B.C.Hydro

Meager Creek Geothermal Project

Summary Report for 1982-83

Meager Creek Project staff
Vancouver
July 1983

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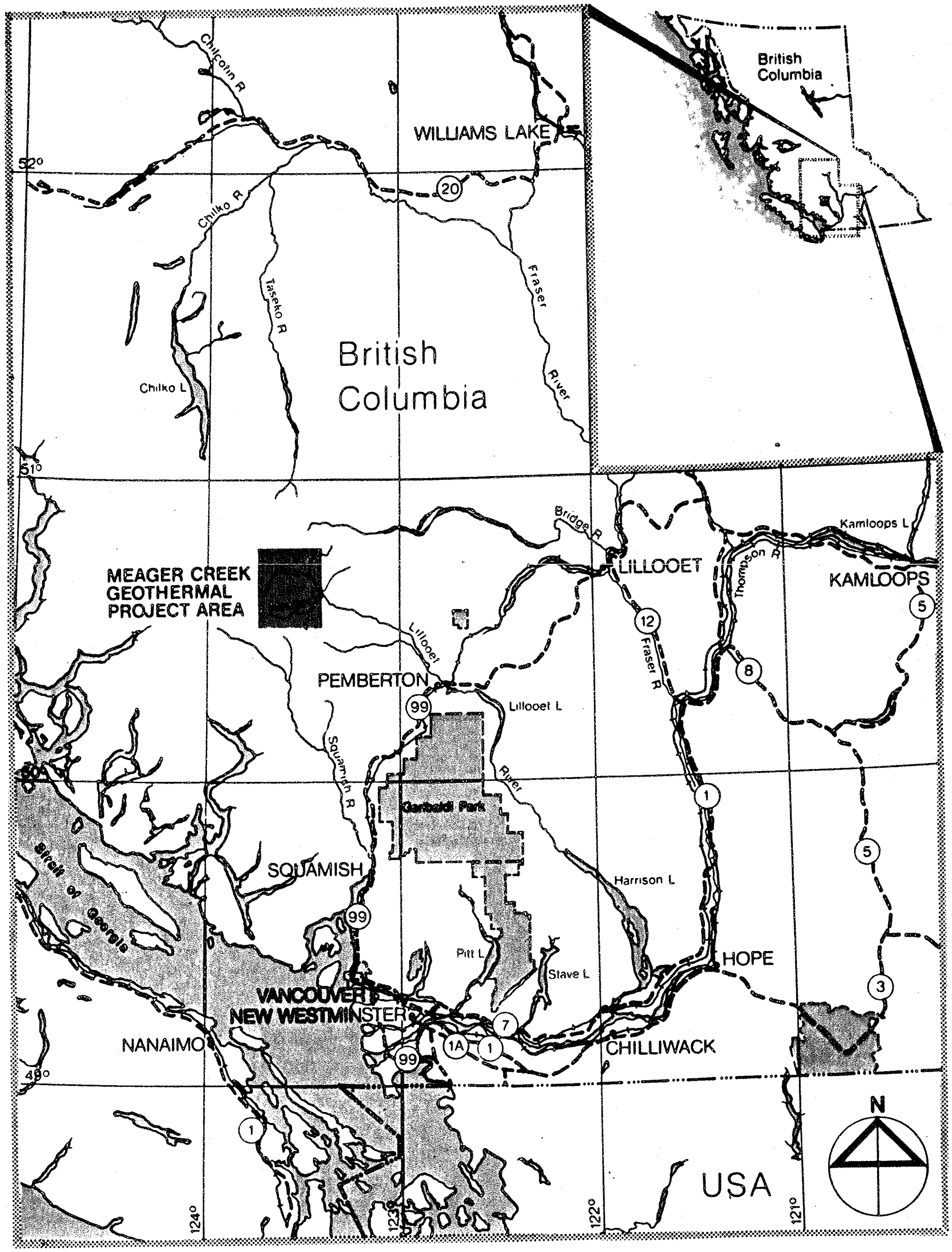


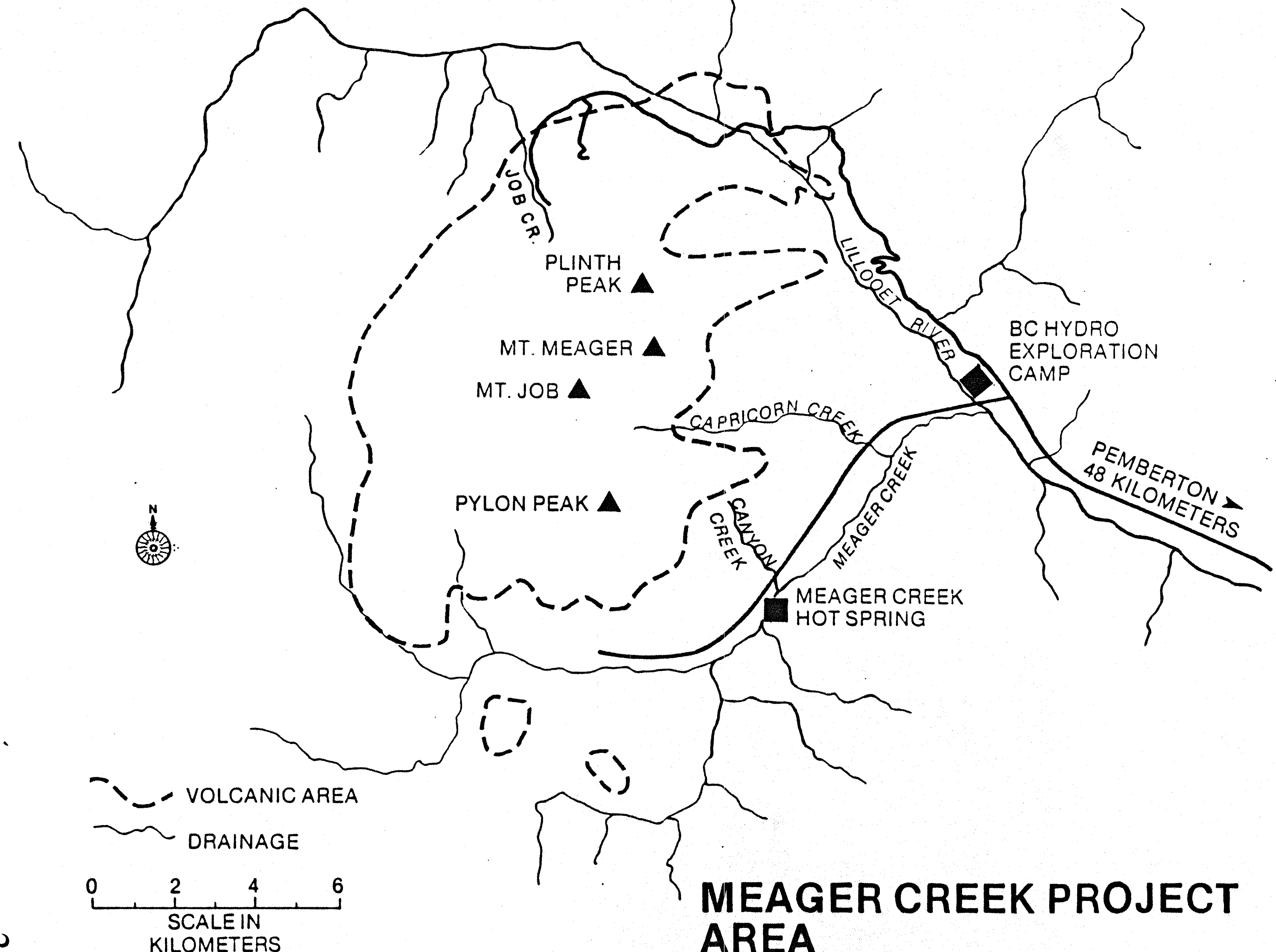
LEGEND

- highway
- railway
- city town
- park

SCALE 1 : 2 000 000

Kilometres 20 0 20 40 60 80 100

Location map



MEAGER CREEK PROJECT AREA

1. SUMMARY CONCLUSIONS

1. A geothermal resource with a base temperature of 190-200°C has been identified in the South Reservoir area of the Meager Creek Project. Intersected at a depth of 1 200 to 1 600 m, geothermal fluids are postulated to originate from beneath the Meager Volcanic Complex and to upflow along the Meager Creek Fault Zone.

2. Alteration studies indicate recent volcanic activity has produced two chemically distinct hydrothermal systems with a possibility of a third one yet to be discovered. Alteration patterns indicate that the shallow, low temperature (<140°C) reservoir is the result of near surface mineral deposition, producing a low permeability barrier to deeper, hotter fluids. The second 190 to 200°C reservoir was partially intersected by the MC-1, and possibly MC-3 wells. Geochemical data suggest that an undiscovered, high temperature (>200°C) resource may be present at depth.

3. The resource is fracture dominated; host rocks demonstrate low permeability and porosity. As such, the discharge capability of the wells drilled to date appears to be limited by the low flow/recharge characteristics of the rocks surrounding the bore. However, the No-Good Zone (encountered by MC-3) may provide a highly fractured conduit to geothermal fluids. The present condition of the MC-3 bore, however, makes an accurate evaluation of this feature impossible.

4. The discharge of MC-1 has provided the most comprehensive information on present reservoir conditions. Within environmental and budgetary constraints, the discharge will be continued and monitored on a regular basis. The information gained on pressure, temperature and chemical changes should be a useful guide to future exploitation strategy.

5. The results of exploration at Meager Creek are promising and the possibility of a successful geothermal discovery are encouraging. However, before an accurate evaluation of the preliminary exploration program can be made, more exploratory and testing work is required. A brief discussion of further requirements for a successful development is presented within this text.

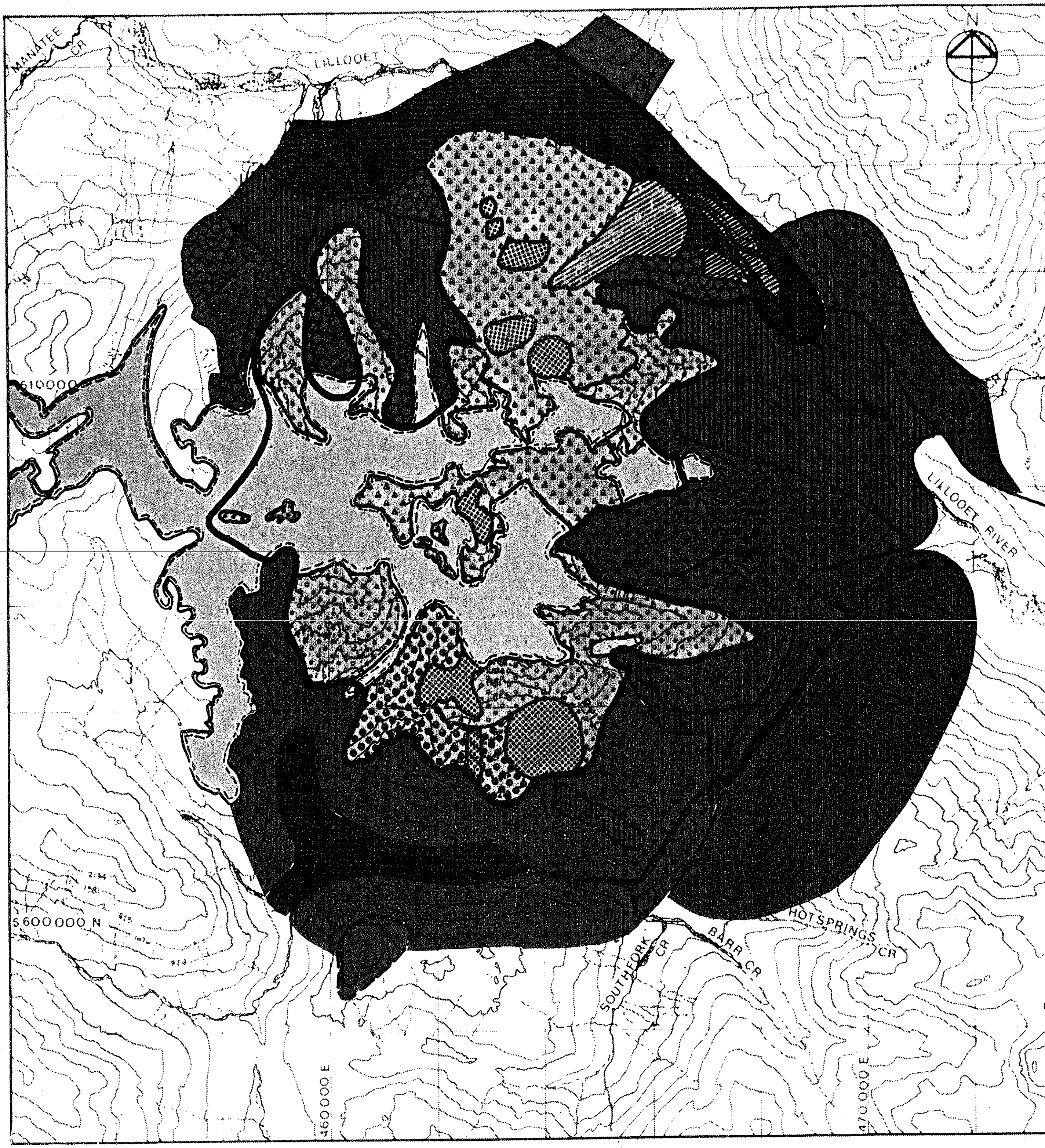
2. INTRODUCTION

2.1 Previous Work

Prior to 1981, a program of geothermal reconnaissance and exploration in the Meager Mountain area of the upper Lillooet River region of southwest British Columbia was conducted (Figures 1, 2). The program, initiated late in 1973, identified a near surface thermal anomaly along Meager Creek in an area referred to as the South Reservoir.

Intensified exploration, primarily involving surface geological mapping, geophysical resistivity surveying, and shallow (100 m to 1200 m) diamond drilling, progressively narrowed the target area. Earlier work (1974-1978), utilizing geophysical resistivity surveys, identified a broad, low resistivity anomaly thought to be associated with upwelling thermal groundwater. Subsequent diamond drilling confirmed the presence of shallow, hot water with five of fourteen wells encoutering temperatures in excess of 100°C (including a maximum of 202°C measured at a depth of 367 m in drill hole "M7-79D"). Work in 1979-1981 focussed on targeting a deep exploratory well with continued diamond drilling, detailed surface mapping, geochemical prospecting, and geophysical surveying (Figures 3, 4). Exploration was also extended to include geothermal reconnaissance in surrounding areas of the Meager Mountain Complex. Included is the "North Reservoir" where one diamond drill hole, situated on a resistivity anomaly, encountered a temperature of 103°C.

The scale of exploration was further expanded, in 1981,



LEGEND

Quaternary-debris Flows, overburden

MEAGER VOLCANIC COMPLEX (Quaternay-Tertiary)

Vent showing age (from K-Ar dates) in millions of years (Read 1979).
Bridge River Assemblage (<.025 my) - rhyodacite flow, ash & pumice.
Mosaic Assemblage (<0.1 my) - basalt.
Plinth, Capricorn, Devastation Glacier Assemblages (0.1 my) - rhyodacite flows, breccia, ash.
Devastation Glacier & Pylon assemblage (0.5-0.9my) - andesite flows & breccia.
Devastator Assemblage (1.0-1.9my) - rhyodacite & dacite flows and basal breccia (plutonic blocks).
Extent of Meager volcanic complex.

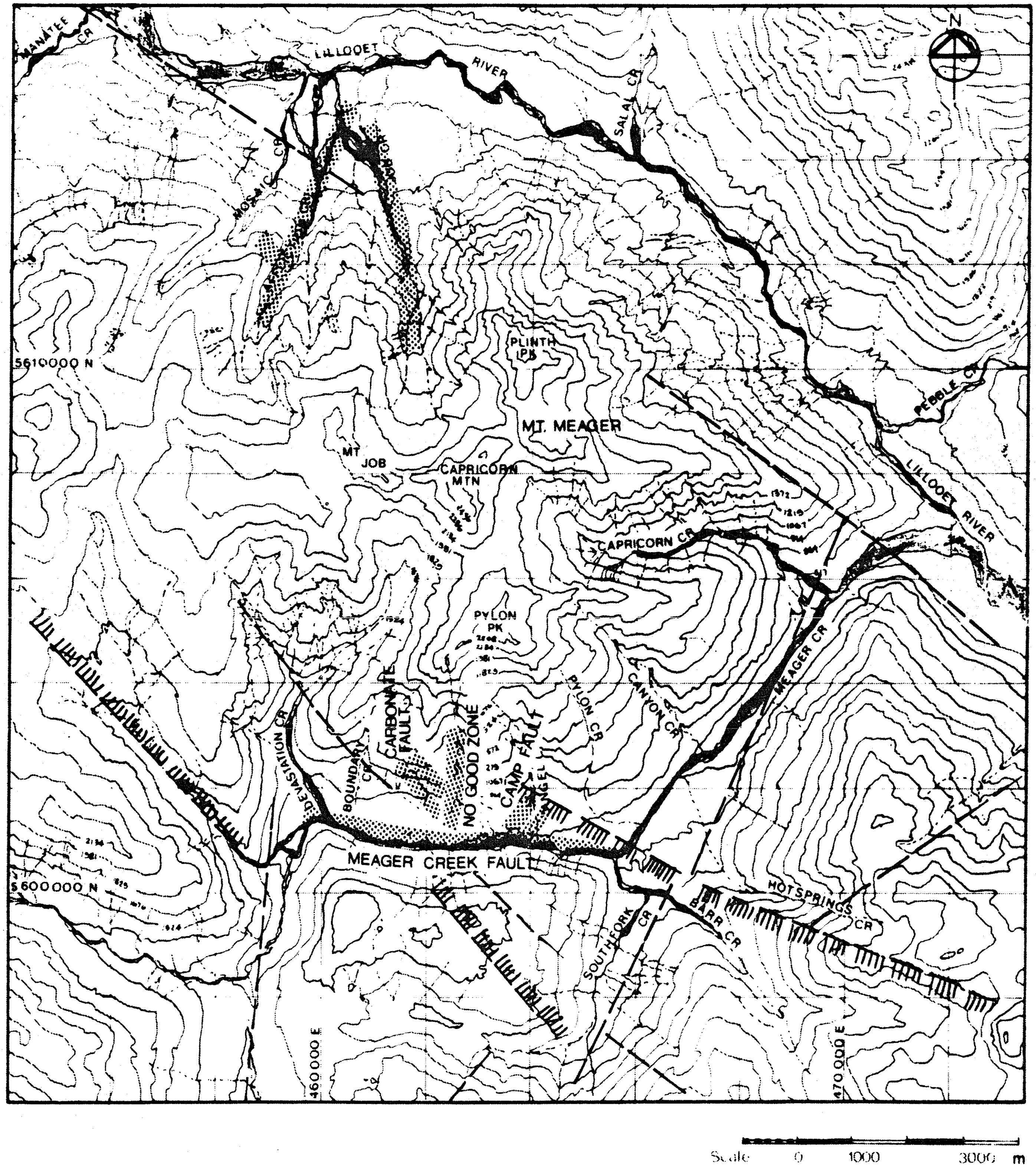
Scale 0 1000 3000 m

BASEMENT COMPLEX

Fall Creek and Affliction Creek Stocks (Tertiary) - quartz monzonite.
Spidery Peak Pluton (Cretaceous) - fresh biotite-hornblende quartz diorite.
Quartz Diorite (Cretaceous and/or Jusassic) - variably foliated and altered with related plutonic rocks.
Metamorphics (Triassic?) including amphibolite, greenstone & phyllite

Extent of Permanent Ice Sheet

General geology of the Meager Creek area



LEGEND

Possible Faults (from field mapping and aerial photo interpretation (NSBG 1979-82 a)

Lineations (from satellite and aerial photo interpretation (NSBG 1981).

Extent of Ryan Creek Lineation (NSBG 1981)

Structural map of Meager Creek project area

with the decision to commence a deep well exploration program involving the drilling of three large diameter exploratory test holes to depths of approximately 3 500 m. The first deep well, MC-1, was spudded on 11 July 1981 and was completed four months later. Despite the loss of 500 m of drill pipe in the bottom of the 3 000 m hole, an encouraging temperature of 219°C was recorded at 2 500 m and the well became the first (and to date, the only) geothermal bore capable of sustained steam production in Canada. A second deep well started in late 1981 was directed northeastward beneath the Meager Mountain complex. Drilling and completion testing extended into the 1982-83 season.

Deep exploration was augmented by continued resistivity surveys, soil and water geochemistry surveys, geological mapping, and diamond drilling in both the North and South Reservoir areas.

2.2 Work Done in 1982-83

Full scale exploration in the South Reservoir area continued through the winter of 1981-82 with the successful completion of MC-2, the second deep exploratory well, in late March. Completion tests were conducted over the next month, recording a maximum bottom hole temperature of 270°C. Drilling of a third deep well commenced in late April, shortly after the rig was moved from the MC-2 site, and was completed in early August. Temperatures up to 290°C were measured in the subsequent completion tests. Initial attempts to stimulate the deep wells have met with limited success with neither MC-2 nor MC-3 proving capable of sustained discharge in their present state. Due to the poor

How about lack of positive chlg. results.

economic climate and low electrical load forecasts, the geothermal program was suspended in August of 1982. Most of the major site equipment inventory had been demobilized and the work was reduced to include limited testing and the site maintenance program. All three deep wells continued to be monitored through the autumn and winter of 1982-83.

Activity in the North Reservoir during 1982-83 was aimed towards evaluation of the resource potential as identified in seasons previous. Geophysical and geochemical surveys conducted during the summer were performed on a broad scale, covering the northern flanks of the Mount Meager complex as far north as Manatee Creek and partially extending toward Silt Lake. Attention was focussed on the Job-Affliction Creeks area where H_2S gas emmanations and low resistivity values have been recorded. Resistivity coverage was extended and, augmented with data from previous seasons, succeeded in defining a number of new anomalous areas as well as closing off previously open-ended anomalies. Water geochemistry performed in most of the major drainages in the North Reservoir did not reveal any major anomalies although several elevated values were coincident with zones of low resistivity. Surface geological mapping was continued in the Job-Affliction-Mosaic region, completing preliminary efforts initiated in late 1981.

During 1982, five diamond drill holes, again mostly in the North Reservoir area were completed. Three holes, L4, L5, and L6 were re-occupied in the spring after operations had been suspended for the 1981 winter season. L4 proved to be the most significant, attaining a temperature of 125°C at a depth of 1279 m (to date, the deepest diamond drill hole at Meager Creek). Two additional holes were drilled later in the season to test resistivity, geochemical and geological targets. Both L7, drilled at the 1850 m elevation (6000'), and L8, in the lower reaches of Affliction Creek added significantly to the body of information regarding the nature of the North Reservoir.

In addition to fieldwork, a number of laboratory studies were conducted.

1. An alteration study by University of Utah Research Institute (UURI) on diamond drill core distinguished at least two distinct alteration events occurring in response to recent geothermal activity and suggested an active, high temperature reservoir remains to be discovered. Petrographic studies by UURI on rotary drill chips are still in progress.

2. The dating of alteration events is currently being undertaken by Southern Methodist Univeristy in Dallas, Texas, although results are not anticipated before fall, 1983.

3. A heat flow study was conducted in order to provide a basis of comparison between temperature and lithological data throughout the Meager Creek Project area.

In order to provide more efficient management of the growing body of information on the Meager Creek Project, a computer based data retrieval system was implemented in January 1983. The system will allow improved access to drilling, survey and invoice information, and will greatly expand the data processing capabilities of the project.

2.3 Consultants, Contracting and Subordinate Services

The following organizations carried out specific areas of the work under direct control of the Project Engineer.

Deep Drilling:

Drilling Contractor	-	Westburne Drilling (Canada) Ltd.
Major Service Contractors		
Cementing	-	Dowell Canada Ltd.
Directional Drilling	-	Canadian Directional Drilling Services
Drilling Fluid	-	Reef Mud
Supply Contractors		
Drill Bits	-	Smith Tool
	-	Western Rock Bit Company Company Ltd.
	-	Dresser Industries
Casing	-	Dominion Oilfield Supply Company Limited
	-	Wilson Oilfield Supply
	-	Ash Pipe Co.
Wellheads	-	ACF Canada Limited
Testing Equipment	-	Otis Engineering
	-	NOWSCO
	-	Dowell of Canada
Rig Supervision	-	KRTA Ltd. (to June 1982)
	-	B.C. Hydro (from June 1982)
Rig Geology	-	Nevin Sadlier-Brown Goodbrand Ltd.

Slim Diamond Holes:

Drilling Contractors	-	B.C. Hydro, Force Construction
	-	D.W. Coates Enterprises Ltd.
Rig Supervision	-	Nevin Sadlier-Brown Goodbrand Ltd.

Exploration:

Field work	-	KRTA Ltd.
	-	Nevin Sadlier-Brown Goodbrand Ltd.
Resistivity	-	Premier Geophysics Inc.

Other Analytical Work:	-	University of Utah Research Institute
	-	Southern Methodist University

Geochemistry Laboratory Testing:

Routine analysis	-	KRTA Ltd. (using B.C. Hydro field laboratory)
	-	B.C. Hydro R & D Laboratory
Isotope analysis	-	University of Waterloo, Ontario
	-	Institute of Nuclear Sciences, New Zealand
	-	University of Utah Research Institute (UURI)

Well Measurements:

Logging Services	- N L McCullough - Bear Tools
Other Measurements	- KRTA Ltd. (to March 1982) - B.C. Hydro (from April 1982) - Well Production Testing, Inc.

Environmental Studies:

Implementation	- B.C. Hydro, Environmental and Socio-Economic Services - Reid Crowther & Partners Ltd.

Data Retrieval System:

Consultants	- Nevin Sadlier-Brown Goodbrand Ltd.

B.C. Hydro was responsible for overall coordination of the project activities of KRTA, drilling and service contractors, B.C. Hydro personnel and other contractors.

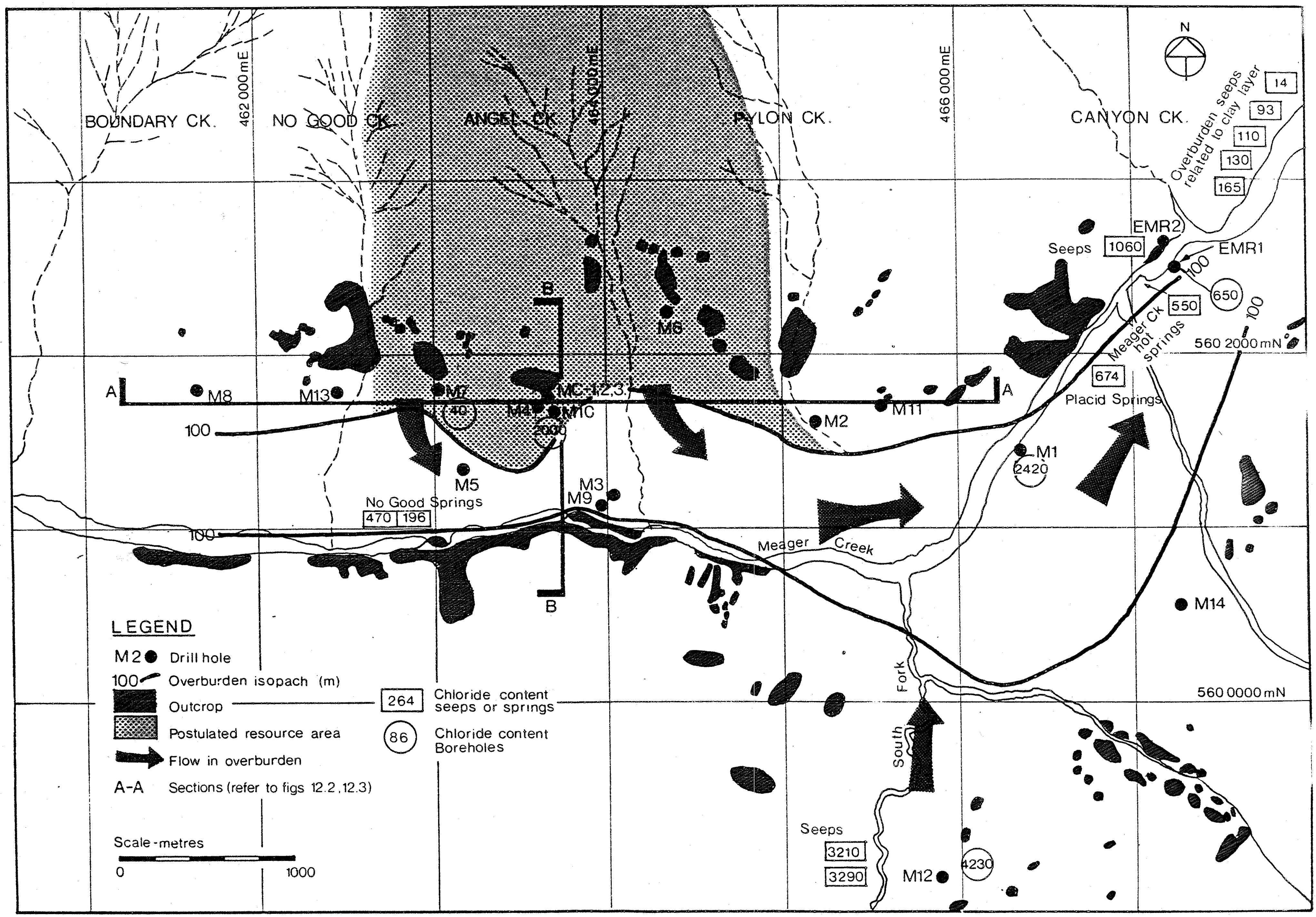
3. SUMMARY OF RESULTS AND EVALUATION

3.1 Geothermal Exploration Strategy

Exploration for geothermal resources in the Cascades Range of the Pacific Northwest has been significantly advanced over the past decade. Methods utilized elsewhere are not always applicable to exploration in this region and a unique stategy has evolved. Because of its geographic setting, coastal British Columbia has proven to be an extremely difficult region to mount any geothermal exploratory investigations, and the Meager Creek area is no exception.

The coastal climate provides a plentiful supply of cold groundwater (in the form of glacial runoff and precipitation), diluting the near surface geothermal waters to a greater extent than is usual in other localities. This is probably the main reason for the lack of high temperature surface manifestations of geothermal activity in British Columbia. Because of dilution of geothermal water, the chemical techniques commonly used as indicators of subsurface temperatures become less reliable, and careful interpretation of results is required (Figure 5).

Resistivity surveys have proven to be an effective tool for identifying possible subsurface thermal activity. The techniques employed were designed to minimize logistical problems while maximizing the amount of data collected. Both the dipole-dipole and Schlumberger arrays have been successfully utilized at Meager Creek.


BOUNDARY CK.
NO GOOD CK.
ANGEL CK.
PYLON CK.
CANYON CK.
462 000 mE
464 000 mE
466 000 mE
560 2000 mN
560 0000 mN
N
Overburden seeps related to clay layer
14
93
110
130
165
EMR2
EMR1
Seeps
1060
100
650
550
Meager Ck hot springs
674
Placid Springs
M1
2420
A
A
B
B
M8
M13
M7
40
M4
MC-1,2,3.
M1C
2000
M6
M2
M11
M5
M3
M9
No Good Springs
470
196
100
100
Meager Creek
South Fork
M14
Seeps
3210
3290
M12
4230
LEGEND
M2 Drill hole
100 Overburden isopach (m)
Outcrop
Postulated resource area
Flow in overburden
A-A Sections (refer to figs 12.2, 12.3)
264 Chloride content seeps or springs
86 Chloride content Boreholes
Scale-metres
0
1000

The interpretation of anomalous geophysical responses was assisted by geological information from surface mapping and shallow diamond drill holes. The shallow holes provide temperature gradient data, subsurface lithological and petrological information and many other characteristics of the potential reservoir rocks. Numerous other surface exploration techniques including soil and water geochemistry, electromagnetic and seismic surveys, and aerial infrared photography have been employed.

The final stage of exploration involved drilling a deep (3 000 m+) exploratory well. Geothermal reservoir parameters such as resource temperature, production zones, permeability and injectivity are calculated from post-drilling tests.

Exploration in the South Reservoir area of Meager Creek is approaching its final phase with testing in progress on the first deep exploratory well and continued monitoring and testing on another two. Although the proven electric generation potential is small at this time, results have been encouraging and further exploration in both the North and South Reservoir areas of Meager Creek appears warranted.

3.2 Meager Creek - South Reservoir

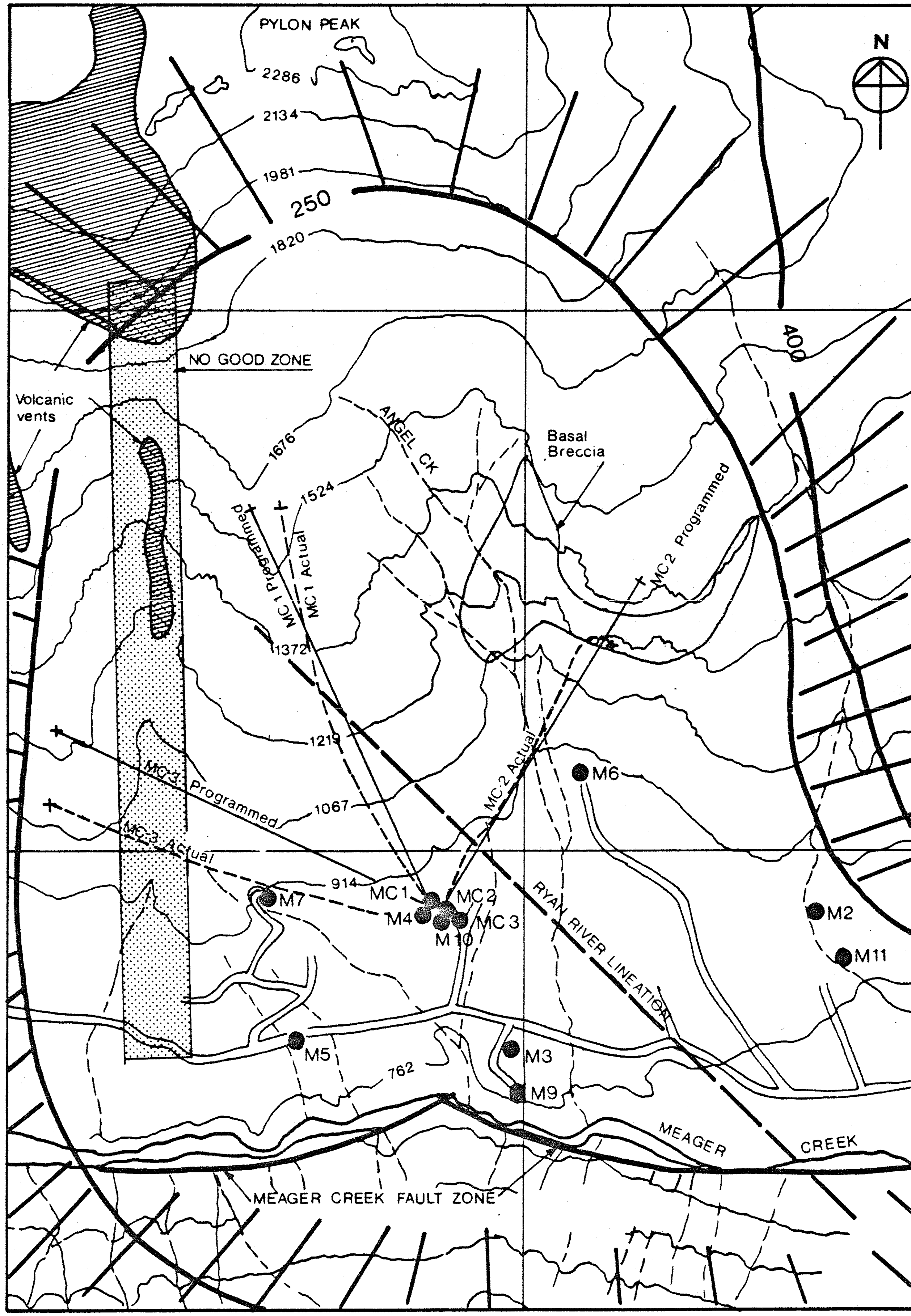
3.2.1 Deep Drilling Program

Following completion of MC-1 in late 1981, continuation of the deep drilling program in the South Reservoir area involved the completion of an additional two wells during the spring and summer of 1982 (Figure 6).

MC-1

MC-1 was spudded July 11, 1981 and was drilled to a measured depth of 3 040 m by late October. The hole was angled beneath the mountain, attaining an offset of 1 598 m towards N 25° W (Figure 7). However, the drill string became stuck 3 m off the bottom following an attempt to wash the hole prior to running the completion liner and was subsequently broken at a measured depth of 2 511 m. Following three weeks of unsuccessful fishing, the 500 m of pipe was abandoned and a slotted liner was run to the top of the fish. The rig was released on November 15, 1981 (Figure 8).

Completion tests were run following drilling, indicating a permeable area extending from 1 200 m to 1 700 m, with two zones in particular showing higher permeability. These coincide with zones of lost circulation encountered during drilling and are considered to be associated with the Meager Creek Fault. Subsequent temperature surveys conducted with the well on discharge confirmed that fluid was being produced at a temperature of approximately 195 to 200°C from more than one zone; although, no flow from below a depth of 1 700 m was indicated. Calculations from pressure fall-off tests



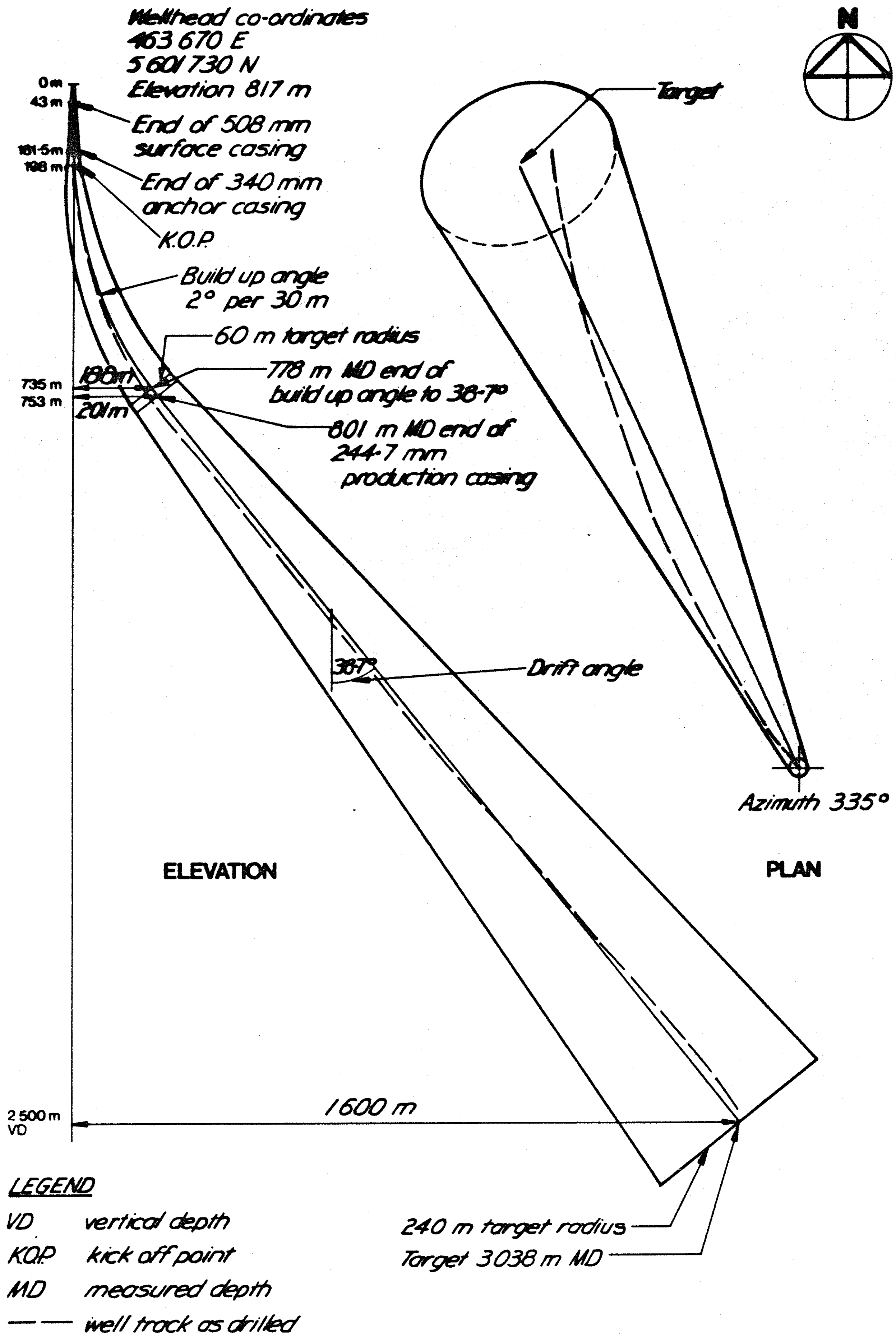
LEGEND

Scale 1:20,000

Programmed well tracks and targets — Drilled well tracks and targets

Interpreted field boundary at a depth of 300-600m — 250 Resistivity contours in Ohm metres

Deep exploration drilling programme targets and well tracks



Well MC-1 programmed target / well track as drilled

DRILLING SUMMARY WELL MC-1

MUD & CHEMICALS USED

Bentonite	81,170 kg
Sepiolite	41,119 kg
Lignite	2,900 kg
Caustic Soda	3,968 kg
Soda Ash	6,258 kg
Bicarbonate of Soda	454 kg
Lime	40 kg
Barite	5,200 kg
Sawdust	726 kg
Mica	2,225 kg
Walnut Shells	1,497 kg
Kwik Seal	454 kg
Glass Beads	454 kg
Oxygen Scavenger	2,819 l

CASING *-Tonnes

SIZE (mm)	METRES	SAX CEM	RUN CSG	WOC
508		220	9.25	49
339	161.5	35.9*	9	111
244.5	800	80*	19	61
/177.8				
Liner		20.75		

MUD & CHEMICALS USED - Cont'd.

High Temp. Filming Agent	303 l
Friction Base	7,002 l
No Stik	852 l
Reef Cide II	132 l
Torque Trim II	4,580 l

TIME ANALYSIS

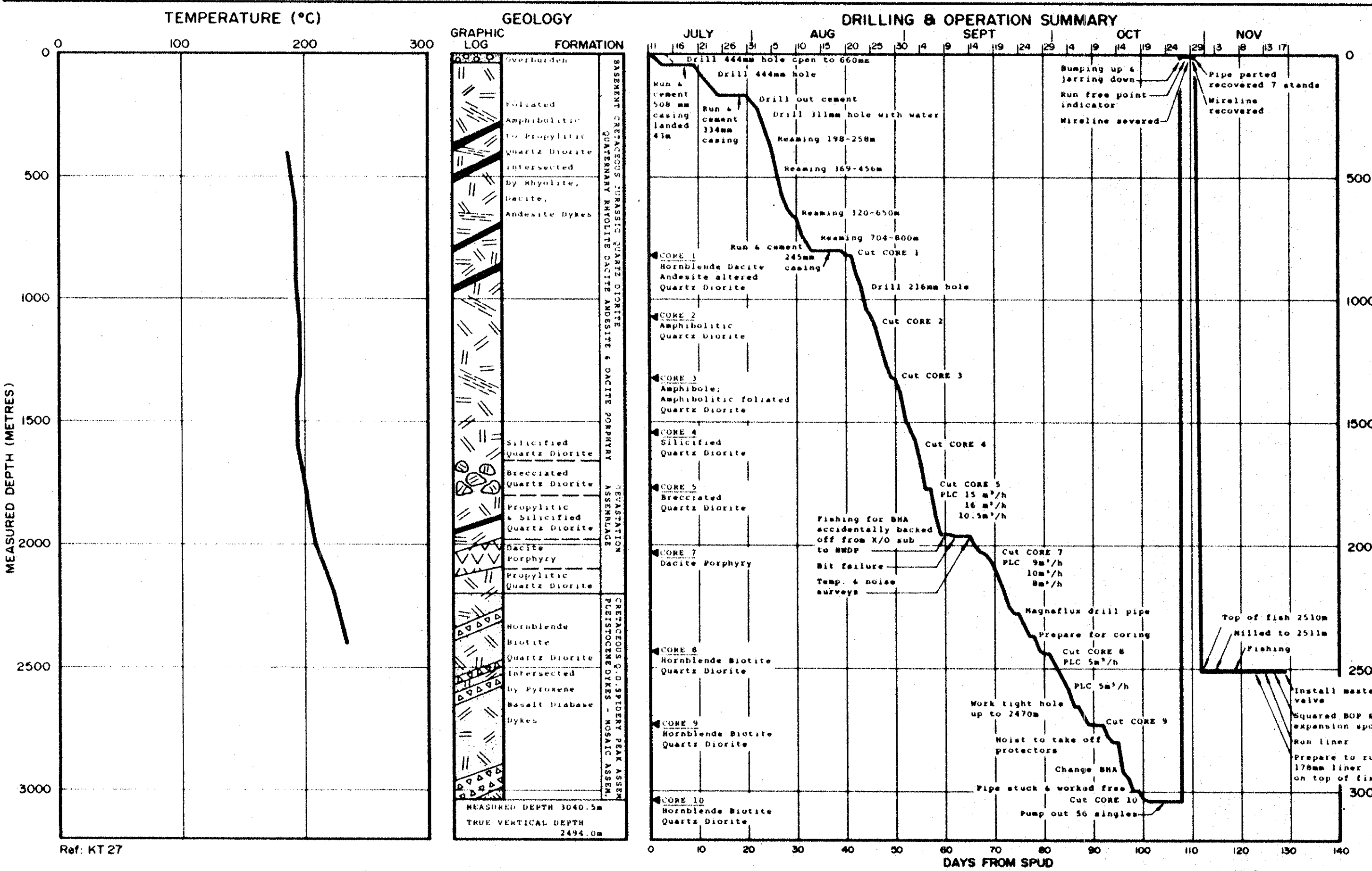
CONTRACTING DAYS		DAY WORK	
Rotating	39.78	Testing	
Trips	10.74	Coring	40.20
Mech.Down Time	0.41	Logging	
Running Casing	2.42	Lost Circulation	
W.O.C.	9.21	Compl.	3.41
Stuck or Fishing	0.56	Misc.:	
Rig Service, etc.	3.12	Check Flow	0.10
Condition Hole Mud	1.69		
Ream & Clean	6.06		
Open Hole to 660mm	2.22		
Trouble Rng. 319m Casing	0.94		
Inspect D.C.'s	1.63		
Circ. & Survey	4.22	TOTAL	43.71
TOTAL	83.00	TOTAL DAYS ON WELL	126.71

WELL NAME B.C.Hydro MC-1 Meager Creek, British Columbia
CONTRACTOR Westburne RIG No. 1 T.D. 3040m
DATE SPUDDED July 11/81 DATE RELEASED Nov.15/81 ROTATING HOURS 785.75 T.D.

EQUIPMENT
DWKS MODEL NAT 80B
PUMP DB700 191x406mm
PUMP DB700 191x406mm
DRILL PIPE SIZE 127mm

MUD SERVICE COMPANY Reef Mud Company Ltd.
TYPE OF DRILLING FLUID
Gel Chemical 0m TO 800m
Flocculated Water 800m TO 1500m
Sepiolite-Chemical 1500m TO 3040m

ADDITIONAL INFORMATION
Open hole to 660 mm on surface (53.25h).
Work stuck pipe at 2,999m (12 h).
Maximum deviation 42°N25W at 1950m.



DRILL BIT RECORD

BIT No.	BIT SIZE (mm)	TYPE	DEPTH OUT (m)	INTERVAL (m)	HOURS	WOB 1000 (daN)	RPM	CONDITION (T/B/G)
1A	444	V2J	36	36	24.75	5	45	1/1/1
2A	444	Q9J	42	6	14.75	6	40	1/2/1
2ARR	444	Q9J	64	22	21.5	12	45	-
3A	444	Q9J	76	12	13.5	13	45	1/3/1
4A	444	Q9J	111	35	16	14	35	RR/RR/I
5A	444	Q9J	164	53	51.25	12	40	-
1B	311	J77	198	34	12.75	12	40	-
2B	-	DIAMOND	201	3	6	12	300	-
3B	311	Q7JL	220	19	4.75	5	300	NR/RR/I
4B	311	Q7JL	235	35	9	5	300	NR/RR/I
5B	311	Q7JL	322	67	10	15	300	NR/RR/I
6B	311	J55R	372	50	6.5	25	300	RR/RR/I
7B	311	Q7JL	477	105	11.5	10	300	NR/RR/I
8B	311	J55R	577	100	19.5	30	60	RR/RR/I
9B	311	Q7JL	631	54	8.25	10	300	NR/RR/I
10B	311	J77	659	28	7.25	30	45	-
11B	311	J77	659	119(Ream)	6.25	2	80	I/RR/I
12B	311	J55R	753	94	20.25	30	45	-
13B	311	O7J	800	47	6	-	300	I/RR/I
14B	216	F4	819	19	7.25	3	40	-
1C	-	DIAMOND	821	2	5.25	7	70	-
2D	216	F4	941	120	55.25	10	78	RR/RR/I
3D	216	J44	1071	130	31.5	16	60	BT/NR/I
2C	-	DIAMOND	1071.9	0.9	1.75	6	70	-
4D	216	F4	1181	109	21.5	16	40	BT/NR/O
5D	216	J44	1259	78	20.75	10	80	1/1/1
6RRS	216	J44	1321	62	18.75	16	40	BT/NR/0.0625
3C	-	DIAMOND	1322	1	4	6	46	-
7	216	J55	1539	217	78.25	18	40	BT/NR/0.0625
4C	-	DIAMOND	1542	3	5	6	48	-
8	216	J55	1765	223	45.75	18	75	BT/NR/0.5
5C	-	DIAMOND	1766	0.4	2.25	25	70	-
9	216	F5	1955	187	70.25	18	80	BT/NR/0.5
10	216	J08	1960	5	3.25	10	70	-
6C	-	DIAMOND	1960	0	4	8	40	-
11	216	J55	2000	40	11.25	18	80	BT/NR/0.25
12	216	F7	2029	29	17.75	16	60	NR/RR/I
7C	-	DIAMOND	2030	1.3	7.75	14	50	-
13	216	F7	2086	56	29.75	15	60	RR/RR/0.125
14	216	F7	2182	96	13.25	16	65	WT/3/0.125
15	216	J55	2275	93	30.25	16	65	RR/RR/1
16	216	J55	2367	92	31	16	65	BT/NR/0.125
17	216	FP63	2435	68	21	15	70	NR/RR/0.125
8C	-	DIAMOND	2437	1.8	6	10	70	-
18	216	J55	2508	71	25	15	60	BC/NR/0.25
19	216	J55	2574	66	24	15	60	-
20	216	J55	2656	82	30.25	15	60	-
21	216	J77	2726	70	30.25	15	60	-
9C	-	DIAMOND	2728	1.4	12.75	10	60	-
22	216	J55	2797	69	27.5	15	60	B/6/0
23	216	J77	2919	122	40	17	60	B/2/I
24	216	J77	2999	80	30.25	16	60	NR/B/0.125
25	216	F7	3039	40	14.75	16	60	WC/NR/0.125
10C	-	DIAMOND	3040	1.2	4	9	50	-

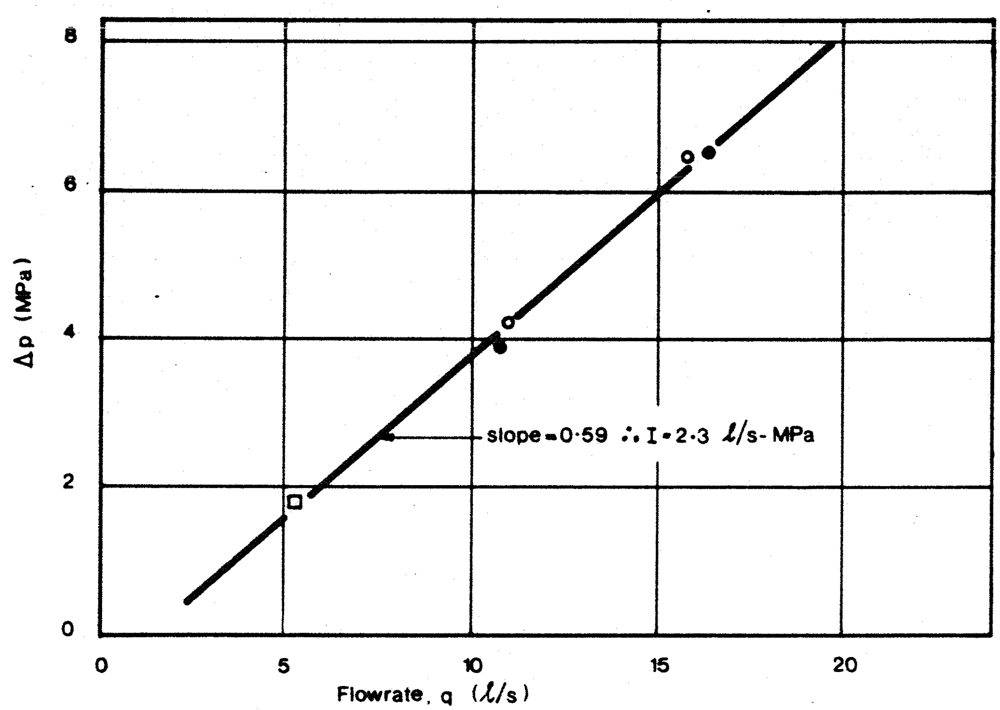
B.C. Hydro & Power Authority
MEAGER CREEK PROJECT
BRITISH COLUMBIA, CANADA

showed an injectivity of 2.3 L/s-MPa and an average transmissivity of 0.26 dm (Figure 9).

MC-1 was shut-in following completion and, after 18 days, was found to have a positive wellhead pressure. The well was subsequently discharged on December 22 1981, through the 250 mm side valve, and maintained the flash for 30 minutes before the flow died. By October 1982 the well could sustain discharge through both 100 mm and 150 mm end pipes and the output was fitted with a silencer/separator and a 90° V-notch weir in order to obtain the well output. Since November 1982, the well has been discharged continually at the rate of 12 t/hr+ of hot fluid and pressures in excess of 360 kPa.

MC-2

MC-2, spudded in November 1981, was completed to a depth of 3 502 m on March 27, 1982. The hole, designed to test the northeast sector of the postulated reservoir, was angled beneath the Meager Volcanic Complex attaining a vertical depth of 3 223 m and an offset of 1 193 m towards N 30° E (Figures 10, 11). A 177.8 mm slotted liner was hung from production casing at a depth of 900 m. Completion testing was begun immediately, revealing temperatures up to 270°C, and an airlift to flash the well was attempted. However, as a result of a hole in the casing at a depth of 195 m, cold surface water was mixed with upwelling thermal waters cooling the column sufficiently to suppress the ability of the bore to flash to steam. The problem was eventually solved by extending the liner to the surface and packing



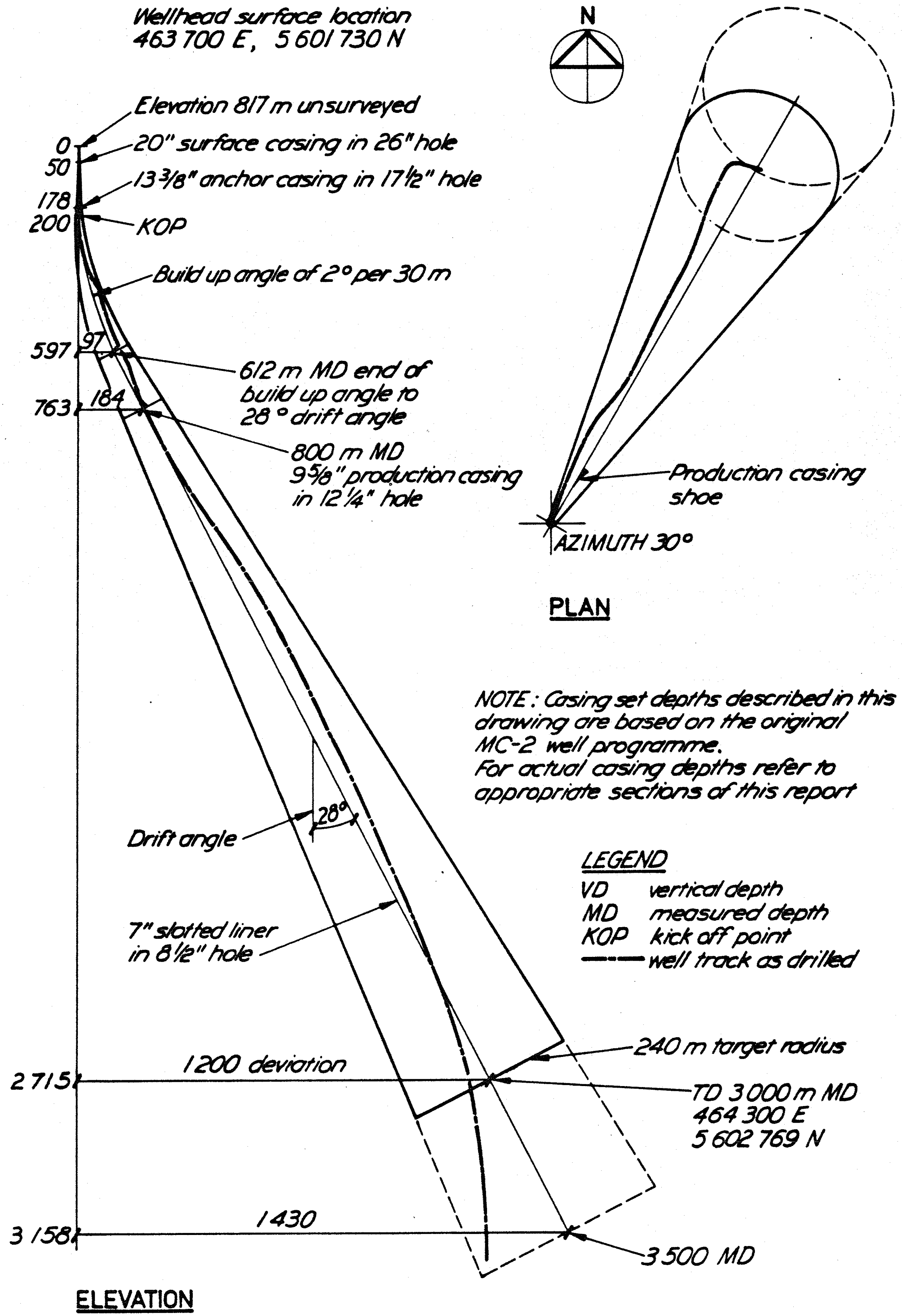
LEGEND

- □ KP-2 23 Nov, 1981
- o ELP-22 27 Oct, 1982
- ● ELP-25 3 Nov, 1982

(KP = Kuster pressure survey)

(ELP = Sperry-Sun pressure survey)

Well MC·1 Injectivity analysis



SCALE 1 : 15 000
All dimensions are in metres unless stated otherwise

Well MC-2 programmed target / well track as drilled

DRILLING SUMMARY
WELL MC-2

MUD & CHEMICALS USED

Bentonite	1694 Sks
[illegible]	127 Sks
Thermo-[illegible]	234 Sks
Soda Ash	2 Sks
Sawdust	88 Sks
Diesel	60 Bbls
Torque Trim	24 Bbls
Plus	2 Sks
Torque Trim II	17 Bbls
Torque [illegible]	84 Sks
Defoam	87 Pails
Kwik Seal	4 Sks
Separon	6 Kg
Plus	4 Cups
Poly Sed	137 Sks

CASING

SIZE (mm)	METRES	SAX CEM	RUN CSG	WOC
508	49.5	400	4	52
339.7	179.4		8	167
244.5	952.6	2200	17.75	148.75
177.8	914.5			
Liner	3497.8		19	

MUD & CHEMICALS USED Cont'd.

Reef O₂	147 Pails
Reef Film	81 Pails
Friction Base	8 Bbls
Plus	330 Gals
Plus	189 Pails

TIME ANALYSIS

CONTRACTING DAYS		DAY WORK	
Rotating	39.64	Testing	
Trips	16.26	Coring	10.55
Mech.Down Time	0.53	Logging	
Running Casing	2.86	Lost Circulation	
W.O.C.	15.32	Compl.	14.46
Stuck or Fishing	4.89	Misc.:	
Rig Service, etc.	4.65	Circ. Samples	0.04
Condition Hole Mud	2.17	Check Flow	0.12
Ream & Clean	9.91		
Open Hole to 660mm	2.59		
Attempt to Run 508mm Casing	1.24		
Inspect D.C.'s	1.10		
Circ. & Survey	4.38	TOTAL	25.17
TOTAL	105.54	TOTAL DAYS ON WELL	130.71

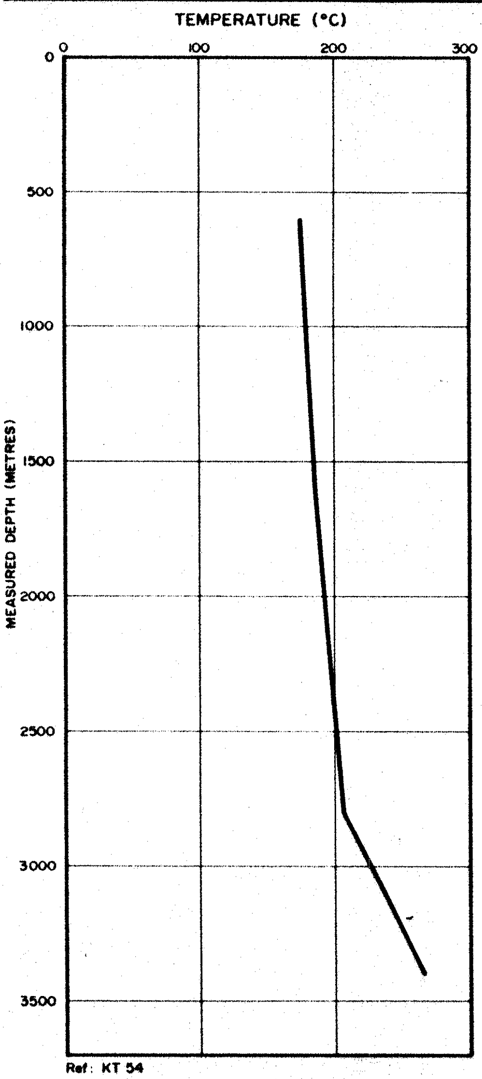
WELL NAME B.C. Hydro MC-2 Meager Creek, British Columbia
CONTRACTOR Westburne **RIG NO.** 1 **T.D.** 3502.6m
DATE SPUDDED Nov.24/81 **DATE RELEASED** Apr.4/82 **ROTATING HOURS** 804.25 T.D.

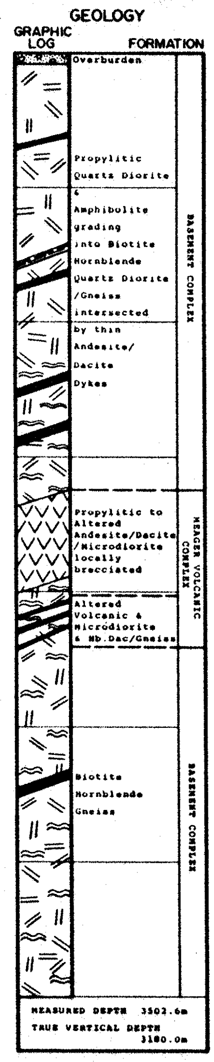
EQUIPMENT
DWKS MODEL NAT 80B
PUMP DB700 191x406mm
PUMP DB700 191x406mm
DRILL PIPE SIZE 127 & 89mm

MUD SERVICE CO. Reef Mud Company Ltd.
TYPE OF DRILLING FLUID
Gel Chemical 0m TO 954m
Flocculated Water 954m TO 1348m
Sepiolite-Chemical 1348m TO 3502.6m

ADDITIONAL INFORMATION

Open hole to 660mm on surface (62.25h).
Fish at 1406m (70h), and at 2408m (21.25h).
Work stuck pipe at 3310m (26.25h).
Maximum Deviation 35°N35E at 1206m.





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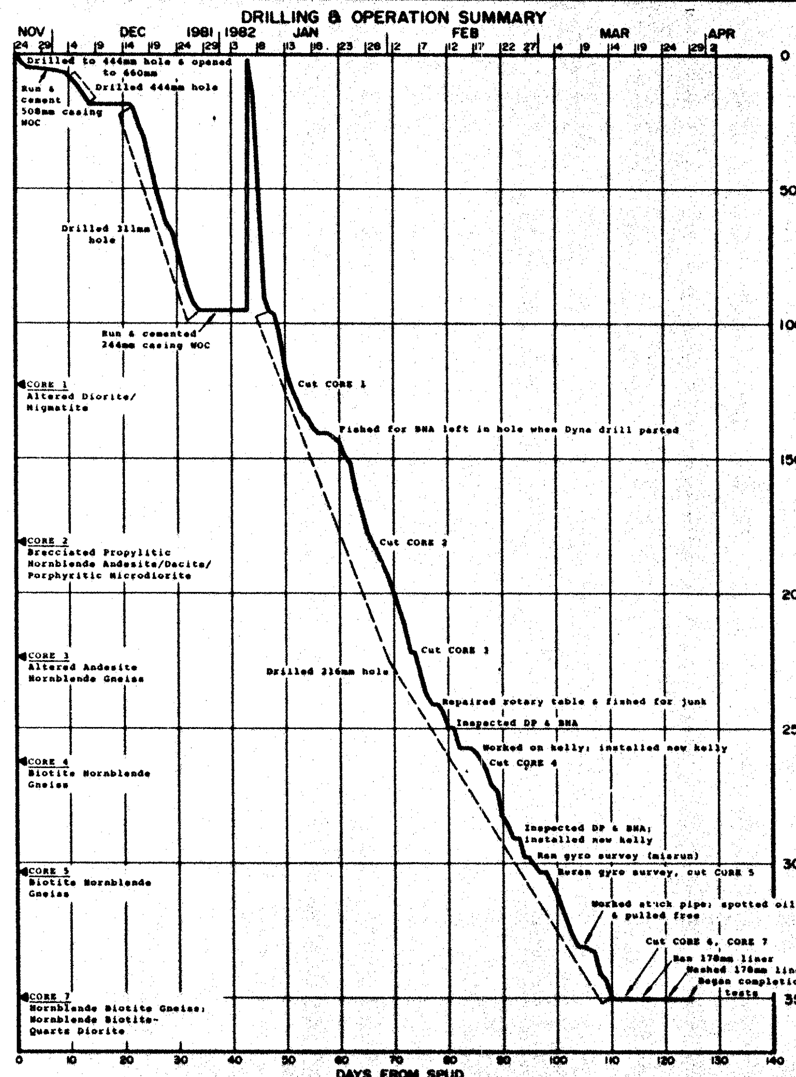

DRILL BIT RECORD

BIT No.	BIT SIZE (mm)	TYPE	DEPTH OUT (m)	INTERVAL (m)	HOURS	WOB 1000 (daN)	RPM	CONDITION (T/B/G)
1	444	V2J	44	44	24.75	4.6	65	4/2/I
2	444	Q9J	62	18	18.5	6.0	40	BR/RR/I
3	444	Q9J	183	121	112	14	50	1/3/I
4	311	7JA	272	89	8	14	400	1/1/.125
5	311	7JA	318	46	3.5	10	400	-/NR/.125
6	311	7JA	420	102	11.25	20	120	RR/RR/.125
7	311	7JA	510	90	12.5	20	120	NR/NR/I
8	311	7JA	580	70	8.75	20	120	NR/NR/.125
9	311	7JA	628	48	6.25	12	350	RR/RR/.125
10	311	F5	676	48	13.75	20	80	RR/RR/.125
11	311	7JA	775	99	17	22	120	BT/NR/I
12	311	7JA	876	101	17.75	22	120	NR/RR/I
13	316	7JA	954	78	21.75	22	120	NR/NR/I
14	216	J55	967	13	6.25	2	400	NR/RR/.25
15	216	J55	1027	60	17	10	80	BT/RR/I
16	216	J55	1230	203	33.5	14	80	RR/RR/I
17*	-	CORE 1	1232	2	1.5	5	35	-
18	216	J55	1348	116	48.75	5	80	BT/NR/.063
19	216	F7	1399	51	5.25	14	350	RR/RR/.063
20	216	F7	1406	7	1	4	350	RR/RR/.063
21	216	F5	1430	25	5	4	350	NR/NR/.125
22	216	RGXJ	1439	9	3	6	76	RR/RR/I
23	216	7J8	1493	54	9.25	3	350	NR/NR/.125
24	216	J55	1616	123	28	10	80	TB/NR/I
25	216	J55	1770	154	31	12	80	NR/RR/I
26	216	J55	1815	45	9	12	77	-
27*	-	CORE 2	1816.5	1.5	1.5	6	45	-
28	216	J55	1901	84	24.25	10	77	NR/NR/I
29	216	F9	1988	87	31	14	77	BT/RR/I
30	216	F7	2067	79	25.75	14	77	RR/RR/I
31	216	J55	2219	152	32.5	16	77	NR/RR/.063
32*	-	CORE 3	2220.5	1.5	1.5	5	57	-
33	216	J77	2405	184	40.25	16	77	NR/RR/.125
34	216	J77	2495	90	30.75	8	75	RR/RR/I
35	216	J55	2571	76	22.25	6	75	NR/NR/.125
36	216	J77	2625.6	54	19	18	77	NR/NR/.125
37*	-	CORE 4	2628	2.4	2	4	45	-
38	216	F7	2704	76	21.25	18	79	RR/RR/I
39	216	F7	2821	117	30.75	18	78	NR/NR/.125
40	216	J77	2905	84	25.5	18	78	NR/NR/.88
41	216	F7	2977	72	16.25	18	80	BT/NR/.125
42	216	F7	3006	29	7.25	18	60	NR/NR/.125
43	216	J77	3034	28	4.5	18	80	NR/NR/.125
44*	-	CORE 5	3037	3	1.75	4	40	-
45	216	F7	3062	25	6.75	18	40	RR/NR/.125
46	216	F7	3110	48	18	18	47	RR/RR/I
47	216	J99	3202	92	32.25	18	60	NR/RR/I
48	216	F7	3310	108	32	18	60	NR/RR/I
49	216	F7	3328	18	3.75	18	60	NR/RR/I
50	216	F7	3429	101	29.25	18	60	RR/RR/.125
51	216	F7	3498	69	18.75	18	60	RR/RR/I
52*	-	CORE 6	3499.5	1.5	0.75	4	45	-
53*	-	CORE 7	3502	2.5	2.6	5	45	-

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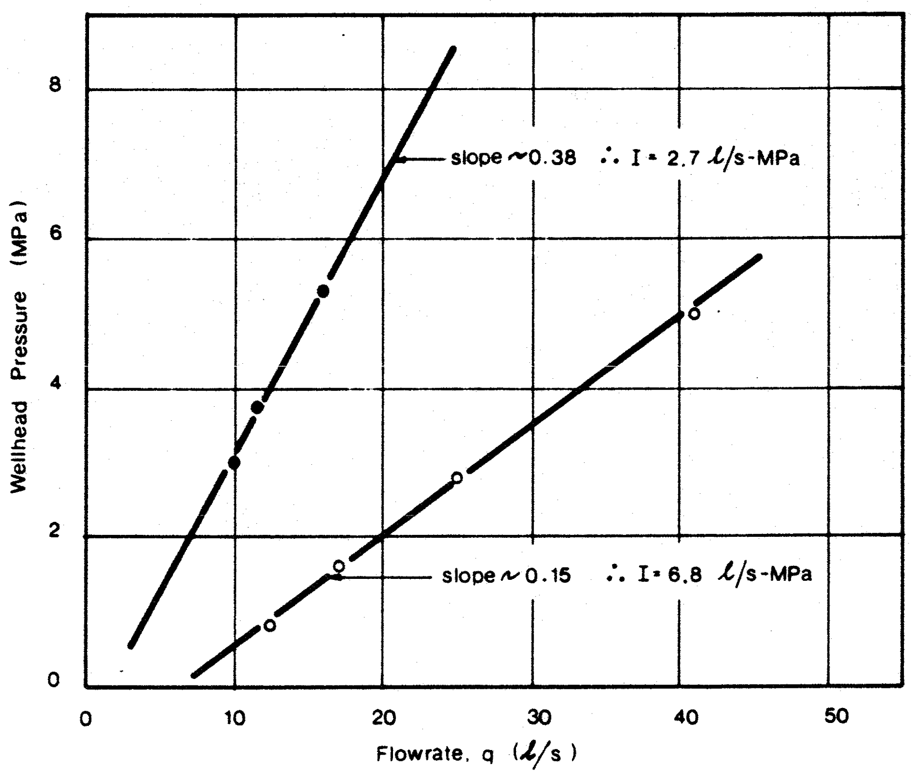
off the annulus between the liner and production casing in the vicinity of the hole.

Permeable zones between depths of 1 600 to 1 800 m and 2 600 to 3 000 m were encountered during drilling with substantial drilling losses noted in these areas. Subsequent surveys indicated significant temperature inflections in the vicinity of these zones. Fluid enters the bore at a temperature of approximately 195°C in the upper zone. In order to stimulate and test the higher temperature 3 000 m zone, the upper zone would have to be isolated.

Further attempts to flash MC-2 (by airlifting in September and October, and nitrogen lifting in early November) failed to initiate discharge although a number of reservoir parameters were tested. Pressure tests indicate an injectivity of 2.7 l/s-MPa and a transmissivity of 0.20 dm (Figure 12). Although these values are low in comparison to other geothermal systems and indicate a limited flow capacity, they are very similar to those of MC-1 which flows spontaneously. In all probability, the depth of the entry for fluid in MC-2 is about 1 600 m, approximately 400 m deeper than MC-1. Although reservoir temperatures are comparable, the difference in depth may prevent MC-2 from developing a sufficiently light fluid column to discharge naturally.

The model proposed for MC-2 involves the following:

1. A major permeable zone encountered at 1 600 to 1 800 m is associated with the Meager Creek Fault,



LEGEND

- o Pump test 30 March, 1982
- ● Data from injectivity tests Oct-Nov, 1982

Well MC-2 Injectivity analysis

while the lower zone at 2 600 to 3 000 m is probably due to discrete dikes.

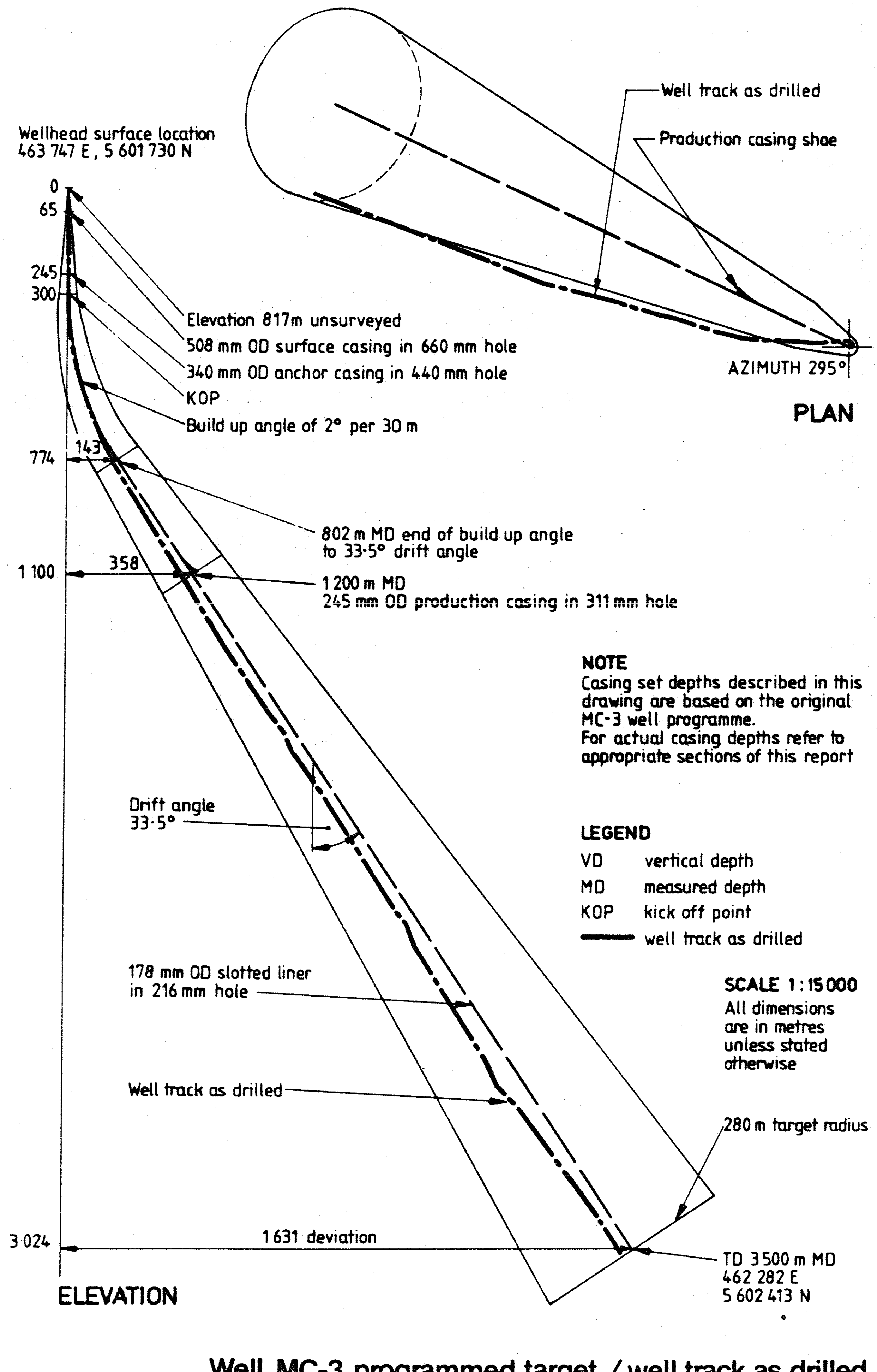
2. Petrological and goechemical studies indicate the fluid has a source temperature of 190 to 205°C and is similar in composition to that in MC-1.

3. Mineralogical evidence suggests present day fluid flow is minimal in this region of the reservoir.

4. There is evidence of invasion damage and possible obstruction of the fracture permeability by drilling fluids.

MC-3

A third deep exploratory well, MC-3, was spudded on April 17, 1982 approximately 50 m east of the MC-2 collar. The well was completed to a total depth of 3 503 m on August 5, 1982, attaining a vertical depth of 3 036 m and an offset of 1 598 m towards N 74° E. The well was targeted to intersect the No-Good Zone at a measured depth of 3 000 m, passing approximately 150 m north and 1 600 m below the M7-79D drill site enroute (Figure 13). Drilling was interupted at a measured depth of 3 025 m where substantial drilling losses were encountered. Risking loss of a potential production zone against the possibility of enhanced permeability deeper within the No-Good structure, drilling was resumed. The hole was subsequently completed without further incident (Figure 14).



Well MC-3 programmed target / well track as drilled

DRILLING SUMMARY
WELL MC-3

MUD & CHEMICALS USED

Caustic Soda	3,(1 kg
Friction Ease	57 l
Sawdust	1,591 kg
High Temp Filming Agent	1,760 l
Oxygen Scavenger	704 l
Kwik Seal	1,324 kg
Walnut Shells	113 kg
Mud Lube	12,896 l
Bentonite	95,280 kg
Lime	1,360 kg
Poly Sec	50 kg
Sepiolite	84,736 kg
No Stik	227 l
Reef Defoamer	227 l
Calcium Chloride	362 kg
Lignite	90.7 kg

CASING

SIZE (mm)	METRES	SAX CEM	RUN CSG	WOC
509	65	31	6.75	55
339.7	247	7	9	74½
244.5	1196	133	26.5	69½
177.8	1090-			
Liner	-3500			

MUD & CHEMICALS USED Cont'd

Torque Trim II	681 l
Reef Floc	1 kg
Soda Ash	160 kg
Kum Free	3,179 l
Cypan	2,812 kg
SAPP	2,000 kg

TIME ANALYSIS

CONTRACTING DAYS		DAY WORK	
Rotating	40.44	Testing	-
Trips	9.51	Coring	8.20
Mech. Down Time	0.22	Logging	3.34
Running Casing	3.09	Lost Circulation	0.18
W.O.C.	8.27	Compl.	4.83
Stuck or Fishing	18.65	Misc:	
Rig Service, etc.	3.28	Check Flow	0.11
Condition Hole Mud	2.65	Circ. Samp.	0.15
Ream & Clean	2.97		
Open Hole to 660mm	1.39		
Inspect D.C.'s	0.68		
Circ. & Survey	2.21	TOTAL	16.81
TOTAL	93.36	TOTAL DAYS ON WELL	110.71

WELL NAME B.C. Hydro MC-3 Meager Creek, British Columbia
CONTRACTOR Westburne RIG NO. 1 T.D. 3503m
DATE SPUDDED Apr.17/82 DATE RELEASED Aug.5/82 ROTATING HOURS 812 T.D.

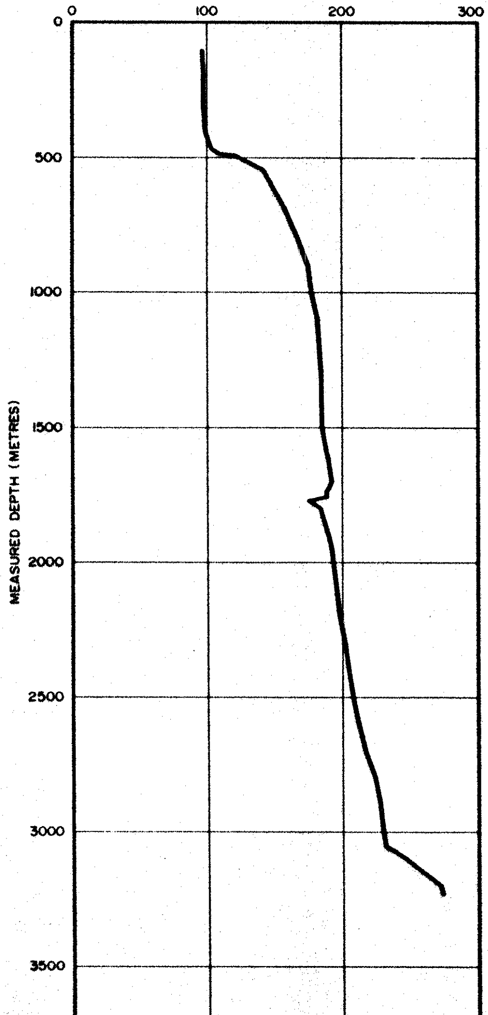
EQUIPMENT
DWKS MODEL NAT 80B
PUMP DB 700 191x406mm
PUMP DB 700 191x406mm
DRILL PIPE SIZE 127 mm

MUD SERVICE COMPANY Reef Mud Company Ltd.
TYPE OF DRILLING FLUID

Gel Caustic Lime	0m TO 67m
Water	67m TO 250m
Water/Corrosion Chemicals	250m TO 1196m
Sepiolite-Caustic-Corrosion Chem.	1196m TO 3503m

ADDITIONAL INFORMATION

TEMPERATURE (°C)



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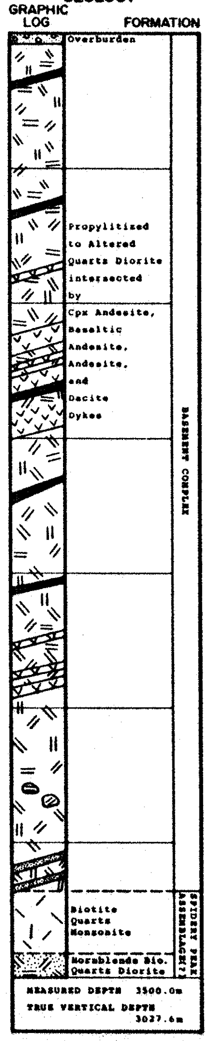
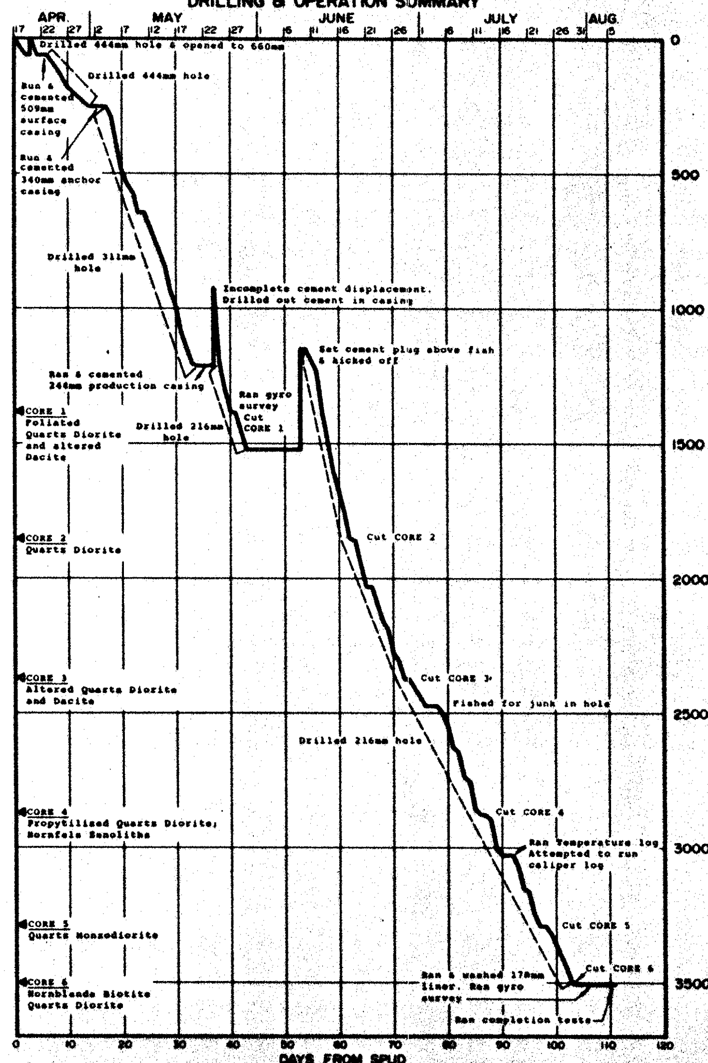
GEOLOGY



DRILLING & OPERATION SUMMARY



DRILL BIT RECORD

BIT No.	BIT SIZE (mm)	TYPE	DEPTH OUT (m)	INTERVAL (m)	HOURS	WOB 1000 (daN)	RPM	CONDITION (T/B/G)
1*	444	V2J	50	50	26	6	60	-
2*	444	Q9J	65	15	17.5	4	60	-
3*	444	Q9J	116	51	43.75	14	40	NR/RR/O
4*	444	Q9J	184	68	45	6	120	NR/NR/.125
5	444	Q9J	207	23	17.25	8	125	-
6	444	Q9J	238	31	27.25	14	125	NR/NR/O
7	444	Q9J	250	12	6.75	12	125	RR/NR/O
8	311	J44	300	50	9	10	70	RR/RR/O
9	311	7JA	429	129	17.5	8	300	RR/NR/O
10	311	F7	540	111	18.75	8	300	-
11	311	7JA	571	31	4.5	20	120	RR/RR/O
12	311	J55	642	71	18	20	90	-
13	311	7JA	667	25	5	8	330	NR/NR/O
14	311	7JA	743	76	16	8	330	NR/NR/.125
15	311	Q7J	846	103	28.25	20	80	NR/NR/O
16	311	J55	966	120	29.25	20	80	BT/RR/-
17	311	7JA	1094	128	31.5	25	80	NR/NR/O
18	311	7JA	1206	112	28	28	80	NR/NR/O
19	311	7JA	1211	5	3	28	80	RR/RR/O
20	216	JD4	1211	DOC	24.25	5	60	NR/RR/O
21	216	F7	1380.5	169.5	31	12	60	RR/RR/O
22	158	CORE 1	1382	1.5	3	7	60	-
23	216	F7	1522	140	38	18	60	LOST IN HOLE
24	216	JD4	DOC AFTER PLUGGING BACK					
25	216	9JS	1235	38	-	18	80	RR/RR/-
26	216	F7	1492	257	34.75	20	60	NR/NR/.125
27	216	F5	1645	153	25.75	20	70	NR/NR/.5
28	216	F5	1747	102	18	20	60	NR/NR/.25
29	216	F7	1857.3	110.3	20	20	60	NR/NR/.25
30	158	CORE 2	1860.9	3.6	6	6	60	-
31	216	J99	2030	169.1	41.5	20	60	NR/NR/.125
32	216	J99	2186	156	46.5	20	60	NR/NR/.031
33	216	F5	2272	86	22.25	20	60	NR/NR/.031
34	216	HPHMJ	2369.8	97.8	31.75	20	55	NR/NR/.125
35	158	CORE 3	2372.8	3	7.5	5	60	-
36	216	HPHJ	2413	40.2	11.75	20	60	NR/NR/1.0
37	216	J99	2470	57	12.75	20	60	NR/NR/1.0
38	216	F7	2470	-	-	-	-	RR/RR/.125
39	216	46A	2470	-	-	5	75	RR/RR/O
40	216	F7	2540	70	19.5	20	60	BT/RR/.25
41	216	F7	2626	86	22	20	60	NR/NR/.25
42	216	F7	2739	113	29.5	20	60	BT/RR/.125
43	216	F7	2870.6	131.6	31.25	20	60	BT/RR/.125
44	158	CORE 4	2873.8	3.2	6.75	4	60	-
45	216	4GA	2878	4.2	1.25	15	60	RR/NR/O
46	216	F7	3025	147	31.25	18	70	NR/NR/.125
47	216	F7	3161	136	34.75	14	60	NR/RR/.125
48	216	F7	3287.9	126.9	33.75	14	60	NR/RR/.125
49	158	CORE 5	3290.4	2.5	8	6	50	-
50*	216	J77	3291	0.6	3	13	55	BT/NR/O
51	216	F7	3358	67	27.25	13	60	NR/RR/.125
52	216	HPHJ	3437	79	24.5	13	60	NR/NR/O
53	216	HPHJ	3500	63	24.5	13	60	NR/NR/O
54*	158	CPRE 6	3503	3	5.25	5	60	-

NOTE: * Denotes rerun bits

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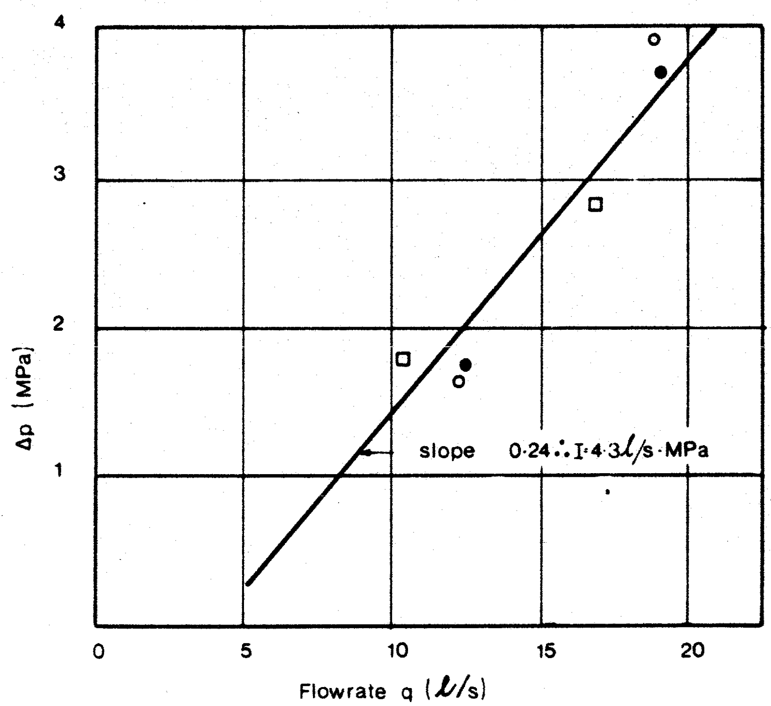
The well did not discharge spontaneously and, in order to clean out the bore as soon as possible after the completion of drilling, testing was delayed and an attempt to flash MC-3 was made. Nitrogen lifting (August and November) and airlifting (September, October) succeeded in producing low temperature discharge from a shallow, low permeability zone. However, this flow effectively choked the bore and discharge from the zone of primary interest at 3 100 m was not achieved.

Tests conducted in MC-3 indicate a maximum temperature of 290°C. However, because of transient testing conditions, a stable temperature profile of the well has not been surveyed. The logs indicate permeable zones at 1 700 to 1 900 m and 2 900 m to 3 100 m with a possible downflow between the zones. Minor permeability in the zone from 1 200 to 1 300 m is probably associated with volcanic dikes following the Meager Creek Fault. The deeper zone, from 2 900 to 3 100 m, is interpreted as the No-Good Zone, indicated by the occurrence of anhydrite and vuggy quartz in cuttings, and by brecciated quartz diorite /hornfels encountered in core 4 (2 870 m).

From pressure tests, well flow capacity measurements indicate an injectivity of 4.4 l/s-MPa and a transmissivity of 0.5 dm (Figure 15). These values are approximately double the values obtained for MC-1 and MC-2 but are still considered very low for a conventional geothermal well. However, because of the influences of wellbore storage and skin effect, it is



LEGEND

- o ELP-2 23 Oct, 1982 (ELP = Sperry-Sun pressure survey)
- ● ELP-3 30 Oct, 1982
- □ ELP-7 12 Nov, 1982

Well MC·3 Injectivity analysis

impossible to tell if MC-3 is a potentially good well with severe wellbore damage or a well with no permeability. As with MC-2, invasion damage and possible obstruction of the fracture permeability by drilling fluids has adversely affected the well performance.

In a fracture dominated resource it is possible that large variations in local permeability will occur within the reservoir. The presence of 200°C temperatures at 350 m in diamond drillhole M7-79D suggests that permeability in some portions of the reservoir area is significantly greater than in the zones encountered to date. Features of both the Meager Creek Fault and the No Good Zone indicate that these structures provide a good conduit for thermal fluids. Because the evaluation of the significance of these structures is uncertain satisfactory evaluation, further drilling would be required.

Preliminary work could involve shallow diamond drilling from the M7 site in order to explore the near surface features of the Meager Creek Fault and No Good Zones. Alternately, consideration chould be given to siting of a deep drillhole, to be deviated along the No Good Zone in order to more fully investigate the production possibilities of this structure. It is also possible that by kicking off at depth in the present deep wells, better permeablility could be intersected.

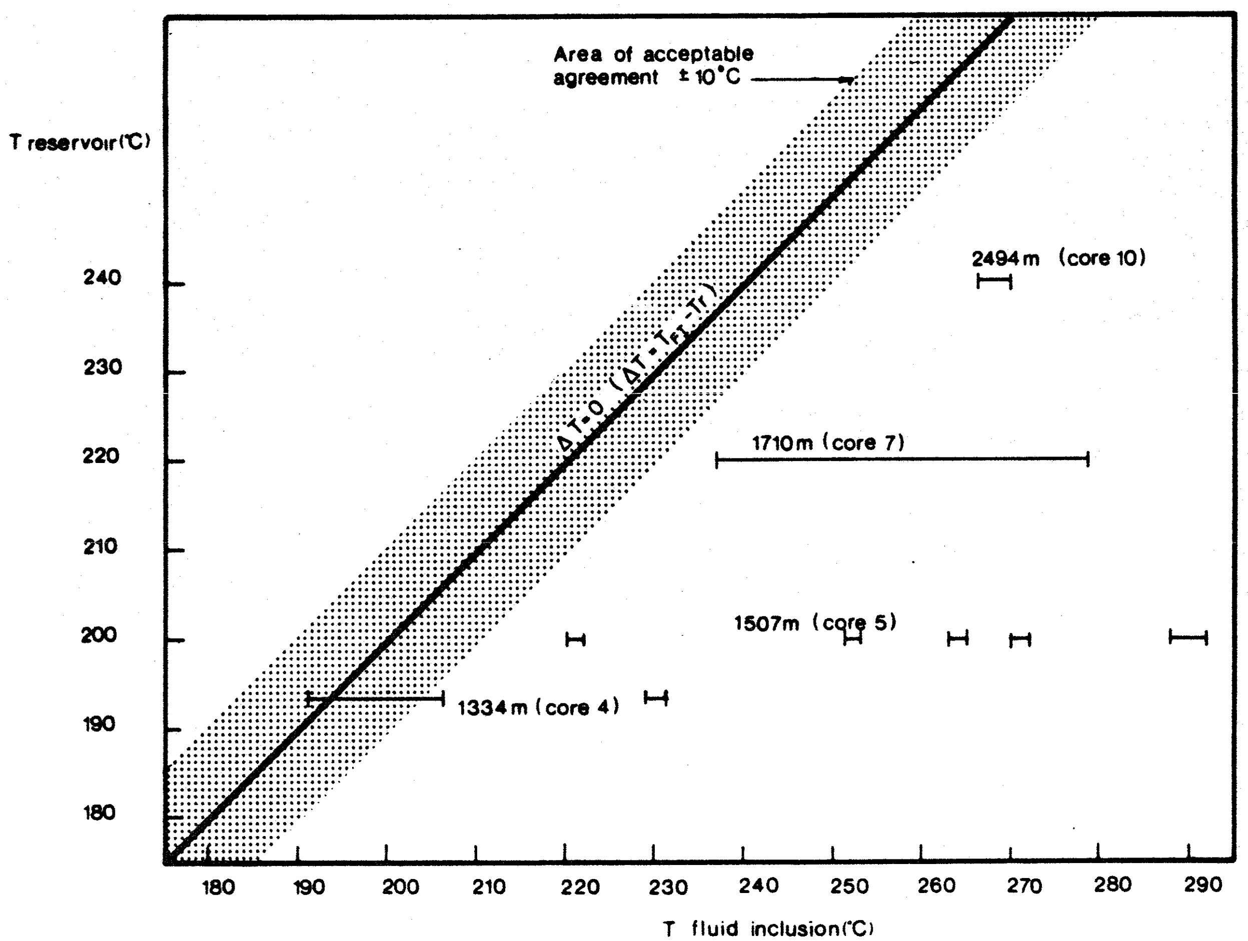
3.2.2 Well Maintenance Program

Geochemistry

Following the suspension of drilling activities in late summer, a maintenance program involving well testing and monitoring was conducted on the three deep exploratory wells in the South Reservoir area. Measurements on MC-2 and MC-3 were continued, and well geochemistry samples were obtained during airlift attempts in September - October and during nitrogen lifting in November.

Water samples from MC-2 indicate Na-K-Ca geothermometer temperatures in the range 197° to 203°C with silica geothermometer temperatures betweem 185° and 212°C. Both values are in close agreement with chemical geothermometry data from MC-1 (Figure 16).

Periodic sampling in MC-3 shows a progressive increase in chloride content with time and an accompanying increase in most cations and anions except for sulphate, calcium, magnesium and bicarbonate. These four ions are characteristically high in drilling/completion test fluids, and, because the well was not successfully discharged, it appears the fluids have not been entirely "flushed" from the well. Geothermometry calculations indicate a temperature between 179° and 207°C based on silica content, and between 177° and 199°C using the Na-K-Ca model. These temperatures are somewhat lower than those indicated for MC-1 and MC-2 (Figures 17, 18).



Well MC-1 comparison of anhydrite fluid inclusion and estimated reservoir temperature

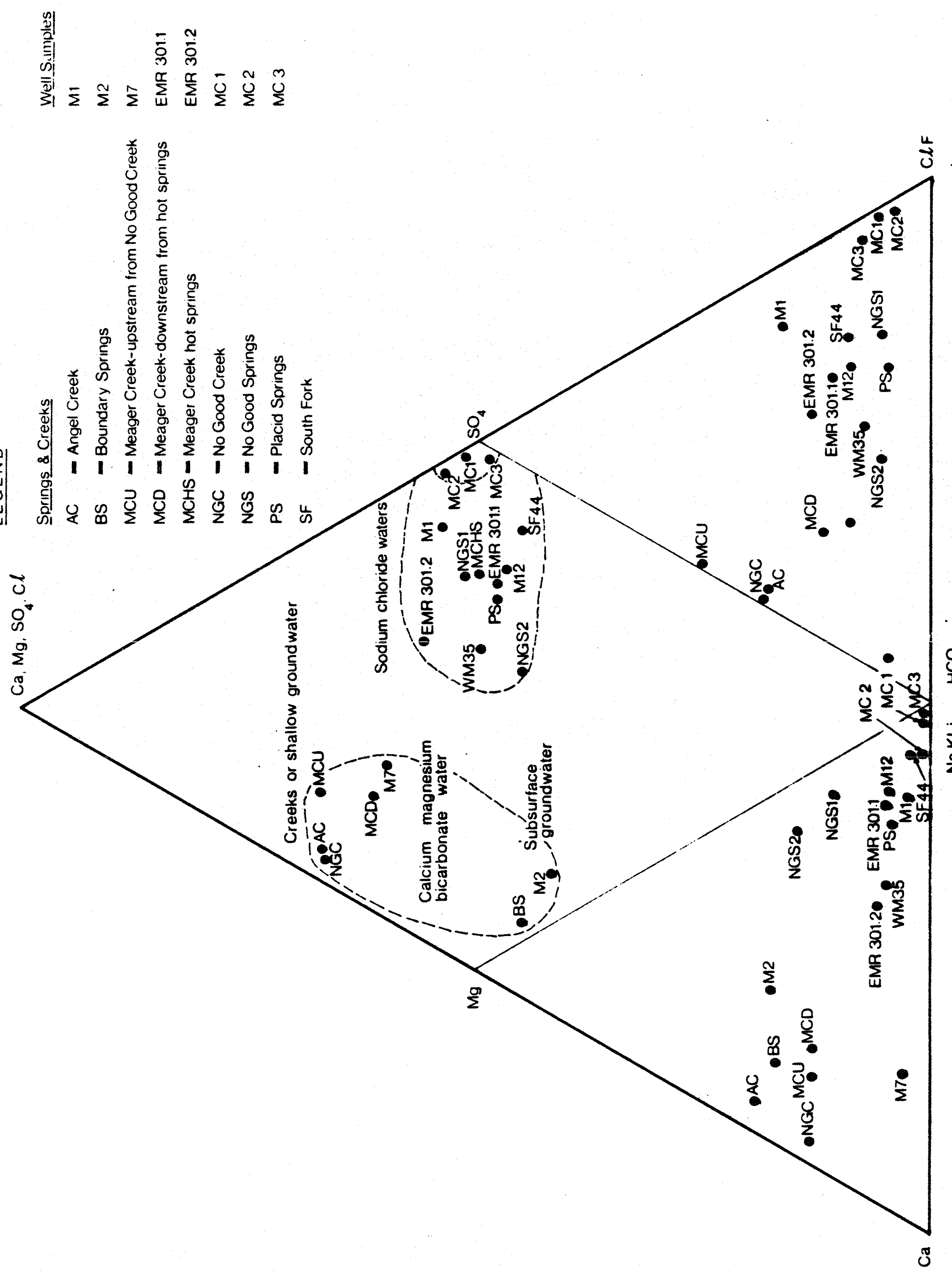
Discharge from MC-1

Since November 1982, MC-1 has been discharged continuously at a rate of 10 to 12 tonnes/hr, with an estimated flash of 15%. Discharge is to a silencer/separator with a weir box at the water discharge for water outflow measurement. Samples of the discharge have been collected regularly in order to monitor geochemical changes in reservoir conditions. Chloride values show a progressive increase from December 1981 to September 1982, after which a stable discharge chemistry appears to have been achieved. An enthalpy test in July indicates the outflow fluid contains 825 kJ/kg; this is equivalent to a single phase source fluid at 194°C. Pressure at the wellhead has been stable at 375 kPa.

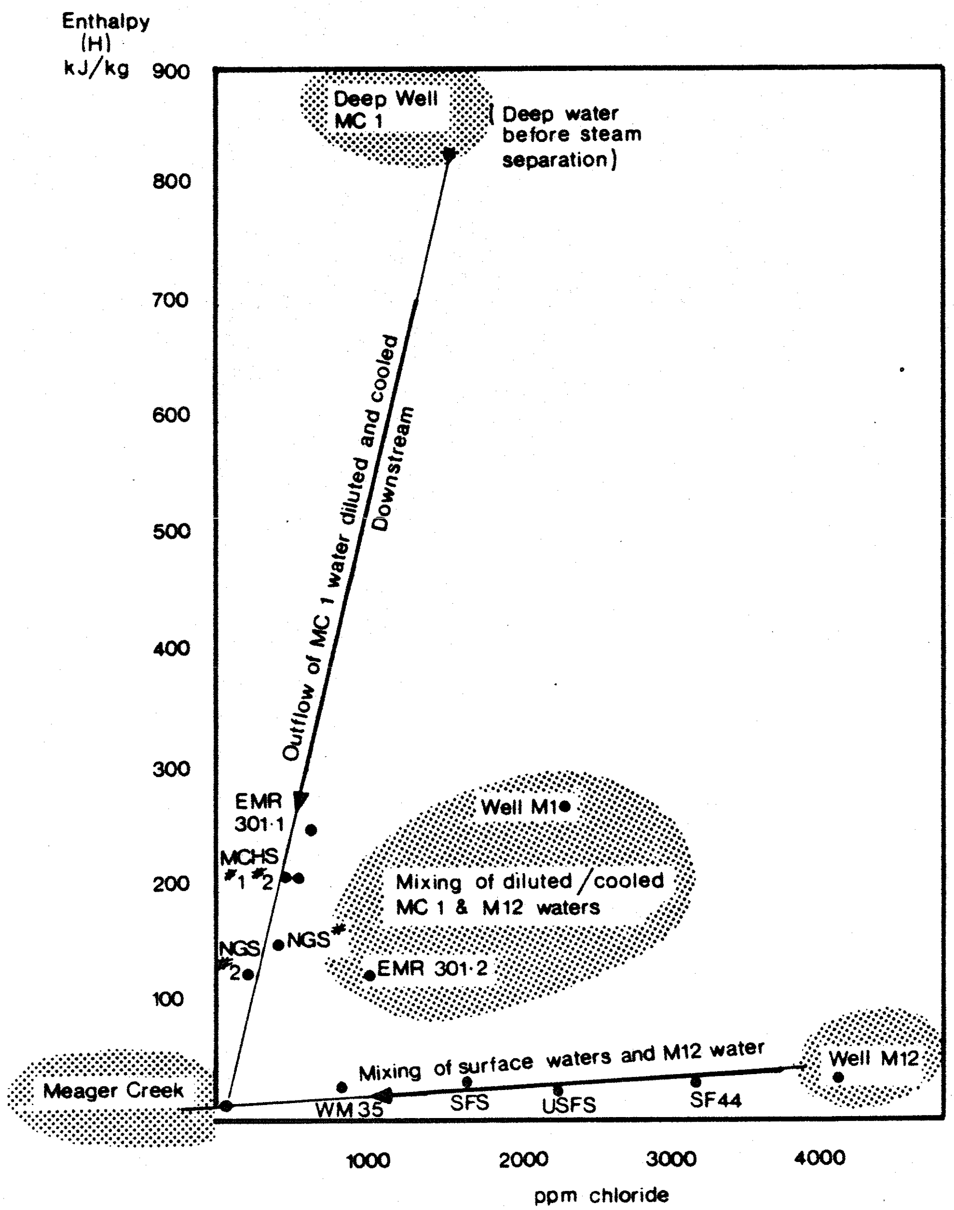
Overview of Well Testing

From the well testing conducted on the deep exploration wells to date, it has been possible to obtain a general understanding of the reservoir processes involved at South Meager.

Temperature surveys under various conditions have indicated that the main permeable zones are either associated with the Meager Creek Fault Zone or the No Good Zone. Other permeable zones were encountered in MC-2 and MC-3 which may be associated with discrete dikes. The overall flow capacities of the wells, as reflected by the injectivities and transmissivities, are low for geothermal wells and may lead to difficulty in exploiting the resource.



Piper diagram Meager Creek fluid types



LEGEND

WM — West Meager
MCHS — Meager Creek hot springs
NGS — No Good Springs
SF — South Fork
SFS — South Fork swamp
USFS — Upper South Fork swamp

Enthalpy versus chloride plot for selected South Meager waters

Temperatures of 270°C at a depth of 3 100 m (V.D.) were measured in MC-2. In consideration of a regional geothermal gradient of 90°C/km, high temperatures should be anticipated and are not necessarily attributable to a hydrothermal system. The only anomalous temperatures appear to be associated with the Meager Creek Fault Zone, suggesting that this is the conduit for the upflowing geothermal fluid.

The present deep wells have not been fully tested and in order to effectively evaluate preliminary results, further monitoring of downhole temperatures, pressures, and borehole chemistry is requiried. This would be of particular importance in MC-2 and MC-3 where stable temperature, pressure and chemical data are not available.

Well discharge data obtained to date indicates that the potential of the present deep wells for electricity generation may be limited. Their potential could, however, be enhanced by various well stimulation techniqes. Current technology in the geothermal industry utilizes such procedures as air-lifting, hydraulic fracturing and acidization, and installation of downhole pumps in order to improve the flow capacity of low production bores.

Air-lifting and nitrogen lifting were used on the deep exploration wells during 1982. There appeared to be a measurable increase in the discharge of MC-1, suggesting that stimulation may improve the well outputs at Meager

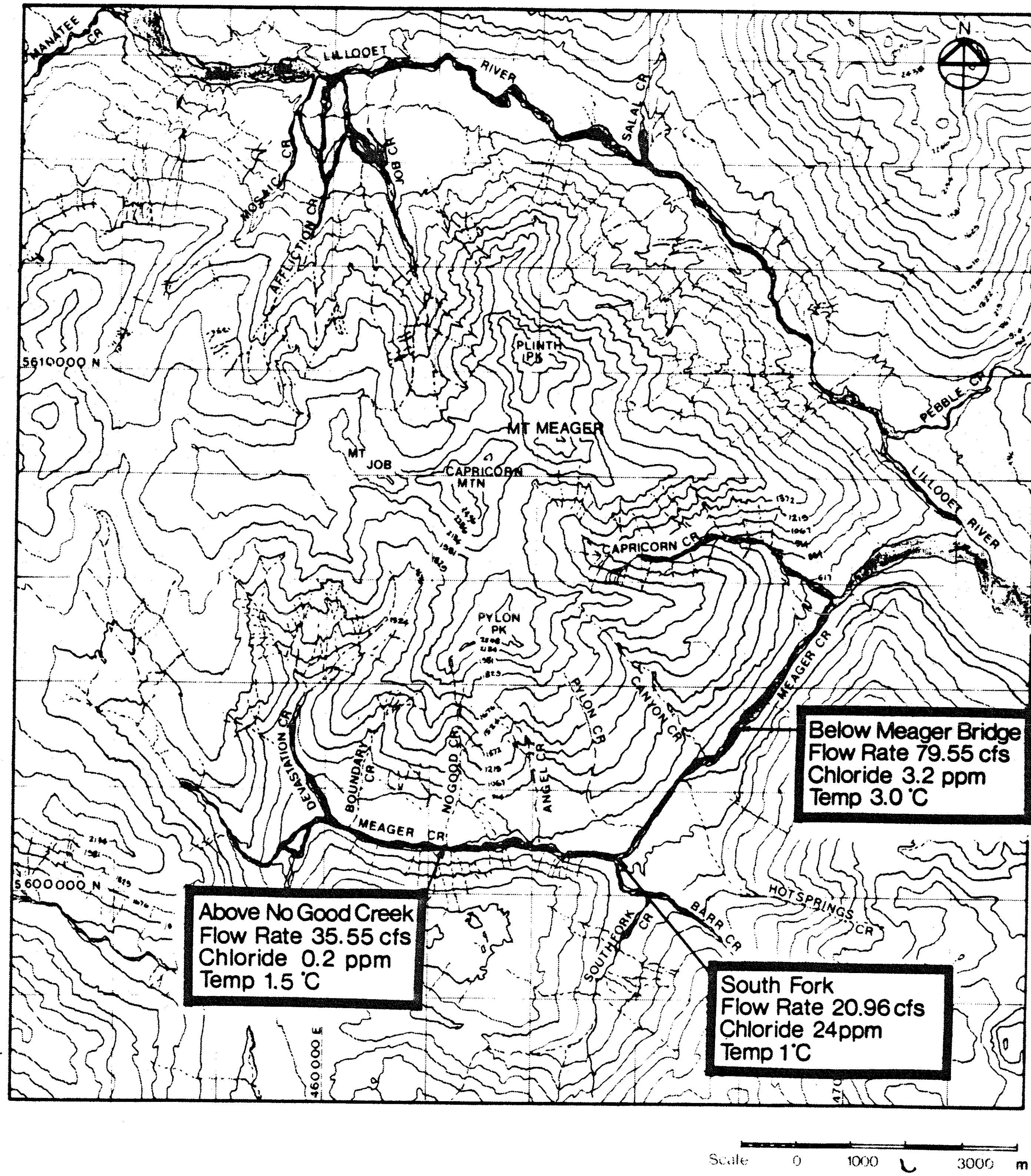
Creek. Further evaluation of other techniques such as hydro-fracturing or explosive fracturing has yet to be determined.

The flowrate from the present exploratory bores could well be increased by the use of downhole pumps. The increased flow capacity from downhole pumping combined with a total flow or binary system for electricity generation may provide a suitable method of exploitation. This option would require thorough testing and evaluation.

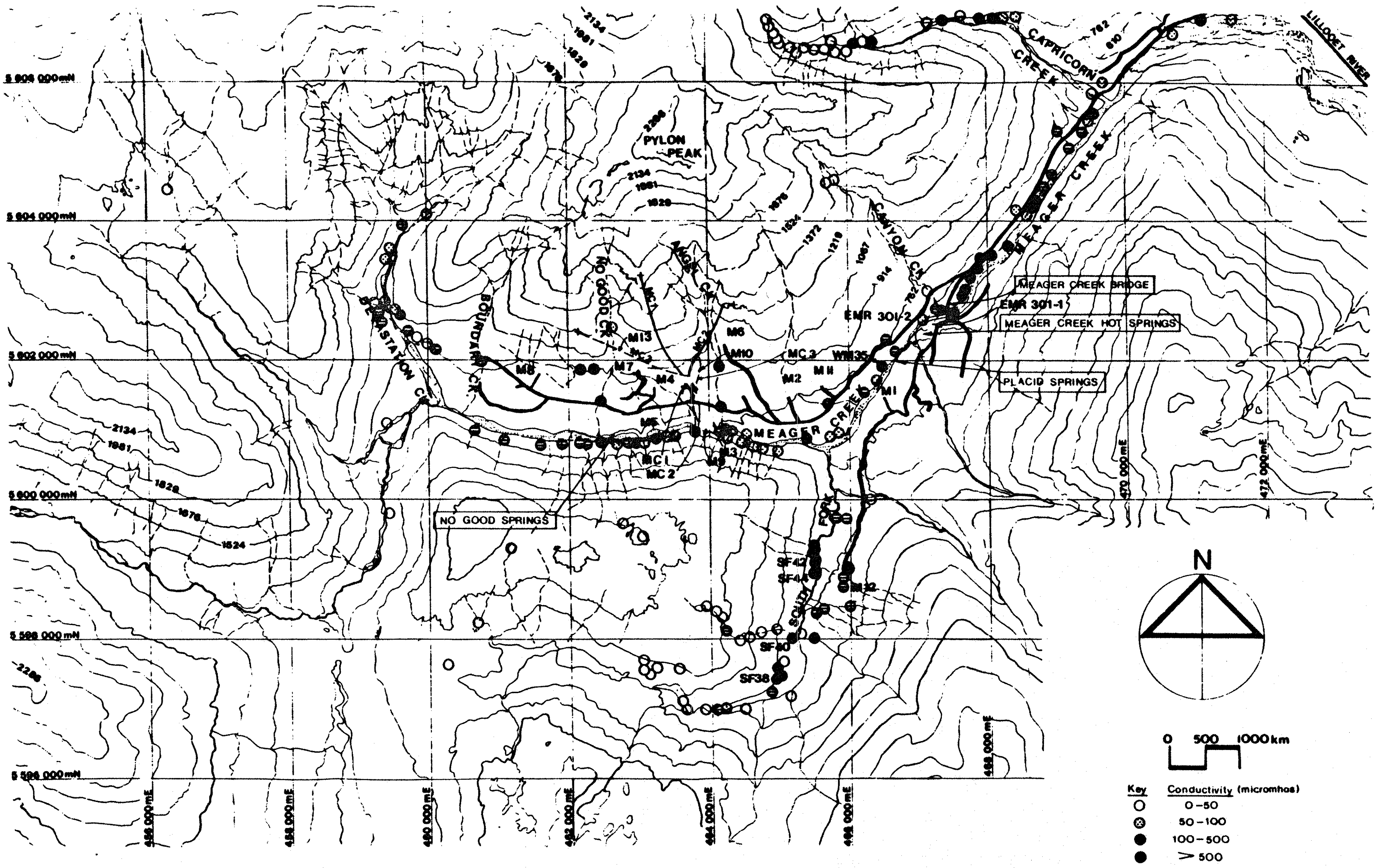
3.2.3 Surface Exploration

Surface exploration in the South Reservoir during the 1982 field season was limited to stream geochemistry. The study was geared towards identification of high chloride outflow channels which might be used to more closely define the limits of the geothermal resource. Approximately 180 water samples were collected during the course of the survey and were analysed for chloride and sulfate ions, and specific conductivity. The program was implemented as part of the regional reconnaissance exploration which also investigated the North Reservoir and upper Lillooet River areas.

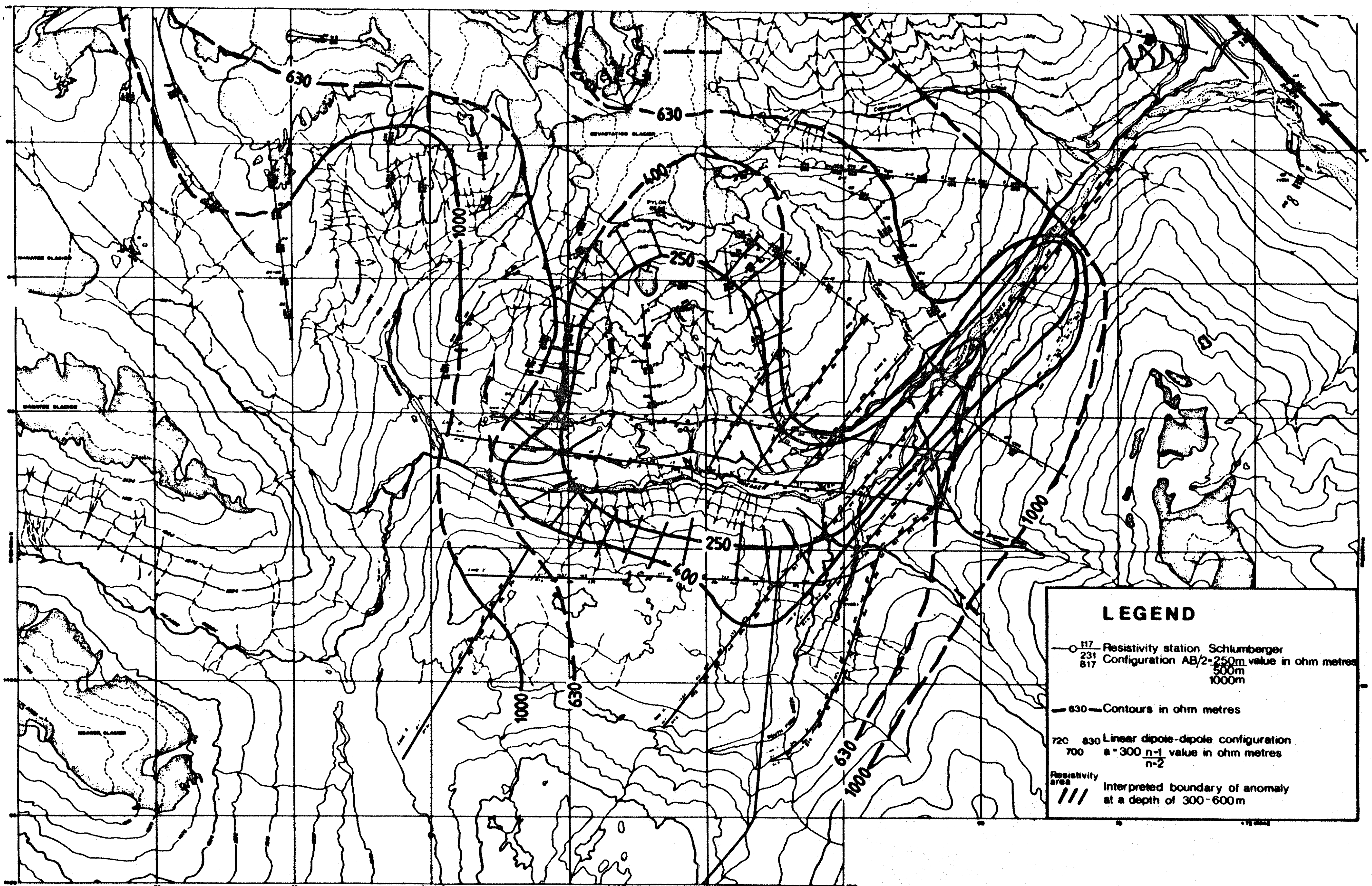
The study identified a zone in Meager Creek valley below No-Good Creek as an area of anomalously high chloride flow (Figures 19, 20). Results of full suite analyses of selected borehole and surface samples indicate varying degrees of mixing in all areas of the outflow



Sampling station locations, flow rate and chloride contents (March 1982 R. Beniston B.C.H)



Geochemical conductivity data South Meager



Geophysical Anomaly South Meager

plume from No-Good Creek downstream to Meager Creek Hot Springs. In addition, a number of swamps in the South Fork Meager Creek area were found to have high chloride and high conductivity. The source of the anomalous waters (which were also encountered in diamond drill hole M12-80D) is not immediately apparent, although it is improbable they are directly related to South Reservoir geothermal waters.

Geochemical sampling results and resistivity surveys show good correlation, identifying the large outflow plume extending down Meager Creek (Figure 21).

Some further surface exploration is required to investigate the causes for the northern and western boundaries of the geophysical anomaly. The significance of the Carbonate Springs also requires further investigation as the Ryan River Lineation with which they are aligned may be of structural importance to the South Meager resource.

3.3 Meager Creek - North Reservoir

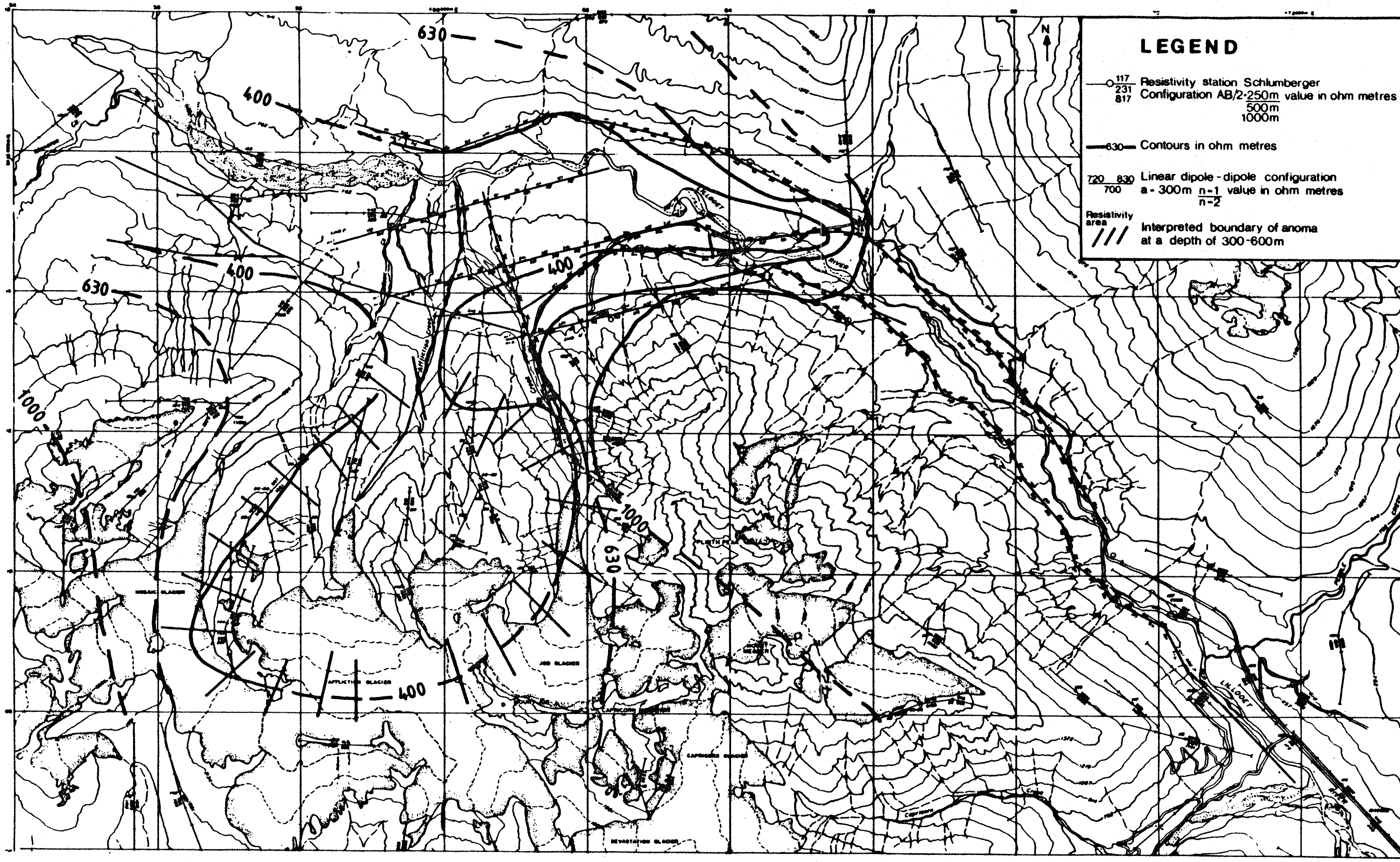
The 1982 field season saw continued geothermal reconnaissance at Meager Creek with emphasis on the postulated North Reservoir area. On the premise that the geothermal resource encountered in the South Reservoir may extend northward, an exploration program entailing resistivity surveying, geochemical and geological prospecting, and shallow temperature gradient hole drilling was designed.

3.3.1 Resistivity Program

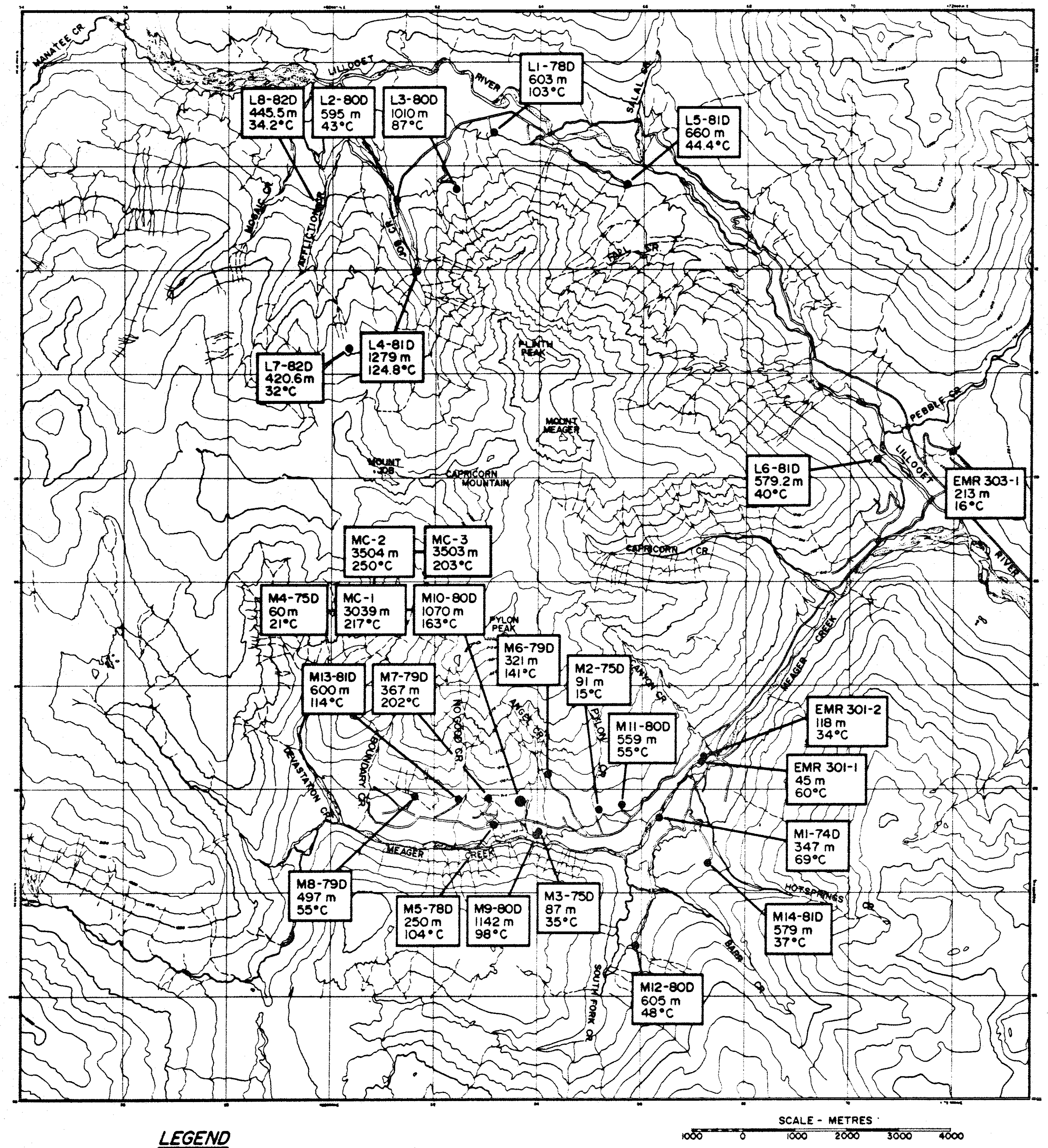
An extensive resistivity program, utilizing the Schlumberger array, was conducted on the north slopes of the Meager complex. Despite steep terrain, extensive glaciation and difficult access, a relatively low resistivity anomaly was identified.

Set against a background of resistivities ranging from 800 ohm-m to several thousand ohm-meters, a number of anomalous values of 400 ohm-m are centered on the headwaters of Affliction Creek. The anomaly tapers downstream spreading both east and west where Affliction Creek joins the Lillooet Valley. Here, the anomaly is open to the west and continues eastward as far downstream as Salal Creek (Figure 22).

A number of vertical electric soundings were collected to augment Schlumberger data. Of these, a sounding at Silt Lake in the upper reaches of the Lillooet Valley indicates the most significant resistivity profile. Resistivities drop from about 12 000 ohm-m at the surface to 11 ohm-m at a depth of 120 m; a profile typical of soundings measured in proven geothermal areas. Although it would be unwise to draw any firm conclusion in the absence of other data, preliminary results justify further geophysical investigation and possibly diamond drilling in this area.



Geophysical Anomaly North Side

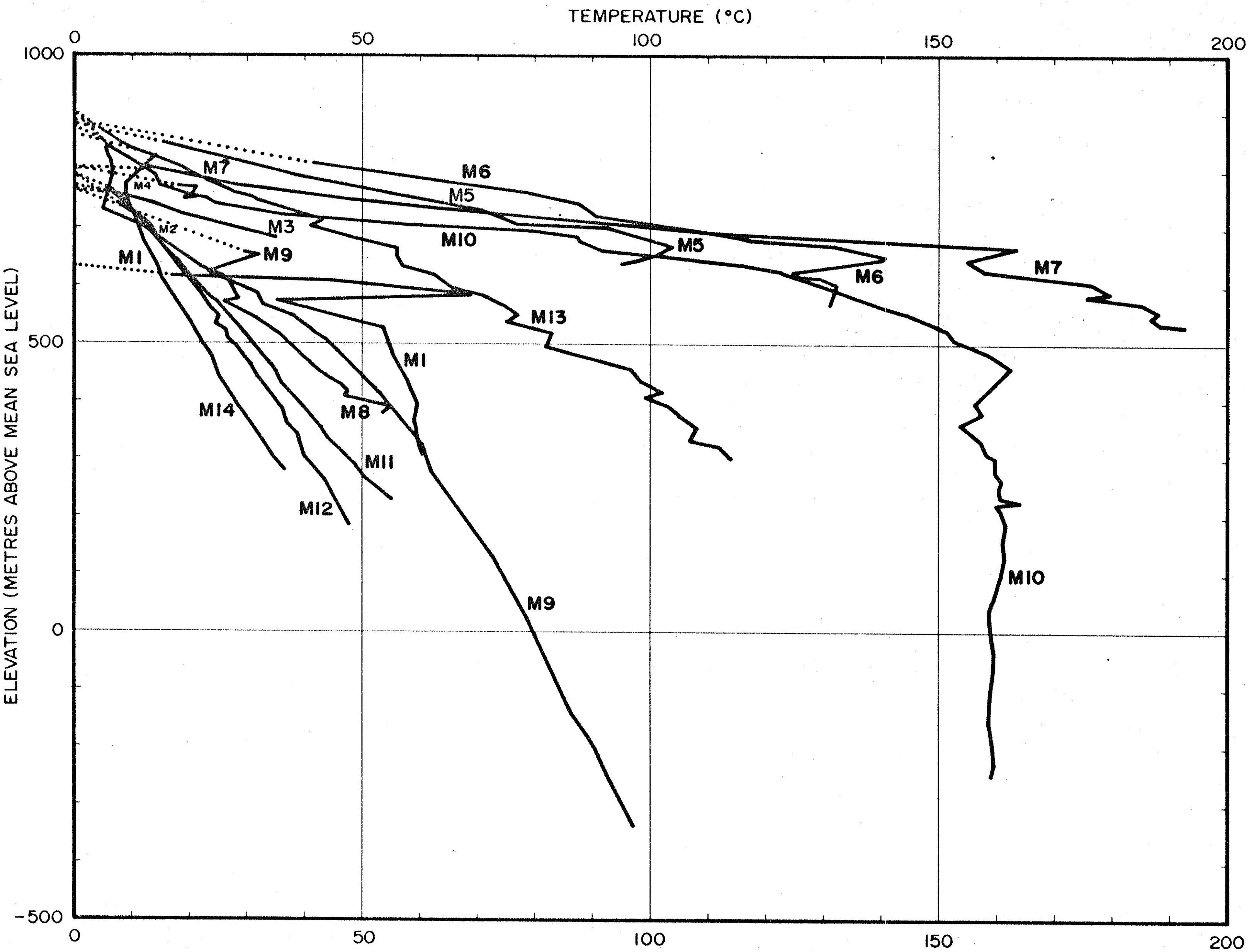


LEGEND

● LOCATION OF HOLE

M3-75D	HOLE DESIGNATION EMR - Energy, Mines & Resources, Canada L - Lillooet Drainage M - Meager Drainage MC - Deep Exploration Rotary
87 m	DEPTH IN METRES
35°C	MAXIMUM HOLE TEMERATURE

SUMMARY MAP OF DRILL SITES



NOTES:

M1 - 74D
el. 635.0 m; TD 347.0 m

M2 - 75D
el. 774.0 m; TD 91.0 m

M3 - 75D
el. 770.0 m; TD 87.0 m

M4 - 75D
el. 808.0 m; TD 60.0 m

M5 - 78D
el. 882.0 m; TD 250.0 m

M6 - 79D
el. 885.0 m; TD 321.0 m

M7 - 79D
el. 900.0 m; TD 367.0 m

M8 - 79D
el. 875.0 m; TD 497.0 m

M9 - 80D
el. 765.0 m; TD 1,142.0 m

M10 - 80D
el. 807.5 m; TD 1,070.0 m

M11 - 80D
el. 791.0 m; TD 559.4 m

M12 - 80D
el. 792.5 m; TD 605.0 m

M13 - 81D
el. 899.0 m; TD 599.5 m

M14 - 81D
el. 861.0 m; TD 578.5 m

FIGURE

SUMMARY OF TEMPERATURE PROFILES SOUTH RESERVOIR

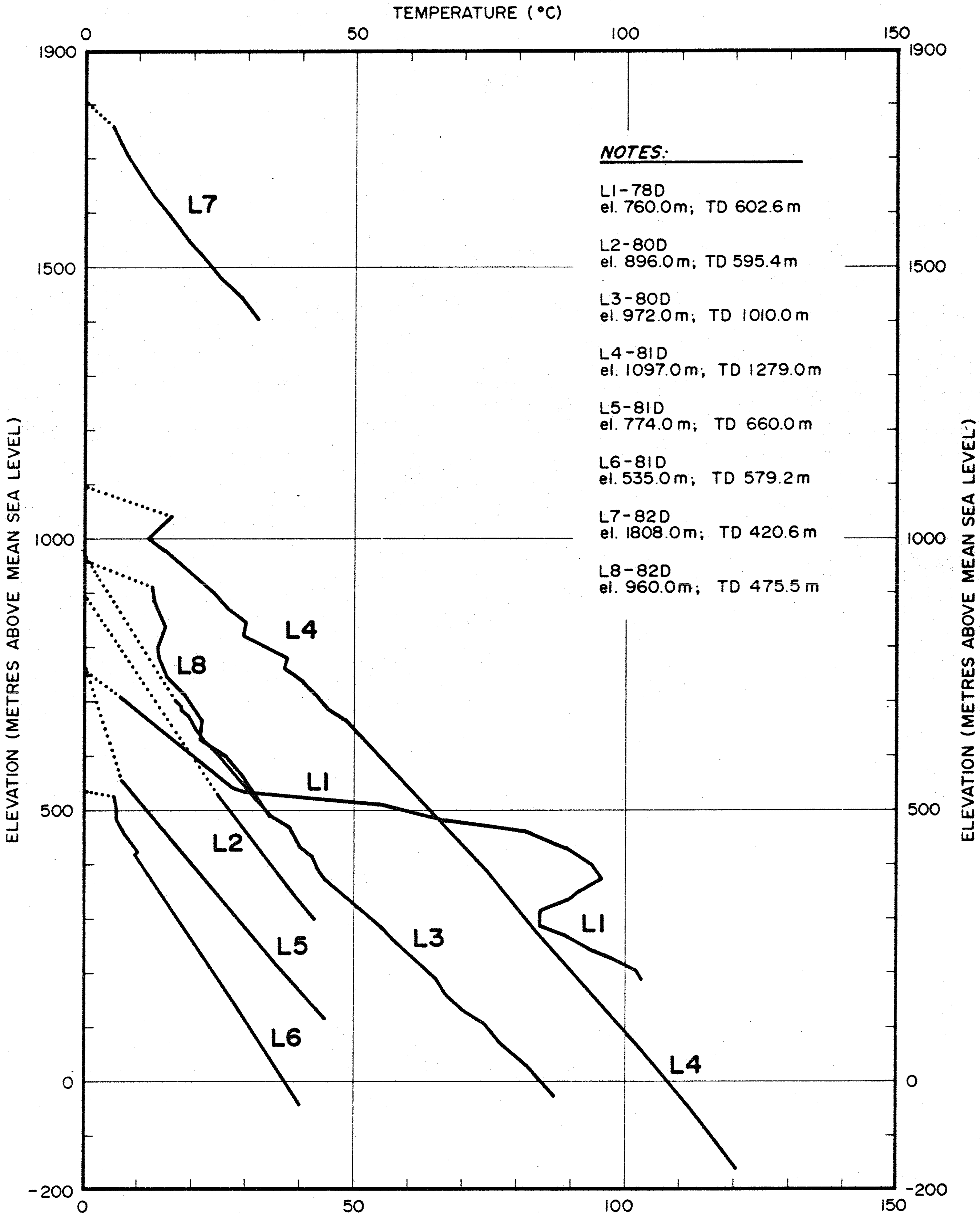
3.3.2 Diamond Drilling

In total, five diamond drill holes were completed in the North Reservoir during the 1982 season. Drilling on three holes, L4, L5, and L6, was resumed in the spring after operations were suspended for the winter (Figures 23, 24).

Drilling in the upper reaches of Job Creek, to evaluate the significance of a broad resistivity anomaly and an H_2S gas occurence in the L4 area was completed in mid-August, reaching a depth of 1 279 m. A bottom hole temperature of 124.8°C was measured at that depth, with a temperature gradient of approximately 80°C/km. Although the hole penetrated strongly foliated metasediments, groundwater flow in the lightly fractured rock is probably minimal (Figure 25).

L5 was targeted to test the heat flow in the vicinity of the Recent rhyodacite flows of the Bridge River Ash event. The hole was extended to a depth of 660 m where a temperature of 44.4°C and a gradient of 88°C/km were recorded. Leucogranite of the Fall Creek Stock was encountered beneath the volcanics, although alteration in this unit is limited.

L6 is situated in a belt of metasediments near the confluence of Meager Creek and Lillooet River, and was extended from 150 m to 579 m during 1982. The hole, drilled to test a broad regional geophysical anomaly, encountered a bottom hole temperature of 40°C and a uniform, conductive temperature gradient of 60°C/km. Apparently, the resistivity anomaly was caused by a



FIGURE

SUMMARY OF TEMPERATURE PROFILES NORTH RESERVOIR graphitic phyllite unit as no recent hydrothermal activity is evident.

L7 was sited at the 1 900 m (6 000') elevation of the Affliction Creek basin in order to test a low resistivity anomaly in the vicinity. The hole encountered a temperature of 32°C at a total depth of 421 m, with a temperature gradient of 87°C/km. The resistivity anomalies are possibly indicating the extensive clay alteration in shear zones which halted drilling short of the 500 m target depth. However, mineralogy of the clays in L7 suggests that they are unlikely to have formed from any current geothermal system.

L8 was drilled in order to evaluate the downstream extension of the Affliction Creek resistivity anomaly. Situated on the west bank of the creek at the break in slope on the Lillooet Valley, the hole was drilled to a depth of 475 m, and encountered a temperature of 34.2°C. A thermal gradient of approximately 65°C/km was measured although temperature fluctuations indicate considerable groundwater movement within the drillhole. The amphibolite unit was broken and strongly sheared over much of the length of the drill hole and, as in L7, the associated clays are suspected to be weathering products of the basement rocks rather than products of alteration by geothermal fluids. Again, the anomalous resistivity response could be attributed to these conductive clays.

3.3.3 Geochemical Stream Sampling

A geochemical stream sampling program was carried out in the upper Lillooet River drainages from the Lillooet Glacier in the northwest to the intersection of Meager Creek in the southeast. Over 300 samples were collected and analysed from creeks, streams and seeps draining into the Lillooet River in an attempt to locate waters indicative of outflow from an active geothermal system. Emphasis was placed on detailed sampling of the Job - Affliction Creek area where the presence of H_2S gas emanating from beneath the Job Glacier, plus existing geophysical data, suggest such an outflow. Data was sectioned into ten geographic groupings for statistical analysis (Figure 26).

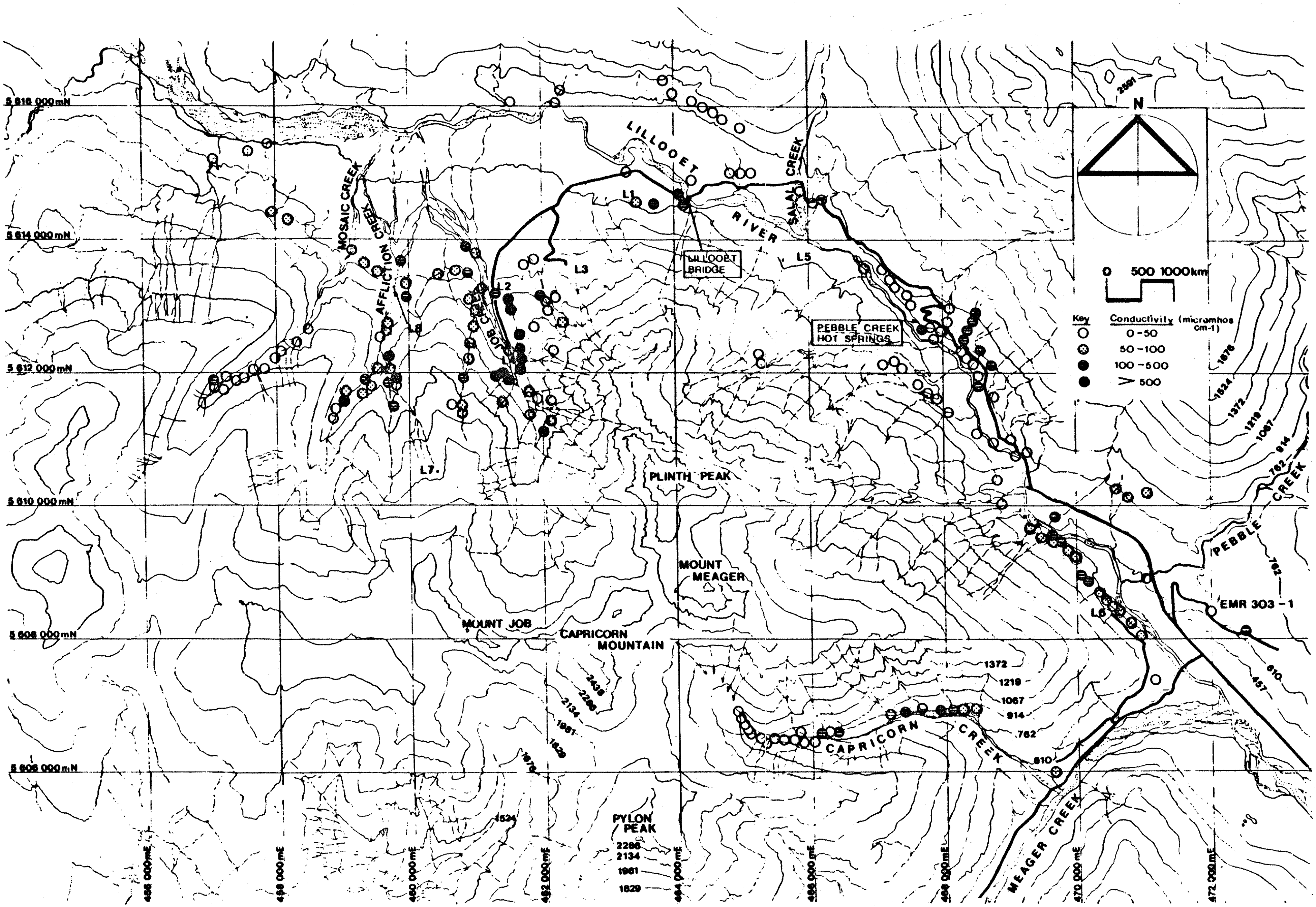
In most areas, both chloride and sulphate ionic concentrations were found to be very low, with conductivities being low to moderate. Job and Affliction Creek areas, however, were characterized by high conductivity (300 to 500 micromhos/cm) and high sulphate (approx. 200 ppm) but by very low chloride values. Geochemical work in the Silt Lake area failed to identify any cause for the low resistivity anomaly.

In addition to stream sampling, full suite analyses were performed on samples collected from L1-78D and the Pebble Creek Hot Springs. Waters in L1 are only slightly mineralised with a chloride content of 33 ppm although dilution by near surface cold groundwater is indicated. Pebble Creek Hot Spring water was found to be similar to that in L1, with low chloride, high fluorine values and a low level of mineralisation.

3.3.4 Surface Geological Mapping

Detailed geological mapping initiated in late 1981 in the Affliction - Job Creek areas was completed in August, 1982. The study determined that the structure of the metamorphic rocks in the area is that of a gently southeast plunging synform. Such a structure may have a related fracture system that could provide a regional porosity to the area, particulary in more competent units. Faults are small and localized although there can be intense brecciation along them. Fractures are widespread although no regional pattern has been determined. Although exposure is too poor to entirely discount the existence of major faults in Affliction or Job Creek valleys, detailed examination indicates there is sufficient stratigraphic continuity to suggest either that such faults do not exist or that movement on them is very small. The Affliction Creek drainage, particularly the vicinity of L7, is an area of greater than average fracturing, faulting, alteration and, volcanic intrusion. These features, combined with the resistivity anomalies and high temperature gradient in L7, suggest that an active geothermal system may be present.

The hydrogen sulphide emanating from beneath the glacier in the Job Creek area was not explained by diamond drilling or by surface geochemical prospecting. Because the evolution of H_2S is common in geothermal fields, further geological and geochemical work would be requried to establish the significance of these emanations.



Geochemical conductivity data North Side

3.4 Environmental Studies

Environmental baseline data collection and monitoring of exploration phases of the Meager Creek Geothermal project commenced in the summer of 1979 and was continued during 1982. The study involved characterization of various environmental parameters (including meteorology, hydrology, surface water quality, air quality and noise), and fish and wildlife resources in the study area. Further studies were conducted to evaluate the effects of exploration activities on water and air quality (specifically changes in H_2S levels) in the vicinity of the deep well drilling.

The principal activities and findings of the environmental program are as follows:

1. Preliminary fisheries studies were conducted to initiate a baseline of the fish resources in the project area. The fishery in the upper Lillooet watershed may well be the most sensitive and important environmental resource component within the geothermal project area.

2. Collection of baseline water quality data at five sites in the vicinity of deep well drilling activity indicate minimal effect on Meager Creek (although exploration activities have had a notable

impact on a small tributary in close proximity to the deep well site).

3. A nearly continuous record of water level dating back to July, 1980 has been collected for the upper Lillooet River, although similar measurements on Meager Creek have been frustrated by the shifting streambed.

4. Meteorological data collection was continued in the Meager Creek valley and at the B.C. Hydro base camp although data is not yet available for the upper Lillooet valley from the MATER unit. Additional preliminary data includes precipitation and snow levels from several sites in the study area.

5. The air quality program concentrated on establishing background levels of H_2S and radon gas on a year round basis.

6. Preliminary wildlife studies were initiated with a review of incidental wildlife observations and a winter range survey to identify the kinds of habitats used by ungulates in the study area.

7. Background noise levels were recorded.

8. Present land uses were documented and a land use map of the primary study area was updated.

It would appear that, in most respects, sufficient baseline data is available to provide adequate planning information for any project activity likely to occur in the near future. The need for further environmental data should be assessed when the planned exploration or resource assessment program is known. Early additional work at South Meager could include groundwater hydrology studies, and further fisheries studies.

3.5 Labortatory Studies

3.5.1 UURI Alteration Study

Multielement investigations of geothermally altered rocks have proven to be an effective technique for mapping zones of fluid flow and temperature distribution in active thermal systems. However, little data is available in hydrologically complex volcanic terrane such as those which characterize the Cascades. Whole-rock trace element determinations were made on 270 samples of diamond drill core from six wells which provide an illustrative cross-section of the thermal anomaly in the South Reservoir area. In addition, information from analyses of thermal fluids from springs and shallow wells was incorporated into the study.

Three distinct geochemical associations were mapped within the reservoir. The first is restricted to propyllitically altered crystalline and metamorphic basement rocks which underly the Mt. Meager Volcanic Complex. This assemblage evolved from the circulation of high temperature waters generated during the emplacement of the Cretaceous stocks of the Coast Range Plutonic Complex. The other two assemblages resulted from alteration by two chemically different geothermal fluids. Within the high temperature portion of the field, the dikes are enriched in Hg + As + Zn and Hg + Zn. Although wells containing rocks with these assemblages did not encounter high temperature fluids, base metal deposition has been associated with high temperature brines in the Broadlands geothermal area. A charcteristic high salinity, high temperature fluid may be present at depth at Meager Creek. It is proposed that the shallow, low temperature (<140°C) reservoir encountered in earlier exploration is the result of low permeability near the surface, and that there is a high TDS, high temperature reservoir yet to be found. (Moore, et al., 1983)

3.5.2 Heat Flow Study

Temperature gradients in geothermal drill holes provide valuable information about the nature of thermal anomalies in the crust. However, due to variations in thermal conductivity, interpretations of the geometry for the geothermal system may be misleading if gradients alone are used. In order to provide an absolute comparison of thermal data across a varied geologic terrane, it is necessary to combine temperature gradient data with various heat conductivity characteristics to arrive at a value for heat flow.

A total of 166 thermal conductivity measurements from the core of fifteen exploration gradient holes at the Meager Creek project were analysed. Heat flow determinations show a convectively disturbed high flux area in the South Reservoir, with distinct boudaries to the south and east, remaining open to the west and north. Background values are low and consistent. North Reservoir background values are nearly twice the magnitude of those in the south; the difference is attributed to a combination of higher thermal conductivity and heat productivity and a possible unseen thermal anomaly of considerable size.

3.6 Data Retrieval System

Because of the increasing scale of exploration at the Meager Creek Project, the body of information has been greatly expanded and convential data storage techniques have become somewhat cumbersome. In order to provide improved information accessibility, a data retrieval system was implemented in early 1983.

The system hardware is centered around an IBM Personal Computer (equipped with 128k RAM expansion option, color/graphics adaptor and two built-in 320kB 5.25 inch diskette drives), a standard IBM PC keyboard and a Zenith 10" 80 column green phosphor monitor. Two printers were selected in order to provide both dot matrix and letter quality printing. The Epson MX-100 F/T is an extremely versatile dot matrix printer capable of producing high resolution dot graphics, standard and italic character sets and ten different type styles. The letter quality printer selected was the Daisywriter Peacock 2000, with 30CPS daisywheel printing, 4k internal memory buffer and fully addressable platten movements.

In addition to standard IBM PC software (MS-DOS, BASIC), a FORTRAN compiler, EASYWRITER II wordprocessor, MULTIPLAN electronic spreadsheet and DBASE II data base management system were added to the inventory. The DBASE II package is the central database management facility, storing information by means of a number of separate sub-programs.

To date, information regarding exploratory well temperature and pressure surveys, geochemical analyses and invoice/costing data has been recorded, with further plans for storage of diamond drill, tour sheet and reservoir parameter data.

References

Britton, J.M., 1983. 1982 Geological Mapping Program, North Reservoir Area, Meager Creek, B.C. Unpublished report to B.C. Hydro & Power Authority. Nevin Sadlier-Brown Goodbrand Ltd., Vancouver, B.C. 14 pp.

KRTA, 1982. Meager Creek Geothermal Project, MC-2 Well Completion Report. Unpublished report to B.C. Hydro & Power Authority. Kingston Reynolds Thom and Allardice Limited, Auckland, New Zealand. 63 pp.

____, 1983(a). Meager Creek Geothermal Project, MC-3 Well Completion Report. Unpublished report to B.C. Hydro & Power Authority. Kingston Reynolds Thom and Allardice Limited, Auckland, New Zealand. 70 pp.

____, 1983(b). Meager Creek Geothermal Project, 1981-1982. Unpublished report to B.C. Hydro & Power Authority. Kingston Reynolds Thom and Allardice Limited, Auckland, New Zealand.

Moore, J.N., Adams, M.C. and Stauder, J.J., 1983. Geochemistry of the Meager Creek Geothermal System. Unpublished paper.

NSBG, 1981. Meager Creek Geothermal Area, Slim Hole Drilling Summary. Unpublished report to B.C. Hydro & Power Authority (2 volumes). Nevin Sadlier-Brown Goodbrand Ltd., Vancouver, B.C.

Petty, S., 1983. Written communication to B.C. Hydro & Power Authority, January 19, 1983. Well Production Testing, Inc., Carlsbad, California.

Reader, J.F., 1983. Thermal Conductivity and Heat Flow in Diamond Drill Holes, Meager Creek Geothermal Area, Southwestern British Columbia. Unpublished report to B.C. Hydro & Power Authority. Nevin Sadlier-Brown Goodbrand Ltd., Vancouver, B.C. 6 pp.

Reid, Crowther & Partners Limited, 1982. Meager Creek Geothermal Project: Environmental Status Report, 1981. Unpublished preliminary report to B.C. Hydro & Power Authority. Reid, Crowther & Partners Limited, North Vancouver, B.C. 85 pp.

Stauder, J.J., Menzies, J.M., Harvey, C.C., and Leach, T.M., 1983. Meager Creek Geothermal Project - Preliminary Resource Evaluation. Proceedings of the 7th Annual EPRI Geothermal Conference and Workshop (in press).