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BROWN, ERDMAN & TURNER LTD.

1409 BEWICKE AVENUE, NORTH VANCOUVER, BRITISH COLUMBIA V7M 3C7
TELEPHONE 986-1557

**GROUNDWATER DEVELOPMENT
LOWER REACHES CLUXEWE RIVER
NEAR
PORT MCNEILL, BRITISH COLUMBIA
FOR
SKOOKUMCHUK SALMON FARMS LIMITED**

**W.L. Brown, P.Eng.
R.B. Erdman, Senior Geologist**

FEBRUARY 1987

86-400

1.0 INTRODUCTION

The drilling and testing of the groundwater potential along the lower reaches of the Cluxewe River was carried out in February 1987. Test results indicate that several hundred litres per second (thousand gallons per minute) of groundwater can be produced in the area from properly located and constructed water wells. The Cluxewe River is located six kilometers west of the Town of Port McNeill, British Columbia. The location tested is 1.5 kilometers south of Broughton Strait.

Two test wells were drilled with a cable tool machine. A short pump test was run on the first well which was then plugged and abandoned. An extensive pump test was run on the second test well which was left as a production well.

2.0 TEST DRILLING

Two locations adjacent to the Cluxewe River were drilled. The first test well was located approximately 1.3 kilometers upstream from where Highway 19 crosses the Cluxewe River. At this location sandstone bedrock was encountered at a depth of 7.3 meters. Please see the attached well log for details of the lithology. A short pumping test showed that the sands and gravels above the bedrock could only produce small amounts of water. The 200 mm diameter casing was pulled and the test well was plugged and abandoned.

The location of the second test well is approximately 700 meters upstream from the Highway 19 bridge and is at the end of an "old haulage road" that has been eroded and cutoff by the river. This well was drilled to a depth of 23.8 metres using 200 mm diameter casing. Please see the attached well log for details of the lithology. As can be seen, drilling was terminated before bedrock was encountered. The sand between 21.3 meters and the bottom of the well has the outward appearance of being a highly productive zone. However, pump testing and material response to drilling indicate a very low groundwater productive potential for this unit.

The sand and gravel aquifer between 15.2 and 20.4 meters was screened with a 200 mm telescopic diameter well screen set between depths of 16.97 and 20.27 meters. The well screen has a slot opening of 2 mm and is of continuous wire wound construction. Development of the well was done with a one-way surge and pumping. The larger sand grains pulled into the well screen were removed by bailing. The well was completed on February 13, 1987 after 8 hours of development.

3.0 TEST PUMPING

Test Well No. 1 was test pumped using a small contractor's pump with a suction lift. With open end 200 mm casing at 5.7 m, the well was capable of producing only 4 gpm. The transmissivity as calculated from the recovery data is $2.19 \text{ m}^2/\text{day}$ (176 US gpd/foot). Transmissivity is a field measurement of the amount of water that can be transmitted through a unit width of aquifer under a unit hydraulic gradient.

Test Well No. 2 was test pumped for 21.67 hours using a 20 hp electrically powered submersible pump. Test pumping started on the afternoon of February 18, 1987 and was terminated at 14:00 hours on February 19, 1987. At the termination of the test the pumping level was 7.80 m below the measuring point. A constant pumping rate of 29.33 L/sec (465 US gpm) was maintained through the test. The specific capacity of the well at the end of the pumping test was 7.43 L/sec per metre of drawdown (117.72 US gpm/metre of drawdown). Water level measurements were taken in the pumping well at predetermined times throughout the test. The flow rate from the well, the river level and precipitation were all monitored during the test. Information obtained is shown on the attached pump test data forms.

The Cluxewe River dropped 2.5 cm during the test and 2 mm of rain fell.

4.0 GROUNDWATER HYDROLOGY

A detailed examination has been made of the drawdown and recovery data obtained during the pumping test of Well 2. The drawdown data indicates a transmissivity of 2 628 m²/day (211 600 US gpd/ft.). The recovery data shows a transmissivity of 2 033 m²/day (163 680 US gpd/ft.).

An examination of the drawdown curve shows a first leg from 1 to 20 minutes with a transmissivity of 2 628 m²/day. After 20 minutes a second leg is evident with a transmissivity of 2 033 m²/day. The drawdown continued on the second leg until 600 minutes into the test, when there was a drop of 1.7 mm in the pumping level. At approximately the same time the river level dropped 1.3 cm (13 mm).

The break in the drawdown curve at 20 minutes would indicate that the cone of influence around the well had reached a recharge area (Cluxewe River). The plot of the recovery data shows that the water level returns to a point approximately 1.7 mm below the original static water level. The pump test data indicates that the river is hydraulically connected to the groundwater source adjacent to Test Well 2 and affects the pumping level by a ratio of 10 to 1 (well drops 1/10 of river drop).

The temperature of the groundwater varied between 8 and 8.5°C during the pumping test when the water temperature in the Cluxewe was 5 to 5.5°C and the air temperature varied from 5 to 6.5°C. The 2 mm of rain that fell during the pumping test did not have any apparent effect on the water levels.

5.0 WELL CAPACITY

The safe productive capacity of the Cluxewe River Well 2 is calculated as follows:

		<u>Depth Below Existing Ground Surface (m)</u>
Top of Screen		16.97
Static Water Level		<u>3.85</u>
Total Available Drawdown		13.12
Less Pump Submergence	1.00	
Interference*	<u>1.00</u>	<u>2.00</u>
Total Usable Drawdown		11.12
Safety at 100%		<u>5.56</u>
Safe Usable Drawdown		5.56

Safe Productive Capacity $5.56 \times 7.43 \text{ L/sec/m drawdown} = 41.31 \text{ L/sec (655 US gpm)}$

The safe productive capacity rated above is the approximate maximum capacity of a pump that can be set in the 200 mm diameter casing.

The safe productive capacity of a new well located approximately 150 m west of Cluxewe River No. 2 Well, assuming that the same hydrogeologic conditions are present as in Cluxewe River No. 2 Well, are calculated below.

		<u>Depth Below Existing Ground Surface (m)</u>
Top of Screen		17.00
Static Water Level		<u>4.00</u>
Total Available Drawdown		13.00
Less Pump Submergence	1.00	
Interference*	<u>1.00</u>	<u>2.00</u>
Total Usable Drawdown		11.00
Safety at 73%		<u>4.00</u>
Safe Usable Drawdown		7.00

- * Note: assume a second well approximately 150 m (500 feet) to west of Cluxewe River Well 2.

A specifically designed and constructed 406 mm (16 inch) diameter production well should have a specific capacity of 9.15 L/sec per metre of drawdown (145 US gpm/metre of drawdown). Therefore the safe productive capacity of the new well will be $7 \times 9.15 = 64.1$ L/sec (1 015 US gpm). A well of 406 mm diameter can accept a pump capable of producing over 63 L/sec (1000 US gpm).

6.0 RECOMMENDATIONS AND CONCLUSIONS

We recommend that a set of technical specifications be prepared and sent to several contractors before the drilling of the large 406 mm (16 inch) diameter well is carried out. This will allow competitive prices to be compared before the contract is let.

Samples of water from the test well and the Cluxewe River have been sent to a commercial laboratory for analysis. The results will be forwarded to you as soon as they are available.

Based on the results of the exploration program to date, we conclude that a buried channel filled with productive sands and gravels has been discovered by the Cluxewe River No. 2 Well. This channel is of significant areal extent and when fully developed should produce several hundred L/sec (thousand U.S. gallons per minute) to a properly designed, located and constructed well field. We recommend that further exploration of this channel be done with the drilling and testing of 406 mm (16 inch) diameter production wells.

We have obtained a quotation for a Byron Jackson vertical lineshaft turbine pump that will discharge 650 U.S. gpm with a total dynamic head of 150 feet (55 feet of lift from the well plus an estimated system water pressure of 95 feet). The outside

diameter of the two stage bowls is 7 3/4 inches and they only need a minimum 75 cm (2 1/2 feet) of water submergence, thereby maintaining adequate safety.

The estimated price of the pump, motor, column and accessories is slightly under \$10 000 Canadian plus taxes if applicable to this installation.

If any of the above needs amplification or clarification please do not hesitate to call.



BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL RECORD

OWNER Skookumchuk Salmon Farms LOCATION Cluxewe River #1
ADDRESS P. O. Box 609 Port McNeill
Sechelt, B.C. V0N 3A0 LEGAL _____
DATE: Start Feb. 3/87 Complete Feb. 5/87 ELEVATION _____

FORMATION LOG

FROM	TO	TIME	Q	DESCRIPTION
0	9			Sand & Gravel Fill
.9	6.7			Sand & Gravel Trace of Silt
6.7	7.3			Clay with Some Sand
7.3	8.5			Sandstone Total Depth
				Plug and Abandoned

CASING TALLY

LENGTH	TOTAL	LENGTH	TOTAL	LENGTH	TOTAL

SCREEN

TYPE	LENGTH	DIA.	SLOT	FROM	TO

PACKER: Depth Top _____ Type _____
RISER: Dia. _____ From _____ To _____
SAND PACK _____
CEMENT _____
DEVELOP _____
STATIC WATER LEVEL _____

CONTRACTOR Drillwell Enterprises
DRILLER C. Slade
RIG Cable tool Loomis
HYDROGEOLOGIST R. B. Erdman



BROWN, ERDMAN & ASSOCIATES LTD.
NORTH VANCOUVER, BRITISH COLUMBIA

WELL RECORD

OWNER Skookumchuk Salmon Farm LOCATION Cluxewe River
 ADDRESS P. O. Box 609 #2 Port McNeill, B.C.
Sechelt, B.C. V0N 3A0 LEGAL _____
 DATE: Start Feb. 6/87 Complete Feb. 13/87 ELEVATION 16M

FORMATION LOG

FROM	TO	TIME	Q	DESCRIPTION
0	2.7			Clay, Silty
2.7	11.6			Gravel, Some Sand, Water Bearing
11.6	15.2			Sand & Gravel with Silt Binder
15.2	16.4			Gravel, Some Sand, Water Bearing
16.4	18.3			Sand & Gravel, Very Loose, Water Bearing
18.3	18.9			Clay with Gravel
18.9	20.4			Gravel, Some Sand, Water Bearing
20.4	21.0			Sand, Medium to Coarse with Clay Stringers
21.0	21.3			Sand Medium to Coarse, Gravel, Water Bearing
21.3	23.8			Sand, Medium to Coarse, Some Silt

CASING TALLY

LENGTH	TOTAL	LENGTH	TOTAL	LENGTH	TOTAL

SCREEN

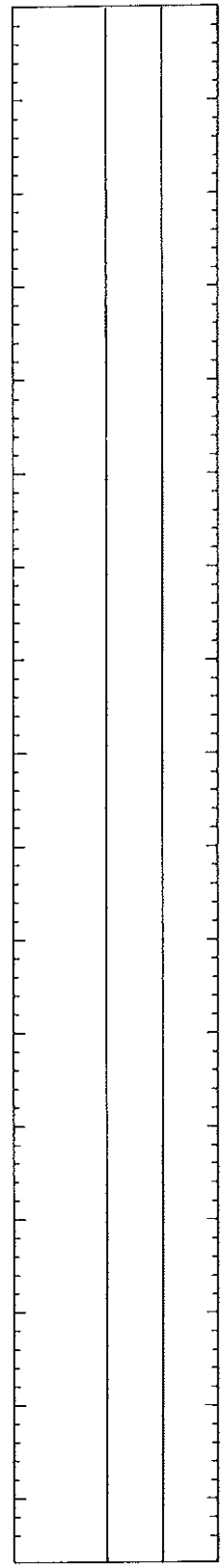
TYPE				
	SS			
LENGTH	3.3 M			
DIA.	203 MM			
SLOT	2 MM			
FROM	16.97			
TO	20.27			

PACKER: Depth Top 16.97 Type K
 RISER: Dia. _____ From _____ To _____
 SAND PACK _____

 CEMENT _____

 DEVELOP Surge & Pump
 STATIC WATER LEVEL 3.2 M

CONTRACTOR Drillwell Enterprises
 DRILLER C. Slade
 RIG Cable tool Loomis
 HYDROGEOLOGIST R. B. Erdman





BROWN, ERDMAN & TURNER LTD.
1409 BEWICKE AVENUE, NORTH VANCOUVER, BRITISH COLUMBIA

PROJECT Skookumchuk Salmon Farms
Cluxewe River #2
Pump Test No. 2

DATE	TIME	ELAPSED TIME MINUTES	DEPTH TO WATER		RATE		REMARKS
			FT <input type="checkbox"/>	M <input checked="" type="checkbox"/>	USGPM <input checked="" type="checkbox"/>	LPS <input type="checkbox"/>	
Feb. 18/87							
	16:20	0		3,934			
		.5		7,279			
	16:21	1		7,406	465		
		1.5		-			
	16:22	2		7,496			
		2.5		7,515			
	16:23	3		7,540			
		3.5		7,557			
	16:24	4		7,567			
		4.5		7,575			
	16:25	5		7,580			
		6		7,600			
		7		7,612			
		8		7,616			
		9		7,625			
	16:30	10		7,683			
		12		7,644			
		14		7,654	465		
		16		7,668			
		18		7,678			
	16:40	20		7,679			
		25		7,689			
	16:50	30		7,701	465		River Staff 31"
		35		7,705			
	17:00	40		7,708			
		45		7,708			
	17:10	50		7,708	465		
	17:20	60		7,712			
	17:30	70		7,718			
	17:40	80		7,714	465		River Staff 31"
	17:50	90		7,716			
	18:00	100		7,720	465		River Staff 31"
	18:25	125		7,723			
	18:50	150		7,725	465		



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PROJECT ookumchuk Salmon Farms PAGE 5
Cluxewe River #2
Pump Test No. 2

DATE	TIME	ELAPSED TIME MINUTES	DEPTH TO WATER		RATE		REMARKS
			FT <input type="checkbox"/>	M <input checked="" type="checkbox"/>	USGPM <input checked="" type="checkbox"/>	LPS <input type="checkbox"/>	
Feb./19	14:00	1300	7,800		465		Pump Off
		Recovery				T/T'	
		.5	4,394			2601	
	14:01	1	4,290			1301	
		1.5	4,236			868	
	14:02	2	4,192			651	
		2.5	4,170			521	
	14:03	3	4,149			434	
		3.5	4,131			372	
	14:04	4	4,119			326	
		4.5	4,105			290	
	14:05	5	4,096			261	
	14:06	6	4,076			218	
	14:07	7	4,061			187	
	14:08	8	4,048			163	
	14:09	9	4,035			145	
	14:10	10	4,022			131	
	14:12	12	4,000			109	
	14:14	14	3,991			94	
	14:16	16	3,982			82	
	14:18	18	3,975			73	
	14:20	25	3,955			53	
	14:30	30	3,948			44	
	14:35	35	3,940			38	
	14:40	40	3,933			33.5	
	14:45	45	3,930			30	
	14:50	50	3,925			27	
	15:00	60	3,925			23	
	15:10	70	3,921			19.6	
	15:20	80	3,919			17	
	15:30	90	3,917			15.5	
	15:40	100	3,915			14.0	

BROWN, ERDMAN & TURNER LTD.

1409 BEWICKE AVENUE, NORTH VANCOUVER, BRITISH COLUMBIA V7M 3C7
TELEPHONE 986-1557

March 26, 1987

86-400

Skookumchuk Salmon Farms Limited
P.O. Box 609
Sechelt, British Columbia
V0N 3A0

Attention: Syd Heal, Director

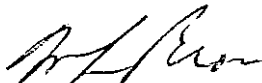
Subject: Chemical Analysis Reports
Cluxewe River at Well No. 2 Water

Dear Sir:

Attached please find the chemical analyses of the subject water. Would you please assure yourself that these waters are suitable for your purposes and that they will not corrode or encrust the components of your proposed water system.

Would you please pay the attached bill directly to Analytical Service Laboratories.

Yours truly,



W.L. Brown

WLB/mt
Encl.

Date: March 18, 1987

File No. 3891A

ASL

Report On: Water Analysis

Report To: Brown Erdman & Turner Ltd.
1409 Bewicke Avenue
North Vancouver, B. C.
V7M 2W0

We have analysed the 2 water samples submitted by you on February 23, 1987 and report as follows:-

SAMPLE INFORMATION

The samples were submitted in proper laboratory containers labelled:-

- #1 Cluxewe River Water Feb 19, 1987
- #2 Cluxewe River Test Well #2 Feb. 19, 1987

METHODOLOGY

The analyses were carried out using procedures described in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, 1985.

RESULTS

See attached table.

REMARKS

Sample #1

The water as represented by the sample submitted can be characterized as low with respect to dissolved mineralization. The sample was above normal with respect to colour, organic carbon and aluminum.



analytical service laboratories

CONSULTING CHEMISTS & ANALYSTS

1650 Pandora Street
Vancouver, B.C. • V5L 1L6
(604) 253-4188

REMARKS (Contd.)

File NO. 3891A

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Sample #2

The water as represented by the sample submitted can be characterized as low with respect to dissolved mineralization.

ASL ANALYTICAL SERVICE LABORATORIES LTD.



A. W. Maynard, M.Sc.
Senior Partner

AWM/mm

RESULTS OF ANALYSIS

File No. 3891A

Page 3 of 3

Physical Parameters		1	2
pH		7.52	7.50
Conductivity (μ mhos/cm)		41.6	82.0
Colour (CU)		39.4	<5.0
Turbidity (NTU)		2.2	<1.0
Total Hardness (mg/L)		14.0	37.3
Dissolved Solids (mg/L)		38.8	74.9
		3.6	<1.0
Dissolved Anions (mg/L)			
Bicarbonate	HCO ₃	22.4	42.3
Carbonate	CO ₃	-	-
Chloride	Cl	1.00	3.00
Sulfate	SO ₄	1.7	<1.0
Fluoride	F	<0.020	<0.020
Nitrate + Nitrite	N	0.056	0.25
Silicate	SiO ₂	6.78	13.2
Dissolved Metals (mg/L)			
Calcium	Ca	3.85	10.9
Magnesium	Mg	1.06	2.45
Sodium	Na	1.10	1.90
Potassium	K	0.14	0.15
Iron	Fe	0.07	0.03
Manganese	Mn	<0.005	<0.005
Aluminum	Al	0.12	<0.005
Arsenic	As	<0.0001	<0.0001
Barium	Ba	<0.005	<0.005
Cadmium	Cd	<0.001	<0.001
Chromium	Cr	<0.005	<0.005
Copper	Cu	0.005	0.001
Lead	Pb	<0.001	<0.001
Zinc	Zn	0.018	0.023
Total Metals (mg/L)			
Iron	Fe	0.17	0.04
Manganese	Mn	<0.005	<0.005
Ammonia	N	0.015	<0.005
Total Organic Carbon	TOC	4.9	1.3

< = Less than

mg/L = milligrams per liter

*1 "Maximum acceptable concentration" as published by Health & Welfare Canada, 1985