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TACOMA, WASHINGTON

COMPLETION REPORT

WATER WELL DRILLING AND TESTING PROGRAM

for

DORMAN BAY ESTATES LTD.

Bowen Island, British Columbia

by

W. L. Brown, P.Eng.
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October 1972

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INTRODUCTION

This report summarises the drilling and pump testing work that has been carried out to prove a reliable source of water for the property owned by Dorman Bay Developments Ltd. The property is located just south of Snug Cove, on the eastern shores of Bowen Island in Howe Sound. Figure: 1 shows the extent of the property and the approximate location of the three drilled wells.

Two of the wells PW-1 and PW-2 were drilled deep into the bedrock, 350 and 400 feet respectively, and produce water from water-bearing fractures in the rock. The third well is shallow, 25 feet deep and yields water from the overburden material. The rated combined capacity of the three wells is 18.5 US gpm. (15.5 Imp. gpm).

GEOHYDROLOGY

The subject property has a steeply sloping topography with bedrock close to or at the ground surface. The rock is composed of altered volcanic and sedimentary rocks. There are two minor bedrock fractures which transect the property and run parallel with the coast line (see Figure: 1). The two deep wells were drilled into these fractures. PW-1 is located on the lower fracture and PW-2 on the upper fracture. The third well PW-3 is producing water from a shallow sand and gravel filled depression in the bedrock surface, which results from the upper fracture.

The natural groundwater recharge to the water-bearing fractures is estimated to be 23 gpm. This assumes an area of recharge, as shown in Figure: 1, which is 0.21 square miles. The average annual precipitation is 33 inches and the recharge is assumed to be 10% of the precipitation.

WELL CONSTRUCTION

Three wells were drilled on the subject property. The two deep bedrock wells were drilled in October 1972. The third, overburden well, was drilled at an earlier date.

PW-1

An 8-inch diameter hole was first drilled to a depth of 33 feet. Bedrock was encountered at a depth of 21 feet (see Figure: 2). Thirty-three feet of 6¼ inch diameter casing was set in the 8-inch hole and the annular space outside the casing was cement-sealed. The bedrock was then drilled using a 6¼ inch diameter bit. When the drilling had reached the final depth at 350 feet the hole was blown and washed out.

PW-2

This well was constructed in a similar manner to PW-1. The surface casing was set and sealed to a depth of 31.5 feet and the total depth is 400 feet (see Figure: 3).

PW-3

This well was not drilled by contractors working under our supervision. The information that we have on this well is that it was drilled using an 8-inch diameter casing. A 6-inch diameter casing was set with the bottom five feet perforated and the 8-inch casing was then removed (see Figure: 4).

HYDRAULICS

Pump tests were run on each of the completed deep rock wells and a siphon test run on the shallow well.

DR-1

Water-bearing fractures were encountered while drilling at depths 132 and 265 feet below ground. A two day pumping test was run on the well and the continuous pumping rates were as follows:

Pumping Rate (US gpm)	Duration (hours)
6	20
8	5
6.7	22½
Total	47½

The pumping level in the well after one day's pumping at 6 gpm was 145 feet. When the pumping rate was increased to 8 gpm the pumping level dropped rapidly to 280 feet. The rate was then reduced to 6.7 gpm and the well remained fairly stable.

From an analysis of the pump test and the well recovery data we rate the well's safe pumping capacity at 6 US gpm.

PW-2

Water-bearing fractures were encountered at depths 190, 237, 345 and 367 feet. A two day pumping test was run at the following pumping rates:

Pumping Rate (US gpm)	Duration (hours)
8	3
10	19
10.5	25

The pumping level at the end of the two day test was stable at 200 feet below ground. Using data from the pump test and recovery of the well the safe pumping capacity of the well is calculated to be 10 US gpm.

PW-3

A siphon test was run on July 20-22, 1972. The siphoning rates were controlled by means of a valve and were as follows:

Flow Rate (US gpm)	Duration (hours)
18	8
9	10
5	24

A study of the pump test and well recovery data indicate that the well has a safe productive capacity of 2.5 US gpm. The aquifer immediately around the well has a storage of 4,300 gallons. The recharge to this aquifer is from fractures in the rock to the west of the well. Measurements in PW-3 during the testing of PW-2 showed that there is no direct connection between the two wells. The static water level in PW-2 is at elevation 431 and in PW-3 at 446.5. This indicates that there is a natural seal between these two aquifers.

WATER QUALITY

Water samples were taken at the start and finish of each of the pump tests run on the two deep wells. The water samples were submitted to a chemical laboratory for inorganic chemical analysis. A copy of the chemists report is enclosed with this report.

The chemist reports that the water is slightly alkaline and extremely soft. The water contains a fairly high sodium carbonate and bicarbonate content which accounts for the high pH content and the dissolved silica in the samples.

The pH content for well No. 1 dropped during the pumping test from 9.35 to 9.00. We would expect that this trend would continue with pumping and that in time the pH would drop to around 8.5 which is the recommended limit laid down in the Canadian Drinking Water standards. Our chemist informs us that storing the water in a well ventilated storage tank will also help to reduce the pH.

While the lower fractures in well No. 1 are below sea level there is no evidence to suggest that the sea water is intruding into the fractures. During the pumping test in well No. 1 the chloride and sulphate content rose but there was no accompanying increase of the dissolved metals such as magnesium and calcium which are common in sea water.

The water has a slight sulphurous (rotten egg) odour which is common in most bedrock wells in the Howe Sound area. It is our experience that

this odour will decrease after the well is pumped for several weeks. It will also disappear if the water is stored for 24 hours in a well ventilated tank.

The chemical analyses show that the water from PW-2 meets the recommended standards for drinking water. The water from PW-1 is marginal with respect to pH and sulfate. We believe that the chemical content of the PW-1 water will improve with use.

WELL OPERATION AND MAINTENANCE

1. Pump

A submersible type pump is recommended for the deep wells. The bottom of the pump motor should be set at the depths recommended. (See recommendations).

2. Pump Housing

The submersible well head fitting is best housed in a below ground manhole structure. This will protect the well head fittings and controls from both vandalism and freezing temperatures. The manhole cover should be located directly over the well to allow the pump to be readily set and withdrawn. No surface water should be allowed to run into the ground in the annular space immediately outside the surface casing. To prevent this the concrete floor or pad should be laid up against this surface casing.

If a pump house is being considered it should be so designed that the pump can be withdrawn from the well. One wall should be within two feet of the well and a window or removable section of the wall installed in this wall so that machine operators can see the well. Also a 4' x 4' removable section of the roof should be placed over the pump.

Great care and supervision will be necessary during pump house or manhole construction to ensure that no debris, cement, etc., enters the well. We emphasize this as we have had past experiences of

wells being junked by innocent carelessness.

3. Monitoring Program

A program of water level and flow measurements must be started on a weekly schedule when production starts. This means that the access hole provided should be maintained free so that a 3/8-inch probe can easily pass. These records should be reviewed by us at regular intervals during the first year of production.

CONCLUSIONS

1. Based on available data we judge that the wells have the following safe productive capacities:

PW-1	6
PW-2	10
PW-3	2.5
Total	18.5 US gpm

2. The water quality should be acceptable.

3. If additional water is required at a future date a fourth well located on the property would most probably be successful. The location of this well would be very critical if the productivity of the existing wells are to be maintained. Data from the recommended monitoring program on the wells will be valuable in selecting this new well site. At the present time we believe that the fourth well would have a productive capacity of approximately 5 US gpm.

RECOMMENDATIONS

1. Submersible type pumps should be set in the two deep wells with the pump suction as follows:

PW-1	300 feet below ground
PW-2	385 feet below ground

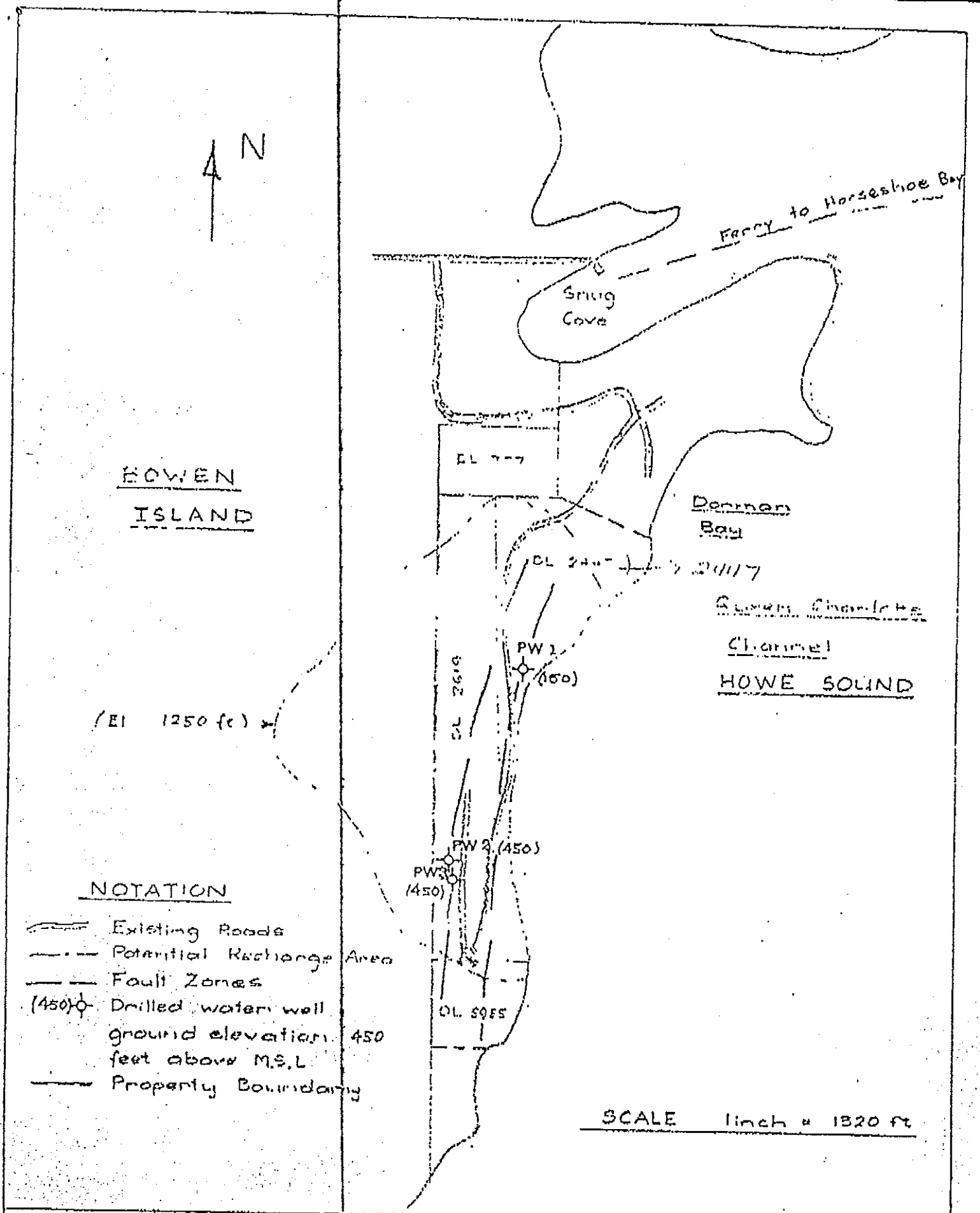
2. The shallow well PW-3 could be pumped using a centrifical pump set three feet below ground. It may be possible to set up a jet pump system which uses the flow of water from PW-2 to draw the water from PW-3.

3. The well pumps and fittings should be chlorinated prior to use.

4. Sufficient storage should be provided to hold the water for a minimum of 1 day prior to consumption. The storage tanks or reservoirs should be well ventilated.

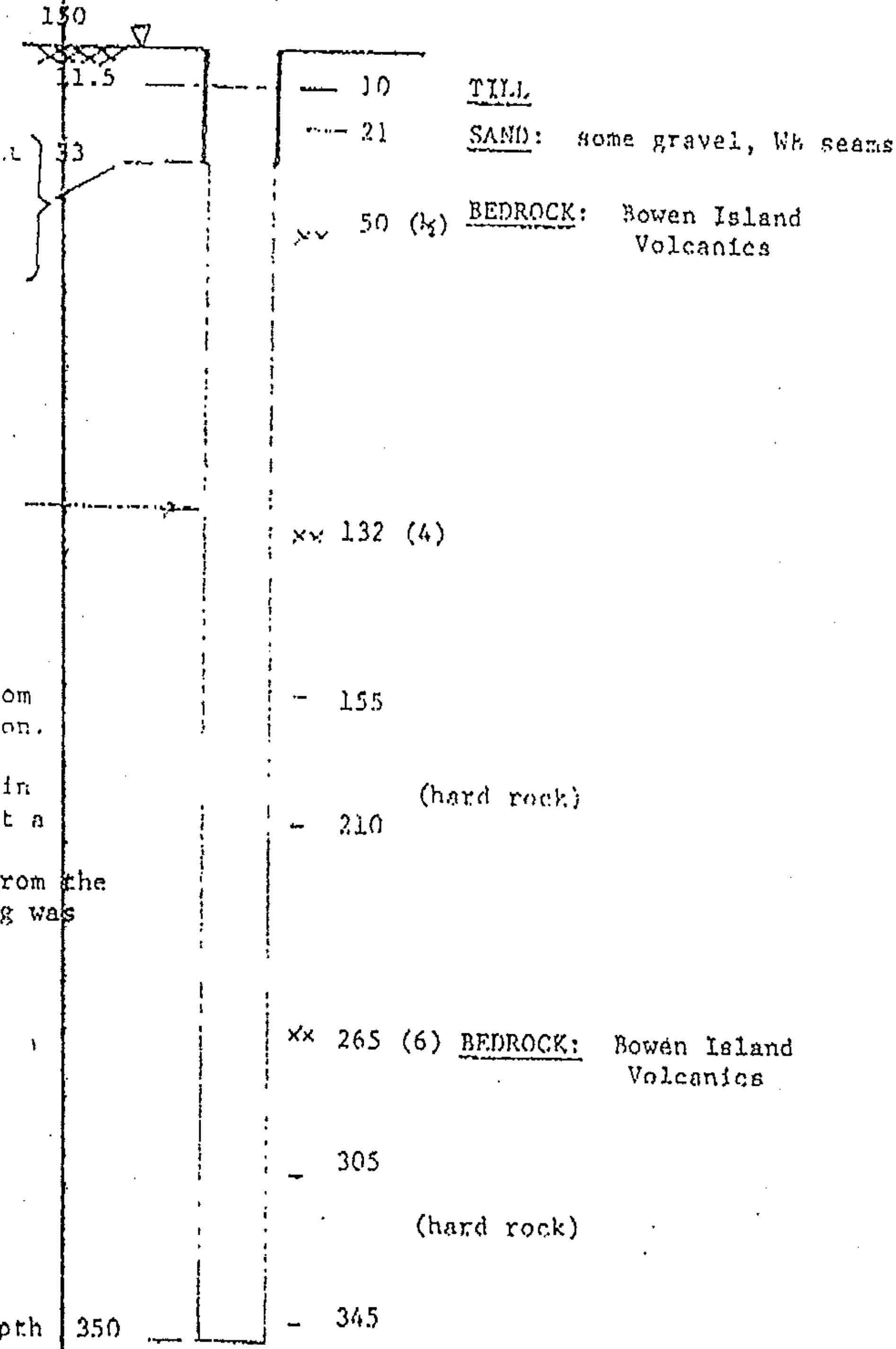
5. The well operation and maintenance program set out in this report should be closely followed.

6. A sample of the water from PW-3 should be submitted for chemical analysis.



DORMAN BAY DEVELOPMENTS LTD.	WELL LOCATION MAP	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA	
BOWEN ISLAND, British Columbia		October 1972	Fig: 1

Approximate Ground Surface Elevation (ft-MSL)



NOTES:

1. All depths are given from existing ground elevation.
2. xx 132 (4) represents a water-bearing fracture in the rock which occurs at a depth of 132 feet.
   The total water blown from the well at time of drilling was 4 Imp. gpm.
3. WB = water-bearing

SCALES:
Vertical: 1" = 50 ft.
Horizontal: N.T.S.

DORMAN BAY DEVELOPMENTS LTD.	LOG:	ROBINSON, ROBERTS & BROWN LTD. CONSULTING GROUNDWATER GEOLOGISTS NORTH VANCOUVER, CANADA
BOWEN ISLAND, British Columbia	Production Well: 1	October 1972 — Fig: 2

CAN TEST LTD.

1650 PANDORA STREET, VANCOUVER 6, B.C. • TELEPHONE 254-7278

Report On: Water Samples for Chemical Analysis

File No. 3871 A

Report No.

Reported to: Robinson, Roberts & Brown
1632 McGuire
North Vancouver, B.C.

Date. October 12, 1972

We have tested 4 samples of water submitted by you on September 29, and October 2, 1972 and report as follows:

Sample Identification

The samples were submitted in plastic bottles labelled -

Sample 1	Dorman Bay Estates, Well #1	September 28, 1972	1500 hours
Sample 2	Dorman Bay Estates, Well #1	September 26, 1972	1600 hours
Sample 3	Dorman Bay Estates, Well #2	October 1, 1972	0940 hours
Sample 4	Dorman Bay Estates, Well #2	September 29, 1972	1130 hours

Method of Testing

The samples were tested in accordance with the procedures set down in "Standard Methods for the Examination of Water and Waste Water" - 13th Edition, published by the American Public Health Association, 1971.

Chemical Analysis of Water Samples

Test		1	2	3	4		
pH (electrometric)		9.00	9.35	8.40	8.20		9.4
Color (Pt-Co scale)		1.0	-	L 0.5	-	ppm	
Turbidity (SiO_2 scale)		1.25	-	24.0	-	ppm	3.6
Suspended Matter		2.8	-	19.6	120.9	ppm	
Fixed		2.2	-	18.8	115.3	ppm	
Volatile		0.6	-	0.8	5.6	ppm	
Hardness (Calculated)		L 2.5	L 2.5	L 3.3	13.1	ppm	11.3
Dissolved Anions							
Alkalinity							
Bicarbonates	HCO_3	154.	168.	155.	126.	ppm	96
Carbonates	CO_3	29.5	40.5	6.5	0.5	ppm	
Hydroxyl Ion	OH	nil	nil	nil	nil	ppm	
Chlorides	Cl	144.5	50.0	4.0	0.5	ppm	
Sulfates	SO_4	256.1	101.7	12.3	13.2	ppm	
Phosphates	PO_4	L 0.1	-	L 0.1	-	ppm	
Nitrates	N	0.70	L 0.1	L 0.1	-	ppm	
Dissolved Cations							
Silica	SiO_2	45.2	-	44.8	-	ppm	
Iron	Fe	0.05	-	0.05	-	ppm	.06
Aluminum	Al	L 0.05	-	L 0.05	-	ppm	
Calcium	Ca	L 0.5	L 0.5	L 0.5	L 0.5	ppm	
Magnesium	Mg	L 0.3	L 0.3	0.5	3.2	ppm	
Sodium	Na	288.	195.	73.	59.	ppm	
Potassium	K	2.0	1.4	0.7	0.9	ppm	
Manganese	Mn	L 0.05	-	L 0.05	-	ppm	
Copper	Cu	0.005	-	0.010	-	ppm	
Chromium	Cr	L 0.005	-	L 0.005	-	ppm	
Lead	Pb	L 0.01	-	L 0.01	-	ppm	
Zinc	Zn	L 0.005	-	L 0.005	-	ppm	.01
Nickel	Ni	L 0.005	-	L 0.005	-	ppm	
Total Iron	Fe	0.31	-	1.00	-	ppm	
Total Silica	SiO_2	46.2	-	54.8	-	ppm	
Total Dissolved Solids		924.	605.	292.	250.	ppm	
Fixed		847.	521.	214.	187.	ppm	
Volatile		77.	84.	78.	63.	ppm	174

L = less than

Remarks

Examination of the above results indicated that all waters as represented by the submitted samples were slightly alkaline and extremely soft. All samples contained sodium carbonate and bicarbonate as the primary dissolved minerals. The samples were also quite high in dissolved silica. The presence of sodium bicarbonate and carbonate would account for the high pH content and the dissolved silica in the samples.

Samples 3 and 4 were within the standards set for domestic water supplies by the American Public Health Association. Samples 1 and 2 were above the standards set for pH content and sample 1 was also slightly above (256. ppm) the standard (250. ppm) set for sulfate content.

Prior to their use as drinking waters we would suggest that the samples be tested for their bacteriological qualities.

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D. L. Dixon