# GROUNDWATER SUPPLY POTENTIAL IN THE SOUTHWEST CORNER OF D.L. 28 WEST OF THE ISLAND HIGHWAY AT DEEP BAY

Prepared for

DEEP BAY WATERWORKS DISTRICT
R.R. 1, Site 150, C-4
BOWSER, B.C. V0R 1G0

Prepared by

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December 20, 1991

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December 20, 1991

Deep Bay Waterworks District
R.R. 1, Site 150, C-4
BOWSER, B.C. V0R 1G0

Attention: Mr. E.L. DeCosta
Chairman of the Trustees

Subject: Groundwater Supply Potential in the Southwest Corner of D.L. 28 West of the Island Highway at Deep Bay

Dear Sirs:

This letter is further to several recent telephone discussions between Mr. John Motherwell, P. Eng., of John Motherwell & Associates Engineering Ltd., and either Mr. Ed Livingston, P. Eng., or Ann Badry, Hydrogeologist, of Pacific Hydrology Consultants Ltd., concerning an evaluation of the potential of the Quadra Sand Aquifer to supply additional groundwater to several more wells in the area of Deep Bay Production Wells No. 4, No. 5 and No. 6. This letter is also in reply to a letter from John Motherwell & Associates Engineering Ltd. of November 15, 1991 which authorized, on behalf of Deep Bay Waterworks District, the present investigation.

## 1.0 INTRODUCTION

From the aforementioned discussions between Motherwell and Badry and Motherwell and Livingston, we understand that the situation concerning

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establishment of the southwest part of D.L. 28 as a Well Field for Deep Bay is as follows:

1. Provided that it is realistic to construct several additional production wells on the subject parcel of land, Deep Bay Waterworks District are considering the purchase of the property in order to expand present Well Field.

2. If the Property is purchased, it would be reserved for the future construction of Production Wells, with Wells installed as required to meet the demands of the Deep Bay Water System.

3. Once the capacity of the Quadra Sand Aquifer on the subject parcel of land has been reached, consideration would be given to further exploration on D.L. 28 at sites on the southwest side of the Highway.

In evaluating groundwater potential on the subject parcel of land we have:

Reviewed the various reports and letter-reports and letters in our file concerning the construction, testing and performance of all of the Deep Bay Wells (No. 1, No. 2, No. 3 (Kopina), No. 4, No. 5 and No. 7 and of the 1977 Test Well which is now part of the Provincial Observation Well Network No. 310). A summary table in Appendix B contains details about these Wells.

Obtained from B.C. Environment, the hydrograph from the aforementioned Provincial Observation Well which is attached in Appendix C.

Ran a computer program, using estimated aquifer parameters from Well lithologs and from aquifer parameters shown by pumping tests of the three Deep Bay Production Wells on the subject parcel of land.

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The issues to be considered in evaluating whether additional wells can be constructed on the subject parcel of land are the following:

1. What is the distribution of the thickest saturated part of the Quadra Sand Aquifer?

2. What is the present degree of interference between Production Wells and what is it likely to be if additional Wells are constructed?

3. What is the seasonal water table fluctuation in the Quadra Sand Aquifer at that location?

## 2.0 ISSUES AFFECTING GROUNDWATER SUPPLY POTENTIAL

### 2.1 Quadra Sand Aquifer Distribution

In detail, the distribution of the Quadra Sand Aquifer - in particular, the saturated thickness - is largely unknown. Table 1 in Appendix B shows that the depth to the bottom of the Quadra Sand Aquifer in the existing Deep Bay Waterworks District Wells varies from 11.0 m (36 ft) in Well No. 2, which is located in the southwest corner of District Lot 27, to a maximum of about 21.3 m (70 ft) in Wells No. 4, No. 5 and No. 6 on D.L. 28. In Provincial Observation Well No. 310, which was drilled for water supply for Deep Bay, encountered less saturated thickness of the Quadra Sand Aquifer because of a deeper static water level. Obviously the greater is the thickness of saturated sand, the higher will be the well capacity. Slight variations in sediment grain size may also result in better well performance and higher well capacity, at any particular site. It is not possible, however, to predict the distribution of the coarser zones within the Sand, nor is it possible from present subsurface knowledge to predict where the thicker parts of the Sand are, other than to say that

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the Sand apparently thickens in a southward direction. This certainly suggests that potential well sites exist on D.L. 28 on the southwest side of the Highway.

## 2.2 Seasonal Water Table Fluctuation

The hydrograph prepared by B.C. Environment, and attached in Appendix C, of water level observations in Provincial Observation Well No. 310, starts in February 1990 when the Well was equipped with an automatic water level recorder and established as a Provincial Observation Well. The hydrograph is prepared from month-end readings only; although the recorder charts are on file with B.C. Environment, Groundwater Section is no longer able to process the charts to produce detailed hydrographs which show the day-to-day fluctuations that are caused by, for example, the pumping of the nearby Deep Bay Production Wells. Thus, the hydrograph which B.C. Environment has provided shows only the month-by-month changes, with straight lines joining the points to better show trends. In examining the hydrograph, it is important to remember that the actual water level trend is far from regular as is indicated; rather, in detail, the water level has many small fluctuations due to such influences as: variations in water use from the Deep Bay Production Wells; barometric influences; patterns of recharge; changes in evapotranspiration; etc.

In summary, the hydrograph for Provincial Observation Well No. 310, which covers a period of about 20½ months, illustrates the following:

1. Highest groundwater levels occur in the early March to mid-April period.

2. Low water levels occur near the end of October.

3. In 1991, the maximum water level fluctuation in the Deep Bay Observation Well was about 2.4 m (7.9 ft); in 1990, the fluctuation was about 1.6 m (5.2 ft).

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4. The average difference between the water levels in 1990 and 1991 is about 1.2 m (4 ft); the water level was consistently higher in 1991 than in 1990.

5. The hydrograph does not seem to show any effects due to the pumping of the Deep Bay Production Wells, either in 1990 or 1991. A detailed hydrograph would certainly show small fluctuations due to pumping but the main trends are those we would expect from the Quadra Sand Aquifer under the hydrogeologic conditions at Deep Bay.

The natural water table fluctuations are caused by recharge from precipitation and probably also by deep groundwater flow systems originating in the topographic high recharge area to the south. In years with higher than average precipitation, the water level in the Aquifer rises to a level which is higher than in dry years. The present hydrograph covers too short a time span to indicate overall trends.

## 2.3 Production Well Interference

As discussed in the previous section, the hydrograph from Provincial Observation Well No 310 does not show any indication of influence from the pumping of the Deep Bay Production Wells. This agrees with the results from the testing of well No. 6 in December 1990. The maximum interference drawdown recorded in Well No. 5, at an approximate distance of 189 m (620 ft) from the pumping of Well No. 6, was 0.06 m (0.19 ft); the maximum interference drawdown in Well No. 4, which is located at a similar distance of about 173 m (570 ft), was 0.05 m (0.16 ft). Thus, it is not surprising that no interference was detected in Provincial Observation Well No. 310, at an approximate distance of 500 m (1640 ft).

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A microcomputer program was used to simulate interference drawdown at various times and distances. Inherent in such programs are various assumptions, such as an infinite aquifer; this assumption and others - for example, the aquifer is homogeneous - urge a note of caution when interpreting data from such simulations. However, having said this, the results from our simulation show that the drawdowns observed in Wells No. 4 and No. 5 during the 1990 test pumping of Well No. 6 are those expected for the prevailing hydrogeologic conditions. Thus a well spacing in the range of 170 to 185 m (560 to 610 ft) is a suitable spacing for keeping well interference to a minimum. On this basis, two additional wells on the subject parcel would be feasible. If a larger interference factor were accepted, as many as four wells could be constructed provided, of course, that hydrogeologic conditions are everywhere suitable. To put interference into perspective, an interference drawdown of 0.3 m (1 ft) in Well No. 5, which has the poorest performance (specfic capacity) of the three existing Wells on the subject parcel, represents a loss in well capacity of about 0.22 L/sec (3½ USgpm); for Well No. 6, which has the best performance of the three existing Wells, an interference drawdown of 0.3 m represents a loss in well capacity of about 0.3 L/sec (5 USgpm). As mentioned previously, the actual interference drawdown in Wells No. 4 and No. 5 during the test pumping of Well No. 6 at a rate of 9.15 L/sec (145 USgpm) was 0.05 and 0.06 m (0.16 and 0.19 ft), respectively, indicating that closer spacing is unlikely to significantly reduce individual well capacities.

## 3.0 DISCUSSION

All indications are that additional Production Wells can be installed on the subject parcel of D.L. 28 west of the Island Highway. The obvious main risk in purchasing the subject parcel of land without first carrying out the test-production drilling of at least one additional site is that the aquifer may be too thin on the southwest part of the parcel to support well(s) of economical capacity. Thus, the District may wish to

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consider purchase of the subject parcel of land under an option agreement so as to permit the drilling of a test-production well in the southwest corner of the site. Such test drilling would show the saturated aquifer thickness and also the static water level, from which it would be possible to estimate potential well capacity. Completion of a screened test-production well would obviously provide an even more definite answer, as it would permit careful pump testing during which interference on water levels in the existing Production wells could be observed. Further, it would be advisable to proceed with such pump testing at the end of the summer drought period, as the nature of recharge at the time of complete saturation of the aquifer when it is "full" might be different than at the time of minimum groundwater conditions. As previously discussed in Pacific Hydrology's Report of December 20, 1990 concerning the "Construction and Testing of Deep Bay Waterworks District Well No. 6", the amount of water which can be withdrawn by Wells completed in the Quadra Sand Aquifer in the subject area is limited by the permeability of the fine-grained Sand which restricts the amount of water that any particular well can withdraw; in other words, there is more water available in the groundwater flow system moving under the site than wells are able to withdraw. With Provincial Observation Well No. 310 in place, there will be plenty of warning if the capacity of the Aquifer is approaching its limit or being exceeded.

## 4.0 SUMMARY AND CONCLUSIONS

1. There is every indication that additional groundwater can be developed fron one or more production wells on the subject parcel of land comprising that part of D.L. 28 west of the Island Highway at Deep Bay.

2. All things considered, before purchasing the subject Property, it would be prudent to construct and test a test-production well in the southwest corner of the subject parcel of land to confirm that there is a sufficient thickness of saturated Quadra Sand Aquifer on that part of the parcel in which to construct wells of economical capacity.

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We trust that this letter and attachments contains the information which you require. Please call if you wish to further discuss any aspect of the contents of the letter, the attachements or any other issue which the District may wish to consider in making a decision concerning purchase of the subject parcel of land.

Yours truly,

PACIFIC HYDROLOGY CONSULTANTS LTD.

Ann Badry,
Hydrogeologist

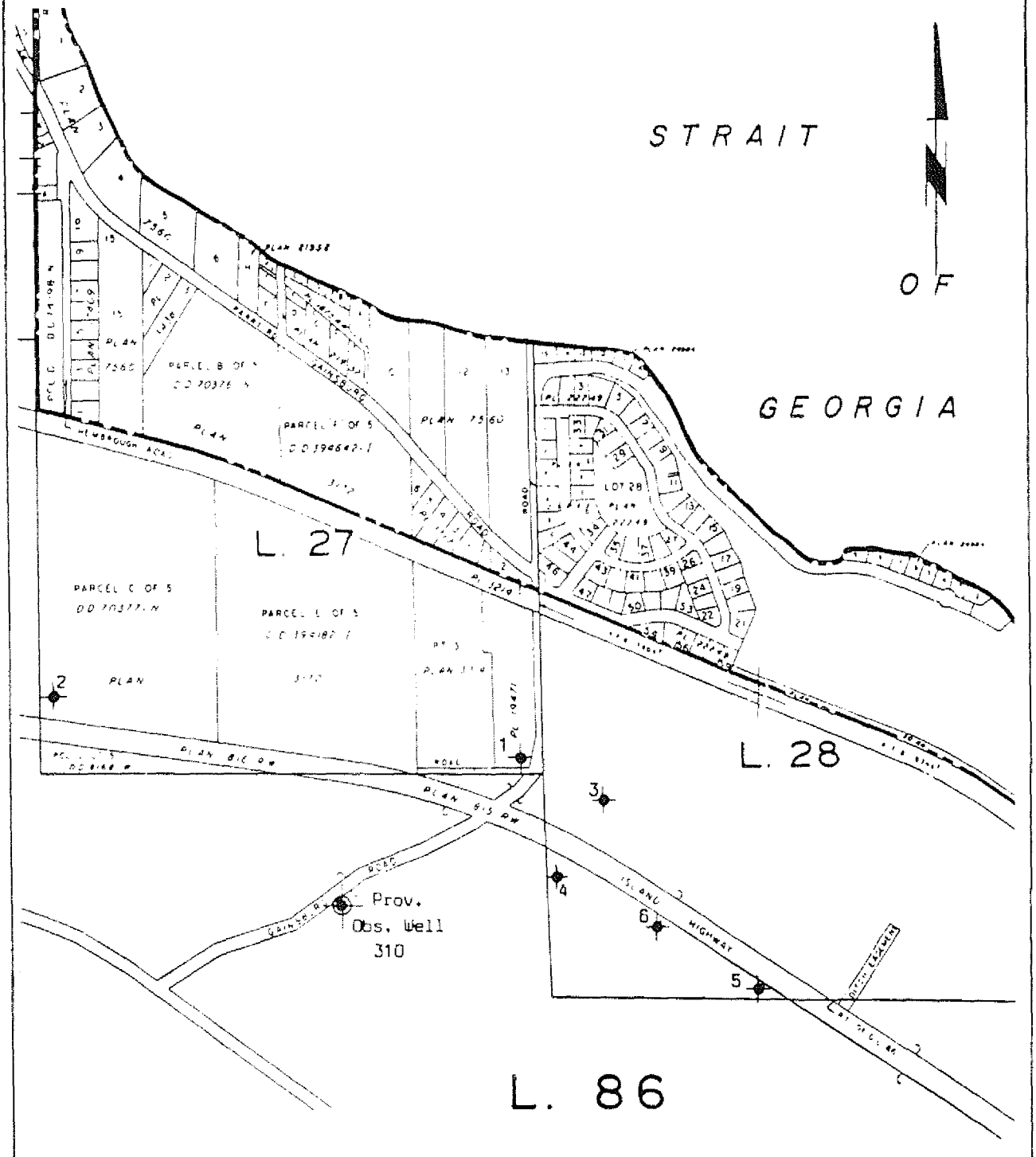
Attachments

c.c. John Motherwell & Associates Engineering Ltd.

# APPENDIX A

## DEEP BAY WATERWORKS DISTRICT WELL LOCATION PLAN

| FIGURE 1 | DEEP BAY WATERWORKS DISTRICT<br>WELL LOCATION PLAN |
|---|---|




Notes:

1. The scale of the base map is 1:9600.
2. 1 approximate (unsurveyed) location of a Deep Bay Production Well, as identified.
3. approximate (unsurveyed) location of Provincial Observation Well No. 310.

# APPENDIX B

## DETAILS ABOUT DEEP BAY WATERWORKS DISTRICT PRODUCTION WELLS

Table 1. Summary of Deep Bay Waterworks District Wells and Test Wells

| Deep Bay Well | Completion Date | Completed Well Depth (ft) | Static Water Level (ft) | Aquifer Material and Screen Interval | Litholog | | Remarks |
|---|---|---|---|---|---|---|---|
| No. 1 | Sept./73 | 52 | 7.33 (09/10/73)<br>11.45 (11/88) | sand; completed with 15 ft of 0.010" slot 8" nominal diameter Johnson stainless steel well screen, with the assembly set between 36 and 52 ft. | 0- 3 ft<br>3- 18 ft<br>18- 52 ft<br>52- 82 ft | silty sand and gravel<br>silty sand with water below 10 ft<br>fine brown sand<br>clay till. | 8" diameter; capacity rated at 4.16 L/sec (66 USgpm; 55 igpm) in 1973. |
| No. 2 | Sept./73 | 38 | 5.25 (09/11/73)<br>8.00 (11/88) | sand; completed with 10 ft of 0.010" slot 8" nominal diameter Johnson stainless steel well screen, with the assembly set between 27 and 38 ft. | 0- 18 ft<br>18- 36 ft<br>36- 44 ft<br>44- 50 ft | silty sand<br>fine brown sand<br>interbedded sand and silt<br>light grey soft till. | 8" diameter; capacity rated at 2.40 L/sec (38 USgpm; 32 igpm) in 1973. |

(Note that all measurements are referenced to ground level.)

**Table 1. Summary of Deep Bay Waterworks District Wells and Test Wells** (cont'd)

| Deep Bay Well | Completion Date | Completed Well Depth (ft) | Static Water Level (ft) | Aquifer Material and Screen Interval | Litholog | Remarks |
|---|---|---|---|---|---|---|
| No. 3 | June/69 | 53.7 | 2.65 (09/11/73)<br>1.10 (11/88) | sand; 12 ft of 6" nominal diameter 0.010" slot Johnson stainless steel well screen, with the assembly set between 40 and 53.7 ft. | 0- 4 ft soil<br>4- 14 ft till<br>14- 53 ft sand. | 8" diameter; capacity rated at 5.68 L/sec (75 igpm) in 1973. |
| No. 4 | Sept./77 | 63.5 | 14.79 (01/16/78)<br>18.60 (11/88) | sand; completed with an assembly of 8" nominal diameter Johnson stainless steel well screen as follows: 5 ft of 0.013" slot screen over 10 ft of 0.015" slot screen, with a lead packer at the top and a bail bottom, and with the screen assembly set between 47 and 63½ ft. | No log available but well is reported to have been drilled entirely in sand; sand and clay encountered at a depth of 70 ft. | 8" diameter; capacity rated at 6.37 L/sec (84 igpm) from from pump testing in January 1978. |

(Note that all measurements are referenced to ground level.)

**Table 1. Summary of Deep Bay Waterworks District Wells and Test Wells** (cont'd)

| Deep Bay Well | Completion Date | Completed Well Depth (ft) | Static Water Level (ft) | Aquifer Material and Screen Interval | Litholog | Remarks |
|---|---|---|---|---|---|---|
| No. 5 | June/85 | 70.5 | 4.15 (06/11/85)<br>7.01 (11/88) | sand; completed with 15 ft of 0.015" slot screen, with the assembly set between 55.4 and 70.5 ft. | 0- 2 ft topsoil<br>2- 12 ft brown sand<br>12- 20 ft brown sand and some gravel; water-bearing<br>20- 24 ft brown sand and occasional pebbles; water-bearing<br>24- 26 ft brown sand with occasional pebbles and a few pieces of brown silt; water-bearing<br>26- 34 ft brown sand and occasional pebbles; water-bearing<br>34- 56 ft brown sand; water-bearing<br>56- 58 ft brown sand and a small amount of gravel; water-bearing<br>58- 72 ft brown sand; water-bearing<br>72- 74 ft brown sand with pieces of grey silt; water-bearing<br>74- 76 ft greyish-brown fine silty sand<br>76- 86 ft greyish-brown fine silty sand with pieces of dark brown silt. | 8" diameter; capacity rated at 7.44 L/sec (98 igpm) from pump testing in June 1985. |

(Note that all measurements are referenced to ground level.)

**Table 1. Summary of Deep Bay Waterworks District Wells and Test Wells** (cont'd)

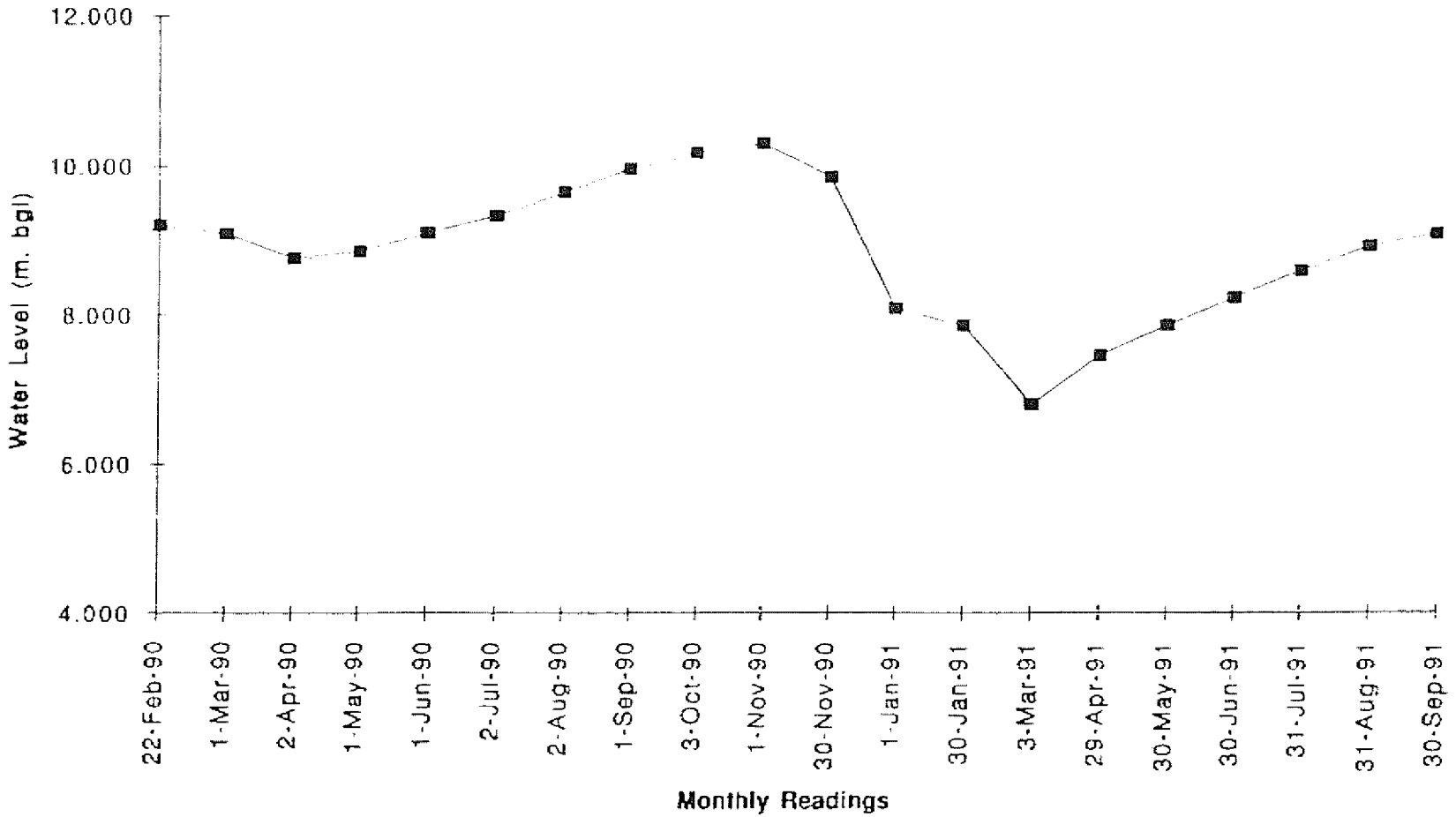
| Well | Completion Date | Completed Well Depth (ft) | Static Water Level (ft) | Aquifer Material and Screen Interval | Litholog | | Remarks |
|---|---|---|---|---|---|---|---|
| Deep Bay No. 6 | Dec./90 | 76 | 1.95 (12/19/90) | sand; completed with an assembly of 8" nominal diameter type 304 stainless steel well screen and 6" diameter pipe as follows: type 5 packer at top of 5 ft of 0.013" slot screen over 10 ft of 0.012" slot screen over 7 ft of 6" pipe, with a flat steel plate at the bottom of the assembly, set between 53.3 and 76 ft. | 0- 67 ft<br>67- 72 ft<br>72- 74 ft<br>74- 89 ft | yellow-brown medium sand; water-bearing below 25 ft<br>grey-brown silt and gravel<br>grey-brown sand and gravel containing chunks of peat<br>grey compact clay and gravel. | 8" diameter well; capacity rated at 9.5 L/sec (125 igpm) from pump testing in December 1990, with an allowance for interference and lower static water level at the time of minimum groundwater levels. |
| Prov. Obs. Well 310 | June/77 | 59.5 | 29.22 (06/26/77) | sand; completed with 15 ft of 8" nominal diameter stainless steel well screen with 0.015" slots, and with the assembly set between 43.2 and 59.5 ft. | - 3 ft<br>3- 10 ft<br>10- 32 ft<br>32- 40 ft<br>40- 58 ft<br>58- 59 ft<br>59- 63 ft<br>63- 83 ft | brown soil and roots<br>brown sand and gravel<br>brown silty sand<br>brown sand<br>brown sand; water-bearing<br>brown sand with traces of clay<br>clay and till<br>blue clay. | Test well drilled for Deep Bay Waterworks in 1977; now equipped as Provincial Observation Well No. 310; capacity of well rated at 37.5 igpm from pump testing in June 1977. |

(Note that all measurements are referenced to ground level.)

# APPENDIX C

## HYDROGRAPH FOR PROVINCIAL OBSERVATION WELL NO. 310

## Hydrograph Obs. Well #310 Deep Bay




(Note that the distance to water below ground reads from high to low contrary to convention so that at first glance the low water level has the appearance of occurring in March.)