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Pumping test of new well for Little
River Improvement District near Comox, B.C.

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A new well was recently completed by the Pacific Water Wells Ltd. for the Little River Improvement District. Mr. J. Rainsford, Manager, Pacific Water Wells Ltd., forwarded data from two pumping tests. Water requirement is 150 U.S. gallons per minute. The log of this well is as follows:

Vashon	0 - 1	Soil
	1 - 12	Brown tight compact sand and gravel
	12 - 36	Blue-grey tight compact silty sand and gravel
	36 - 43	Medium to coarse sand with boulders and lenses of compact silt
	43 - 50	Tight silty clay with pebbles
	50 - 66	Tight compact sand with lenses of clay, some pebbles
Quadra?	66 - 76	Wet silty sand and gravel
	76 - 106	Blue silty clay
	106 - 110	Silty sand and gravel with water
	110 - 111	Compact hard pan
	111 - 117	Clean coarse gravel, little sand
	117 - 120	Medium to fine sand, some gravel
	120 - 122	Medium to fine sand lenses of clay and silt

I believe that the material from surface to about 66' is a complex of till and outwash of Vashon age. The static level is about 10' above ground level.

A 6-inch (nominal) screen was set between 108' and 121'. This consisted of 6 feet of .060 slot screen above 4 feet of .020 slot screen.

The Pacific Water Wells Ltd. carried out a preliminary pump test with a pump on surface but this was not entirely satisfactory as the rate decreased as the pumping level decreased. I tried to analyze the recovery data from this test but the period of observation was too short. This is discussed later.

Following this, Mr. J. Gulliver took a pressure recorder to the well site to try out a pump testing technique mentioned in the literature. In this procedure, the well is turned on and allowed to flow. It is then shut off and the pressure rise is recorded. The recorder was left on for five days. These data were analyzed and will be discussed later.

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A proper pump test lasting over two days was carried out at a rate of 154 U.S. gallons per minute by Pacific Water Wells Ltd. An observation hole was not used and the drawdowns were taken with an air line so these data are not as precise as might be desired.

The results are quire interesting but are difficult to analyze for several reasons. Since there was no observation hole, the non-equilibrium method could not be used and coefficient of storage cannot be found. An approximation of this method was finally tried.

Plots of the recovery data from all tests using the Theis approximate recovery method all show three straight line segments. These probably represent changing conditions as the cone of depression encounters two barriers. Theoretically, these should show slope ratios of 1:2:3. In the case of a plot of drawdown versus log of time, they do show this ratio; in other cases, the ratios are somewhat greater. The first segment of the drawdown curves and the last segment of the recovery curves should represent conditions in an undisturbed cone of depression provided that pumping lasted long enough so that boundary effects are noticeable. These portions of the curves should enable determination of transmissibility.

The results have been summarized in Table I. The range of values is very great. For the first pump test, transmissibility, T, cannot be calculated as the observations were not carried on long enough to enable plotting of the third segment of the curve. However, if the slope should be twice as great as segment two as theory demands, T should be about 5000. Results are summarized below:

TABLE I

Test	Method	Remarks	Segment	Transmissibility
First pump	Theis recovery	Only 2 segments	second	9,900
		present	first	22,580
Artesian flow	Theis recovery	Flow rate decreased	third	310
		from 50 gpm to 20 gpm	second	620
		20 gpm used	first	1,460
Second pump	Theis recovery		third	1,235
			second	3,100
			first	9,700
Second pump	Jacob approx. drawdown		first	6,250
			second	3,200
			third	1,540
Second pump	approx.non-equilibrium			5,000

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The transmissibility values from the artesian flow test are much less than the others. The three segments of the curve plotted may not represent the same conditions as those from the other tests; because of the low rate of flow and the short time during which the well was allowed to flow, the boundary effects may not have been felt. For this reason, the first segment of the curve may correspond to the third segment of the other recovery curves. T from this equals 1460.

The recovery data from the second pump test gives T = 1235.

The Jacob approximate drawdown method where drawdown is plotted in log of time is ordinarily used only on data from an observation well as the well losses make up part of the drawdown in the pumped well. However, in this case where the drawdown and recovery are both fairly slow, the well loss at the constant pumping rate of 154 U.S. gallons per minute seems to be 17'. Plotting the drawdown in the well minus 17' is then considered to be drawdown in the aquifer outside the well. The curve obtained consists of three segments with ratios 1:2:3. From the first segment T = 6250.

A non-equilibrium curve of log drawdown versus log time was plotted on the same basis as the above. The end of the first segment of the Jacob method plot ends at 200 minutes after the start so it was assumed that the curve for the first 200 minutes could be considered to be following non-equilibrium conditions. From this, T = 5000.

Thus, T ranges from 6250 to 1460 with three values near 5000. From here on in this discussion, T will be considered to be 5000 and coefficient of storage, $S = 10^{-4}$ usually considered average for artesian conditions.

The condition of an aquifer with an impermeable boundary is approximated by an image well of size equal to the pumped well located at an equal distance beyond the boundary. Drawdowns in the aquifer will be duplicated by this condition.

Thus, the additional drawdown in the pumped well above that due to normal radial flow will be assumed to be due to such an image well. This will be represented by the distance between a projection of the first segment of the drawdown curve and the actual drawdown represented by the second segment. At time 400 minutes from start, this drawdown from the image well is 2'.

Using $s = \frac{(115)(Q)(Wu)}{T}$ Wu = .565, from tables u = .5

Using $u = \frac{(1.9)\, r^2 s}{Tt}$ $r_1 = \frac{uTt}{1.9S} = 1900'$

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At t = 1000 minimum drawdown from the image well representing the first boundary is 4.3' and the additional amount representing the second well is 5.0'.

Here Wu = 1.41 u = .22

r_2 = 2000'

The fact that these rough calculations show that the two boundaries are so close shows why the segment of the curve representing the nearer boundary is so short.

The intersection of the first and third segments of the curve is the time at which drawdown is 0 at the pumped well caused by the second image well this time is 345 minutes.

Coefficient of storage can be determined roughly according to Jacob by setting $\frac{.3Tt_o}{r^2 s} = 1$ when t_o is the time at which drawdown is 0 at distance r from this

$$S = 9 \times 10^{-5} \text{ or almost } 10^{-4}$$

Thus, the assumption of $S = 10^{-4}$ is acceptable.

TABLE II

Rate of Flow US gpm	Time of Pumping Days	Partial dd Well	Partial dd r = 1900 Image 1	Partial dd r = 2000 Image 2	Total old. Aquifer	Total + well loss	Pumping level
50	30	21	5.1	5.0	31	33	23
	60	22	5.8	5.6	33.5	35.5	25.5
	100	22	6.4	6.2	34.5	36.5	26.5
100	30	46	11	11	68	75.5	65.5
	60	47.5	12.5	12.5	72.5	80	70
	100	48.5	14	13.5	76	83.5	73.5
150	30	69	16.5	16	101	128	118
	60	71	19	18.5	108.5	135.5	125.5
	100	73	21	20.5	114.5	141.5	131.5

Table II has been constructed showing drawdowns for pumping rates of 50,100 and 150 U.S. gallons per minute for periods of 30, 60 and 100 days continuous pumping based on the aquifer characteristics determined above and assuming two impermeable boundaries in the aquifer at distances of 1900' and 2000'. Other assumptions are also made here: these are that there is no recharge, the aquifer is homogeneous and does not thin or thicken and that the aquifer is of infinite extent except in the direction of the two boundaries.

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The table indicates that the capacity of the well for long periods of pumping is between 100 and 150 U.S. gallons per minute. The well is quite capable of supplying over 150 gallons per minute peak flow as long as such a rate of flow is not continued for more than about 10 days. The capacity should probably be based on a weekly rate of flow.

I must emphasize here that this analysis is based on inadequate data. In order to really analyze this rather complex situation, several observation wells should be used in conjunction with a pump test at a rate about the same as that used in the second test (150 U.S. gpm). However, I feel that recharge is probably taking place at all times in this aquifer. I think the large springs (Anderton Springs, etc.) in this area show that there is considerable movement of water from the higher area to the southwest. For this reason, the figures given here may be based on conditions worse than those found in the field.

Unless the District is prepared to carry out a rather elaborate program of testing, the best procedure is to put the well into use keeping track of water levels by means of an automatic recorder on the well or preferably in a nearby observation well.

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