Box 1000
Faro, Yukon
Y0B 1K0

Attention: Jack Bowers, Project Development Engineer

Dear Sirs:

Re: Grum Open Pit - Development of Dewatering System

In response to your invitation, Piteau Associates Engineering Ltd. is pleased to submit the attached proposal to carry out the design, construction supervision and evaluation of a dewatering system for the Grum Open Pit. We believe we have the experience and knowledge to successfully implement a practicable mine dewatering system, and look forward to working with you on this interesting project.

We estimate that our cost will be in the order of \$49,000 for the proposed program. Actual cost will depend upon the duration of the well construction and testing programs, and the amount of field supervision you wish Piteau Associates Engineering Ltd to provide. We would be happy to modify our proposal to reflect any reductions in field supervision that you feel are warranted, based on availability of Curragh personnel. However, we would want to discuss the level of supervision and monitoring that is required before we would be prepared to reduce our time in the field by a substantial amount.

If you require any clarification on this proposal, or would like additional information on our proposed approach to this project, please contact us at your earliest convenience.

Your truly,

PITEAU ASSOCIATES ENGINEERING LTD.

Andrew T. Holmes, P.Eng.

ATH/rg

Att.



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**PROPOSAL TO CURRAGH RESOURCES INC.
TO SUPPLY ENGINEERING SERVICES FOR THE**

**DESIGN, CONSTRUCTION SUPERVISION AND TESTING
OF A DEWATERING SYSTEM FOR THE GRUM OPEN PIT
LOCATED NEAR FARO, Y.T.**

89-193

October 1989



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1. INTRODUCTION

Curragh Resources is currently developing the Grum orebody, located near Faro in the Yukon Territories. A sand and gravel aquifer exists at the base of the unconsolidated sediments in the pit area. At present, this aquifer is highly confined by the overlying glacial moraine, and is artesian at some locations. It will be necessary to depressurize and partially dewater this aquifer before mining in the Grum Pit area proceeds below the current elevation. To avoid any unnecessary delays, it is essential that an initial dewatering system be operational this fall, and that a final dewatering system be installed and operational by the spring of 1990.

Some piezometers and a test well have been installed in the Grum Pit area as part of previous programs. This data is to be reviewed, and a phased plan for dewatering the Grum Pit is to be developed by an outside consultant. Piteau Associates Engineering Ltd. (PAEL) was invited to submit a proposal to carry out this work, in a letter dated September 12, 1989 (Appendix A). Our proposed approach to this project is described in the following.

2. PROPOSED PROGRAM

PAEL proposes to carry out this work as a number of phases. Each phase is discussed separately below.

2.1 PHASE I - REVIEW DATA, DEVELOP STAGE I DEWATERING PLAN

PAEL would review all the hydrogeological information relevant to the pit, plus any data from the development drilling program which would assist with determining the shape and extent of the bedrock channel in which the sand and gravel aquifer is situated. A water balance approach would then be used to estimate the quantity of water that must be pumped from the aquifer. The water balance would consider the quantity of water stored in the aquifer, potential recharge sources and rate of recharge, pit development schedule and required dewatering rate.

Based on the water balance and the interpreted geometry of the aquifer, a two or three well dewatering system would be designed (in addition to the existing 89-01). A simple analytical model would then be used to predict the probable drawdown that would be obtained from the Stage I dewatering system. A short letter report would be prepared to summarize the Phase I work and to present recommendations for the Stage I dewatering system. Proposed well designs, well locations, pump test requirements and preferred drilling methods would be included in this report.

2.2 PHASE II - INSTALLATION AND TESTING OF STAGE I DEWATERING SYSTEM

Mr. Holmes would visit the mine early in the well drilling program to discuss the Stage I dewatering system with Curragh personnel and to reconnoitre the mine site. A junior engineer would accompany Mr. Holmes to the site, but would stay

on to assist mine personnel with supervision of the drilling and testing program, and to evaluate data as it becomes available.

Ideally, each well would be tested as soon as it is completed, so that the effect of the first well is known by the time the second well is completed. This would assist us in making any decisions regarding the location and requirements for additional wells. In this regard, if Well 89-01 is to be put into service before our arrival on site, it would be necessary to arrange for frequent monitoring of water levels in it and the surrounding piezometers, so that drawdown trends due to this well are properly documented before any additional wells are pumped.

*Substitution
for
Discussion*

Water samples from selected wells would be collected for laboratory analysis, to be used for the permitting of any discharges from the pit dewatering system.

2.3 PHASE III - ANALYSIS AND REPORT

All data collected during Phase I and Phase II would be analyzed, and the interpretation of the aquifer's geometry and properties would be reviewed. A simple finite element or finite difference computer model would be used to back analyze the pumping tests of the new wells, and to predict the performance of the Stage I dewatering system. A report would be prepared to summarize the results of the Stage I dewatering program, and to present the requirements for a Stage II dewatering system.

If any additional investigations are required prior to developing the Stage II dewatering plan, they would be discussed in the Stage I report. These additional investigations could include a detailed computer modelling study, and a geophysical survey to accurately determine the location of the aquifer channel outside the pit limits. As the proposed dewatering strategy is iterative, involving well construction, monitoring, well construction, monitoring etc., it is unlikely that a detailed modelling study will be required. However, in the event that monitoring of the Stage I dewatering system displays some unpre-

table trends, it may be necessary to carry out some detailed modelling in an attempt to more accurately define the aquifer characteristics.

2.4 PHASE IV - DEVELOP STAGE II DEWATERING PLAN

Once the Stage I dewatering system is in operation, and initial drawdown data is available, a Stage II dewatering plan could be developed. This plan would include intermediate or step out wells on an as required basis. If step out wells are necessary, exploratory drilling or the geophysical investigation discussed above would possibly be required. A finite difference or finite element model would be used to simulate the various well configurations, and to predict the probable extent of drawdown that could be obtained at various times in the mine development schedule. The proposed Stage II dewatering plan would be presented to Curragh personnel in a short letter report.

2.5 PHASE V - INSTALLATION AND TESTING OF THE STAGE II DEWATERING SYSTEM

We envision that this Phase of the program would be very similar to the Stage I implementation program, and would involve a brief visit by Mr. Holmes, with longer duration supervision provided by a junior engineer.

2.6 PHASE VI - ANALYSIS AND FINAL REPORT

All data collected during Phase V would be analyzed, and a brief modelling study would be performed to simulate the long term performance of the dewatering system. Recommendations regarding monitoring of water levels and criteria for evaluating dewatering system performance would be included in a final report, along with a summary of all relevant data.

It should be noted that although a system of dewatering wells will be able to depressurize and partially dewater the aquifer, some groundwater inflow from the aquifer will have to be handled in the pit. The report will therefore include recommendations for measures to collect this seepage and to prevent erosion and eventual instability of benches constructed at the bedrock/aquifer contact, as well as locations at which sumps will likely be required on the pit walls.

3. COMPANY EXPERIENCE AND PERSONNEL

3.1 PITEAU ASSOCIATES ENGINEERING LTD.

Piteau Associates Engineering Ltd. is a firm of consulting engineers with extensive experience in the mining field, including the design of dewatering systems, design of open pit slopes and design of waste dumps. Piteau Associates personnel have been involved with the development of the Faro pit since 1975, and are therefore familiar with local conditions.

In addition to previous work in the Faro Pit, and a brief hydrogeological/geotechnical review of the Grum and Vangorda deposits, PAEL has undertaken hydrogeological investigations and devised dewatering strategies for a number of base metal and coal mines in Canada and overseas, including: Carol Lake Mine in Labrador, Suncor Oil Sands, Gregg River Coal and Cardinal River Coal in Alberta, Harmer Ridge, Byron Creek Collieries and Wingdam Placer Mine in British Columbia, the Disputada Project in Chile, and the Palabora Mine in South Africa. PAEL has also designed high capacity well fields for salmon hatcheries and municipalities located throughout British Columbia.

Lists of previous projects relevant to the proposed dewatering program are included in Appendix B.

3.2 PERSONNEL

Mr. Holmes would coordinate the dewatering system development program and would be responsible for the design of the dewatering system. He would be assisted with data compilation and analysis by Messrs. Tiplady, Hogg and Tod. Either Mr. Hogg or Mr. Tod would be the field engineer for the project. A brief description of the senior personnel who would be involved with this project is provided below. Detailed resumes are included as Appendix C.

Mr. Andrew Holmes, P.Eng., (Senior Hydrogeologist) has acquired over 13 years' experience in the field of hydrogeology. He has been involved with many mining projects, and is very aware of the constraints that dewatering systems must be designed around in operating mine environments. Mr. Holmes was responsible for hydrogeological investigations at a number of coal mines in Alberta and southeastern British Columbia, and devised dewatering strategies for many of these mines. He is well versed in the use of computer models to evaluate well field performance (eg. Spius Creek Hatchery (1983), Alouette Dam dewatering (1983). Mr. Holmes is also familiar with the Faro Pit, as he investigated possible water control measures in 1985 and 1986, when the mine was first reopened by Curragh Resources Inc.

Mr. David Tiplady, P.Eng. (Intermediate Hydrogeologist) has five years' experience with carrying out hydrogeological and hydrology studies in British Columbia and Alberta. These studies have included site investigations for proposed seepage control systems, water wells and groundwater quality monitoring networks. He has developed considerable expertise with computer applications and is familiar with a number of numerical groundwater modelling codes.

4. COSTS AND SCHEDULE

4.1 COSTS

Personnel will be charged at hourly rates as follows:

	\$/Hour	\$/Day
A.T. Holmes	68	544
D.J. Tiplady	50	400
J. Tod/D. Hogg	40	320
Drafting	35	280
Secretarial	30	240

Expenses will be billed at substantiated cost.

Estimated costs for the proposed dewatering system development program are summarized in Tables I, II and III. Total cost of the proposed program is estimated to be approximately \$49,000. It should be noted that the contingency items costed on Table III are not included in the \$49,000 total cost. Also, it is assumed that all drilling, pump testing and well servicing will be contracted by Curragh Resources Inc.



4.2 SCHEDULE

The schedule for the dewatering system development program is presented on Fig. 1. This schedule assumes there would be minimal delays incurred while waiting for drilling or pump testing contractors to mobilize to the site.

Respectfully submitted,

PITEAU ASSOCIATES ENGINEERING LTD.

Andrew T. Holmes, P.Eng.

PROPOSED SCHEDULE

1989 | 1990

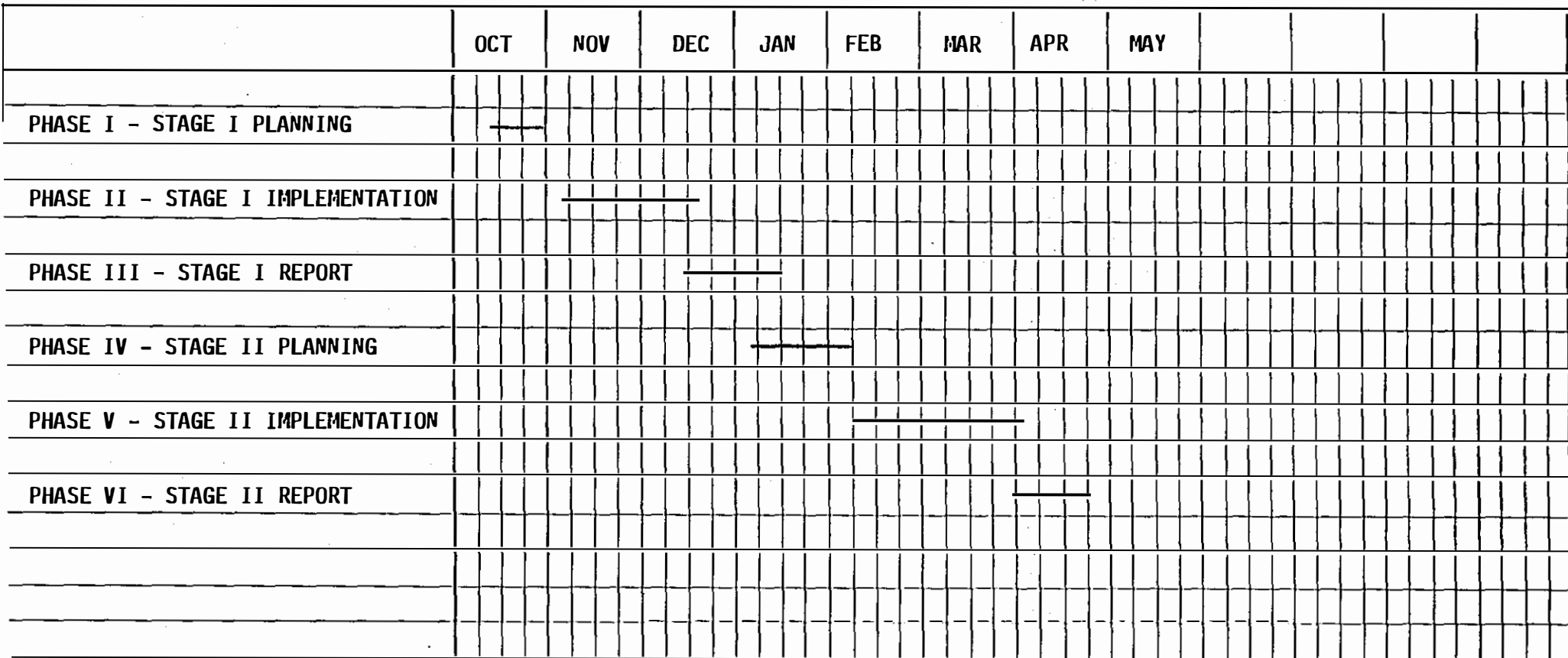


FIG. 1

TABLE I
SUMMARY OF ESTIMATED COSTS¹

PHASE	ITEM	TIME (MAN DAYS)					TOTAL PERSONNEL	EXPENSES ²	CONTINGENCY ³ ITEMS	TOTAL ³ COST
		HOLMES 544/Day	TIPLADY 400/Day	HOGG/TOD 320/Day	DRAFTING 280/Day	SECRETARIAL 240/Day				
I	Develop Stage I Dewatering Plan	3	1	3	1	½	3,392	300	-	3,692
II	Stage I Dewatering System Installation and Testing	3	1	20	-		8,432	7,000	-	15,432
III	Stage I Analysis and Report	4	3	5	2	1	5,776	400	-	6,176
IV	Develop Stage II Dewatering Plan	3	2	2	½	½	3,332	300	17,850	3,632
V	Stage II Dewatering System Installation and Testing	2	1	20			7,888	7,000	-	14,888
VI	Stage II Analysis and Report	3	3	5	1	1	4,952	400	-	5,352
TOTAL		18	11	55	4½	3	33,772	15,400		49,172

- NOTES: 1. Day rates are based on an 8-hour day, as listed in Section 4.
2. See a breakdown of expenses and contingency items on Tables II and III.
3. Contingency items not included in totals.

TABLE II
ESTIMATED EXPENSES

PHASE I: Develop Stage I Dewatering Plan

Fax, telephone, courier, reproduction, etc. \$ 300.00

PHASE II: Stage I Dewatering System Installation and Testing

Airfare - Whitehorse and return	2 @ \$780/each	\$1,560.00
Truck rental	20 days @ \$100/day	2,000.00
Accommodation	22 days @ \$90/day	1,980.00
Equipment rental (for three weeks)		
Data logger -	\$350	
Sieves -	80	
Sounder -	<u>30</u>	
		460.00
Water Quality Analyses		500.00
Telephone, Fax, photography, miscellaneous		<u>500.00</u>

\$7,000.00

PHASE III: Stage I Analysis and Report

Report reproduction, telephone, Fax, etc. \$ 400.00

PHASE IV: Develop Stage II Dewatering Plan

Data logger rental		\$ 400.00
Fax, telephone, etc.		<u>200.00</u>

\$ 600.00

PHASE V: Stage II Dewatering System Installation and Testing

Airfare - Whitehorse and return	2 @ \$780/each	\$1,560.00
Truck rental	20 days @ \$100/day	2,000.00
Accommodation	22 days @ \$90/day	1,980.00
Equipment rental (for three week)		
Data logger -	\$350	
Sieves -	80	
Sounder -	<u>30</u>	
		460.00
Water Quality Analyses		500.00
Telephone, Fax, photography, miscellaneous		<u>500.00</u>

\$7,000.00

PHASE VI: Stage II Analysis and Report

Report reproduction, telephone, Fax, etc. \$ 400.00

TABLE III

POSSIBLE CONTINGENCY ITEMS
 (Would be performed prior to Developing
 Stage II Dewatering Plan)

Geophysical Survey

Field crew (including equipment and accommodation)	5 days @ 1,650/day	\$8,250.00
Office analysis and report and Report	8 days @ 450/day	3,600.00
Travel Costs - Airfare	2 @ 780/each	1,560.00
Truck rental	4 days @ \$100/day	400.00
Report reproduction, telephone, misc.		<u>240.00</u>
		<u>\$14,050.00</u>

Detailed Computer Modelling Study

A.T. Holmes	2 days @ 544/day	\$1,088.00
D.J. Tiplady	6 days @ 400/day	2,400.00
Report, telephone, FAX, misc		<u>312.00</u>
		<u>\$ 3,800.00</u>

APPENDIX A

REQUEST FOR PROPOSAL

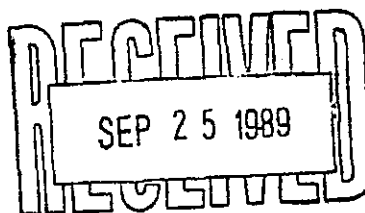


Curragh
Resources Inc.

P.O. Box 1000
Faro, Yukon
Y0B 1K0
Tel.: (403) 994-2600

September 12, 1989

Mr. Andrew Holmes
Piteau Associates
Kapilano 100, Suite 408
West Vancouver, B.C.
V7T 1A2



Dear Mr. Holmes:

I am forwarding as discussed in our conversation of August 28, 1989, information Curragh has collected for the development of a dewatering plan for the Grum Open Pit. Curragh is seeking a proposal from Piteau Associates to evaluate this information and to develop a dewatering strategy for the Grum Open Pit.

BACKGROUND:

Stripping began in the Stage I area of the Grum Pit in November, 1988. Mine advance progressed along the 1294m bench and intersected the southern portion of the Doal Lake bed before mine activities were suspended in May of 1989. Mining is scheduled to resume in December, 1989.

It is essential that we resolve our dewatering requirement as soon as possible and that groundwater presence in the mine workings be minimized.

A pump test was conducted during May that intersected the main aquifer and the results are included in with the information provided. Artesian pressures at the test site can be controlled by resuming pumping at the test well once permanent power is available. This may provide temporary relief while a detailed dewatering scheme is being implemented.

PRELIMINARY DEWATERING PLAN

A conceptual dewatering plan envisaged up to 12 deep wells would be needed to intercept from the aquifer located along the N.E. side of the pit. Pump size and spacing were to be determined from the pump test. An additional site targeted for a deep well would be the S.E. corner, near the shop.

SCOPE OF WORK

Develop a comprehensive dewatering plan that will achieve the following:

1. Dewater the immediate mine working area.
2. Intercept the groundwater flows utilizing a perimeter dewatering well network. Such a system must be of sufficient size to dewater the aquifer and maintain this condition during the life of the mine.

PROPOSED TIMETABLE

<u>EVENT</u>	<u>Sept</u>	<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>
1. Restart test well	[]							
2. Develop Stage I dewatering plan	[]							
3. Well installations, well testing			[]				[]	
4. Stage II dewatering plan				[]				
5. Electrical			[]				[]	

I am looking forward to your proposal regarding the above. Should you have any questions, please contact me at (403) 994-2600, extension 148.

Yours truly,
CURRAGH RESOURCES INC.



Jack Bowers
Project Development Engineer

APPENDIX B

COMPANY INFORMATION

**Project Lists
Available Groundwater Modelling Programs**

GROUNDWATER GROUP

The Groundwater Group has a team of highly specialized engineers and hydrogeologists who have worked on a wide variety of projects, ranging from single well evaluations to large scale regional hydrogeological studies. All personnel are fully conversant with field techniques and standard groundwater evaluations. This group has developed its own computer based system for data capture and analysis, computer graphics and modelling.

The following is an illustration of the range of typical groundwater projects that are within the capability of the Groundwater Group.

MAPPING AND ANALYSIS OF GROUNDWATER FLOW SYSTEMS

- . Delineation and computer modelling of regional groundwater flow systems.
- . Analysis of air photographs and satellite imagery.
- . Permeability and pumping tests.
- . Determining safe aquifer yield.
- . Remote automatic monitoring of piezometers and wells.

SEEPAGE STUDIES

- . Supervising installation of standpipe and pneumatic piezometers in exploration drillholes (maximum depth 550m).
- . Carrying out inflated packer permeability tests either through-the-bit while drilling proceeds, or using a double inflatable packer system for profiling the open hole after drilling has ceased.
- . Performing transient finite element modelling for both saturated and unsaturated groundwater flow systems.
- . Carrying out specially designed pump tests to determine the hydraulic properties and anisotropic nature of fractured rock.
- . Measurement of downhole groundwater velocity and temperatures.

DEWATERING AND DEPRESSURIZATION

- . Determining the overall groundwater budget for mine or construction excavation, both open pit and underground.
- . Predicting the rate of pore water pressure dissipation or water table decline in the walls of an excavation so that stability can be assessed.
- . Design of dewatering and depressurization systems; wells, horizontal drains and drainage galleries.

HYDROGEOCHEMISTRY

- . Water sampling, filtering field testing and sample preservation.
- . Hydrogeochemical studies including:
 1. Interpretation of inorganic chemical analyses.
 2. Stable isotope studies applied to water and/or solids.
 3. Radioactive isotope analysis for dating groundwater.
 4. Dissolved gases in groundwater.
- . Graphical presentation of geochemical data.
- . Determination of geochemical stability of waters using the WATEQF computer program.
- . Determination of corrosion potential of water.
- . Using data from specialized tests on rock and soil samples (leach tests, acid generation, CEC, etc.), to predict changes in groundwater chemistry.
- . Developing specialized water sampling systems.

GROUNDWATER SUPPLY STUDIES

- . Locating and mapping potential water bearing strata.
- . Supervision of drilling, completion and aquifer pump testing of water wells.
- . Computer processing of both step and constant rate aquifer pump test data. This includes data processing, inter-active graphics, plotting of time-drawdown trends and calculation of aquifer properties from test data.
- . Modelling of well or well field hydraulics.
- . Determining safe well yield.
- . Assessing effects of water chemistry, bacteria, dissolved gases and water temperature on long term yield of a well.
- . Assisting with establishment of a National Groundwater Authority and training of drill rig operators and hydrogeologists.
- . Design of solar powered pumping systems for irrigation, village and livestock water supply.

GEOHERMAL STUDIES

Piteau Associates have carried out hydrogeochemical studies at a number of geothermal sites in British Columbia. These projects generally involve sampling thermal waters for evidence of the past history of the water as it passes through the subsurface. These data are used to supplement other studies in assessing the long term viability of a geothermal source for producing electricity or providing heat to supplement local water heating systems.

The possibility of using shallow aquifers for storage and supply of low grade heat has also been investigated. By using a two well system and a water-to-air heat pump, it is possible to abstract heat from the groundwater during the winter time for space heating in homes and buildings. The process is then reversed in the summer time by abstracting heat from the air using the heat pumps, and discharging warm water back into the ground. In this manner, air conditioning is provided for the house or building, and heat energy is stored in the ground for subsequent use in the winter time.

by
PITEAU ASSOCIATES

PROJECT Title/Date	CLIENT	DESCRIPTION
ANVIL MINE Faro, Yukon 1976-77	Cyprus Anvil Mining Corporation Vancouver, British Columbia	Designed an inclined drainhole dewatering system to relieve groundwater pressure in the overburden slopes above an open pit, and established appropriate monitoring of the system.
CAROL LAKE MINE Labrador City, Newfoundland 1980-81	Iron Ore Company of Canada. Sept-Isles, Quebec	Reviewed all relevant geologic and hydrogeologic data and made recommendations for further testing and design of an open pit mine dewatering system.
CARDINAL RIVER COAL MINE Luscar, Alberta 1980-81	Cardinal River Coals Ltd. Hinton, Alberta	Carried out hydrogeologic investigations, piezometer installation, geochemical sampling, in-situ packer testing, aquifer pump testing and finite-element analyses for mine dewatering, pit wall depressurization, and environmental studies. Studies included an evaluation of waste dump seepage and dewatering of existing underground mine workings and review of dewatering of surficial sediments at perimeter of proposed pit.
LINE CREEK COAL MINE Sparwood, B.C. 1981	Crows Nest Resources Ltd. Calgary, Alberta	Installed piezometers in drillholes, conducted falling head permeability tests and prepared a base line hydrogeologic map of a proposed open pit expansion area. Carried out an initial assessment of rock depressurization and/or dewatering for mine planning.
HALIFAX STREET HIGHRISE Burnaby, B.C. 1981	R.A. Spence Engineering Ltd. Vancouver, British Columbia (for Qualico Development Ltd., Vancouver, B.C.)	Drilled nine test holes to delineate extent of permeable sands and installed piezometers. Conducted two aquifer pump tests and ran computer simulations of dewatering, with and without a well point system. Designed optimum dewatering scheme for the 100 x 85m excavation that penetrated 12m below the groundwater table.
FINCHAA HYDROELECTRIC PROJECT Ethiopia 1982	Ethiopian Electric Light and Power Authority Addis Ababa, Ethiopia (for World Bank)	Provided design and construction supervision of a dewatering system in residual soils. These soils contained swelling clay which was causing uplift, affecting a hydroelectric penstock.
ROBERTS BANK SUPERPORT Delta, B.C. 1982	Canadian Dewatering Ltd. Richmond, British Columbia	Reviewed dewatering procedures employed for excavation below water table in permeable sands, adjacent to the sea. Made recommendations for improvements.
BROOKSWOOD SUBDIVISION Langley, B.C. 1982	Corporation of the Township of Langley, British Columbia	Researched hydrogeological and historical climatic data for a residential area, and designed a dewatering system to minimize surface flooding of a portion of the area that used soaker pits to absorb storm runoff.
ALOUETTE DAM Haney, B.C. 1983	B.C. Hydro and Power Authority Vancouver, British Columbia	Supervised construction and testing of a sample dewatering well and designed a dewatering system for dam foundation excavation into permeable sand with artesian water pressures.
HARMER RIDGE MINE Sparwood, B.C. 1983	Westar Mining Sparwood, British Columbia	Installed piezometers in drillholes and performed two aquifer pumping tests to determine permeability and drainability of rock around an open pit coal mine. Assessed methods for controlling shallow groundwater flow in subgrade and in waste rock placed near the open pit, in order to minimize number of wet blastholes.
MILDRED LAKE AQUIFER DEWATERING Fort McMurray, Alberta 1983	Suncor Inc., Oil Sands Division Ft. McMurray, Alberta (Joint venture with EBA Engineering Consultants Ltd.)	Installed piezometers and a test dewatering well in an alluvial channel to determine design parameters for dewatering system, and to estimate possible seepage flows from Mildred Lake into ultimate pit. Designed dewatering system and made recommendations for installation of seepage cutoff measures along Mildred Lake Dam.
WEST END MINE Stibnite, Idaho 1983	Superior Mining Company Stibnite, Idaho	Mapped groundwater discharge zones and installed piezometers to enable an assessment of depressurization options to stabilize areas of slope movement. Designed and recommended a deep inclined drainhole system.
CHAMBERS CREEK TUNNEL Pierce County, Washington 1983	Jensen Drilling Ltd. Eugene, Oregon	Carried out preliminary design of well dewatering systems for preparation of bids to carry out an excavating contract.

by

PITEAU ASSOCIATES

PROJECT Title/Date	CLIENT	DESCRIPTION
OPAL SPRINGS HYDROELECTRIC PROJECT Jefferson County, Oregon 1983	Jensen Drilling Ltd. Eugene, Oregon	Carried out preliminary design of dewatering systems for preparation of bids to carry out an excavating contract.
HOLLY MEADOWS SUBDIVISION Ladner, B.C. 1984	LandPlan Group Inc. Vancouver, British Columbia	Installed piezometers and performed an aquifer pumping test to determine design parameters for dewatering system. Determined optimum system to dewater an 8m deep excavation in permeable sands that was required for construction of a below grade storm water detention pond. Provided estimates of steady state groundwater inflows to a permanent subdrain system.
WATER STORAGE IN PLAYING FIELDS Surrey, B.C. 1985	Hub Engineering Ltd. Surrey, British Columbia	Assessed rates of drainage and infiltration of storm water into and out of a 0.5m thick layer of sand fill placed under a playing field. The office based study involved grain size analysis of sand and two-dimensional (profile) analyses of transient movement of water in both saturated and unsaturated portions of sand layer.
SHEARNES PUMP STATION Finnegan, Alberta 1985	Milner & Steer, Lawyers Calgary, Alberta	Provided technical advice to lawyers and acted as an expert witness in a dispute between a consulting engineer and contractor involved with the project.
MOLIKPAQ WELL SYSTEM DESIGN Amuligak F-24 Development 1987	Komex Consultats Ltd. Calgary, Alberta for for Gulf Canada Corporation	Evaluated the efficiency of a well system required for core dewatering of a caisson retained artificial island in the Beaufort Sea. Design of each well considering highly corrosive saline water operation and difficult drilling conditions. Expected dewatering requirements in order of 0.5 m ³ /s.
CEDARBROOK FARM SUBDIVISION Langley, B.C. 1986	Township of Langley Langley, British Columbia (In association with Norjay Projects Ltd.)	Evaluated methods for control of groundwater table beneath a new subdivision where subsurface disposal of storm runoff from houses and roads was proposed. Study involved computer simulation of effects of a seepage cost of trench system.
WINGDAM PLACER MINE Quesnel, B.C. 1986	Gold Ridge Resources Inc. Vancouver, British Columbia	Determined hydrogeological conditions at site, assessed feasibility of dewatering with wells and drainholes, and developed conceptual dewatering system designs. Project currently ongoing.
82nd AVE. LAND ENHANCEMENT PROJECT Glen Valley, North Langley, B.C. 1987	Norjay Developments Ltd. Langley, British Columbia	Assessment of impact that a proposed excavator and land enhancement project would have on neighbour's water wells. Also carried out ongoing monitoring.
SUBDIVISION SEWER PIPE CONSTRUCTION Greenville, B.C. 1987	Department of Indian and Northern Affairs. Vancouver, British Columbia	Carried out a field program and office evaluation to determine seasonal depth to water table, and feasibility of controlling seepage while sewer trenches were constructed.
256th STREET LAND ENHANCEMENT PROJECT Aldergrove, B.C. 1987	Breaks Gravel Sales Ltd. Langley, British Columbia	Assessment impact that a proposed excavation and land enhancement project would have on neighbour's water wells. Also carried out ongoing monitoring.
60th AVE. LAND ENHANCEMENT PROJECT North Langley, B.C. 1987-88	Corporation of Township of Langley, Langley, British Columbia	Review of baseline hydrogeology reports and available data and preparation report on possibility that an excavation had gone below the water table and affected neighbour's groundwater sources.
ATLIN PLACE Coquitlam, B.C. 1987	Vanac Developments Corp. Burnaby, British Columbia	Review of geotechnical report, constructing well point system records, test drilling and assessment of measures to control 43 L/s artesian flow into building basement excavation. Design of a permanent seepage diversion system, that has integrated into building basement construction.

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PROJECT Title/Date	CLIENT	DESCRIPTION
GRANISLE MINE Granisle, B.C. 1975-76	Granby Mining Co. Vancouver, British Columbia	Installed piezometers and carried out a preliminary groundwater seepage study.
PIT SLOPE MANUAL 1975-76	CANMET Energy Mines and Resources, Canada Ottawa, Ontario	Carried out and coordinated a review of the slope design chapters which discuss the approach and methods in the overall analysis, and the Groundwater Chapter which discusses aspects involving investigation, monitoring and analysis of groundwater.
SAGE CREEK COAL MINE Flathead Valley, B.C. 1975	Rio Algom Mines Ltd. Toronto, Ontario	Assisted with hydrogeological aspects of geotechnical and environmental investigations for open pit slopes, mill sites, waste and tailings disposal sites and mine environmental impact assessment.
ANVIL MINE Faro Valley Dewatering Faro, Yukon 1976-77 and 1986	Cyprus Anvil Mining Corporation Vancouver, British Columbia and Curragh Resources, Vancouver, British Columbia	Designed an inclined drainhole dewatering system (including appropriate system monitoring) to depressurize overburden slopes in Faro Valley above the pit. Assisted Curragh Resources in establishing a pit water control strategy following reopening of the mine in early July.
UNDERGROUND STORAGE FACILITY Prince Rupert, B.C. 1977	British Columbia Development Corporation Vancouver, British Columbia	Carried out office and field studies including groundwater seepage evaluation for comparative analysis of costs of underground storage versus surface storage for 50 million bushels of grain and 76 million gallons of oil.
ISLAND COPPER MINE Port Hardy, B.C. 1977-78	Utah Mines Ltd. Vancouver, British Columbia	<ol style="list-style-type: none"> 1. Carried out a comprehensive review of all hydrogeological related data that was assembled by mine personnel in a 320m deep operating open pit mine. Investigated possibility of depressurization of low permeability rock and potential seepage from adjacent arm of the sea. 2. Carried out a program of drilling, sampling and pump testing to assess seepage quantities through a 30m thick section of surficial sediments separating the pit perimeter from the ocean. Used finite-element computer model to simulate potential future seepage in order to assess possibility of piping failure.
SAVAGE RIVER MINE Tasmania, Australia 1978	Pickands Mather & Co. Cleveland, Ohio	Reviewed hydrogeological data and recommended a drilling and testing program to assess feasibility of slope depressurization. Reviewed drainhole depressurization scheme during installation.
DISPUTADA PROJECT Los Bronces Mine Chile 1979-82	Exxon Minerals International Inc. Houston, Texas; Cia Minera Disputada De Los Condes, S.A. Santiago, Chile and Wright Engineers Limited Vancouver, British Columbia	<ol style="list-style-type: none"> 1. Assessed regional hydrogeology along a proposed 35km tunnel route. Carried out a hydrogeological study involving in-situ packer testing of drilled holes to determine hydraulic conductivity, installed piezometers and carried out monitoring below ground: maximum testing depth was 500m. Carried out finite-element computer simulation of flow systems to determine potential seepage and sudden inrush flows into the tunnel. Conducted geothermal and hydrogeochemical studies. 2. Carried out an extensive hydrogeological study for a proposed new open pit mine. The final pit wall would exceed a height of 650m. Studies included in-situ packer testing in exploration drillholes, piezometer installation, temperature profiling and finite-element computer modelling of transient drainage and depressurization of pit walls.
PALABORA MINE South Africa 1979-85	Palabora Mining Company Pty. Ltd. Phalaborwa, South Africa (RTZ Group)	Carried out a detailed review of hydrogeologic data and assessed feasibility of depressurization of rock slopes in both the existing 250m deep pit and planned 600m deep open pit and in selected unstable areas of the existing pit.
GRIFFITH MINE Red Lake, Ontario 1979-80	Pickands Mather & Co. Cleveland, Ohio	Reviewed hydrogeologic data collected by mine personnel. Carried out in-situ packer tests to determine rock permeability, installed piezometers and carried out seepage analysis to assess feasibility of depressurizing rock slopes to improve stability in 290m deep pit.

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PROJECT Title/Date	CLIENT	DESCRIPTION
KITSAULT PROJECT Alice Arm, B.C. 1979-80	Amax of Canada Vancouver, British Columbia	Carried out preliminary evaluation of seepage for the design of waste dumps and related surface drainage.
CAROL LAKE MINE Labrador City, Nfld. 1980-81	Iron Ore Company of Canada Sept-Iles, Quebec	Reviewed relevant geologic and hydrogeologic data in order to make recommendations for further testing and design of open pit mine dewatering systems.
CARDINAL RIVER COAL MINE Hinton, Alberta 1980-81	Cardinal River Coals Hinton, Alberta	Carried out hydrogeologic investigations, piezometer installation, geochemical sampling, in-situ packer testing, pump testing and finite-element computer simulation of mine dewatering and pit wall depressurization. Assessed waste dump seepage and dewatering of existing underground mine workings.
COALSPUR PROJECT Robb, Alberta 1980-81	Denison Mines Limited Vancouver, British Columbia	Reviewed information on regional hydrogeology for an 80km by 22km area. Installed piezometers, conducted aquifer pumping tests and carried out hydrogeochemical studies for geotechnical and environmental assessment of proposed 7km long open pit coal mine. Assessed feasibility of dewatering old mine workings.
Y GOLD MINE Shandong Province, People's Republic of China 1980	China National Technical Import Corporation Peking, People's Republic of China	Reviewed hydrogeological test results and conducted finite-element computer simulations of seepage into underground workings and from a proposed tailings pond. Carried out a study of geochemical data to determine the origin of very saline groundwater. (Project in association with Wright Engineers Limited).
LODGEPOLE COAL PROPERTY Fernie, B.C. 1980	Crows Nest Resources Limited Calgary, Alberta	Installed standpipe piezometers in ten drillholes as part of a preliminary geotechnical evaluation of slope stability of potential open pit slopes.
GREGG RIVER COAL MINE Hinton, Alberta 1981-82	Gregg River Resources Ltd. Hinton, Alberta	Carried out hydrogeological assessment for geotechnical evaluation of seven proposed open pits, including piezometer installations, finite-element seepage analyses, assessment of seepage from diversion channels and slope depressurization work.
LINE CREEK COAL EXPANSION Sparwood, B.C. 1981	Crows Nest Resources Limited Calgary, Alberta	Installed piezometers in drillholes, conducted falling head permeability tests and prepared a baseline hydrogeologic map. Carried out initial assessment of rock depressurization and/or dewatering for mine planning.
QUINTELETTE COAL MINE Tumbler Ridge, B.C. 1982-85	Quintette Coal Limited Tumbler Ridge, British Columbia	Supervised installation of piezometers and trained mine site personnel to install same in other test holes. Evaluated groundwater inflow to an open pit and seepage from a proposed diversion channel.
CHIMNEY ROCK COAL COMPANY Pagosa Springs, CO 1982	Perma Mining Corporation Colorado Springs, Colorado	Reviewed existing hydrogeologic data, performed two aquifer tests and prepared a hydrogeologic assessment for open pit mine located adjacent to an alluvial valley.
COLORADO COAL MINE NO. 1 Walsenburg, CO 1982	Perma Mining Corporation Colorado Springs, Colorado	Carried out a program involving test hole drilling, piezometer installation, pump testing, groundwater sampling and computer modelling to prepare a baseline hydrogeological assessment of the mine site. Report required for mine planning and for submission to regulatory agencies.
REO MOUNTAIN MOLYBDENITE PROJECT Rossland, B.C. 1982	International Environmental Consultants Ltd. Richmond, British Columbia	Carried out in-situ tests in boreholes using inflatable packers so that assessment of quantity of groundwater inflows into proposed open pits and waste dumps could be made.
HARMER RIDGE MINE Sparwood, B.C. 1983	Westar Mining Sparwood, British Columbia	Carried out a program of piezometer and well installation, aquifer pump testing and computer modelling to determine rock permeabilities and groundwater flow systems. Proposed options for controlling shallow groundwater flow (which was causing wet blastholes) into the open pit mine.
WEST END MINE Stibnite, IO 1983	Superior Mining Company Stibnite, Idaho	Hydrogeologically mapped discharge zones and piezometer installation to assess methods of depressurization to stabilize areas of slope movement. Designed and recommended a deep inclined drainhole system.

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AOSTRA UNDERGROUND TEST FACILITY Fort McMurray, Alberta 1983	Hardy Associates (1978) Ltd. Calgary, Alberta	Installed piezometers, carried out hydraulic conductivity testing and geochemical sampling to assess pressure head distribution and potential groundwater quality and inflows to a proposed shaft and underground oil sands extraction facility.
BYRON CREEK MINE EXPANSION Corbin, B.C. 1983	Esso Resources Canada Limited - Coal Division Calgary, Alberta	Carried out hydrogeologic mapping, piezometer installation, packer testing and computer modelling to assess groundwater inflows and slope depressurization requirements for a proposed pit expansion.
SUNCOR OIL SANDS MINE Fort McMurray, Alberta 1983	EBA Consultants Limited Edmonton, Alberta	Carried out a program of well and piezometer installation, aquifer pump testing and computer modelling. Designed a system for dewatering an alluvial channel (Mildred Lake aquifer) that passed through a proposed open pit expansion area.
MONKMAN PROPERTY Tumbler Ridge, B.C. 1983	Petro Canada Resources Calgary, Alberta	Reviewed existing hydrogeological information. Developed a finite-element model and determined probable groundwater flows into different mining sequences. Evaluated hydrochemical and hydrothermal impacts of discharging mine dewatering wells into receiving surface drainage system.
OSLO, LEASE 31 Fort McMurray, Alberta 1983-84	Esso Resources Canada Limited Calgary, Alberta	Assessed hydrogeological conditions in the area of the proposed new oil sands development. Upgraded 2D and 3D finite difference computer model used for determination of probable groundwater flows into the open pits. Provided hydrogeological input into environmental impact assessment.
CASSIAR ASBESTOS MINE Cassiar, B.C. 1983-85	Brinco Mining Limited Vancouver, British Columbia	Worked with mine personnel to install piezometers to determine local groundwater flow systems and to assess necessity for methods of slope depressurization. Recommended that either subhorizontal drains or radial drains from an existing adit be installed.
LAWYERS MINE Smithers, B.C. 1985	Serem Inc. Vancouver, British Columbia	Evaluated potential for developing a groundwater supply for plant make up water. Recommended a number of locations where wells or well fields could be developed (Project in association with Wright Engineers Limited).
GULF SANDALTA PROJECT Fort McMurray, Alberta 1985	SCA Engineers Ltd. Calgary, Alberta	Assessed hydrogeological and geotechnical conditions in the area of the proposed new oil sands development.
CANSTAR OIL SANDS Daphne Area, Fort McMurray, Alberta 1985	Canstar Oil Sands Ltd. Calgary, Alberta	Reviewed existing hydrogeological information, assessed potential impact of the proposed open pit oil sands mine on groundwater conditions, and developed a short term and long term exploration strategy.
OMBILIN II COAL MINE Sumatra, Indonesia 1985-1986	Norwest Resource Consultants Calgary, Alberta	Assessed regional and local groundwater conditions in the area of a proposed underground coal mine. Outlined short and long term hydrogeological exploration program.
WINGDAM PLACER MINE Quesnel, B.C. 1986	Gold Ridge Resources Inc. Vancouver, British Columbia	Determined hydrogeological conditions at site, assessed feasibility of dewatering with wells and drainholes, and developed conceptual dewatering system designs. Project currently ongoing.
EAGLE POINT MINE Collins Bay, Saskatchewan 1986	Eldor Mines Saskatoon, Saskatchewan	Evaluated hydrogeological aspects of underground development beneath Collins Bay. Evaluation involves data review and finite-element modelling. Project in progress.
SAND CONTROL IN HEAVY OIL WELLS Fort McMurray, Alberta 1986-1987	Gulf Canada Corporation Calgary, Alberta	Reviewed present methods of oil well completion compared with water well completion and recommended different design for enhanced oil recovery wells.
BYRON CREEK COLLIERIES LTD. Sparwood, B.C. 1989	Esso Resources Canada Ltd. - Coal Division Calgary, Alberta	Advised mine operating personnel on strategy to control water in pit after the water table was encountered in early 1989.

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VILLAGE WATER SUPPLY Elkford, B.C. 1979-80	Ministry of Municipal Affairs Victoria, British Columbia	Investigated potential groundwater resources in a 28km ² area, involving field survey and office evaluation of topographic and geologic data, test drilling and pump testing of three production wells with yields to 50 L/s, sampling for water quality and seepage evaluation for estimation of long term groundwater potential.
BOWRON RIVER SALMON HATCHERY Prince George, B.C. 1979-80	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Explored, pump tested and evaluated groundwater potential for proposed hatchery site requiring a 570 L/s well field delivering groundwater at a temperature not less than 5°C during winter months. Carried out computer modelling of stream aquifer interaction and heat transfer relationships.
QUESNEL RIVER SALMON HATCHERY Likely, B.C. 1979-84	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Explored, test drilled and evaluated aquifer potential; developed two 180 L/s wells. Computer simulated hydraulic performance of two wells and one test well over two years and heat transport analyses for river-aquifer convective thermal regime.
CHEHALIS RIVER SALMON HATCHERY Harrison Mills, B.C. 1980	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	This project was similar to the Bowron River Project, except that three 65 to 183 L/s capacity production wells were installed and pump tested in addition to the original testing program.
SHELL BEACH SUBDIVISION Ladysmith, B.C. 1979-80	Allison Properties Ltd. West Vancouver, B.C.	Reviewed performance of existing bedrock wells, supervised drilling and testing of a new well, determined safe well yields and carried out investigation of proposed on-site disposal of treated sewage effluent.
STUART RIVER SALMON HATCHERY Fort St. James, B.C. 1980	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Regional hydrogeologic evaluation of aquifers. Supervised drilling program to complete and test a well in an artesian aquifer. Completed 150mm well had a shut-in head of 26m above ground and free flow of 68 L/s. Flow tested well and evaluated data to determine long term aquifer yields.
BLACKCOMB MOUNTAIN SKIFIELD Whistler, B.C. 1980	Kerr Wood Leidal Associates Ltd. North Vancouver, British Columbia	Evaluated and designed 32,400 L/d capacity drainfield for septic tank discharge into the ground. Conducted geophysical investigation and supervised pump testing of a 0.5L/s capacity water well on a mountaintop location.
ALOUETTE RIVER SALMON HATCHERY Haney, B.C. 1980	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Supervised two hole test drilling program, pump tested and evaluated proposed 450 L/s well field. Evaluated long term well yields and predicted changes in aquifer temperatures.
MATHERS CREEK SALMON HATCHERY Sandspit, B.C. 1980	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Supervised three hole testing program and evaluated long term yields from a confined aquifer extending underneath the sea. Evaluated pump tests, analyzed tidal responses, computer modelled 160 L/s well field and assessed potential for salt water intrusion.
ANAHIM IRRIGATION PROJECT Alexis Creek, B.C. 1980	Talisman Land Resource Consultants Ltd. Vancouver, British Columbia	Evaluated local hydrogeology for proposed 242 L/s well field to supply water to an irrigation project.
GRANITE MOUNTAIN SKIFIELD DEVELOPMENT Rossland, B.C. 1980	Sigma Resource Consultants Ltd. Vancouver, British Columbia	Evaluated regional hydrogeology to assess a 0.2 L/s capacity well for a restaurant located near a mountaintop.
SILVERSTAR MOUNTAIN SKI DEVELOPMENT Vernon, B.C. 1981	Sigma Resource Consultants Ltd. Vancouver, British Columbia	Evaluated regional hydrogeology to assess a 3 L/s well field located on the side of a steep mountain.
CHRISTIAN CREEK SALMON HATCHERY SITE Heffley Lake, B.C. 1981	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Conducted hydrogeologic assessment and supervised 150m deep test hole in an artesian aquifer. Completed 200mm diameter flowing artesian well.
COALSPUR PROJECT Robb, Alberta 1982	Wright Engineers Limited Vancouver, British Columbia (for Dentherm Resources Ltd. Edmonton, Alberta)	Assessed regional hydrogeology for 95 L/s groundwater source for proposed mine coal processing plant. Conducted seismic refraction survey and evaluated the possibility of using an abandoned underground mine as a water storage reservoir, or as a water source.

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GROUNDWATER SUPPLY INVESTIGATION Deroche, B.C. 1979	Sigma Resource Consultants Ltd. Vancouver, British Columbia (for Public Works Canada Vancouver, British Columbia)	Surveyed information on existing wells in the area, and made recommendations for drilling and water supply development at an existing gravel pit.
FINN CREEK SALMON HATCHERY Blue River, B.C. 1981	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Designed and supervised drilling and pump testing of a 250 L/s well. Assessed aquifer to determine feasibility of developing a 450 L/s well field.
COLDWATER RIVER VALLEY HATCHERY Merritt, B.C. 1981	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Evaluated three potential hatchery sites along a 22km section of the Coldwater River Valley, with special emphasis given to probable groundwater temperatures and methods of groundwater temperature enhancement.
NICOLA RIVER SIDE CHANNEL HATCHERY PROJECT Lower Nicola, B.C. 1981	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Conducted preliminary evaluation of groundwater supply potential for a proposed salmon hatchery.
GEOCHEMICAL INVESTIGATIONS OF A REGIONAL AQUIFER San Luis Potosi, Mexico 1981	Comision Federal Electricidad, Mexico City, Mexico	Sampled water and evaluated natural isotope content and inorganic groundwater quality to assess probable extent of recharge to a regional aquifer, to determine potential aquifer yield.
WHISTLER SKI AREA Whistler, B.C. 1981	Sigma Resource Consultants Ltd. Vancouver, British Columbia	Assessed two potential well sites to evaluate the possibility of providing a groundwater supply to a restaurant on the mountain side.
WATER SUPPLY EVALUATION FOR A CONSTRUCTION CAMP Fort St. John, B.C. 1981	H.A. Simons (International) Ltd. Vancouver, British Columbia (for B.C. Hydro and Power Authority, Vancouver, British Columbia)	Carried out a field investigation, including drilling and pump testing of a well, to provide an assessment of potential water supply for a proposed hydroelectric project construction camp.
IRRIGATION WELL DESIGN Fraser Valley, B.C. 1981	Columbia Water Wells Ltd. Langley, British Columbia	Carried out a well screen design to ensure maximum productivity of an irrigation well penetrating fine grained sediments.
FRASER INDUSTRIAL PARK Langley, B.C. 1982	Dayton and Knight Ltd. West Vancouver, British Columbia (for Gloucester Properties Ltd., Surrey, British Columbia)	Carried out a hydrogeological assessment of a proposed industrial park site to determine the probability of developing a 152 L/s well field.
NORTH THOMPSON RIVER VALLEY Thompson River, B.C. 1982	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Assessed groundwater supply potential at proposed hatchery sites along a 90km section of the North Thompson River. Sites with high groundwater potential were indicated and recommendations were made for carrying out more detailed hydrogeologic investigations.
CLEARWATER RIVER SALMON HATCHERY Clearwater, B.C. 1982-84	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Design and supervision of drilling and pump testing programs for two wells with a combined yield of 105 L/s. Provided an assessment of possibility of developing a well field with an ultimate yield of 450 L/s. Assisted with drilling and testing of a third 100 L/s well.
WATER SUPPLY ASSESSMENT LOTS 1 AND 5 Sakinaw Lake, B.C. 1983	Artan Holdings Ltd. Vancouver, British Columbia	Assessed regional and local fracture patterns to evaluate potential of groundwater supply to two subdivision lots.
EAGLE RIVER SALMON HATCHERY Taft, B.C. 1983	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Supervised construction and testing of a 300mm diameter, 145 L/s well and hydrogeologic assessment of the hatchery site area.
SPIUS CREEK SALMON HATCHERY Canford, B.C. 1983	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Designed and supervised drilling and pump testing programs for three wells with a combined yield of 125 L/s which penetrate a confined aquifer. Assessed development of a well field with an ultimate yield of 460 L/s.

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BALFOUR SUBDIVISION Balfour, B.C. 1983	B.C. Ministry of Lands Parks and Housing Cranbrook, British Columbia	Evaluated water supply alternatives for a proposed combined subdivision and campground. Assessed potential for both groundwater supply and lake intake systems in conjunction with Intermountain Engineering and Surveying Ltd., Nelson, B.C.
LINDBERGH PILOT PLANT Lindbergh, Alberta 1984	Murphy Oil Company Ltd. Calgary, Alberta	Project included modification of an oil well into a water well. Waterbearing strata was badly damaged by drilling mud. Performed preliminary aquifer test and evaluated the results.
LITTLE CAMPBELL RIVER HATCHERY Langley, B.C. 1984	Fisheries and Oceans Canada Pacific Region Vancouver, British Columbia	Carried out hydrogeological assessment of an existing artesian well that was passing sand through a well screen. Reviewed performance data on well and aquifer and supervised deepening the well. At completion of the operation well yield had been restored and delivery was sand free.
DIDI AND KORON PLACER PROJECTS Siquiri, Guinea 1984-86	Wright Engineers Limited Toronto, Ontario (for Chevaning Mining Ltd., London, England)	Carried out hydrogeological assessment of a savanna area underlain by laterite soils and schistose bedrock. Prepared an assessment report on developing well fields capable of producing 70 and 125 L/s safe yields in two areas. Also assessed drainability of 12m deep excavations in lateritic sediments.
GROUNDWATER EVALUATION AND TRAINING Mbabane, Swaziland 1985-91	Canadian International Development Agency (CIDA) Hull, Quebec	Provide assistance to the Government of Swaziland for establishment of a National Water Authority, training of hydrogeologists and water well drillers to carry out a five-year groundwater evaluation program over the entire country.
BROOKSWOOD-FERNRIDGE WATER SUPPLY Langley, B.C. 1984	The Corporation of the Township of Langley British Columbia	Reviewed past performance of five production wells, total aquifer water balance and assessed potential future yields from new wells in the area. Study included an assessment of potential for nitrate contamination of the aquifer.
CHILLIWACK HATCHERY Chilliwack River Valley, B.C. 1984-85	Fisheries & Oceans Canada Pacific Region Vancouver, British Columbia	Reviewed previous testing information and three years of monitoring data on two production wells in an artesian aquifer in a narrow valley. Developed a finite-element model to simulate the declining well field performance and recommended drilling a new well in a deeper portion of the aquifer. Carried out a gravity survey to develop a profile of the bedrock surface so that the centre of the deepest zone could be outlined. Supervised drilling and testing of a 200m deep, 125 L/s production well. Ran additional simulations of well field performance for various well abstraction rates, so that the optimum well field yield could be determined.
SALMON RIVER HATCHERY Campbell River, B.C. 1985	J.S. McMillan Fisheries Ltd. Vancouver, British Columbia	Carried out hydrogeological assessment for 200 L/s groundwater supply to potential salmon hatchery sites in the Salmon River Valley. Supervised drilling of two test holes which both indicated presence of high yield aquifers. Completed one test hole as a production well for a pilot hatchery.
TYNEHEAD HATCHERY Surrey, B.C. 1985	Tynehead Zoological Society Surrey, British Columbia	Carried out hydrogeological assessment for a 15 L/s groundwater source for a proposed salmon hatchery in the upper reaches of the Serpentine River Valley.
CUSHEON COVE HATCHERY Saltspring Island, B.C. 1985-87	Hatfield Consultants Ltd. West Vancouver, British Columbia	Carried out hydrogeological assessment for a 3 L/s groundwater source in surficial sediments and fractured bedrock for a proposed salmon hatchery. Analyzed pump test data and prepared an assessment report on potential for impact on neighboring wells.
ANACLA INDIAN RESERVE NO. 12 Banfield, B.C. 1985	Chatwin Engineering Nanaimo, British Columbia (for Department of Indian and Northern Affairs, Nanaimo, British Columbia)	Carried out an assessment of performance of existing wells in the area and recommended two options for location of a new well for expansion of existing water system.
WAPITI OIL FIELD WATERFLOOD Grande Prairie, Alberta 1985	Petro-Canada Resources Calgary, Alberta	Evaluated local aquifers as potential alternative sources of injection water. Supervised drilling, production well completion and pumping tests in a jointed aquifer.

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LITTLE BOW RIVER RESERVOIR Alberta 1985	Alberta Environment Edmonton, Alberta	Conducted preliminary assessment of potential water losses from a proposed reservoir into the surrounding geological formation.
PINE COULEE RESERVOIR 1985	Alberta Environment Edmonton, Alberta	Conducted drilling and piezometer installation program. Assessed potential water losses from a proposed reservoir into the surrounding geological formation. Determined the distance at which the groundwater regime would be affected by reservoir impoundment. Delineated areas where local flooding might occur.
DRIFTWOOD SHOPPING CENTRE North Pender Island, B.C. 1985	Holouskey, Whitfield Piets & Associates Sydney, British Columbia	Conducted hydrogeologic assessment for a water well in fractural sandstone rock. Evaluated short pump test data of high capacity well in confined aquifer.
SPRING AND ARTESIAN WELL SURVEY Huxley, Alberta 1985	Alberta Transportation Airdrie, Alberta	Conducted hydrogeological survey of spring and wells prior to, during and after road construction to assess potential impact of activities on groundwater quality and yields.
HOLLANDALE WATER SOCIETY Hollandale, Alberta 1986	Alberta Environment Edmonton, Alberta	Supervised drilling, well installation and pumping tests in an alluvial aquifer under consideration as a groundwater supply for a farming community, in connection with a provincial drought relief scheme.
GRANUM GROUP WATER CO-OP Granum, Alberta 1986	Alberta Environment Edmonton, Alberta	Supervised drilling, well installation and pumping tests in an alluvial aquifer under consideration as a groundwater supply for a farming community, in connection with a provincial drought relief scheme.
WATERTON COMPLEX Waterton, Alberta 1986	Shell Canada Resources Limited Calgary, Alberta	Developed and aquifer tested an emergency water supply well with a safe yield of 20 L/s, for a sour gas plant.
RED DEER LAKE SCHOOL Red Deer Lake, Alberta 1986	Foothills School Division High River, Alberta	Evaluated local aquifers as potential sources of potable water. Supervised drilling, well completion and aquifer testing.
BADGER FLATS WATER WELL ASSOCIATION Claresholm, Alberta 1986	Alberta Environment Edmonton, Alberta	Supervised drilling, well installation and aquifer tests in a glaciofluvial aquifer. Well yield 3 L/s used to supply water for a farming community.
MUNICIPAL WELL FIELD Fruitvale, B.C. 1986	Regional District of Kootenay-Boundary Trail, British Columbia (in association with Kerr Wood Leida) Associates North Vancouver, British Columbia)	Conducted hydrogeological and extensive geophysical surveys to locate potential waterbearing zones within discontinuous glacial sediments. Drilled seven test holes and developed three production wells. Total developed well field capacity was 46.7 L/s.
NORTH HOWE WATER SOCIETY Fort McLeod, Alberta 1987	Alberta Utilities Edmonton, Alberta	Evaluated existing well impact on other groundwater users in the area.
WALHALLA WATERFLOOD PROJECT Grande Prairie, Alberta 1987	Petro-Canada Inc. Calgary, Alberta	Evaluated performance of operating supply wells and proposed program leading to increase in water production.
CAROLINE WELL TESTING Caroline, Alberta 1987	Gulf Canada Corporation Calgary, Alberta	Conducted a hydrogeological survey of existing wells and a spring prior to drilling of a gas well.
WAINWRIGHT WATERFLOOD Wainwright, Alberta 1987	Petro-Canada Inc. Calgary, Alberta	Conducted an aquifer test of a well 800m deep, yielding 5 L/s. Saline water to be used for waterflood.
HANGINGSTONE WATER SUPPLY Fort McMurray, Alberta 1987	Petro-Canada Inc. Calgary, Alberta	Evaluated local aquifers as potential source of water supply for an enhanced oil recovery project. Exploration drilling conducted included assessment of Quaternary and Cretaceous deposits. Supervised drilling, well installation and aquifer testing. Well yield in the order of 2 L/s.

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<p>LONGBOTTOM WATER SOCIETY Fort McLeod, Alberta 1987</p>	<p>Alberta Utilities Edmonton, Alberta</p>	<p>Evaluated existing well impact on other groundwater users in the area.</p>
<p>BROOKSWOOD NO. 9 WELL Langley, B.C. 1987</p>	<p>Township of Langley Langley, British Columbia</p>	<p>Supervised drilling of seven test holes and one 100 L/s test production well to assess hydraulics and water quality in a sand and gravel aquifer with stratified zones of high dissolved iron and Manganese concentrations. Feasibility of developing 50 to 100 L/s wells and eventual total well field capacity of greater than 250 L/s was assessed. Impact on a nearby existing well and a spring fed lake was also assessed.</p>
<p>FRASER VALLEY HATCHERY PROJECT 1987</p>	<p>Royal Pacific Sea Farms Ltd. Vancouver, British Columbia</p>	<p>Assessed feasibility of developing a 1,000 L/s capacity well field in the Fraser Valley. This office study involved a review of all high capacity wells in the lower Fraser Valley and delineation of areas where high yielded wells could be developed with little impact on neighboring wells and also maintain a discharge water temperature in excess of 8° C.</p>
<p>ILLICILLEWAET SPRING Revelstoke, B.C. 1987-88</p>	<p>CNSW Industries Inc. Vancouver, British Columbia</p>	<p>Assessment and monitoring of seasonal discharge quantities and quality of spring water, for proposed bottled water source.</p>
<p>LYTTON INDIAN BAND WATER SOURCES Lytton, B.C. 1987-88</p>	<p>David Nairne & Associates Ltd., North Vancouver, British Columbia</p>	<p>Supervised drilling and testing of three holes to assess feasibility of developing groundwater sources in discontinuous aquifers in an arid area.</p>
<p>SHIPS POINT AQUAFARM PROJECT Fanny Bay, B.C. 1987</p>	<p>Hatfield Consultants Ltd. West Vancouver, British Columbia</p>	<p>Assessed available data, carried out test pitting and geophysical survey to assess feasibility of developing a 150 L/s groundwater source. Also assessed possibility of recycling waste and impacts on neighboring wells.</p>
<p>CAPE MUDGE WATER SUPPLY Quadra Island, B.C. 1987</p>	<p>Kerr Wood Leidal Associates North Vancouver, British Columbia</p>	<p>Hydrogeological assessment, site selection and aquifer testing on a new 4.3 L/s well.</p>
<p>GREY CREEK FISH HATCHERY Sechelt, B.C. 1987</p>	<p>Aquarius Sea Farms Ltd. Sechelt, British Columbia</p>	<p>Assessed hydraulics of existing 95 L/s field, and potential for salt water intrusion into aquifer.</p>
<p>MUNICIPAL WATER SUPPLY Queen Charlotte City, B.C. 1987-89</p>	<p>Fownes Construction North Vancouver, British Columbia</p>	<p>Review of reports prepared by others on well field yields in fractured bedrock; carried out groundwater balance studies and assessment of actual yields and potential for salt water intrusion.</p>
<p>ZAMA LAKE PROJECT Zama, Alberta 1988</p>	<p>Esso Resources Canada Ltd. Calgary, Alberta</p>	<p>Groundwater survey, drilling and aquifer pump testing of a 12 L/s well source for water flooding of deep oil bearing formations.</p>
<p>BROOKSWOOD NO. 10 WELL Langley, B.C. 1988</p>	<p>Township of Langley Langley, British Columbia</p>	<p>Design, drilling and aquifer pump testing of new 27 L/s production well. Study also included an assessment of interference effects on nearby production wells.</p>
<p>STABRAWA SUBDIVISION South Langley, B.C. 1988</p>	<p>Bell & Giuriato Surveying and Engineering Ltd. Langley, British Columbia</p>	<p>Assessment of hydrogeology, groundwater supply potential and impact of septic tanks on proposed and existing wells. Supervision of aquifer pump testing of seven new wells and preparation of a summary report.</p>
<p>ESLER PARK WELL Williams Lake, B.C. 1988</p>	<p>Esler Soccer Association Williams Lake, British Columbia</p>	<p>Supervision of aquifer pump test of a 4.1 L/s well, monitoring of neighbours' wells, water balance assessment and preparation of a report in impact.</p>
<p>COMMUNITY WATER SUPPLY Prophet River Indian Reserve, B.C. 1988</p>	<p>David Nairne & Associates Ltd., North Vancouver, British Columbia</p>	<p>Hydrogeological assessment, site selection and aquifer testing on a new well.</p>
<p>COMMUNITY WATER SUPPLY 108 Mile, B.C. 1989</p>	<p>Cariboo Regional District Williams Lake, British Columbia</p>	<p>Review of data on existing wells, hydrogeological assessment, geophysics studies, drilling and development of a new 10 L/s water well and assessment of impact on existing wells.</p>

by
PITEAU ASSOCIATES

PROJECT Title/Date	CLIENT	DESCRIPTION
REGIONAL GROUNDWATER SUPPLY ASSESSMENT south of Powell River, B.C. 1988	Kerr Wood Leidal Associates North Vancouver, British Columbia	Review of available data, review of performance of existing wells, delineation of aquifers and assessment of potential for developing new groundwater sources.
MUNICIPAL WELL NO. 5 City of Grand Forks 1988	Kerr Wood Leidal Associates North Vancouver, British Columbia	Review of data on existing wells, hydrogeological assessment, drilling and development of a new 150 L/s water well and assessment of impact on existing wells.
HOPETOWN VILLAGE WATER SUPPLY Watson Island, B.C. 1987-89	Kerr Wood Leidal Associates North Vancouver, British Columbia and Indian and Northern Affairs Canada	Site assessment and evaluation of aquifer pump test of 0.8 L/s well in fractured bedrock.
GROUNDWATER SOURCES IN UPPER LILLOOET VALLEY British Columbia 1989	Kerr Wood Leidal Associates North Vancouver, British Columbia	Site assessment for groundwater supply to six small Indian Band communities and one small village.
FRASER VALLEY TROUT HATCHERY WELL REDEVELOPMENT 1988-89	Urban Systems Ltd. Richmond, British Columbia	Evaluation of performance of four existing production wells with yields ranging from 40 L/s to 160 L/s. Supervision of screen redevelopment and re-testing of wells.

LIST OF MICRO-COMPUTERS AND SOFTWARE
USED BY PITEAU ASSOCIATES GROUNDWATER GROUP

APPLICATION	NAME	PROGRAM TYPE	DESCRIPTION OF PROGRAM ³	ORIGIN	COMPUTER HARDWARE ² USED
STEADY STATE SEEPAGE ANALYSIS	GEOSPG ⁽¹⁾	Two dimensional finite element model.	Develops a contoured graphical plan or section of seepage pressures and potential heads. Has free-surface capability for determination of water table position.	University of Waterloo and Piteau Associates	HP 9845
	GEOSAT ⁽¹⁾	Two dimensional finite element model.	Develops digital data of the unsaturated and saturated flow zones in both plan and section. Will handle evapotranspiration and both constant head and flux boundary conditions.	UNSAT-2 program developed by Shlomo Neuman at University of Arizona. Modified by Lynx Geosystems	HP 9845
TRANSIENT SEEPAGE ANALYSIS	GEOTSP ⁽¹⁾	Two dimensional finite element model	Develops a contoured graphical section of saturated seepage pressures and potential heads at predetermined time steps. Faster to run than GEOSAT-2 but does not consider flow in unsaturated zone.	Piteau Associates and Lynx Geosystems	HP 9845
	GEOBAS	Two or three dimensional finite difference model.	Computes equipotential distribution at successive time steps and plots results of selected time steps.	Piteau Associates	HP 9845
	MOD-FLOW	Two or three dimensional finite difference model.	Computes equipotential distribution at successive time steps and plots results of selected time steps.	U.S. Geological Survey	IBM - XT/AT
TRANSIENT HORIZONTAL FLOW	GEUAQF	Two dimensional finite element model.	Develops a contoured graphical plan of potential head distribution in an aquifer. Can consider constant head, constant and variable flux and constant and variable flux and partially penetrating boundary conditions.	Based on the AQUIFEM-1 program developed at Department of Civil Engineering, MIT	HP 9845
TRANSIENT HEAT TRANSPORT SIMULATION	GEOCCS	Two dimensional finite element model.	Superimposes transient conduction of heat upon two-dimensional steady-state groundwater flow.	Piteau Associates	HP 9845
	GEUDRW ⁽¹⁾	Two dimensional analytical Theis program.	Uses the Theis formulae to calculate well field drawdowns. Will handle simple boundary conditions. Contoured output of drawdown or water table surface.	Piteau Associates and Lynx Geosystems	HP 9845
WELL FIELD HYDRAULIC AND PUMP TEST	GEOPMP ⁽¹⁾	User interactive analytical data processing program.	Accepts digitized data from the field and calculates drawdown and elevations of piezometric heads and the water table.	Piteau Associates and Lynx Geosystems	HP 9845
	GEOGPR ⁽¹⁾	User interactive analytical data analysis program.	Using formulae or type curve methods, allows for interactive analysis of aquifer parameters.	Piteau Associates and Lynx Geosystems	HP 9845
GEOCHEMICAL ANALYSIS	GEOCEM	Analytical data analysis program.	Determines ionic concentrations mineral, saturation levels and plots graphical output of data.	Piteau Associates (modified from USGS WATEQF Program)	HP 9845 (Not user friendly)
CONTAMINANT DISPERSION	SOLUTE	Two dimensional finite element	Calculates concentrations of specific ions in a groundwater flow systems, both in plan and section.	International Groundwater Modelling Institute	IBM - XT/AT
GROUNDWATER ANALYSES	SWAZOO ⁽¹⁾	Borehole data base management	Stores information on borehole lithology, construction, water chemistry, etc. Enables plotting and tabulation of regional trends.	Lynx Geosystems and Piteau Associates	HP 300 series

- NOTES: 1. All these programs are available from Lynx Geosystems Ltd.
2. Piteau Associates have a Hewlett-Packard 9845 computer, one IBM - PC AT and one IBM - PC XT compatibles. Plotting is carried out using standard graphics packs: On either a dot matrix printer or on an HP 7475 multi pen plotter.
3. In addition to those listed, the group also uses a number of Utility Programs, eg. VP-Planner/Lotus 1-2-3, Word Perfect, Time Line, etc.

APPENDIX C

RESUMES

ANDREW T. HOLMES, B.A.Sc., P.Eng.

Senior Hydrogeologist

Mr. Holmes joined Piteau Associates in 1979. He graduated from the University of British Columbia in 1976 with a B.A.Sc. in geological engineering.

During the past thirteen years, Mr. Holmes has been working on hydrogeological and some geotechnical studies for municipal, mining and industrial projects in western Canada and abroad. He has acquired practical and technical experience in geology, aquifer analysis, computer modelling and instrumentation techniques.

During the last ten years, he has worked on a wide range of hydrogeological studies including geological mapping, pit dewatering, slope depressurization, underground mine and tunnel seepage evaluation, planning and supervision of test drilling programs, well hydraulic and aquifer analyses, water level and quality monitoring and extensive computer modelling. Most of the field programs involved drilling, installation of piezometers, field tests to determine soil or rock mass permeability and hydrogeological mapping. Office analyses included aquifer pump test analysis and seepage analysis using transient and steady-state finite-element computer models for both saturated and unsaturated porous media.

Mr. Holmes has worked on many mine related projects. He has carried out hydrogeology programs at many coal and base metal mines as part of slope stability, mine dewatering and environmental studies, and has also performed seepage analyses for underground mines and tunnels in Canada, China and the Andes Mountains in Chile. He has recently completed hydrogeological investigations and prepared environmental submissions for a number of small mines in British Columbia, most of which have now been permitted and are currently operating.

Mr. Holmes has been involved with the design of dewatering systems for municipal and construction projects. These include the Brookwood Subdivision, Langley, British Columbia, the Alouette Dam Rehabilitation Project in British Columbia, and the Suncor Inc. oil sands mine at Fort McMurray, Alberta. More recently, he has evaluated two schemes for subsurface detention of storm water for proposed subdivisions.

He has also been involved with or has carried out evaluations for environmental assessments of a proposed Greater Vancouver Regional District Landfill in Delta, British Columbia and for numerous small landfills around the Province, for drainfields on proposed subdivisions in various parts of British Columbia and for gas plants in Alberta. Recently, he has been involved with the hydrogeological aspects of cleaning up a chemical spill near the Fraser River at Fort Langley, British Columbia.

Mr. Holmes has performed a variety of hydrogeological evaluations for proposed well fields at salmon hatchery sites involving supervision of construction and testing of the high capacity wells, evaluating well field yields and long term water temperature trends.

June 1989

ANDREW T. HOLMES, B.A.Sc., P.Eng.

Senior Hydrogeologist

EDUCATION

- . B.A.Sc., Geological Engineering, University of British Columbia, Vancouver, B.C., 1976.
- . Short course in computer modelling of groundwater flow, International Groundwater Modelling Center, Butler University, Indianapolis, Indiana.

FIELDS OF SPECIAL COMPETENCE

- . Mine dewatering studies, tunnel inflow studies, design, construction and testing of well fields.

PROFESSIONAL HISTORY

1985/Present - Associate and Senior Hydrogeologist, Piteau Associates Engineering Ltd.

1979/1985 - Senior Hydrogeologist, Piteau Associates Engineering Ltd.

- . Hydrogeological studies for mine dewatering and slope depressurization at Island Copper Mine, Cassiar Asbestos, Quintette Coal, Westar Mining and Byron Creek Collieries, British Columbia; Los Bronces Mine, Chile, Cardinal River Coals, Dentherm Coalspur Project and Gregg River Coal, Alberta; Anvil Mine, Yukon Territories.
- . Hydrogeological studies for mine permitting of North American Metals' Golden Bear Property, Minnova Inc.'s Samatosum Project, Cheni Gold Mines' Lawyer Mine, Skyline Exploration Ltd.'s Johnny Mountain Mine, and Candorado Mines' Hedley Tailings Project.
- . Preliminary test work for a proposed in-situ leach method gold mine near Quesnel, B.C.
- . Installation of systems to monitor groundwater quality at seven gas plants in Alberta. Program involved installing and monitoring piezometers, and analyzing and reporting initial results.
- . Chemical spill cleanup at Fort Langley, B.C. The study involved delineating the extent of the contaminated area, and then designing and implementing a recovery program to remove the ethylene dichloride and caustic soda from the soil and groundwater at the site.

ANDREW T. HOLMES, B.A.Sc., P.Eng.

Senior Hydrogeologist

**PROFESSIONAL
HISTORY (cont'd.)**

- . Modelling study to determine groundwater flow directions and velocities as part of environmental impact assessment for proposed Greater Vancouver Regional District Landfill, Delta, British Columbia.

Hydrogeological evaluation to address closure of Jackman Landfill, Langley, British Columbia. The evaluation included computer modelling, review of geochemistry data, an assessment of environmental impacts, and recommendation of possible remedial measures. Currently monitoring groundwater quality around the landfill on a regular basis.

- . Hydrogeologic studies to assess seepage to underground openings: Y Gold Mine Project, China; Los Bronces Transport Tunnel, Chile; CP Rail Rogers Pass Tunnel, British Columbia; Eagle Point Mine, Saskatchewan.
- . Site investigations and design of dewatering systems for the Alouette Dam Rehabilitation Project, British Columbia, and for the Suncor Inc. oil sands mine, near Fort McMurray, Alberta.
- . Design of seepage interception trench and water supply well pumping schedule to mitigate flood conditions at Brookwood Subdivision, Langley, British Columbia.
- . Design and installation of interception system to control artesian flow of water at Vanac Development Corporation's Terrace Court Development in Coquitlam, B.C.
- . Evaluation of groundwater impact on proposed storm water detention pond for Holly Meadows Subdivision, Ladner, B.C.
- . Assessment of all-weather playing fields proposed for storm water detention in Surrey, B.C.
- . Hydrogeological studies to locate and design community drainfields for disposal of domestic effluent on Saltspring Island, on Quadra Island and in the interior of British Columbia. The Saltspring Island project required a number of fields with a total capacity of 640,000 Lpd.

ANDREW T. HOLMES, B.A.Sc., P.Eng.

Senior Hydrogeologist

**PROFESSIONAL
HISTORY (cont'd.)**

- . Site investigation to evaluate potential for on site disposal of septic effluent on an individual lot basis. These investigations have been carried out for a subdivision in Langley, for many Indian Reserves in northern and southwestern British Columbia, and for a property south of Powell River on which a small apartment building had previously been condemned and removed due to septic effluent contamination.
- . Site investigations and design of wells for groundwater supply including Bowron River Hatchery, Chilliwack River Hatchery, Spius Creek Hatchery, Clearwater River Hatchery, Quesnel River Hatchery, Mahood River Hatchery, Salmon River Hatchery, Fruitvale Waterworks District and Blackcomb Mountain Restaurant.
- . Geotechnical and hydrogeological evaluation of a number of Indian Reserves in British Columbia, to determine water supply and subdivision potential, generally performed as part of community planning or subdivision design studies.

1976/1978 - Junior Engineer; Golder Geotechnical Consultants Ltd., Vancouver, British Columbia.

- . Hydrogeological study for dewatering and slope depressurization, Hat Creek Coal Project, Cache Creek, British Columbia.
 - . Geotechnical and hydrogeological study for design of Key Lake Mine, Saskatchewan.
- PROFESSIONAL
AFFILIATIONS**
- . Association of Professional Engineers of British Columbia.
 - . International Association of Hydrogeologists.

June 1989

DAVID J. TIPLADY, B.A.S.c., P.Eng.

Groundwater Engineer

Mr. Tiplady is an intermediate groundwater engineer with Piteau Associates. He holds a Bachelor of Applied Science Degree in Civil Engineering from the University of British Columbia, and is a registered Professional Engineer (B.C.).

Mr. Tiplady's experience includes design, construction and evaluation of well fields and dewatering systems, hydrogeological evaluation of sites for septic effluent disposal, as well as collection, synthesis and interpretation of groundwater related data. He is also experienced with management, analysis and presentation of information using a variety of computers.

Since joining Piteau Associates in July, 1987, Mr. Tiplady has been involved with, or has carried out, hydrogeological evaluations for groundwater supply studies, dewatering, leaking underground gasoline storage tanks and groundwater quality. This has involved supervision of exploratory well drilling, aquifer testing, installation of piezometers and water quality monitoring.

Prior to joining Piteau Associates, Mr. Tiplady was with Hydrogeological Consultants Ltd. in Edmonton, Alberta. His responsibilities included supervision of test drilling and aquifer testing at several locations including Edson, Alberta. He was also responsible for design and implementation of various groundwater related computer applications.

November, 1988

DAVID J. TIPLADY, B.A.Sc., P.Eng.

Hydrogeologist

EDUCATION

- . B.A.Sc., Civil Engineering, University of British Columbia, 1984.

FIELDS OF SPECIAL COMPETENCE

- . Design, construction and testing of well fields and dewatering systems, electronic data acquisition, processing and analysis.

PROFESSIONAL HISTORY

July, 1987/Present - Hydrogeologist, Piteau Associates Engineering Ltd.

- . Hydrogeological studies and site investigation of a groundwater supply of up to 75 L/s to be used for proposed land based salmon farm on western Vancouver Island.
- . Hydrogeological studies for design and construction of dewatering systems in Coquitlam, B.C. and Pemberton, B.C. Design field supervision and evaluation of: test pits, dewatering wells, well point systems, and infiltration trenches.
- . Hydrogeological investigations related to push/pull testing conducted at Wingdam, B.C. Program included supervision of drilling six drillholes in unconsolidated sediments, installation of piezometers and well screens, and hydraulic testing of completions. Field program included aquifer testing, pump testing, water quality monitoring and supervision of push/pull test using a soluble tracer material.
- . Investigations related to leaking underground gasoline storage tanks under a major road intersection in Richmond, and Victoria, B.C. Both programs included interpretation of existing information and drawings for the area and delineation of possible contaminant flow paths.
- . Supervision of groundwater exploration drilling programs near Lytton, B.C., Prophet River, B.C. and Zama, Alberta. Collection and interpretation of field data and preparation of covering reports.
- . Supervision of a test drilling program to investigate seepage losses from mine tailings pond in northern B.C.
- . Evaluation of surficial soils for suitability for inground waste water disposal at several locations in B.C. including Prophet River, River's Inlet, Tofino and Lytton.

DAVID J. TIPLADY, B.A.Sc., P.Eng.

Hydrogeologist

PROFESSIONAL
HISTORY (cont'd.)

- . Establishment of electronic monitoring station near Revelstoke, B.C. to establish minimum groundwater flows from a mountain spring.

Sept '85/July '87 - Junior Engineer, Hydrogeological Consultants, Edmonton, Alberta.

- . Conducted hydrogeological investigations relating to development of additional groundwater supplies for the Town of Edson, Alberta. Coordination of preliminary field investigation, supervision of exploratory water well drilling and completion. Program included extensive aquifer testing at rates up to 50 L/s, and automatic monitoring of water levels at five observation wells; plotting and interpretation of data, finite difference modelling and preparation of project report.
- . Designed and implemented personal computer data base to access and process data from over 275,000 water wells in Alberta. Also supervised development of a colour graphic system to display data.
- . Responsible for coordination and supervision of field work and preparation of project reports for several water supply related studies.

May 1984/May 1985 - Engineer-in-Training, First Watercourt Systems Ltd., Vancouver, B.C.

- . Assessed water pumping and distribution system of small village and prepared technical report. Installed and calibrated stream flow measuring network in central B.C. watershed. Developed subroutines for water resource computer software package.

PROFESSIONAL
AFFILIATIONS

- . Association of Professional Engineers of British Columbia.

LANGUAGE CAPABILITY

- . English

CITIZENSHIP

- . Canadian

November, 1988

DWAYNE HOGG, B.A.Sc.

Junior Geotechnical Engineer

Mr. Hogg is a junior geotechnical engineer with Piteau Associates. He holds a B.A.Sc. degree in Geological Engineering from the University of New Brunswick.

Since joining Piteau Associates, Mr. Hogg has been involved with numerous hydro-geological investigations and monitoring programs. These include groundwater monitoring programs around two landfill sites, an assessment of soil and groundwater conditions for a proposed subdivision adjacent to the Fraser River, and an inventory of groundwater supplies near Powell River as part of a groundwater resource study. He has supervised drilling for a foundation investigation and has recently been involved with site inspection services for construction of a tailings dam, sedimentation pond and related works for a new mine north of Kamloops, B.C.

April, 1989

DWAYNE HOGG, B.A.Sc.

Junior Geotechnical Engineer

EDUCATION

B.A.Sc., Geological Engineering, University of New Brunswick, 1988.

FIELDS OF SPECIAL COMPETENCE

Geotechnical and hydrogeological data collection and analysis, site services, laboratory testing.

PROFESSIONAL HISTORY

1988/Present - Junior geotechnical/hydrogeological engineer, Piteau Associates Engineering Ltd.

- . Site supervision/inspection for tailings dam, sedimentation pond and related works for new mine near Kamloops, B.C.
- . Piezometer installation and initial monitoring of groundwater, Katzie Indian Reserve No. II.
- . Environmental impact assessment for a demolition materials landfilling project, including drilling supervision and ongoing groundwater monitoring, Delta.
- . Ongoing groundwater sampling and monitoring program for sanitary landfill, Langley.
- . Laboratory analysis and classification of soil samples from various sites.
- . Stability analysis of open pit walls at Cassiar Mine from daily surveyed prism co-ordinates, using Lotus 1-2-3.

1987/Summer - Brunswick Mine, Bathurst, New Brunswick

- . Designed cable bolting plans for stope backs.
- . Assisted in locating seismic events using a multi-channel microseismic monitor.
- . Assisted in grouted cable bolt pull tests to determine strength characteristics of different grout mixtures.
- . Mapped structures in recently mined underground stopes; classified rock strength of structures using Geomechanics and NGI classification systems.
- . Took extensometer readings in various stopes to measure convergence rate.
- . Worked with members of Noranda Research Centre (NRC) in gathering data on the roughness and waviness of the joint planes found on the sedimentary hanging wall.

LANGUAGE CAPABILITY

- . English

CITIZENSHIP

- . Canadian

April, 1989

JAMES D. TOD

Junior Geotechnical Engineer

EDUCATION

B.A.Sc., Geological Engineering, University of British Columbia, 1988.

FIELDS OF SPECIAL COMPETENCE

Rock mechanics and engineering geology.

PROFESSIONAL HISTORY

1988/Present - Junior geotechnical engineer, Piteau Associates Engineering Ltd.

- . Geological/geotechnical field mapping for a downtown realty development, Vancouver.
- . Laboratory analysis and classification of soil and rock samples from various sites.
- . Laboratory durability testing of proposed rockfill from Brinco Mining Limited, Cassiar, B.C.
- . Preliminary pillar design, evaluation of proposed underground mining layouts for Pioneer Metals Corp., Puffy Lake Mine.
- . Stability analysis of open pit walls at Cassiar Mine, from daily surveyed prism coordinates using Lotus 1-2-3.

1988/Summer-Fall - Highwall Monitoring Engineer, Thurber Consultants Ltd., Ft. McMurray, Alberta.

- . Supervised dragline operations.
- . Monitored slope inclinometers and pneumatic piezometers; evaluated data with respect to dragline stability.
- . Monitored and documented heave failures on dragline bench.

1987/Summer - Junior Geologist, Placer Dome Inc., Laonil Lake, Saskatchewan.

- . Local and regional mapping/prospecting, soil sampling, channel sampling, drafting.

LANGUAGE CAPABILITY

- . English

PROFESSIONAL AFFILIATIONS

- . Engineer-in-training, Association of Professional Engineers of British Columbia

CITIZENSHIP

- . Canadian

January 1989