Hotel Lake

Summary of May 2002 Hydrology Report by Hugh G. Harris & Associates

Prepared by Hotel Lake Water Conservation Association

R.R. 1, Site 11, Comp 15
Garden Bay, B.C. V0N 1S0
Contact Phone: 604.883.9248
Contact Fax: 604.883.9938

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Cover photo: View of Hotel Lake looking east from top of Pender Hill – June 2003

Introduction

This summary describes the contents of the report entitled "Preliminary Report – Hydrology of Hotel Lake at Pender Harbour Area, Sunshine Coast, B.C.," dated May 30, 2002, prepared by Hugh G. Harris & Associates Inc.

The report is 50 pages long, plus appendices. The main text covers the fieldwork program conducted for the study; a general technical discussion of "the hydrologic cycle" and its associated water capture and release processes; an explanation of the applicable empirical calculation methods used to interpret hydrological data; and a detailed description of the regional setting with regard to precipitation, runoff, and evaporation. Given the lack of direct hydrometeorological information for Hotel Lake, much of the author's assessment is based on regional data for the rest of the Sunshine Coast. The combined fieldwork and regional data were used for spreadsheet analysis of the lake level water balance.

The report includes an executive summary, conclusions, and recommendations. The appendices contain details of lake level, precipitation, and outflow measurements obtained during the study period, and copies of the regional precipitation and stream flow records used for the analysis.

Purpose of Study

Hugh G. Harris and Associates Inc. was commissioned by Sunshine Coast Engineering (1993) to undertake a hydrological investigation of the potential of Hotel Lake to supply fresh water for domestic purposes for a new development at Daniel Point. The development would consist of 58 separate residential properties and 26 strata cottage lots, and would be served by the existing Hotel Lake water supply system operated by the Sunshine Coast Regional District (SCRD). Estimated demand during the high-use summer months is 2,300 litres/property/day for the 58 separate homes and 1,500 litres/unit/day for the 26 strata lots, for a total of 172,400 litres/day (37,921 Imp. gpd). This new housing development is additional to the Daniel Point Phase 2 plan, which consists of 57 properties.

The SCRD pumping station is located at the west end of Hotel Lake and provides filtrated and chlorinated water to residences further west, extending down to Irvines Landing, Lee Bay, and Daniel Point. Hotel Lake also supplies raw domestic and irrigation water to a small number of landowners around the lakeshore.

The Harris study was based on direct field measurements taken between May 2001 and April 2002, information supplied by the SCRD, and analysis of regional stream flow and precipitation data. In the absence of continuous records for the immediate area, the regional data were used to extrapolate and interpret conditions for Hotel Lake.

Other sources of information for the study included earlier, less-detailed work by Sunshine Coast Engineering (1993) Ltd., Dayton and Knight Ltd., Westland Resources Group, and Peter Peart Consulting Engineers. Records and observations by Peter Steernberg and Terry Mulligan, long-time property owners along the lakeshore, were also used in the evaluation.

Description of Hotel Lake

Hotel Lake is a summit, cistern lake assumed to have formed as a result of glacial recession during the Pleistocene. As a summit lake, it is not susceptible to contaminants entering from other lakes higher in elevation. The lake has two deep pockets, one extending to 10.5 m depth at the west end and the other to 10 m at the eastern end. The lake is full for about half of the year but drops seasonally from May/June to October/November due to water losses from outflow, evaporation, groundwater seepage, transpiration, water licence usage, and SCRD pumping. Other notable features of Hotel Lake are as follows:

- The lake and watershed are small compared to other lakes in the Pender Harbour area. The basin walls and bedrock formations in the watershed are quite steep, particularly in the vicinity of Pender Hill, Harbour Peak, and the areas above and below Hotel Lake Road.
- The lake is fed by direct precipitation on the lake water surface, overland runoff (including occasional snowmelt) down the surrounding slopes, and seasonal groundwater flows. The lake has no well-defined or active inlet streams, creeks, or rivers. Recharge to the lake after a major rainfall event is generally rapid and intense as water flows down the steep side slopes into the basin.
- Based on average annual precipitation of 1,100 mm in Pender Harbour (taken from the local building code), mean annual inflow to Hotel Lake is 1,120,000 m^3 and retention time is 1.4 years.
- Most of the precipitation that falls on Hotel Lake is derived from oceanic evaporation. The lake is a natural reservoir that collects this precipitation and overflows seasonally to Mixal Lake via a channel at Acadian Road and wetlands near Beaumont Road. The flow system continues down gradient from Mixal Lake to Sakinaw Lake to the Agamemnon Channel in Malaspina Strait.
- There is no surface outflow from Hotel Lake in the summer. Outflows through the Acadian Road outlet occur only from November/December to May/June.
- The subsurface structure at the Acadian Road outlet is a glacial moraine that acts as a dam to retain the water within the lake and minimizes losses to groundwater aquifers. The glacial fill has high clay content and is essentially impervious to groundwater seepage; D10 values (particle size distribution) of 0.0056 mm and 0.0398 mm were indicated from analysis of lake bottom core samples taken in this area. Excavation or other disturbance of the clay zone could result in uncontrolled spillage from the lake.
- Hotel Lake lies at an elevation of 51 m, is only 10.5 m deep (maximum), and does not extend below sea level. This may have implications for groundwater seepage from the lake, but no assessment has been done to date. In comparison, Mixal Lake and Sakinaw Lake are 24 m and 137 m deep, respectively, and do reach below sea level.
- Historical observations by residents along the lakeshore indicate that water levels in Hotel Lake may have dropped by as much as 609.6 mm (24 inches) in previous dry years. The hydrological calculations completed for this study indicate that the lake would have dropped by a maximum of 282.1 mm (11.2 inches) in September of 1985, the driest year on record with regard to regional precipitation.

Size and capacity data for Hotel Lake are summarized in Table 1.

Table 1: Hotel Lake Classification

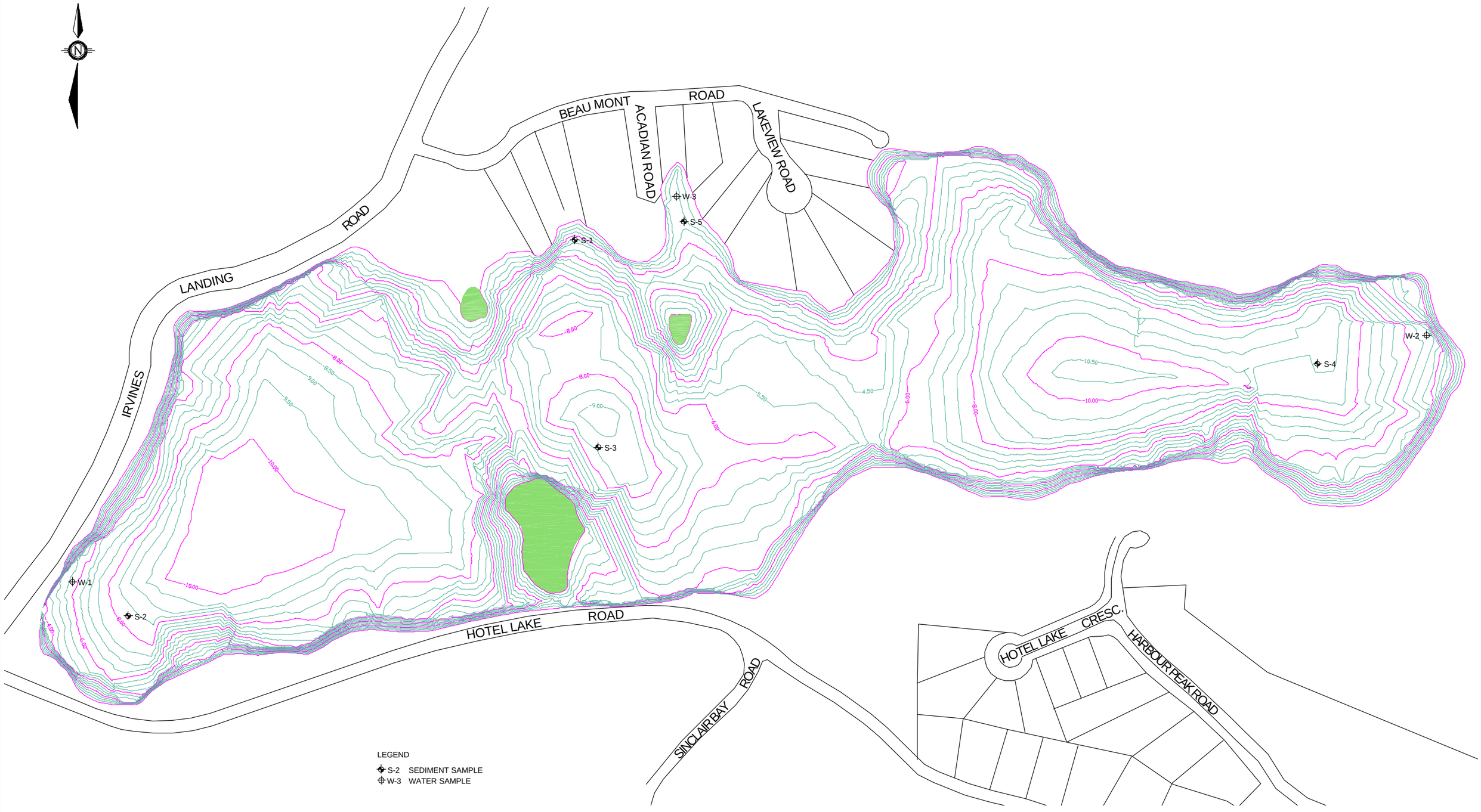
Lake formative process	Glacial, effectively
Open water length	1.16 km
Maximum effective length (fetch)	1.12 km
Maximum width	0.36 km
Surface area @ zero depth contour	273, 720 m^2
Surface area @ 0.50 m depth contour	267,840 m^2
Surface area @ 1.00 m depth contour	261,765 m^2
Mean width	0.24 km
Maximum depth	10.5 m
Lake volume below zero depth contour	1,718,360 m^3 (1,393 acre-feet)
Lake volume below 0.25 m depth contour	1,634,360 m^3
Lake volume below 0.50 m depth contour	1,552,930 m^3
Lake volume below 0.75 m depth contour	1,466,100 m^3
Lake volume below 1.00 m depth contour	1,208,060 m^3
Mean depth	6.3 m
Mean depth to maximum depth ratio	0.60
Overall tributary drainage area	1.019,609 km^2
Tributary drainage area above lake	0.745,899 km^2
General lake classification	Subcircular or elliptical

Fieldwork

Initial work included a visual inspection of the lake, the shoreline, and the surrounding watershed area. A bathymetric survey of the lake bottom was conducted on May 28, 2001. The survey plot (overleaf) shows the location and shape of islands, submerged sand spits, bars, and shoals, and points of maximum depth. Samples of the lake water and bottom sediments in selected areas were taken for laboratory analysis.

Three types of water measuring devices were installed during the study: a rainfall gauge, a lake level staff gauge, and a V-notch weir. Except as noted below, readings were taken at each station at 4:00 p.m. daily until April 30, 2002.

- The lake level gauge was installed offshore from Lot 14, at the east-central end of the lake, on September 5, 2001. The gauge was set an estimated 4 inches above the assumed low level of the lake that year, but was later moved to a more reliable site at the foot of Acadian Road to assure contact with the water surface.
- The rainfall gauge was installed beyond the end of the Lot 15 dock, also at the east-central end of the lake, on September 19, 2001. The site was carefully chosen to avoid the influence of trees, buildings, or other structures that could interfere with accurate measurement of total daily precipitation.



SURVEY DATE MAY 28, 2001
LAKE VOLUME 1,718,360m 3

HOTEL LAKE BATHYMETRIC SURVEY

PENDER HARBOUR, BRITISH COLUMBIA

PROJECT No:	DRAWING No:	
BCV40545	1	
DATE:	DRAWN BY:	SCALE:
OCTOBER 12, 2001	RR	1:3 000

Jacques Whitford

- The V-notch weir was installed upstream of the culvert below the lake outlet at Acadian Road in early November 2001, when there was no outflow from the lake. Although water was first noted at the weir on November 15, February and April of 2002 were the only full months of daily measurements. Despite permits being in place for continuous operation of the weir over the study period, it was removed twice under instructions from the DFO, first in November 2001, by the road maintenance contractor, and again at the beginning of March 2002, to accommodate "end of the year" small fish. The weir disappeared – assumed to be stolen – on January 2, 2002, and could not be replaced until January 29. Except for the DFO interruption in March, flow measurements were then taken through to the end of April 2002. When the weir was reestablished in March, however, it could not be sealed properly because of high water flows at the outlet at that time. Daily measurements during March had to be corrected for an estimated 30% leakage at the weir.

Spreadsheet & Water Balance Calculations

The report presents a detailed explanation of the spreadsheet calculations performed to derive monthly water balances and permit the estimation of changes in the lake level during the study period. The spreadsheet was based on the data acquired during the field program, supplemented by regional hydrometeorological records. Data sources for the water balance components are summarized below.

Precipitation

The Sunshine Coast region receives relatively large amounts of precipitation, much of it due to frontal systems that produce heavy rainfall on the windward sides of mountains. Rainfall levels increase northward along the Sunshine Coast. Mean annual precipitation in the Pender Harbour area is reported to be 1,100 mm, but very little site-specific information is available. Discontinuous daily records exist for May through April 1962, June through November 1962, January through March 1963, and the single months of May and November 1963. To generate representative numbers for the Hotel Lake water balance, comparisons were made with long-term daily precipitation records (1931–1998) for the Stillwater Power House, located between Earles Cove and Powell River at an elevation similar to that of Hotel Lake. Precipitation patterns between Pender Harbour and the Stillwell station were found to correspond well.

The driest year on record at the Stillwell regional rainfall gauge is 1985, with total precipitation of only 834.5 mm. This is probably the year when residents observed the lowest water levels in Hotel Lake and the surrounding lakes.

Inflow (Runoff)

Runoff that discharges to streams and lakes consists of surface (overland) runoff, subsurface runoff that infiltrates soils and fissures, and groundwater runoff resulting from deep percolation of infiltrated water. Groundwater runoff is thought to contribute to seasonal springs flowing into Hotel Lake, but most inflow to the lake is considered to result from precipitation runoff. Runoff into Hotel Lake is not clearly defined, however. The calculation of runoff is complicated by the

inability to develop a typical stream flow hydrograph, the most common calculation method, because of the lack of well-developed creeks or streams entering the lake.

Discharge records are available from Environment Canada and the Provincial Ministry of Water, Air and Land Protection for several regional watersheds; none of the records are long term, however. The data for Chapman Creek and Roberts Creek were considered to be most applicable for the extrapolation of minimum daily discharge rates and 7-day low flow rates for Hotel Lake. (Seven-day low flows are operating standards for water works.) The fact that Hotel Lake is north of, and receives more precipitation than, these other two drainages provides a degree of conservatism in the water supply calculations. This conservatism is reinforced by the characteristically swift inflows to Hotel Lake after a rainfall event, compared to lower recharge rates at Chapman and Roberts creeks.

August is the month of minimum flows in all regional watersheds and is therefore one of the critical months for water supply. The next lowest flow months are September, July, and June, in that order.

Design rainfall curves (rainfall intensity and duration for various return periods) provided by the SCRD were also used for the analysis. The curves are based on data collected at the Vancouver International Airport.

Water Pumping

Monthly water pumping volumes measured at the SCRD station on Hotel Lake over the study period were obtained from the SCRD Infrastructure Services Department. The water consumption figures are listed in Table 2. The figures indicate a downward trend in water consumption with time from June 2001 to April 2002. The pumping data and other losses were used to calculate the change in lake level, or drawdown, in each month based on a formula that incorporated the calculated area of the lake for that particular month.

Table 2: SCRD Hotel Lake Pumping Station Water Consumption

2001	Imp. Gallons	Cubic Metres	2002	Imp. Gallons	Cubic Metres
January	578,194		January	504,846	2,295
February	620,485		February	533,082	2,422
March	704,405		March	679,295	3,084
April	868,722		April	713,344	3,241
May	780,396				
June	952,203	4,329			
July	1,683,921	7,655			
August	1,247,797	5,672			
September	1,114,815	5,068			
October	1,169,600	5,317			
November	651,542	2,962			
December	516,300	1,886			

Outflow

Outflow represents the discharge leaving Hotel Lake during the months when it overflows to Mixal Lake via the Acadian Road outlet and adjacent culvert. The difficulties in obtaining continuous data from the weir installed at this location for study purposes were outlined previously. The data that could be acquired were factored in accordance with the measured lake levels and calculated surface area for each month.

Evaporation

No evaporation data are available for the Hotel Lake area. Environment Canada calculations for various other sites in B.C. were reviewed. Data from Agassiz, Comox, and Vancouver UBC were considered most representative for use in this study. Vancouver UBC is the only station that has data for all 12 months of the years of record (1951−1980) and was used as the basis of the Hotel Lake estimates. The Vancouver UBC levels fall within the range of mean annual lake evaporation figures for this general area of the Sunshine Coast given in the Hydrological Atlas of Canada.

Losses, including Water Licences

For this component of the water balance, losses intrinsic to the Hotel Lake hydrological cycle were estimated and combined with potential water consumption through licences for water extraction from the lake. Excluding SCRD usage (covered under "Water Pumping"), the study identified eight licences authorizing a total of 9,001 Imp. gpd. The lake drawdown resulting from this use was calculated at 0.15 mm for the month of September 2001, when the lake was at its lowest level of the year because of minimal rainfall in August. The report states: "In other months, when the lake is fuller and the surface area is larger, the water licences will be even less significant."

Minimum Water Balance

The assumptions and data used for the study period water balance (June 2001 to April 2002) were applied to the construction of a minimum monthly water balance reflecting conditions in 1985, the driest year on record. The input data were modified as possible where regional records were available for that year. These included precipitation records from the Stillwater Power House and evaporation records from Environment Canada. The results are shown in Table 3; all figures are millimetres.

The table shows that in the driest year on record, the lake is full and overflowing from January to April, draws down from June to October, then fills and overflows in November and December. The "Level" column indicates that the lake is full for one-half of the year. These trends generally corroborate the preliminary calculations from fieldwork and research performed during the study. According to the hydrological spreadsheet analysis, the maximum drawdown of Hotel Lake under the driest known conditions is 282.1 mm (11.2 inches).

Table 3: Minimum Lake Level Water Balance Spreadsheet for Hotel Lake (mm)

Month	Precip.	Inflow	Pumped	Outflow	Evapor.	Loss, WL	Level
January	41.2	43.9	-8.4	-25.9	-10.8	-40.0	Full
February	85.4	36.3	-8.9	-82.2	-15.5	-14.5	Full
March	91.5	40.2	-11.3	-121.2	-37.4	-38.2	Full
April	93.7	35.3	-11.8	-29.7	-82.8	+4.7	Full
May	36.6	46.1	-10.3	-21.5	-98.1	-129.9	-129.9
June	30.2	52.2	-15.8	-13.3	-110.7	-57.4	-187.3
July	0	42.9	-28.0	0	-124.7	-53.8	-241.1
August	37.9	43.0	-20.7	0	-101.2	-41.0	-282.1
September	69.3	65.3	-18.6	0	-60.7	+55.3	-226.8
October	170.4	64.6	-19.5	0	-27.6	+187.9	-38.9
November	114.0	103.9	-10.8	-0.5	-11.5	+195.1	Full
December	64.6	152.6	-6.9	-56.4	-7.3	+146.6	Full
Total	834.8	726.3	171.0	350.7	688.3	214.8	½ year full

Water Quality

The author makes two points with regard to water quality in Hotel Lake:

- Small lakes such as Hotel Lake that serve as a source of drinking water should be used for environmentally benign recreation activities only, and not for general transportation. The use of boats with outboard motors should not be permitted. Signage should be provided to emphasize the restrictions that are supposed to be in force in the area.
- Water samples taken near the SCRD pumping station during the course of the study indicated no E. coli. Minor E. coli was detected in samples from the more remote, eastern end of the lake, but levels were not unusual for raw water in drinking water lakes.

Conclusions for Development

Estimated water supply requirements for the new development at Daniel Point were based on average demand for the existing properties serviced by the current SCRD pumping system during the months of June, July, and August in 2001. The average summer demand for the development is conservatively estimated at 2,300 litres/property/day for the 58 separate homes and 1,500 litres/unit/day for the 26 strata cottages. Total demand would therefore be 172,400 litres/day, or 5,344,400 litres/month (5,344.4 m^3/month) for a summer month of 31 days.

To determine the drawdown resulting from this demand, calculations based on the surface area and storage capacity of the lake in these months were performed for three scenarios:

- If the potential drawdown of the lake level is assumed to be 609.6 mm (24 inches), as reported previously by local residents, the planned development would lower the lake level by 20.05 mm/month (0.79 inches/month).

- If the potential drawdown of the lake in the driest year on record is assumed to be 282.1 mm (11.2 inches), as indicated by the hydrological calculations for 1985, the planned development would lower the lake level by 19.77 mm/month (0.78 inches/month).
- Under a worst-case scenario, where the lake is drawn down at summer rates for a continuous seven-month period from May to November, the maximum overall lake drawdown would be 140.46 mm (5.53 inches) under the most extreme "previously observed" conditions.

Given these calculations, the lake would be drawn down by about 1% of its depth under even the most extreme dry conditions. The lake would still have between 1,464,000 m^3 and 1,558,00 m^3 of storage capacity, representing between 85% and 91% of the total volume of the lake.

Recommendations

The report concludes with the following recommendations:

1. More signs should be posted around Hotel Lake indicating that it is used for drinking water. No outboard motors or contaminants should be used or generated in or near the lake.
2. To assist in carrying out proper water resources management, the rainfall gauge and the lake level staff gauge should continue to be monitored until at least the end of September 2002 to gather more hydrological data for Hotel Lake.
3. A proper flow control structure that would allow for "end of the year" fish passage, and a coarse screen or trash rack, should be provided at the lakeside end of the Acadian Road gravel apron, which serves as the flow outlet from Hotel Lake
4. Any existing septic tanks operating in the Hotel Lake tributary area should be monitored for proper performance. Owners should improve and upgrade any malfunctioning systems.
5. The filtration and chlorination facilities in the SCRD pumping station should be operational at all times.
6. No large excavations should be permitted in the outlet moraine south of Beaumont Road in case the moraine is weakened and breached. This moraine dams the lake outflow and provides for its storage capacity. If a breach were to occur, a large volume of water could be lost from Hotel Lake.
7. It is recommended that the SCRD be requested to approve the proposed Daniel Point development of 58 upland residential properties and 26 waterfront cottage lots, all to be connected to the sanitary sewer system. The impact to Hotel Lake will be a maximum 140.5 mm (5.53 inches) of additional drawdown, or about 1% of the depth of the lake.