PLACER DOME INC. BERG PROJECT
ENVIRONMENTAL AND ROAD CORRIDOR STUDY

APPENDICES

PART 2 of 2

Prepared for

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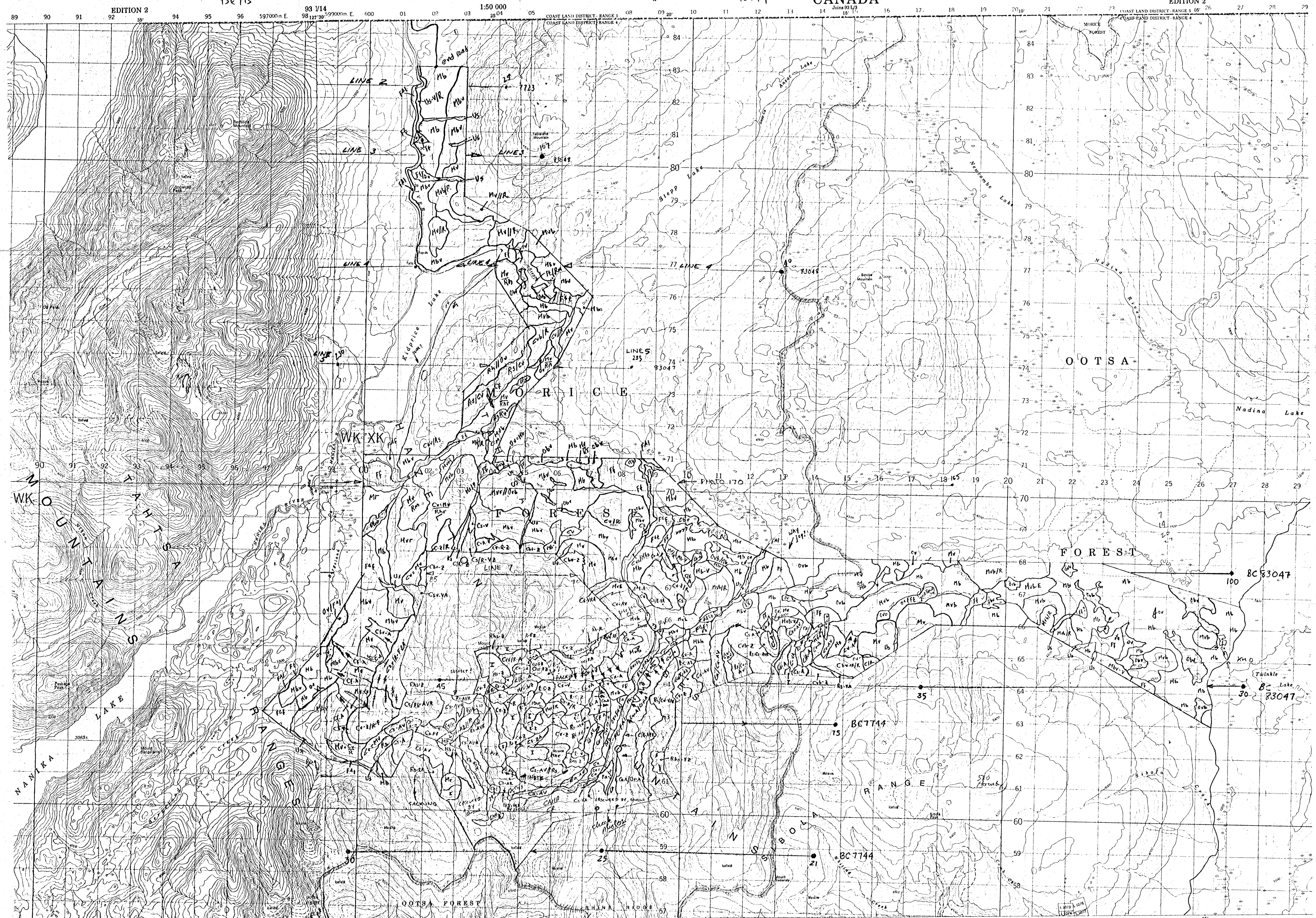
December 1989

File: 1-168-02.12

LIST OF APPENDICES

APPENDIX 2.2.1-1

Access Corridor Surficial Geology



NEWCOMBE LAKE

BRITISH COLUMBIA

Scale 1:50 000 Échelle

19749

BERG CREEK

FORT MORECA

19-161-15

TEXTURE ①

(Particle sizes based upon Unified Soil Classification System and N.R.C. Field Description)

Specific Clastic Terms:

a	blocks	angular 203 mm plus
b	bouldery	203mm plus
k	cobbly	76 — 203mm
p	gravelly	5 — 76mm
s	sandy	.075 — 5mm
$	silty	.002 — .075mm
c	clayey	minus — .002mm

Common (Grouped) Classes:

d	mixture of fragments	
r	rubbly	angular cobbles and boulders
g	mixture of gravel and coarser	
-s-	silt and sand	mixture $ and s
f	fines	mixture $ and c

Organic Soils

e fibric u mesic h humic

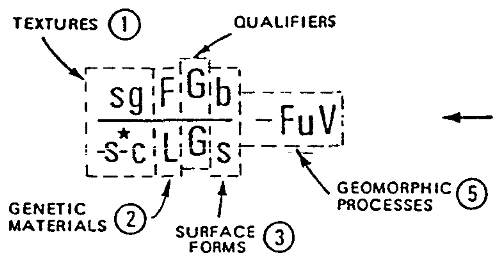
Well-sorted materials are described by the use of a single textural term; less well-sorted and poorly sorted materials are described using two textural terms with the subordinate textural term given first.

SURFICIAL MATERIAL ②

A	Anthropogenic▲	M	Morainal (Till)
C	Colluvial▲	O	Organic▲
D	Weathered Bedrock	R	Bedrock
E	Eolian	U	Undifferentiated
F	Fluvial (Alluvial)	V	Volcanic
FG	Glaciofluvial	W	Marine
I	Glacier Ice▲	WG	Glaciomarine
L	Glaciolacustrine		
LG	Lacustrine		

▲ Materials for which formative processes are assumed to be active; all others are assumed inactive. In areas mapped by photo interpretation with little or no fieldwork, textures of surficial materials may not be shown. Textures are then assumed to lie within a range defined in a supporting document.

EXAMPLE



Interpretation: A blanket of sandy gravel and coarser glaciofluvial material (outwash) overlies water-bearing silt-sand and clayey glaciolacustrine (glacial-lake) deposits in steep erosional slopes. The entire unit is subject to soil slumps and active gullying.

GEOMORPHIC PROCESSES ⑤

▲ Geomorphic processes assumed to be active; others are assumed inactive.

ARCTIC, ALPINE AND PERIGLACIAL PROCESSES

-C	Cryoturbated▲
-N	Nivated▲
-S	Soliflucted▲
-Z	Grouped (-C,-N,-S)▲
-X	Permafrost▲
-H	Kettled
-T	Thermokarst▲

FLUVIAL PROCESSES

-B	Braided▲
-E	Channelled by Meltwater
-J	Anastomosing▲
-M	Meandering▲
-U	Flooded▲
-I	Irregularly sinuous▲

MISCELLANEOUS EROSION PROCESSES

-D	Deflated▲
-K	Karst▲
-P	Piping▲
-V	Gullied▲
-W	Washed▲

MASS MOVEMENT PROCESSES

All of these processes are assumed to be active

-A Snow Avalanched

-F Extremely slow to moderate rates of failure in soil and bedrock:
- c soil creep
- g rock creep
- e earthflow
- u soil slump
- m rock slump

-R Moderate to extremely rapid rates of failure in soil and bedrock (1.5m/d to >3m/s):
- m rock slump
- s debris slide
- r rockslide
- d debris flow
- t debris torrent
- a debris avalanche
- f rockfall
- x rock avalanche

Where possible, lower case letters are given as subscripts to -F or -R. In some cases more than one subscript may be used.

19749 Part 2

ON-SITE SYMBOLS

These and other symbols are used to show features of special interest and limited extent.

- Drumlin, crag-and-tail or drumlinoid ridge
- Glacial fluting or striae
- Esker. Known and unknown direction of depositional flow
- Large glacial meltwater channel
- Small glacial meltwater channel
- Moraine ridge
- Cirque
- Erosional escarpment
- Landslide escarpment
- Snow avalanche track. Runout limits are not implied.
- Borrow pit: active and inactive
- Mine or quarry: active and inactive
- Observation of frozen ground or ground ice; observation of thaw
- Spring or seep; saline seep
- Numbered sample location; numbered photo orientation

Linear Landslide Symbols and Mass Movement Types

- Rapid mass movement (debris torrent) with known point source
- Slow mass movement (earthflow) with landslide escarpment source

Limits of landslide runout are not implied by these symbols

SURFACE FORM ③

a	moderate slope unidirectional 15-26° (apron)	l	level
b	blanket	m	rolling
d	depression	p	plain
c	cone	r	ridged
f	fan	s	steep
h	hummocky (15-35°)	t	terraced
j	gentle slope	u	undulating (hills-hollows to 15°)
k	moderately steep uidirectional (26-35°)	v	veneer

The use of two (or rarely three) surface forms together implies there is a mixing of discrete forms and not a combination of intermediate forms. Blanket indicates deposits greater than 1 metre thick; veneer indicates deposits less than 1 metre thick. The use of s is reserved for erosional slopes generally greater than 26° on both consolidated and unconsolidated materials.

QUALIFIER ④

These superscripts are used to qualify genetic materials or geomorphic processes.

G	Glacial	B	Bog	Reserved for organic genetic materials
A	Active (contemporary)	F	Fen	
I	Inactive (has ceased)	S	Swamp	

Superscript modifiers A and I are used only where process states are contrary to the assumptions made for genetic materials and geomorphic processes.

SITE-SPECIFIC STRATIGRAPHY

Brackets tied to point locations shown stratigraphic details at significant exposures. Locations typically consist of isolated sections on steep erosional slopes. Asterisk (★) shows units with seepage. Materials may be texturally and/or genetically identifiable. Unit thickness not given or implied.

gF / cLG / sg★ / R

Example:

Gravelly alluvium-(texturally and genetically identifiable) overlying clayey glaciolacustrine deposits overlying water-bearing sandy gravel (texturally identifiable); the entire sequence rests on bedrock.

COMPOSITE UNITS

=	Units are of roughly equal extent (1:1)
/	Unit to the left is more extensive than the unit to the right (approx. 2:1)
//	Unit to the left is much more extensive than the one to the right (>2:1)

Modified by Thurber Consultants Ltd. from "Terrain Classification System British Columbia", B.C. Ministry of Environment Manual 10.

TERRAIN MAPPING LEGEND

THURBER CONSULTANTS LTD.

CALGARY EDMONTON VANCOUVER VICTORIA

PLACER DOME BERG PROJECT

APPENDIX 3.2.4-1

Regional and Site Precipitation Data for the Berg Project Area

APPENDIX 3.2.4-1

TABLE 1

PRECIPITATION COMPARISONS BETWEEN THE BERG PROJECT AREA AND REGIONAL AES CLIMATE STATIAES CLIMATE STATIONS

STATION	PRECIPITATION	SEPT(88)	OCT	NOV	DEC	JAN(89)	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP(89)
TAHTSA LAKE WEST	1988-1989													
	Rain	215.0	227.3	103.9	96.6	98.0	0.0	3.2	18.5	-	57.0	35.9[b]	67.3[b]	64.8[b]
	Snow		34.0	212.0	131.2	474.5	15.0	159.5	41.5	-				
	Total precip	215.0	261.3	315.9	227.8	572.5	15.0	162.7	60.0	-	57.0	35.9	67.3	64.8
	LONG TERM													
	Rain	155.3	249.2	117.7	56.2	42.7	32.7	29.5	40.5	44.3	55.3	56.3	74.6	155.3
	Snow	1.7	45.1	154.8	241.2	214.3	170.1	131.1	71.1	11.1				1.7
	Total precip	157.0	295.0	272.5	297.4	257.0	202.8	160.6	111.6	55.3	55.3	56.3	74.6	157.0
WISTARIA	1988-1989													
	Rain	-	21.2	11.6	0.0	12.4	0.0	0.0	3.6	23.8	28.4	78.2[b]	89.0[b]	18.4[b]
	Snow	-	2.6	37.9	52.8	31.2	7.6	33.2	8.2	0.0				
	Total precip	-	23.8	49.5	52.8	43.6	7.6	33.2	11.8	23.8	28.4	78.2	89.0	18.4
	LONG TERM													
	Rain	38.5	30.4	11.7	5.2	1.8	1.9	1.2	4.9	22.6	38.4	39.9	44.5	38.5
	Snow	1.1	13	31.4	47.4	45.7	24.5	20.8	12.5	3.8				1.1
	Total precip	39.6	43.4	43.2	52.5	47.5	26.4	22.1	17.4	26.5	38.4	39.9	44.5	39.6
BERG PROJECT AREA	1988-1989													
	Rain									20.6[a]	33.0	53.8	58.4	15.5[a]
	Snow													
	Total precip													
	LONG TERM													
	Rain	106.7	171.2	80.9	38.6	29.3	22.5	20.3	27.8	30.4	38.0	38.7	51.3	106.7
	Snow	1.2	31.0	106.4	165.7	147.2	116.9	90.1	48.8	7.6	0.0	0.0	0.0	1.2
	Total precip	107.9	202.7	187.2	204.3	176.6	139.3	110.4	76.7	38.0	38.0	38.7	51.3	107.9

a Only partial month.

b Preliminary data from AES.

APPENDIX 3.2.4-1

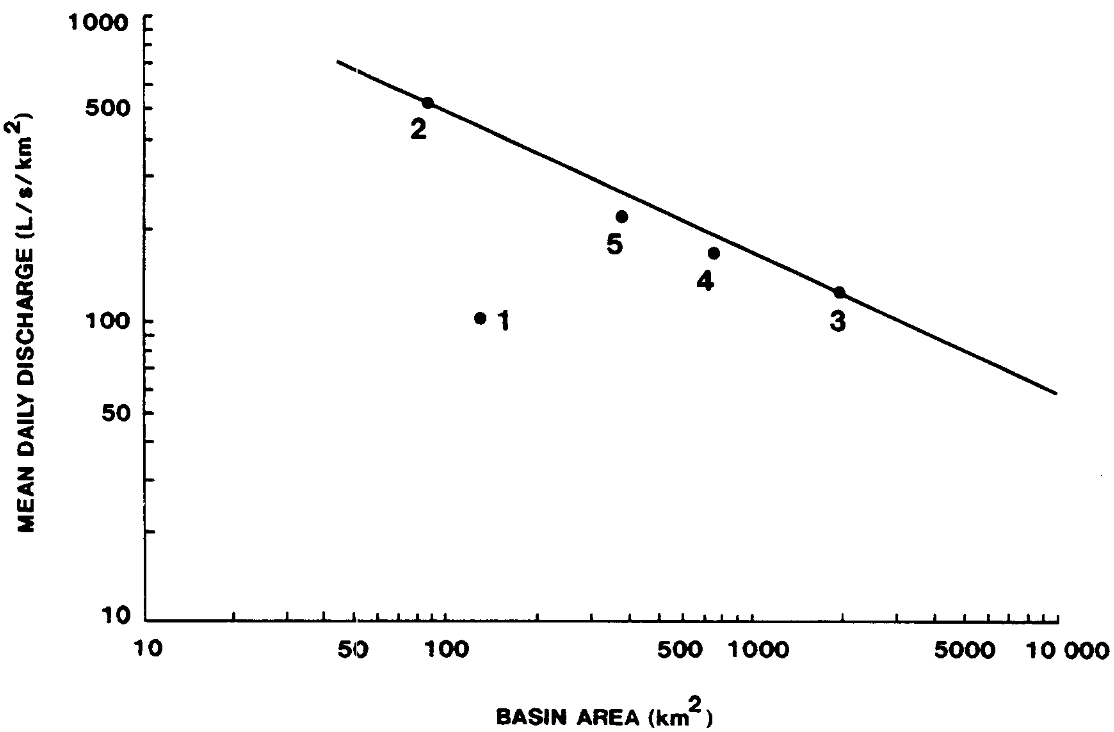
TABLE 2

DAILY RAINFALL (mm) FOR THE BERG PROJECT AREA, MAY 6 TO SEPTEMBER 20, 1989

DAY	MAY	JUN	JUL	AUG	SEP
1			13.2		
2			2.3	1.5	
3			4.1		
4			0.3		3.6
5					
6	8.6			0.3	
7	3.3			0.3	
8			0.5		
9	0.8		1.3		
10			5.8		
11			1.3		
12				14.7	
13				2.0	
14		7.1	1.0	5.8	
15		0.5	0.3	8.3	
16	1.5				0.3
17	0.3		0.5	3.8	5.8
18	1.3	0.8	2.3	0.3	
19	3.3	1.5	1.5		4.8
20			0.5		1.0
21			1.3	5.3	
22		7.6		7.1	
23				6.6	
24					
25					
26	0.3				
27	1.0	2.5			
28	0.3	11.7	17.5		
29			0.3	2.0	
30		1.3		0.3	
31					
TOTAL	20.7	33.0	54.0	58.3	15.5

APPENDIX 3.3.2-1

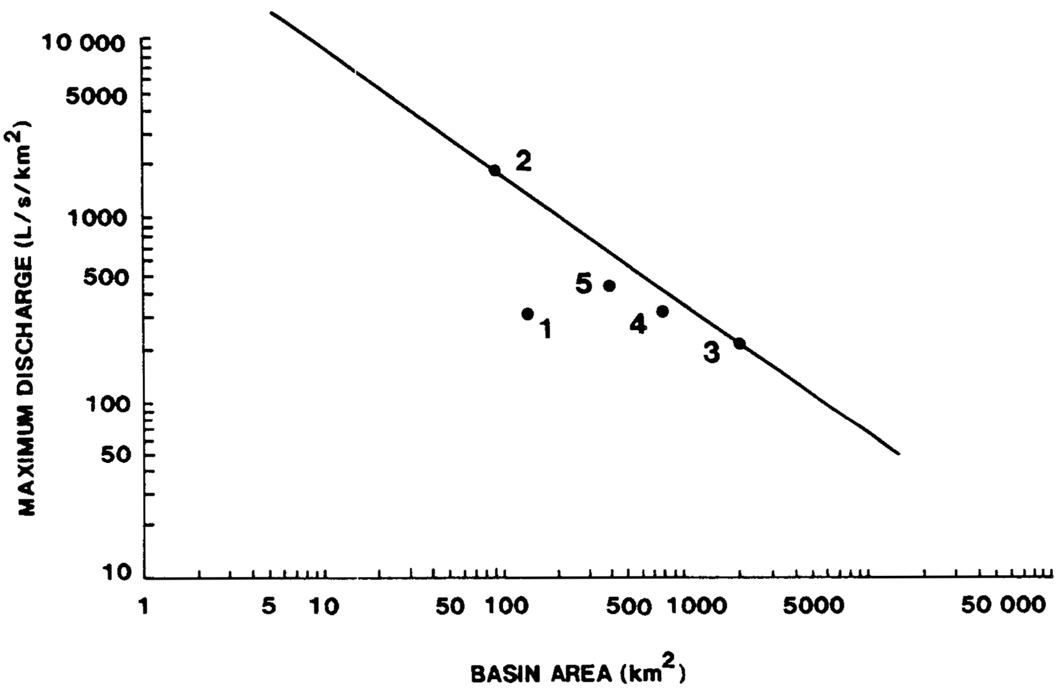
Berg Report Summary of Regional Hydrology Data



Note: See Table 3.2.2-2 for reference numbers.

Source: Based on data from Environment Canada 1985, a.b, 1986

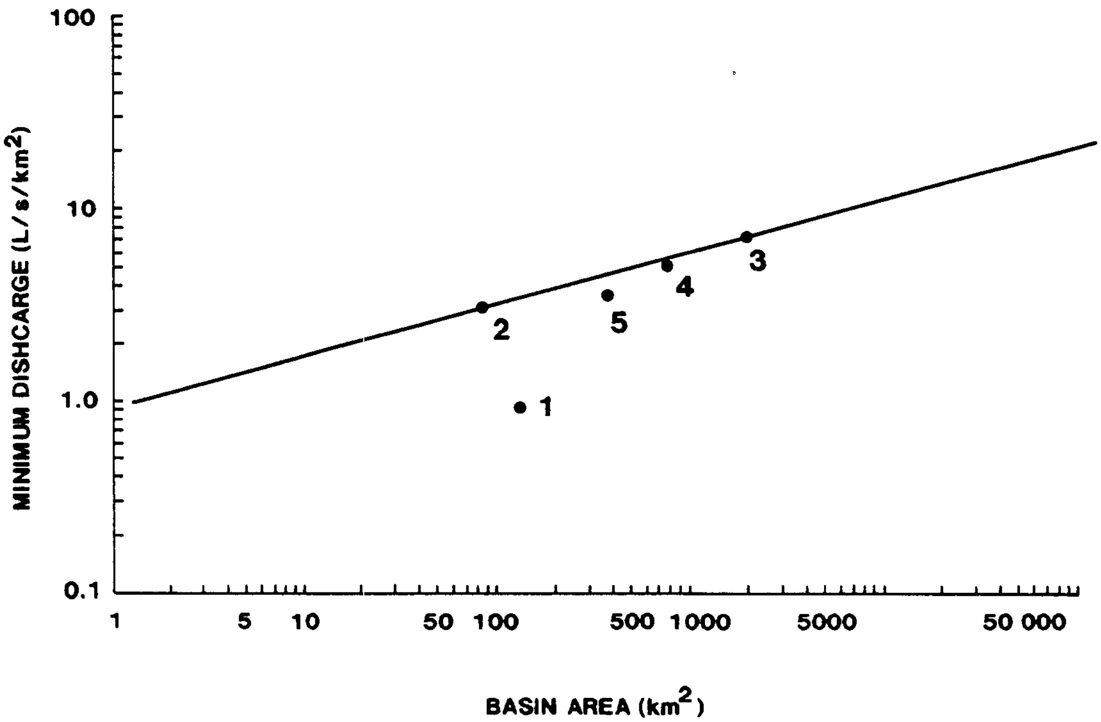
MEAN ANNUAL FLOOD VS. BASIN AREA	
Figure no. 1	PLACER DOME BERG PROJECT
Date Dec. 1989	Drawn by NORECOL



Note: See Table 3.2.2-2 for reference numbers.

Source: Based on data from Environment Canada 1985, a,b, 1986

MAXIMUM RECORDED UNIT AREA DISCHARGE VS. BASIN AREA	
Figure no. 2	PLACER DOME BERG PROJECT
Date Dec. 1989	Drawn by NORECOL



Note: See Table 3.2.2-2 for reference numbers

Source: Based on data from Environment Canada 1985, a,b, 1986

MEAN MINIMUM DISCHARGE VS. BASIN AREA	
Figure no. 3	PLACER DOME BERG PROJECT
Date Dec. 1989	Drawn by NORECOL

APPENDIX 3.3.2-1

TABLE 1

SUMMARY OF REGIONAL HYDROLOGY DATA

REF #	STATION NAME	WSC STATION NO.	BASIN AREA km^2	PERIOD OF RECORD YEARS	RECORD LENGTH YEARS	MEAN ANNUAL RUNOFF (mm)	ANNUAL PEAK FLOWS ($L/s/km^2$) MEAN	MAX	ANNUAL MINIMUM FLOWS ($L/s/km^2$) MEAN	MIN	INSTANTANEOUS TO MEAN DAILY FLOW AVG RATIO	MAX RATIO	PERCENT GLACIATED
1	Goathorn Creek near Telkwa	08EE008	132	1960-86	25	414.5	112	309	0.93	0.40	1.26	1.60	-
2	Laventie Creek near the Mouth	08JA015	86.5	1976-86	11	1793	606	1861	3.18	1.07	1.80	3.13	17
3	Morice River near Houston	08ED002	1910	1961-86	25	1220	128	205	7.17	3.99	1.01	1.02	-
4	Nanika River at outlet of Kidprice Lake	08ED001	741	1950-52 1972-86	17	1180	173	324	5.02	3.58	1.05	1.16	5
5	Telkwa River below Tsai Creek	08EE020	368	1975-86	11	1187	233	424	3.66	1.85	1.12	1.53	-

SOURCE: Data from Environment Canada, 1985a,b; 1986.

APPENDIX 3.3.2-1

TABLE 2

FREQUENCY ANALYSIS OF ANNUAL MAXIMUM DAILY DISHCARGE

STATION NAME	AREA	UNIT PEAK DAILY DISCHARGE ($L/s/km^2$)					
	sq km	2 yr	10 yr	20 yr	50 yr	100 yr	MAXIMUM RECORDED
Goathorn Creek near Telkwa	132	102	179	211	253	285	309
Laventie Creek near the Mouth	86.5	490	1128	1429	1864	2225	1861
Morice River near Houston	1 910	125	165	179	196	208	205
Nanika River at outlet of Kidprice Lake	741	165	246	275	313	340	324
Telkwa River below Tsai Creek	368	218	344	392	453	499	424

Source: Based on data from Environment Canada 1985a,b; 1986.

APPENDIX 3.3.2-1

TABLE 3

RATIO OF ESTIMATED FLOOD MAGNITUDE TO MEAN ANNUAL FLOOD (Q2.33)

STATION NAME	BASIN AREA sq km	Q2	Q5	Q10	Q20	Q50	Q100
Goathorn Creek near Telkwa	132	0.93	1.32	1.60	1.88	2.26	2.55
Laventie Creek near the Mouth	86.5	0.86	1.40	1.86	2.36	3.08	3.67
Morice River near Houston	1 910	0.98	1.17	1.29	1.40	1.53	1.62
Nanika River at outlet of Kidprice Lake	741	0.96	1.24	1.42	1.59	1.81	1.96
Telkwa River below Tsai Creek	368	0.94	1.27	1.48	1.69	1.95	2.15

SOURCE: Based on data from Environment Canada 1985a,b; 1986

APPENDIX 3.3.2-2

Berg Project Stream Flow Data Collected by Norecol

APPENDIX 3.3.2-2

TABLE 1

STREAM DISCHARGE MEASUREMENTS MADE BY NORECOL PERSONNEL
IN THE BERG PROJECT AREA

STATION	CREEK NAME	DATE	STAFF GAUGE HEIGHT (m)	DISCHARGE (m^3/s)	DRAINAGE AREA (km^2)	DISCHARGE $L/s/km^2$
H1	Berg Creek	Oct 27, 1988	-	0.106	3.23	32.8
	Above Deposit	Jul 13, 1989	-	0.506		156.7
		Sep 21, 1989	-	0.087		26.9
H2	Red Creek	Oct 27, 1988	-	0.033	1.10	30.0
	(South Deposit Creek)	Jul 13, 1989	-	0.103		93.6
		Sep 21, 1989	-	0.018		16.4
H3	Pump Creek	Oct 27, 1988	0.23	0.022	1.25	17.6
	(North Deposit Creek)	Jul 13, 1989	0.29	0.069		55.2
		Sep 21, 1989	0.21	0.008		6.4
H4	Berg Creek	Oct 27, 1988	0.05	0.610	30.6	19.9
		May 6, 1989	0.42	2.65		86.6
		May 6, 1989	0.42	2.96		96.7
		Jul 12, 1989	0.68	3.18		103.9
		Sep 20, 1989	0.50	1.14		37.3
		Sep 21, 1989	0.56	1.32		43.1

continued . . .

APPENDIX 3.3.2-2

TABLE 1 (concluded)

STREAM DISCHARGE MEASUREMENTS MADE BY NORECOL PERSONNEL IN THE BERG PROJECT AREA

STATION	CREEK NAME	DATE	STAFF GAUGE HEIGHT (m)	DISCHARGE (m^3/s)	DRAINAGE AREA (km^2)	DISCHARGE $L/s/km^2$
H5	Bergeland Creek above Berg Creek	Oct 27, 1988	0.10	0.834	53.0	15.7
		May 6, 1989	1.34[a]	10.0		189
		Jul 12, 1989	0.75	3.63		68.5
		Sep 20, 1989	0.46	0.909		17.0
		Sep 21, 1989	0.48	0.980		18.5
H8	Ney Creek	Oct 27, 1988	-	1.05	48.7	21.6
		May 6, 1989	-	5.40		111
		Jul 12, 1989	-	6.50		133
		Sep 20, 1989	-	2.84		58.3
H9	Berg Creek above North Berg Creek	Jul 14, 1989	-	1.14	9.53	120
H10	North Berg Creek at Mouth	Jul 14, 1989	-	0.795	10.6	75.2

a New staff gauge installed.

APPENDIX 3.3.2-2

TABLE 2
CALCULATED MEAN DAILY AND MONTHLY DISCHARGES (m^3/s) FOR CREEKS
NEAR THE BERG PROJECT AREA (1989)

BERG CREEK NEAR THE MOUTH (SITE H4)					
DAY	MAY	JUNE	JULY	AUG	SEPT
1		3.90	2.84	2.12	0.941
2		3.57	2.74	2.03	0.952
3		3.45	2.72	2.02	1.38
4		3.76	2.59	2.03	1.42
5		3.81	2.46	1.89	1.08
6	2.80	3.68	2.47	1.71	1.20
7	3.23	2.96	2.47	1.71	1.55
8	2.90	2.80	2.55	1.47	1.43
9	2.57	2.75	2.74	1.27	1.09
10	2.27	2.78	3.09	1.14	0.916
11	1.94	3.09	3.16	1.52	0.921
12	1.70	3.42	3.39	1.55	0.949
13	1.58	3.63	3.18	1.85	0.890
14	1.55	3.67	2.86	1.83	0.720
15	1.65	2.74	2.60	1.83	0.565
16	1.88	2.37	2.34	1.84	0.535
17	1.86	2.18	2.42	1.92	0.420
18	1.75	1.82	2.42	1.95	0.343
19	1.64	1.55	2.34	1.76	0.660
20	1.55	1.52	2.29	1.81	0.990
21		1.50	1.67	2.16	1.84
22		1.50	1.87	2.02	1.48
23		1.64	2.31	1.92	1.50
24		1.81	3.03	1.98	1.47
25		1.85	3.46	2.00	1.33
26		1.82	3.23	2.11	1.34
27		1.86	2.22	2.26	1.32
28		2.21	2.40	1.91	1.53
29		2.63	2.32	1.88	1.59
30		3.41	2.53	2.00	1.47
31		3.66		2.03	1.15
MEAN	2.11	2.82	2.45	1.65	0.948

BERGELAND CREEK UPSTREAM OF BERG CREEK (SITE H5)					
DAY	MAY	JUNE	JULY	AUG	SEPT
1		10.4	4.67	2.54	0.921
2		9.88	5.19	2.51	0.704
3		9.19	4.17	2.52	0.700
4		9.20	4.33	2.37	1.13
5		10.0	4.06	2.37	1.06
6	8.74	10.4	3.70	2.17	0.708
7	10.1	9.06	3.58	1.79	0.721
8	10.9	8.50	3.31	1.69	0.969
9	10.5	8.41	3.54	1.34	0.911
10	9.14	8.35	3.97	1.21	0.714
11	6.97	8.39	4.40	0.964	0.683
12	5.55	8.73	3.99	1.60	0.671
13	4.53	8.51	3.96	1.52	0.684
14	4.12	9.11	4.44	2.03	0.670
15	4.45	8.38	3.88	2.10	0.650
16	5.49	6.41	3.33	1.89	0.619
17	6.70	5.30	3.11	2.02	0.621
18	5.88	4.76	3.15	2.19	0.596
19	5.04	4.30	2.95	2.03	0.571
20	4.88	3.95	2.88	1.80	0.656
21	4.29	4.54	2.64	2.05	
22	3.94	5.35	2.30	2.38	
23	4.01	5.26	2.21	1.76	
24	4.65	6.40	1.99	1.58	
25	5.53	7.20	2.09	1.45	
26	5.81	7.30	2.04	1.27	
27	5.35	5.61	2.22	1.18	
28	6.35	4.06	3.65	1.16	
29	8.25	4.29	2.77	1.35	
30	9.34	4.17	2.38	1.28	
31	10.0		2.49	1.20	
MEAN	6.56	7.18	3.33	1.79	0.748

APPENDIX 3.3.3-1

Water Quality Data Tables for Berg

**ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q1**

ANALYTICAL PARAMETER	OCT.27/88	JULY 13/89	SEPT. 21/89
Temperature (°C)	-	-	-
pH	6.6	6.8	7.2
Alkalinity (mg $CaCO_3$/L)	12	10	18
Turbidity (NTU)	0.3	0.9	0.7
Conductance (µmhos/cm)	85	36	71
Total Solids (mg/L)	59	30	56
Suspended Solids (mg/L)	<1	<1	<1
EDTA-Hardness (mg $CaCO_3$/L)	37	19	38
Sulfate (mg/L)	30	11	22
Ammonia (mg N/L)	<0.005	<0.005	0.005
Nitrate (mg N/L)	0.007	<0.005	<0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	0.025	0.003	0.003
Total Cyanide (mg/L)	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)			
Ag	<0.0002	<0.0001	<0.0001
Al	0.06	0.08	0.036
As	<0.001	<0.001	<0.001
Ba	0.019	0.013	0.017
Cd	0.0004	<0.0002	0.0002
Co	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001
Cu	0.0028	0.0026	0.0013
Fe	0.017	0.031	0.013
Hg (µg/L)	<0.05	<0.05	<0.05
Mn	0.0067	0.0044	0.0050
Mo	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	0.004
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.0052	0.0037	0.0038
DISSOLVED METALS: (mg/L)			
Ag	<0.0002	<0.0001	<0.0001
Al	0.05	0.06	<0.01
As	<0.001	<0.001	<0.001
Ba	0.018	0.010	0.011
Cd	0.0003	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001
Cu	0.0021	0.0010	<0.0005
Fe	<0.005	<0.005	<0.005
Mn	-	0.0035	0.0030
Mo	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.0052	-	0.0036

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q2

ANALYTICAL PARAMETER	OCT.27/88	JULY 13/89	SEPT. 21/89
Temperature (°C)	-	-	-
pH	4.0	4.0	3.8
Alkalinity (mg $CaCO_3$/L)	-	-	-
Turbidity (NTU)	15	5.0	9.0
Conductance (µmhos/cm)	539	447	699
Total Solids (mg/L)	561	442	787
Suspended Solids (mg/L)	17	4	4
EDTA-Hardness (mg $CaCO_3$/L)	300	228	378
Sulfate (mg/L)	365	267	475
Ammonia (mg N/L)	0.055	0.037	0.007
Nitrate (mg N/L)	0.020	0.024	0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	0.047	0.009	0.005
Total Cyanide (mg/L)	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)			
Ag	0.0004	<0.0001	0.0003
Al	9.3	5.5	12
As	0.002	<0.001	<0.001
Ba	0.029	0.012	0.012
Cd	0.0057	0.0040	0.012
Co	0.028	0.022	0.05
Cr	<0.001	<0.001	<0.001
Cu	4.30	3.03	6.0
Fe	1.30	1.26	2.3
Hg (µg/L)	<0.05	<0.05	<0.05
Mn	0.85	0.61	1.14
Mo	0.007	<0.005	0.007
Ni	0.025	0.020	0.045
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.86	0.62	1.13
DISSOLVED METALS: (mg/L)			
Ag	0.0003	<0.0001	<0.0001
Al	8.9	5.3	12
As	<0.001	<0.001	<0.001
Ba	0.023	0.010	0.009
Cd	0.0057	0.0039	0.011
Co	0.027	0.020	0.05
Cr	<0.001	<0.001	<0.001
Cu	4.28	3.00	6.0
Fe	0.80	0.67	1.30
Mn	0.85	0.58	1.14
Mo	0.006	<0.005	<0.005
Ni	0.023	0.020	0.044
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.86	0.61	1.12

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q3

ANALYTICAL PARAMETER	OCT.27/88	JULY 13/89	SEPT. 21/89
Temperature (°C)	-	-	-
pH	4.6	4.6	4.9
Alkalinity (mg $CaCO_3$/L)	<1	2	3
Turbidity (NTU)	0.2	0.2	0.8
Conductance (µmhos/cm)	241	152	285
Total Solids (mg/L)	218	138	276
Suspended Solids (mg/L)	<1	<1	<1
EDTA-Hardness (mg $CaCO_3$/L)	132	71	189
Sulfate (mg/L)	136	74	176
Ammonia (mg N/L)	<0.005	<0.005	0.026
Nitrate (mg N/L)	0.014	0.028	<0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	<0.003	<0.003	0.005
Total Cyanide (mg/L)	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)			
Ag	<0.0002	<0.0001	0.0001
Al	1.5	1.3	1.5
As	<0.001	<0.001	<0.001
Ba	0.027	0.014	0.022
Cd	0.0017	0.0015	0.0037
Co	0.006	0.004	0.007
Cr	<0.001	<0.001	<0.001
Cu	0.52	0.34	0.55
Fe	0.013	0.022	0.06
Hg (µg/L)	<0.05	-	<0.05
Mn	0.25	0.20	0.28
Mo	<0.005	<0.005	<0.005
Ni	0.003	0.004	0.008
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.20	0.14	0.23
DISSOLVED METALS: (mg/L)			
Ag	<0.0002	<0.0001	<0.0001
Al	1.4	1.3	1.4
As	<0.001	<0.001	<0.001
Ba	0.026	0.010	0.021
Cd	0.0017	0.0013	0.0034
Co	0.005	0.004	0.007
Cr	<0.001	<0.001	<0.001
Cu	0.52	0.34	0.55
Fe	0.007	0.013	0.020
Mn	0.25	0.19	0.28
Mo	<0.005	<0.005	<0.005
Ni	0.003	0.003	0.005
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	0.20	0.14	0.23

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q4

ANALYTICAL PARAMETER	SEPT.28/88	OCT.27/88	MAY 6/89	JULY 12/89	SEPT. 21/89
Temperature (°C)	-	-	-	-	-
pH	6.7	6.5	7.4	6.7	7.0
Alkalinity (mg $CaCO_3$/L)	14	25	22	17	17
Turbidity (NTU)	83	0.3	24	2.8	7.5
Conductance (µmhos/cm)	56	90	76	52	78
Total Solids (mg/L)	240	71	111	46	75
Suspended Solids (mg/L)	153	2	57	3	4
EDTA-Hardness (mg $CaCO_3$/L)	29	51	37	29	41
Sulfate (mg/L)	16	29	21	14	22
Ammonia (mg N/L)	0.009	<0.005	0.008	<0.005	0.008
Nitrate (mg N/L)	0.023	0.007	0.033	<0.005	<0.005
Nitrite (mg N/L)	0.006	<0.002	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	1.07	0.005	0.084	0.006	0.017
Total Cyanide (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)					
Ag	0.0003	<0.0002	<0.0001	<0.0001	<0.001
Al	1.4	0.14	0.19	0.36	0.54
As	0.005	<0.001	0.001	<0.001	0.001
Ba	0.06	0.021	0.031	0.011	0.009
Cd	0.0020	0.0003	0.0005	<0.0002	0.0003
Co	0.007	<0.001	0.001	<0.001	0.001
Cr	0.004	<0.001	<0.001	<0.001	<0.001
Cu	0.87	0.0021	0.17	0.06	0.13
Fe	4.3	0.07	0.57	0.15	0.26
Hg (µg/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Mn	0.37	0.024	0.08	0.031	0.05
Mo	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	0.004	<0.002	<0.002	<0.002	<0.002
Pb	0.009	<0.001	0.002	0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	0.15	0.013	0.03	0.012	0.035
DISSOLVED METALS: (mg/L)					
Ag	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.15	-	0.19	0.06	0.040
As	<0.001	<0.001	<0.001	<0.001	<0.001
Ba	0.011	0.020	0.019	0.008	0.008
Cd	0.0002	0.0002	0.0002	<0.0002	0.0002
Co	<0.001	<0.001	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cu	0.05	0.0013	0.038	0.0080	0.0067
Fe	0.10	0.017	0.08	<0.005	<0.005
Mn	0.025	0.016	0.030	0.015	0.026
Mo	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	0.011	0.012	0.0053	0.11	0.015

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q5

ANALYTICAL PARAMETER	SEPT.28/88	OCT.27/88	MAY 5/89	JULY 12/89	SEPT. 21/89
Temperature (°C)	-	-	-	-	-
pH	6.1	6.2	6.7	6.3	6.8
Alkalinity (mg $CaCO_3$/L)	6	14	9	14	20
Turbidity (NTU)	77	0.3	2.8	3.6	5.7
Conductance (µmhos/cm)	14	29	20	23	36
Total Solids (mg/L)	190	24	31	22	41
Suspended Solids (mg/L)	140	1	9	2	<1
EDTA-Hardness (mg $CaCO_3$/L)	7	18	25	15	19
Sulfate (mg/L)	5	4	1	2	3
Ammonia (mg N/L)	0.013	<0.005	<0.005	<0.005	0.006
Nitrate (mg N/L)	0.024	<0.005	0.007	<0.005	<0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	0.408	0.005	0.004	0.005	0.019
Total Cyanide (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)					
Ag	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001
Al	3.1	0.07	0.30	0.15	0.31
As	<0.001	<0.001	<0.001	<0.001	<0.001
Ba	0.031	0.011	0.006	0.006	<0.005
Cd	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Co	0.003	<0.001	<0.001	<0.001	<0.001
Cr	0.002	<0.001	<0.001	<0.001	<0.001
Cu	0.0081	<0.0005	0.0008	0.0027	<0.0005
Fe	2.9	0.07	0.12	0.11	0.19
Hg (µg/L)	<0.05	<0.05	<0.05	<0.05	<0.05
Mn	0.18	0.0091	0.030	0.0096	0.018
Mo	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	0.002	<0.002	<0.002	<0.002	<0.002
Pb	0.003	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	0.013	0.0009	<0.0005	0.0005	0.0015
DISSOLVED METALS: (mg/L)					
Ag	<0.0002	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.33	-	0.08	0.032	<0.01
As	<0.001	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	0.007	<0.005	<0.005	<0.005
Cd	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Co	0.003	<0.001	<0.001	<0.001	<0.001
Cr	0.002	<0.001	<0.001	<0.001	<0.001
Cu	0.0022	<0.0005	0.0005	<0.0005	<0.0005
Fe	0.28	0.042	0.07	0.015	0.009
Mn	0.17	0.0075	0.010	0.0059	0.0063
Mo	<0.005	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002	<0.002
Pb	0.003	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001	<0.001
Zn	0.0024	0.0009	<0.0005	-	0.0006

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q6

ANALYTICAL PARAMETER	SEPT.28/88	MAY 6/89	JULY 12/89	SEPT. 21/89
Temperature (°C)	-	-	-	-
pH	5.9	6.3	6.3	7.2
Alkalinity (mg $CaCO_3$/L)	3	6	12	12
Turbidity (NTU)	20	0.6	2.7	0.6
Conductance (μmhos/cm)	8	14	21	22
Total Solids (mg/L)	66	16	22	25
Suspended Solids (mg/L)	34	1	1	<1
EDTA-Hardness (mg $CaCO_3$/L)	5	5	13	11
Sulfate (mg/L)	2	1	2	1
Ammonia (mg N/L)	0.007	<0.005	<0.005	<0.005
Nitrate (mg N/L)	<0.005	<0.005	<0.005	0.177
Nitrite (mg N/L)	<0.002	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	0.077	<0.003	0.003	0.006
Total Cyanide (mg/L)	<0.001	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)				
Ag	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.69	0.06	0.11	<0.01
As	<0.001	<0.001	<0.001	<0.001
Ba	0.018	0.029	0.008	0.022
Cd	<0.0002	<0.0002	<0.0002	<0.0002
Co	0.001	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001	<0.001
Cu	0.0037	0.0006	0.0016	<0.0005
Fe	0.94	0.05	0.26	0.011
Hg (μg/L)	<0.05	<0.05	0.05	<0.05
Mn	0.08	0.0041	0.0063	<0.001
Mo	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002
Pb	0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001
Zn	0.0064	<0.0005	<0.0005	0.0007
DISSOLVED METALS: (mg/L)				
Ag	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.11	0.05	0.028	<0.01
As	<0.001	<0.001	<0.001	<0.001
Ba	<0.005	0.018	0.005	0.021
Cd	<0.0002	<0.0002	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001	<0.001
Cu	0.0010	0.0006	0.0005	<0.0005
Fe	0.09	0.031	0.011	<0.005
Mn	0.011	0.0027	0.0021	<0.001
Mo	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001
Zn	0.0014	<0.0005	<0.0005	0.0005

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q7

ANALYTICAL PARAMETER	SEPT.28/88	MAY 5/89	JULY 13/89	SEPT. 21/89
Temperature (°C)	-	-	-	-
pH	6.4	6.8	6.4	7.1
Alkalinity (mg $CaCO_3$/L)	8	12	15	20
Turbidity (NTU)	197	16	6.1	3.6
Conductance (μmhos/cm)	23	32	37	57
Total Solids (mg/L)	818	65	38	54
Suspended Solids (mg/L)	584	38	8	<1
EDTA-Hardness (mg $CaCO_3$/L)	12	16	22	32
Sulfate (mg/L)	3	6	7	15
Ammonia (mg N/L)	0.008	0.006	<0.005	0.005
Nitrate (mg N/L)	0.055	0.017	<0.005	<0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	1.10	0.053	0.020	0.010
Total Cyanide (mg/L)	<0.001	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)				
Ag	<0.0002	<0.0001	<0.0001	
Al	1.5	0.93	0.43	
As	0.007	0.001	<0.001	
Ba	0.13	0.015	0.010	
Cd	0.0012	0.0002	<0.0002	
Co	0.010	<0.001	<0.001	
Cr	0.010	<0.001	<0.001	
Cu	0.44	0.030	0.027	
Fe	7.3	0.86	0.24	
Hg (μg/L)	<0.05	<0.05	<0.05	<0.05
Mn	0.72	0.05	0.030	
Mo	<0.005	<0.005	<0.005	
Ni	0.016	<0.002	<0.002	
Pb	0.025	<0.001	<0.001	
Sb	<0.002	<0.002	<0.002	
Se	<0.001	<0.001	<0.001	
Zn	0.13	0.0029	0.0080	
DISSOLVED METALS: (mg/L)				
Ag	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.22	0.21	0.039	0.06
As	<0.001	<0.001	<0.001	<0.001
Ba	0.015	0.007	0.006	<0.005
Cd	<0.0002	<0.0002	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001	<0.001
Cu	0.030	0.013	0.0054	0.0054
Fe	0.24	0.11	0.006	0.026
Mn	0.033	0.017	0.0074	0.019
Mo	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001
Zn	0.0051	0.0018	0.0024	0.0085

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE SITE: Q8

ANALYTICAL PARAMETER	SEPT.28/88	MAY 5/89	JULY 12/89	SEPT. 21/89
Temperature (°C)	-	-	-	-
pH	6.9	7.0	6.5	6.6
Alkalinity (mg $CaCO_3$/L)	19	14	10	12
Turbidity (NTU)	340	35	6.0	9.5
Conductance (µmhos/cm)	43	38	26	34
Total Solids (mg/L)	1270	105	30	47
Suspended Solids (mg/L)	1229	77	6	10
EDTA-Hardness (mg $CaCO_3$/L)	22	18	14	19
Sulfate (mg/L)	1	9	6	8
Ammonia (mg N/L)	0.012	0.011	0.006	0.005
Nitrate (mg N/L)	0.057	0.013	<0.005	<0.005
Nitrite (mg N/L)	0.019	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	2.81	0.138	0.012	0.030
Total Cyanide (mg/L)	<0.001	<0.001	<0.001	<0.001

TOTAL EXTRACTABLE METALS: (mg/L)

ANALYTICAL PARAMETER	SEPT.28/88	MAY 5/89	JULY 12/89	SEPT. 21/89
Ag	0.0003	<0.0001	<0.0001	
Al	1.7	1.5	0.38	
As	0.026	<0.001	<0.001	
Ba	0.61	0.028	0.010	
Cd	0.0018	<0.0002	<0.0002	
Co	0.04	<0.001	<0.001	
Cr	0.05	<0.001	<0.001	
Cu	0.08	0.0026	0.0014	
Fe	22	0.51	0.28	
Hg (µg/L)	<0.05	<0.05	<0.05	<0.05
Mn	1.68	0.06	0.016	
Mo	<0.005	<0.005	<0.005	
Ni	0.05	0.002	<0.002	
Pb	0.06	0.001	<0.001	
Sb	<0.002	<0.002	<0.002	
Se	<0.001	<0.001	<0.001	
Zn	0.28	0.0027	0.0026	

DISSOLVED METALS: (mg/L)

ANALYTICAL PARAMETER	SEPT.28/88	MAY 5/89	JULY 12/89	SEPT. 21/89
Ag	<0.0002	<0.0001	<0.0001	<0.0001
Al	0.63	0.17	0.018	0.011
As	0.001	<0.001	<0.001	<0.001
Ba	0.023	0.008	0.005	<0.005
Cd	<0.0002	<0.0002	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001	<0.001
Cr	0.001	<0.001	<0.001	<0.001
Cu	0.0025	0.0009	<0.0005	<0.0005
Fe	0.99	0.12	0.006	0.016
Mn	0.07	<0.001	0.0032	0.0051
Mo	<0.005	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001	<0.001
Zn	0.0086	0.0007	0.0005	0.0006

ANALYTICAL RESULTS FOR WATER SAMPLES FROM
PLACER DOME BERG PROJECT
SAMPLE: Q9

ANALYTICAL PARAMETER	MAY 5/89	JULY 13/89	SEPT. 21/89
Temperature (°C)	-	-	-
pH	7.4	6.8	7.1
Alkalinity (mg $CaCO_3$/L)	28	20	22
Turbidity (NTU)	0.8	13.5	14
Conductance (µmhos/cm)	61	37	46
Total Solids (mg/L)	47	46	52
Suspended Solids (mg/L)	1	10	7
EDTA-Hardness (mg $CaCO_3$/L)	32	23	29
Sulfate (mg/L)	9	5	7
Ammonia (mg N/L)	<0.005	0.013	0.005
Nitrate (mg N/L)	0.075	<0.005	<0.005
Nitrite (mg N/L)	<0.002	<0.002	<0.002
Total Phosphorus (mg P/L)	<0.003	0.027	0.040
Total Cyanide (mg/L)	<0.001	<0.001	<0.001
TOTAL EXTRACTABLE METALS: (mg/L)			
Ag	<0.0001	<0.0001	0.0001
Al	0.05	0.72	0.65
As	<0.001	<0.001	<0.001
Ba	0.019	0.018	0.014
Cd	<0.0002	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001
Cu	0.0006	0.0024	0.0008
Fe	0.030	0.51	0.40
Hg (µg/L)	<0.05	<0.05	<0.05
Mn	0.0043	0.07	0.06
Mo	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002
Pb	<0.001	0.002	0.003
Sb	<0.002	<0.002	<0.002
Se	<0.001	0.001	<0.001
Zn	<0.0005	0.0060	0.014
DISSOLVED METALS: (mg/L)			
Ag	<0.0001	<0.0001	<0.0001
Al	<0.01	0.012	0.025
As	<0.001	<0.001	<0.001
Ba	0.016	0.011	0.006
Cd	<0.0002	<0.0002	<0.0002
Co	<0.001	<0.001	<0.001
Cr	<0.001	<0.001	<0.001
Cu	<0.0005	<0.0005	<0.0005
Fe	0.007	<0.005	<0.005
Mn	<0.001	0.0029	0.0060
Mo	<0.005	<0.005	<0.005
Ni	<0.002	<0.002	<0.002
Pb	<0.001	<0.001	<0.001
Sb	<0.002	<0.002	<0.002
Se	<0.001	<0.001	<0.001
Zn	<0.0005	0.0011	0.0013

APPENDIX 3.3.3-2

Water Quality Procedures and Quality Control

TABLE OF CONTENTS

Revised: February 9, 1989

RECOMMENDED MINIMUM DETECTABLE CONCENTRATIONS (MDC'S) FOR WATER QUALITY MONITORING

Variable*	Water Quality Criterion µg/L	Recommended Minimum** Detectable Concentration µg/L
Aluminum, Dissolved	20(AL,pH 6)++	2
	50(AL,pH≤6.5)	10
Antimony	50(D,AL)	5
Arsenic	50(D,AL)	5
Barium	1000(D,AL)	100
Beryllium	11(AL)	3
Boron	500(I)-5000(D)	50
Cadmium	0.2-1.8(AL)	0.1-0.2
Chromium	2-20(AL)	0.3-1
Cobalt	≤50(AL,I)	5
Copper	2-10(AL)	0.5-1
Cyanide, weak-acid dissociable	1-10(AL)	1-5
Fluoride	1000(D,AL)	100
Iron	300(D,AL)	30
Lead	3-16(AL)	1
Manganese	50(D)	5
Mercury	0.02-0.1(AL)	0.02-0.05
Molybdenum	10-30(I)	1
Nickel	25-150(AL-FRESH)	5
	8(AL-MARINE)	1
Nitrogen, Total Ammonia	100-2000(AL)	10(as N)+
Total Nitrate	contributes to algal growth	20(as N)+
Total Nitrite	20-200(AL)	5(as N)+
Phosphorus (all forms)	any amount can contribute to algal growth	1-3+(as P)
Selenium	1(AL)	0.1-1
Silver	0.1(AL)	0.1-0.2
Uranium	10(I)-100(D)	1
Vanadium	100(D,I,L)	10
Zinc	30(AL)	5

* Only those variables for which MDC's are normally a problem have been included.

++ Water uses in brackets: AL = aquatic life, D = drinking water, I = irrigation, L = livestock.

** MDC's should be at least as low as the lowest applicable water quality criterion, and preferably 5 to 10 times lower, technology permitting. The recommended MDC's are the higher to 0.1 to 0.2 of the water quality criterion for the most sensitive water use, or the lowest concentrations normally detectable by laboratories.

\+ The lowest possible MDC's should be used in nutrient-sensitive waterbodies.

INSERT MOE Recommended Minimum Detectable Concentrations for Water Quality Monitoring

B.C. RESEARCH
WATER QUALITY PARAMETERS AND DETECTION LIMITS

CHARACTERISTICS	DETECTION LIMITS
Temperature	field
pH	field + lab
Suspended Solids	1 mg/l
Turbidity	0.1 NTU
Specific Conductivity	1 umhos
Total Hardness	1 mg/l
Total Alkalinity	1 mg/l
Sulfate	1 mg/l
Phenols	1 mg/l
Nitrate	5 ug/l as N
Nitrite	2 ug/l as N
Ammonia	5 ug/l as N
Total phosphorus	3 ug/l as P
Total Cyanide	1 ug/l
WAD Cyanide	1 ug/l
Total Mercury	0.025 ug/l
<u>Total and dissolved</u>	
Aluminum	10 ug/l
Antimony	2 ug/l
Arsenic	1 ug/l
Barium	100 ug/l
Cadmium	0.2 ug/l
Cobalt	2 ug/l
Chromium	5 ug/l
Copper	0.5 ug/l
Iron	2 ug/l
Lead	1 ug/l
Manganese	0.5 ug/l
Molybdenum	5 ug/l
Nickel	2 ug/l
Selenium	1 ug/l
Silver	0.1 ug/l
Zinc	0.5 ug/l

1.0 NORECOL WATER SAMPLING PROCEDURE

1.1 Sample Bottles and Analytical Parameters

Four to six separate sample bottles (depending upon the project) must be filled at each of the designated water quality sites. The bottles and their uses are characterized as follows:

BOTTLE DESCRIPTION	PRESERVATIVE REQUIRED	PARAMETERS ANALYZED
1 - 2 Litre, Plastic, Rectangular	None	General Parameters
1 - 1 Litre, Plastic, Round	NaOH pellets, ALREADY ADDED	Cyanide (CN)
1 - 1 Litre, Dark glass wrapped in paper	H_2SO_4 + Dichromate, ALREADY ADDED	Mercury (Hg)
2 - 250 ml, Plastic	Require preservation as described below	Dissolved & Total Metals
Sterile Whirl-pak bags	Keep on ice	Coliforms
Glass	Require filtration described below	Orthophosphate

1.2 Sample Bottle Preparation

Prior to collection of the water samples, the sample bottles should be labelled with the information required by the laboratory for identification purposes. The following information should be printed on each bottle with a permanent black felt marker:

SITE #:	(on the bottle cap, neck and face)
DATE:	(on the bottle face only)
PROJECT NAME:	(" " " " ")
PARAMETER:	(i.e. Gen. Par., CN, Hg, D. Metals, T. Metals, Ortho-P; write on bottle face only)

Be careful! Proper labelling of bottles is essential. Unlabelled or incorrectly labelled samples may be useless.

1.3 Sample Collection Procedure

1.3.1 General Surface Water Samples

The sampling site should be located in a portion of the stream which is well mixed and uninfluenced by potential sources of contamination (other than those under investigation). Whenever possible, avoid braided channels. Sample upstream from confluences or far enough downstream that you are certain the tributary and the main channel have mixed. Samples should be collected upstream from bridges, culverts and other artificial structures.

It is important when approaching a sampling site that caution be exercised to avoid disturbing the water or streambed upstream of the point of collection. This will reduce the possibility of sample contamination.

Where stream flows permit, collect samples at mid-stream and at mid-depth (bottles must be fully submerged) in water of moderate velocity (i.e. riffle or glide, not a pool or back eddy). Hold the bottle away and upstream of where you are positioned when collecting a sample.

<u>Except for the cyanide (CN) and mercury (Hg) samples bottles</u> (which contain preservative), all bottles and caps must be rinsed with the water to be sampled. First rinse the outside of the bottle with the cap on. Then, remove the cap, fill the bottle about one third full and shake the contents out over the cap of the bottle held in the other hand. Repeat this procedure for a total of <u>three</u> rinses. Be careful not to touch the inside of the cap or the mouth of the bottle.

NOTE: The dissolved and total metals sample bottles contain deionized water which must be emptied just prior to rinsing the bottle and collecting the sample. It is a good idea to collect the metals samples first at each site to avoid confusion as to whether a full bottle contains stream water or deionized water. When collecting the total metals sample, leave about 1/2 inch of air clearance in the bottles to allow room for the addition of preservative.

See Section 1.3.2 additional instructions for the collection of drinking water samples.

The air and water temperature must be read and recorded for each site at the time of water sampling. Also make note of the date, time, and the general weather and stream flow conditions. The "Water Quality Field Check List" (attached) should be used to document this information, while also serving as check list of the required activities at each site.

Once all of the samples have been collected from the designated sites, the total and dissolved metal samples require the described preservation in Section 1.4.1.

1.3.2 Drinking Water Sample Collection Procedures

When sampling creeks to investigate potential as drinking water sources, collect the samples at mid-stream, mid-depth, as described under general collection procedures. When sampling streams already in use as drinking water supplies sample just upstream of the water intake. When sampling from an inside water supply, turn on tap and allow to run for about 15 seconds before you start to collect samples. Fill containers from tap. Otherwise, treat containers as described for creek samples.

Coliform samples require special handling. Do not rinse the inside of the Whirl-Pak bag, and do not remove its sterile seal until you are ready to collect the sample. Dip the bag to fill it, and seal it with a twist tie. Be especially careful not to touch the inside of the bag. Immediately place the sample on ice. It is essential that the sample be kept cold (not frozen).

Coliform samples should be shipped to the laboratory on the day of collection. Analysis must begin within 24 h of collection.

1.4 Sample Filtration and Preservation

1.4.1 Dissolved metals

The dissolved metal sample must be filtered. This procedure produces the greatest potential for contamination. Extreme care must be taken to avoid touching any area coming into contact with the sample (inside of funnel, filter paper, mouth of bottle or flask). Also be sure that the work area where filtration is to occur is clean (i.e., no dust).

In addition to filtering the stream samples, "blanks" will also have to be run at the start and end of the filtrations. The procedures for filtering "blank" samples is the same as for the dissolved metals samples except that deionized water is filtered through the apparatus rather than stream water. Pour the filtered deionized water into the 125 ml bottles provided and label them as START D.BLANK and END D.BLANK with the project name and date.

After filtering the START BLANK, filter stream samples. Any potentially "dirty" sample (eg. tailings impoundments, experimental waste rock pads) should be filtered LAST.

The filtration procedure is as follows: (See attached diagram of the filtering apparatus.)

a) Rinse well the inside of the filtering apparatus (funnel, membrane filter base, and lower receptacle flask) with deionized water and shake and swirl out excess.

b) Place a membrane filter on the filter base of the apparatus. Handle only the edges of the filter paper using the plastic forceps provided. (Be sure to rinse the forceps between each use.) Screw top funnel on carefully to avoid wrinkling the filter paper. Do not touch the inside of the filter funnel.

c) Pour about 25 ml of water from the dissolved metals sample bottle into the top of the filtering apparatus. Filter the 25 ml of sample through the apparatus. Detach the lower receptacle flask, and swirl and discard the contents (for the purpose of rinsing the filtering apparatus with the sample water). Carefully re-attach the receptacle flask to the filtering apparatus.

d) Pour approximately 75 ml of the dissolved metals sample into the top of the filtering apparatus and again filter this through the apparatus. If all of the sample water passes freely through the filter then pour an additional 75 ml into the top and continue pumping the sample through the filtering apparatus.

NOTE: In the event that the first 75 ml of dissolved metals sample stops passing freely through the filter (an indication that the membrane filter has become clogged with particulate matter), a new filter will have to be used.

Simply remove the upper funnel from the membrane filter base, remove the dirty filter, rinse the forceps, and place a new membrane filter on the filter base. Then re-attach the funnel, pour a second 75 ml of sample into the apparatus and continue filtering the remaining sample into the receptacle flask.

e) The filtrate, collected directly into the receptacle flask of the apparatus, is then poured into a 125 ml bottle that is provided. (But first, the deionized water in the 125 ml bottle will have to be discarded.) Then pour about 10 ml of the filtrate into the 125 ml bottle, rinse the bottle thoroughly and discard the filtrate water. Pour the remaining filtrate into the 125 ml bottle.

f) The new 125 ml bottle, containing the filtrate, will have to be labeled with the same information as on the 250 ml dissolved metal sample bottle used to collect the water sample. The 250 ml bottle used to collect the dissolved metal sample can now be discarded (assuming no more sample is needed for filtration).

g) To preserve the dissolved metals sample, add 1 ml of HNO_3 ("METAL PRESERVATIVE") to the 125 ml bottle and shake well. (For more details on sample preservation, see the following section.) DO NOT ADD METAL PRESERVATIVE BEFORE FILTRATION, ONLY AFTER.

h) After filtering each sample, rinse filtering apparatus (funnel, base and flask) thoroughly with the deionized water provided. Use a new filter for each site.

NOTE: If a water sampling device such as a Van Dorn or Niskin type water bottle is used (as is for lake water sampling), then separate blanks for both total and dissolved metals will have to be run using deionized water in the sampling device.

Pour about 200 ml of deionized water into the sampling device, shake to rinse, discard the water, and repeat. Then pour an additional 500 ml of deionized water into the sampling device and collect a total and dissolved metals sample from the device into the 250 ml bottles provided. Label the total metals blank sample as SAMPLER T.BLANK, with the project name and date and preserve as described in the following section. Label the dissolved metals blank as SAMPLER D.BLANK and proceed with the filtering procedures previously described.

1.4.2 Total metals

It is best to first filter the dissolved metals samples (as described in the previous section) and then add preservative to both the dissolved and total metals samples all at the same time. This saves time and reduces the chances of contamination. (For example, it should not be necessary to set the pipette down between preservation of different samples).

Once the dissolved metals samples have been filtered and preserved the total metals samples can be preserved as follows:

a) To preserve the 250 ml total metals sample add 2 ml of HNO_3 ("METAL PRESERVATIVE") to the sample bottle using the glass pipette provided. Do not insert the tip of the pipette into the water sample. Do not try to rinse any drops, remaining at the end of the pipette, into the sample.

   NOTE: HNO_3 CAN CAUSE SEVERE SKIN BURNS AND DAMAGE CLOTHING.

1.4.3 Orthophosphates

Orthophosphate samples must be filtered as described for dissolved metal samples, except that NO PRESERVATIVE is added. Ideally, filtration of orthophosphate samples should be done in the field rather that upon return to the laboratory. In any case, the time between sample collection and filtration should be minimized.

Orthophosphate samples must be kept cool and shipped to the laboratory as soon as possible. Ideally, the samples should be analyzed within 24 h.

2.0 SEDIMENT SAMPLING PROCEDURE

Whenever possible, stream bed sediments are collected with the stainless steel syringe sampler. The intention is to collect sediment fines. Therefore, seek areas of deposition (pools or eddys).

Insert tip of syringe (the area covered with holes) into the sediment. Pull plunge to fill samples. Pour sample into a plastic bottle. Rinse sampler thoroughly before using at another site. Samples should be frozen, if possible, or at least kept cool.

3.0 SHIPPING

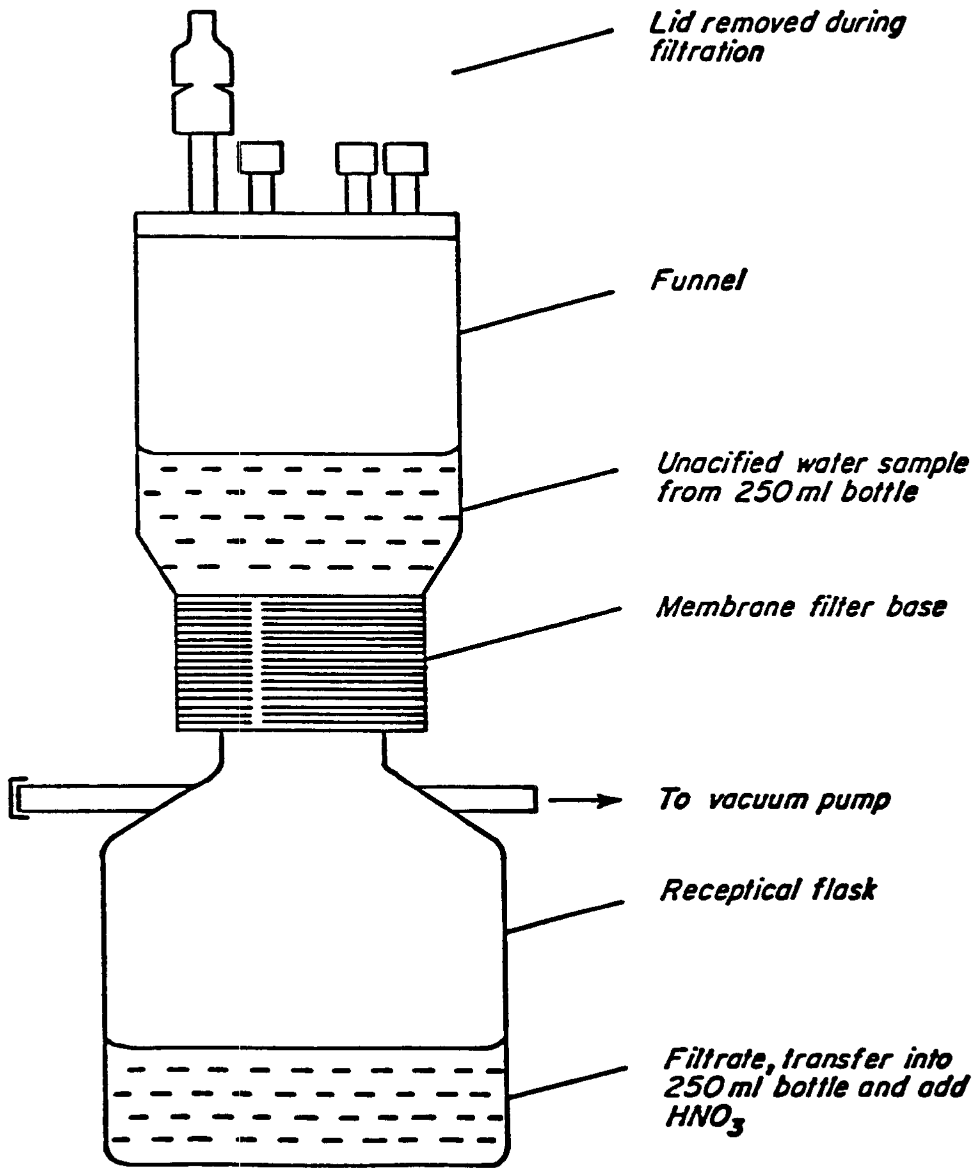
For return, prepare a "LAB TRANSMITTAL FORM" to include with the samples upon shipment to the laboratory. Be sure that the LAB TRANSMITTAL FORM is in agreement with the Water Quality Field Check List and the actual bottles being shipped. Keep copies of the transmittal forms for Norecol's records.

Carefully pack all bottles into cooler. Both the dissolved metal and total metal samples should be placed in plastic bags and sealed with a twist tie. Be especially careful with the glass bottles - these should not touch each other but should be staggered so that each glass bottle is surrounded by the larger plastic bottles (1-L or 2-L size). The small bottles can be used as fillers to prevent rattling. Samples should be kept cool (about $4^{o}C$ if possible) and returned to the laboratory within 48 hours of collection. Add ice (if available) to keep samples cold. Remember that coliform samples must be kept on ice and analyzed within 24 h. Tape coolers tight so lids do not come off. Label and address (eg.):

B.C. Research (Laboratory name and address)
3650 Wesbrook Mall
Vancouver, B.C.
Attention: H. Lanz (Person in charge of analyses)
Phone: (604) 224-4331

If you are not returning with the samples, notify Norecol of when shipment was sent out, carrier, waybill number, etc. Send Norecol a copy of the LAB TRANSMITTAL FORM at the same time samples are shipped out. This is essential so that we can track down the shipment if there is a problem with delivery.

FILTRATION OF WATER SAMPLES



Norecol

NORECOL WATER QUALITY FIELD CHECK LIST

SITE NO.	LOCATION	DATE	TIME (24 hour clock)	WEATHER	AIR (°C)	WATER (°C)	PLASTIC 2 L General	PLASTIC 1 L CN	GLASS 1 L Hg	2 PLASTIC 250 ML Metals	125 ml PLASTIC Dissolved Metals (after filtration)

COMMENTS: ______________________________

____

____

____

____

SAMPLES COLLECTED BY: ______________________________

INSERT Norecol Water Sampling Guidelines

NORECOL
SAMPLE ANALYSIS

T R A N S M I T T A L   F O R M

TO: ______________________ File: __________
______________________ Date: __________

ATTENTION: ______________________

PROJECT: ______________________

FROM: NORECOL ENVIRONMENTAL CONSULTANTS LTD.
Suite 700, 1090 West Pender Street
Vancouver, B.C.
V6E 2N7 (PH: 682-2291; FAX: 682-8323)

BILLING INSTRUCTIONS: ______________________
____

ATTENTION: ______________________

SAMPLES COLLECTED BY: ______________________ Date: __________

Sample ID	Description	Analyses to be Completed

Blanks, Reference or Duplicates Results Required (See sample ID list): YES [ ] NO [ ]

Please include the following information on the invoice: **Number of Samples Analysed**
Date Submitted
Unit Price of Sample Analysis

DATA ANALYSIS CATEGORY: RUSH [ ]
REGULAR [ ]

Date Results Required: __________

(For Norecol Use)

Date Data Received: __________ Signed: __________
__________ Notes: __________

INSERT Norecol Environmental Consultants Ltd. laboratory transmittal form.

B.C. RESEARCH
ANALYTICAL PROCEDURES

ANALYTICAL PARAMETER	METHOD	REFERENCE
pH	pH-meter	-
Alkalinity	Titration with 0.02N H_2SO_4	1
EDTA-Hardness	Titration with 0.01M EDTA	1
Turbidity	HACH Turbidimeter	-
Conductance	Seibold Conductivity Meter	-
Total Solids	Gravimetric	1
Suspended Solids	Gravimetric	1
Ammonia	Indophenol Method	2
Nitrate	Colorimetric (Cadmium Reduction)	1
Nitrite	Colorimetric (Diazotization)	4
Colour	Spectrophotometer (450 nm pH 7.6)	1
Total Phosphorus	Colorimetric	1
Total Cyanide	Colorimetric	1
WAD Cyanide	Colorimetric	1
Total Mercury	Flameless Atomic Absorption	3
Sulphate	Gravimetric	1

Total and Dissolved Metals

Metal concentrations were determined by flameless atomic absorption using a Perkin-Elmer Model 5000 atomic absorption spectrophotometer, HGA-500 graphite furnace and AS-40 autosampler. Deuterium background correction was employed through analyses.

REFERENCES

1. Standard Methods for the Examination of Water and Wastewater, 16th ed. 1985. Published by the American Public Health Association.

2. Determination of Ammonia and Kjeldahl Nitrogen by Indophenol Method. D. Sheiner Water Research Vol. 10: 31-36.

3. A Laboratory Manual for the Chemical Analysis of Waters, Wastewaters, Sediments and Biological Materials (2nd ed.) 1976. Environmental Laboratory, B.C. Ministry of Environment.

4. Wood, E.D., F.A.J. Armstrong, and F.A. Richards. Determination of Nitrate in Seawater by Cadmium-Copper. Reduction to Nitrite. J. Mar. Biol. 47: 23-31, 1967.

QUALITY CONTROL PROCEDURES FOR WATER SAMPLES ANALYZED BY B.C. RESEARCH

Sample Control, Storage, and Disposition

Test samples are logged in by shipping/receiving personnel. The samples are delivered to testing personnel and are marked with a date and project number code prior to storage and analysis. An analysis card is prepared indicating project number code and required analysis for each set of samples.

Laboratory personnel unpack samples and record missing or damaged samples on the analysis card. Samples are stored at room temperature, under refrigeration (e.g. 4°C). Test samples are kept up to six months in case of client queries regarding test results or requests for additional testing.

Test Data, Test Reports, and Records

Test data are recorded in bound and indexed laboratory notebooks. Testing personnel sign and date the notebooks and record the project numbers assigned to the test samples. Computations are done by the individual testing personnel. Random checks on calculations are carried out by senior testing personnel. If an error in computation or method is detected, the client is advised accordingly and samples are re-analyzed if appropriate. Reports are amended as necessary.

All test data are stored in the laboratory notebooks and in technical files which are maintained indefinitely. Generally, senior project personnel prepare final test reports for the client. Testing personnel and/or senior testing personnel sign the reports, which are identified by project numbers. Confidentiality is maintained by giving limited access to laboratory notebooks and technical files. All authorized personnel are identified by security badges.

Measurement Accuracy and Monitoring of Test Work

Maintenance and repair of test equipment is done internally or contracted out. Generally one or two testing personnel are responsible for maintenance of each piece of testing equipment.

All testing personnel are responsible for equipment calibration. B.C. Research testing personnel calibrate all instruments except analytical balances, which are recalibrated annually under subcontract. Test equipment calibration procedures are described in bound laboratory notebooks or in the test method references.

Accuracy of testwork is assured by using a combination of certified standards, reference materials, spiked samples, blanks, replicate tests and by participation in inter-laboratory studies.

Standard reference materials are obtained from a variety of sources including the United States National Bureau of Standards, the National Research Council of Canada Chemistry Standards Program, and the International Atomic Energy commission of Vienna Austria, etc. Use of certified reference materials is matched as closely as possible to the sample matrix. Standards are stored as appropriate (e.g. room temperature, refrigeration, in the dark, etc.).

BC RESEARCH
BRITISH COLUMBIA RESEARCH CORPORATION
3650 Wesbrook Mall
Vancouver, B.C.
Canada V6S 2L2
FAX (604) 224-0540
Phone (604) 224-4331

January 30, 1990
Our File: 4-01-441

Dr. B. Ott
Norecol Environmental Consultants Limited
Suite 700, 1090 West Pender Street
Vancouver, B.C.
V6E 2N7

Dear Bruce:

The enclosed table contains the analytical results obtained for "starting and end blanks" prepared during collection of water samples for the Placer Dome Berg project on September 28/88, May 5/88, July 12 and 13/88 and September 21/89. These blanks are an important part of the overall sample integrity and provide information on possible contaminants from the filtration unit, sample containers, filters, deionized water, acidification acid and pipets used for the field preparation and preservation of dissolved metal samples. The "end blank", in addition to the above is also an indicator of possible contamination from previously filtered samples. In this laboratory checks carried out on filter blanks is focused on zinc, copper and iron which are the most likely elements to appear as contaminants.

If you have any questions about the information please contact me.

Yours sincerely,

B.C. RESEARCH

H. Lanz
Program Leader
Inorganic Analysis Group
Industrial Chemistry Division

HL/md
Enc.

ANALYTICAL RESULTS FOR FILTER BLANKS FROM

PLACER DOME BERG PROJECT

SAMPLE	DATE	Cu (mg/L)	Zn (mg/L)	Fe (mg/L)
Starting Blank	Sept. 28/88	<0.0005	<0.0005	-
End Blank	Sept. 28/88	<0.0005	0.0010	-
Starting Blank	May 5/89	<0.0005	<0.0005	<0.005
End Blank	May 5/89	<0.0005	<0.0005	<0.005
Starting Blank	July 12/89	<0.0005	0.0008	<0.005
Starting Blank	July 13/89	<0.0005	0.0005	<0.005
End Blank	July 12/89	<0.0005	0.0006	<0.005
Starting Blank	Sept. 21/89	<0.0005	<0.0005	<0.005
End Blank	Sept. 21/89	<0.0005	<0.0005	<0.005

APPENDIX 3.3.4-1

Fish Sampling Activities and Fork Lengths of Fish Specimens Captured by Norecol in the Berg Project Area, July 1989

APPENDIX 3.3.4-1

FISH SAMPLING ACTIVITIES AND FORK LENGTHS OF FISH SPECIMENS CAPTURED BY NORECOL IN THE BERG PROJECT AREA, JULY 1989

STREAM	SAMPLE NO.	CAPTURE METHOD	DURATION	SPECIES	FORK LENGTH (cm)	
Mystery River	F1	Minnow Traps (5)	24 h	Dolly Varden Char	9.4	11.4
					15.2	11.9
					7.1	11.9
					14.5	11.9
					10.2	12.7
					11.4	9.7
					9.1	8.9
					11.9	10.9
					10.2	7.6
						$\bar{X}$ = 10.8
Desacroix Creek	F2	Minnow Traps (5)	24 h	Dolly Varden Char	12.7	6.3
					5.8	7.8
					8.1	10.2
					8.9	7.6
					7.6	6.4
					12.9	6.4
					6.1	5.8
					8.9	6.1
					14.5	6.1
					9.1	4.8
					9.6	6.4
					11.4	6.4
					8.1	5.8
					10.2	6.6
					10.2	6.6
					6.3	6.9
					8.9	6.6
					9.6	
					11.7	
					9.1	
					9.4	
					8.1	
					7.1	
					5.6	
					5.1	
					6.3	
						$\bar{X}$ = 7.9
		Angling	0.5 h	NO FISH		
Stepp Creek	F3	Angling	1.0 h	Rainbow Trout	25.0	
Bergeland Creek	F4	Angling	0.5 h	NO FISH		

APPENDIX 3.4.2-1

Characteristics of 1989 Wildlife Studies in the Placer Dome Berg Property and Road Proposal Study Area

APPENDIX 3.4.2-1
CHARACTERISTICS OF 1989 WILDLIFE STUDIES IN THE
PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA

INTRODUCTION

The 1989 studies described below were directed to identification of local wildlife values and potential wildlife/habitat impacts associated with development of a mineral property and access road in the Tahtsa Range area in northcentral B.C. Included here are a description of the extent and nature of study activities (1-A), a brief account of study methods (1-B), and a map of the functional study area for wildlife assessment purposes (1-C). That study area is larger than the immediate boundaries of the proposed developments might suggest, to account for the fact that most of the wildlife species of interest in the area are large mammals, with individual ranges and/or seasonal movement patterns that may include, but extend well beyond the development boundaries.

1-A. STUDY ACTIVITIES AND OBJECTIVES

1) Aerial survey on 24 March (approximately 3 hours). This flight was to assess late winter ungulate distribution and to document other species occurrence in the area, primarily through aerial snow-tracking.

2) Aerial surveys on 13 and 14 July (approximately 3 hours, not including time for incidental observations during logistical flights for concurrent fisheries and engineering studies). The primary objectives of the mid-summer flight were to a) provide a preliminary perspective on mountain goat distribution and numbers in the entire study area and in relation to proposed developments, b) assess bear and moose habitats in the proposed development areas, and c) document occurrence/status of caribou in the area.

3) Local ground observations (13-14 July at upper Berg Creek, Kidprice Mountain, Ney Creek, Bergeland Creek, and the north slope of the Tahtsa Range), to complement the aerial observations.

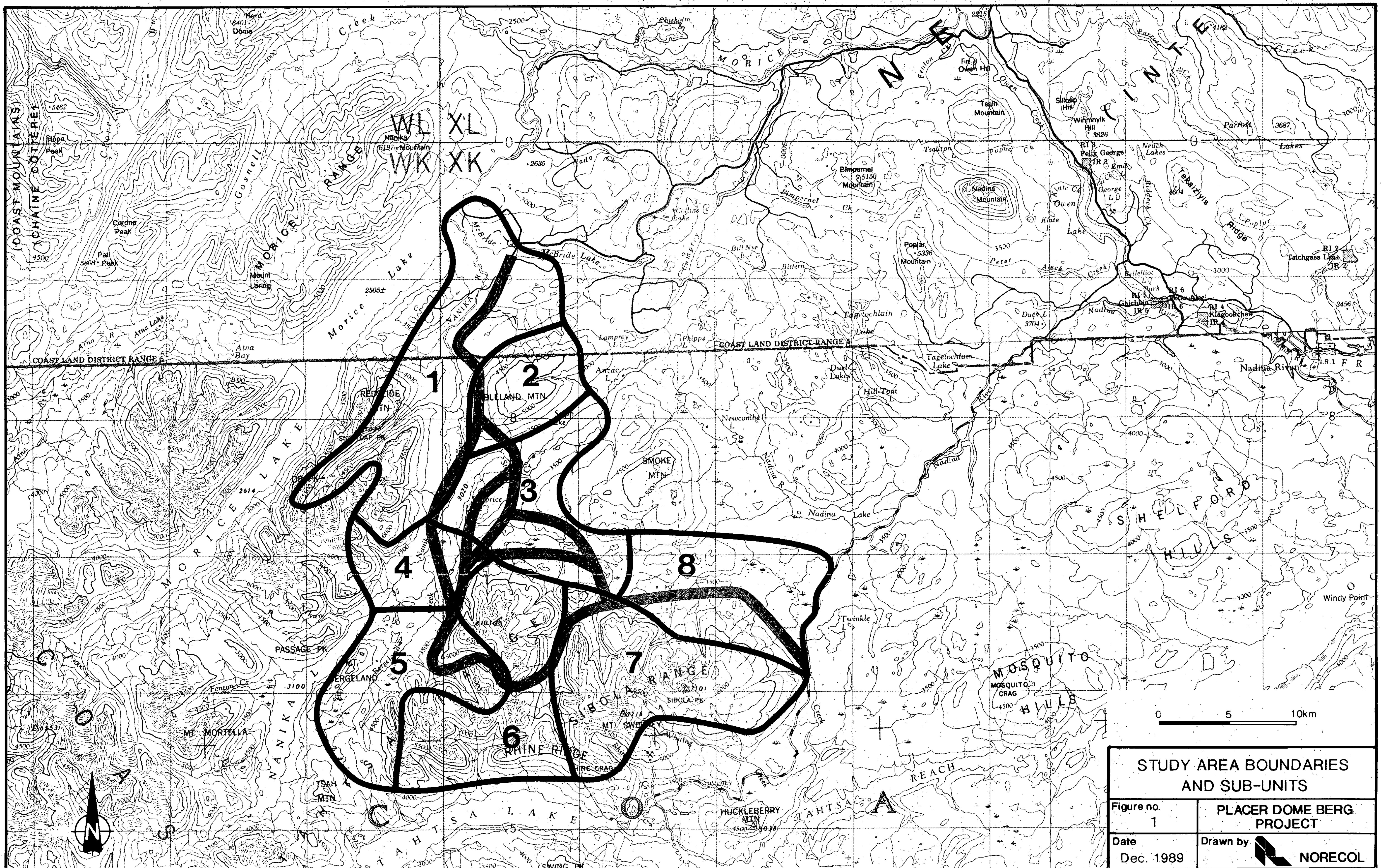
4) Compilation and review of government file information pertaining to the study area (courtesy B. Fuhr and D. Steventon, MOE, Smithers).

1-B. FIELD STUDY METHODS AND CONDITIONS

Both aerial surveys were conducted by Bell 206 helicopter. The March flight was undertaken in the morning on a clear, calm, relatively warm day. Light conditions were excellent for observation of animal tracks in the snow, which could be seen from a considerable distance, and snow conditions were ideal for registering tracks, i.e., not crusted on the surface. Visibility conditions were also good in July, with clear, sunny skies, although there were moderate to strong winds in the uplands. Also, air temperatures during the July work were high, to 30° C, and it is likely that animals were preferentially using cooler, shaded areas in which they are not easily seen.

Flight characteristics for both surveys (search pattern, speed, elevation) were determined on an ad hoc basis, with modifications as appropriate to visibility conditions in particular cover types. Generally, a flight speed of about 100 km/hr at an elevation of 50-100 m above the ground pertained. The objective for both surveys was to ensure that coverage was satisfactorily intensive for particular local habitat types and extensive for the study area as a whole.

To facilitate data comparisons both between local areas (e.g., the two proposed road options), and between surveys (to show seasonal changes and differences in distribution), the study area was subdivided into 8 separate survey blocks, as depicted on the following page (1-C). The boundaries of those sub-units were determined subjectively, based on major topographic or habitat breaks, and/or the needs of this particular study. In general, Blocks 1-4 relate to the northern (Morice) road option, Block 5 to proposed mine site developments, and Blocks 6-8 to the southern (Twinkle Lake) road option.



STUDY AREA BOUNDARIES AND SUB-UNITS

Figure no. 1

PLACER DOME BERG PROJECT

Date Dec. 1989

Drawn by NORECOL

APPENDIX 3.4.2-2

Wildlife Surveys in the Placer Dome Berg Property and Road Proposal Study Area Through Summer 1989

APPENDIX 3-4.2-2
WILDLIFE SURVEYS IN THE
PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA
THROUGH SUMMER 1989

The following table identifies and characterizes pertinent wildlife survey activities for the area, both as reported in accessible documents on file at the Ministry of Environment office (Smithers) and as recently completed during the present study. The file information was primarily from reconnaissance surveys under the Canada Land Inventory program, and from a combined MOE/B.C. Hydro study assessing wildlife values in the proposed Kemano II impoundment area (see Sutherland 1979). There have been more recent and possibly more extensive wildlife studies in the general area (Vol. 10 of Kemano Completion Reports, 1981, Envirocon for Alcan), but that report has not yet been officially released and was not available for reference in the present report. Note that the principal investigator for the recent Berg property studies ("B" series, below), also conducted and/or directed all of the Kemano II ("K" series) surveys, thus providing a better collective experience and basis for interpretation than might have been the case otherwise.

SERIES NO.	DATES MONTH/DAY	YEAR	TYPE[1]	AREA COVERAGE[2] 1	2	3	4	5	6	7	8
CANADA LAND INVENTORY											
CLI-1	01/5-02/8	1968	FW	X	X*	X	X	X	-	-	X
CLI-2	02/11-26, 03/21	1974	FW	X*	-	X	X	X*	X*	X*	X
KEMANO II SURVEYS											
K-1	07/10	1974	FW	X	-	-	X	X	-	-	-
K-2	10/4-8	1974	GD	X	-	-	X	-	-	-	-
K-3	10/4-8	1974	HE	X	-	X	X	X*	-	-	-
K-4	12/31	1974	FW	X*	-	X	X*	X*	-	-	-
K-5	02/28	1975	HE	X	-	X	X*	X*	-	-	-
K-6	04/2	1975	FW	X*	-	X	X*	-	-	-	-
K-7	05/1	1975	FW	X*	-	X	X*	?	-	-	-
K-8	06/11	1975	HE	X*	-	X	X*	X*	-	-	-
K-9	06/17	1975	HE	X*	-	X	X*	X*	-	-	-
K-10	06/30	1975	HE	X	-	X*	X*	X*	-	-	-
K-11	01/15	1976	HE	X*	-	X*	X*	X*	-	-	-
BERG PROPERTY ROAD PROPOSAL STUDIES											
B-1	03/24	1989	HE	X*	X	X*	X*	X*	X	X*	X*
B-2	07/13-14	1989	HE	X	X*	X*	X	X	X	X	X
B-2	07/13-14	1989	GD	-	-	X	-	X	X	-	-

[1]Survey type: FW - Fixed-wing aircraft; HE - Helicopter; GD - Ground observations.

[2]Area Coverage - For each of the 8 survey blocks shown in Appendix 1-C, an X indicates at least partial coverage (part of the area, or unintensive over most of the area), while X* indicates extensive and/or intensive coverage.

APPENDIX 3.4.2-3

Results of 1989 Aerial Surveys in the Placer Dome Berg Property and Road Proposal Study Area

APPENDIX 3.4.2-3
RESULTS OF 1989 AERIAL SURVEYS IN THE
PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA

Purpose of Flight: Determine winter wildlife occurrence, distribution and potential conflict areas in relation to proposed corridors for a mining access road, and to the mine site development area.

Location: Nanika River, Tahtsa-Sibola Ranges, and vicinity, northcentral B.C.

Dates: 24 March and 13-14 July 1989

Weather: March - Clear, calm, -5° C; ideal visibility conditions.
July - Generally clear and hot, with moderate winds.

Aircraft: Bell 206, Jet Ranger (Canadian Helicopters Ltd.)

Pilot: Lyle Ledoux Observers: March - D. Hatler; July - D. Hatler and occasionally B. Dunford.

Species Key:
M = Moose   C = Caribou   G = Mountain Goat
Wv = Wolverine   W = Wolf   MD = Mule Deer
O = Other species, as designated under remarks.

Classification:
M = male; F = female; J = juvenile (young-of-the-year); Y = yearling;
U = unclassified; A = unclassified adult.

Location	Species	Remarks
24 MARCH 1989 SURVEY:		Depart Smithers, 09:15, and return about 12:55; Flight lines and observations are shown on the accompanying map (Appendix 3, page 7).
Telkwa Range	C G C	Seen, in passing: scattered group of 10 just east of the "Camel Humps" (1M, 1F, 1J, 7U); 7 more (6M, 1F), on the west edge of the Dockrill Plateau; four goats (3A, 1J) also seen in that area; two more caribou (1F, 1J) seen low on the plateau east of the Dockrill Creek headwaters.
Morice Lake		Commencing "official" survey at mouth of Nanika River; there is open water here, and much of the upper Morice River was also open.
Lower Nanika River	M	Fresh tracks (probably one animal) at several locations along the lower 2 km, but none seen.
Lower Nanika River	O	Furbearer tracks common along the river--mink, otter, coyote identified so far.
	O	Snow depth measurement in a shrub meadow just east of the river--105 cm; one lynx track crossing this meadow.

Location	Species	Remarks
Lower Nanika River	Wv	Set of wolverine tracks along the river; still open water.
	W	Tracks of a single wolf--it waded across the river at two locations; the wolverine track is still present here, and otter tracks appear occasionally; no ungulate tracks.
Nanika River		Small lake northwest of Kidprice--only a few marten tracks; no large mammal sign.
Kidprice Lake area	O	Three Common Mergansers on the river about 2 km below the falls.
	G O Wv	Low uplands at the southeast end of the lake--two billies (2M) seen; there are tracks down to low bluffs just above the creek; 14 more goats (11U, 3J) and abundant tracks along the ridge to the east; the kid count is minimal as the animals crowded together under a ledge and a complete classification was not possible; one White-tailed Ptarmigan and tracks of a wolverine and one or more porcupines also seen on the S-facing slope occupied by the goats.
Upper Nanika River	O	The flat lowlands between Kidprice and Nanika Lakes is almost trackless; a few marten and weasel tracks only.
Bergeland Creek		Few tracks, even of furbearers, in the broad valley in this area.
Mine site area (old camp)	Wv	Tracks of two wolverines, apparently traveling together, seen at several locations on both slopes and in the valley below the old mine camp buildings; snowmobile tracks also present in this area.
Upper Berg Creek	G	A few goat tracks all along the ridge between the two upper forks, and one animal seen at the east end; flock of White-tailed Ptarmigan (about 15) also seen in that area.
Sibola Range	 G	Flew high over the various ridges and plateaus, getting wide coverage there, but not on steep slopes facing south; the uplands are windblown and look good for goat or caribou foraging; ideal light conditions for seeing tracks, but the only ungulate tracks observed were older goat tracks (one animal) along a low cliff on the north side.
Twinkle Lake		Covering the proposed corridor from the Nadina Road; snow depth on a small lake along

Location	Species	Remarks
		the lower section of the existing road (elevation 1125 m) was 135 cm; no ungulate tracks; the general forest cover in this area is pine, but with numerous meadows, swamps, and small lakes fringed with spruce--looks like good summer moose range.
Ney Creek	Wv	The only conspicuous wildlife tracks along the entire corridor from the Nadina Road into the Upper Ney Creek Valley were those made by a single wolverine; there has also been much snowmobile activity along the road and well into the mountains.
Tahtsa Range	G	No ungulates or sign, though the potential for goats looks good; one porcupine trail seen in subalpine balsam.
NE Tahtsa Range	G O	One young billy (1M) seen on the low mountain at the entrance to the proposed access valley (Upper Ney Crk); tracks indicate that it is the only goat there at this time; a few furbearer tracks also present there including marten and a small canid, possibly fox.
Tableland Mtn	G	Nine goats (6A, 3J) seen, in passing, on low bluffs overlooking a recent cutblock on the northwest end.
13-14 JULY SURVEY:		Depart Smithers about 09:00 each day, and return in early evening; actual flight times variable, as dictated by logistical needs of other work crews. Flight lines and observation locations are shown on the accompanying map (Appendix 3, Page 8).
Tahtsa Range		Commenced aerial surveys from the mine site area, working that basin to the west, and then northward along the west side.
North Tahtsa Range	G	Four animals seen on the ridge at the northwest corner (1F, 1J, 1Y, 1A).
Kidprice Mountain	G M	One young billy (1M) seen on a low ledge on the south end; during the subsequent thorough search of this mountain, no more goats were seen; two moose (2F) seen near a subalpine pond on the north side.
Tableland Mountain	G	Thorough coverage of uplands found a total of only four goats, three on the southwest-facing side (2A, 1Y--all moulted), and a small billy (1M) moving up from thick krummholz on the north side. There are well-used trails

Location	Species	Remarks
		leading downslope at that location, possibly to mineral lick sites, but the extent and destinations of those trails could not be determined from the air.
Berg Creek	G	Two nanny/kid pairs (2F,2J) on a low knoll on the north-facing slope at the lower end of the valley south of Berg Ridge.
Berg Creek	G	Large billy (1M) in the short side-canyon just around the corner (south) of the valley mouth.
SW Tahtsa Range	bird	One Blue Grouse flushed from a subalpine ridge.
SW Tahtsa Range		Still lots of snow in uplands in this area, and no tracks.
South Tahtsa Range	G	Two partly moulted (shaggy) females with one kid (2F,1J) low (1225 m) on the southernmost ridge.
W. of Rhine Ridge	G	Still in Tahtsa Range, two billies (2M) seen on a north-facing knoll.
Rhine Creek	marmot	Burrows and trails abundant in the headwaters area.
Mt. Sweeney area		No recent trails on scree slopes and no tracks seen on snow patches.
Sibola Peak area	birds	Five White-tailed Ptarmigan flushed from a rocky ridge.
Sibola Peak area		There are many snow patches in the uplands north and west of the peak, where caribou used to occur, but no tracks or trails seen; there is evidence of regular use of these uplands by people with ATV's and/or other vehicles.
Twinkle Lake		Down for fuel and to pick up Bill Dunford and Kelly.
Lower Ney Creek	M	Cow and calf (1F,1J) on a gravel bar.
Nanika-Kidprice area		After various ground study stops, returned at 18:00 to Smithers, covering the lowlands between the lakes and along the Nanika River enroute; no animals seen, but there are well-used trails through the meadows and tracks on all mudbars and shores (probably mostly moose).

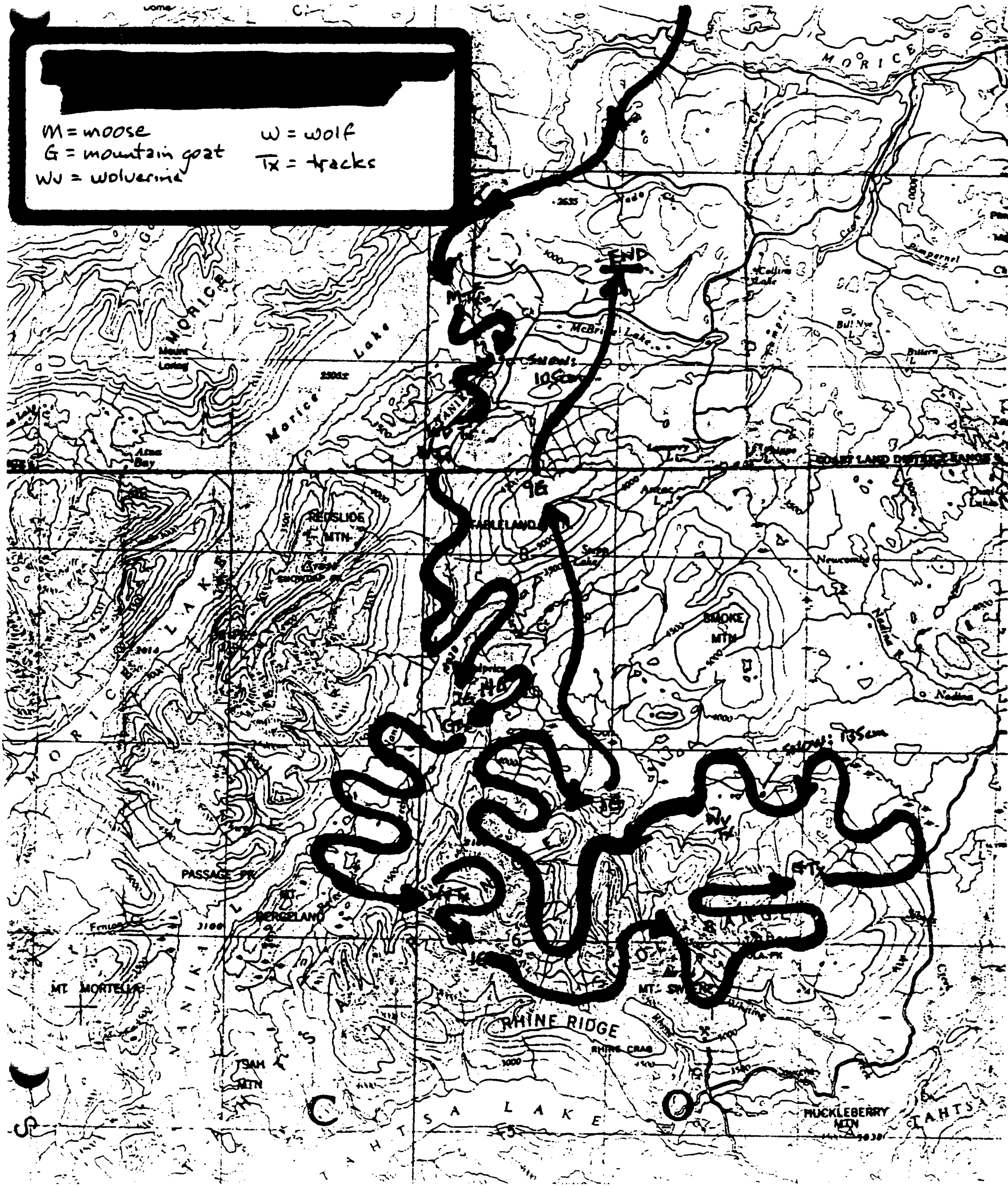
END OF DAY

Location	Species	Remarks
14 July 1989: Clear and warm.		
Telkwa Mountains	M	Enroute to the study area, incidental sightings of two different cow/calf pairs in high subalpine meadows.
Thautil River	C	W. of Starr Crk mouth, incidental sighting of 7 caribou, including one radio-collared female, two mature bulls, a female with a calf, and two uncl. adults (2M,2F,1J,2A).
Redslide Mountain	G	A minimum of 8 animals (8U) seen, in passing, on bluffs on the ridge south of the peak.
Kidprice Lake	geese	Pair of adults Canada Geese with 5 downy young at the north end of the lake.
Kidprice Mountain		No conspicuous trails seen off the south or east sides of the mountain, and yesterday's billy has apparently moved.
Kidprice Mountain	G	Following an intensive ground search for migration trails off the mountain, it was concluded that none exist, and another aerial survey was undertaken; a nursery group (adults and kids) was glimpsed briefly, low on the west-facing side, but they quickly hid in thick cover (alder/fir) in that area; at least seven were present (7U).
Ney Creek	M	The pilot observed a large bull moose in the upper valley, during a logistical overflight in that area.
Kidprice Mountain		Enroute back to Smithers, passed along the west end of the mountain, where the goats were seen a few hours earlier, but no animals were observed this time.
Tableland Mountain		A casual pass along the western edge failed to locate any goats.

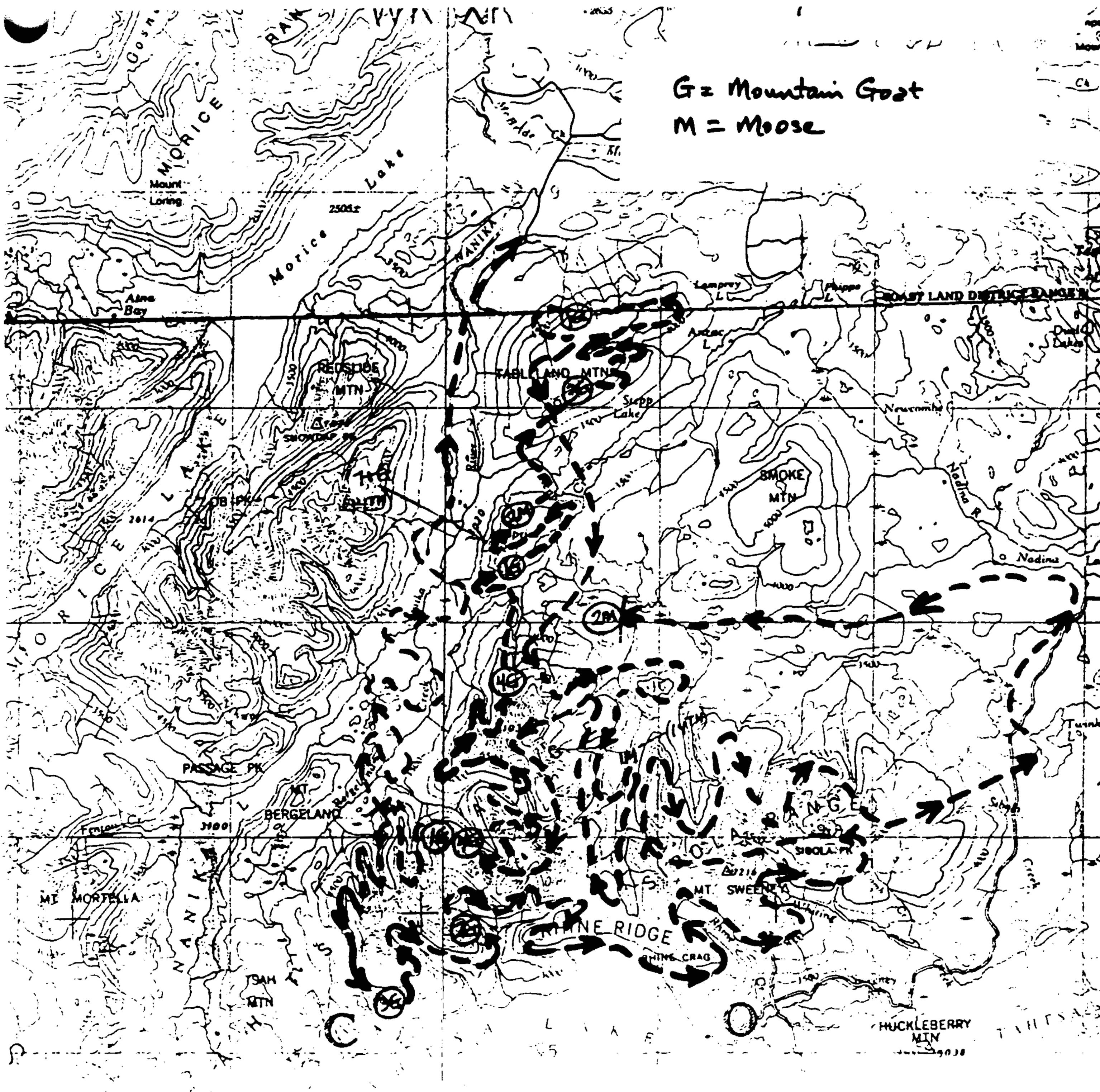
End of Surveys.

* * * * *

FLIGHT LINES AND OBSERVATIONS DURING AERIAL SURVEYS ON 24 MARCH 1989.



FLIGHT LINES AND OBSERVATIONS DURING AERIAL SURVEYS ON 13-14 JULY 1989.



APPENDIX 3.4.2-4

Seasonal Observations of Moose During Aerial Surveys in the Placer Dome Berg Property and Road Proposal Study Area through Summer 1989

APPENDIX 3.4.2-4

SEASONAL OBSERVATIONS OF MOOSE DURING AERIAL SURVEYS IN THE PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA THROUGH SUMMER 1989

SEASON FLIGHT NO.[1]	MONTHS	YEAR	NO. MOOSE OBSERVED PER SURVEY BLOCK[2] 1	2	3	4	5	6	7	8
WINTER										
CLI-1	JAN,FEB	1968	0	0	2	0	0	-	-	t
CLI-2	FEB,MAR	1974	0	-	0	0	0	0	0	0
K-4	DEC	1974	2	-	0	0	0	-	-	-
K-5	FEB	1975	0	-	0	0	0	-	-	-
K-11	JAN	1976	0	-	0	0	t	-	-	-
B-1	MAR	1989	t	0	0	0	0	0	0	0
SPRING										
K-6	APR	1975	t	-	0	0	0	-	-	-
K-7	MAY	1975	0	-	0	0	?	-	-	-
K-8	JUN	1975	4	-	6[3]	16[3]	0	-	-	-
K-9	JUN	1975	0	-	3	6[3]	4	-	-	-
SUMMER										
K-1	JUL	1974	2	-	-	5	8	-	-	-
K-10	JUN	1975	0	-	9	7	5	-	-	-
B-2	JUL	1989	t	0	4	0	t	1	0	0
FALL										
K-3	OCT	1974	0	-	4	0	4	-	-	-

[1]Flight Number, as listed in Appendix 2.

[2]Numbers in the body of the table are number of moose seen (all sex and age classes) in each of the 8 study area sub-units shown in Appendix 1-C; the presence of tracks, without an animal sighting, is indicated by "t".

[3]Number not including one calf whose presence was inferred from behavior of an adult female, but not seen.

APPENDIX 3.4.2-5

Seasonal Observations of Mountain Goats during Aerial Surveys in the Placer Dome Berg Property and Road Proposal Area through Summer 1989

APPENDIX 3.4.2-5
SEASONAL OBSERVATIONS OF MOUNTAIN GOATS DURING AERIAL SURVEYS IN THE PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA THROUGH SUMMER 1989

SEASON FLIGHT NO.[1]	MONTHS	YEAR	NO. GOATS OBSERVED PER SURVEY BLOCK[2] 1	2	3	4	5	6	7	8
WINTER										
CLI-1	JAN,FEB	1968	2	3	0	0	0	-	-	0
CLI-2	FEB,MAR	1974	14	-	15	0	30	3	3	0
K-4	DEC	1974	0	-	0	0	0	-	-	-
K-5	FEB	1975	0	-	9	0	0	-	-	-
K-11	JAN	1976	0	-	7	0	0	-	-	-
B-1	MAR	1989	0	9	16	0	1	-	1	0
SPRING										
K-6	APR	1975	0	-	10	0	0	-	-	-
K-7	MAY	1975	0	-	7	0	?	-	-	-
K-8	JUN	1975	4	-	11	0	0	-	-	-
K-9	JUN	1975	8	-	11	0	0	-	-	-
SUMMER										
K-1	JUL	1974	0	-	-	0	0	-	-	-
K-10	JUN	1975	0	-	0	0	0	-	-	-
B-2	JUL	1989	8[3]	4	8+	0	5	9	0	0
FALL										
K-3	OCT	1974	0	-	7	0	t[4]	-	-	-

[1]Flight Number, as listed in Appendix 2.
[2]Numbers in the body of the table are number of mountain goats seen (all sex and age classes) in each of the 8 study area sub-units depicted in Appendix 1-C.
[3]At least 8 distant animals seen, in passing, in the Redslide Mtn. area (incidental observation only).
[4]Tracks and droppings seen during ground investigation of a mud bar in Bergeland Creek.

APPENDIX 3.4.2-6

Ground Observations Relating to Wildlife and Habitat in the Placer Dome Berg Property and Road Proposal Study Area, 13 to 14 July 1989

APPENDIX 3.4.2-6
GROUND OBSERVATIONS RELATING TO WILDLIFE AND HABITAT IN THE PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA, 13-14 JULY 1989.

1) 13th - Set down on the low ridge above the old camp area at the mine site, to investigate tracks, observed fresh yesterday (12 July) by John Brody. The tracks were mountain goat and wolf, apparently one of each and possibly representing a predator-prey pursuit.

2) 13th - During engineering investigations in the mine camp area yesterday, J. Brody saw marmots and, from descriptions, a few ptarmigan that were probably White-tails.

3) 13th - Fisheries sampling area, lower Ney Creek: fresh wolf and coyote tracks seen in the mud.

4) 13th - Northernmost ridge in Tahtsa Range: Goat tracks and pellets common down to about 1300 m, but little sign below that point, and no evidence of a regularly used trail off the mountain to the north. Other than goat sign, saw only lemming droppings and burrows, a few ptarmigan droppings, 2 American Robins, and 5 Water Pipits (2 carrying insects). Also found some unfamiliar rodent droppings, and having some small mammal snap traps in my pack, set 10 to check tomorrow. Whitebark pine (Pinus albicaulus) is abundant in the subalpine zone in this area (it is rare farther north).

5) 13th - Bergeland Creek (waiting for other crews to be picked up): 1 grizzly bear track (155 cm wide), moose tracks (adult and young), a smaller ungulate track believed to be goat but possibly a mule deer, wolf tracks, and goose tracks. There is lodgepole and whitebark pine side-by-side in this valley. One Clark's Nutcracker also seen in this area.

6) 13th - In a walk out along the road east from the mine site and down Ney Creek, J. Brody apparently saw only marmots and ptarmigan.

7) 14th - No small mammals caught in the 10 traps set yesterday, but a grayish chipmunk (probably E. minimus) was seen in the area.

8) 14th - Ground surveys on Kidprice Mountain, to look for possible goat "migration" trail(s)--I was dropped at the east end of the main upland, and worked around the north side to the west end, then back south to the last rocky promontory on the east end, with the following results:

- Mountain Goat: There is little sign on the ridges and knolls at the center of the mountain, or along the north and east sides; however, all west and south exposures show evidence of heavy use in the form of abundant pellets, well-worn trails, and shed wool.
- Moose: This is a regenerating burn, and it is well-used by moose. Sign seen included abundant winter pellets (early winter?) and evidence of browsing (common at all elevations), as well as fresh summer droppings and tracks of adults and one or more young near a pond at the east end. One adult was flushed, but only glimpsed, in thick alder at the east end of the ridge.
- Other Mammals: Hoary marmot (a few burrows and droppings, and one animal seen); chipmunk (one seen, that not as gray as the one seen in the northern Tahtsa Range earlier today.
- Birds: Seen and/or heard--Golden-crowned Sparrow, Hermit's Thrush, male Blue Grouse, Gray Jay, Clark's Nutcracker.

- Vegetation notes: This is an old burn, and much of the ground cover on the south side is huckleberry (Vaccinnium sp.), which has been fairly heavily browsed--apparently mostly by goats. I saw only a few berries, but expect that in some years berry crops are better and would be an attraction to bears. Mountain ash is also present, and has been heavily browsed by moose and possibly also by goats.

9) 14th - Upper Ney Creek: I walked about 2 km downstream, starting at the lower end of the valley where the present "road" comes out from the mine site area. The entire valley along Ney creek from that point is lined with willow, and moose tracks and pellets are present (though not abundant) in that area. At least 1 set of calf tracks was seen. It is likely good summer range for moose, and probably receives some use by bears (heavy growth of Equisetum seen in several seepage areas along the short section traversed, and other food species also present). However, no unique habitats or clearly significant wildlife concentration areas were identified.

* * * * *

APPENDIX 3.4.2-7

Summary and Interpretation of Wildlife Occurrence and Values in the Placer Dome Berg Property and Road Proposal Study Area

APPENDIX 3-4.2-7

SUMMARY AND INTERPRETATION OF WILDLIFE OCCURRENCE AND VALUES IN THE PLACER DOME BERG PROPERTY AND ROAD PROPOSAL STUDY AREA.

The following species statements are summarized from historic and recent data, as presented in Appendices 3-6 and in Sutherland (1979). The numbers in parentheses refer to the study area sub-units identified in Appendix 1-C.

BIG GAME

Moose - Formerly and apparently still common, early summer through fall, in lowland flats and subalpine meadows in the Nanika-Kidprice-Bergeland areas (1,3,4,5); most animals move completely out of the study area for winter; see Appendix 4 for a detailed listing of moose observations in the study area.

Mountain Goat - Present year-round in uplands throughout the study area (1,2,3,5,6,7); 35 animals were observed in the Tahtsa-Sibola uplands (5,6,7) on one winter flight in 1974, but only 14 were seen in that same area on our July 1989 flight; current numbers may, in fact, be much lower than in the mid-1970's (see text), but neither that nor aspects of seasonal distribution are clear with data in hand; Appendix 5 provides a detailed listing of mountain goat observations in the study area.

Caribou - A total of 58 were seen on upland plateaus of the Sibola Range (7) in February 1974 (CLI flight), and 10 were seen on Sibola Peak in May 1975 (Sutherland 1979); there are only two other documented sightings, both in summer 1976 (Stevenson and Hatler 1985): 3 animals (unclassified) reportedly seen by hikers near the headwaters of Bergeland Creek (5) and an unspecified number seen by a Min. of Forests employee near Sibola Peak (7); there have been unconfirmed reports of summer/fall occurrence on Tableland Mountain (2) in the past; the population affinities and seasonal distribution of animals seen in the area in the 1970's are unknown; no caribou or sign were seen in the area during the 1989 surveys, suggesting that the species is no longer present, but negative information is difficult to interpret with certainty.

Mule Deer - Tracks were reported from the shore of Kidprice Lake (1) and from a mudbar (possibly misidentified goat track?) in Bergeland Creek (5) in the mid-1970's; goat or deer tracks also present at Bergeland Creek in July 1989; a few individual deer may occasionally pass through or reside in the study area during the snowfree season, but neither the climate nor local habitats appear suitable for significant occurrence of this species.

Grizzly Bear - Tracks of two different individuals in Kidprice-Lower Nanika area (1) in October 1974; fisheries employees reported observations of grizzlies along the lower Nanika in previous years, and pilots recalled past grizzly sightings in the Upper Nanika (4) and Bergeland (5) areas (no specific data); tracks of one individual at Bergeland Creek near the mouth of Berg Creek in July 1989; the species probably occurs at least occasionally throughout the study area, but no concentration areas other than the fish-rich lower Nanika River are known at this time.

Black Bear - Tracks of 2-3 individuals along lower Nanika R. (1) in October 1974, and one seen on the flats between Nanika and Kidprice Lakes (4) at that time; one seen east of Kidprice Lake (3) in June 1975, and a sow with cub seen in the Bergeland Creek area (5) in August 1975; the species is believed to be common to abundant below timberline throughout the study area, but especially in the northern sections (1,3,4 and possibly 8).

Wolf - No direct sightings; tracks of one individual along the lower Nanika (1) in March 1989--probably looking for fish carcasses, and tracks of singles at Lower Ney Creek (3) and in the mine site area (5) in July 1975; wolves probably occur throughout the area during the snowfree season, but apparently move out (with the moose) in winter.

SMALL GAME (MAMMALS) AND FURBEARERS

Coyote - Tracks along the lower Nanika R. (1) in March 1989, and along lower Ney Creek (3) in July 1989.

Lynx - Tracks of one crossing a shrub meadow along the Lower Nanika River (1) in March 1989.

Wolverine - Tracks of 1 between Stepp and Kidprice Lakes (3) in February 1975; tracks of 1 on Stepp Lake (3) in January 1976; tracks of 1 along the lower Nanika R. (1), 1 on goat bluffs east of Kidprice Lake, 2 in east (Tahtsa Range) fork of Bergeland Creek (6), and at least 1 at mid-slope on the north side of the Sibola Range (8), March 1989.

River Otter - Tracks at the south end of Kidprice Lake (3) and along the lower Nanika R. (1) in October 1974; tracks along upper Nanika R. (4) in December 1974; five otters in a pool near the mouth of Fenton Creek (Nanika Lake, outside the study area) in September 1975; tracks of 2-3 at Lower Nanika R. (1), 1 at Kidprice Lake (3), and 1 at Upper Nanika R. (4) in February 1975; tracks of 2-3 along Lower Nanika R. (1) in April 1975; tracks of 1 or more along the Lower Nanika River in March 1989.

Other Mustelids - Marten droppings seen in uplands along lower Nanika River (1) in October 1974; marten tracks seen near Spill Lake (1) in February 1975; marten tracks noted at Spill Lake (1), Nanika-Kidprice Flats (4), and the northwest Sibola Range (7) in March 1989; mink tracks seen along the Lower Nanika River (1) in March 1989.

Beaver - Active lodge noted on Stepp Lake (3), June 1975; activity noted on a small lake southwest of Smoke Mountain (3) in mid-June 1975; some sign of activity in ponds on Nanika-Kidprice flats (4) in July 1989.

Non-game Mammals - Porcupine tracks noted east of Kidprice Lake (3) and in northern Sibola Range (7) in March 1989; sign and/or sightings of hoary marmots and least chipmunks at Kidprice Mountain (3) and those species plus brown lemmings on the northern Tahtsa Range (6) in July 1989.

BIRDS

Waterfowl - 7 Canada Geese on the Bergeland Flats (5) and 5 downy young at the mouth of Fenton Creek (Nanika Lake) in July 1974; 18 Canada Geese and 2 Mallards at the Nanika River Inlet of Kidprice Lake (3,4), 8 Surf Scoters, and one Common Goldeneye on the lake (3), and goose sign on a mudbar of the creek south of Smoke Mountain (3)--all in October 1974; 10 Trumpeter Swans and several unident. ducks at mouth of Nanika R. (1) in April 1975; 10 male Common Mergansers on Spill Lake (1) and one pair on Kidprice Lake (3) in mid-June 1975; 3 Common Mergansers along Lower Nanika River (1) in March 1989; pair of Canada Geese with 5 downy young at S. end of Kidprice Lake (3) in July 1989. .

Upland Game Birds - 3 Spruce Grouse and one unidentified grouse flushed from berry patches in uplands west of Nanika Falls (1), October 1974; 1 White-tailed Ptarmigan seen just SW of Kidprice Lake (3) and 15 more seen in uplands of Tahtsa Range (6) in March 1989, 5 White-tailed Ptarmigan flushed from Sibola Peak area (7) in July 1989; single Blue Grouse seen in SW Tahtsa Range (5) and on Kidprice Mtn. (3) in July 1989.

Other Birds - In October 1974--19 Western Grebes, 12 Red-necked Grebes, and 7 Arctic Loons on Kidprice Lake (3), and numerous other birds in adjacent uplands (1,4)--Pine Siskin (abundant), Gray Jay (common), Bald Eagle (2), Clark's Nutcracker, Golden-crowned Sparrow, Savannah Sparrow, Sharp-shinned Hawk (1 each); 1 adult Bald Eagle at Stepp Lake and 1 at Kidprice Lake (3) in May 1975; unspecified number of Herring Gulls at Stepp Lake (3) and 2 Bonaparte's Gulls on a small pond in Nanika-Kidprice Flats (4) in June 1975; 1 adult Bald Eagle at Kidprice Lake (3) in mid-June 1975; many of the same species seen in July 1989--the only "new" ones being Hermit Thrush, American Robin, and Water Pipit.

* * * * *

APPENDIX 3.5-1

Placer Dome Berg Project Heritage Overview

A HERITAGE OVERVIEW AND

PRELIMINARY IMPACT ASSESSMENT OF THE BERG PROPERTY,

MOUNT NEY, WEST CENTRAL BRITISH COLUMBIA

(Heritage Conservation Act Permit 1989-66)

Prepared by:

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23 October 1989

MANAGEMENT SUMMARY

Placer Dome Inc. has conducted a preliminary enviromental evaluation of their Berg Property, a porphyry copper-molybdenum deposit, located at Mt. Ney in west central British Columbia. A heritage resource overview was prepared, and a preliminary heritage resource impact assessment carried out on July 12 1989 as part of this evaluation.

Based on a literature review, an archaeological site potential map was prepared of the study area, including the Berg Property and proposed mine access road corridors. Field survey included a helicopter flight of the proposed road corridors and ground inspections of nine locations along these corridors. Consultations were also made with several geologists who have worked on the Berg Property.

Corridor 2 and associated options have the highest potential to impact recorded and unrecorded archaeological resources. They include up to 9 km of terrain with high potential for archaeological sites, and 14 km of medium potential terrain. Corridor 1 options have a much lower potential to impact archaeological resources, with 1 km or less of high potential terrain and up to 10 km of medium potential terrain.

Subjective ranking of the corridor options indicate Corridor 1-1B-2 and 1-1C-2 which will not impact any recorded archaeological sites, have the lowest potential of all options for impacting unrecorded archaeological sites and would require the least amount of impact assessment work of all corridor options. Either of these two corridor options are recommended for any mine access road to the Berg Property.

Native Indian artifacts were surface collected from FlSu 1 situated on or near Corridor 2, and (out of situ artifact) from the location of the Berg Camp. It is believed that the latter artifact was originally collected by geologists from an area of glacial deposited boulders on the side of Mt. Ney. No archaeological concerns were identified for the Berg Property.

It is recommended that archaeological site survey be conducted of the "Berg" Creek valley, the only portion of Corridors 1-1B-2 and 1-1C-2 to contain terrain of high and medium potential for unrecorded archaeological sites. This assessment should also include further evaluation of portions of Mt. Ney adjacent to the Berg Property in an attempt to locate any possible welded tuff sources which Native Indians may have used as quarry sites. There should also be a review of evidence currently being presented in the Gitksan Wet'suwet'en land claim case.

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

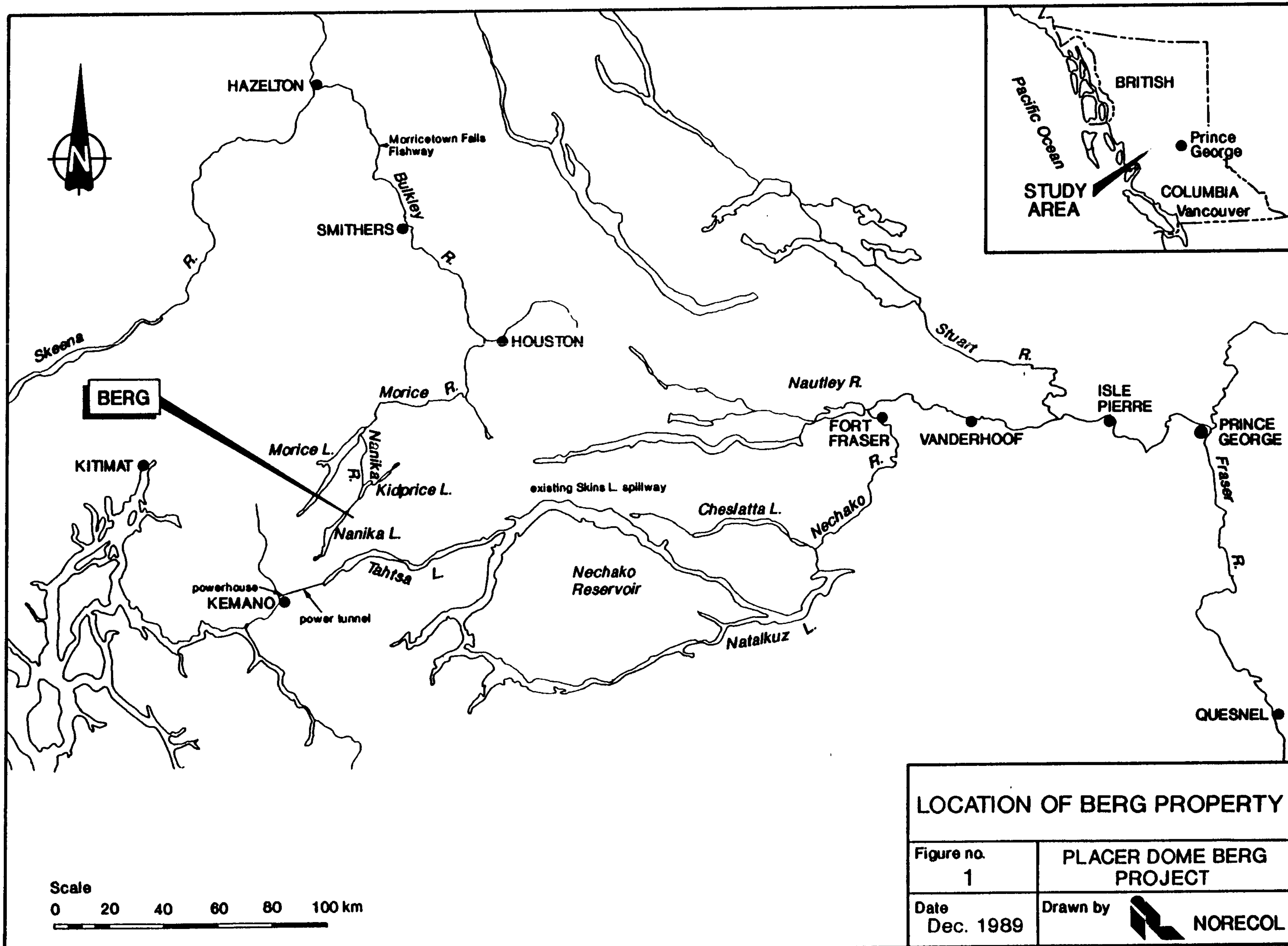
This report presents the results of a heritage resource overview and preliminary impact assessment for the Placer Dome Inc. and Kenco Exploration Ltd. Berg Property, a porphyry copper-molybdenum deposit located at Mt. Ney in west central British Columbia. The field study was conducted under Heritage Conservation Act Permit 1989-66 by Leonard C. Ham, Ph.D., on 12 July 1989.

The Berg Property is located along the eastern slope of the Coastal Mountains of British Columbia, in the Tahtsa Ranges of the Hazelton Mountains, 120 km south of Houston, and 10 km north of Tahtsa Lake (Figure 1).

The British Columbia Heritage Conservation Act defines heritage resources as property of "...historic, architectural, archaeological, palaeontological or scenic significance to the Province..." (1979 R.S., Chapter 165). The Heritage Conservation Act is administered by the Archaeology and Outdoor Recreation Branch (British Columbia Ministry of Municipal Affairs, Recreation and Culture) who have issued British Columbia Archaeological Impact Assessment Guidelines (1989) which provide procedures for heritage resource impact assessment of proposed developments.

1.1 Proposed Development

The Berg Deposit is located in a west-facing alpine cirque on the south side of Mt. Ney at an elevation of approximately 1375 m, at the head of "Berg" Creek, a tributary of Bergeland Creek which flows into Kidprice Lake.

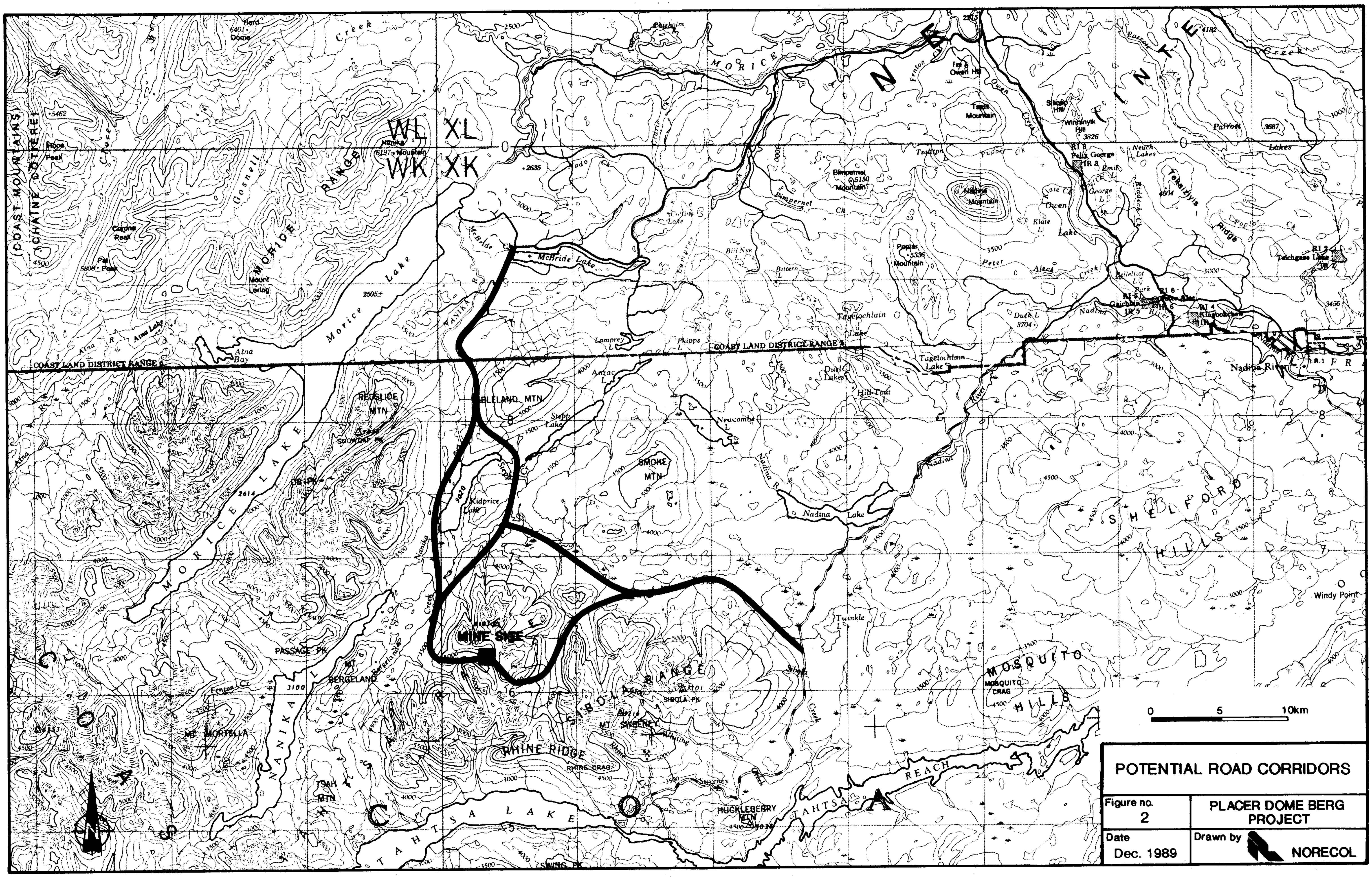


LOCATION OF BERG PROPERTY

Figure no. 1	PLACER DOME BERG PROJECT
Date Dec. 1989	Drawn by NORECOL

This study was part of a preliminary investigation to assess probable environmental study requirements should Placer Dome Inc. decide to initiate the mine development approval process for its Berg Property. During mineral explorations in the late 1970s a camp was established on the property with access via a 40 km tote road from the Owen Lake - Tahtsa Lake Road near Twinkle Lake. Both camp and tote road are now closed and access is by helicopter.

For purposes of the present study Norecol (1988) has assumed development would consist of an open pit mine with road access from forestry roads. These roads would be within corridors from either McBride Lake, or approximately along the former tote road from Twinkle Lake (Figure 2). A number of variations of the proposed route corridors are also being considered.



WL XL
WK XK
MORICE
Morice Lake
MORICE LAKE
MORICE RANGE
COAST LAND DISTRICT RANGE 5
COAST LAND DISTRICT RANGE 4
McBride Lake
Nanika R
REDSLIDE MTN
SMOKE MTN
Kidprice Lake
Nadina Lake
Nadina River
SHELFORD HILLS
Windy Point
MINE SITE
PASSAGE PK
BERGELAND
SIBOLA RANGE
SIBOLA PK
MT SWEENEY
RHINE RIDGE
RHINE CRAG
MT MORTELLA
MOSQUITO HILLS
MOSQUITO CRAG
HUCKLEBERRY MTN
TAHTSA LAKE
TAHTSA REACH
SWING PK
Twinkle
Nadina Mountain
Poplar Mountain
Tahtsa Mountain
Owen Lake
Pimpernel Mountain
0 5 10km
POTENTIAL ROAD CORRIDORS
Figure no. 2
PLACER DOME BERG PROJECT
Date Dec. 1989
Drawn by NORECOL

2.0 STUDY METHODS

A heritage resource potential map was generated to assist in the assessment of potential impacts from proposed developments. Sources for this map included environmental data and review of previous environmental and archaeological studies in the area, as well as regional ethnological and historic sources.

A three level ranking system was used to identify areas of different heritage resource potential, ranging from high to medium to low. High potential areas contain recorded archaeological sites, have been reported as locations of Native Indian activity, and/or contain terrain and ecological resources which would have made it attractive for human use. Medium potential areas are those which, although no archaeological sites have been recorded, contain suitable terrain and ecological resources which might have made it attractive for Native Indian use. Areas of low potential meet none of the above criteria, or have been found by archaeological site survey to be lacking any heritage resources.

Field investigations on July 12, 1989 included helicopter flights of proposed mine access road corridors and the Berg Deposit with limited ground survey. Examples of all types of heritage potential terrain were examined. Consultations were also made with geologists who have worked on the Berg Property and environs. No subsurface tests were made as more than adequate exposures were available at all ground locations which were examined. Some exposure faces were cleaned to facilitate examination.

3.0 STUDY AREA

3.1 The Environment

A variety of vegetation communities have been noted in the study area. The Alpine Zone, much of it consisting of boulder fields, extends down to the tree line on Mt Ney at an average elevation of 1500 m. Here it meets the Subalpine Engelmann Spruce - Subalpine Fir Zone (and along Bergeland Creek, Whitebark Pine - Fir Forest). Lower elevation areas are within the Cariboo Aspen - Lodgepole Pine - Douglas Fir Zone, except along lower elevation portions of Bergeland Creek which are in the Sub-Boreal Spruce biogeoclimatic zone (Envirocon 1981a; Krajina 1973; Norecol 1988).

A number of tree species found in the study area were of importance to Native Indians (Borden 1951; Morice 1893). These include lodgepole pine (cambium used for food), spruce (logs used for construction, pitch and bark used for canoes and covering houses), and the willow whose bark was made into twine for fish nets. Other economically important plants in the area include blueberry, twinberry, wild current, high bush cranberry, wild raspberry, and kinnikinnick.

The most common large mammal in the study area are moose which summer in the area, but winter elsewhere due to extreme snow depths (Hatler 1989). Moose are recent residents first reported in the area early this Century (Borden 1951). Other large mammals include caribou (last reported in 1976), mountain goat, grizzly bear, black bear and wolf (both seasonal), and possibly mule deer (Hatler 1989). Concentrations of grizzly bears were observed along the lower Nanika River which has salmon runs (Hatler 1989).

Large game is scarce in the winter when bears are hibernating, and moose (and possibly caribou) are at wintering grounds outside the study area. Migration routes are not known. Mountain goats winter in the study area, but Native Indian access to them at that time of year would be difficult due to heavy snow accumulations. Hatler (1989) reports accumulations of over 100 cm along both main corridor options.

Fur bearing mammals include beaver which were once widespread but are presently rare, muskrat, river otter, mink, marten, ermine, fisher, and wolverine (Hatler 1989; Norecol 1988; Envirocon 1981). Other mammals include coyote, fox, lynx, porcupine and red squirrel (Envirocon 1981; Norecol 1988).

Waterfowl are not numerous in the study area. Small numbers of loons, grebes, Canada geese, dabbling and diving ducks have been noted, primarily in the Nanika - Kidprice Lakes area (Norecol 1988). Upland game birds noted by Envirocon (1981) include white-tailed ptarmigan (mountains), willow grouse (lowland areas), spruce grouse (coniferous forests), and blue grouse (southern mountain slopes).

Fisheries resources in the study area (Nanika and Kidprice Lakes) include rainbow trout, Dolly Varden char and longnose suckers (Norecol 1988). The Nanika River is part of the Skeena River drainage and is the most important sockeye salmon stream of the Morice River system, although falls near the outlet of Kidprice Lake prevent salmon from going further upstream (Aro and Shepard 1967:276; Norecol 1988). Tahtsa Lake is part of the Fraser River system, although falls on the Nechako River prevent salmon from reaching the area (Galloway 1917:137).

3.2 Native Indian People

The study area lies within the traditional territories of the Dene or Athapaskan speaking Bulkley River Carrier, and the Cheslatta Carrier (Jenness 1943, 1972; Morice 1893, 1906, 1978). A Bulkley River clan used the Nanika-Kidprice-Stepp Lakes drainage while the Cheslatta used the Tahtsa Lake drainage, both groups hunting and fishing in their respective areas. The Bulkley River people knew the area they used as "Neneka" (Jenness 1943).

Smallpox epidemics during the 1800s (1838 and 1862 ?) decimated the Native Indian population to the south of the study area (Borden 1951; Morice 1906). The Bulkley River Carrier were spared by the onset of winter which segregrated them from infected neighbouring groups, but by the end of the 19th Century were greatly reduced in numbers and had become confined to reserves (Jenness 1972; Morice 1978). Jenness (1943) states that following the smallpox epidemics, the Bulkley River Carrier moved into Cheslatta territory south of the study area.

Carrier settlement patterns consisted of spring and summer aggregrations of people at fishing villages and late summer and autumn hunting and gathering by small groups of related families. In the winter they used small lake ice fishing camps, often consisting of single families, although Harmon estimated some 2000 Babine Carrier ice fishing on Lake Babine when he visited in 1812 (see Morice 1978).

Although fish appear to have formed the staple dietary item, hunting was also important and included caribou, deer, bear, marmots and rabbits. There was restricted hunting in the winter due to heavy snows, and travel would have been restricted to wind cleared and frozen waterways.

Several different types of roots and other plant foods including bark cambium were used in the spring. Berry harvesting was important, especially in the late summer when they were preserved for winter use.

The Carrier made use of canoes for water transportation and trails for land travel. Summer dwellings were large (6 m x 9 m) gabled communal houses of low split plank walls with spruce bark or plank roofs, while the similar winter dwelling lacked the walls, the gabled roof continuing to the ground (Jenness 1972, Morice 1893). Small bark, brush and hide covered pole/sapling frame shelters were used by family groups in the winter, often placed amongst a grove of spruce trees for additional shelter (Morice 1906). Other structures included well ventilated pole frame fishing lodges, raised caches, sweat houses and menstrual huts. Underground caches and cooking ovens were also used (Borden 1951).

In 1951 Wilson Duff (while with Borden in Tweedsmuir Park) was able to obtain some information on the Cheslatta use of Tahtsa Lake immediately south of the study area (Borden 1952). In historic times annual hunting trips were made from villages at the eastern end of Cheslatta Lake some 160 km away. The head of Tahtsa Lake was also the start of a 'grease trail' to the coast where during the historic period furs were traded for eulachon oil and European trade goods with the Haisla, the northernmost Kwakiult. It is likely this trade route was in use before European contact (Borden 1952). These trading trips would have been made in early summer after the snow was gone from the mountain passes.

Borden (1952) speculates there were contacts between the Cheslatta and other groups including the Bulkley River Carrier, but offers no suggestions about other trails which may have facilitated this interaction. This area was not explored in any detail by Europeans until around the turn of the

Century, and as prospectors and geologists were among the first, it is probable that most of the routes they followed were Native Indian trails.

On a sketch map attached to a report by J.D. Galloway (Ministry of Mines 1917), two trails are indicated in use by mineral exploration in the Tahtsa and Sibola Ranges. These include the White River Trail from Owen Lake via the Nadina River valley, and the Bonthrone Trail from Ootsa Lake which was probably part of the Tahtsa Lake/Kemano River Trail to the coast. These trails correspond to the approximate locations of the Native Indian trails mentioned above and reported by MacDonald (1984). The present Tahtsa Lake Road follows approximately this same route as the White River Trail.

Another trail route to the north, the Morice River Trail to McBride and Morice Lakes, is described by D. Lay who used it in 1928 (Ministry of Mines 1929; see also MacDonald 1984). This trail ascended the Morice River valley from Houston on the Bulkley River as far as Lamprey Creek which it crossed and followed to its headwaters, and then west along the north shore of McBride Lake to the north end of Morice Lake (Ministry of Mines 1929). The present Morice River Forest Development Road follows approximately this same route. At the southwestern end of Morice Lake this trail followed a pass to a branch of the Kemano River and the coast (MacDonald 1984).

Another trail followed up the Nanika River to Kidprice Lake, and east and north via Stepp Lake to Lamprey Creek and has been reported as a Native Indian trapping trail (Envirocon 1981b). It was also probably used prior to European contact, given that there are two recorded archaeological sites situated along its route.

At the present time there is no documentary evidence for a Native Indian trail from Kidprice Lake (via Nanika Lake/Bergeland Creek) to Tahtsa Lake through the pass immediately north of Tsah Mountain. This is, however, a logical route for a trail to follow from Morice Lake to Tahtsa Lake. A recreational canoe and portage route exists from Kidprice Lake to Nanika Lake, and along Cabin Creek to Morice Lake (Envirocon 1981b). There is no evidence this was a Native Indian trail route, but it may have been.

3.3 Historic Settlement

Although Alexander Mackenzie passed through the Blackwater River drainage to the south of the study area in 1793 (Robertson 1906), over 100 years passed before any permanence of European settlement was obvious in the region surrounding the study area.

In 1806 the Nechako Plateau to the east of the study area was visited by Simon Fraser and John Stuart of the North West Company who established trading posts at Fort St. James on Stuart Lake and Fort Fraser on Fraser Lake (Morice 1978). In the winter of 1812, D.W. Harmon visited Babine Lake northeast of the study area where in 1822 the Hudson's Bay Company established Fort Kilmars (Morice 1978).

While the early fur trading posts were established to intercept some of the trade which flowed to the coast along the Skeena River, Fort Kilmars was built primarily to obtain salmon to supply other posts in New Caledonia (Morice 1978). In 1836 Fort Babine was constructed at the north end of Babine Lake and in 1845 Fort Kilmars was abandoned.

In 1866 the Collins Overland Telegraph was constructed through the Bulkley River valley and when the project was halted, many of the workmen turned their attention to rumours of gold, precipitating the 1870 Omineca goldrush (Morice 1978; McHarg and Cassidy 1980; McDonald _et al_. 1974). By 1873 the fever was gone from the goldrush, and fur traders dominated the area for most of the remainder of the century. It was not until the early 1900s when government assistance in upgrading trails into wagon roads and the building of the railroad along the abandoned telegraph line opened up the Bulkley River valley to settlement (McDonald _et al_. 1974; McHarg and Cassidy 1980).

In the early days Hazelton was the only European settlement in the upper Skeena - Bulkley River valleys, one Thomas Hankin, after exploring the area for the HBCo. between 1866 and 1868 settled at what became the townsite (McDonald _et al_. 1974). He was soon joined by workers from the Collins Telegraph who had turned to prospecting. The first homesteaders trickled into the area in the late 1800s, with the first settlers at Burns Lake in 1904, and Telkwa and Smithers becoming established after the 1906/07 arrival of railway construction crews (McDonald _et al_., 1974).

In 1876 geologist George Dawson surveyed the area south of Francois Lake, and in 1879 the Bulkley River valley in conjunction with preliminary surveys for a railway route to the coast (Dawson 1877, 1879). In 1916 British Columbia Assistant Mineralogist John Galloway traversed and reported upon the White River Trail from Owen Lake to Sweeney Mountain (Galloway 1917).

Not only is the use of the study area by Native Indian People documented by the name of a lake, so too is early European use. In 1914 a man by the name of "Kid" Price initiated a small gold rush with his finds on Sibola Creek (Ministry of Mines 1917). Several properties have subsequently been worked on in the area and the Emerald Property on Mount Sweeney explored between 1927 and 1931 went into production in 1951

(Ministry of Mines 1951). The largest modern development in the study area was the creation of the Nechako Reservoir by Alcan in the early 1950s (Borden 1951).

3.4 Previous Archaeological Studies

The earliest archaeological research in west central British Columbia were Borden's 1950 excavations at Chinlac Village near the confluence of the Stuart and Nechako Rivers (Borden 1953). Closer to the study area was the first archaeological impact assessment in British Columbia, the 1951 survey of the upper Nechako River drainage prior to flooding of Tweedsmuir Park (Borden 1951, 1952, 1953). Borden recorded 130 sites and noted that archaeological site density was lowest in western parts of the region near the Coast Mountains with most major settlements located in the east.

Borden (1953) summarized the nature of archaeological site distribution in the area as follows:

> Most of the sites along the lakes and rivers of Tweedsmuir Park are hunting, fishing, berry-picking, and cambium-gathering camps without indications of permanent habitations. Sites are often located at the head or outlet of lakes, near marshes or game crossings, in sheltered bays or coves with sandy beaches, near headlands affording a sweeping view of the lake. Most sites are found on the north shore of the lakes, indicating that southern exposure was a desirable feature.

Unfortunately, the shoreline of Tahtsa Lake had already been flooded before Borden conducted his survey.

No further archaeological research was conducted near the study area until the 1970s. Between 1974 and 1976 the British Columbia Heritage Conservation Branch conducted a number of surveys in the region (see Burley 1975; Mohs 1974, 1975; Mohs and Mohs 1976; Rafferty 1975). Nearest the study area was the survey of Morice and McBride Lakes conducted by Burley (1975) who recorded 26 archaeological sites, the majority being food caches and food processing pits. Burley has postulated that the sites he found along Morice and McBride Lakes were "...part of the areas's Athapaskan settlement strategy" (1975).

The vast majority of the cache pit sites are generally within 100 m of the lake shore and either on gravel bars or hillsides overlooking a lake or river. As well as good drainage, exposed locations would be windy which may have served to deter scavengers from picking up any smell of the cache. Some of the larger pit features Burley found may have been used for processing of berries. Lithic scatter sites, possibly the remains of old camps were also noted at the western end of McBride Lake.

Closer to the study area, and overlapping part of it, were the archaeological studies conducted by Aresco Ltd. for Envirocon Limited (1981, 1982) which included the Nanika - Kidprice - Stepp Lakes valleys. Sites recorded include lithic scatters representing the remains of hunting and fishing camps. A single pit feature was also observed on Stepp Creek but was not recorded.

At present there has not been sufficient archaeological research to compile a culture history for the region under consideration. As Native Indian presence has been documented for most of the last 9000 years for sites in surrounding parts of British Columbia, it is reasonable to assume the study area has the same potential. Archaeological knowledge of northern British Columbia relevant to the study area may be found summarized in several sources (Carlson 1983; Clark 1981; Fladmark 1982; MacDonald and Inglis 1981).

Recorded archaeological sites located in the vicinity of mine access road corridors under consideration are tabulated in Table 1.

Table 1

Recorded Archaeological Sites In Study Area

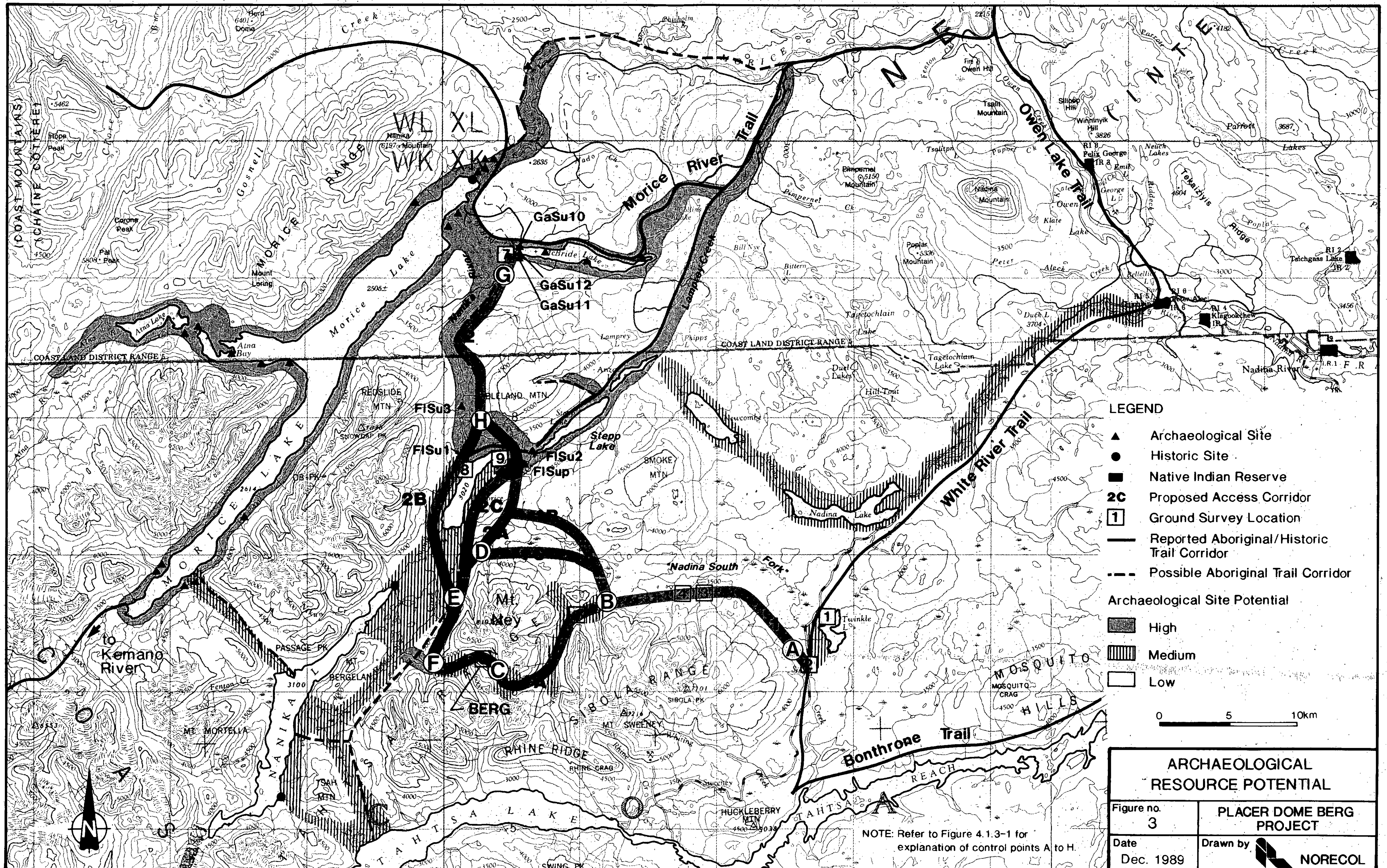
site #	location	type	possible use
GaSu 10	McBride L.	lithic scatter	summer fishing camp
GaSu 11	McBride L.	pit feature	food processing/storage
GaSu 12	McBride L.	lithic scatter	summer fishing camp
FlSu 1	Kidprice L.	lithic scatter	summer fishing camp, or autumn hunting camp
FlSu 2	Stepp L.	lithic scatter	summer fishing camp, or autumn hunting camp
FlSu 3	Nanika R.	lithic scatter	salmon fishing camp
FlSu p	Stepp C.	pit feature	food processing/storage

4.0 ARCHAEOLOGICAL SITE POTENTIAL

Based upon the data sources reviewed above, an archaeological resource potential map has been prepared for the study area (see Figure 3). Although Borden's (1951, 1952) research south of the study area suggested low site densities and limited Native Indian use of the western slopes of the Coastal Mountains, subsequent studies west of the study area indicate it was an area of relatively intense use (Burley 1974; Envirocon 1981a, 1982). This area was in fact a named hunting territory of a clan of Bulkley River Carrier (Jenness 1943), and it would appear that recent archaeological studies have located a number of their settlements.

Contrary to Morice (1978), fish would have been the staple food of the Athapaskan people of the Skeena - Bulkley River drainages. Large game animals are simply not available in sufficient quantities to provide the most important source of food for any Athapaskan group from the southern Yukon to the Chilcotin of British Columbia. Even in areas where they are relatively plentiful, large game animals do not represent a stable and dependable resource. The uncertainty surrounding timing, location and density of caribou migrations have been pointed out by Burch (1972) as severely limiting the number of animals one might hope to obtain. The present apparent decline in study area caribou populations may be just such an example of natural fluctuations in local herd size, distribution and behaviour. Other large mammals will follow their own distinct patterns of population fluctuation. A salmon run failure on the lower Nanika River would deny hunters the opportunity to obtain grizzly bear, for example.

Morice (1893) has described the settlement pattern of the Carrier as consisting of large aggregations of people from May through September at salmon fishing sites. These groups segregrated into smaller bands during


LEGEND
Archaeological Site
Historic Site
Native Indian Reserve
2C Proposed Access Corridor
1 Ground Survey Location
Reported Aboriginal/Historic Trail Corridor
Possible Aboriginal Trail Corridor
Archaeological Site Potential
High
Medium
Low
0 5 10km
ARCHAEOLOGICAL RESOURCE POTENTIAL
Figure no. 3
PLACER DOME BERG PROJECT
Date Dec. 1989
Drawn by NORECOL
NOTE: Refer to Figure 4.1.3-1 for explanation of control points A to H.
Owen Lake Trail
White River Trail
Bonthrone Trail
Morice River Trail
to Kemano River
Morice Lake
Nadina Lake
Tahtsa Lake
Tahtsa Reach
GaSu10
GaSu11
GaSu12
FlSu1
FlSu2
FlSu3
FlSup
BERG
Mt. Ney
Nadina South Fork
COAST LAND DISTRICT RANGE 5
Mosquito Hills
Sibola Range
Rhine Ridge
Nanika
Stepp Lake
Twinkle

the winter. However, access to salmon would not have been equal to all Bulkley River Carrier, especially those in upper portions of the drainage who would have spent considerably more time freshwater fishing. Without sufficient supplies of salmon to last through the winter, these people would have segregrated into even smaller groups. Much of their seasonal settlement pattern would have been similar to that of more northern groups.

Northern Athapaskan groups forage through their territory, filling a cache at a fish camp before moving onto another camp and repeating the process (see McClellan 1975). In the winter young men either haul out stored supplies, or one or more families will visit the cache and live off its provisions while trapping, hunting and ice fishing near by. As fresh provisions became more difficult to obtain and the cache emptied, the group would move on to the next cache. The archaeological record of Morice Lake suggests a similar pattern.

Two criteria of value in predicting site location in the Stikine River drainage include caribou migration routes (especially river crossings), and historic and aboriginal trail systems (Friesen 1983, 1985). As caribou may once have been more common the implications to humans of their presence should be considered for the study area as well. Goat migration routes could also be indicators of site locations.

Portions of the Tahtsa and Sibola Ranges, and Tableland Mountain (Hatler 1989) (and possibly Smoke Mountain) contain both caribou and goat habitat, and there would be seasonal migrations between these areas. Two sites recorded by Aresco Ltd. (Envirocon 1981a, 1982) may be situated to take advantage of game movements. These include FlSu 1 at the outlet of Kidprice Lake, and FlSu 2 at the western end of Stepp Lake. Both are located along potential game routes between the habitats noted above.

It is not known how much further up the Nanika River valley late period Carrier settlements extended. It is possible, however, to suggest several high and medium potential areas for archaeological sites. Lower "Berg" Creek valley is considered as a high potential area for the location of an autumn hunting camp given just such a site was recorded at Metsantan in the Toodoggone in a similar environmental setting (see Ham 1987). It is possible that the "Rhine" Creek valley between Mt. Ney and Mt. Sweeney may have also been used. The alpine pass between "Berg" and Ney Creeks would at certain times be an opportune location to obtain game and was no doubt used at some time in the past. These latter two localities have been assigned a medium site potential.

A number of trail systems have been documented for the study area. They are most common to the west and north of the study area, reflecting late period Native Indian use of that area. There were probably trails up both sides of the upper Morice River and the lower Nanika River. These drainages contain recorded archaeological sites as well as documented trails. A 2 km zone either side of these rivers have been assigned a high potential.

In addition, the creek drainages along the eastern bank of the lower Nanika River may have been used to gain access to Tableland Mountain, and the remains of hunting camps may be located on the lower (southwestern) slope of the mountain. Thus this area has been assigned a high potential for archaeological sites.

There may also have been a trail from the north end of Kidprice Lake south to Bergeland Creek and up the "Berg" Creek valley through the pass to

Ney Creek. Originally, the White River Trail may have followed the Nadina River to Newcombe Lake and on to join the Stepp Lake Trail, rather than continuing on to Tahtsa Lake. Portions of such routes have been assigned a medium potential for containing unrecorded archaeological resources.

There is no evidence at the present time to document the time depth of Native Indian use of the study area earlier than the late period. Archaeological sites are in general small and shallow and even with environmental change, it is unlikely this characteristic has varied much over the last 7000 to 8000 years. As most known sites are located near waterways which occasionally dramatically alter their valley bottoms, sites may have a short lifespan. This would seem particularly true of lakeshore sites.

The possible recent demise of both beaver and caribou in the study area may suggest some climatic change, but at the present there is no evidence with which to map out the environmental history of the area. It is not unreasonable, however, to propose that at some periods in the past it may have been drier and vegetation may have been different. Archaeological sites associated with Native Indian use of the area during such times have not been been found, and thus there is scant information to use in suggesting where early sites may be located. Evidence from other parts of northern British Columbia suggest the use of high elevation areas were more frequent between 8000 and 3000 years ago (Fladmark 1982).

5.0 STUDY RESULTS

Archaeological survey of the study area was conducted on the 12 July 1989 which included a helicopter flight of proposed road corridors. This provided the opportunity to investigate examples of all three types of archaeological site potential terrain. Proposed access road corridors were flown at least twice and nine locations were inspected on the ground. At all areas subject to ground survey, extensive exposures were available for examination, and therefore excavation of subsurface tests were not required.

General comments about the proposed access corridors and ground inspections are presented below (see Figure 3). Cultural materials were collected during this study from one previously recorded site, and in addition, out of situ material was collected from the former mine camp. A photographic record is appended to this report (Section 10.0).

5.1 Corridor 1.

Twinkle Lake

The area around the Twinkle Lake (Slide 1) campground and nearby portions of the shore were briefly surveyed on foot. Numerous exposures, barren patches and a gravel beach provided adequate locations for observation allowing coverage of most of the area. Although no archaeological evidence of Native Indian use of the area was observed, this area is still considered to have a medium potential for sites.

Tahtsa Lake Road

The intersection of the abandoned tote road to the Berg Property and the Tahtsa Lake Road was inspected on the ground (Figure 3, location 2). Extensive exposures were available for examination (see Slide 2) including several areas which had been grubbed for gravel procurement. Approximately 200 m were walked along the Tahtsa Lake Road in both directions examining both sides of the road. No archaeological evidence of Native Indian use was observed. Both this intersection, and the proposed new intersection are well removed from Twinkle Lake and any streams and should be downgraded to a low heritage potential.

"Nadina River South Fork" Valley

The proposed road corridor approximates the route of the abandoned tote road through the pine forest valley of the "Nadina River South Fork" (Slide 3). There are numerous areas of small swamps or overgrown ponds surrounded by spruce (see Slide 1).

Two areas along this portion of the corridor were examined on the ground (see Figure 3, locations 3 and 4). Both locations were Norecol water quality sampling stations on streams flowing from the northern slopes of the Sibola Range. Riverbank exposures and disturbances associated with the abandoned tote road were examined. No archaeological evidence of Native Indian use of these locations was noted. The low site potential of these locations is felt to be valid.

"Rhineland" Creek Valley

The lower portion of "Rhineland" Creek was assigned a medium potential for archaeological sites due to the possiblility the area might have supported an autumn hunting camp. Ground observations were made at the "Rhineland Hotel", a former rest stop/road maintenance depot along the abandoned tote road (Figure 3, location 5, see also Slides 5 and 6). A recent log cabin was in use as recently as 1988 and associated with it are a latrine and garbage pit. The collapsed log cabin (4 m N/S x 5 m E/W) at this location has large spikes and thus is not very old.

There were extensive grubbed and exposed areas, both around the cabins and along the abandoned tote road which were examined (see Slide 6). The tote road cut through an upper river terrace was also examined. No archaeological evidence of Native Indian use was observed, nor was any evidence found to support the inference this area has a medium site potential. Any hunting camp location might be further up the valley.

Ney Creek Valley

The Ney Creek portion of the proposed route was assigned a medium archaeological site potential because of the possible location of an autumn hunting camp in the upper valley (Slides 7 to 9). No suitable locations were observed for such a site during aerial passes, and thus no ground inspections were made. Portions of this valley, especially in the vicinity of the confluences of the various upper forks of Ney Creek, should be examined in more detail if this corridor is selected.

Ney Creek/"Berg" Creek Pass

This portion of the proposed corridor was assigned a medium potential for archaeological sites due to possible presence of ambush and kill sites. No opportunity was available to ground survey the pass (Slides 10 and 10a) and although no clear sign of any game trail was observed, it should be carefully inspected should this corridor be selected.

Berg Property

The Berg Property was assigned a low potential for unrecorded archaeological sites due to its rugged terrain (Figure 3, location 6; Slide 11, 27 and 28). A portion of the abandoned exploration camp was ground surveyed.

While no in situ cultural remains were found, some welded tuff flake shatter and a large tuff bifacial thinning or reduction flake was found. These materials were scattered in front of a cabin littered with a variety of other rock samples leading to the conclusion the cabin had been used by a project geologist. Contact was made with several geologists who have worked on the Berg Property. Mr. David Heberline (1989) carried out rock sampling in the area in the early 1980s and used a cabin in the area where the flakes were noted. He suggests that it was unlikely they were found on the Berg Property, but were more likely from areas of glacial deposited boulders on Mt. Ney. Any future archaeological studies should attempt to locate this welded tuff source.

The surface collected flake (FkSu y:1) is illustrated in Figure 4. The dimensions of the artifact are 6.82 cm x 4.21 cm x 0.69 cm and it weighs 13.8 g.

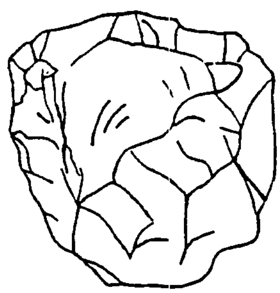
5.1.1 Corridor 1B and 1C.

Variations of Corridor 1 follow around the north face of Mt. Ney to approach the Berg Property from "Berg" Creek (Slide 12). Corridor 1B follows the Ney Creek valley to Corridor 2, while Corridor 1C remains along the north side of Mt. Ney and is joined by Corridor 2 further south.

With one exception, all of proposed Corridors 1B and 1C are located in terrain assigned a low potential for archaeological sites. The exception is the pass to the Berg Property through upper "Berg" Creek which could have been a good location to ambush game. No evidence of a game trail was observed in the area, but as an autumn hunting camp could be located below the pass, it should retain its medium potential.

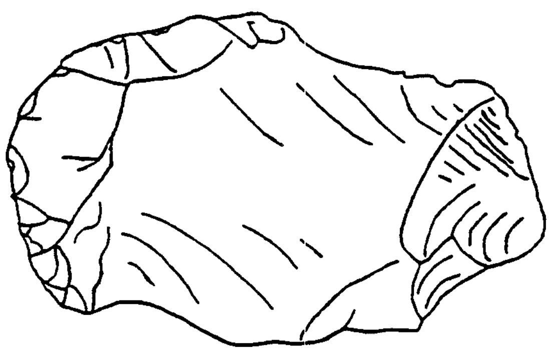
FlSu 1:1

leaf shaped chipped basalt biface



FlSu 1:2

thumbnail chipped basalt scraper



FkSu y:1

welded tuff bifacial thinning flake

scale: all are actual size

Figure 4   Surface Collected Artifacts

5.2 Corridor 2

McBride Lake to Tableland Mountain

Corridor 2 approaches the Berg Property from the north from existing logging roads on the western side of Tableland Mountain (see Slides 12, 13 and 14). A 200 m stretch of the forest road at McBride Lake was walked on foot as there are three recorded sites nearby on McBride Lake (Figure 3, location 7; Slides 16 and 17) . No archaeological remains were observed in the ditches and road cuts.

As it would not be necessary to upgrade this piece of road to accomodate mine traffic, no impacts are anticipated to nearby sites. The road would presumably follow the existing logging road to Tableland Mountain (Slide 18), and it would pass through terrain of low potential for archaeological sites.

However, any portions of the road which should approach the Nanika River would require additional investigation. At present, there are two recorded archaeological sites along this river, and a reported old Native Indian trapping trail which may have existed along both banks of the river.

Tableland Mountain to Kidprice Lake

Corridor 2 from Tableland Mountain along the north shore of Kidprice Lake to Stepp Creek has been asigned a high potential for archaeological sites. This rating was based upon the presence of a site at the outlet to Kidprice Lake, another on Stepp Creek, reports of an old trapping trail, and possible hunting camps on the south slopes of Tableland Mountain. Ground survey at the mouth of Stepp Creek found no evidence of archaeological sites (Figure 3, location 9).

No suitable site locations were observed from the air (Slide 19a), nor was the location of the pit feature reported (but not recorded) by Aresco Ltd. found (Envirocon 1981a). Previous archaeological research has established that cache pits without associated cultural materials are part of the archaeological record of the area. Further fieldwork will be necessary to locate the feature if Corridor 2 is selected as it would cross Stepp Creek (Slide 19) near the suspected location of this site.

Stepp Creek to "Berg" Creek

This portion of Corridor 2 passes through terrain which has been assigned a low potential for archaeological sites, with the exception of the upper approaches of "Berg" Creek near the Berg Property which is shared with Corridors 1B and 1C (see Slides 21 through 26). It is possible that a Native Indian trail may have followed the Bergeland Creek valley to access game using the alpine portions of Mt. Ney, perhaps from an autumn hunting camp in the lower "Berg" Creek valley.

If the "Berg" Creek valley is selected as the route for the proposed road, the area should receive more in depth archaeological survey.

5.2.1 Corridor 2B

This corridor option crosses the Nanika River near the outlet of Kidprice Lake and passing down the west side of the lake, crosses Bergeland Creek to join the main corridor on the western side of Mt. Ney.

An archaeological site (FlSu 1) has been recorded at the outlet of Kidprice Lake (see Figure 3, location 8), and two artifacts were surface collected from beach gravels at the site. They include a leaf shaped basalt biface and a basalt hide scraper are illustrated in Figure 4. Artifact measurements are presented in Table 2.

The corridor crossing of the Nanika River has been assigned a high potential for archaeological sites due to the presence of a recorded site. The balance of Corridor route 2B has been assigned a medium potential due to the possibility of a former trail route down the western side of Kidprice Lake and through Bergeland Creek valley, and because of the suspected use of Bergeland Creek valley for hunting.

Additional archaeological field survey should be conducted if this route is selected.

5.2.2 <u>Corridor 2C</u>

This proposed corridor would pass down the eastern shore of Kidprice Lake (Slide 20), and rejoins Corridors 2, 1B and 1C along the western side of Mt. Ney.

The Stepp Creek portion of the route was assigned a high potential, while the remainder of the route was assigned a medium potential due to the possibility of a trail along the eastern side of Kidprice Lake, and the possible use of the Bergeland Creek valley for hunting. Additional archaeological survey should be conducted of the northern and southern portions of this corridor, should it be selected.

Table 2

Metric Attributes of Artifacts From FlSu 1

artifact #	class	length	width	thickness	weight
FlSu 1:1	biface knife	4.06	1.98	0.69 cm	5.1 g
FlSu 1:2	scraper	3.53	3.32	1.06 cm	15.3 g

6.0 RESOURCE IMPACTS

Only two potential direct impacts to archaeological resources were identified during this study. These are potential conflicts with FlSu 1 and FlSu p, both located along Corridor 2 (see Table 3).

FlSu 1 is a lithic scatter/general activity site possibly used as a hunting camp during game migrations. Only flake scatters had been reported at this site prior to the present study which recovered two artifacts. Additional artifacts may be present along the upper shoreline.

Although the single cache pit feature located on Stepp Creek was not recorded as an archaeological site (Envirocon 1981a), it is clear from proposed models of Athapaskan adaptation to the study area, and from Athapaskan adaptation in similar environments elsewhere, that it is part of the archaeological record of the study area. The precise location of this feature is not currently known, but may be within or near the proposed corridor.

Corridor 2 (and associated options) has the greatest potential to impact recorded archaeological sites, even though it may be possible to avoid direct impacts with minor route realignments. Corridor 1 will not impact any recorded archaeological sites.

To assess the overall potential of corridor options to impact unrecorded archaeological resources, a subjective ranking was applied to each corridor option. To arrive at this rank, each km of high potential was assigned a value of 2, and each km of medium potential a value of 1 (see Table 4).

Table 3

Impacts To Recorded Archaeological Resource Base

site #	route	distance	nature of impact
GaSu 10	2	100 m	indirect
GaSu 11	2	100 m	indirect
GaSu 12	2	75 m	indirect
FlSu 1	2	50-100 m	could be direct
FlSu 2	2	5 km	indirect
FlSu 3	2	5 km	indirect
FlSu p	2	within corridor ?	possibly direct ?

The Corridor 2 options have a high rank or potential to impact unrecorded archaeological sites with rankings ranging between 21 and 30. These corridor options contain between 8 km and 9 km of high potential terrain, and between 3 km and 14 km of medium potential terrain. Nearly the entire corridor is within 1 km of high and medium potential terrain.

The Corridor 1 options have much lower rankings ranging between 5 and 10 (see Table 4). Corridors 1-1C-2 and 1-1B-2 each have 1 km or less of high potential terrain, and 3 km of medium terrain. Corridor 1-1A has no high potential terrain and 10 km of medium terrain. Although this analysis is subjective, it does indicate the Corridor 1 options, in particular Corridors 1-1C-2 and 1-1B-2, have the least potential to impact unrecorded archaeological resources.

Further archaeological study of the proposed corridors may find additional impacts in high and medium potential areas. The most critical areas of concern are;

1) Lower Ney Creek/"Rhine" Creek valley (Corridor 1)
2) Ney Creek/"Berg" Creek pass (Corridor 1)
3) Tableland Mountain to Stepp Creek (Corridor 2)
4) Nanika River crossing (Corridor 2B)
5) Bergeland Creek valley (Corridor 2B and 2C)
6) Lower "Berg" Creek (Corridor 1B and 1C, and 2)

No potential impacts to archaeological resources were noted on the Berg Property.

Table 4

Archaeological Potential Ranking of Proposed Corridors

Corridor	archaeological site potential		Corridor ranking
	high	medium	
1-1A	0 km	10.0 km	10
1-1C-2	1.0 km	3.0 km	5
1-1B-2	1.0 km	3.0 km	5
2-2A	9.0 km	3.0 km	21
2-2B	8.0 km	14.0 km	30
2-2C	8.0 km	9.0 km	25

subjective rankings: high = 2
medium = 1

corridor ranking = (km high potential x 2) + (km medium potential x 1)

7.0 RESOURCE ASSESSMENT

The conclusion of Borden's (1951, 1952, 1953) survey of the Nechako River basin led him to conclude that archaeological sites were scarce and thus Native Indian use of the eastern slopes of the Coast Mountains was sporadic and limited. More recent investigations (Burley 1975; Envirocon 1981, 1982) have recorded a number of archaeological sites on Morice Lake and the Nanika River system, which indicates Borden's interpretation may not apply to the study area under consideration here.

At the time of Borden's study, Tahtsa Lake had already been submerged and along with it any traces of Native Indian trails and sites. It is proposed that both Morice Lake (Burley 1975) and Babine Lake (Mohs and Mohs 1976) may be suitable analogues for what may have been the archaeological record of Tahtsa Lake. Kidprice and Nanika Lakes are oligotrophic (low in nutrients and biological productivity - see Norecol 1988) as may be many of the other smaller lakes in the region, while the archaeological record seems to indicate that the larger lakes, at least in the past, supported large fish populations.

Thus the range of sites reported from the upper Morice River system may be an anomaly and of scientific significance in that the nature of overall Native Indian use of the area is poorly understood. The settlement pattern of the area may more closely resemble those found in more northern settings, than the pattern outlined in the ethnographic literature for central British Columbia.

The widespread distribution of cache pits indicate the area was used more than once during the year. In addition, two sites (FlSu 1 and 2) may be hunting camps situated on caribou or goat migration routes.

There is presently insufficient information to accurately model Native Indian use of the upper Morice River system. However, as no evidence of bark stripped pine trees have been reported, the area may not have been used in the spring. Cache pits along Morice and McBride Lakes (and Stepp Creek) suggest summer fishing with the preserved fish being cached for later use. Possibly these stores were retrieved in the autumn during the hunting season, or alternatively, used during the winter while ice fishing.

In the majority of cases, artifact recovery from these sites has been very low. This is not surprising for if the area was used during the late summer and autumn, and while a shelter for sleeping may have been erected in the edge of the forest back from the lake, most activities would have taken place along the lake shore. This area would be subject to higher water levels later in the autumn as well as in the spring which would remove most archaeological evidence. Any cultural materials observed along lake shores in the area should be surface collected as it will probably not be possible to find them the following year.

Burley (1975) surmised that the archaeological record of the Morice Lake - McBride Lake area represented the remains of Athapaskan adaptation to the area. Combined with the results of subsequent studies (Envirocon 1981, 1982), it may represent the most complete archaeological record we currently have of Athapaskan use of the eastern slopes of the Coastal Mountains of British Columbia. The possible nature of the settlement pattern responsible for this archaeological record appears markedly similiar to that much further north (see McClellan 1975), and thus Burley's inference may indeed be correct. It may also be noted that MacNeish (1964:330) has remarked upon the similarity of the assemblages from Chinlac village to Bennett Lake and Taye Lake materials from the southwestern

Yukon. The archaeological record of the study area and environs may be important in understanding Athapaskan adaptations throughout the Coastal Mountains of British Columbia.

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APPENDIX 5.1.1-1

Placer Dome Berg Project Humidity Cell Results

APPENDIX 5.1.1-1

TABLE 1

PLACER DOME PROJECT
BERG HUMIDITY CELLS - CELL 01
HAZELTON VOLCANICS

Sample: 29-260
Surface Area: 10.95 m^2/kg
Weight: 200 g
Leach 250 ml

DATE	TIME week	H^+ pH	Eh mV	CONDUCT umho/cm	ALKALIN. pH 4.5 $mgCaCO_3/l$	ACID. pH 8.3 $mgCaCO_3/l$	SULFATE mg/l	SULFATE mg/m^2	Ca mg/l	Mg mg/l	Fe mg/l
80889	1	7.3	2060	500	15	3	1495.0	682.6	680.0	6.2	0.1
150889	2	6.9	1623		14	1	1290.0	589.0	650.0	2.5	0.1
220889	3	7.3	1320	482	13	2	900.0	411.0	350.0		0.1
290889	4	7.2	1119	543	16	2	700.0	319.6	297.0		0.1
50989	5	7.3		1000		2	530.0	242.0	250.0		0.1
120989	6	7.3		807		1	470.0	214.6	177.0		0.1
190989	7	7.2		756		2	395.0	180.4	172.0		0.1
260989	8	7.0		595		4	370.0	168.9	158.0		0.1
31089	9	7.0		658		4	325.0	148.4	153.0		0.1
101089	10	6.8		638		4	325.0	148.4			
171089	11	6.9		315		5	315.0	143.8			
241089	12	7.0		400		7	400.0	182.6			

APPENDIX 5.1.1-1

TABLE 2

PLACER DOME BERG PROJECT
HUMIDITY CELLS - CELL 02
QUARTZ DIORITE

Sample: 93-208
Surface Area: 11.34 m^2/kg
Weight: 200 g
Leach 250 ml

DATE	TIME week	H^+ pH	Eh mV	CONDUCT umho/cm	ALKALIN. pH 4.5 $mgCaCO_3$/l	ACID. pH 8.3 $mgCaCO_3$/l	SULFATE mg/l	SULFATE mg/m^2	Ca mg/l	Mg mg/l	Fe mg/l
80889	1	4.8	372	215	1	35	89.0	39.2	7.4	1.3	10.5
150889	2	5.2		91	2	16	41.0	18.1	5.1	0.7	2.8
220889	3	5.9	470	52	2	5	15.0	6.6	1.5		0.1
290889	4	5.6	538	49	2	7	16.0	7.1	1.5		0.1
50989	5	5.5		35		5	12.0	5.3	1.3		0.1
120989	6	5.5		31		5	11.0	4.9	1.1		0.1
190989	7	5.4		30		6	10.0	4.4	1.1		0.1
260989	8	5.4		32		6	12.0	5.3	1.4		0.1
31089	9	5.4		39		9	12.0	5.3	1.3		0.1
101089	10	5.4		71		9	12.0	5.3			
171089	11	5.5		34		10	14.0	6.2			
241089	12	5.4		41		8	15.0	6.6			

APPENDIX 5.1.1-1

TABLE 3

PLACER DOME BERG PROJECT
HUMIDITY CELLS - CELL 03
HAZELTON VOLCANICS

Sample: 77-311
Surface Area: 11.34 m^2/kg
Weight: 200 g
Leach 250 ml

DATE	TIME week	H^+ pH	Eh mV	CONDUCT umho/cm	ALKALIN. pH 4.5 $mgCaCO_3/l$	ACID. pH 8.3 $mgCaCO_3/l$	SULFATE mg/l	SULFATE mg/m^2	Ca mg/l	Mg mg/l	Fe mg/l
80889	1	7.5	872	405	18	2	460.0	202.8	205.0	6.0	0.1
150889	2	7.0	466		19	1	295.0	130.1	75.0	4.0	0.1
220889	3	7.2	466	458	18	7	231.0	101.9	80.0		0.1
290889	4	7.1	358	513	19	1	192.0	84.7	69.0		0.1
50989	5	7.5		352		1	152.0	67.0	61.0		0.1
120989	6	7.5		255		1	110.0	48.5	44.0		0.1
190989	7	7.5		240		1	100.0	44.1	43.0		0.1
260989	8	7.1		191		2	86.0	37.9	38.0		0.1
31089	9	7.2		172		3	60.0	26.5	29.0		0.1
101089	10	7.3		154		4	57.0	25.1			
171089	11	7.1		128		5	44.0	19.4			
241089	12	7.2		112		3	45.0	19.8			

APPENDIX 5.1.1-2

Control of Acid Mine Drainage

1.0 CONTROL OF ACID MINE DRAINAGE

The control of AMD includes both prevention and abatement techniques. Prevention refers to measures designed before mining starts and with the knowledge of the acid generation potential of the waste. Abatement refers to measures implemented either at facilities where AMD is occurring and was not anticipated, or at facilities where control measures are not sufficiently effective.

The objective of AMD control is to achieve the necessary control to satisfy environmental criteria using the most cost effective technique. There are at present three generally accepted stages in AMD control, as follows:

1) Control of the acid generation process
2) Control of acid mine drainage migration
3) Collection and treatment of acid mine drainage

The above three control categories are listed in order of preference. If acid generation is prevented there is no risk of the products, or contaminants, entering the environment. Where acid generation is not prevented, control of contaminant migration should be implemented. If neither of these control measures are in effect, it is necessary to collect and treat the AMD.

A combination of control measures from one or more of these categories may provide the most secure control.

1.1 Control of Acid Generation

The objectives of acid generation control is to prevent the formation of acid at the source by inhibiting sulphide oxidation. This may be done by excluding one or more of the essential ingredients to the reactions, or by controlling the environment around the sulphides. The available control measures are summarized in Table 1.1-1 below.

The conclusions that can be drawn from the currently available technology for acid generation control may be summarized as follows:

1. The control of acid generation is the most preferable form of control and should, if at all possible, be the primary long-term control. The design of AMD prevention at proposed facilities should aim to exclude one or more of the essential ingredients in the acid generation reactions

2. The exclusion of oxygen from reactive wastes by means of a water cover is currently the most effective acid generation control measure. Underwater disposal or a saturated soil/bog cover for preventing acid generation should be evaluated first.

TABLE 1.1-1

AVAILABLE ACID GENERATION CONTROL MEASURES

OBJECTIVE OF CONTROL	CONTROL MEASURES
Sulphide removal or isolation	Conditioning of tailings/waste rock
Exclusion of water	Covers and seals
Exclusion of oxygen	Subaqueous deposition Covers and seals (other than water)
pH control	Waste segregation and blending Base additives
Control of bacterial action	Bactericides

3. The control of acid generation is often not practical or is extremely costly for the abatement of AMD at some facilities. In these cases, acid generation control techniques may be used to reduce the rate of acid generation in conjunction with control of AMD migration and, if necessary, collection and treatment of AMD.

4. A combination of various measures may produce the most efficient control of AMD for both existing and proposed facilities and in the short or long term. Measures for the control of acid generation should be evaluated in conjunction with control of AMD migration and collection and treatment.

5. Construction methods or procedures and extraction processes that result in conditions favourable for preventing acid generation, such as bulk sulphide floatation of tailings, separating high sulphide rock waste, etc. should be considered for proposed facilities. However, additional control measures are likely to be required.

6. Covers and seals show promise as inhibiters of acid generation provided these are maintained in good order as designed. Certain types of covers and seals are very effective in reducing infiltration of precipitation and soil covers, in particular, are suitable for rehabilitation and re-vegetation purposes.

7. The use of bactericides is in many cases a suitable short-term acid generation control measure. It should be remembered that bactericides control only the biological oxidation processes and not chemical oxidation of the sulphides. Additional controls are necessary if the waste has insufficient natural potential to neutralize acid generated by chemical oxidation.

8. Base additives are generally a suitable short-term control measure. In some cases, base additives may be suitable in the long-term, depending on the quantity, type and reactivity of the sulphide minerals. Blending of mine wastes is a form of base addition in areas where limestone or other alkaline strata occur in the overburden. This method has been successfully used in the coal mining industry.

Mitigation of AMD by Control

Where acid generation is not prevented, the next level of control is to prevent or reduce the migration of AMD to the environment. Since water is the transport medium for contaminants, the control technology relies on the prevention of water entry to the AMD source. Control of water exit is of little value since in the long term all water entering the AMD source must exit, long term storage being negligible. Water entry may be controlled by:

- Diversion of all surface water flowing towards the AMD source.

- Prevention of groundwater flow into the AMD source.

- Prevention of infiltration of precipitation into the AMD source.

- Controlled placement of acid generating waste.

The conclusions that can be drawn from current technology for control of AMD migration may be summarized as follows:

1. Diversion of surface water is best achieved during operation (short term) by means of diversion ditches or berms. In the long term, site selection to minimize contact with surface water runoff should be considered, if possible. If necessary, ditches, berms and other structures may be used in the long term, however, a certain level of inspection and maintenance will be required.

2. Interception of groundwater by means of wells and pumps may be suitable in the short term only. Impermeable cut-off walls and gravity drains may be suitable in the long term but will require on-going monitoring and maintenance.

3. Infiltration control is essential for controlling AMD migration. This is best achieved by means of soil and/or synthetic materials or a combination of these. Synthetic membrane liners are most suitable in the short term to cover, for example, ore stockpiles. The design of soil covers must consider the degree of infiltration control

required and requirements for revegetation, long-term disruptive forces and maintenance requirements. All types of covers require some form of long-term monitoring and maintenance.

4. Methods of placing waste rock, spoil or tailings to minimize infiltration should be considered in conjunction with the other control methods.

5. The methods of control of AMD migration are sensitive to both the nature of the site and the duration for which control is required. Consideration of all site parameters is critical to selecting the optimum combination of methods.

Collection and Treatment of AMD

Collection and treatment of AMD is to date the most widely applied AMD control measure. This is due to the fact that at many existing operations where AMD was not anticipated or adequately controlled, collection and treatment is the only practical option available.

Collection systems may be required to recover both surface waters and groundwater contaminated by AMD. Collection of surface flows is usually fairly readily achieved by means of surface ditches. The collection of subsurface flows requires the installation of collection trenches, wells, or cut-off walls to force groundwater flow to the surface where it can be collected. Most collection systems require long-term maintenance.

Treatment measures may be classified as either active systems that require continuous operation, such as a chemical treatment plant, or passive systems that are intended to function with only occasional intervention by man, such as wetlands, alkaline trenches, etc.