PROVINCE OF BRITISH COLUMBIA
MINISTRY OF ENVIRONMENT, LANDS AND PARKS
VANCOUVER ISLAND REGION

DENMAN and HORNBY ISLANDS

WATER ALLOCATION PLAN

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written by:

Sharon Pitt
George Bryden

Regional Water Management
Vancouver Island Region
Nanaimo, B.C.

Approved

Regional Water Manager
Vancouver Island Region

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DENMAN & HORNBY ISLANDS WATER ALLOCATION PLAN

1.0 INTRODUCTION

The Water Management Program's goals are to sustain a healthy water resource through anticipating and planning for water uses. Water Allocation Plans are a means of identifying water demands and ensuring that water use is compatible with the goals of a sustainable environment. The advantages are:

1. Water Managements position on water allocation decisions is available to applicants and the public.

2. Response time is reduced.

3. Eliminates the need for individual studies and reports on each application.

4. Consistency of decisions are improved.

5. Specific allocation directions and decisions are defined.

6. Plans are more comprehensive.

7. Eliminates the need for referrals on individual applications.

The following regional policy was developed to provide direction:

Regional Policy:

The region shall be subdivided into watershed areas and a water allocation plan shall be prepared for each watershed area. Water licence decisions will be made in accordance with approved plans.

Assessments undertaken as part of the water allocation planning process include identifying the surface water resources available, the instream requirements for fish, the existing and potential licensable water demands and providing direction regarding further water licence allocations.

Input may be sought from other agencies. Referrals go to Federal & Provincial Fisheries agencies and to Water Management in Victoria.

2.0 GENERAL WATERSHED INFORMATION

2.1 Plan Area

The Water Allocation Plan area encompasses the whole of Denman Island, Hornby Island, Sandy Island and numerous small Islets. The plan area is located off the east coast of Vancouver Island between Nanaimo and Campbell River and encompasses a total land area of 82 km^2 (32 mi^2). Ferries link Denman Island to Vancouver Island and Hornby Island to Denman Island for both passengers and vehicles. Figure 1 illustrates the Denman and Hornby Island Water Allocation Plan Area.

Denman and Hornby Islands Plan Area

Islands	Area km^2
Denman Island	52
Hornby Island	30
Sandy Island	0.2
Seal Islets	0.1
Flora Islet	0.02
Chrome Island	0.01

2.2 History and Development

Denman Island is the largest of the islands within this plan area. Denman Island was used as a summer home by the indians of the Puntledge tribe whose winter homes were at Comox on Vancouver Island. Denman Island was named in 1864 after Rear-Admiral The Honourable Joseph Denman, Commander-in-Chief of the Pacific Station Esquimalt from 1864 to 1867.

The first white settlement started in 1874. Denman Island had an estimated 500 residents in 1979. The lifestyle of the residents is predominantly rural residential. Approximately 43% of the land base is within the Agricultural Land Reserve and is being actively farmed or utilized for the growth and harvesting of trees. The scarcity of water is one of the factors which limits the amount of active farming and farm production on lands devoted to farming. Crown Land makes up approximately 6% of the land base.

DENMAN & HORNBY ISLANDS WATER ALLOCATION PLAN

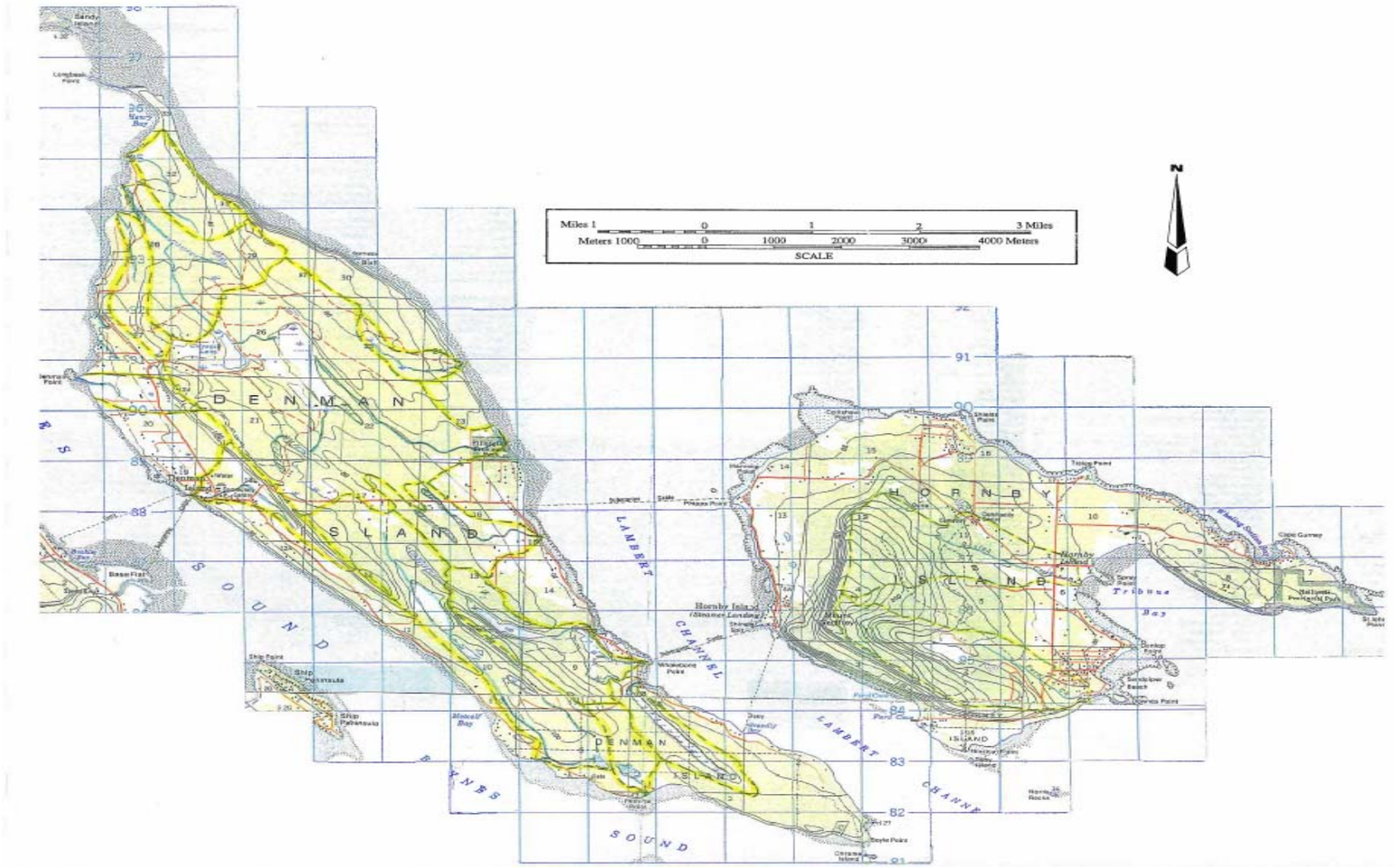


figure 1

DENMAN AND HORNBY ISLAND WATER ALLOCATION PLAN AREA

Hornby Island was used seasonally by the Pentlatch people of the Coast Salish group of west coast First Nations people before the onset of European settlement. In 1791 the Island was named, Isla de Lerena, by the Spaniards. It was renamed Hornby Island by the British in 1850 after Rear Admiral Phipps Hornby.

During the early 1860's Hornby Island was virtually uninhabited. By 1960 the island was inhabited by approximately 150 people; mainly fishermen, subsistence farmers and resort owners. The 1986 census reports the population of Hornby Island as 800. By 1990 the B.C. Telephone Company estimated the population to be 1,524 people.

In 1990 there were 661 small residential lots (218 vacant - 33%), 236 rural residential lots (69 vacant), 36 agricultural parcels (7 of which are mariculture), 10 commercial properties and various public use lots (ie. schools, community centre, cemetery) on Hornby Island. Land in the agricultural land reserve is 27% of the land base on Hornby Island.

2.3 Topography and Climate

Denman Island covers approximately 52 km^2 (20 mi^2). Denman Island is approximately 5,000 meters wide at its widest point by 18,250 meters long with its long axis lying in a northwest direction. It has a dominant ridge paralleling its west coast. Maximum elevation is 124 m (400 feet) and minimum elevation is sea level.

Hornby Island lies to the west of Denman Island and covers approximately 30 km^2 (12 mi^2). The maximum elevation of Hornby Island is 300m (984 feet), minimum elevation is sea level.

The climate on Denman and Hornby Islands is indicated by the Canadian Climatic Normals records for the station on Denman Island for the period 1951 to 1980. The lowest average mean daily temperature is in January and is 2.1^0C; with a mean daily maximum temperature of 4.4^0C and a mean daily minimum temperature of -0.6^0C. The highest average mean daily temperature is in July and is 17.3^0C; with a mean daily maximum temperature of 23.4^0C and a mean daily minimum temperature of 11.0^0C. See **Appendix A** for climatic normals and precipitation records for the period of 1951 to 1980.

2.4 Groundwater

Denman Island groundwater was assessed in May of 1979 in a report entitled "Preliminary Review of Groundwater Conditions and Availability - Denman Island, British Columbia" by F. Chwojka of the provincial Ministry of Environment. This report contains a list of all known wells, a well location map and a watershed map for the Island, estimates of groundwater recharge and usage, and water quality. The September 1977 groundwater records indicated that there were 85 dug wells with an average depth of 4.2 metres (14 ft) and 78 drilled wells with an average depth of 40 metres (130 ft). Further information on groundwater availability on Denman Island may be obtained from the report.

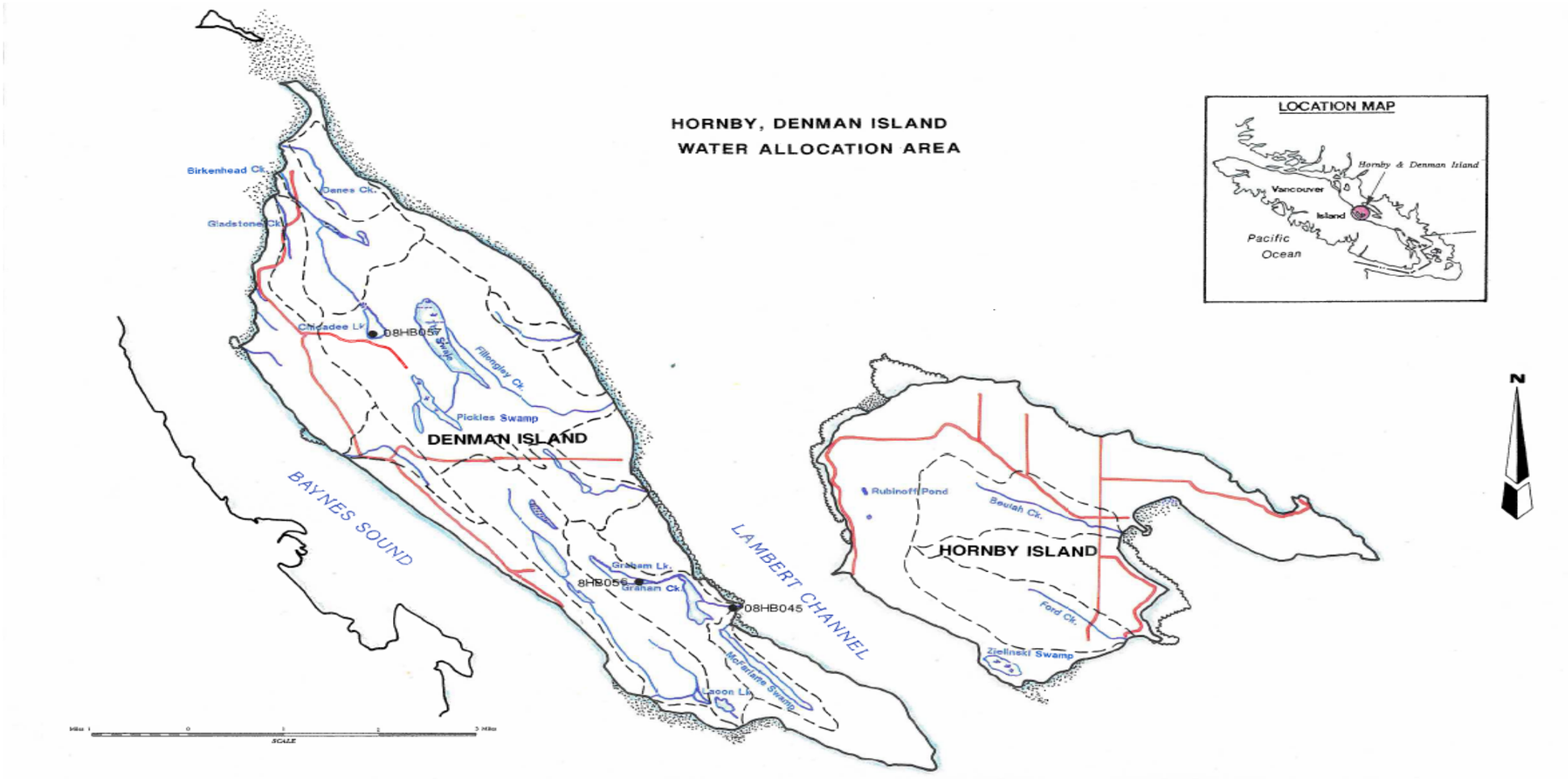
Hornby Island groundwater was assessed in October of 1984 in a report entitled "A Preliminary Review of Groundwater Conditions on Hornby Island, British Columbia" by F. Chwojka of the provincial Ministry of Environment. The 1984 groundwater records indicated that there were 73 dug wells with an average depth of 4.0 metres (13 ft) and 281 drilled wells with an average depth of 41 metres (135 ft). Further information on groundwater availability on Hornby Island may be obtained from the report and from an a further assessment entitled "Hornby Island Groundwater Pilot Project" by the provincial Ministry of Environment and anticipated to be completed by February 1994.

2.5 Significant Watershed Areas

For the purpose of assessing water supplies for allocation demands, the following watershed areas were identified and the drainage areas determined. The watershed areas were measured by planimeter from 1:50,000 NTS maps. These watersheds are illustrated in Figure 2.

Watershed Areas	
Drainage	**Area (km^2)**
Denman Island	
Graham Creek	2.69
McFarland Ditch	1.87
Unnamed (Repulse Point) Brook	0.85
Lacon Creek	5.42
Unnamed (Ferry) Brook	1.37
Unnamed (Denman Point) Brook	0.77
Unnamed (Northwest) Brook	0.50
Gladstone Creek	1.57
Birkenhead Creek	2.69
Danes Creek	2.00
Unnamed (Komass Bluff) Brook	0.61
Fillongley Creek	12.81
Unnamed (Longswamps) Brook	2.43
Hornby Island	
Ford Creek	4.08
Beulah Creek	3.94

DENMAN & HORNBY ISLANDS WATER ALLOCATION PLAN



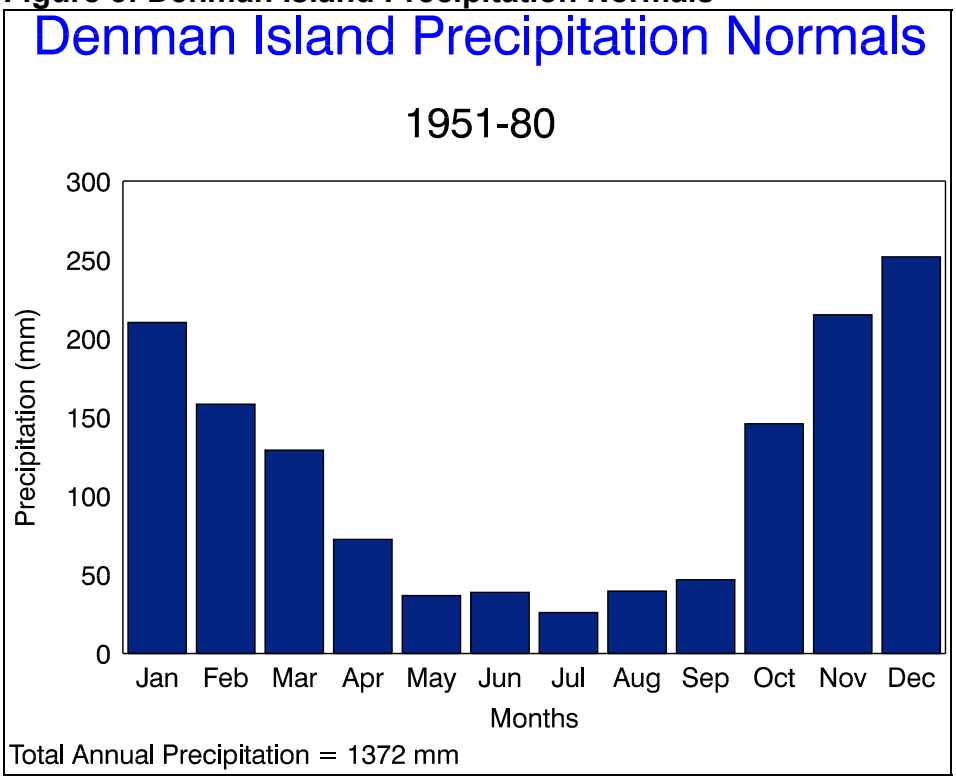
3.0 HYDROLOGY

3.1 Precipitation

There is one AES precipitation station within the plan area located on Denman Island. A bar graph showing the monthly precipitation normals during the 1951 to 1980 period for these stations is shown in Figure 3. The Canadian Climatic Normals 1951-1980 data is provided in Appendix A.

The mean total annual precipitation is 1,372 mm (54.0 inches). The minimum mean monthly precipitation is 26.0 mm (1.0 inch) in July and the maximum mean monthly precipitation is 251.9 mm (9.9 inches) in January. The mean number of days with measurable precipitation is 134 days; with 128 days with rain and 9 days with snow.

Figure 3: Denman Island Precipitation Normals



3.2 Hydrometric Information

There are three Water Survey Canada (WSC) hydrometric stations on Denman Island. Only one of these hydrometric stations records stream flows, namely; Graham

Creek at the Mouth (08HB045). Graham Creek has records for May through September in 1971, June through December in 1972 and the complete year for 1973 through 1978. The mean monthly flows and mean annual discharge (MAD) for this station are in the following table.

Graham Creek at the Mouth (08HB045) Mean Monthly Discharge litres/sec 1971 to 1978												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
249	167	171	49	8	2	0	4	2	19	294	396	119

For the period of record, the mean monthly flow is below 20% of MAD (24 litres/sec) for the period of May through October. Therefore, for the purpose of assessing water supply and demand in the plan area, the low flow period will be May through October. The high flow period will be the remaining months of November through April when the mean monthly flow is above 20% of MAD.

In 1972 there was zero flow for the period of July through October. In 1977 there was zero flow for the period of June through September. The flow records indicate that there has been zero mean monthly flow recorded in the months of June, July, August, September and October. Therefore the flow records indicate that, within the plan area, there is no water supply, from surface flows, for five months of the low flow period during low flow years.

The flows in Graham Creek were used to estimate the mean monthly discharge and mean annual discharge (MAD) in all significant drainages within the Denman and Hornby Islands Allocation Plan area. The estimated flow per unit area for this station are in the following table.

Graham Creek at the Mouth (08HB045) Unit Area Monthly Discharge litres/sec/km^2												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
93	62	64	18	3	1	0	1	1	7	109	147	44

The above flows were multiplied by the watershed area to obtain an estimated MAD and mean monthly flows for each identified significant watershed.

The remaining two hydrometric stations record water levels on Graham Lake on Denman Island (08HB056) and Chickadee Lake on Denman Island (08HB057). The

water level records for both stations extend from April through October for 1977 and 1978 and from April through September for 1979 through 1981. A summary of WSC flow records may be found in Appendix B.

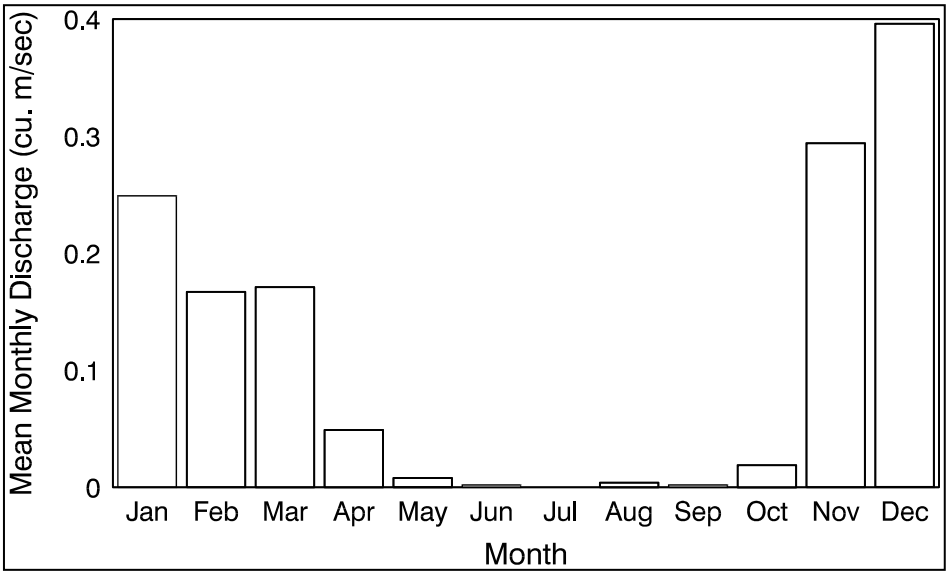
In addition to the hydrometric stations, further information related to stream flows and water volumes are available from past site inspections, reports and observations related to water licence applications. Also bathymetric surveys of Graham Lake and Chicadee Lake were completed by Water Management Branch of the Ministry of Environment.

3.3 Streamflow Estimates

3.3.1 Graham Creek

The Graham Creek drainage area is 2.69 km^2 (1.04 mi^2). The hydrometric station on Graham Creek at the Mouth (08HB045) has records for May through September in 1971, June through December in 1972 and the complete year for 1973 through 1978. The mean monthly flows are illustrated in the following figure.

Figure 4: Graham Creek at the Mouth (08HB045)



Morrison Swamp is connected directly to Graham Creek and has a surface area of approximately 19.4 ha (47.9 acres). Prior to the construction of McFarlane Ditch, McFarlane Swamp is believed to have been a part of Morrison Swamp.

3.3.1.1 Graham Lake

A bathymetric survey was done by Water Management Branch of the Ministry of Environment in June of 1981. The surface area of Graham Lake is approximately 15.4 ha (38.1 acres) at full supply level and the lake volume is 756 dam^3 (613 acft). A copy of the Storage Capacity and Area Curves and the bathometry is in Appendix C.

The water level records indicate that the lake level drops between 0.26 metres (0.84 ft) and 0.40 metres (1.31 ft) from April 1 to the lowest lake level; which occurs from mid-August to mid-September. Net annual evaporation loss from the surface is estimated to be approximately 0.3 metres (1.0 ft).

Cicero Slough is tributary to Graham Lake and has a surface area of approximately 3.0 ha (7.4 acres). The slough was to be dredged to obtain a total volume of water of 59 dam^3 (48 acft).

3.3.2 McFarlane Ditch

McFarlane Ditch flows from McFarlane Swamp and has a total drainage area of 1.87 km^2 (0.72 mi^2). McFarlane Swamp as been dammed at the outlet to store water for conservation purposes. Prior to the construction of McFarlane Road and McFarlane Ditch, McFarlane Swamp is believed to have been a part of Morrison Swamp.

The mean monthly discharge and mean annual discharge (MAD) flow estimates (using Graham Creek unit area flow and McFarlane Ditch drainage area) is in the following table:

McFarlane Ditch Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
174	116	120	34	6	2	0	2	2	13	204	275	82

The flow in McFarlane Ditch was 0.36 litres/sec (0.013 cfs) on June 14, 1979 as measured by Brono Blecic (in report on water licence file 0341857).

A bathymetric survey of McFarlane Swamp was done by Ducks Unlimited in 1983. The surface area of the swamp is 28.63 ha (70.7 acres) at full supply level and the volume is 191.07 dam^3 (154.9 acft).

3.3.3 Unnamed (Repulse Point) Brook

This Unnamed (Repulse Point) Brook was mistakenly named Lacon Creek as it was believed to naturally flow from Lacon Lake. However the natural outflow from Lacon Creek flows west towards a confluence with Valens Brook. The estimated drainage area is 0.85 km^2 (0.33 mi^2).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Repulse Point) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
79	53	54	15	3	1	0	1	1	6	93	125	37

This drainage area has two identified unnamed marsh areas with a surface area of 7.33 ha (18.1 acres). The lower in elevation of the two marshes is flooded and drained for agricultural activities.

3.3.4 Lacon Creek

Lacon Creek flows from Lacon Lake toward the west and a confluence with Valens Brook before entering Baynes Sound. The estimated drainage area of Lacon Creek is 5.42 km^2 (2.09 mi^2).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
504	336	347	98	16	5	0	5	5	38	591	798	239

Flow measurements of 1.16 litres/sec (0.04 cfs) on October 23, 1979 and 142 litres/sec (5.0 cfs) on January 20, 1988 where made on Valens Brook which is main tributary to Lacon Creek. These flow measurements indicate that the above mean

monthly and mean annual may be generous. Further measurements would be necessary to confirm or adjust the above estimates.

Lacon Lake is tributary to Lacon Creek. The surface area of the lake is 3.0 ha (7.41 acres). An estimated volume of the lake, using an estimated average depth of 2.6 metres (8.5 ft), is 78 dam^3 (63 acft).

Upstream on Valens Brook, the largest tributary to Lacon Creek, there is an unnamed small lake and associated swampy area with a surface area 6.28 ha (15.5 acres). Still further upstream there is The Maddigan, a large marsh area with a surface area of 14.5 ha (35.8 acres). There is evidence of drainage improvements in The Maddigan for cultivation. Still further upstream on a side channel of Valens Brook there is an unnamed swamp with a surface area of 4.35 ha (10.7 acres).

3.3.5 Unnamed (Ferry) Brook

The estimated drainage area of the Unnamed (Ferry) Brook is 1.37 km^2 (0.53 mi^2). This drainage area contains Avery Spring and Alonzo Swamp. An unnamed marsh, with a surface area of 7.59 ha (18.8 acres), has evidence of drainage improvements for cultivation.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Ferry) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
127	85	88	25	4	1	0	1	1	10	149	201	60

3.3.6 Unnamed (Denman Point) Brook

The estimated drainage area of the Unnamed (Denman Point) Brook is 0.77 km^2 (0.30 mi^2).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Denman Point) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
72	48	49	14	2	1	0	1	1	5	84	113	34

3.3.7 Unnamed (Northwest) Brook

The estimated drainage area of the Unnamed (Northwest) Brook is 0.5 km^2 (0.19 mi^2). The stream flows from a small marsh area with a surface area of 6.13 ha (15 acres) and which shows evidence of drainage improvements for cultivation.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Northwest) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
47	31	32	9	2	0	0	0	0	4	55	74	22

3.3.8 Gladstone Creek

The estimated drainage area of Gladstone Creek is 1.57 km^2 (0.61 mi^2). The Gladstone Creek drainage has two small swamp areas with a total surface area of 1.41 ha (3.5 acres).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Gladstone Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
146	97	101	28	5	2	0	2	2	11	171	231	69

3.3.9 Birkenhead Creek

The estimated drainage area of Birkenhead Creek is 2.68 km^2 (1.03 mi^2). The Birkenhead Creek drainage has four swamp areas with a total surface area of 6.98 ha (17 acres).1 Birkenhead Swamp is tributary to Birkenhead Creek. The flow from Chicadee Lake may overflow a low divide and flow into Birkenhead Creek when a beaver dam at the main outflow channel into Fillongly Creek raises water levels in the lake.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Birkenhead Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
250	169	172	48	8	3	0	3	3	19	293	395	118

3.3.10 Danes Creek

The estimated drainage area of Danes Creek is 2.0 km^2 (0.77 mi^2). An unnamed marsh, with a surface area of 6.13 ha (15 acres), has evidence of drainage improvements for cultivation.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Danes Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
186	124	128	36	6	2	0	2	2	14	218	294	88

3.3.11 Unnamed (Komass Bluff) Brook

The estimated drainage area of the Unnamed (Komass Bluff) Brook is 0.61 km^2 (0.24 mi^2). The Unnamed (Komass Bluff) Brook drainage has two small swamp areas with a total surface area of 6.31 ha (15.6 acres).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Komass Bluff) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
38	38	39	11	2	1	0	1	1	4	67	90	27

3.3.12 Fillongley Creek

The Fillongly Creek drainage area is the largest drainage area within the plan area at 12.81 km^2 (4.95 mi^2).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Fillongley Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
1,191	794	820	231	38	13	0	13	13	90	1,396	1,883	564

Upstream on Fillongly Creek is the largest marsh area on Denman Island, known locally as The Swale, with a surface area of 56.87 ha (140.5 acres). The Swale has evidence of drainage improvements for cultivation.

From a side channel a large swamp, known locally as Pickels Swamp, with a surface area of 17.21 ha (42.53 acres), flows into The Swale.

There are seven other significant swamps identified within this drainage, including Johanson Swamp and Cramer Swamp, with a total surface area of 10.34 ha (25.6 acres).

3.3.12.1 Chicadee Lake

Further upstream of The Swale on Fillongly Creek there is Chicadee Lake. A bathymetric survey was done by Water Management Branch of the Ministry of Environment in June of 1981. The surface area of Chicadee Lake is approximately 13.8 ha (34.1 acres) at full supply level and the lake volume is 1,183 dam^3 (959 acft). A copy of the Storage Capacity and Area Curves and the bathometry is in Appendix C.

Water levels on Chicadee Lake on Denman Island (08HB057) were collected for the months of April through October, 1977 and 1978, and April through September, 1979, 1980 and 1981. Water levels records indicate that the lake level drops between 0.034 metres (0.11 ft) and 0.760 metres (2.30 ft) from April 1 to the lowest lake level; which occurs from August through September. The average water level drop is 0.362 metres (1.19 ft) for the period of record. Net annual evaporation loss from the surface is estimated to be approximately 0.3 metres (1.0 ft).

3.3.13 Unnamed (Longswamps) Brook

The estimated drainage area of the Unnamed (Longswamps) Brook is 2.43 km^2 (0.94 mi^2). The Unnamed (Longswamps) Brook drainage has three long narrow swamps that lie in a north-west to south east direction in approximately the centre of Denman Island with a total surface area of 10.53 ha (26.02 acres).

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Unnamed (Longswamps) Brook Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
226	151	156	44	7	2	0	2	2	17	265	357	107

3.3.14 Ford Creek

The estimated drainage area of Ford Creek is 3.74 km^2 (1.44 mi^2). Three small swamps named Aspen Swamp, Crabapple Swamp and Canary Swamp have a total estimated surface area of 1.1 hectares (2.75 acres) and may be tributary to Ford Creek. Pipsissewa Creek is a tributary to Ford Creek.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Ford Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
348	232	239	67	11	4	0	4	4	26	408	550	165

3.3.15 Beulah Creek

The estimated drainage area of Beulah Creek is 3.67 km^2 (1.42 mi^2). Slade Spring is tributary to Beulah Creek and may help maintain flow during the summer months.

The mean monthly discharge and mean annual discharge (MAD) flow estimates is in the following table:

Beulah Creek Mean Monthly and Mean Annual Discharge litres/sec												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	MAD
341	228	235	66	11	4	0	4	4	26	400	539	161

3.3.16 Other Small Drainages

There are many small drainages on Denman and Hornby Islands. Information from investigations and reports associated with water licence applications indicate that there is no significant flow from most springs or streams in these smaller drainages from mid-June or mid-July to the end of September.

3.4 Water Supply

The following table summarizes the estimated water supplies for each significant drainage and for a unit drainage:

Mean Annual Discharge			
Drainage	**MAD (l/sec)**	**May-Oct Min. Flow (l/sec)**	**Nov-Apr Volume (dam^3)**
Denman Island			
Graham Creek	119	0.0	3,479
McFarlane Ditch	82	0.0	2,418
Unnamed (Repulse Point) Brook	37	0.0	1,099
Lacon Creek	239	0.0	7,009
Unnamed (Ferry) Brook	60	0.0	1,772
Unnamed (Denman Point) Brook	34	0.0	996
Unnamed (Northwest) Brook	22	0.0	647
Gladstone Creek	69	0.0	2,030
Birkenhead Creek	118	0.0	3,466
Danes Creek	88	0.0	2,586
Unnamed (Komass Bluff) Brook	27	0.0	789
Fillongley Creek	564	0.0	16,565
Unnamed (Longswamps) Brook	107	0.0	3,142
Hornby Island			
Ford Creek	165	0.0	4,836
Beulah Creek	161	0.0	4,746
Unit Drainage Area	44	0.0	1,293

4.0 INSTREAM FLOW REQUIREMENTS

Maintaining the natural stream environment and instream uses is of paramount importance for present and future generations. Maintaining water for the fisheries resource is a key factor in maintaining instream flow requirements for water quality, wildlife, recreational, aesthetic and cultural values. The Ministry of Environment Provincial policy is:

> **In situations where a water allocation decision will significantly impact instream uses of water, the comptroller or regional water manager may refuse the application or include water licence conditions to protect the instream use.**

Instream fisheries flow requirements are based on a provincially modified version of the Tennant (Montana) Method.

Modified Tennant (Montana) Method Instream Flow Requirements	
Flows	**Description**
30-60% MAD	Excellent spawning/rearing
20-30% MAD	Good spawning/rearing
10-20% MAD	Fair spawning/rearing
5-10% MAD	Poor spawning/rearing
>5% MAD	Severely degraded spawning/rearing

In drainages where fish are present, the minimum flow required to sustain the fisheries resource for fair spawning and rearing habitat is 10% of the Mean Annual Discharge (MAD). Therefore, the Regional policies to implement the Provincial policy are:

> **The minimum flow required to sustain the fisheries resources for spawning and rearing is 10% of the Mean Annual Discharge (MAD); unless a more rigorous analysis indicates a different minimum flow requirement.**
>
> **For streams where the natural mean monthly flow falls below 10% of the MAD, extractive licensed demands should only be allowed for the period of months when the mean monthly flow is above 60% of the MAD**

For streams where the mean 7-day average low flow falls below 10% of the MAD, extractive demands should only be allowed for the period of months when the mean monthly flow is above 60% of the MAD (Figure 1.3). Where the mean 7-day average low flow remains above 10%, then the 7-day low flow amount above 10% MAD is available)

Withdrawals from natural water bodies (lakes, ponds, swamps and marshes) supporting natural fisheries resources shall not reduce the shoal area more than 10%.

The shoal area is the area from the lake shore at average summer lake level to a 6 metre depth.

No significant natural fish resources have been identified in any stream channels on Denman or Hornby Islands. The main limiting factor may be the lack of a sustained flow through the summer months. Some streams have been identified as having fisheries development potential and a salmon enhancement project is being considered for Beulah Creek and Slade Spring on Hornby Island.

Both Graham Lake and Chickadee Lake on Denman Island support resident fish populations. Therefore the instream water volumes may not be reduced in these lakes by more than 10% of the shoal area or 0.6 meters without supporting storage.

4.1 Graham Lake Instream Requirements

Graham Lake maintains a natural population of resident fish. To maintain habitat for fish in the lake the shoal area or top 6 meters (20 feet) of the natural lake height shall not be reduced by more than 10% or 0.6 meters (2 feet).

4.2 Chicadee Lake Instream Requirements

Chicadee Lake maintains natural populations of fish. To maintain primary habitat for fish in the lake the shoal area or top 6 meters (20 feet) of the lake height shall not be reduced by more than 10% or 0.6 meters (2 feet).

To prevent fish and debris entering intakes, adequately designed and constructed fish screens are required on both lakes that support fish.

5.0 WATER DEMAND

There are 102 water licenses currently (December 1993) within the Denman and Hornby Islands Water Allocation Plan area. More than half of these water licences (53) are for domestic purposes for rural residential demands. Figure 5 illustrates the number of water licences issued for each purpose for streams within the plan area. There are 27 water licences for irrigation purposes, 15 water licences for storage purposes, 3 water licences for municipal waterworks purposes, 2 water licences for industrial purposes, 1 water licence for conservation and 1 water licence for land improvement purpose.

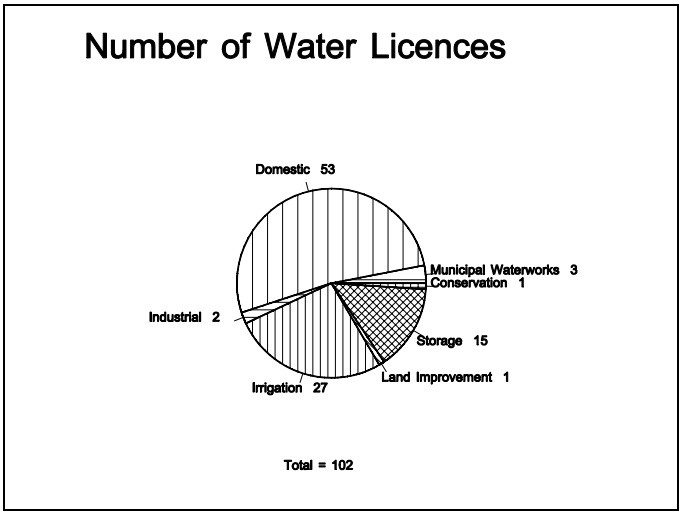


Figure 5: Number of Water Licences

The total estimated average annual licenced water demand for the plan area is 955.9 dam^3. Figure 6 illustrates the estimated average annual licenced water demands for each purpose under which water licences have issued within the plan area. The largest annual water demand is for irrigation purpose. The second largest annual water demand is for storage purpose; followed by conservation purpose, municipal waterworks purpose, industrial purpose, domestic purpose and finally land improvement purpose. The following table summarizes these annual water demands.

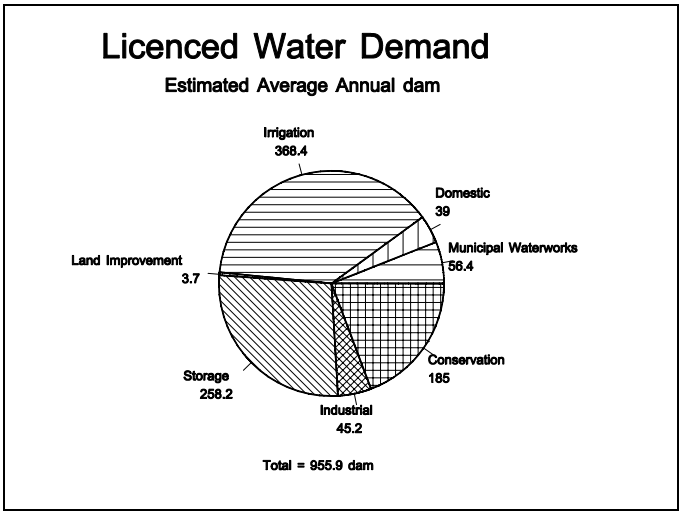


Figure 6: Licenced Water Demand

Estimated Average Annual Licenced Demand				
Purpose	No. of Lic	Quantity Licenced	Average Annual Licenced Demand*	
			l/sec	dam^3
Municipal Waterworks	3	12,410,000 gal/yr	1.8	56.4
Domestic	53	47,000 gpd	1.2	39.0
Industrial				
(Workshop)	1	500 gpd	0	0.8
(Crop Suppression)	1	36 acft	1.4	44.4
Sub total	2		1.4	45.2
Irrigation	27	298.63 acft	11.7	368.4
Storage	15	209.34 acft	8.2	258.2
Land Improvement	1	3 acft	0.1	3.7
Conservation (Storage)	1	150 acft	5.9	185.0
Total	102		30.3	955.9

* Based on assumption that: Municipal waterworks demand and domestic demand is the authorizes maximum daily licenced divided by 2 to estimate the average daily demand. Industrial, irrigation, storage, land improvement and conservation licenced flow is a uniform demand over the year and licenced volume is the total annual demand; except Conservation (fish fence) which has no demand.

There is little or no flow during the low flow period of May through October. Licenced water demand during this period requires storage to support and ensure water supply. Supporting storage is also critical to ensure water supplies for competing water uses and to maintain instream flow requirements for the fish resource. The estimated low flow licensed demand for each identified drainage area and for other drainages in the Denman and Hornby Islands Water Allocation Plan area is summarized in the following table.

Low Flow Licensed Demand by Drainage Area		
Drainage	**Licenced Demand (May - Oct)***	
	(l/sec)	**(dam^3)**
Denman Island		
Graham Creek	-2.23	-17.4
McFarlane Ditch	0.05	0.4
Unnamed (Repulse Point) Brook	0	0
Lacon Creek	0.14	1.0
Unnamed (Ferry) Brook	0.04	0.3
Unnamed (Denman Point) Brook	0	0
Unnamed (Northwest) Brook	0	0
Gladstone Creek	0	0
Birkenhead Creek	0.03	0.2
Danes Creek	0	0
Unnamed (Komass Bluff) Brook	0	0
Fillongley Creek	3.14	24.9
Unnamed (Longswamps) Brook	0	0
Other Drainages	0.55	4.3
Hornby Island		
Ford Creek	0.06	0.4
Beulah Creek	3.20	24.9
Other Drainages	15.04	116.8
Total	20.02	155.4

* Based on an estimated 90 day period demand assuming that; irrigation and industrial demands are totally withdrawn over the 90 day period; domestic and municipal waterworks demand is the authorizes licenced maximum daily for 90 days; authorized storage balances demand and therefore is a negative demand over 90 days; land improvement and conservation are non-consumptive and therefore have no demand.

5.1 Municipal Waterworks Water Demand

Two of the three water licences for municipal waterworks purposes are held by the Graham Lake Improvement District. The Graham Lake Improvement District provides a water service from Graham Lake, on Denman Island, to approximately 66 subdivision lots along the shore of Lambert Channel, between McFarlane Road and Keith Wagner Drive. The 12,045,000 gallon per year licenced water quantities (27 dam^3 - 90 day low flow demand) are adequately supported by 38 acre-feet (46.9 dam^3) of storage on Graham Lake.

The third water licence is held by the Shire Community Co-operative on Godfrey Springs on Hornby Island. The Shire Community Co-operative waterworks purpose licence is for 2,000 gallons per day (0.8 dam^3 - 90 day low flow demand) and is supported by 1.0 acre-feet (1.2 dam^3) of storage.

5.2 Domestic Water Demand

Despite the larger number of domestic water licences, the licenced domestic water demand represents only 4.1% of the total average annual demand. Of the 28 domestic water licences on Denman Island 5 are on springs (10,700 gpd - 4.4 dam^3 low flow demand), 8 are on Chicadee Lake (8,000 gpd - 3.3 dam^3 low flow demand), 6 are on Graham Lake (6,000 gpd - 2.5 dam^3 low flow demand), 5 are on creeks and brooks (4,700 gpd - 1.9 dam^3 low flow demand) and 2 are on swamps (1,500 gpd - 0.6 dam^3 low flow demand).

Of the 25 domestic water licences on Hornby Island 18 are on springs (12,500 gpd - 5.1 dam^3 low flow demand), 5 are on creeks and brooks (2,500 gpd - 1.0 dam^3 low flow demand) and 2 are on swamps (1,100 gpd - 0.4 dam^3 low flow demand). Most of the springs on Hornby Island are situated around the base of Mount Geoffrey.

Except for local competition for water on small streams and springs, domestic demand is not significant.

5.3 Industrial Water Demand

The water demand under this category would be better described as commercial or agricultural demands; but under the Water Act Regulations are categorized as sub-categories under the industrial water demand category for purposes of water licensing.

One of the two industrial purpose water licences is for 500 gpd (0.2 dam^3 low

flow demand) from Chickadee Lake for a workshop. The other industrial demand is 36 acre-feet (44.4 dam^3) to flood a potato field situated south of Lacon Lake during the winter months and suppress the growth of volunteer potatoes. There is no low flow demand associated with the industrial (crop suppression) water licence.

5.4 Irrigation Water Demand

Irrigation water demand is the largest demand and will have the most significant impact on low flows. Irrigation water demand occurs only during the low flow period when competition for water is the greatest.

There are 13 irrigation water licences on Denman Island. The largest irrigation water licences is 40 acft (49.3 dam^3) from Cicero Slough; a tributary to Graham Lake. It is supported by a 40 acft (49.3 dam^3) storage dugout in the slough. The second largest irrigation licence is 18.0 acft (22.2 dam^3) on Lacon Lake which is likewise supported by 18.0 acft (22.2 dam^3) of storage in Lacon Lake. The remaining irrigation water licences from Chickadee Lake and swamps, brooks, creeks and sloughs are less significant. Most irrigation demands on Denman Island have supporting storage water licences.

There are 13 irrigation water licences on Hornby Island. The three largest irrigation water demands are 65 acft (80.2 dam^3) on Harry Spring, 61.7 acft (50 dam^3) on Slade Spring, 30 acft (37.0 dam^3) on Rubinoff Spring and 20 acft (24.7 dam^3) on Maude Spring. The latter two water licences have supporting storage. Most of the irrigation demand on Hornby Island is not supported by storage.

5.5 Storage Water Demand

There are 27 water licences for storage purpose within the plan area. Storage demand is the second largest licenced water demand and supports municipal waterworks and the irrigation demand noted above. However adequate storage has not been developed to supply and support the licenced irrigation demands during the low flow period.

5.6 Land Improvement Water Demand

There is one water licence for land improvement on Denman Island. The licence is for the development, on a small marsh, of a decorative pond and dyke to prevent

flooding of neighbouring lands. These improvements have no significant impact on flows and other licenced demands.

5.7 Conservation Water Demand

There is one water licence for conservation purpose on Denman Island. This water licence is held by the Ministry of Environment, Lands and Parks, authorizes the construction of a small dam in McFarlane ditch and the storage of 150.0 acft (185.0 dam^3) of water in McFarlane Swamp. The dam, reservoir and other improvements were constructed by Ducks Unlimited to develop and improve a wild foul refuge.

This water licence for conservation purposes does not create a significant consumptive demand and provides storage for a domestic and small irrigation demand.

5.8 Projected Demand

There are only 17 water license applications pending as of July 1993. These pending water licence application demands are for 36.4 dam^3 (29.5 acft) irrigation purpose, 5.2 dam^3 (6,250 gpd) domestic purpose, 0 dam^3 industrial (fire protection) purpose and 5.6 dam^3 (4.5 acft) storage purpose. The storage purpose is intended to support the 2 small irrigation demands.

Future water demands are anticipated to be similar to existing licenced water demands. Future water demands in the plan area will primarily relate to domestic, irrigation and conservation. These water demands will require that winter high flows be stored for summer low flow demands (supporting storage).

6.0 CONCLUSIONS and RECOMMENDATIONS

Within the plan area the low flow period is the six months from May through October; when the flow is below 20% of the mean annual discharge (MAD). There is no significant flow in any stream during the five months of June through October in some lower than average flow years. The minimum mean monthly flow is 0.0 litres/second in July.

Mean monthly flows higher than 20% MAD occur from November through April (6 months). The mean monthly flow is above 60% MAD for the period of November through March (5 months). Therefore there is considerable flow available for part of the

year to develop supporting storage.

There is no significant fish resources identified in any of the streams on Denman or Hornby Islands except in Graham Lake and in Chickadee Lake. Both Graham Lake and Chickadee Lake on Denman Island support resident fish populations. There may be some potential fish habitat and marginal fish habitat in other drainages within the plan area, however there is no evidence of significant fish utilization and low flows will limit any potential fish habitat utilization.

It is recommended that Fish screens be required on water intakes in Graham Lake and Chickadee Lake.

The licenced water demand on Denman and Hornby Islands are for irrigation, storage, conservation, municipal waterworks, industrial, domestic and land improvement purposes. The most significant water demands are for irrigation, storage and conservation purposes. As little or no flow occurs during the low flow period of May through October, licenced water demand during this period requires storage to support and ensure water supply. There is not sufficient storage developed or proposed to maintain and support the existing and projected water demands through the low flow period.

It is recommended that no further significant allocation of water be made unless licence application demands (and existing demands where the licensee is expanding the supply) are supported with proposed storage. Where there is no natural storage (ie. lakes, swamps or marshes), or where natural storage is inadequate for water demands, storage reservoirs (dams or dugouts) may be developed to supply water demands.

Potential for development of storage may exist in marshes, swamps, ponds and small lakes such as The Swale, The Maddigan, Morrison Swamp and Pickles Swamp. Drainage improvements for cultivation have reduced the water supply in several of the large swamps and marshes.

Graham Lake and Chickadee Lake are the only identified sources of water supply on the islands where significant natural storage volumes may still be available.

6.1 Graham Lake

Existing licenced supporting storage for municipal waterworks demands is 46.9 dam^3 (38.0 acft). The 12,045,000 gallon per year municipal waterworks licenced water demands (27 dam^3 - 90 day low flow demand) are adequately supported by the storage

on Graham Lake.

To maintain fish habitat in the lake, no more than an additional 0.6 meters (2 feet) of water from the natural lake control elevation should be withdrawn from Graham Lake. The natural lake control elevation is 0.3 metres (1.0 ft) below the spillway elevation of 33.4 metres GSC.

It is recommended that the surface of Graham Lake should not be drawn down below elevation 32.5 metres GSC. Assuming a 0.3 metre (1.0 ft) evaporation loss from the natural surface of the lake (36.0 dam^3), the additional volume of water available in Graham Lake for extractive use during the summer months is 34.0 dam^3 (27.6 acft).

6.2 Chickadee Lake

To maintain fish habitat in the lake, no more than 0.6 meters (2 feet) of water from the natural lake control elevation should be withdrawn from Chickadee Lake. The natural control elevation of Chickadee Lake is at the invert of a road culvert at elevation 51.06 metres GSC.

It is recommended that the surface of Chickadee Lake should not be drawn down below elevation 50.5 metres GSC. Assuming a 0.3 metre (1.0 ft) evaporation loss from the natural surface of the lake (40.0 dam^3), the volume of water available in Chickadee Lake for extractive use during the summer months is 35.0 dam^3 (28.4 acft).

6.3 Municipal Waterworks

Waterworks purpose in the Water Act is the carriage or supply of water by a municipality, improvement district, regional district or private utility for the purpose of providing water to a residential area.

The local populations of Denman and Hornby Islands have reacted negatively to any significant residential development on the islands. Local zoning by-laws and public concern for the maintenance of a rural lifestyle on the islands may limit any further urban size residential development and thus municipal waterworks demands.

If a residential development is permitted then storage must be developed to support the waterworks demand. The applicant for a waterworks demand shall be require to assess the supply for a ten year projected demand and provide evidence that

the projected demand is not excessive in comparison with adjoining community demands, water conservation is being promoted (ie. residential meters, pricing practices, education) and adequate system balancing storage (ie. volume difference between maximum hour and maximum day demands) will be constructed or is available for peek hour demands. Water Utilities will also have to provide evidence that the appropriate requirements for a Certificate of Public Convenience and Necessity (CPCN) have been met and a CPCN will be obtained. Licenced allocations will be limited to a 10 year projected demand except where the applicant can provide satisfactory evidence that a longer projection period is required (ie. because the cost of construction of works must be amortised over a longer period).

The licensee shall be required to meter or measure and record the water diverted from the source stream.

The licensee shall be required to treat the water supply in accordance with Ministry of Health requirements.

Adequate system balancing storage shall be required to ensure that the rate of withdrawal from the source during short term or maximum hour demand does not exceed the maximum daily demand. Good conservation techniques must be practised at all times and no increase in the amount of water in existing community waterworks licences shall be allowed unless meters and other conservation measures have been used.

6.4 Domestic

A domestic water licence shall be 2,273 litres per day (500 gallons per day) maximum daily demand for each rural dwelling as indicated on the plan attached to the water license application. This amount will allow for the maintaining of 0.10 hectares (0.25 acres) of garden associated with the dwelling. Domestic water licences shall not be issued solely to maintain green lawns and gardens where groundwater and other sources of water supply provide the primary domestic household needs.

Domestic water licence shall not be issued to provide evidence of an "adequate potable water supply" to subdivision approval authorities for subdivision development. Large subdivision of land for residential development (more than 10 residential lots) shall be encouraged to develop and use a municipal waterworks (community) water system.

To ensure an adequate domestic water supply for household uses, from a

surface water source, applicants shall be required to develop storage or use the water naturally stored in marshes, swamps, ponds or lakes. The quantity of storage required is the average daily demand of 1,136 litres per day (250 gpd) for a five month period (150 days), say 170 m^3 (6,000 ft^3) or 0.2 dam^3 (0.1 acft). This requires a reservoir or dugout approximately 6 metres (20 ft) wide by 9 metres (30 ft) long, with an average depth of 3.5 metres (11 ft); allowing approximately 0.3 metres (1 ft) for evaporation loss.

A water licence for domestic use shall not be issued to a residence within a community water supply area unless written leave to do so is obtained from the community water supply agency.

6.5 Industrial

Industrial water licenses on Denman and Hornby Islands are uses typically associated with small household commercial and agricultural enterprises. Also water demands for small resort or bed and breakfast and stock watering enterprises may be anticipated.

Industrial demands related to commercial and resort development should be handled similar to multiple domestic demands with the same requirements. Livestock requiring more than 450 l/day (100 lgpd) are to be considered an Industrial (agricultural) demand. Cattle or livestock requiring 450 l/day (100 lgpd) or less will be considered a Domestic (livestock) demand. Estimated livestock demands are:

Recommended Livestock Water Requirements

	Water Requirements	
Livestock	l/day	lgpd
cattle (beef) per animal	45	10
cattle (dairy) per animal	132	29
chickens per 100 animals	27	6
turkeys per 100 animals	55	12

6.6 Irrigation

The crop rooting depth, soil type and climatic characteristics determine requirements for irrigation.

Different crops and their rooting depth and water availability coefficient were classified into shallow (0.5 metre) and deep (1.0 metre) effective rooting depths. The available water storage capacity (AWSC) was estimated for shallow and deep root zone depth for classes of similar soil associations identified on the maps in the publication Soils of Southern Vancouver Island (J.R. Jungen, P.Ag., Ministry of Environment, August 1985). Where composites of two or three soil associations are intermixed or occupy such small areas that they cannot be separated at the scale of the mapping, only the predominant soil association was considered. The following table was made using the climatic information for Parksville and the AWSC for different crop effective rooting depth classes and soil classes. A colour map of irrigation requirements is provided in Figure 7.

If the applicant for a water licence can provide more specific soil assessment information for a given area, that soil assessment may be used to assess irrigation demands.

It should be noted that these annual irrigation water requirements are for sprinkler irrigation systems only.

Irrigation gun or flood irrigation systems require greater irrigation quantities and should be discouraged. If irrigation gun and flood irrigation practices are to be used then suitable meters shall be installed and water withdrawals limited to the equivalent annual irrigation requirements for sprinkler systems. As the equivalent annual irrigation water requirements for sprinkler systems may not be adequate to sustain crops using these less efficient methods of irrigation, the applicant may be required to reduce crops, limit the acreage irrigated or convert to a more efficient sprinkler irrigation system.

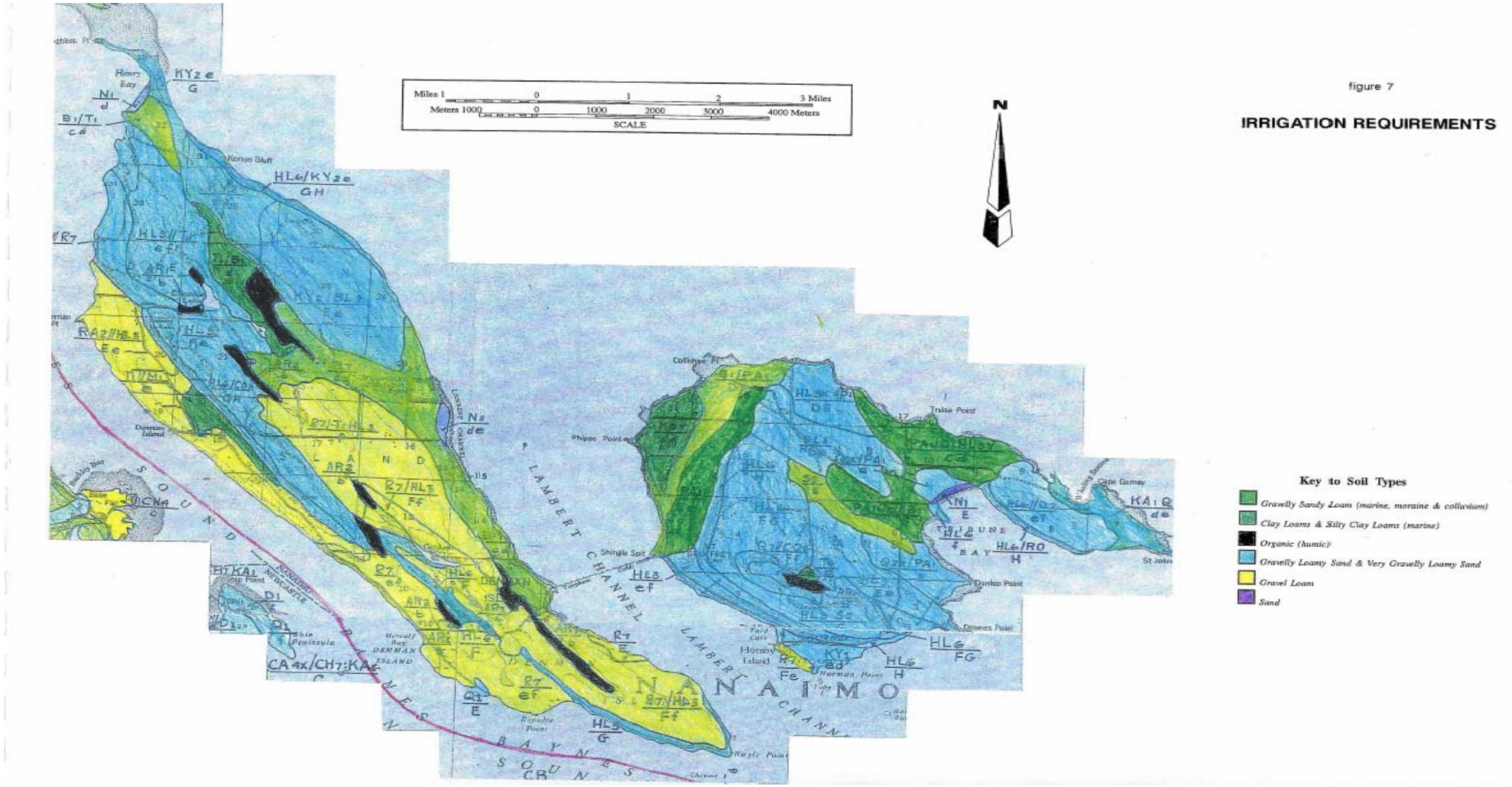
Trickle irrigation can reduce water requirements by 35% and should be encouraged where practical.

The maximum irrigation system flow rate shall not exceed 19.1 l/sec (4.2 imperial gals. per minute) per 0.4 hectare (1 acre), and users must be encouraged to employ good agricultural practices (field size, system selection and farm management) to conserve water.

The authorized period of use for irrigation shall be from April 1 to September 30.

All irrigation water demands must be supported by storage development. Storage required to support irrigation demands is the total required amount as per crop and soils, plus an additional allowance for evaporation and other losses from the storage reservoir.

DENMAN & HORNBY ISLANDS WATER ALLOCATION PLAN



Annual Irrigation Water Requirements millimetres (inches)		
Crops	Peas, Potatoes, Tomatoes, Lettuce, Pasture Species, Cranberries	Brussels Sprouts, Corn, Clover Grapes, Fruit trees, Alfalfa, Raspberries
Effective Rooting Depth	Shallow 0.5 m (1.6 ft)	Deep 1.0 m (3.3 ft)
Arrowsmith (AR) - Organic - Black	380 (15)	305 (12)
Tolmie (T) - Sandy clay loam - Dark Green Merville (M) - Silty clay - Dark Green Parksville (PA) - Sandy loam over silty clay - Light Green	460 (18)	305 (12)
Bowser (B) - Loamy sand over gravelly sandy loam - Blue Royston (R) - Gravelly loam - Yellow Ronald (RA) - Gravelly loam - Yellow Shawnigan (S) - Gravelly sandy loam - Light green	530 (21)	460 (18)
Kuhushan (KA) - Sandy Loam over loamy sand - Light green Kye (KY) - Loamy sand - Blue Hiller (HL) - Gravelly loamy sand - Blue Qualicum (Q) - Very gravelly loamy sand - Blue	610 (24)	610 (24)

6.7 Land Improvement

Water required for land improvement aesthetic ponds shall be the volume of the pond to be created. All the requirements noted for storage development shall apply to for land improvement development where applicable.

6.8 Conservation

Conservation purpose is the use and storage of water or the construction of works in and about a stream for the enhancement of fish or wildlife for non-profit purposes.

The requirements for storage development for dams and reservoirs developed to improve a wild foul or fish habitat shall apply where applicable.

Salmon enhancement proposals that would increase fish stocks in the stream channels will require the development of supporting storage to maintain required low flows. All the requirements noted for storage development shall be required for conservation development where applicable.

6.9 Storage

Storage purpose is the impoundment of water, either on-stream or off-stream in a dugout or behind a dam. In the unlikely event that a large storage development (ie. for power, pulp & paper, large waterworks) is proposed a more specific supply versus demand and environmental impact assessment will be required.

The storage quantity required to support the smaller water demands associated with domestic, industrial, commercial and irrigation uses anticipated in this plan, shall be the volume of the water demand plus an additional allowance of 0.3 metres (1.0 foot) depth over the surface area of the storage reservoir for evaporation and other losses.

It is recommended that the applicant be required to submit a completed report form entitled "Dam and Reservoir Information Required in Support of a Water Licence Application for Storage Purpose (Schedule 2)" before the application be considered.

It is recommended that design plans must be submitted and accepted in writing before construction commences on any proposed dam over 3 m (10 ft) in height or on storage of 12 dam^3 (10acft) or more.

It is recommended that the applicant must obtain written agreement, right-of-way or easement for works or flooding affecting lands other than his own.

Total storage (dead and live) will be licensed. Dead storage should be licensed as it will in most cases have some intrinsic value such as providing conservation of water for wildlife or aesthetic value.

Diversion of water into off-stream storage will be during the period November to March. All in-stream storage may be required to pass any stream flows during the period May to October.

6.10 Allocation Plan Revision

The Denman and Hornby Islands Water Allocation Plan should be reviewed and updated on or before January 1999 (5 years).

Appendix A

Temperature and Precipitation

From: CANADIAN CLIMATIC NORMALS

1951 - 1980

Temperature and Precipitation

BRITISH COLUMBIA/COLOMBIE-BRITANNIQUE

DENMAN ISLAND 49° 32'N 124° 49'W 35 m	JAN JAN	FEB FÉV	MAR MAR	APR AVR	MAY MAI	JUN JUIN	JUL JUIL	AUG AOÛT	SEP SEPT	OCT OCT	NOV NOV	DEC DÉC	YEAR ANNÉE	CODE CODE	
Daily Maximum Temperature	4.4	7.5	9.2	12.9	17.2	20.2	23.4	22.9	19.3	13.7	8.4	6.1	13.8	8	Température Maximale Quotidienne
Daily Minimum Temperature	-0.6	0.1	0.6	2.8	5.6	8.7	11.0	10.7	7.5	4.7	1.6	0.3	4.4	8	Température Minimale Quotidienne
Daily Temperature	**2.1**	**3.8**	**5.0**	**8.0**	**11.8**	**14.6**	**17.3**	**17.1**	**13.7**	**9.2**	**5.1**	**3.3**	**9.3**	**8**	**Température Quotidienne**
Standard Deviation, Daily Temperature	1.1	1.2	0.8	0.5	0.8	0.8	1.3	1.4	1.2	0.7	1.2	1.4	0.4	6	Ecart Type de la Température Quotidienne
Extreme Maximum Temperature	12.8	15.6	19.4	20.6	28.3	30.0	35.6	33.3	28.3	20.6	15.6	15.0	35.6		Température Maximale Extrême
Years of Record	5	6	6	6	6	6	6	6	6	6	6	6			Années de Relèves
Extreme Minimum Temperature	-12.2	-7.8	-9.4	-3.3	-2.8	1.7	3.9	3.9	0.0	-2.8	-5.6	-12.8	-12.8		Température Minimale Extrême
Years of Record	5	6	6	6	6	6	6	6	6	6	6	6			Années de Relèves
Rainfall	168.7	141.3	118.0	72.3	36.7	36.8	26.0	39.6	46.8	145.6	205.1	230.3	1269.2	8	Chutes de Pluie
Snowfall	38.8	13.2	10.8	0.4	0.0	0.0	0.0	0.0	0.0	0.1	6.8	22.6	92.7	8	Chutes de Neige
Total Precipitation	**210.3**	**158.7**	**129.1**	**72.5**	**36.8**	**36.8**	**26.0**	**39.6**	**46.8**	**145.9**	**215.1**	**251.9**	**1371.5**	**8**	**Précipitations Totales**
Standard Deviation, Total Precipitation	125.6	91.7	50.6	32.0	15.7	18.4	24.7	34.7	21.7	83.1	81.6	82.0	179.1	5	Ecart Type des Précipitations Totales
Greatest Rainfall in 24 hours	99.6	72.9	73.2	68.6	55.9	44.2	44.5	37.3	54.1	74.9	78.7	80.3	99.6		Chute de Pluie Record en 24 heures
Years of Record	50	52	52	52	53	51	51	53	53	52	53	50			Années de Relèves
Greatest Snowfall in 24 hours	76.2	45.7	45.7	7.6	0.0	0.0	0.0	0.0	0.0	5.1	40.6	40.6	76.2		Chute de Neige Record en 24 heures
Years of Record	48	52	52	54	54	52	53	54	54	55	54	52			Années de Relèves
Greatest Precipitation in 24 hours	99.6	72.9	73.2	68.6	55.9	44.2	44.5	37.3	54.1	74.9	78.7	80.3	99.6		Précipitation Record en 24 heures
Years of Record	48	52	52	52	53	51	51	53	53	52	52	49			Années de Relèves
Days with Rain	14	12	11	10	9	9	6	7	7	13	16	14	128	8	Jours de Pluie
Days with Snow	4	1	1	0	0	0	0	0	0	0	1	2	9	8	Jours de Neige
Days with Precipitation	16	13	12	10	9	9	6	7	7	13	16	16	134	8	Jours de Précipitation

Appendix B

Hydrometric Data

From: SURFACE WATER DATA

BRITISH COLUMBIA

1977

GRAHAM LAKE ON DENMAN ISLAND - STATION NO. 08HB016

DAILY WATER LEVEL IN FEET FOR 1977

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	---	---	---	3.99	3.99	---	---	2.32	---	---	3.23	---	1
2	---	---	---	---	---	3.68	3.58	---	3.02	3.21	---	---	2
3	---	---	---	3.91	3.81	---	---	2.30	---	---	---	---	3
4	---	---	---	---	---	3.90	3.58	---	3.05	3.19	---	---	4
5	---	---	---	3.87	3.81	---	3.59	2.28	---	---	---	---	5
6	---	---	---	---	---	3.88	3.58	---	3.07	3.19	---	---	6
7	---	---	---	3.83	3.99	---	---	2.24	---	---	---	---	7
8	---	---	---	---	---	3.87	3.54	---	3.11	3.21	---	---	8
9	---	---	---	3.81	3.97	---	---	2.20	---	---	---	---	9
10	---	---	---	---	---	3.85	3.54	---	3.09	3.19	---	---	10
11	---	---	---	3.82	3.95	---	---	2.18	---	---	---	---	11
12	---	---	---	---	---	3.83	3.56	---	3.07	3.19	---	---	12
13	---	---	---	3.84	3.95	---	---	2.16	---	---	---	---	13
14	---	---	---	---	---	3.79	3.56	---	3.05	3.19	---	---	14
15	---	---	---	3.90	3.95	---	---	2.10	---	---	---	---	15
16	---	---	---	---	---	3.77	3.52	---	3.04	3.17	---	---	16
17	---	---	---	3.90	3.93	---	---	2.08	---	---	---	---	17
18	---	---	3.17	---	---	3.75	3.48	---	3.12	3.17	---	---	18
19	---	---	---	3.92	3.94	---	---	2.06	---	---	---	---	19
20	---	---	---	---	---	3.73	3.46	---	3.21	3.17	---	---	20
21	---	---	---	3.93	3.92	---	---	2.04	---	---	---	---	21
22	---	---	---	---	---	3.71	3.44	---	3.23	3.39	---	---	22
23	---	---	---	3.98	3.92	---	---	2.04	---	---	---	---	23
24	---	---	---	---	---	3.69	3.42	---	3.24	3.57	---	---	24
25	---	---	---	3.00	3.88	---	---	2.10	---	---	---	---	25
26	---	---	---	---	---	3.66	3.40	---	3.23	3.57	---	---	26
27	---	---	---	3.00	3.88	---	---	2.08	---	---	---	---	27
28	---	---	---	---	---	3.64	3.36	---	3.21	3.03	---	---	28
29	---		---	3.98	3.86	---	---	2.06	---	---	---	---	29
30	---		---	---	---	3.60	3.34	---	3.21	3.05	---	---	30
31	---		---		3.90		---	2.04		---		---	31
MEAN	---	---	---	---	---	---	---	---	---	---	---	---	MEAN
MAX	---	---	---	---	---	---	---	---	---	---	---	---	MAX
MIN	---	---	---	---	---	---	---	---	---	---	---	---	MIN

TYPE OF GAUGE - MANUAL
LOCATION - LAT 49 30 41 N
LONG 124 45 04 W

NATURAL FLOW

WATER LEVELS ARE REFERRED TO ASSUMED DATUM

From: SURFACE WATER DATA

BRITISH COLUMBIA

1979

GRAHAM LAKE ON DENMAN ISLAND - STATION NO. 08HB056

DAILY WATER LEVEL IN METRES FOR 1979

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	---	---	---	0.891	0.787	0.821	---	0.623	0.597	---	---	---	1
2	---	---	---	---	---	---	0.790	---	---	---	---	---	2
3	---	---	---	0.890	0.789	0.821	---	0.623	0.599	---	---	---	3
4	---	---	---	---	---	---	0.791	---	---	---	---	---	4
5	---	---	---	0.881	---	---	---	0.622	0.601	---	---	---	5
6	---	---	---	---	---	0.791	0.697	0.609	---	---	---	---	6
7	---	---	---	0.892	---	0.791	---	---	0.602	---	---	---	7
8	---	---	---	---	---	---	0.717	0.608	---	---	---	---	8
9	---	---	---	0.882	0.817	0.790	---	0.597	0.606	---	---	---	9
10	---	---	---	---	---	---	---	---	0.691	---	---	---	10
11	---	---	---	0.181	0.825	0.790	0.705	0.597	---	---	---	---	11
12	---	---	---	---	---	---	---	---	0.691	---	---	---	12
13	---	---	---	0.882	0.825	0.789	---	0.598	---	---	---	---	13
14	---	---	---	---	---	0.789	0.701	---	0.690	---	---	---	14
15	---	---	0.820	0.883	0.828	---	0.696	0.599	---	---	---	---	15
16	---	---	---	0.884	---	0.790	---	---	0.699	---	---	---	16
17	---	---	---	---	0.827	---	0.689	0.600	0.699	---	---	---	17
18	---	---	---	0.884	---	0.790	---	---	---	---	---	---	18
19	---	---	---	---	0.827	---	---	0.600	0.698	---	---	---	19
20	---	---	---	0.884	0.826	0.789	0.678	---	---	---	---	---	20
21	---	---	---	---	0.824	---	---	0.599	0.697	---	---	---	21
22	---	---	---	0.882	0.825	---	0.664	---	---	---	---	---	22
23	---	---	---	0.857	---	0.788	---	0.599	0.697	---	---	---	23
24	---	---	---	0.850	0.824	0.788	0.656	---	0.697	---	---	---	24
25	---	---	---	0.849	---	---	---	0.597	---	---	---	---	25
26	---	---	---	---	0.825	0.787	0.655	0.597	0.696	---	---	---	26
27	---	---	---	0.847	---	---	---	---	---	---	---	---	27
28	---	---	---	---	0.824	0.787	0.655	0.597	0.696	---	---	---	28
29	---		---	---	---	---	---	---	---	---	---	---	29
30	---		---	---	---	0.788	0.654	0.595	0.697	---	---	---	30
31	---		---		---		---	---		---		---	31
MEAN	---	---	---	---	---	---	---	---	---	---	---	---	MEAN
MAX	---	---	---	---	---	---	---	---	---	---	---	---	MAX
MIN	---	---	---	---	---	---	---	---	---	---	---	---	MIN

SUMMARY FOR THE YEAR 1979

MINIMUM DAILY WATER LEVEL, 0.595 M ON AUG 30

TYPE OF GAUGE - MANUAL
LOCATION - LAT 49 30 41 N
LONG 124 45 04 W

NATURAL FLOW

WATER LEVELS ARE REFERRED TO ASSUMED DATUM

From: SURFACE WATER DATA

BRITISH COLUMBIA

1980

GRAHAM LAKE ON DENMAN ISLAND - STATION NO. 08HB056

DAILY WATER LEVEL IN METRES FOR 1980

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	---	---	---	0.950	---	---	---	0.620	---	---	---	---
2	---	---	---	---	0.952	0.900	0.742	---	0.554	---	---	---
3	---	---	---	0.950	---	---	---	0.610	---	---	---	---
4	---	---	---	---	0.952	0.899	0.730	---	0.556	---	---	---
5	---	---	---	0.951	---	---	---	0.602	---	---	---	---
6	---	---	---	---	0.951	0.900	0.720	0.598	0.556	---	---	---
7	---	---	---	0.951	0.951	---	---	0.598	---	---	---	---
8	---	---	---	---	---	---	0.720	---	0.560	---	---	---
9	---	---	---	0.951	0.951	0.899	---	0.593	---	0.576	---	---
10	---	---	---	0.951	---	---	0.702	---	0.558	---	---	---
11	---	---	---	---	0.951	0.901	---	0.588	---	---	---	---
12	---	---	---	0.951	---	---	0.703	---	0.556	---	---	---
13	---	---	---	0.951	0.950	0.901	---	0.578	---	---	---	---
14	---	---	---	---	---	0.902	0.690	---	0.552	---	---	---
15	---	---	---	0.951	0.952	---	---	0.565	---	---	---	---
16	---	---	---	---	---	0.901	0.688	---	0.552	---	---	---
17	---	---	---	0.951	0.899	---	---	0.564	---	---	---	---
18	---	---	---	---	---	0.899	0.686	---	0.552	---	---	---
19	---	---	---	0.951	0.899	---	---	0.562	---	---	---	---
20	---	---	---	---	---	0.900	0.679	---	0.553	---	---	---
21	---	---	---	0.951	0.899	---	---	0.552	---	---	---	---
22	---	---	---	---	---	0.899	0.674	---	0.552	---	---	---
23	---	---	---	0.952	0.899	---	---	0.552	---	---	---	---
24	---	---	---	---	---	---	0.658	---	0.553	---	---	---
25	---	---	---	0.952	0.899	---	---	0.546	---	---	---	---
26	---	---	0.911	---	---	---	0.644	---	0.552	---	---	---
27	---	---	---	0.952	0.901	---	---	0.553	---	---	---	---
28	---	---	---	---	---	---	0.638	---	0.550	---	---	---
29	---	---	---	0.952	0.902	---	---	0.558	---	---	---	---
30	---		---	0.952	---	0.752	0.630	---	0.578	---	---	---
31	---		---		0.901		---	0.552		---	---	---
MEAN	---	---	---	---	---	---	---	---	---	---	---	---
MAX	---	---	---	---	---	---	---	---	---	---	---	---
MIN	---	---	---	---	---	---	---	---	---	---	---	---

TYPE OF GAUGE - MANUAL
LOCATION - LAT 49 38 41 N
LONG 124 45 04 W

WATER LEVELS ARE REFERRED TO ASSUMED DATUM

NATURAL FLOW

From: SURFACE WATER DATA

BRITISH COLUMBIA

1981

GRAHAM LAKE ON DENMAN ISLAND - STATION NO. 08HB056

DAILY WATER LEVEL IN METRES FOR 1981

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	DAY
1	---	---	---	0.963	0.956	---	---	0.826	---	---	---	---	1
2	---	---	---	---	---	0.940	0.893	---	0.767	---	---	---	2
3	---	---	---	0.960	0.953	---	---	0.824	---	---	---	---	3
4	---	---	---	---	---	0.942	0.888	---	0.771	---	---	---	4
5	---	---	---	0.962	1.004	---	---	0.816	---	---	---	---	5
6	---	---	---	---	---	0.946	0.881	---	0.764	---	---	---	6
7	---	---	---	0.960	0.995	---	---	0.805	---	---	---	---	7
8	---	---	---	---	---	0.942	0.878	---	0.762	---	---	---	8
9	---	---	---	0.956	0.993	---	---	0.801	---	---	---	---	9
10	---	---	---	---	---	0.926	0.887	---	0.759	---	---	---	10
11	---	---	---	0.960	0.994	---	---	0.796	---	---	---	---	11
12	---	---	---	---	---	0.922	0.895	---	0.754	---	---	---	12
13	---	---	---	0.967	0.987	---	---	0.790	---	---	---	---	13
14	---	---	---	---	---	0.920	0.887	---	0.749	---	---	---	14
15	---	---	---	0.969	0.985	---	---	0.780	---	0.919	---	---	15
16	---	---	---	---	---	0.904	0.882	---	0.748	---	---	---	16
17	---	---	---	0.967	0.985	---	---	0.768	---	---	---	---	17
18	---	---	---	---	---	0.909	0.877	---	0.750	---	---	---	18
19	---	---	---	0.964	0.985	---	---	0.755	---	---	---	---	19
20	---	---	---	---	---	0.909	0.875	---	0.756	---	---	---	20
21	---	---	---	0.957	0.979	---	---	0.747	---	---	---	---	21
22	---	---	---	---	---	0.909	0.864	---	0.778	---	---	---	22
23	---	---	---	0.959	0.969	---	---	0.743	---	---	---	---	23
24	---	---	---	---	---	0.905	0.858	---	0.783	---	---	---	24
25	---	---	---	0.961	0.983	---	---	0.752	---	---	---	---	25
26	---	---	---	---	---	0.903	0.845	---	0.788	---	---	---	26
27	---	---	0.935	0.959	0.973	---	---	0.752	---	---	---	---	27
28	---	---	---	---	---	0.897	0.839	---	0.800	---	---	---	28
29	---		---	1.006	0.964	---	---	0.755	---	---	---	---	29
30	---		---	---	---	0.893	0.833	---	0.806	---	---	---	30
31	---		---		0.956		---	0.755		---		---	31
MEAN	---	---	---	---	---	---	---	---	---	---	---	---	MEAN
MAX	---	---	---	---	---	---	---	---	---	---	---	---	MAX
MIN	---	---	---	---	---	---	---	---	---	---	---	---	MIN

SUMMARY FOR THE YEAR 1981

TYPE OF GAUGE - MANUAL
LOCATION - LAT 49 30 41 N
LONG 124 45 04 W

NATURAL FLOW

WATER LEVELS ARE REFERRED TO ASSUMED DATUM

From: HISTORICAL WATER LEVELS SUMMARY

BRITISH COLUMBIA

1985

CHICADEE LAKE ON DENMAN ISLAND - STATION NO. 08HB057

MONTHLY AND ANNUAL MEAN WATER LEVELS IN METRES FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1977	---	---	---	1.876	1.923	1.887	1.791	1.685	1.651	1.668	---	---	---	1977
1978	---	---	---	2.018	1.876	1.907	1.797	1.711	1.606	1.858	---	---	---	1978
1979	---	---	---	1.834	1.900	1.803	1.741	1.827	1.696	---	---	---	---	1979
1980	---	---	---	1.885	2.060	2.074	2.113	2.007	1.965	---	---	---	---	1980
1981	---	---	---	2.204	2.130	2.078	2.027	1.843	1.922	---	---	---	---	1981
MEAN	---	---	---	2.044	1.953	1.959	1.885	1.787	1.808	1.773	---	---	---	MEAN

WATER LEVELS REFERRED TO ASSUMED DATUM

LOCATION - LAT 49 33 39 N
LONG 124 46 32 W NATURAL FLOW

CHICADEE LAKE ON DENMAN ISLAND - STATION NO. 08HB057

ANNUAL EXTREMES OF WATER LEVELS IN METRES FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS WATER LEVEL	MAXIMUM DAILY WATER LEVEL	MINIMUM DAILY WATER LEVEL	YEAR
1977	---	---	1.626 ON SEP 14	1977
1978	---	---	1.588 ON AUG 1	1978
1979	---	---	1.675 ON AUG 16 +	1979
1980	---	---	---	1980
1981	---	---	---	1981

WATER LEVELS REFERRED TO ASSUMED DATUM

+ - EXTREME RECORDED FOR THE PERIOD OF RECORD

From: HISTORICAL STREAMFLOW SUMMARY

BRITISH COLUMBIA

1990

GRAHAM CREEK AT THE MOUTH - STATION NO. 08HB045

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1971	---	---	---	---	0.014	0.002	0	0	0	---	---	---	---	1971
1972	---	---	---	---	---	0.001	0	0	0	0	0.011	0.290	---	1972
1973	---	---	---	---	0.002	0.002	0	0	0	0.019	0.481	0.538	0.149	1973
1974	0.236	0.198	0.078	0.014	0.006	0.004	0.001	0.032	0.011	0.002	0.303	0.298	0.123	1974
1975	0.202	0.162	0.192	0.049	0.011	0.001	0	0	0	0.108	0.686	0.252	0.138	1975
1976	0.199	0.108	0.151	0.050	0.006	0.003	0.001	0	0	0.001	0.168	0.614	0.109	1976
1977	0.129	0.188	0.168	0.019	0.001	0	0	0	0	0.002	0.167	0.266	0.118	1977
1978	0.206	0.181	0.150	0.062	0.017	0.003	0	0	0.001	0.001	0.025	0.252	0.076	1978
MEAN	0.249	0.167	0.171	0.049	0.008	0.002	0	0.004	0.002	0.019	0.294	0.395	0.119	MEAN

LOCATION - LAT 49 30 24 N DRAINAGE AREA 3.37 km²
LONG 124 43 52 W NATURAL FLOW 2.91 km²

GRAHAM CREEK AT THE MOUTH - STATION NO. 08HB045

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m^3/s)	MAXIMUM DAILY DISCHARGE (m^3/s)	MINIMUM DAILY DISCHARGE (m^3/s)	TOTAL DISCHARGE (dam^3)	YEAR
1971	---	---	0 ON JUL 03 *	---	1971
1972	---	---	0 ON JUL 01	---	1972
1973	---	0.977 ON DEC 21	0 ON MAY 03	4 710	1973
1974	---	1.15 ON JAN 16	0 ON MAY 03	3 890	1974
		1.33 E ON NOV 24			
1975	---	2.77 E ON NOV 11 *	0 ON JUN 16	4 350	1975
1976	---	1.26 E ON DEC 14	0 ON MAY 03	3 430	1976
1977	---	2.13 ON DEC 31	0 ON MAY 03	3 730	1977
1978	---	0.694 ON MAR 07	0 ON JUL 02	2 400	1978
				3 930	MEAN

E - ESTIMATED * - EXTREME RECORDED FOR THE PERIOD OF RECORD

From: HISTORICAL STREAMFLOW SUMMARY

BRITISH COLUMBIA

1990

GRAHAM CREEK AT THE MOUTH - STATION NO. 08HB045

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN	YEAR
1971	---	---	---	---	0.014	0.002	0	0	0	---	---	---	---	1971
1972	---	---	---	---	---	0.001	0	0	0	0	0.011	0.290	---	1972
1973	0.516	0.108	0.078	0.014	0.002	0.002	0	0	0	0.019	0.401	0.538	0.149	1973
1974	0.230	0.215	0.208	0.079	0.006	0.004	0.001	0.032	0.011	0.002	0.303	0.298	0.123	1974
1975	0.202	0.162	0.192	0.049	0.011	0.001	0	0	0	0.108	0.686	0.262	0.138	1975
1976	0.199	0.108	0.151	0.050	0.006	0.003	0.001	0	0	0.001	0.166	0.613	0.109	1976
1977	0.129	0.188	0.166	0.019	0.003	0	0	0	0	0.005	0.387	0.526	0.118	1977
1978	0.206	0.181	0.150	0.082	0.017	0.003	0	0	0.001	0.001	0.025	0.252	0.076	1978
MEAN	0.249	0.167	0.171	0.049	0.008	0.002	0	0.004	0.002	0.019	0.294	0.396	0.119	MEAN

LOCATION - LAT 49 30 24 N DRAINAGE AREA 3.37 km²
LONG 124 43 52 W NATURAL FLOW 2.69 km²

GRAHAM CREEK AT THE MOUTH - STATION NO. 08HB045

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

YEAR	MAXIMUM INSTANTANEOUS DISCHARGE (m³/s)	MAXIMUM DAILY DISCHARGE (m³/s)	MINIMUM DAILY DISCHARGE (m³/s)	TOTAL DISCHARGE (dam³)	YEAR
1971	---	---	0 OR JUL 03 *	---	1971
1972	---	0.977 ON DEC 27	0 OR JUL 01	---	1972
1973	---	1.75 ON JAN 16	0 OR MAY 05	4 710	1973
1974	---	1.33 E ON NOV 24	0 OR MAY 03	3 890	1974
1975	---	2.77 E ON NOV 13 *	0 OR JUN 26	4 150	1975
1976	---	1.26 E ON DEC 22	0 OR MAR 24	3 430	1976
1977	---	2.12 ON DEC 11	0 OR MAR 31	3 450	1977
1978	---	0.894 ON MAR 07	0 OR JUL 30	2 450	1978
				3 750	MEAN

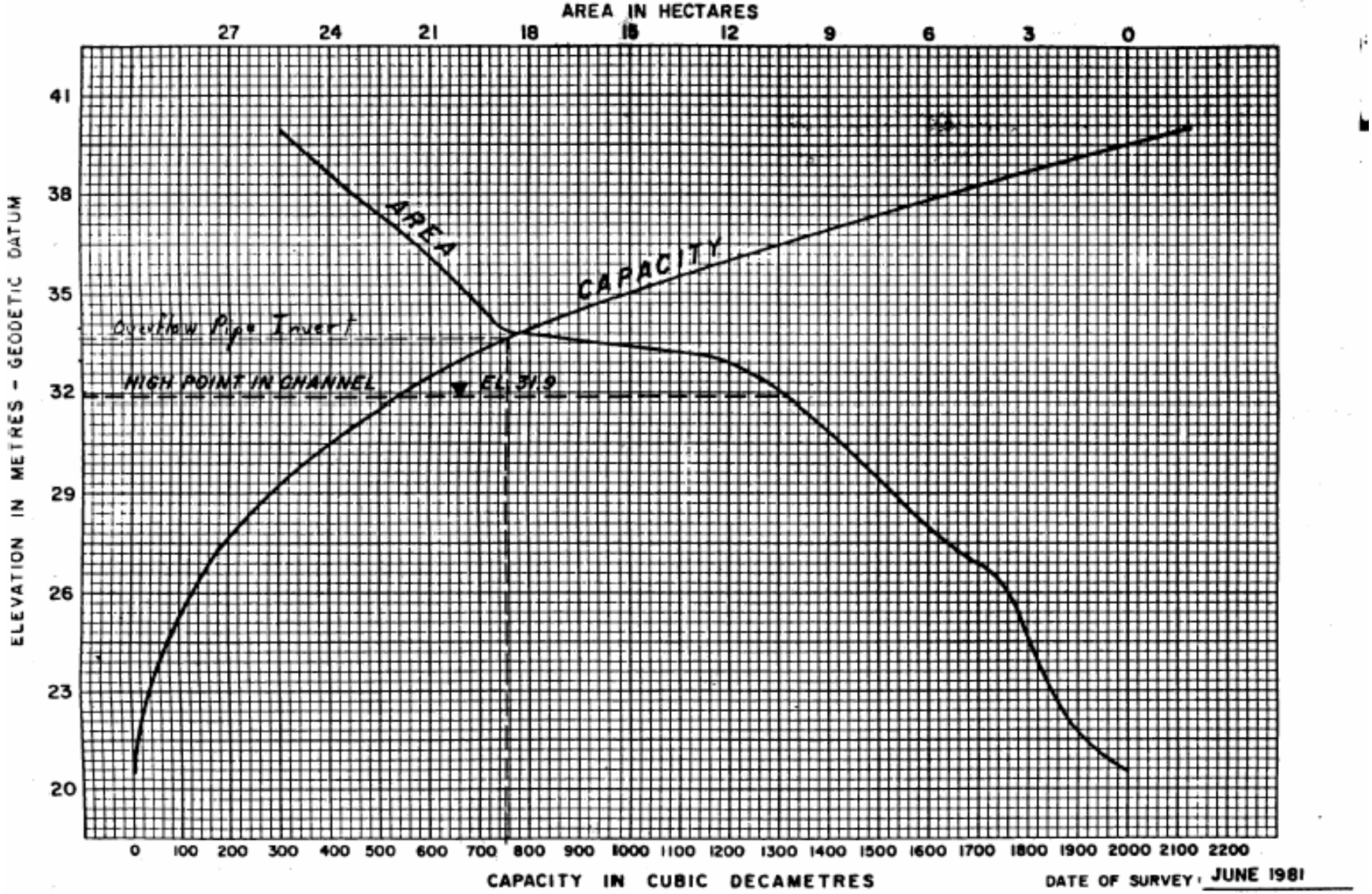
E - ESTIMATED * - EXTREME RECORDED FOR THE PERIOD OF RECORD

Appendix C

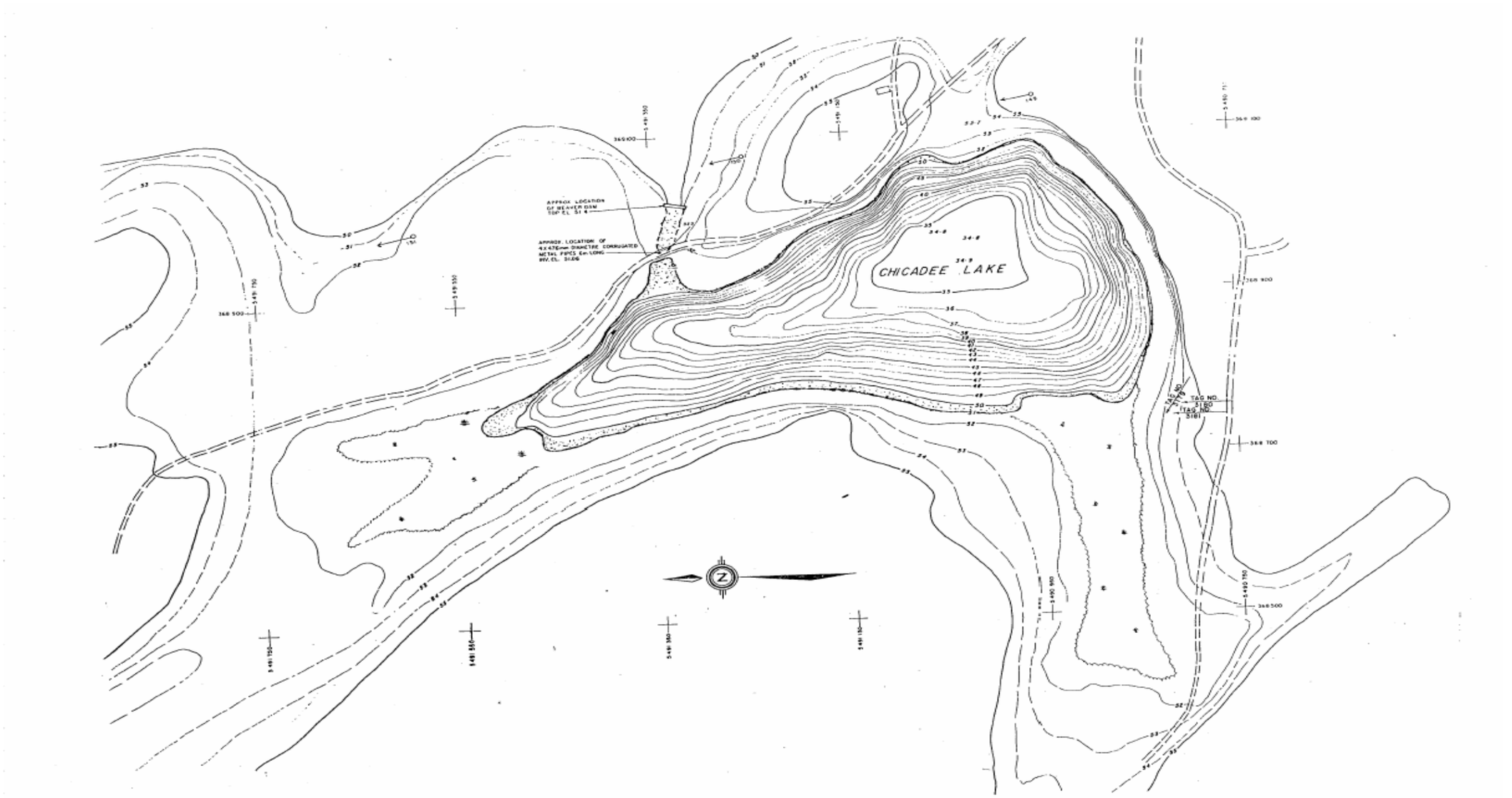
Graham Lake, Chicadee Lake and McFarlane Swamp Bathometry

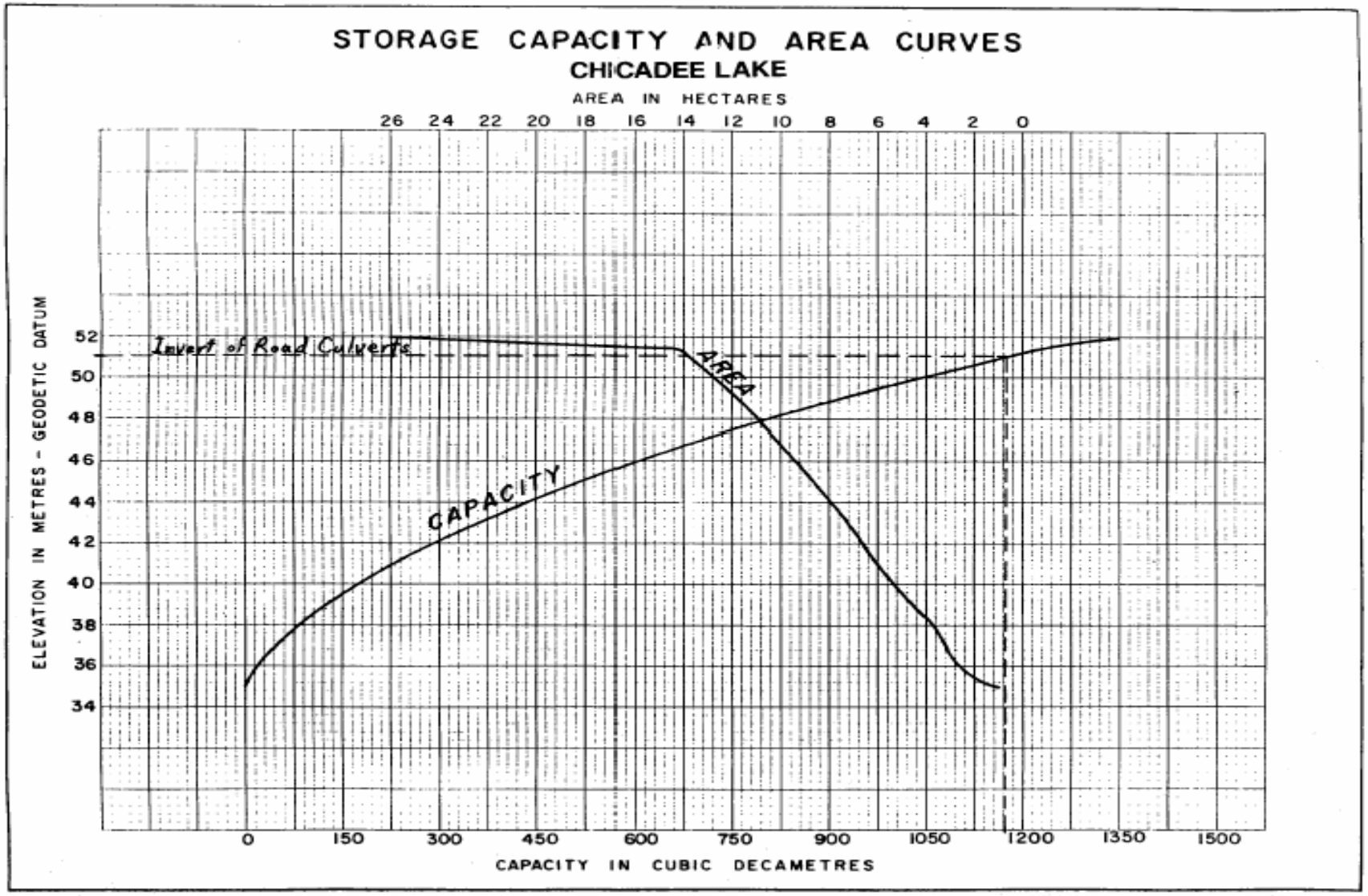
STORAGE CAPACITY AND AREA CURVES

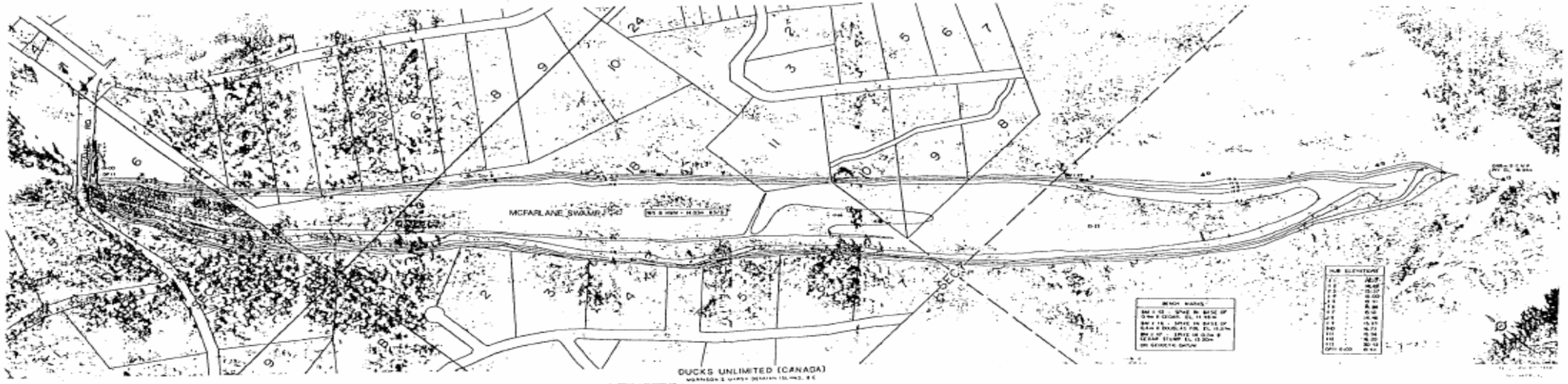
GRAHAM LAKE

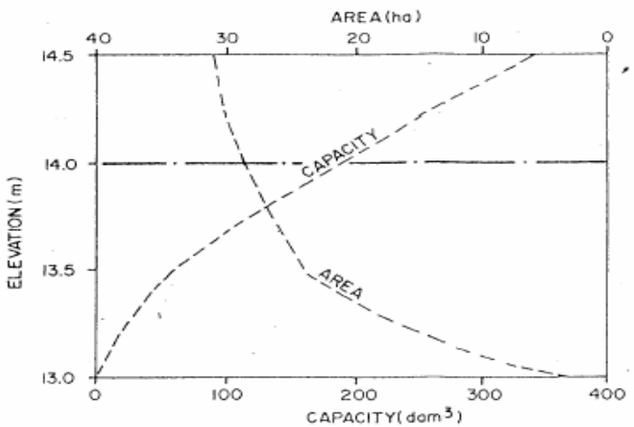


DATE OF SURVEY: JUNE 1981


CHICADEE LAKE
APPROX. LOCATION OF BEAVER DAM TOP EL. 51.4
APPROX. LOCATION OF 475mm DIAMETRE CORRUGATED METAL PIPES 6m LONG INV. EL. 50.06
TAG NO. 5180
TAG NO. 5181
N

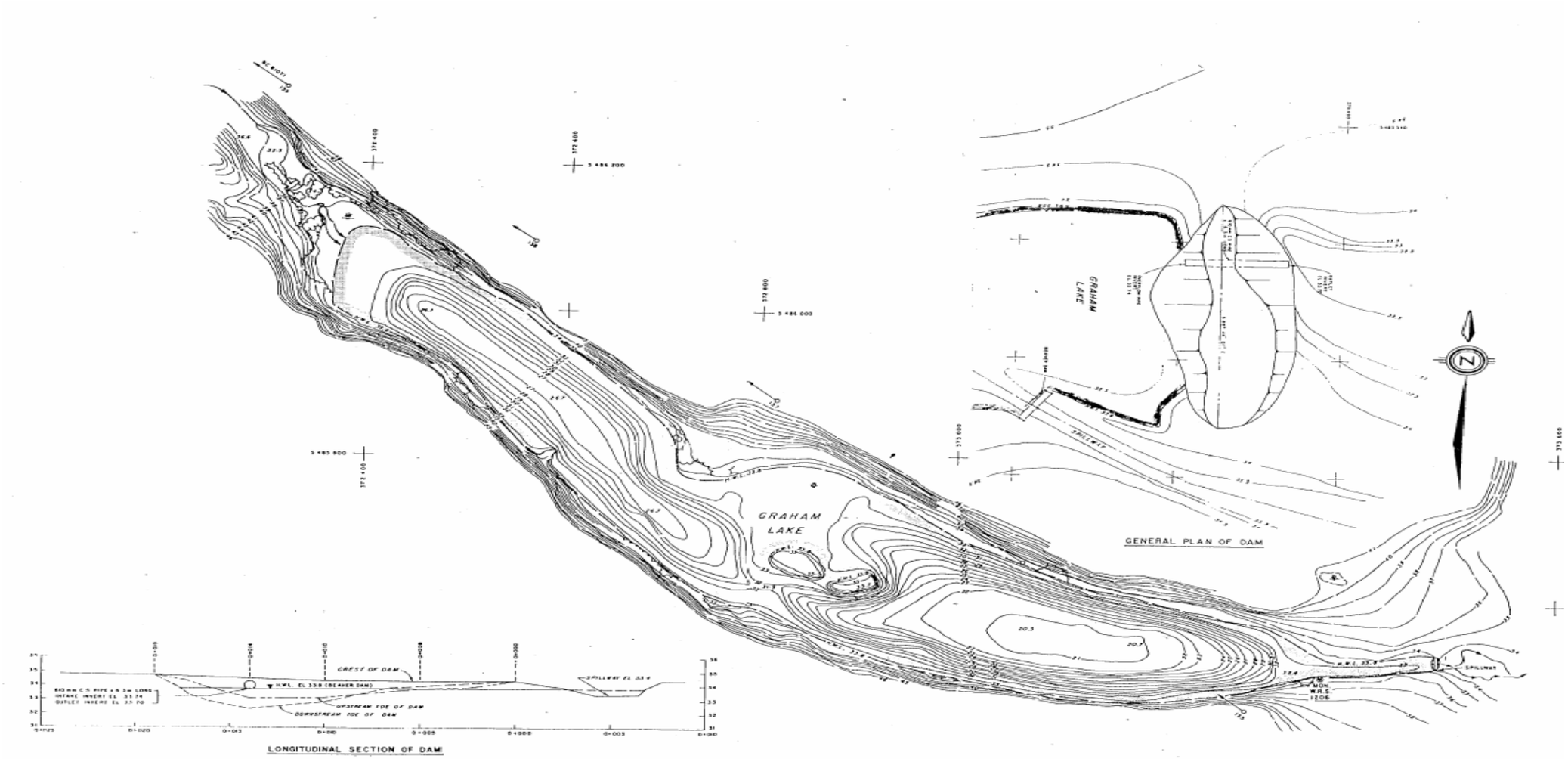

STORAGE CAPACITY AND AREA CURVES
CHICADEE LAKE
AREA IN HECTARES
26 24 22 20 18 16 14 12 10 8 6 4 2 0
ELEVATION IN METRES - GEODETIC DATUM
52
50
48
46
44
42
40
38
36
34
Invert of Road Culverts
AREA
CAPACITY
0 150 300 450 600 750 900 1050 1200 1350 1500
CAPACITY IN CUBIC DECAMETRES





ELEVATION(m)	AREA(ha)	CAPACITY(dam³)
13.00	2.85	0.94
13.50	24.05	59.54
14.00	28.63	191.07
14.50	31.00	340.11

MCFARLANE SWAMP BATHYMETRY


GRAHAM LAKE
GENERAL PLAN OF DAM
GRAHAM LAKE
CREST OF DAM
H.W.L. EL 33.8 (BEAVER DAM)
SPILLWAY EL 33.4
UPSTREAM TOE OF DAM
DOWNSTREAM TOE OF DAM
LONGITUDINAL SECTION OF DAM

Appendix D

Water Licences

DENMAN ISLAND WATER LICENCES
Date: 1993/07/27

LICENSE	FILE	TERM	PRIORITY DATE	SOURCE	QUANTITY
Municipal Waterworks					
C067571	0296159	Jan 01 Dec 31	1970/03/19	GRAHAM LAKE	10,950,000 GY
C067572	1000448	Jan 01 Dec 31	1985/02/21	GRAHAM LAKE	1,095,000 GY
Domestic					
F016243	0195680	Jan 01 Dec 31	1952/07/14	PIERCY SPRING	1,000.00 GD
C026257	0232158	Jan 01 Dec 31	1960/08/04	HALEY SPRING	5,000.00 GD
F053544	0238554	Jan 01 Dec 31	1961/09/25	CHICKADEE LAKE	1,000.00 GD
C032669	0270911	Jan 01 Dec 31	1967/01/05	MEE SPRING	2,000.00 GD
F053545	0296984	Jan 01 Dec 31	1970/09/12	CHICKADEE LAKE	2,000.00 GD
C038900	0305656	Jan 01 Dec 31	1971/07/12	CRAMER SWAMP	500.00 GD
C041343	0310397	Jan 01 Dec 31	1972/06/23	PIERCY SPRING	2,000.00 GD
C046039	0329015	Jan 01 Dec 31	1975/06/23	VALENS BROOK	1,500.00 GD
C053919	0329450	Jan 01 Dec 31	1975/09/11	CHICKADEE LAKE	500.00 GD
C049473	0340673	Jan 01 Dec 31	1976/12/21	HAMILTON CREEK	500.00 GD
C046945	0330238	Jan 01 Dec 31	1976/03/03	VALENS BROOK	1,000.00 GD
C053057	0341857	Jan 01 Dec 31	1977/08/16	McFARLANE SWAMP	1,000.00 GD

LICENSE	FILE	TERM	PRIORITY DATE	SOURCE	QUANTITY
C054033	0365798	Jan 01 Dec 31	1979/06/15	AVERY SPRING	700.00 GD
C054387	0355296	Jan 01 Dec 31	1979/09/01	VALENS BROOK	700.00 GD
C054338	0355987	Jan 01 Dec 31	1980/02/04	CHICKADEE LAKE	1,500.00 GD
C058749	1000059	Jan 01 Dec 31	1982/08/24	CHICKADEE LAKE	1,000.00 GD
C058747	1000064	Jan 01 Dec 31	1982/09/02	CHICKADEE LAKE	500.00 GD
C058748	1000060	Jan 01 Dec 31	1982/08/25	CHICKADEE LAKE	500.00 GD
C058746	1000066	Jan 01 Dec 31	1982/08/25	CHICKADEE LAKE	500.00 GD
C058975	1000058	Jan 01 Dec 31	1982/08/24	CHICKADEE LAKE	500.00 GD
C064077	1000520	Jan 01 Dec 31	1985/08/29	BIRKENHEAD CREEK	500.00 GD
C063936	1000453	Jan 01 Dec 31	1985/03/13	GRAHAM LAKE	1,000.00 GD
C065769	1000634	Jan 01 Dec 31	1986/08/13	VALENS BROOK	500.00 GD
C065722	1000585	Jan 01 Dec 31	1986/04/25	GRAHAM LAKE	1,000.00 GD
C065721	1000584	Jan 01 Dec 31	1986/04/25	GRAHAM LAKE	1,000.00 GD
C065724	1000587	Jan 01 Dec 31	1986/04/25	GRAHAM LAKE	1,000.00 GD
C065723	1000586	Jan 01 Dec 31	1986/04/25	GRAHAM LAKE	1,000.00 GD
C065725	1000588	Jan 01 Dec 31	1986/04/25	GRAHAM LAKE	1,000.00 GD

LICENSE	FILE	TERM	PRIORITY DATE	SOURCE	QUANTITY
Irrigation					
F053544	0238554	Apr 01 Dec 31	1961/09/25	CHICKADEE LAKE	1.80 AF
C038900	0305656	Apr 01 Sep 30	1971/07/12	CRAMER SWAMP	8.00 AF
C056651	0305518	Apr 01 Sep 30	1971/06/08	JOHANSEN SWAMP	3.00 AF
C053919	0329450	Jan 01 Dec 31	1975/09/11	CHICKADEE LAKE	5.00 AF
C050691	0341497	Apr 01 Sep 30	1977/06/28	CICERO SLOUGH	40.0 AF
C053057	0341857	Apr 01 Sep 30	1977/08/16	MCFARLANE SWAMP	1.5 AF
C054387	0355296	Apr 01 Sep 30	1979/09/01	VALENS BROOK	4.00 AF
C054037	03580306	Apr 01 Sep 30	1979/06/19	ALONZO SWAMP	7.50 AF
C058747	1000064	Apr 01 Sep 30	1982/09/02	CHICKADEE LAKE	5.00 AF
C058748	1000060	Apr 01 Sep 30	1982/08/25	CHICKADEE LAKE	5.00 AF
C058975	1000058	Apr O1 Sep 30	1982/08/24	CHICKADEE LAKE	5.00 AF
C061316	1000120	Apr 01 Sep 30	1983/01/19	WOOD SWAMP	7.50 AF
C065729	1000399	Apr 01 Dec 30	1984/07/24	LACON LAKE	18.00 AF
C064077	1000520	Jan 01 Dec 31	1985/08/29	BIRKENHEAD CREEK	4.00 AF
Industrial					
F053545	0296984	Jan 01 Dec 31	1970/09/12	CHICKADEE LAKE	500.00 GD

LICENSE	FILE	TERM	PRIORITY DATE	SOURCE	QUANTITY
C065729	1000399	Jan 01 Dec 31	1984/07/24	LACON LAKE	36.00 AF
Conservation and Land Improvement					
C061356	1000153	Jan 01 Dec 31	1983/04/12	McFARLANE SWAMP	150.00 AF
C056653	0305518	Jan 01 Dec 31	1971/06/08	JOHANSEN SWAMP	3.00 AF
Storage					
C036916	0296331	Jan 01 Dec 31	1970/04/24	CRAMER SWAMP	5.00 AF
C056652	0305518	Jan 01 Dec 31	1971/06/08	JOHANSEN SWAMP	3.00 AF
C038901	0305656	Jan 01 Dec 31	1971/07/12	CRAMER SWAMP	8.00 AF
C050692	0341497	Jan 01 Dec 31	1977/06/28	CICERO SLOUGH	40.00 AF
C054388	0355296	Jan 01 Dec 31	1979/09/01	VALENS BROOK	4.30 AF
C054035	0365806	Jan 01 Dec 31	1979/06/19	ALONZO SWAMP	7.50 AF
C061317	1000120	Jan 01 Dec 31	1983/01/19	WOOD SWAMP	7.50 AF
C067573	1000149	Jan 01 Dec 31	1983/03/25	GRAHAM LAKE	38.00 AF
C065729	1000399	Jan 01 Dec 31	1984/07/24	LACON LAKE	18.00 AF
C064078	1000520	Jan 01 Dec 31	1985/08/29	BIRKENHEAD SWAMP	4.00 AF
C065769	1000634	Jan 01 Dec 31	1986/08/13	VALENS BROOK	0.04 AF

HORNBY ISLAND WATER LICENCES
Date: 93/07/27

Licence	File	Term	Priority	Source	Quantity
Municipal Waterworks					
C067546	0305702	Jan 01 Dec 31	1971/07/22	Godfrey Springs	2,000.00 GD
Domestic					
C054322	0192682	Jan 01 Dec 31	1951/12/03	Fallows Spring	500.00 GD
C054112	0210646	Jan 01 Dec 31	1956/02/01	Parnell Creek	500.00 GD
C058237	0224392	Jan 01 Dec 31	1959/03/03	Cowie Spring	500.00 GD
C027774	0245415	Jan 01 Dec 31	1962/08/06	Maude Brook	500.00 GD
F021522	0262369	Jan 01 Dec 31	1965/05/05	Bond Spring	1,500.00 GD
C041865	0317534	Jan 01 Dec 31	1966/10/11	Lea Spring	500.00 GD
C032665	0270592	Jan 01 Dec 31	1966/09/26	Ford Spring	1,500.00 GD
C041864	0317533	Jan 01 Dec 31	1966/10/11	Lea Spring	500.00 GD
C041863	0270660	Jan 01 Dec 31	1966/10/11	Lea Spring	500.00 GD
C032665	0270592	Jan 01 Dec 31	1966/09/26	Harry Spring	1,500.00 GD
C032603	0273612	Jan 01 Dec 31	1967/06/20	Savoie Brook	500.00 GD
C034301	0277493	Jan 01 Dec 31	1968/01/16	McLachlan Spring	500.00 GD
C042346	0316110	Jan 01 Dec 31	1972/10/23	Anne Spring	500.00 GD

Licence	File	Term	Priority	Source	Quantity
C070765	0317653	Jan 01 Dec 31	1973/08/22	Crabapple Swamp	600.00 GD
C043428	0323063	Jan 01 Dec 31	1974/05/10	Fraser Spring	500.00 GD
C105744	0323909	Jan 01 Dec 31	1974/09/26	Fraser Spring	500.00 GD
C047106	0329888	Jan 01 Dec 31	1975/12/05	Jenny Spring	500.00 GD
C054222	0365442	Jan 01 Dec 31	1979/04/19	Parnell Creek	500.00 GD
C058559	0368983	Jan 01 Dec 31	1981/08/04	Savoie Spring	500.00 GD
C057670	0368350	Jan 01 Dec 31	1981/04/10	Beulah Creek	500.00 GD
C061434	1000102	Jan 01 Dec 31	1982/11/19	Spruce Spring	500.00 GD
C061462	1000100	Jan 01 Dec 31	1982/11/19	Neal Spring	1000.00 GD
C061464	1000099	Jan 01 Dec 31	1982/11/19	Timnick Spring	500.00 GD
C064088	1000463	Jan 01 Dec 31	1985/05/03	Aspen Swamp	500.00 GD
C064100	1000572	Jan 01 Dec 31	1986/03/20	Joshua Spring	500.00 GD
Irrigation					
C029825	0257325	Apr 01 Sep 30	1964/06/15	Maude Brook	20.00 AF
C041863	0270660	Apr 01 Sep 30	1966/10/11	Lea Spring	1.00 AF
C041865	0317534	Apr 01 Sep 30	1966/10/11	Lea Spring	1.00 AF
C032665	0270592	Apr 01 Sep 30	1966/09/26	Harry Spring	65.00 AF

Licence	File	Term	Priority	Source	Quantity
C041864	0317533	Apr 01 Sep 30	1966/10/11	Lea Spring	1.00 AF
C057099	0300050	Apr 01 Sep 30	1970/08/24	Slade Spring	50.00 AF
C067546	0305702	Apr 01 Sep 30	1971/07/22	Godfrey Springs	1.00 AF
C041069	0310975	Apr 01 Sep 30	1972/10/11	Zielinski Swamp	9.00 AF
C045729	0328160	Apr 01 Sep 30	1974/12/04	Rubinoff Pond	30.00 AF
C043428	0323063	Apr 01 Sep 30	1974/05/10	FraserSpring	0.33 AF
C061464	1000099	Apr 01 Sep 30	1982/11/19	Timnick Spring	2.00 AF
C061434	1000102	Apr 01 Sep 30	1982/11/19	Spruce Spring	1.00 AF
C061462	1000100	Apr 01 Sep 30	1982/11/19	Neal Spring	2.00 AF
Storage					
C029826	0257325	Jan 01 Dec 31	1964/06/15	Maude Brook	5.00 AF
C057100	0300050	Jan 01 Dec 31	1970/08/24	Slade Spring	30.00 AF
C041070	0310975	Jan 01 Dec 31	1972/10/11	Zielinski Swamp	9.00 AF
C045730	0328160	Jan 01 Dec 31	1974/12/04	Rubinoff Pond	30.00 AF

Quantity Units
GY - Gallons per year
GD - Gallons per day
AF - Acre-feet

Appendix E

Water Licence Applications

DENMAN ISLAND WATER LICENCE APPLICATIONS
Date: 93/07/27

Licence	File	Term	Priority	Source	Quantity
Domestic					
Z100952	1000700	Jan 01 Dec 31	1987/02/15	ZZ SPRING	2,000.00 GD
Z100984	1001108	Jan 01 Dec 31	1989/08/09	ZZ SWAMP	1,000.00 GD
Z100922	1001287	Jan 01 Dec 31	1990/05/23	GRAHAM LAKE	500.00 GD
Z102234	1001464	Jan 01 Dec 31	1991/06/21	ZZ SWAMP	500.00 GD
Z102968	1001492	Jan 01 Dec 31	1991/08/21	CHICKADEE LAKE	500.00 GD
Z105566	1001629	Jan 01 Dec 31	1992/10/22	GRAHAM LAKE	500.00 GD
Z106536	1001669	Jan 01 Dec 31	1993/03/23	GRAHAM LAKE	500.00 GD
Irrigation					
Z100984	1001108	Apr 01 Sep 30	1989/08/09	ZZ SWAMP	0.50 AF
Z102234	1001464	Jan 01 Dec 31	1991/06/21	ZZ SWAMP	5.00 AF
Storage					
Z102234	1001464	Jan 01 Dec 31	1991/06/21	ZZ SWAMP	1.00 AF

HORNBY ISLAND WATER LICENSE APPLICATIONS
Date: 93/07/27

License	File	Term	Priority	Source	Quantity
Domestic					
Z100944	1001127	Jan 01 Dec 31	1989/09/05	ZZ Creek	500.00 GD
Z100948	1001143	Jan 01 Dec 31	1989/10/12	ZZ Creek	250.00 GD
Irrigation					
Z100944	1001127	Apr 01 Sep 30	1989/09/05	ZZ Creek	2.00 AF
Z100948	1001143	Apr 01 Sep 30	1989/10/12	ZZ Creek	2.00 AF
Z100973	1001159	Apr 01 Sep 30	1989/11/16	ZZ Creek	20.00 AF
Industrial (Fire Protection)					
Z100944	1001127	Jan 01 Dec 31	1989/09/05	ZZ Creek	1.00 GD
Storage					
Z100948	1001143	Jan 01 Dec 31	1989/10/12	ZZ Creek	3.50 AF

Quantity Units
GD - gallons per day
AF - acre-feet