

**PACIFIC HYDROLOGY CONSULTANTS LTD.**  
CONSULTING GROUNDWATER GEOLOGISTS

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September 20, 1985

Fownes Contracting (1980) Ltd.  
1355 Crown Street  
NORTH VANCOUVER, B. C.  
V7J 1G4

Attention: A. Fownes

Subject: Review of the Development of Several Groundwater  
Sources at Queen Charlotte City

Dear Sirs:

The purpose of this letter is to review the sequence of events in regard to the development of several groundwater sources at Queen Charlotte City to supply a total requirement of 125 igpm.

1.0 INTRODUCTION

Details about the test-production drilling, production well construction and testing program at Queen Charlotte City are contained in the following three project reports to David Nairne & Associates Ltd. from Pacific Hydrology Consultants Ltd.:

1. Drilling and Testing of Test-Production Well No. 1 - Queen Charlotte City Water Supply dated April 13, 1984.
2. Completion Report - Test-Production Drilling and Produc-

tion Well Construction and Testing - Queen Charlotte City  
Water Supply dated July 18, 1984.

3. Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984.

Before the project got under way, David Nairne & Associates Ltd. received a letter from McElhanney Surveying & Engineering Ltd. dated March 13, 1984 which says that it will probably be necessary for the Regional District to hire its own groundwater consultant to review the conclusions reached by the contractor's groundwater consultant. This letter specified what the contractor's groundwater consultant should do:

"Please note that, in order to provide a confident prognosis on the water supply we would expect your groundwater consultant to do the following:

- a) Run the test well for a minimum of 7 or 8 days.
- b) Monitor the quality and quantity of water on a continual basis.
- c) Monitor the affects on other wells in the area for both quality and drawdown.

We expect that if your study does not include these tasks as a bare minimum, any conclusions reached may be viewed with significant skepticism.

If the Regional District's specialist cannot concur with your consultant's report, the Regional District will be under no obligation to enter into a contract. The Regional District will not accept responsibility for any costs incurred in the drilling of test wells although they will accept the costs of their own ground water consultant in any event."

Pacific Hydrology regarded this as a most unusual way to start a project. McElhanney Surveying & Engineering Ltd., who (as far as we know) do not ordinarily

act as experts on groundwater and who did not acknowledge receiving advice from a groundwater consultant, defined the procedures for an unspecified groundwater consultant before any work had been done or any data submitted.

Because of the March 13, 1984 letter from McElhanney, Pacific Hydrology had a discussion about the Queen Charlotte Water Supply Project with Groundwater Section of Ministry of Environment in late March 1984 before the project started. From this discussion, Pacific Hydrology understood that Municipal Affairs would be advised by the Groundwater Section on matters relating to groundwater on the Queen Charlotte Project. When Pacific Hydrology invited Groundwater Section to participate in the project because of its unique nature, the offer was turned down in the event that Groundwater Section might be required by Municipal Affairs to advise them if a dispute occurred between the Contractor and Skeena - Queen Charlotte Regional District about groundwater.

## 2.0 REVIEW OF GROUNDWATER PROJECT

The test-production drilling program at Queen Charlotte City started in March 1984. Well No. 1 was pump tested starting on March 31 and Pacific Hydrology's report titled Drilling and Testing of Test-Production Well No. 1 - Queen Charlotte City Water Supply and dated April 13,

1984 was sent to David Nairne & Associates Ltd. A copy of this report was sent immediately to McElhanney Surveying & Engineering Ltd. in Prince Rupert. McElhanney then sent the report to the Regional District's groundwater consultant; Aquaterre Consultants Inc., who notified Pacific Hydrology in a letter dated April 24, 1984 that they had been asked by the Regional District to review the report.

Pacific Hydrology's April 13, 1984 report assigned a capacity of 58 igpm to Test-Production Well No. 1; the report concluded that the groundwater quality was acceptable for domestic use and that salt-water intrusion was unlikely. The report noted that during the pumping test of Well No. 1, an occasional strong odour of hydrogen sulfide gas was evident and that the discharge water contained suspended clay particles. Recommendations were made to deal with both conditions which are not unusual in shaley bedrock aquifers.

A copy of a letter from Aquaterre dated April 29, 1984 regarding Pacific Hydrology's report was received from David Nairne & Associates Ltd. under cover of a memo' dated May 10, 1984. The Aquaterre letter to McElhanney Surveying & Engineering Ltd. titled Report Evaluation - Queen Charlotte City stated,

" Although the yield calculations were not included with the report, it appears that 70% of available drawdown was used to determine the well yield of 58 Igpm. This calculation is correct. Our firm is somewhat more conservative when dealing with bedrock wells and in particular where the bedrock wells are located where a salt water encroachment potential exists.

These factors, combined with the rapid drawdown at 2495 minutes would tend to lead us to use only 50% of available drawdown to help minimize any intrusion potential. This is strictly a matter of design philosophy for the magnitude of safety factor desired. If 50% of available drawdown was to be the design criteria, then the well would be rated at approximately 40 Igpm."

This quote shows that Aquaterre agreed with the rating given Well No. 1 by Pacific Hydrology but suggested that they would use a greater factor of safety in rating the well. However, the quote also shows that Aquaterre incorrectly assumed that Pacific Hydrology used 70% of the available drawdown in the well to calculate the capacity. Pacific Hydrology determined the capacity of Well No. 1 in the usual way for wells constructed in bedrock aquifers by information obtained about the response of the well during pumping. Pacific Hydrology's experience in dealing with rock wells shows that the capacity of a rock well cannot be related to any safety factor; the capacity of such wells is determined by the extent of the fracture system intersected by the well and by the quantity of water that this fracture network will yield to the well. The basis for Pacific Hydrology's rating of Well No. 1 noted above is clearly stated on Page 5 - 1 of their report of April 13, 1984.

The test-production drilling and testing program continued between April and July, 1984. Five additional test wells were drilled and 4 of these were pump tested. Pacific Hydrology submitted a report on the program titled Completion Report - Test-Production Drilling and Production Well Construction and Testing - Queen Charlotte City Water Supply dated July 18, 1984 to David Nairne &

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Associates Ltd. This was sent immediately to McElhanney Surveying & Engineering Ltd. who forwarded it to Aquaterre, the Regional District's groundwater consultant, for review. Aquaterre's report titled Preliminary Report Evaluation Queen Charlotte City British Columbia dated August 1984 was sent to McElhanney with a covering letter dated August 29, 1984. The covering letter signed by Mr. Mark C. Moncur, P. Eng., Principal of Aquaterre, says,

"As I mentioned, this is only a quick overview and I can follow up with a more detailed assessment. The follow-up would include a comprehensive monitoring section and more analysis of interference by long term pumping."

This report was sent by McElhanney to David Nairne & Associates Ltd. with a covering letter dated August 31, 1984.

The Aquaterre Preliminary Report recommended reducing the capacities of the wells as rated by Pacific Hydrology in their Completion Report of July 18. Pacific Hydrology prepared a reply to the Aquaterre Report which was sent to David Nairne & Associates Ltd.; Pacific Hydrology's reply is dated September 6 and is titled Queen Charlotte City Water and Sewer Project - Reply to Aquaterre Consultants Inc.'s "Preliminary Report Evaluation - Queen Charlotte City - British Columbia".

Pacific Hydrology's reply of  
September 6, 1984 states,

" The "Preliminary Report Evaluation" of our report by Aquaterre Consultants Inc. dated August 1984 has little validity for the following reasons:

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1. It completely ignores the groundwater flow system at Queen Charlotte City. The existence of a vigorous flow system from the upland recharge area in the Skidegate Plateau to the discharge area in the sea is clearly shown by:
  - a. static water levels of wells;
  - b. no history of sea water intrusion in spite of the fact that the community is almost completely supplied with water from wells, most of which are closer to the sea than the new community wells;
  - c. observation well data (including water level and quality data) collected during pumping tests of the Community Wells;
  - d. very rapid water level recovery following long duration pumping;
  - e. wells located very close to shore show that salt water does not underlie fresh water (Ghyben-Herzberg effect) in spite of a very large tidal fluctuation.
  
2. The Aquaterre well ratings are apparently based on subsurface sections showing "projected cones of depression" relative to sea level. In our opinion, these cones of depression are not based on principles of groundwater hydrology. They also ignore the data from numerous observation wells used during the pumping tests.
  
3. Aquaterre mentions "calculated aquifer coefficients" (Section 4.0, Page 5). What are they? How are they calculated in a fractured rock aquifer?

Aquaterre does not provide a satisfactory explanation of the Cross Sections in Appendix A of their report. What do the dashed lines represent? Where did the line representing "The projected cone of depression at 30 lqpm" on Section 1 come from? How was it constructed? What time is it based on? Further, it does not show two observation wells (used during the pumping test of Well No. 1) that are located almost on the Section. Why is the cone of depression not shown on the inland ("north") side of the well?

No answers to the questions raised by Pacific Hydrology were received nor was a "more detailed assessment" referred to in the Aquaterre covering letter of August 29, 1984 provided.

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The Pacific Hydrology Completion Report of July 18 was also sent by Municipal Affairs to the Groundwater Section for their assessment. This assessment by Groundwater Section was sent to Municipal Affairs in the form of a memorandum dated September 18, 1984; Municipal Affairs forwarded it to McElhanney Surveying & Engineering Ltd. with a covering letter dated September 24, 1984. The covering letter, signed by Mr. A. A. McTaggart, P. Eng., Director, Engineering Services, says of the Groundwater Section memorandum,

" The report indicates that there is a lack of information regarding the location of the water bearing fractures, information which in his opinion is critical for a proper assessment of well yield. The report therefore, cannot be considered conclusive. In view of your concerns over the estimated yields, as well as possible consequences of over-demand and subsequent salt water intrusion, I would recommend caution in acceptance of the yields estimated by the contractor's representatives. As we are concerned that the rated well yields ensure reasonable safety from future aquifer problems, I would suggest that you should arrange to review your consultants' ratings with the contractor's consultants with a view to arriving at an acceptable conclusion."

The correspondence from the Government, in particular the Groundwater Section Memorandum, does not state what the well ratings should be. The following statements in the Groundwater Section Memorandum, however, are significant:

"We have no specific information to believe that the well ratings proposed by the consultant are unreasonably high."

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"Unfortunately far too little is known about the behavior of fractured bedrock aquifers under long-duration production conditions in locales such as Queen Charlotte City. There are moreover no established hard and fast rules for assessing long term well yields in fractured aquifers as knowledge in this area



has only been evolving during the past fifteen years or so in British Columbia. The new testing methods employed by Pacific Hydrology in conjunction with other methods hopefully will lead to a more reliable assessment of bedrock wells in the province. There is understandably a degree of uncertainty in dealing with groundwater in fractured rock systems and subsequently a need to monitor such systems to determine whether they behave as initially predicted. For these reasons it is recommended that a monitoring program is established in conjunction with any planned operation of the production wells."

Pacific Hydrology's Completion  
Report - Test-Production Drilling and Production Well  
Construction and Testing - Queen Charlotte City Water Supply  
of July 18, 1984 included an inventory of all known wells in Queen Charlotte City. Because the assigned capacities of Wells No. 1, No. 3, No. 5 and No. 6 based on pump testing only totalled 103 igpm, a program of testing existing wells was undertaken in early October, 1984 to identify wells of economic capacity to satisfy a source requirement of 125 igpm.

After the permanent pumps were installed in Wells No. 1, No. 3 and No. 5, the wells were pumped for long periods in early October, 1984 while water levels and pumping rates were observed. These pump test results, along with data collected during the simultaneous pump testing of existing wells carried out to identify additional well capacity, are presented in a report by Pacific Hydrology, Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984. These tests confirmed the capacities of Wells No. 1, No. 3 and No. 5 as assigned in the Completion Report of July 18 and also identified Wells No. 7 and No. 8 with capacities of 16 and 17 igpm, respectively for a total source capacity of 126 igpm.

On October 18, 1984, after discussions with Nairne, Ed Livingston of Pacific Hydrology flew to Prince George and met Mr. Moncur of Aquaterre at his office for about 2 hours to discuss the wells at Queen Charlotte City. Mr. Moncur was presented with a draft copy of the Pacific Hydrology report Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984. The discussion focused on the ratings of all of the wells included in the group proposed to satisfy the contract requirement of 125 igpm. The main emphasis in the discussion was on the plots of data from the tests. Moncur concurred that the recent tests confirmed the ratings that had been assigned to Wells No. 1, No. 3 and No. 5 by Pacific Hydrology in the July 18 Completion Report; he also concurred with the ratings assigned to the two additional wells (No. 7 and No. 8) purchased for the system from private owners.

Subsequently, a final copy of the Addendum Report was sent directly to McElhanney Surveying & Engineering Ltd. and to Aquaterre Consultants Inc. as per Nairne's instructions.

In the discussion of October 18, 1984 with Moncur, Livingston brought up the need for one or more permanent observation wells in the community to show how the water table fluctuated with the seasons and in response to water production from the aquifer. Livingston advocated using existing domestic wells which would no longer be used for water supply when the water distribution system

was operating. He also suggested that observations be made monthly by the system operator using a simple electric water level indicator. Moncur favoured the drilling of one or more observation wells and equipping them with automatic electronic water level recorders. He agreed, however, that manual observations would be adequate to detect seasonal changes and give warning of serious long term lowering of the water table. Mr. Moncur said that he favoured equipping each production well with an electronic water level recorder to collect data for aquifer management. He said that Aquaterre had been using such equipment and had found it to be dependable and trouble free. He did agree, however, that manual monitoring of water levels and other data would be adequate.

In a letter to David Nairne & Associates Ltd. dated October 31, 1984, McElhanney Engineering Services Ltd. stated,

"Aquaterre have agreed that the well ratings are conservative given that the October test results are reliable and repeatable over the long term under varying conditions. They insist, however, that only an effective monitoring system would provide the required information to ensure this. They have urged the installation of electronic level monitors in each well along with totalizing and hour meters. This would provide long term data on well capacities under varying use, weather and recharge conditions. Given the above we do not feel that contract conditions have been met at this time."

Attached to the McElhanney letter was a letter from Aquaterre to McElhanney dated October 25, 1984 which stated,

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" In summary, in light of the new data presented we must concur with the yields suggested by Pacific Hydrology, specifically:

Well #1	58 Igpm
Well #3	20 Igpm
Well #5	15 Igpm
Turner #65	16 Igpm
Williams #24	17 Igpm

Well #6 has not been addressed as no new data has been presented.

We stress that continuous electronic monitoring is essential as well as quarterly chemical analyses of each well.

We feel strongly that this monitoring program should be undertaken by the Skeena Queen Charlotte Regional District or its representative, so that if a problem arises it can be addressed immediately."

Because the "continuous electronic monitoring" issue had apparently not been resolved, on November 15, 1984, after a discussion with Larry Owen of Nairne, Ed Livingston telephoned Mr. Moncur of Aquaterre for further discussion about well ratings and about management of the aquifer, including monitoring and the establishment of observation wells. This discussion is reported to Nairne in a letter from Pacific Hydrology dated November 16, 1984.

McElhanney also wrote to Nairne on November 16, 1984 about monitoring; the McElhanney letter enclosed a copy of a letter from Aquaterre also dated November 16, 1984. Aquaterre states,

" We still feel, based on the pumping test information received, that there is some reasonable doubt whether a safe long term yield of 125 Igpm can be obtained from the existing wells. Although we must concur with the yields suggested by Pacific Hydrology based on the second set of pumptests we are still concerned about the discrepancy between the first and second set of pumptests on Well #1 which indicates the sensitivity of this well

to pumping at rates only slightly above the recommended yield. However, the information clearly indicates that the bedrock groundwater regime is favourable and we have no doubt that the required yield can be obtained, the only question being how many wells are required. With any groundwater evaluation there is always some doubt as to what the long term yield of a well will be. For this reason it is not common for contractors or consultants such as ourselves to work on a "well performance" basis. "

This quote shows that Aquaterre concurs with the well capacity ratings assigned by Pacific Hydrology which total 126 igpm and then seems to indicate that more wells are needed to achieve the required yield of 125 igpm. Statements in the paragraph are contradictory.

The Aquaterre letter of November 16 recommends monitoring of water levels, water quality and production of the wells during use. With regard to a monitoring method, Aquaterre says,

"Adequate water level monitoring can be carried out manually as proposed by Pacific Hydrology, although for an application such as this we prefer continuous electronic monitoring."

The Aquaterre letter also recommends that Well No. 1 be used as the main source well and that monitoring be carried out by the Regional District.

In contrast to the statement quoted above, the McElhanney covering letter of November 16 says of Aquaterre,

"They remain convinced that only continuous electronic monitoring of water levels could confirm such yields."

This is not what the Aquaterre letter says nor is it what Mr. Moncur of Aquaterre told Mr. Livingston during the discussion at Aquaterre's Office in Prince George on October 18, 1984, although it is clear that Mr. Moncur prefers continuous electronic monitoring. Further, McElhanney states,

"We note that you have expressed unwillingness to provide the monitoring that Aquaterre feel is necessary to confirm the data over the long term."

Aquaterre has not stated that such equipment is necessary. The McElhanney letter of November 16 recommends

" . . . that Fownes install continuous electronic water level meters on all wells to facilitate monitoring. It is our understanding that Pacific Hydrology have agreed that these would be desirable."

At no point has Pacific Hydrology made such a statement.

In early 1985, McElhanney requested from Nairne an outline of procedures for the Regional District maintenance personnel for monitoring of the wells. This is presented in a letter to McElhanney from Nairne dated February 6, 1985; the Nairne letter was sent by McElhanney to Aquaterre for review. A letter dated February 28 from Aquaterre to McElhanney deals with this review. It suggests that the Nairne procedures are difficult and may not produce the required information. A letter from McElhanney dated March 6, 1985 includes a section on monitoring which also rejects the Nairne monitoring procedure because it will not yield sufficient data and because it does not provide equipment for the maintenance man to carry out the work.

On instructions from Larry Owen of Nairne, Pacific Hydrology wrote Nairne a letter dated April 15, 1985 about monitoring. The Pacific Hydrology letter proposed the establishment of three monitoring wells in the community, and a suggested monitoring procedure for the maintenance staff of the water system was outlined. Pacific Hydrology's criticism of Nairne's monitoring procedure was only that it was too specific. Pacific Hydrology outlined a general procedure that could be carried out by the Waterworks System Operator on his normal rounds.

At the end of May, Mr. Myshrall, the Queen Charlotte City Water System Operator, reported that the water quality had deteriorated after Wells No. 7 and No. 8 had been in constant use as the sole sources for the system for about 2½ months. He also reported that Well No. 7 had been shut off by the low water control set at about 26.8 m (88 ft). Water samples were taken from Well No. 8 and were sent by Mr. Myshrall to Aquaterre for analysis.

A letter to McElhanney from Aquaterre dated June 14, 1985 reports on the results of partial chemical analyses which confirm that the water from Well No. 8 was brackish after the long period of pumping. The letter states,

"If these problems occur at such an early stage of low usage of the system, the long term implications could be disastrous. This reinforces totally the need for a comprehensive monitoring program for both quantity and quality which should be implemented immediately. The desirability for continuous electronic monitoring is fast becoming a reality."

The Aquaterre letter suggests that the use of the well be stopped and more extensive pump testing and sampling be done before putting the well in use again. The last statement in the letter says that a more detailed report will follow.

In a telephone discussion of June 17 with Nairne, Pacific Hydrology pointed out that, in the original report on Wells No. 7 and No. 8 (Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984), it was recommended that these wells be used to meet peak demand in the system. The use of these two wells as sole sources for the system over a period of 2½ months is most unusual. Following the report of brackish water, Pacific Hydrology suggested that after Well No. 8 had been out of use for a short period of time (say 1 week), the pump be started and water samples be taken after 1 hour and after 1 day to determine whether the flow of fresh groundwater had driven the brackish water back to the sea. A letter from Nairne to McElhanney on June 17 discussed the water quality change at Well No. 8 and recommended the sampling procedure mentioned above. McElhanney later informed Nairne that the recommendations in their June 17 letter had not been carried out. However, Wells No. 7 and No. 8 were used several times later in the Summer and water from Well No. 8 was found to be fresh.

When Wells No. 1, No. 3 and No. 5 were put into production in the Summer of 1985, the water



from all three wells was found to be turbid - apparently because of the presence of very fine clay particles in suspension. This was reported to Nairne by telephone. A letter from Aquaterre to McElhanney dated July 29, 1985 presents analyses for turbidity and iron for Wells No. 1, No. 3 and No. 5. It also mentions dewatering of Well No. 7 which, according to reports from the water system operator, has been shut off several times by the low water control.

A letter from McElhanney to Nairne dated August 12, 1985 deals with several matters concerning the sewer and water distribution systems along with a section on the wells. On Page III, McElhanney make a statement to the effect that the wells of the system are considered to have a capacity of zero so that Fownes must now come up with a source of 125 igpm. At the request of Nairne, Pacific Hydrology prepared a reply to the section of this letter that concerned the wells. This reply is contained in a letter to Nairne dated September 9. The Pacific Hydrology letter rejects the McElhanney assessment of the wells, discusses the problems of turbid water (with iron) and recommends a procedure to deal with turbidity.

In the September 9 letter, Pacific Hydrology states the following,

" The parts of the McElhanney letter dealing with wells are consistent with previous complaints about the wells in that no data are presented to back up their statements. The letter states: "Well #7 has failed on four occasions in the past month due to low water shutdown." Just because the control shut off the pump, it cannot be concluded that the well

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failed. No information is provided on:

1. the pumping rate;
2. how long the pump had been running before it shut off;
3. static water level;
4. location of shut-off probe;
5. recovery of the water level when the pump stopped.

The statements about Wells No. 1, No. 3 and No. 5 are little better in that we are given no facts about their operation. The Aquaterre letter presents data about turbidity of water from Wells No. 1, No. 3 and No. 5 but there is no information about:

1. date and time when samples were taken;
2. conditions at the wells at the time samples were taken - for example, how long the wells had been pumped, the pumping rates and the water levels in the wells;
3. where the analyses were carried out;
4. whether the iron analyses are for total or dissolved iron.

The Aquaterre letter states: "There is a possibility that the elevated iron is due to the high turbidity levels." It is well known that total iron is almost always high in analyses of turbid waters. Analyses at the time of the pumping tests of these wells in 1984 showed that the water was low in iron.

The McElhanney letter again brings up the matter of Well No. 8 which they claim yielded brackish water after a long period (2½ months?) of practically continuous operation earlier this year. The letter states: "... and Well #8 has failed with salt-water intrusion." In the case of Well No. 8, this should not be called a failure. Well No. 8 is closer to the sea than any other well in the system. In our report Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984 we pointed out the possibility of salt-water intrusion on Page 15: "Although the chance of salt-water intrusion is remote, we recommend that if (in future) peak demands on the system approach the combined capacity of the wells supplying the system, the two wells closest to shore (that is, Turner and Williams) be used to meet peak demands.

We understand that the recommendation made in the sentence quoted above was followed in the programming of the panel which controls the sequence in which the wells are called into operation. We understand

that Well No. 8 has since been used twice during the summer to supply much of the system while normal operation was disrupted by work on the system and, further, we understand that the water quality was good.

Well No. 8 has not failed: it is clear that it is a satisfactory source when it is used to meet peak demands as we recommended.

The presence of very fine sediment in new wells completed in soft, shaley rock is not very surprising. We are quite sure that this condition will clear up: Wells No. 1, No. 3 and No. 5 were pumped to waste with the installed permanent pumps in October, 1984 and yielded clear water."

There is little doubt that the sediment condition will clear up again. The September 9 letter recommends a procedure to deal with this occurrence.

### 3.0 CONCLUSIONS

The following conclusions are evident from this review of the development of several groundwater sources at Queen Charlotte City:

1. Adequate testing of several sources has been carried out at Queen Charlotte City according to usual procedures to confirm a potable water source with a capacity greater than 125 igpm.
2. No documentation has been provided by Skeena-Queen Charlotte Regional District's Engineers that proves that a source capacity of 125 igpm has not been provided. Extensive documentation of pumping test data confirming the source capacity along with analysis of the groundwater flow regime has been provided in three project

reports from Pacific Hydrology Consultants Ltd. to David Nairne & Associates Ltd.:

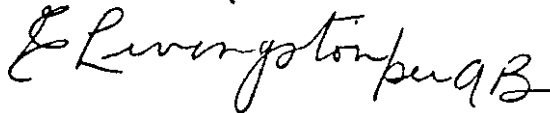
- a. Drilling and Testing of Test-Production Well No. 1 - Queen Charlotte City Water Supply dated April 13, 1984.
  - b. Completion Report - Test-Production Drilling and Production Well Construction and Testing - Queen Charlotte City Water Supply dated July 18, 1984.
  - c. Addendum to Completion Report of July 18, 1984 - Additional Well Capacity - Queen Charlotte City Water Supply dated October 18, 1984.
3. The aquifer supplying water to the Queen Charlotte City Wells is quite unusual in the Province and because of this, careful operation and management of the source is even more important than usual. This fact has been stressed in all three Pacific Hydrology project reports. Such management of the source, including implementation of a monitoring program, is usually the responsibility of the Community or the Waterworks District served by the source; it is not usually the responsibility of the construction company who installs the system. The contractor's responsibility is usually to make provision for monitoring to be carried out as defined in the terms of the contract to install the system. At Queen Charlotte City, adequate provision for monitoring has been provided by the installation of small diameter PVC pipes in each well to measure water levels and by installation of water meters at each well head to measure production.
4. Problems with the wells that have been experienced during start up of the System at Queen Charlotte City are not unexpected in consideration of the unusual aquifer. All of the problems that have been experienced can be easily dealt with by logical procedures of operation and management.

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Please call if you require clarification of any aspect of this letter or if you require additional information.

Yours truly,  
PACIFIC HYDROLOGY CONSULTANTS LTD.

A handwritten signature in cursive script, appearing to read "E. Livingston per AB".

E. Livingston, P. Eng.