1983-04

THE EVALUATION OF THE EFFECTS OF SEISMIC DETONATIONS ON WATER WELLS

Richard I. J. Vogwill

Groundwater Division
Alberta Research Council
Edmonton, Alberta
April, 1979

CONTENTS

ILLUSTRATIONS

TABLES

BACKGROUND AND HISTORY

In the last twenty-five years, the Government of Alberta and more specifically, the Geophysical Inspections Branch of Energy and Natural Resources (formerly Department of Mines and Minerals), have been receiving complaints concerning alledged damage to domestic water wells by seismic detonations associated with petroleum exploration. The number of these complaints has generally increased and in the past few years the Geophysical Inspections Branch has literally been inundated with damage claims. For example, in 1977 and 1978, respectively, a total of 144 and 220 claims concerned with water well damage were received and processed.

For the past ten years the Groundwater Division of the Alberta Research Council has acted as an impromptu advisor and consultant to the Geophysical Inspections Branch concerning these well damage claims. This liaison has included site inspections, aquifer and well testing, teaching basic methods of hydrogeological evaluation and outlining procedures for scientifically evaluating the claims. As a result of this consultation, a logical and scientific procedure to investigate these claims, presented in February 1978 by G. M. Gabert (pers. comm.), will be issued as a procedural directive by Energy and Natural Resources (E&NR).

Unfortunately, in spite of a good general knowledge of domestic water wells and aquifers in Alberta, most of the claims have to be processed with little or no specific information concerning the original hydraulic parameters, construction and efficiency of a particular well. In light of this, settling such claims can be a frustrating and formidable task. In the summer and fall of 1978, therefore, a number of projects concerned with determining the effects, if any, of seismic activity on water wells were initiated by E&NR. This report describes the project completed by the Alberta Research Council, Groundwater Division, near New Norway, Alberta in October, November and December, 1978.

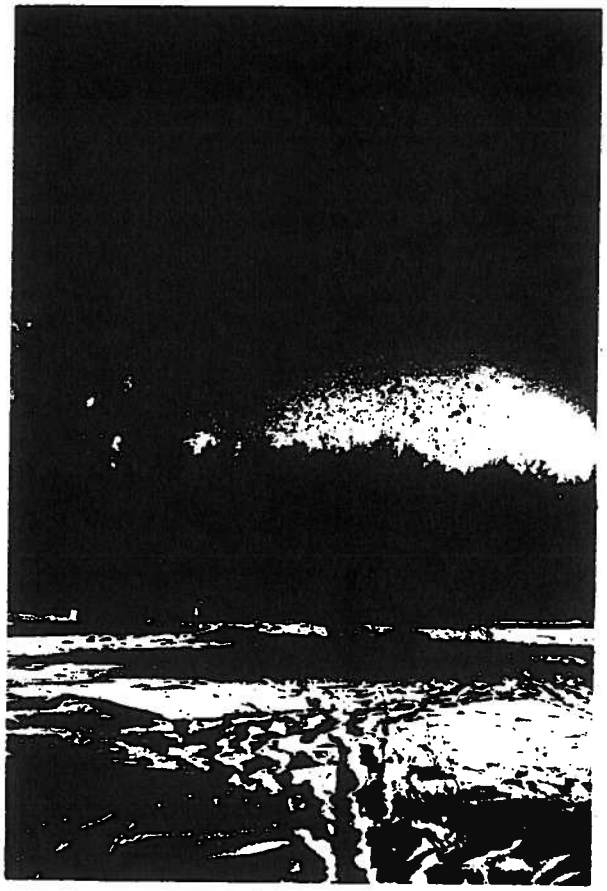
SCOPE AND OBJECTIVES

The scope and objectives for the New Norway seismic project were formulated in various correspondence between Energy and Natural Resources and the Groundwater Division, Alberta Research Council but are probably best outlined in a memorandum by Gordon Gabert dated May 17, 1978 (App. A).

The main objective of the project was to attempt to scientifically evaluate the effects of seismic detonations on water wells and thus aid E&NR in evaluating claims of well damage. According to complaints received, the most common parameters affected were water levels, groundwater chemistry, well hydraulics, well depths, groundwater appearance or smell and well yield. A secondary objective of the project was to establish how far from water wells seismic detonations should take place in order to minimize or eliminate possible damaging effects. This objective would therefore attempt to verify the present legal distance of 183 m.

In establishing the scope of the project, it was important to operate under conditions that were as typical of Alberta as possible. The project was to be located in a plains environment typical of Alberta. A line of four wells were to be completed; two in a typical bedrock aquifer such as a bentonitic sandstone, and two in a typical drift aquifer such as sand or sand and gravel. Well construction was to be either slotted casing or open hole as is common in most domestic water wells in Alberta. Three or four shotholes, 18 m deep, were to be drilled in a line at right angles to the line of water wells and loaded with 4.5 kg of explosive. Well and aquifer conditions were to be evaluated by aquifer and well performance tests prior to detonation. After each detonation, well conditions were to be re-evaluated using the same sequence of aquifer and well performance tests. A down-the-hole camera, supplied by Alberta Environment, would be used to inspect wells after every detonation.

NEW NORWAY SEISMIC PROJECT



The 4.6 m shothole detonation. Continuous water level recorder shown in background. This photo was taken a few seconds after the cover photo.

EXPLORATION AND FINAL SITE SELECTION

After receiving bids from five water well drilling contractors, Schmidt Drilling Ltd. of Tees, Alberta was selected to complete the drilling portion of the project.

As mentioned previously, one of the basic requirements of the project site was that it be typical of Alberta conditions and be underlain by bedrock and drift aquifers suitable for hydrogeological testing. This requirement of two typical aquifers at one site proved rather stringent and the first two weeks of the field portion of the project consisted of exploring for a suitable location. The search area had been narrowed somewhat in that the suitable bedrock was thought to be Horseshoe Canyon Formation at a location within 160 km of Edmonton. The requirement that a drift aquifer of sufficient size be present generally indicated that a buried valley of some description should also be present at the site. On this basis, an area southwest of Camrose, which was underlain by Horseshoe Canyon Formation and traversed by the Red Deer buried valley, was selected for exploration. Pertinent details of the exploration sites are in appendix A.

The first site, located at NW-17-44-21 W4M (Fig. 1), or about 12 km southwest of New Norway, was drilled on October 17, 1978. Wells in bedrock and drift were completed the same day. Drift consists of 15 m of till and clay which yielded approximately 10 cubic meters per day (m^3/d) during airlifting. Bedrock consists of a sandstone and shale sequence which yielded 80 to 130 m^3/day during airlifting. Because of the lack of a suitable drift aquifer the site was abandoned.

The second and third sites (Fig. 1) were located about 6 km southeast of New Norway at NW-25-44-21 W4M and SE-25-44-21 W4M. The second site was located in the northern portion of a meltwater channel in order to locate a suitable drift aquifer. The drift, however, consists of 11 m of till and clay which yielded no groundwater. Bedrock, on the other hand, consists of sandstone and shale, and yielded approximately 70 m^3/day. This site was also abandoned.

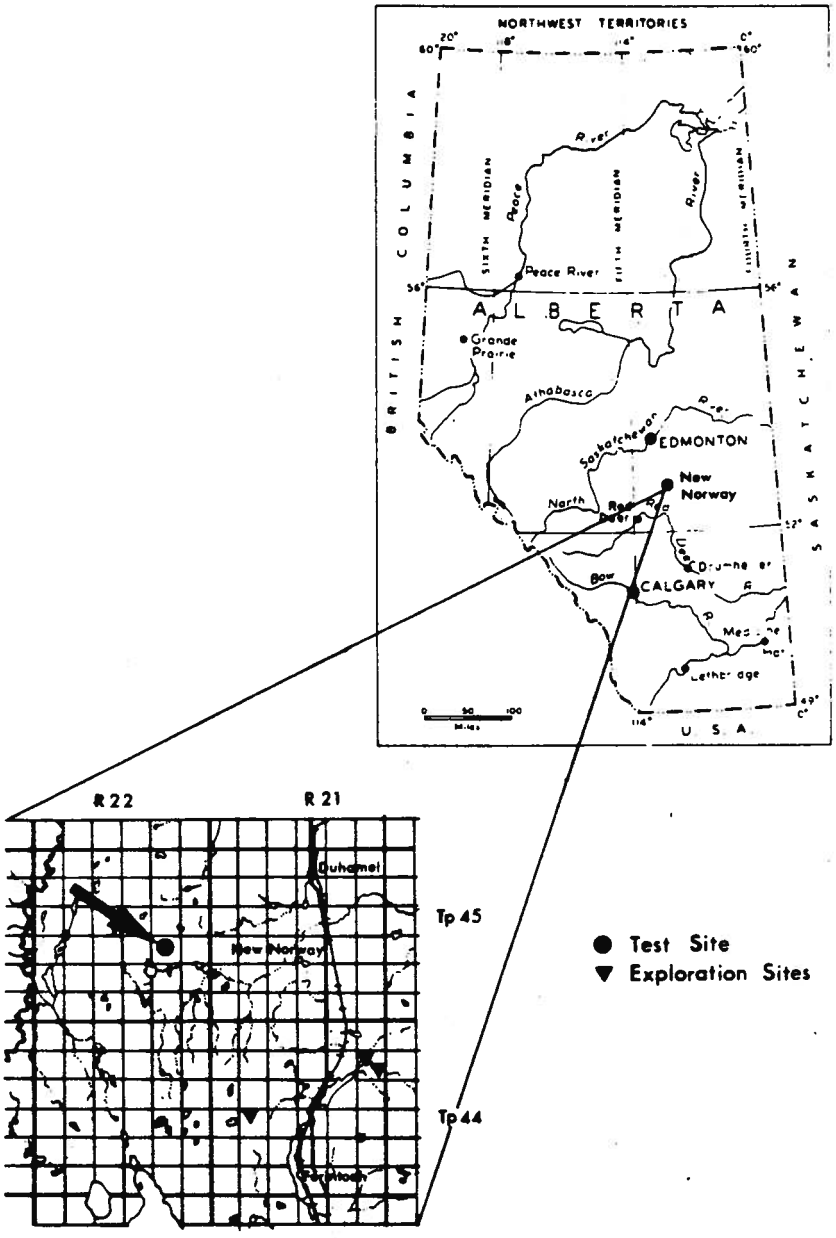


Fig. 1 Location map

The third site was located on the south side of the same meltwater channel. Here, three wells were drilled to depths of 39, 43 and 79 m. The drift, approximately 40 m thick, consists of till, clay, sand and gravel and contained two excellent gravel aquifers between 30 m and 40 m below surface. Using a completion of slotted casing, the top gravel aquifer yielded 200 m^3/day during airlifting. After completion of the drift wells, a bedrock well was drilled to a depth of 79 m in a sequence of shale and sandstone which only yielded 10 m^3/day during airlifting. Because of this, the site was abandoned.

The final exploration site, which ultimately became the project site (Fig. 1) was located 10 km west of New Norway at 11-14-45-22 W4M. A total of four wells were drilled; two to 25 m and two to 73 m. Approximately 25 m of drift is present and consists of till, clay, and a basal, 3.3 m thick, sand and gravel aquifer. During airlifting the gravel aquifer produced approximately 45 m^3/day. Bedrock encountered during drilling consisted of sandstone, siltstone, shale and coal seams which produced approximately 15 m^3/day during airlifting. Although the yield of the bedrock was low, it was considered to be adequate and this location was therefore selected as the project site.

PROJECT SITE DESCRIPTION

Drilling and Well Details

Exploration drilling of the project site commenced on October 30, 1978. The initial pilot holes which were sampled every 1.5 m and electrically logged, were reamed, cased and airlifted to complete the project wells. The resulting four wells were located in a north-south line 15 m apart (Fig. 2). The drift wells were the northern two wells and were identified as DS (drift south) and DN (drift north). Well completion in both cases consisted of 140 mm diameter casing slotted between 22 m and 25 m below ground surface (Figs. 3 & 4). The driller was instructed to cut a typical slot pattern in this 3 m interval, but on inspection the number of slots was increased. In this regard the completion of the drift wells was not, strictly speaking, typical. The bedrock wells were the southern pair and were identified as BOH (bedrock open hole) and

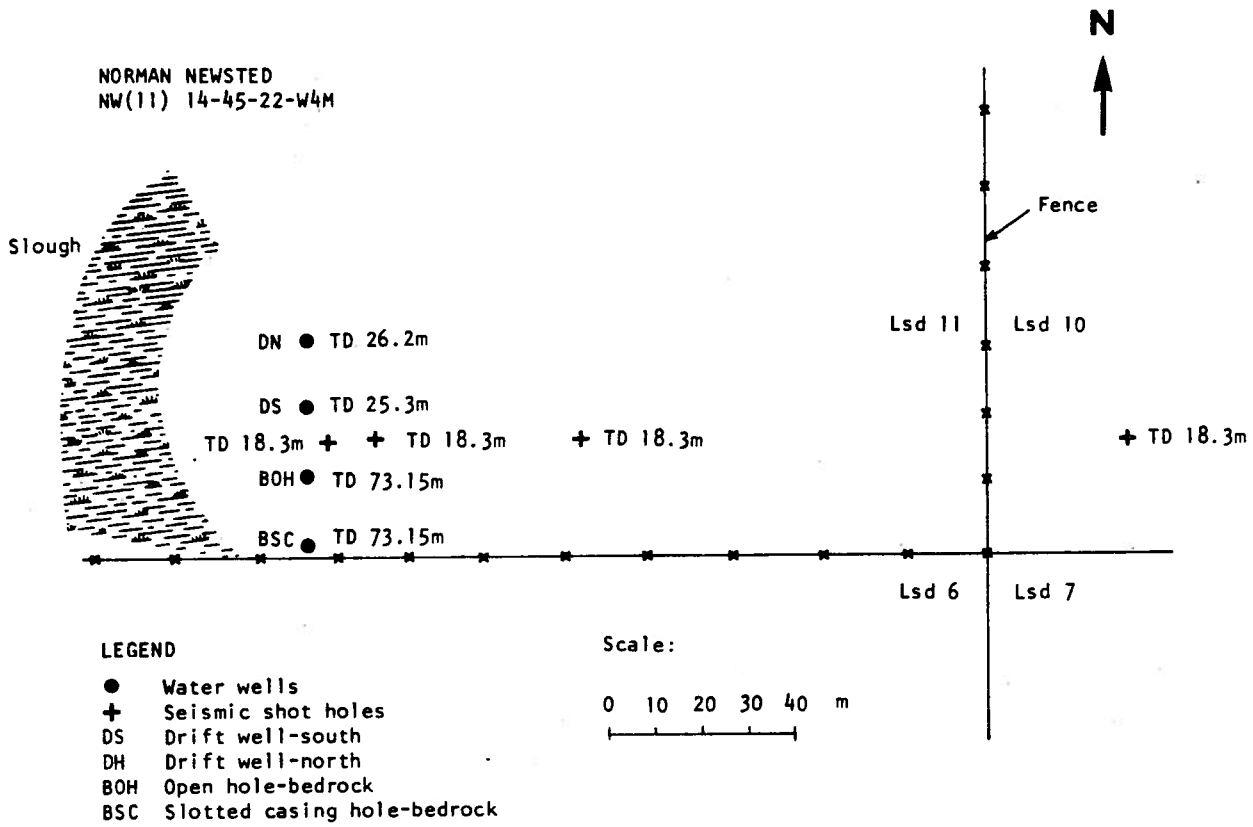


Fig. 2 Well layout

BSC (bedrock slotted casing). Both bedrock wells were drilled to a depth of 73 m (Figs. 3 & 4). Well BOH was completed using 140 mm diameter casing to a depth of 27 m and open hole completion to the bottom of the well. Well BSC was completed using 140 mm diameter casing from surface to 30 m and a 114 mm diameter slotted liner from 28 m to the bottom of the well. In the case of BSC the driller was instructed to slot the liner in a typical pattern which was not subsequently modified. In order to be compatable with domestic water wells no cementing was done during well construction, rather casing seals were attempted by driving casing into the appropriate shale beds.

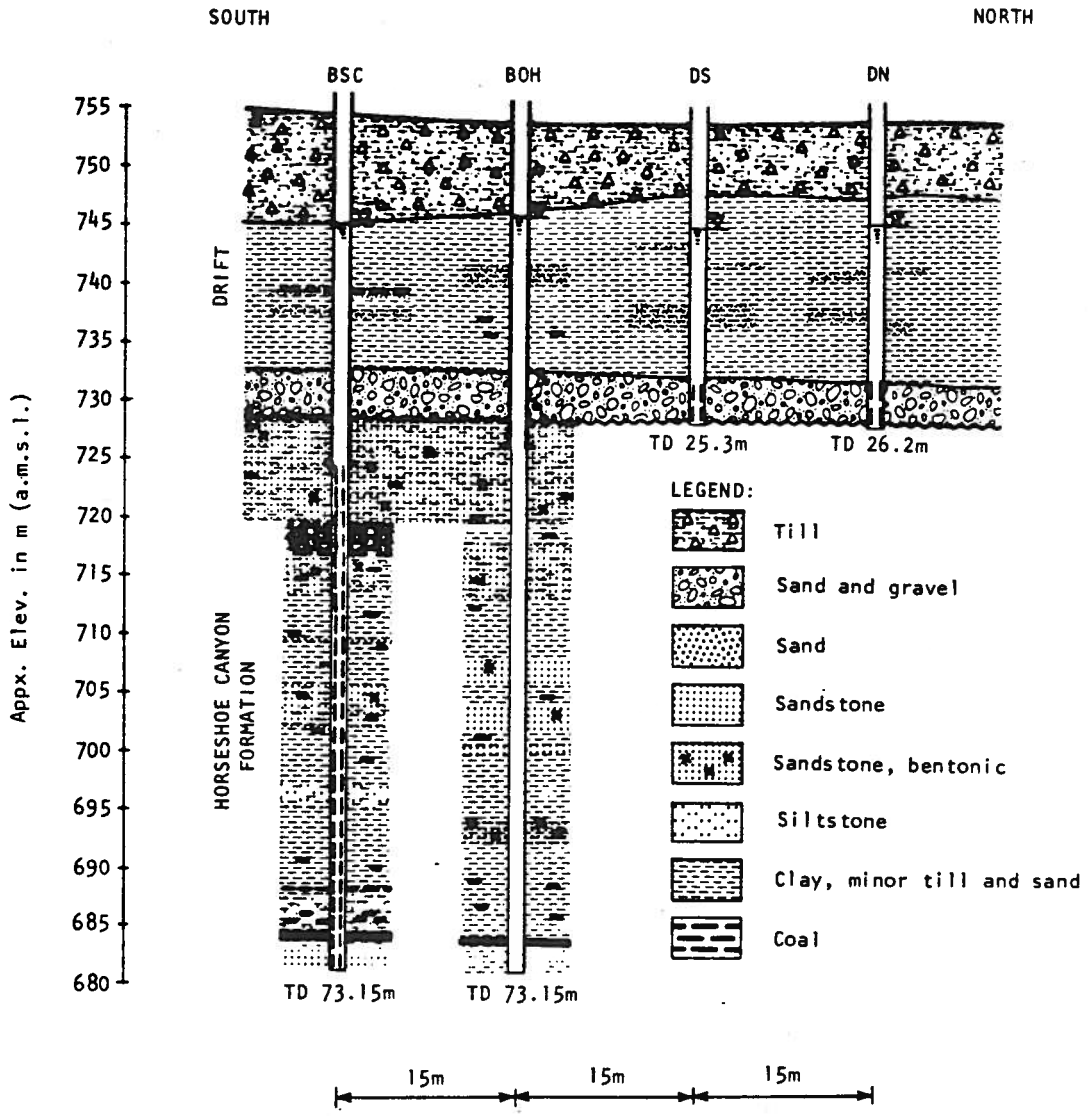


Fig. 3 Geological cross section

Problems occurred during development of the drift aquifer. During airlifting large amounts of sand entered wells DS and DN and between 6 and 8 hours were required to complete development of each well. This is probably atypical when compared to domestic water wells. In spite of development, sand continued to enter well DS during pumping and its total depth was therefore decreasing slightly

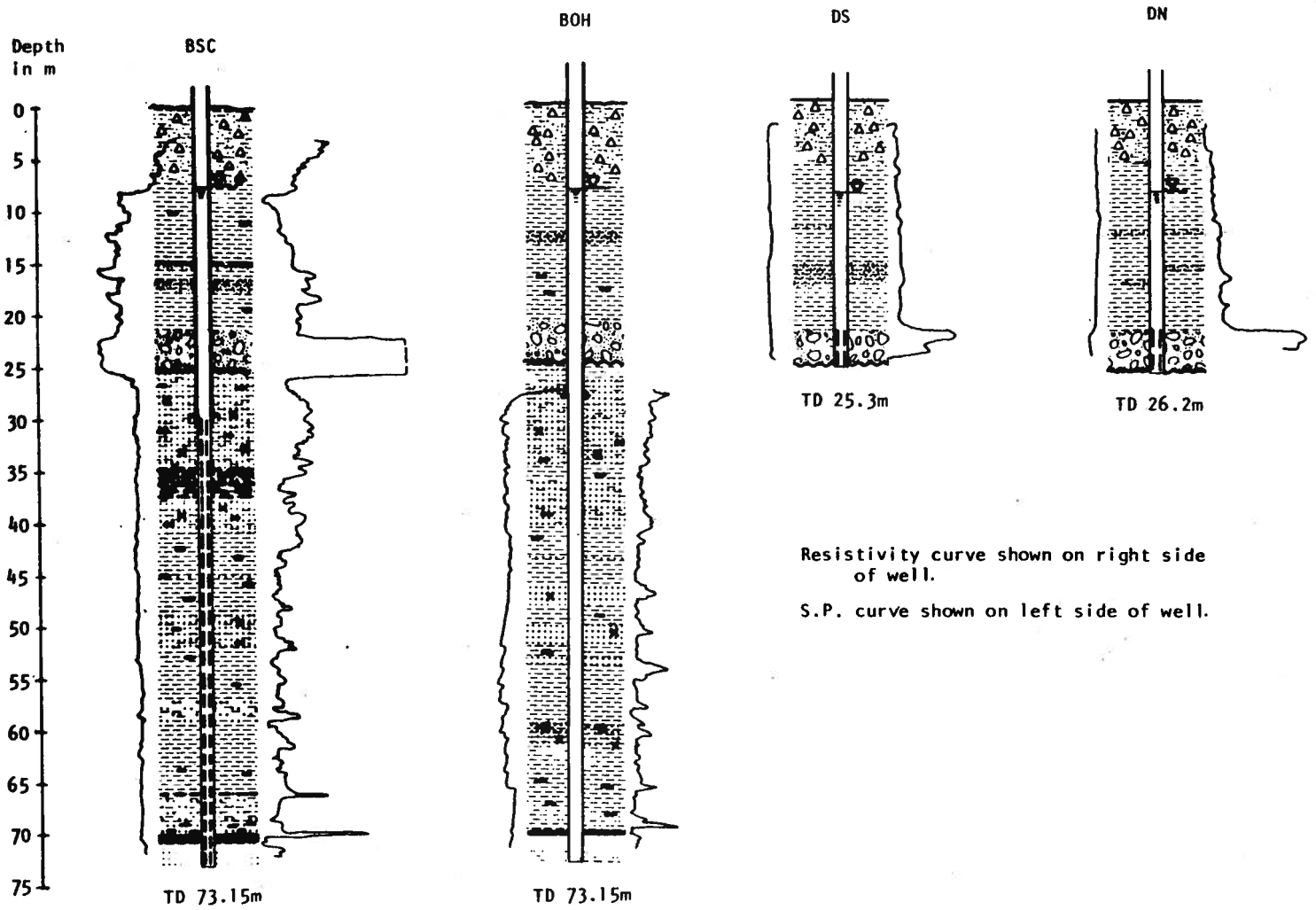


Fig. 4 Lithological and electrical well logs

during testing. Development of the bedrock wells consisted of washing and air-lifting each well for approximately two to three hours. Well BOH, probably because of the open hole completion, bridged at 59 m a few days before detonation began.

Shotholes were drilled in an east-west line at distances of 183, 61, 15, and 4.6 m away from the line of wells (Fig. 2). Shotholes were drilled to a depth of 18 m and loaded with 4.5 kg of explosive. The completion of shotholes in the drift was atypical of seismic exploration procedures in Alberta.

General Geology

The project site occurs in an area underlain by the preglacial Red Deer River valley and Cretaceous Horseshoe Canyon Formation bedrock. The site was approximately 3 km north of the center line of this preglacial valley and is shown by Stalker (1960) to be underlain by a total drift thickness of between 23 and 28 m. The succession of drift underlying the site (Figs. 3 & 4) consists of lake clays, tills, intertill sands and gravels, and preglacial sands and gravels. It is assumed that the basal sand and gravel aquifer, tested during the project, is preglacial in spite of granitic fragements being present in drill cuttings. Contamination from overlying intertill sands and gravels, during drilling, is suspected. The sand and gravel aquifer is composed of medium to coarse dark gray sand in a matrix of well rounded pebbles of chert and limestone up to 75 mm in diameter.

The bedrock consists of fine to medium grained bentonitic sandstones, dark colored shales, minor siltstone and the occasional coal seam (Figs. 3 & 4). The down-the-hole camera showed that in the open hole (BOH), sandstone and siltstone layers preferentially cave compared to shales and coals.

General Hydrogeology

The main aquifers tested during the project were the basal sand and gravel in the drift and a collection of small, indistinct aquifers in the bedrock (Figs. 3 & 4). The sand and gravel aquifer is confined, having a potentiometric surface

approximately 8.3 m below ground surface. The bedrock "aquifer" is composed of several thin low yielding zones which include a sandstone at 38 m, a shale at 44 m, a sandstone at 54 m and a coal seam at 70 m. The combined potentiometric surface for these aquifers is 8.6 m below ground surface. Pre-testing water level fluctuations (Fig. 5) indicated that both bedrock and drift aquifers were responsive to changes in barometric pressure.

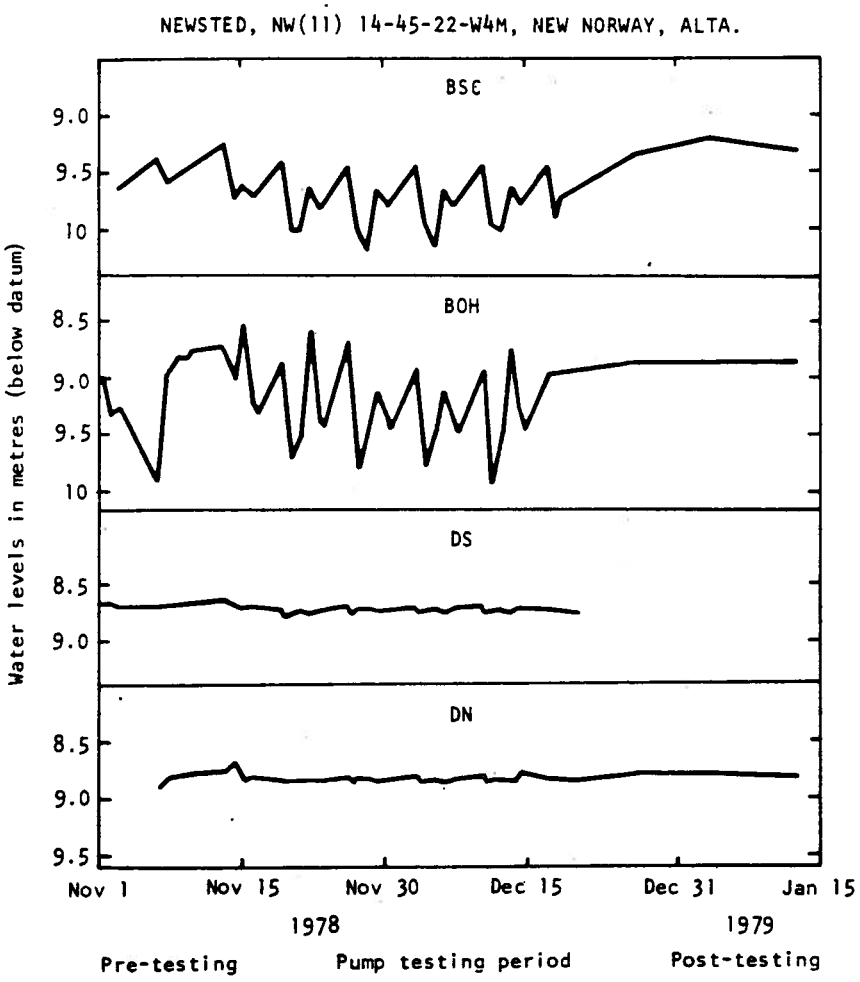


Fig. 5 Water level fluctuations

Assuming wells BOH and DS are at the same elevation a small downward hydraulic gradient exists under the project site. In addition, regional groundwater movement is probably towards the south into the topographic low which coincides with the thickest portion of the preglacial valley.

Both aquifers have total dissolved solids concentrations in the range 1400 to 1700 mg/l. The drift aquifer groundwater is of poor quality because of high concentrations of iron, sulfate, hardness, and alkalinity. Bedrock groundwaters are of slightly better quality but have high concentrations of sodium, sulfate, iron, and alkalinity.

TESTING METHODS AND SEQUENCES

As previously mentioned, the basic purpose of this project was to evaluate the effects (if any) of seismic detonations on water wells. It was felt that any such effects could best be measured by calculating aquifer characteristics and well characteristics prior to any detonations and after each individual detonation.

Aquifer characteristics were calculated by means of constant rate, twelve hour aquifer performance tests conducted in both the drift and bedrock wells. Tests of the bedrock aquifer were completed using well BOH as the pumping location and well BSC as the observation well. Tests of the drift aquifer were completed using well DS as the pumping location and well DN as the observation well. During aquifer performance tests all wells were monitored to evaluate interaction between drift and bedrock aquifers. Recovery measurements were taken after all aquifer performance tests and, in some cases, analyzed (App. B & C).

Well characteristics were calculated by means of variable rate, well performance (step-drawdown) tests consisting of five 100-minute pumping intervals at successively higher pumping rates. For well DS these steps were completed at 10.9, 21.8, 32.7, 43.6, and 54.5 m^3/day and for wells BSC and BOH the appropriate pumping rates were 2.725, 5.45, 8.175, 10.9, and 13.625 m^3/day. Water levels were measured in all wells during all well performance tests. Time-drawdown plots are shown in appendices B and C.

Aquifer and well performance tests were completed in a set sequence as shown in table 1. These testing sequences were numbered according to whether they were pre-detonation (all tests ending with number one) or post-detonation (all tests ending with numbers two through five). Appropriate examples are BOHAT 1 (bedrock open hole aquifer test 1) or DSWT 4 (drift south well test 4). Table 1 shows the testing sequence adopted, as well as dates and test numbers in relation to the particular shothole detonations.

Table 1. Well Testing Sequence - New Norway Seismic Project

Pre-detonation Nov 14-20, 1978	BSCWT 1	DSWT 1	BOHWT 1	DSAT 1	BOHAT 1
-- 183 metre shothole detonation, November 21, 1978 --					
Post 183 metre detonation Nov 21-27, 1978	BSCWT 2	DSWT 2	BOHWT 2	DSAT 2	BOHAT 2
-- 61 metre shothole detonation, November 28, 1978 --					
Post 61 metre detonation Nov 28-Dec 4,1978	BSCWT 3	DSWT 3	BOHWT 3	DSAT 3	BOHAT 3
-- 15 metre shothole detonation, December 5, 1978 --					
Post 15 metre detonation Dec 5-11, 1978	BSCWT 4	DSWT 4	BOHWT 4	DSAT 4	BOHAT 4
-- 4.6 metre shothole detonation, December 12, 1978 --					
Post 4.6 metre detonation Dec 12-18, 1978	BSCWT 5	DSWT 5	BOHWT 5	DSAT 5	BOHAT 5

BSC = Bedrock slotted casing, BOH = Bedrock openhole,
DS = Drift south, DN = Drift north
WT = Step-drawdown well test, 5 steps, 100 minutes per step
AT = Aquifer test, constant flowrate, 12 hours duration

Groundwater samples were collected thirty minutes after the start of each test and a few minutes before the end of each test. Well depths were measured after each weekly set of tests. Detonation of the appropriate shothole then occurred, well depths were remeasured, and wells were logged with the down-the-hole camera. During shothole detonation, continuous water level recorders were operating in order to measure the effects of detonation on the water levels in the wells.

Aquifer performance tests were analyzed using the type curve method (Theis, 1935) and the modified non-equilibrium method (straight line) of Cooper and Jacob (1950). Well performance tests were analyzed using a type curve method (Sheahan, 1971), a graphical procedure (Bierschenk and Wilson, 1961) and a computer method (Labadie and Helweg, 1975).

PRE-DETONATION HYDROGEOLOGICAL CHARACTERISTICS

Aquifer Characteristics

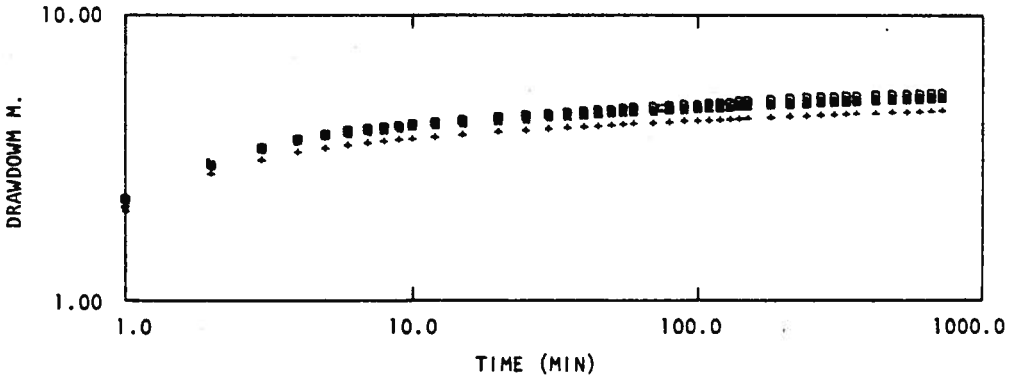
Pre-detonation aquifer characteristics were evaluated by analyzing drawdown (and occasionally recovery) data from aquifer performance tests DSAT 1 and BOHAT 1 (App. B). Time-drawdown plots of these tests, inter alia, are also shown in figures 6a to 6h.

Table 2 shows at the top, drift aquifer parameters obtained from the analysis of DSAT 1. Using the data from the observation well (well DN), the sand and

Table 2. Results of Drift Aquifer Performance Tests - New Norway Seismic Project

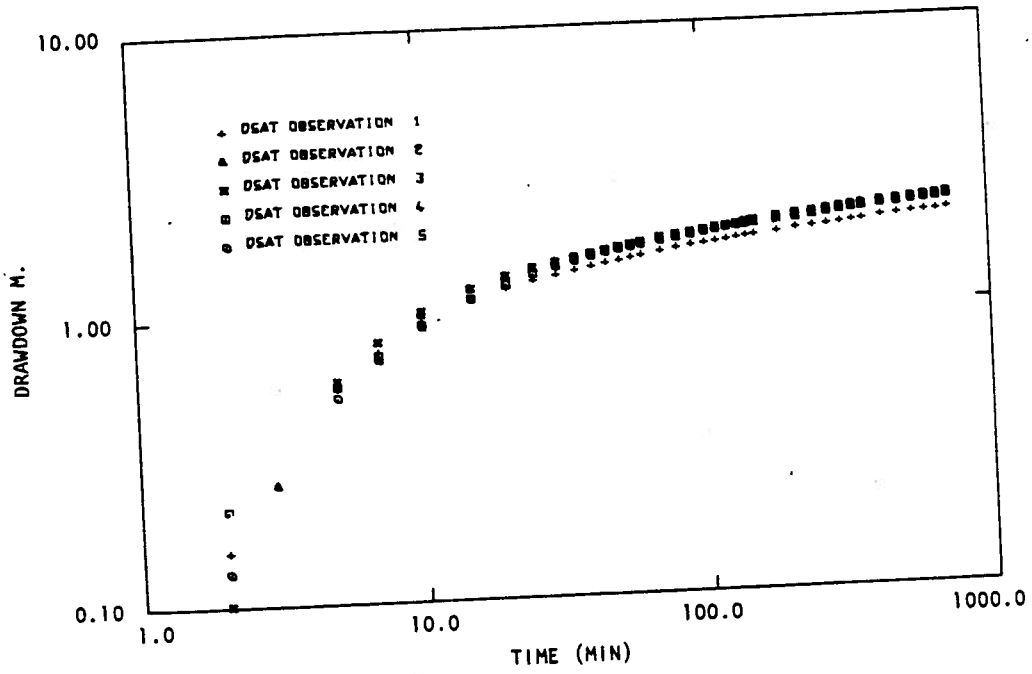
	Pumping Well (Well DS)				Observation Well (Well DN)			
	Straight Line		Type Curve		Straight Line		Type Curve	
	T	S	T	S	T	S	T	S
DSAT 1	21.45	---	13.99	---	17.35	1.52×10^{-5}	17.70	1.28×10^{-5}
DSAT 2	19.18	---	13.55	---	15.35	1.75×10^{-5}	16.18	1.17×10^{-5}
DSAT 3	16.62	---	12.76	---	14.46	2.19×10^{-5}	16.06	1.16×10^{-5}
DSAT 4	18.82	---	13.14	---	15.11	1.73×10^{-5}	16.06	1.16×10^{-5}
DSAT 5	14.05	---	12.68	---	13.85	2.75×10^{-5}	16.06	1.16×10^{-5}

T = Transmissivity (m^2/day)
S = Storativity



	TRANSMISSIVITY (m^2/day)
DSAT PUMP WELL 1	13.99
DSAT PUMP WELL 2	13.55
DSAT PUMP WELL 3	12.76
DSAT PUMP WELL 4	13.14
DSAT PUMP WELL 5	12.68

Fig. 6a Composite drawdown plots for DSAT pumping well



	TRANSMISSIVITY (m^2/day)	STORATIVITY
DSAT OBSERVATION 1	17.70	1.28×10^{-5}
DSAT OBSERVATION 2	16.18	1.17×10^{-5}
DSAT OBSERVATION 3	16.06	1.16×10^{-5}
DSAT OBSERVATION 4	16.06	1.16×10^{-5}
DSAT OBSERVATION 5	16.06	1.16×10^{-5}

Fig. 6b Composite drawdown plots for DSAT observation well

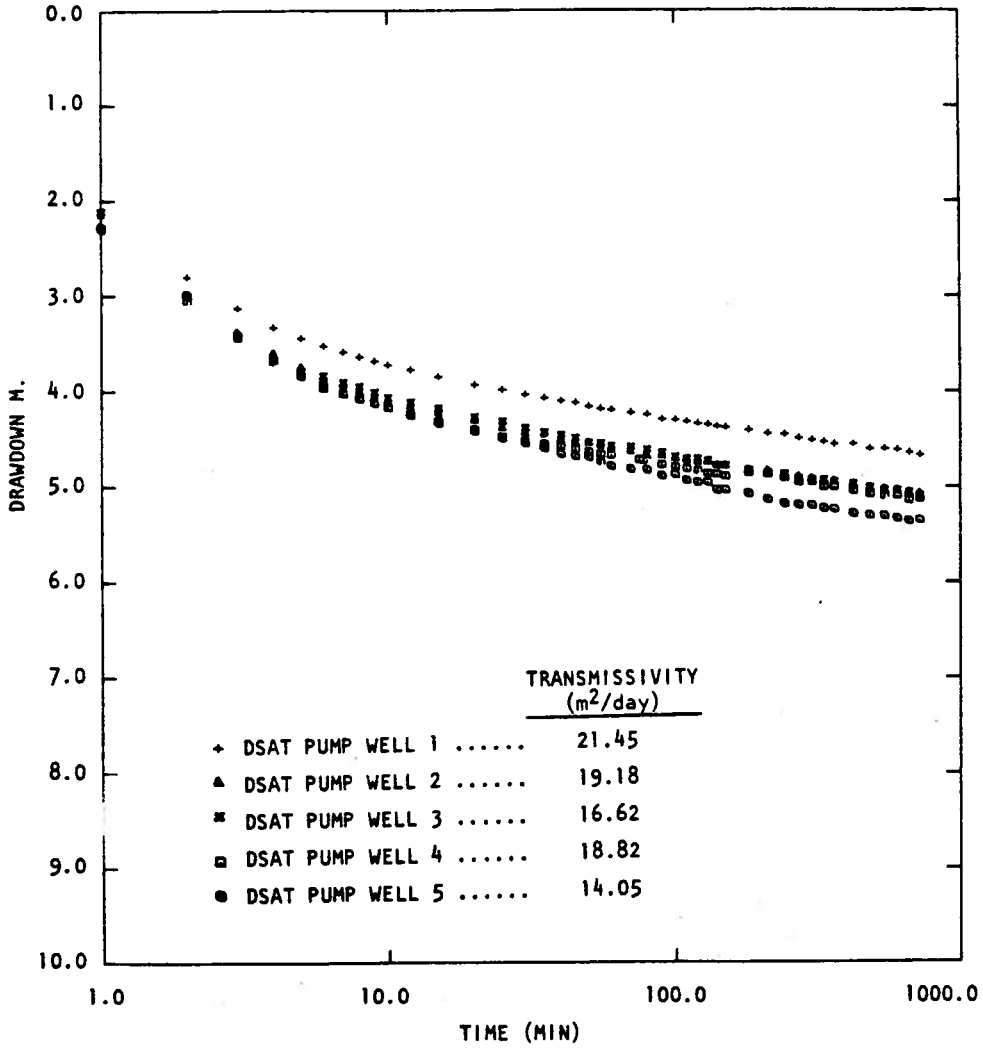


Fig. 6c Composite drawdown plots for DSAT pumping well

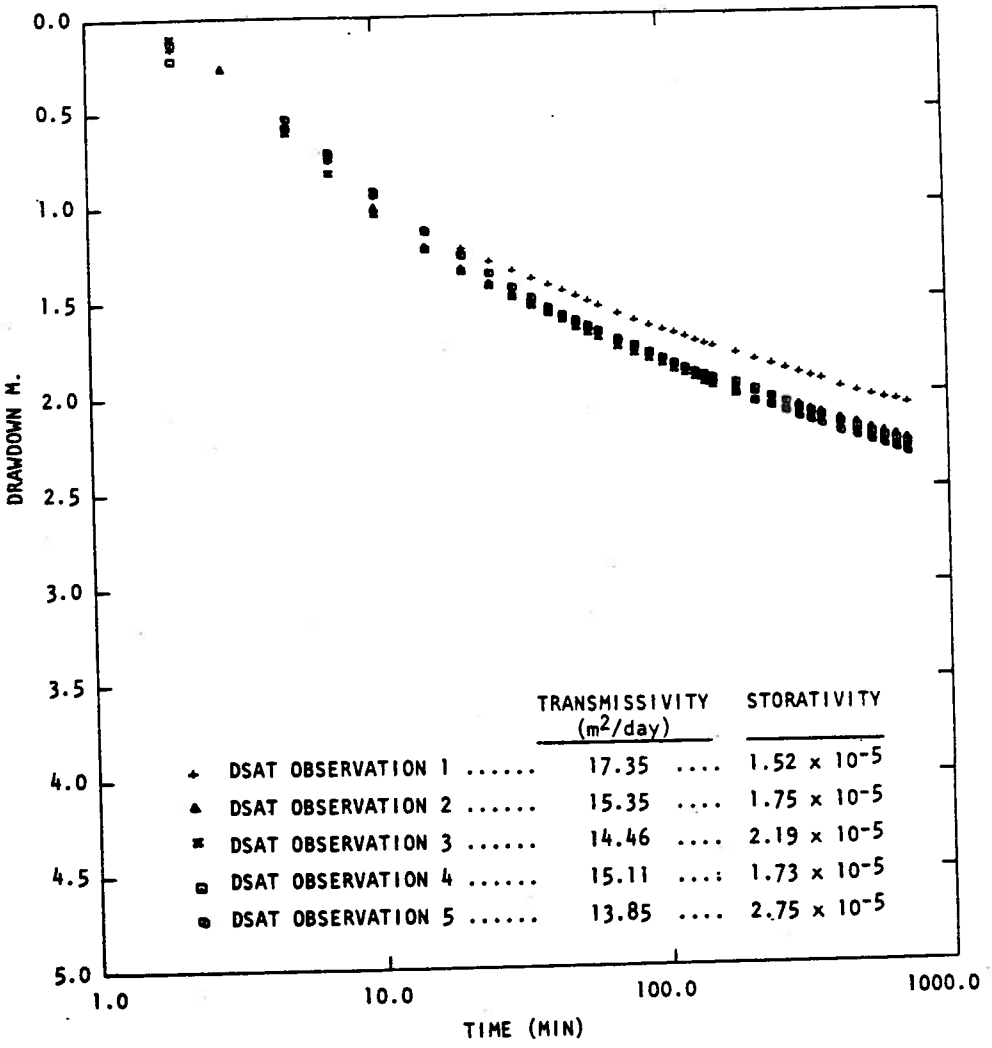


Fig. 6d Composite drawdown plots for DSAT observation well

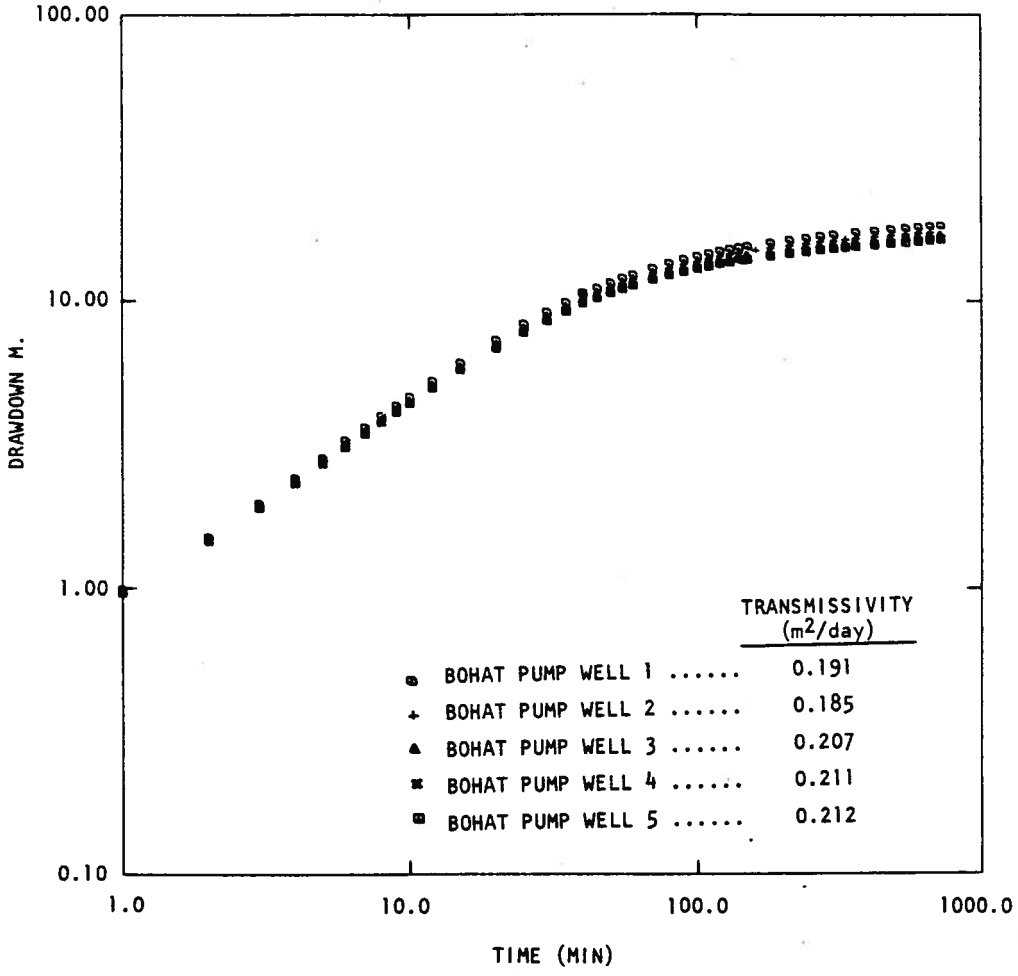
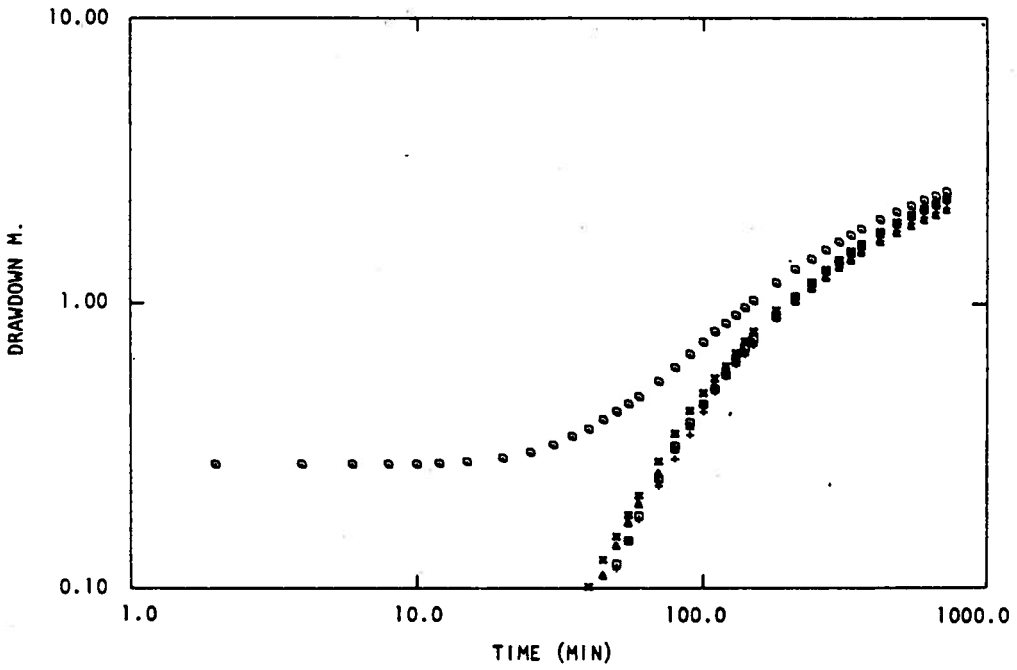


Fig. 6e Composite drawdown plots for BOHAT pumping well



	TRANSMISSIVITY (m^2/day)	STORATIVITY
BOHAT OBSERVATION 1	0.711	5.88×10^{-4}
BOHAT OBSERVATION 2	0.652	6.06×10^{-4}
BOHAT OBSERVATION 3	0.850	4.01×10^{-4}
BOHAT OBSERVATION 4	0.667	6.66×10^{-4}
BOHAT OBSERVATION 5	0.717	6.30×10^{-4}

Fig. 6f Composite drawdown plots for BOHAT observation well

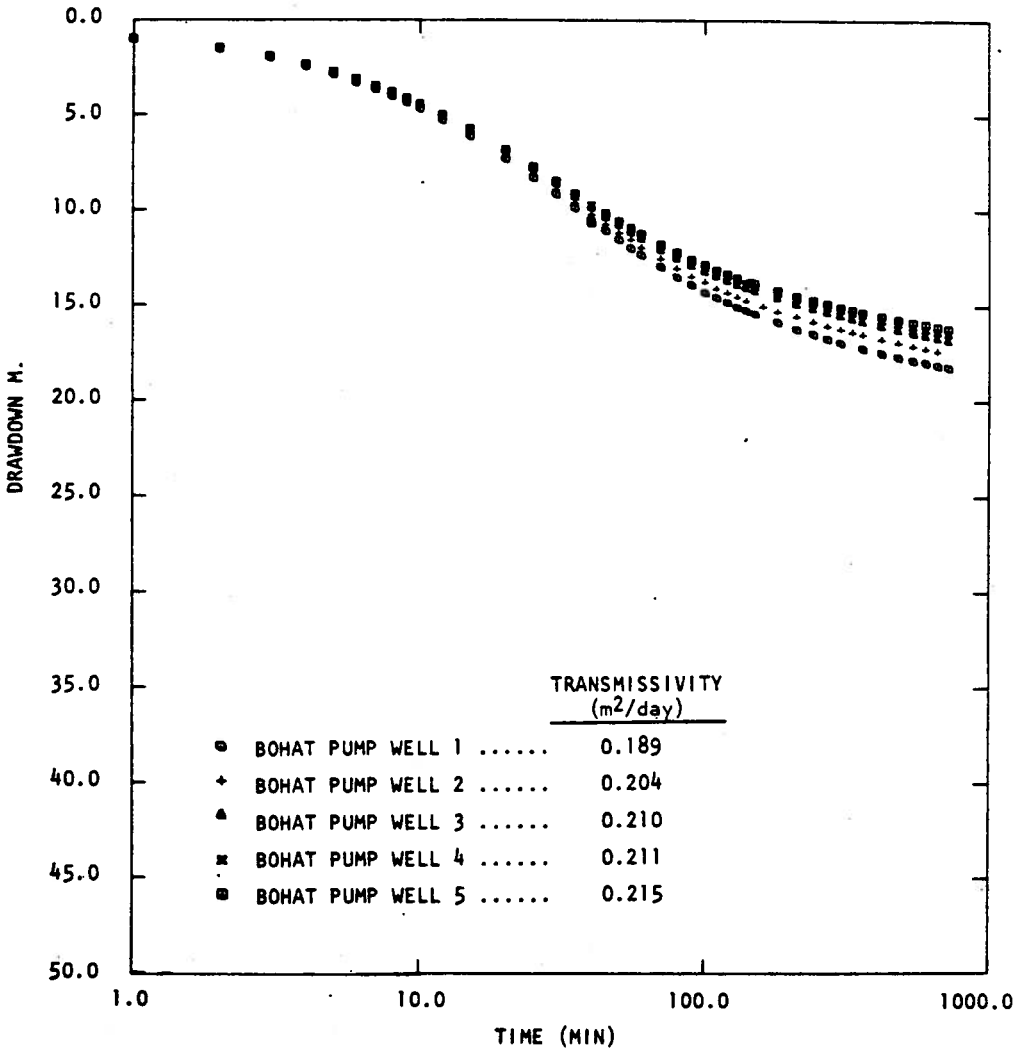


Fig. 6g Composite drawdown plots for BOHAT pumping well

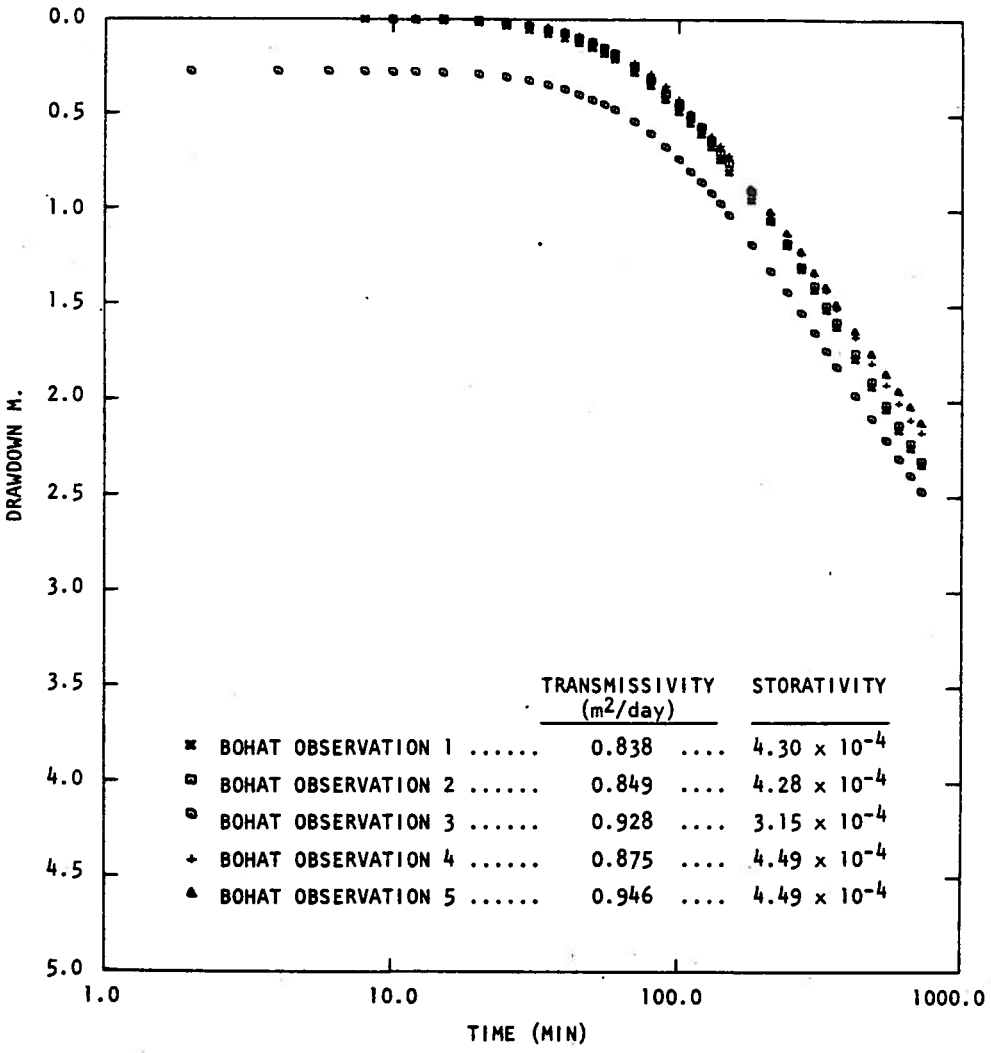


Fig. 6h Composite drawdown plots for BOHAT observation well

gravel aquifer had an average transmissivity of 17.7 square meters per day (m^2/day) and a storativity of about 1.4×10^{-5}. In addition time-drawdown plots for both the pumping and observation wells showed effects (beginning approximately at 200 minutes) which suggest either leakage or the presence of a recharge boundary. Leakage is the more probable explanation because during DSAT 1 water levels in the bedrock wells also responded to pumping. There are three possible causes for this leakage; (1) poor casing seals, (2) the fact that the two drift wells were drilled 0.3 m into the bedrock, or (3) that interformational leakage was occurring. The presence of this leakage, however, did not complicate the analysis of the data as aquifer parameters were calculated before leakage occurred.

The analysis of data from observation well BSC during aquifer performance test BOHAT 1 indicated that the bedrock "aquifer" had an average transmissivity of 0.78 m^2/day and a storativity of about 5×10^{-5} (Table 3). During this test, leakage effects were evident in the pumping well after 100 minutes but were seemingly not present in the observation well data. This would indicate that the leakage was occurring only in the vicinity of the pumping well and not areally into the bedrock aquifer. Another interesting feature of this leakage

Table 3. Results of Bedrock Aquifer Performance Tests - New Norway Seismic Project

	Pumping Well (Well BOH)				Observation Well (Well BSC)			
	Straight Line		Type Curve		Straight Line		Type Curve	
	T	S	T	S	T	S	T	S
BOHAT 1	0.189	---	0.191	---	0.838	4.30×10^{-4}	0.711	5.88×10^{-4}
BOHAT 2	0.204	---	0.185	---	0.849	4.28×10^{-4}	0.652	6.06×10^{-4}
BOHAT 3	0.210	---	0.207	---	0.928	3.15×10^{-4}	0.850	4.01×10^{-4}
BOHAT 4	0.211	---	0.211	---	0.875	4.49×10^{-4}	0.667	6.66×10^{-4}
BOHAT 5	0.215	---	0.212	---	0.946	4.49×10^{-4}	0.717	6.3×10^{-4}

T = Transmissivity (m^2/day)
S = Storativity

was that it began when the water level in the pumping well was approximately 24 m below ground surface or at bedrock-drift contact. Leakage along the casing or conversion from confined to unconfined conditions are possible explanations. As with the drift test, however, analysis of aquifer parameters of the bedrock was not complicated by this effect.

Well Characteristics

Pre-detonation well characteristics were evaluated using well performance tests, BSCWT 1, BOHWT 1, and DSWT 1. No well performance tests were completed using well DN. Basically, the purpose of the well performance tests was to calculate the aquifer loss constant, B, and well loss constant, C, in the equation:

$$s = BQ + CQ^P$$

Where

s = drawdown in the well (m);

B = aquifer or formation loss constant (head loss due to laminar flow); usually assumed to be caused by the aquifer; this term also includes laminar well losses which are not usually separable from the aquifer losses (meters per m^3/day);

C = well loss constant (head loss occurring due to turbulent flow), usually caused by well construction (meters per m^6/day^2)

P = exponent which indicates the severity of the turbulence;

Q = discharge of the well (m^3/day).

The metric units used for these parameters in this report are shown in parentheses. In addition to evaluating the above parameters by the three methods mentioned, well efficiencies at the end of each well performance test were also calculated using the formula:

$$\text{Well efficiency} = \frac{BQ}{BQ + CQ^2} \times 100$$

Because of the testing sequence required there was usually not enough time between well performance tests to allow complete recovery of water levels. This meant, especially for the BSC well tests, that water levels were recovering steeply at the start of the testing. Because it was felt that this recovery may have a significant effect on the calculated parameters, an attempt

was made to correct drawdown readings. Ultimately this was not necessary as the increase in drawdown which could be attributed to the recovering water level trend was less than one percent of the total drawdown caused.

Table 4 shows, inter alia, pre-detonation values of B, C, P, and well efficiencies. Figures 7a to 7f show the methods of calculation of these parameters for the first and last well performance test of each well. Poor data from BSCWT 1 during the first and last steps necessitated using data from the middle three steps of this test. As expected, efficiencies for well DS were slightly lower than the bedrock wells indicating a higher turbulent flow component due to the slotted casing completion at the high pumping rates. Direct comparisons of B and C calculated from BSCWT 1 and BOHWT 1 indicate that these parameters were similar for both wells. The slotted casing completion in well BSC, probably because of the very low pumping rates, did not, therefore, markedly affect turbulent flow components. Well DS, on the other hand, had well effects (CQ^2) which caused a higher percentage of the total drawdown thereby lowering well efficiency.

Using, as example, the results of the Sheahan type curve method gives the following equations for pre-detonation well characteristics after 500 minutes of pumping:

Well BSC: $s = 1.15Q + (4.6 \times 10^{-2})\ Q^2$

Well BOH: $s = 0.96Q + (3.3 \times 10^{-2})\ Q^2$

Well DS : $s = 0.054Q + (5.4 \times 10^{-4})\ Q^2$

Groundwater Quality

Water samples were collected at the beginning and near the end of the pre-detonation aquifer and well performance tests (App. D and Figs. 8a to 8e). Both the drift and bedrock groundwaters were of poor quality with total dissolved solids concentrations of 1400 to 1700 mg/l. The drift groundwater was a calcium-sodium-sulfate-bicarbonate type and had high concentrations of alkalinity, hardness, sulfate, bicarbonate, and iron. The bedrock groundwater was similar, being a sodium bicarbonate-sulfate type of slightly better quality

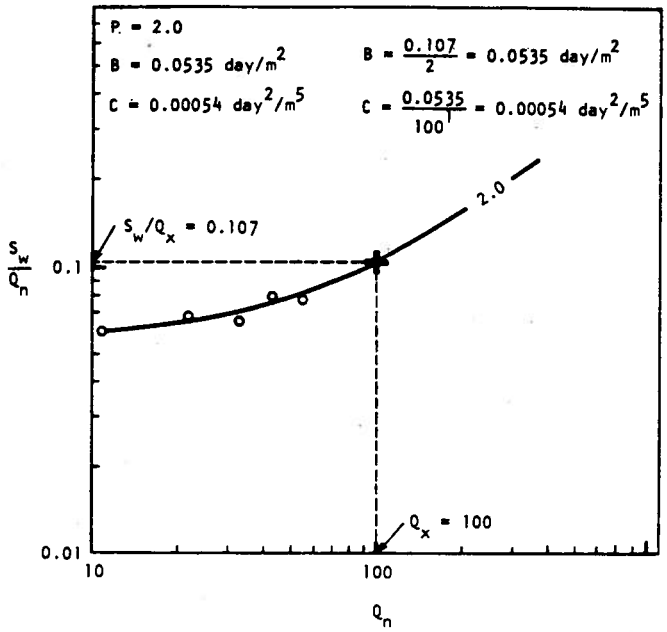
Table 4. Results of Well Performance Tests - New Norway Seismic Project

	Sheahan (1971)			Bierschenk & Wilson (1961)			Labadie & Helweg (1975)			Well Efficiency after 500 Mins. (%)		
Test Number	B	C	P	B	C	P*	B	C	P	Sheahan	Bierschenk Wilson	Labadie Helweg
BSCWT 1	1.15	0.046	2.0	1.23	0.036	2.0	0.600	0.601	1.20	77	82	40
BSCWT 2	1.20	0.03	2.0	1.26	0.024	2.0	1.33	0.004	2.66	79	82	87
BSCWT 3	1.16	0.026	2.0	1.22	0.024	2.0	1.176	0.047	1.79	75	79	76
BSCWT 4	1.175	0.027	2.0	1.15	0.031	2.0	1.123	0.061	1.74	76	75	73
BSCWT 5	1.16	0.026	2.0	1.18	0.027	2.0	1.289	0.0018	2.91	75	76	83
DSWT 1	0.054	0.00054	2.0	0.055	0.00046	2.0	0.0534	0.0004	2.04	68	69	67
DSWT 2	0.050	0.00052	2.0	0.052	0.00043	2.0	0.0426	0.0032	1.59	67	69	57
DSWT 3	0.047	0.00053	2.0	0.047	0.00051	2.0	0.0239	0.01	1.41	63	63	32
DSWT 4	0.043	0.00057	2.0	0.044	0.00056	2.0	0.0376	0.002	1.72	59	60	51
DSWT 5	0.049	0.00054	2.0	0.051	0.0005	2.0	0.0489	0.0003	2.13	62	65	62
BOHWT 1	0.96	0.033	2.0	1.055	0.026	2.0	1.0284	0.0525	1.76	68	75	73
BOHWT 2	0.99	0.032	2.0	1.06	0.026	2.0	1.07	0.017	2.16	70	75	72
BOHWT 3	0.99	0.027	2.0	1.005	0.025	2.0	0.8321	0.1101	1.59	74	75	62
BOHWT 4	1.065	0.023	2.0	1.05	0.027	2.0	1.1152	0.0179	2.04	77	76	80
BOHWT 5	0.81	0.0404	2.0	0.80	0.04	2.0	0.77	0.0715	1.78	62	61	58

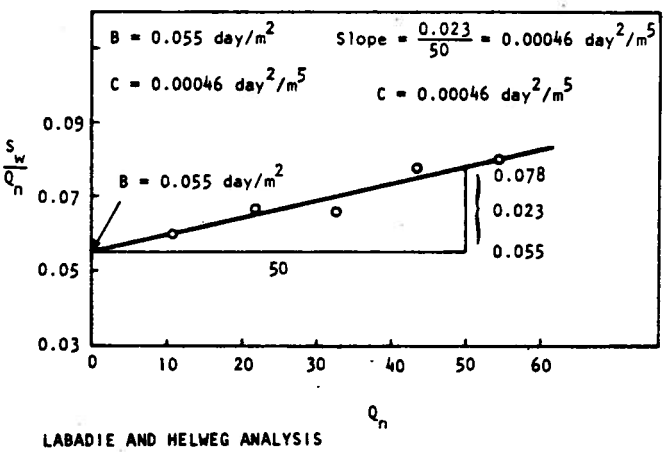
* P is assumed as 2.0 in this method

DSWT 1 Q = 10.9, 21.8, 32.7, 43.6, 54.5 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



LABADIE AND HELWEG ANALYSIS

Q	SW
10.900	0.650
21.800	1.430
32.700	2.145
43.600	3.370
54.500	4.350

OPTIMAL P = 2.0430

B = 0.0534

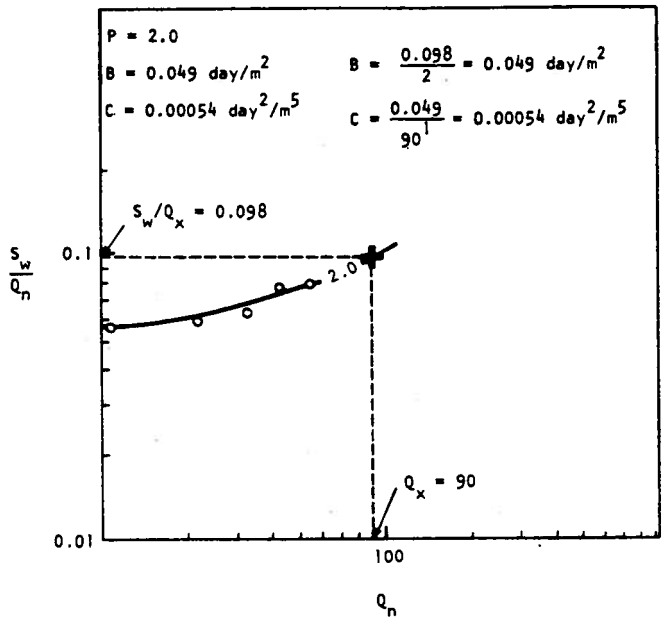
C = 0.0004

MIN.ERROR = 0.0289

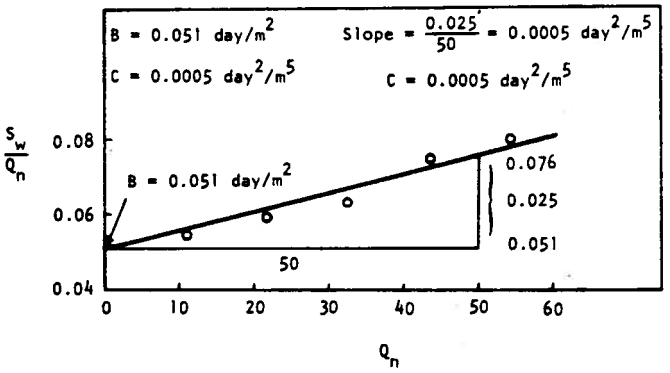
Fig. 7a Analysis of well performance test DSWT 1

DSWT 5 Q - 10.9, 21.8, 32.7, 43.6, 54.5 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



LABADIE AND HELWEG ANALYSIS

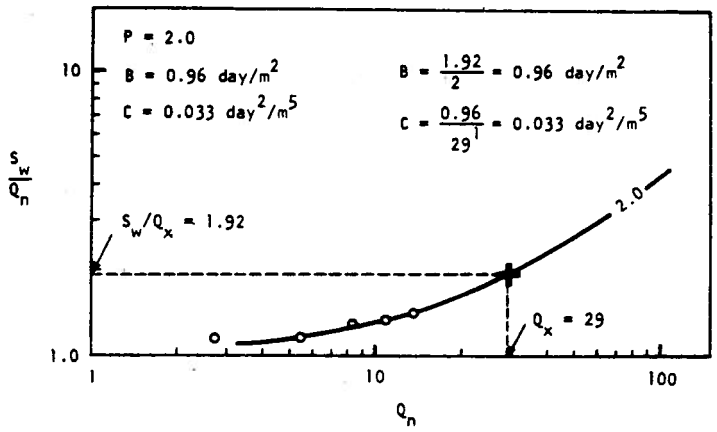
Q	SW
10.900	0.610
21.800	1.315
32.700	2.063
43.600	3.240
54.500	4.280

OPTIMAL P = 2.1300
B = 0.0489
C = 0.0003
MIN.ERROR = 0.0171

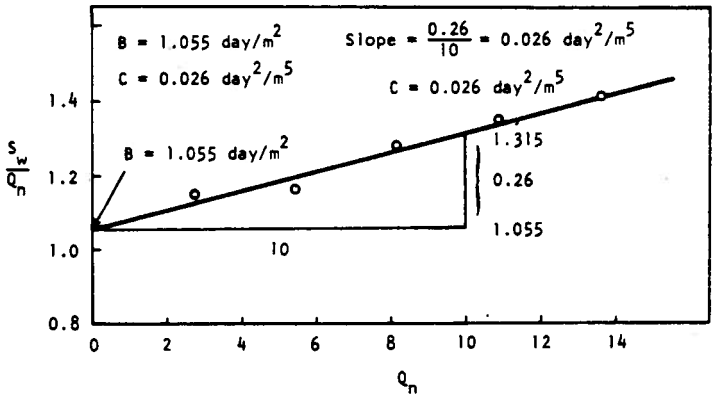
Fig. 7b Analysis of well performance test DSWT 5

BOHWT 1 Q = 2.725, 5.45, 8.175, 10.9, 13.625 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



LABADIE AND HELWEG ANALYSIS

Q	SW
2.725	3.140
5.450	6.640
8.175	10.430
10.900	14.830
13.625	19.170

OPTIMAL P = 1.7590

B = 1.0284

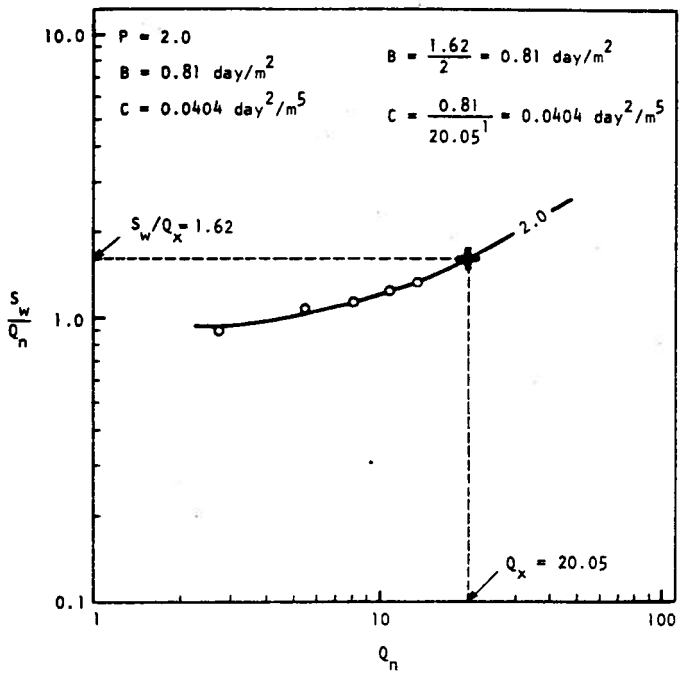
C = 0.0525

MIN.ERROR = 0.0234

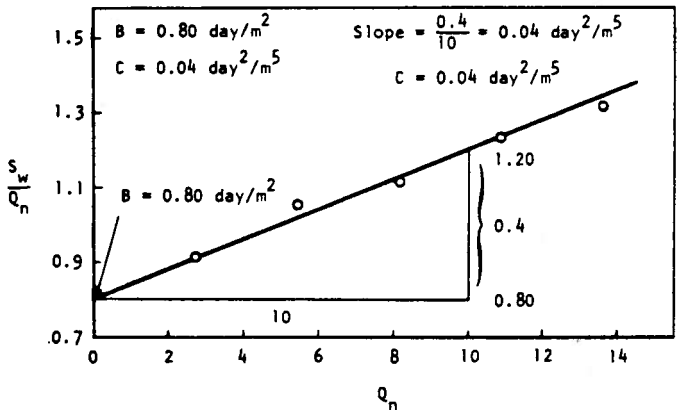
Fig. 7c Analysis of well performance test BOHWT 1

BOHWT 5 Q = 2.725, 5.45, 8.175, 10.9, 13.625 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



LABADIE AND HELWEG ANALYSIS

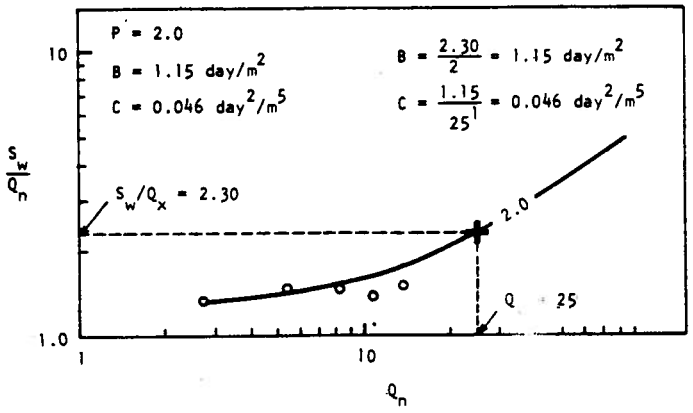
Q	SW
2.725	2.490
5.450	5.750
8.175	9.190
10.900	13.475
13.625	17.935

OPTIMAL P = 1.7790
B = 0.7704
C = 0.0715
MIN.ERROR = 0.0267

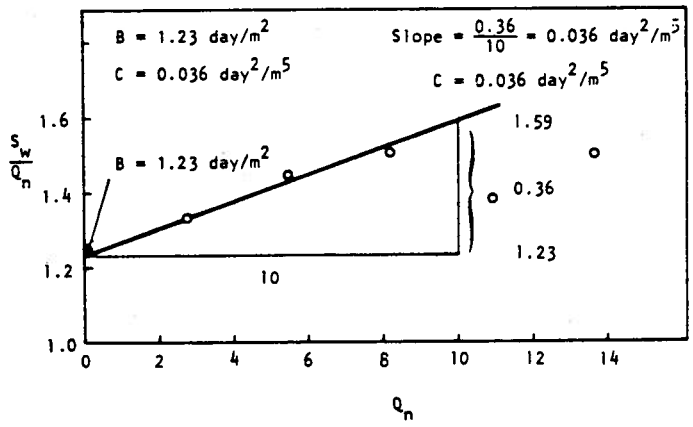
Fig. 7d Analysis of well performance test BOHWT 5

BSCWT 1 Q = 2.725, 5.45, 8.175, 10.9, 13.625 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



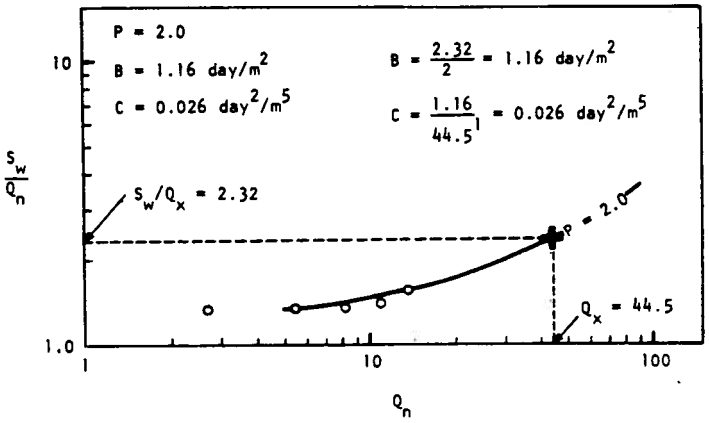
LABADIE AND HELWEG ANALYSIS

Q	SW	OPTIMAL P = 1.1980
2.725	3.636	B = 0.6009
5.450	7.860	C = 0.6014
8.175	12.365	MIN.ERROR = 0.0000

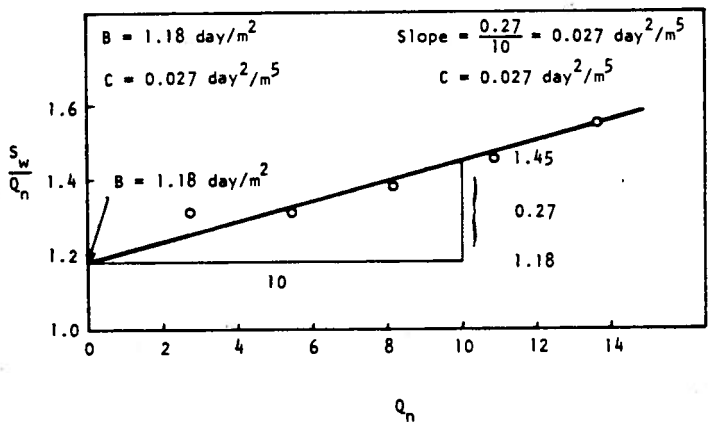
Fig. 7e Analysis of well performance test BSCWT 1

BSCWT 5 Q = 2.725, 5.45, 8.175, 10.9, 13.625 m^3/day

SHEAHAN ANALYSIS



BIERSCHENK AND WILSON ANALYSIS



LABADIE AND HELWEG ANALYSIS

Q	SW
2.725	3.585
5.450	7.220
8.175	11.365
10.900	15.885
13.625	21.085

OPTIMAL P = 2.9070
B = 1.2890
C = 0.0018
MIN.ERROR = 0.0050

Fig 7f Analysis of well performance test BSCWT 5

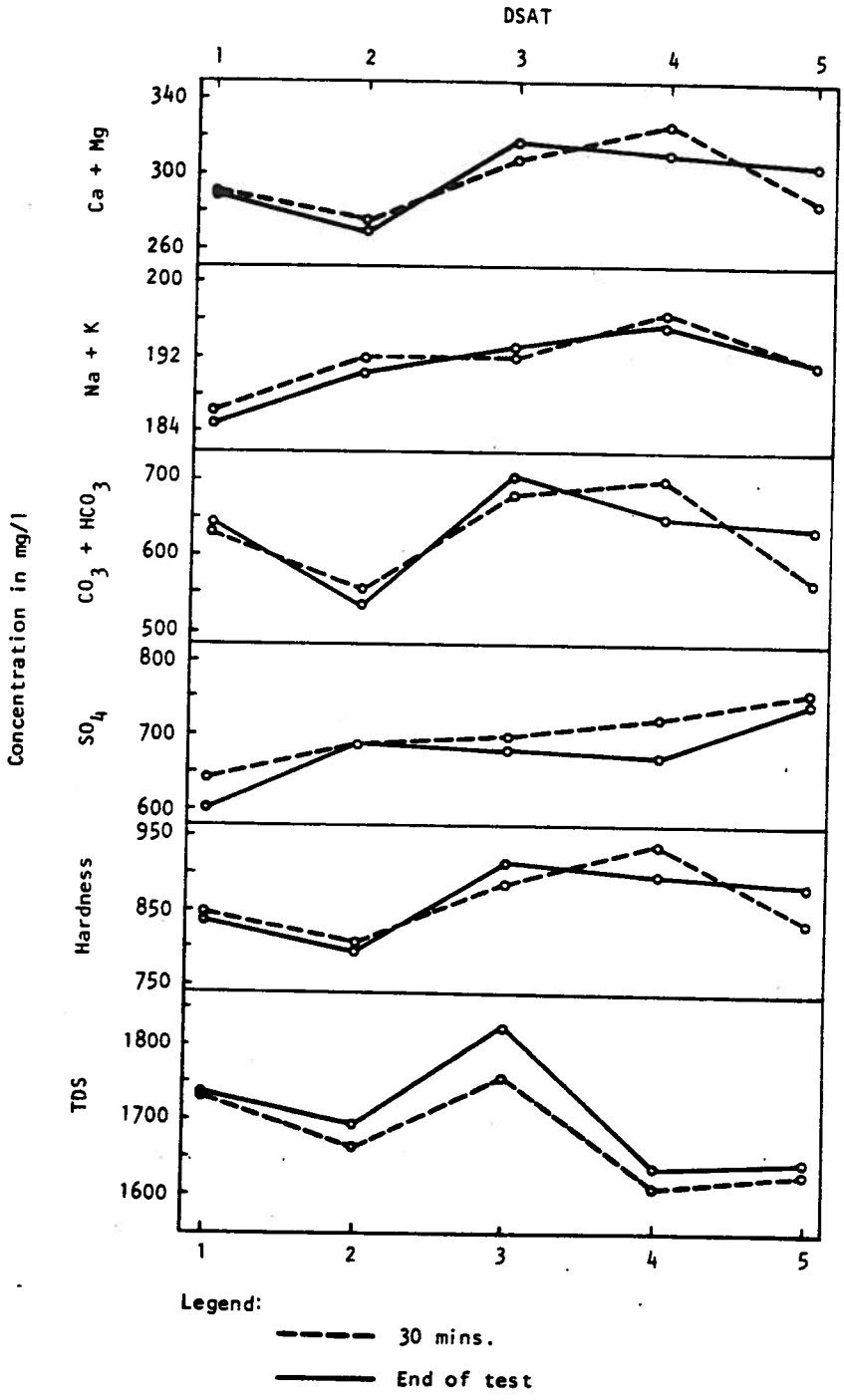


Fig. 8a Chemical variations during DSAT

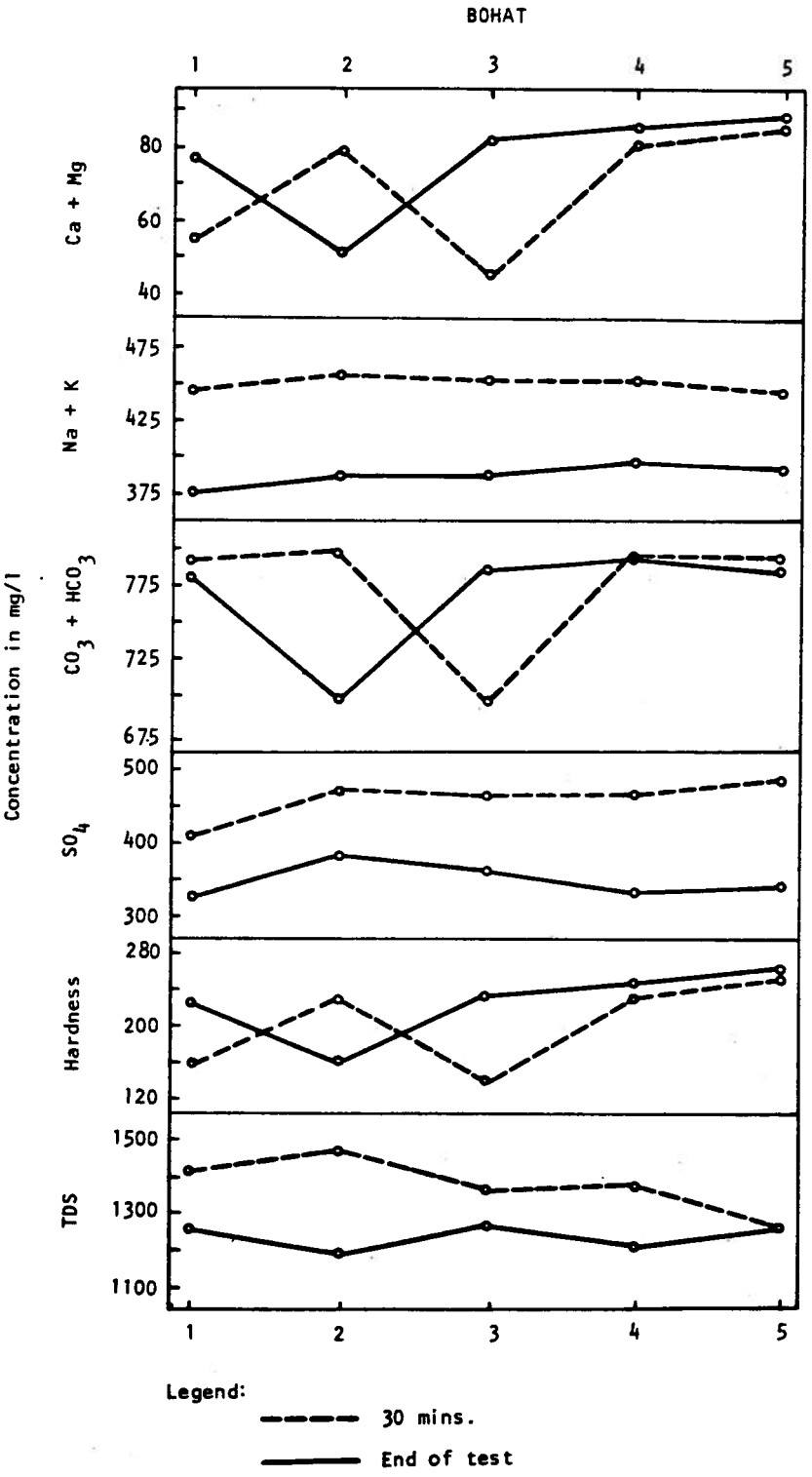


Fig. 8b Chemical variations during BOHAT

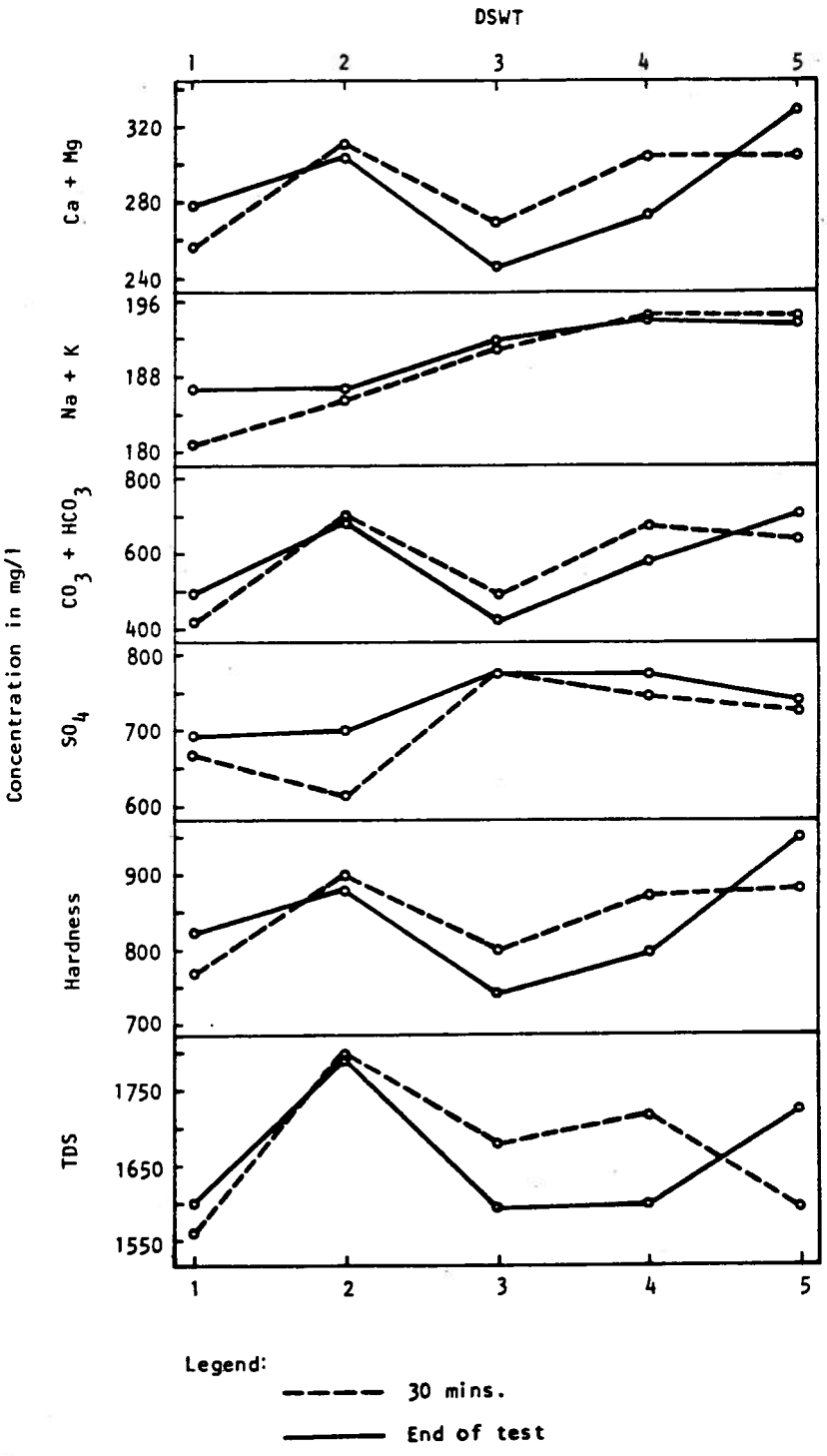


Fig. 8c Chemical variations during DSWT

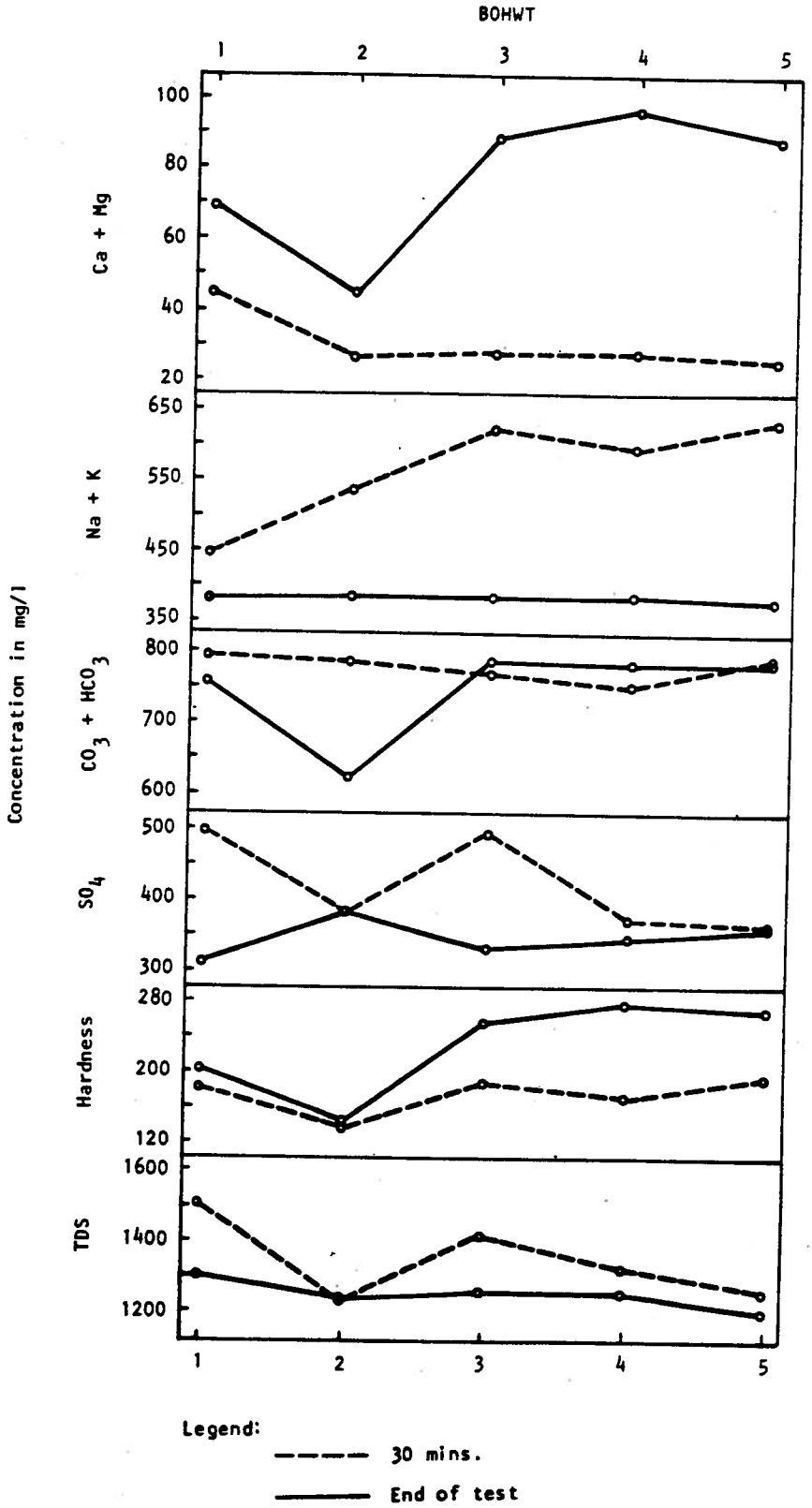


Fig. 8d Chemical variations during BOHWT

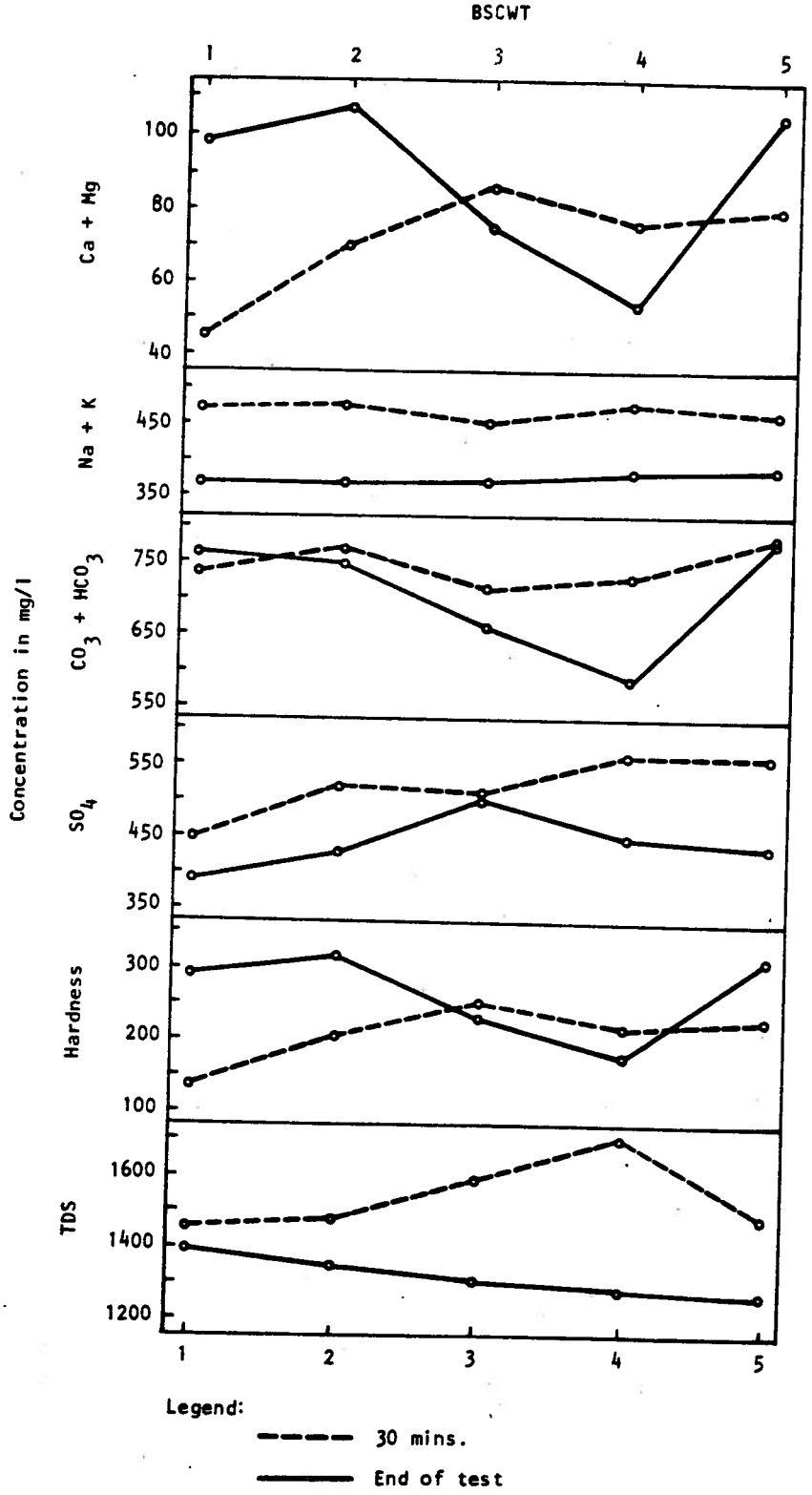


Fig. 8e Chemical variations during BSCWT

with high concentrations of alkalinity, hardness, sulfate, bicarbonate, and iron. Groundwater temperatures for both aquifers were in the range 5°C to 7°C.

Water Level fluctuations

Figure 5 shows water level fluctuations for all wells at the project site. All aquifers were responsive to changes in atmospheric pressure because of the confined groundwater conditions. Static water level fluctuations generally occurred between 8 and 9 m below ground surface for both aquifers, with the bedrock aquifers exhibiting the largest fluctuations during the pre-detonation period.

POST-DETONATION HYDROGEOLOGICAL CHARACTERISTICS

Aquifer Characteristics

Post-detonation aquifer characteristics were evaluated by means of aquifer performance tests BOHAT 2 to BOHAT 5 and DSAT 2 to DSAT 5 (App. C, Tables 2 and 3). In addition, composite time drawdown plots of all (including pre-detonation) aquifer performance tests are shown in figures 6a to 6h.

For the drift aquifer, analysis of the time-drawdown data for the observation well indicates that for post-detonation conditions, the transmissivity ranges between 13.85 and 16.18 m^2/day and the storativity between 1.16×10^{-5} and 2.75×10^{-5}. These values are in excellent agreement with pre-detonation values (Table 2) and indicate that, within the limits of experimental error, the transmissivity and storativity of the drift aquifer were not changed by shothole detonations. This can be seen graphically in figures 6a to 6d, the composite time-drawdown plots, where data from all DSAT tests are extremely similar. One could argue that since the pre-detonation transmissivity average for DSAT 1 observation well is 17.53 m^2/day and the post-detonation values of transmissivity average 15.4 m^2/day, transmissivity has been decreased by 12 percent because of the shothole detonation. This variation, however, is probably due to experimental error, especially since there were four post-detonation tests compared to one pre-detonation test. Besides, a variation

in transmissivity of this magnitude would not really form the basis of a claim for a damaged water well due to aquifer damage. The effects of leakage, mentioned under pre-detonation drift aquifer testing, were also present during all post-detonation drift aquifer testing. As previously mentioned, the effects of this leakage did not complicate the calculation of aquifer parameters.

Bedrock aquifer performance tests basically substantiate the above findings. Analysis of time-drawdown data for the observation well (well BSC) indicated that post-detonation aquifer transmissivities ranged from 13.85 to 16.18 m^2/day and the storativity from 3.15×10^{-4} to 6.66×10^{-4}. Once again, these values were in excellent agreement with pre-detonation values and table 3 summarizes the results of BOHAT 2 to BOHAT 5. Composite plots of the observation well data (Figs. 6a-6h) indicate the relatively constant transmissivity and storativity values of the bedrock aquifer before, during and after the shothole detonations. In this case, however, the aquifer transmissivity, strictly interpreted, shows a five percent increase during post-detonation testing. This variation in transmissivity is certainly possible considering the analytical methods employed and therefore should not be construed as an indicator of well development or an effect caused by shothole detonation. The leakage or conversion effect, mentioned under pre-detonation testing, was consistently obvious during post-detonation testing.

Well Characteristics

Post-detonation well characteristics were evaluated using tests BSCWT 2 to 5, BOHWT 2 to 5, and DSWT 2 to 5. Semi-log plots of these tests are shown in appendix C, typical analyses are shown in figures 7a to 7f and table 4 summarizes the results obtained.

During the post-detonation period, the values of B and C, for individual wells, remained relatively constant using the three methods of analysis. There is no evidence which suggests that shothole detonation has effected laminar or turbulent flow components of drawdown in any particular well. A slow decline in the efficiency of well DS can be attributed to a gradual loss in total depth because of

sand entering the well. As during the pre-detonation period, the efficiency of well DS is slightly lower than the bedrock wells because the turbulent component of flow forms a larger component of drawdown. In comparing B and C values of the two bedrock wells, turbulent flow components (CQ^2) for each well are similar, suggesting that the slotted casing completion did not affect efficiency because of the low pumping rates. The aquifer loss constant, however, averages 20 percent higher for well BSC. This is a result of the drawdown in well BSC being greater than that in well BOH during well performance tests. As the aquifer loss constant affects the drawdown caused by laminar flow (both from the aquifer and the well) this higher value may indicate that the slotted casing completion affected laminar rather than turbulent flow components at low pumping rates.

Examination of wells after each detonation, using the down-the-hole camera, did not indicate any visual damage to wells or aquifers.

Groundwater Quality

Groundwater samples were collected during all post-detonation aquifer and well performance tests and analyzed for standard cations and anions (App. D). The variations in groundwater quality (Figs. 8a to 8e) can basically be examined in two ways: vertically, which shows the relationship between water quality at the start and end of a test; and horizontally, which shows any chemical trends during the post-detonation testing sequences.

Examining figures 8a to 8e, in a vertical sense, indicates that there was a definite interaction, in the form of leakage, between the drift and the bedrock aquifers. Because of the large differences in transmissivity, however, the chemical effects of this vertical movement of groundwater can be more easily recognized during the bedrock tests because the leakage formed a much larger component of total flow to the well and thus affected the groundwater chemistry of the bedrock aquifer to a greater degree. For example, most bedrock groundwaters increased in Ca+Mg concentration during testing which probably indicated movement of drift groundwaters (which are higher in Ca+Mg) into the bedrock via poor casing seals or interformational leakage. Accompanying this increase in Ca+Mg was a

decrease in Na+K, and a slight increase in sulfate. Reversals (especially in BOHAT — figure 8b) in Ca+Mg and CO_3+HCO_3, between the beginning and the end of a particular test are due to the precipitation of $CaCO_3$ in the groundwater sample. The groundwater chemistry of the drift aquifer was also affected, to a lesser degree, by this leakage. Although the changes in concentrations were not as large as for the bedrock, Ca+Mg concentrations generally decreased while Na+K and CO_3+HCO_3 generally increased.

Over the period of post-detonation testing (Figs. 8a to 8e) it is difficult to ascertain any striking trends in water quality caused by shothole detonation. Both the drift and bedrock groundwater showed the favorable trend of a gradual decrease in total dissolved solids. For the bedrock groundwater, most other constituents, although varying considerably over the post-detonation period, had final concentrations which were very similar to the initial pre-detonation values. Drift groundwaters showed a gradual increase in concentration of numerous constituents during the post-detonation period, viz. Ca+Mg, Na+K, and SO_4. Although it is possible that these increases were caused by detonations it is more likely that increases in Ca+Mg and SO_4 were caused by overlying drift (i.e. intertill sands and gravels) groundwaters and that the increase in Na+K was caused by contributions from the bedrock.

Water Level Fluctuations

The response of water levels during shothole detonations and well depths, taken after each detonation, are shown in figure 9. During shothole detonations wells were equipped with mechanical water level recorders which gave an insensitive but adequate record of the water level fluctuations caused by the detonations. As expected, the magnitude of water level response increased the closer the detonations were to the wells. The largest measured response, approximately 2.5 cm, occurred in well BOH during the final (4.6 m) shothole detonation. The water level fluctuation caused by the shothole detonation at 183 m was barely measurable with mechanical equipment (Fig. 9).

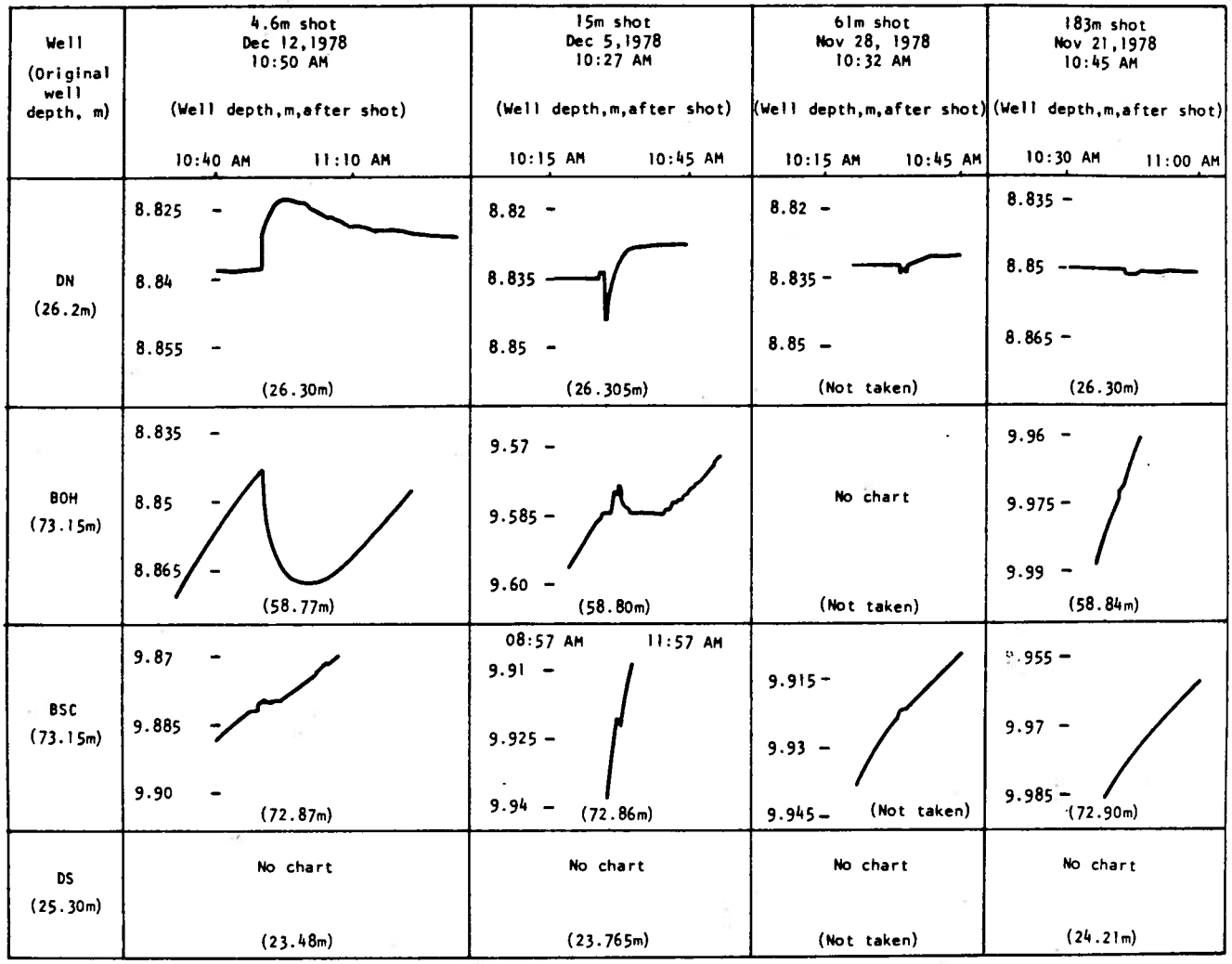


Fig. 9 Water level fluctuations during detonations

Figure 5 shows the water level fluctuations before, during, and after aquifer and well performance tests. Because smaller transmissivities caused greater drawdowns, the bedrock aquifers showed the greatest range in fluctuations during testing. Figure 5 also indicates that during the post-testing period, potentiometric surfaces returned to pre-testing levels, indicating that shothole detonations had not significantly altered static water levels in the wells. A plot of

barometric pressure versus post-testing water levels (Fig. 10) indicates the bedrock and drift aquifers maintained their responsiveness to barometric pressure fluctuations.

The shapes of the water level response curves shown in figure 9 indicate the qualitative transmissivity of each aquifer type. The drift aquifer responded and recovered much more quickly than the bedrock, indicating the effect of its larger transmissivity. Although it was expected that detonation would cause an initial compression of the aquifer, and thereby induce a rise in water level, this is not consistently obvious (Fig. 9). In most cases, the initial (and sometimes only) response is downward indicating a dilation of the aquifer. Although the mechanics of the observed response are not fully understood, it is probable that the recording equipment employed was not sensitive enough to record the complete response sequence. For example, when comparing responses for well DN, it is clear that they differ for the 4.6 m and 15 m detonations. During the 15 m detonation the initial reaction of the aquifer is one of dilation followed by a recovery of water level. During the 4.6 m detonation, however, the aquifer seemed to be solely in compression and it is possible that the initial dilation was not detected by the recording equipment. Another interesting observation is that the slotted casing completion of well BSC seemed to dampen the magnitude of water level response to detonation when compared with well BOH. Admittedly, well BOH was closer to the detonations but this is really only a factor for the last detonation. During the 15 m detonation, for example, actual radial distance from detonation to well BOH was 17 m and to well BSC was 27 m, yet water levels in well BOH responded with a magnitude 3 to 4 times that of well BSC. If this is generally the case, the effects of seismic detonations may cause significantly less water level responses in wells completed with slotted casing.

As mentioned, the mechanics of the water level responses during detonations are not fully understood. Overall, however, the fact that the detonations did not have large effects on water levels in the wells was the more important result.

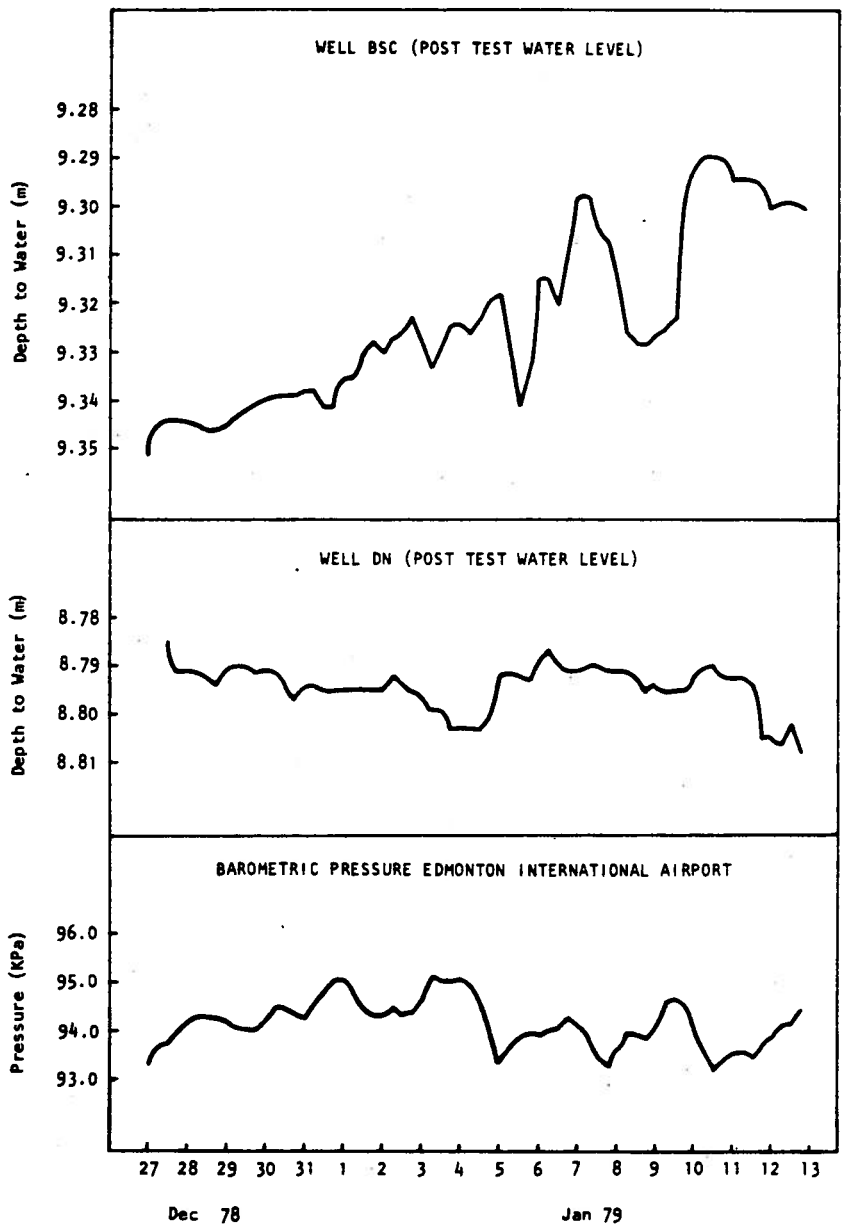


Fig. 10 Post-testing water level fluctuations

CONCLUSIONS

Conclusions from the present study are stated with recognition that the set of aquifer and well conditions encountered and tested at the project site are unique to certain geologic and hydrogeologic areas of the province. In this respect, the results of the study are limited in their applicability and it would be dangerous to apply the results of this project to all areas of the province and make broad generalizations about the effects of seismic detonations on water wells. It is felt, however, that in areas of similar geologic and hydrogeologic conditions, the results of this study will prove useful in evaluating future claims. The fact that the well drilling and construction methods used were very similar to standard methods of constructing domestic water wells in Alberta adds validity to the results. Hopefully, a continuation of similar projects will allow a complete coverage of the aquifer and well types in Alberta.

Some readers may be tempted to criticise the validity of the results of this study because the shotholes were not completed in the bedrock as is normal in petroleum exploration techniques. This may have caused the low velocity drift aquifer to act as a sponge and dampen the effect of the detonations on the bedrock wells. It should be remembered, however, that the objective of this project was to determine any effects of shothole detonations on both the drift and bedrock wells. Considering the well and shothole configuration at New Norway, well DS was the closest well, both horizontally and vertically, to the detonations. Therefore a detonation less than 6 m away, would have had maximum effect on this well and lesser effects on more distant wells. Since well DS remained unaffected by shothole detonations, it would seem that the results of this project are valid.

It would seem timely and practical to concentrate on those parameters which are commonly in question or need evaluation in seismic detonation-water well claims. These are understood to include:

1. Well and aquifer characteristics - e.g. increased drawdowns, no water in well, higher pumping lifts.
2. Well yield and depth - e.g. well doesn't pump as much, increased sand, well caved, loss of depth.

3. Water quality - e.g. bad taste, bad smell, water cloudy.
4. 4. Water levels - e.g. drastic fall or rise in water level.

Well and Aquifer Characteristics

Extensive testing (of the aquifers and wells) at the New Norway site indicate that the seismic detonations had little or no effect on the aquifer and well characteristics. Pre-detonation and post-detonation values of transmissivity, storativity, aquifer losses, well losses and well efficiency were basically in excellent agreement. Minor changes, in these parameters, did occur but in a fashion suggestive of experimental error rather than detonation induced changes. The down-the-hole camera did not indicate any specific damage to any water well at the site. Based on the results of this study it would be difficult, in areas of similar conditions, to entertain the suggestion that seismic detonations had increased drawdowns in wells. Composite time-drawdown plots confirm these findings.

Well Yield and Depth

Seismic detonations, because they did not affect aquifer or well characteristics, did not affect the yield of any well at the site. Aquifer and well performance tests were conducted at exactly the same pumping rates, before and after detonations, with similar pumping water levels. The two wells which showed a significant loss of depth were wells BOH and DS. Well BOH bridged at 59 m before detonations took place, presumably because of unstable hole conditions. Because of the slotted casing completion of well DS, fine sand was continuously entering the well during testing which caused a gradual loss in depth. Loss of depth, well caving or loss of production did not occur in any wells during detonations.

Water Quality

Variations in groundwater quality during testing were mainly attributable to the aquifer conditions encountered. Although many chemical constituents varied during the post-detonation period, the final post-detonation values were similar

to pre-detonation values. Most trends observed during the post-detonation period were due to groundwater leaking vertically between aquifers. The down-the-hole camera indicated that groundwater in the wells was slightly turbid immediately after a detonation, but this condition disappeared after one or two minutes at the beginning of the subsequent pumping test. No chemical changes in groundwater chemistry at the site can be directly attributed to detonations.

Water Level Fluctuations

Observation of water level records show that from a distance of five meters a shothole detonation caused a maximum measured water level fluctuation in well BOH of approximately 2.5 cms. Generally, the water level response recorded during the detonation did not conform to the theory that the first effect of a detonation on an aquifer should be compression thereby causing a rise in water levels. This is attributable to the lack of sensitivity of the measuring devices used. The effects of the detonation 183 m from the wells was barely measurable and in general the shothole detonations had only minor effects on the water levels in the wells. There is an indication that slotted casing completion tends to dampen water level fluctuations caused by detonations.

RECOMMENDATIONS

1. It is strongly recommended that these seismic detonation-water well evaluations be continued in different geologic and hydrogeologic areas of Alberta using the same scientific methodology as the New Norway project. In this way, a set of studies can be produced which will ultimately be applicable for all areas of Alberta. It is suggested that the next site be located in an area where fractured coal seams are important domestic aquifers.
2. A number of scientific improvements and changes could be recommended for the next project. A more sensitive water level measuring device using a pressure transducer, for instance, should be used during detonations. Such a unit is presently being built by the Groundwater Division, Alberta Research Council. Monitoring of pre-detonation groundwater chemistry should take

place over a longer time before testing begins. This would allow a more accurate evaluation of the natural variations in the concentrations of the main chemical constituents. For the sake of completeness, the next project should have one well completed with a well screen.

3. It would be instructive at the New Norway site to deepen existing shotholes and repeat the project. It is possible that the occurrence of a highly transmissive drift aquifer vertically between the detonation and the bedrock may have had a buffering effect. It has to be decided whether this procedure would have priority over a new project site.

ACKNOWLEDGEMENTS

The following Groundwater Division personnel were involved in the project and report preparation and the author gratefully acknowledges their help:

Origination of scope and basic methodology of the project - G. Gabert

Fieldwork - G. Sjostrom and H. Özbey

Data Compilation - A. Beerwald

Photo credits - W. Ceroici

Organization of report - M. Madunicky

Draughting - M. Madunicky and P. Politzer

Typing - B. Brown, M. Flanagan and J. Probert

Critical review of manuscript - G. Gabert, D. Hackbarth and J. Tóth.

Alberta Environment graciously supplied the down-the-hole camera and operator.

REFERENCES

Bierschenk, W. H. and G. R. Wilson. 1961. The exploration and development of groundwater resources in Iran. In Symposium of Athens: Groundwater in arid zones. Publication No. 57 Inter. Assoc. Sci. Hydrology, v. 2, pp. 607-627.

Cooper Jr., H. H. and C. E. Jacob. 1946. A generalized graphical method for evaluating formation constants and summarizing well-field history. Trans. Am. Geophysical Union, v. 27, pp. 526-534.

Labadie, J. W. and O. J. Helweg. 1975. Step-Drawdown Test Analysis by Computer. Ground Water, v. 13, No. 5, pp. 438-444.

Sheahan, N. T. 1971. Type-curve solution of step-drawdown test. Ground Water v. 9, No. 1, pp. 25-29.

Stalker, A. MacS. 1960. Surficial Geology of the Red Deer-Stettler Map Area, Alberta. Geol. Surv. of Canada Memoir 306, 140 pages.

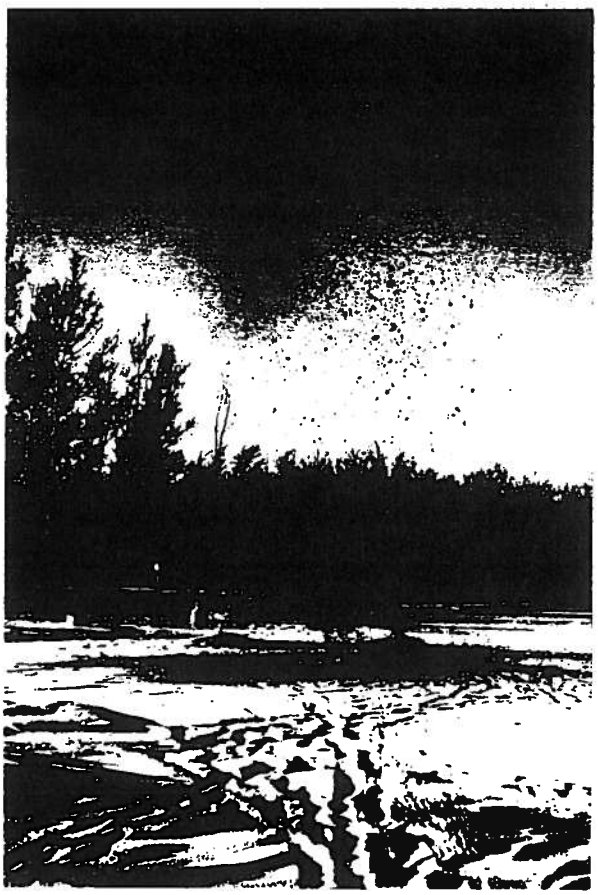
Theis, C. V. 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage. Trans. Am. Geophysical Union, v. 16, pt. 2, pp. 519-524.

Appendix A

ORIGINAL PROJECT PROPOSAL
EXPLORATION AND PROJECT SITE DRILLING

This appendix has been transcribed from field notes. Units are therefore in feet or gallons except where shown.

NEW NORWAY SEISMIC PROJECT



The 4.6 m shothole detonation. Continuous water level recorder shown in background. This photo was taken a few seconds after the cover photo.

A Proposed Study

EVALUATION OF THE EFFECTS OF SEISMIC EXPLOSIONS IN SHOTHOLES ON WATER WELLS AND AQUIFERS

OBJECTIVES

The primary objective of the program is to evaluate the effects of seismic explosions in shotholes on water wells and aquifers typically found in Alberta. A secondary objective is to establish distances at which seismic explosions in shotholes should be conducted away from water wells in order to minimize or eliminate damaging effects.

SCOPE

The study will be limited initially to one site which will be selected on the basis of being a typical Alberta Plains environment in respect of aquifer occurrence and geology. A minimum of four water wells will be completed at the site and the aquifer and well conditions evaluated. Explosive charges will be detonated at separate times in each of three shotholes located at specified distances from the wells. Well and aquifer conditions will be reevaluated after each particular explosion.

METHODS

Four water wells will be completed at the site; two shallow wells in an aquifer in surficial deposits (sand or gravel) and two deeper wells in a bedrock aquifer (sandstone). Water wells will be completed by the slotted casing and open hole methods which are commonly used in Alberta. Two wells will be completed with slotted casing in the aquifer in surficial deposits and two wells will be completed in the aquifer in bedrock; one well with slotted casing and the other open hole. Maximum depths of wells in bedrock are planned to be not greater than 200 ft. The minimum distance between wells at the site will be 100 ft.

3. Complete two wells in the bedrock (sandstone); one with slotted casing and one open hole.

4. Measure "static" water levels.

5. Conduct an aquifer test in the surficial aquifer and the bedrock aquifer.

6. Obtain groundwater samples and water temperatures.

7. Conduct well tests in one well completed in the surficial aquifer and each of the two wells completed in bedrock deposits.

8. Drill three shotholes to 60 ft in depth; at distances of 600, 200 and 50 ft from the nearest water well.

9. Detonate a 10-lb explosive charge in the shothole 600 ft from the nearest water well.

10. Repeat "static" water level measurements, aquifer tests, sampling of groundwater, measurement of water temperature and well tests.

11. Detonate 10-lb explosive charge in the shothole 200 ft from the nearest water well.

12. Repeat step 10 above.

13. Detonate an explosive charge in the shothole 50 ft from the nearest well.

15. Repeat step 10 above.

Information on the sequence and composition of rock types (stratigraphy) and observation of permeable intervals will be recorded during drilling of the wells. Lithologic samples and an electric log of each well will also be obtained. Upon completion of the wells an aquifer test will be conducted on the shallow wells using one as the production well and one as an observation well. Similarly, an aquifer test will also be conducted on the deeper bedrock wells using the open hole well as the production well and the one completed with slotted casing as the observation well. The aquifer tests will be of 12-hour duration. A well test will be conducted on one of the wells in surficial deposits and each of the two wells in bedrock deposits. The test will consist of 5 steps, each at a different pumping rate and continuing for a period of 100 minutes. Aquifer coefficients of transmissivity and storativity will be calculated from aquifer test data and well efficiencies will be calculated from well test data.

A 10 pound explosive charge will be detonated in a 60-foot shothole at distances of 600, 200 and 50 ft from the nearest water well. Following each seismic explosion; aquifer tests, well tests, measurement of "static" water levels and water sampling will be repeated. This procedure will result in eight aquifer tests and twelve well tests.

An explosive charge will be detonated in a shothole while one of the aquifer tests is in progress (probably the one following the 200-foot explosion). Water wells will be observed for any immediate effect resulting from the explosion.

SUMMARY OF PROCEDURE

1. Select site

2. Complete two wells with slotted casing in an aquifer in the surficial deposits (sand or gravel aquifer).

COST ESTIMATES

1.	Completion of water wells: 600 ft @ $15.00/ft (Private Contracter)	9,000.00
2.	Electric logging: 600 ft @ $0.25/ft	150.00
3.	Aquifer tests: 96 hours @ $25.00/hr	2,400.00
4.	Well tests: 75 hours @ $25.00/hr (9-500 minute tests)	1,875.00
5.	Drilling of shotholes 3 hours @ $25.00/hr (3 holes 60 ft in depth)	75.00
6.	Basic salaries (2 man-months @ $18,725.00/annum)	3,120.00
7.	Overhead on basic salaries (60%)	1,872.00
8.	Miscellaneous items	1,000.00
	Total estimated cost	$19,492.00

NEW NORWAY SEISMIC PROJECT

PROJECT SITE

WELL BSC (Bedrock, Slotted Casing)

Location: NW 14-45-22-W4M

Owner: Norman Newsted

Driller: Schmidt Drilling

Date: Nov. 1, 1978

Water Level: 9.63m (Nov. 3/78)

Est. rate of Production: 2-3 igpm (Airlift)

M.P. (Measuring Point): 0.50m agl

Drift			
0	-	2	Top soil, black, organic
2	-	25	Till, clay silty brown (tan) soft with some occasional pebbles and trace of coal chips
25	-	70	Lake clay, silty and sandy, grey, plastic, sticky, soft, impervious with some coal chips At 51-52' 12" coal seam with pebbles At 59-60' 12" sand and gravel layer
70	-	84	Gravel size up to 3-4" mostly chert granite, quartz (water)
Bedrock			
84	-	135	Sandstone, slightly, bentonitic, light grey-beige soft very fine grained alternating with shale layers multiple thin coal seams at 115-125' and hard spot at 124-125'
135	-	160	Shale dark grey, dark brown, brittle alternating with sandstone layers and coal carbonaceous at places
160	-	170	Sandstone (as previously described)
170	-	187	Shale (as above)
187	-	195	Sandstone with shale and siltstone light grey, medium grained
195	-	205	Shale greenish grey
205	-	215	Shale, dark grey carbonaceous dark brown
215	-	225	Sandstone (as above) at 218-219' coal
225	-	230	Siltstone with coal seams
230	-	232	2 ft coal seam
232	-	235	Shale (as above)
235	-	240	Sandstone

NEW NORWAY SEISMIC PROJECT

PROJECT SITE

WELL BSC (Bedrock, Slotted Casing)

- Complete E-log
- 97 ft 5 1/2" Casing and 147 ft slotted casing installed in the hole
- It is a bedrock slotted casing hole (BSC)
- Est. 2-3 igpm production (airlift)

Water Level Measurements

Date	Time	Water Level (m)
Nov. 3/78	8.45	9.63
Nov. 7/78	8.45	9.38
Nov. 7/78	12.00	9.57

NEW NORWAY SEISMIC PROJECT

PROJECT SITE

WELL BOH (Bedrock Open Hole)

Location: NW 14-45-22-W4M

Owner: Norman Newsted

Driller: Schmidt Drilling

Date: Oct. 30, 1978

Water Level: 8.94m (Oct. 31)

Est. rate of Production: 3-4 igpm (Airlift)

Drift			
0	-	5	Clay till brown to tan, some coal (top soil at 0-2 ft)
5	-	26	Till, tan to brown clay with some sand and pebbles
26	-	71	Lake clay, dark grey till, plastic minor coal with occasional sand and pebbles, sandy layer at 46'
71	-	83	Gravel size up to 3-4" mostly consists of chert quartzite granite
Bedrock			
83	-	85	Shale + salt and pepper sandstone grey, very fine grained
85	-	115	Sandstone light grey, salt and pepper slightly bentonitic hard at 86-95' alternating with shale layers and some coal
115	-	120	Shale with sandstone, carbonaceous brownish beige sticky sandstone mostly light grey bentonitic
120	-	136	Sandstone, light to medium grey, slightly bentonitic, very fine grained with some shale layers
136	-	145	Shale, brown to brown grey, relatively hard brittle (at 144' lost some water, sandstone)
145	-	152	Shale greenish grey
152	-	158	Sandstone light grey, very fine grained bentonitic
158	-	166	Carbonaceous shale, dark grey to brown
166	-	170	Sandstone (as previously described)
170	-	176	Shale (as previously described)
176	-	177	Sandstone hard, lost some water
177	-	215	Shale - sandstone interbedded, light grey - dark grey variegated, at 190-195 bentonitic layer, at 205-215 dark brown shale
215	-	230	Carbonaceous shale + coal greenish grey to grey, brittle
230	-	231	12" coal seam
231	-	240	Shale brown, beige to dark brown, brittle
		240	Bottom of Hole

NEW NORWAY SEISMIC PROJECT

PROJECT SITE

WELL DN (Drift North)

Location: NW 14-45-22-W4M

Owner: Norman Newsted

Driller: Schmidt Drilling

Date: November 2, 1978

Water Level: 8.90m (Nov. 7/78)

Est. rate of production: 5-6 igpm (Airlift)

M.P. (Measuring Point): 0.40m agl

Drift			
0	-	20	Till, silty clay, tan to brown, soft, sticky with occasional pebbles and trace of coal chips (top soil at 0-2 ft)
20	-	73	Lake Clay, grey, plastic, sticky, impervious occasional sand, pebbles and gravels and coal chips hard spot at 66 ft, boulder?
73	-	85	Gravel sizes up to 3-4" mostly consists of chert, quartz, granite fragments (Water)
Bedrock			
85	-	86	Sandstone - shale light grey to dark grey, slightly bentonitic
		86	Bottom of Hole
		-	E-logged
		-	Totally 87 1/2 (5 1/2" size) casing installed in the hole

0 - 74 blank casing
74 - 84 slotted casing
84 - 85 1/2 blank casing

Water Level Measurements

Date	Time	Water Level (m)
Nov. 7/78	8.40	8.90
Nov. 8/78	12.00	8.81

NEW NORWAY SEISMIC PROJECT

PROJECT SITE

WELL DS (Drift South)

Location: NW 14-45-22-W4M

Owner: Norman Newsted

Driller: Schmidt Drilling

Date: Oct. 31, 1978

Water Level: 8.70m

Est. rate of Production: 5-6 igpm (Airlift)

M.P. (Measuring Point): 0.40m agl

Drift			
0	-	20	Till - tan to brown silty clay, soft sticky with occasional pebbles and trace of coal chips (Top soil at 0-2 ft)
20	-	72	Lake Clay sand, pebbles, gravels, and coal chips, sandy layer at 55-60 ft, more gravels at 65-72 ft
72	-	82	Gravel sizes up to 3-4" mostly chert, quartz and granite fragments (Water)
Bedrock			
82	-	83	Shale - sandstone, grey salt and pepper slightly bentonitic
		83	Bottom of Hole
		-	E-logged the hole
		-	Totally 85 1/2 ft (5 1/2" size) casing installed in the hole (0-72' blank, 72-82 slotted and 82-84 blank casing)
		-	Water sample taken

Water Level Measurements

Date	Time	Water Level (m)
Nov. 2/78	8.45	8.68
Nov. 3/78	8.45	8.70
Nov. 7/78	-	8.70

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 1

PILOT WELL #1 (Bedrock)

Location: NW 17-44-21-W4M Date: Oct. 17, 1978

Owner: Eldon Graff

Driller: Schmidt Drilling

Drift			
0	-	10	Till - silty clay, brown grey mixture of silt, clay, sand boulders and coal chips
10	-	15	Silty clay grey, sandy, hard spot at 14' boulder
15	-	20	Silty clay grey, sandy, hard spot at 19' boulder some coal chips
20	-	25	Clay, grey
25	-	45	Clay, dark grey clayey, silty
45	-	52	Clay, dark grey clayey, silty at 45' hard spot aquifer
Bedrock			
52	-	60	Weathered sandstone, rusty buff colour at 52', very fine grain
60	-	70	Weathered sandtone, more sandy material, very fine grain
70	-	75	Weathered sandstone, more clayey material, very fine grain
75	-	80	Weathered sandstone, greyish brown, very fine grain
80	-	90	Sandstone - siltstone greenish grey to buff, very fine grain, layered, variegated
90	-	95	Sandstone-bluish grey very fine grain, shaley
95	-	105	Sandstone bentonitic, light grey-ash coloured
105	-	110	Shale, greenish grey with sandstone layers
110	-	115	Shale-sandstone, grey shale dominant with sandstone layers
115	-	120	Sandstone, bentonitic, very fine grained light grey, hard spots at 115 and 117'
120	-	150	Sandstone medium grey very fine grained
		150	Bottom of Hole

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 1

PILOT WELL #1 (Bedrock)

- Hole E-logged

Water Level Measurements

Time	Water Level (m)
13.30	10.00
-13.36	10.00
-13.40	10.00
-13.50	9.96
-14.00	9.91
-14.10	9.88
-14.20	9.86
-14.30	9.84
-14.30	9.81
-14.40	9.81
-15.03	9.81

Estimated rate of Production Bedrock = 15.20 igpm (Airlift)

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 3

PILOT WELL #3 BOH (Bedrock Open Hole)

Location: SE 25-44-21-W4M
(100 ft south of Well-DN)

Date: Oct. 20, 1978

Owner: Noah Toews

Est. rate of Production: 1-2 igpm? (Airlift)

Driller: Schmidt Drilling

Bit Size: 6 3/4" 0-140.5 ft
4 1/2" 142-260 ft

Drift			
0	-	15	Till, silt, brown sandy and clayey with occasional boulders
15	-	20	Till, silt, brown, sandy and clayey trace of coal chips, with occasional boulders
20	-	50	Silty clay, grey, very fine grain with sand and gravel, trace of coal chips
50	-	55	Silty clay, grey with coal seams
55	-	85	Sand, clayey and silty, medium to coarse grain with multiple coal seams
85	-	110	Gravel starts at 87' pebbles quartz, chert, chunks of boulders up to 1-4" size with coal chips
110	-	115	Silty clay, grey, very fine grain (end of gravel zone at 111')
115	-	118	Silty clay, (as piece of sandstone starts at 118' light grey bentonitic
Bedrock			
118	-	126	Sandstone light, grey, bentonitic with plenty of coal chips
126	-	131.5	Gravel coarse size up to 2" coal chips
131.5	-	140	Sandstone with shale layers, light grey to dark grey very fine grain bentonitic with coal seams
140	-	165	Shale with sandstone and siltstone hard spot at 142' siltstone, grey carbonaceous with coal seams
165	-	170	Shale with sandstone and siltstone (12" coal seam at 165 - 166') siltstone grey carbonaceous with coal seams
170	-	180	Shale greenish grey-beige, banded with siltstone
180	-	190	Sandstone light grey, fine grain argillaceous, bentonitic hard at 183 - 185' coal
190	-	195	Shale dark brown

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 2

PILOT WELL #1

Location: NW 25-44-21-W4M

Owner: Noah Toews

Driller: Schmidt Drilling

Date: Oct. 17, 1978

Static Water Level: 2.22m

Est. rate of Production: 10 igpm (Airlift)

Drift			
0	-	10	Till silt, brown sandy, clayey with occasional boulders
10	-	15	Silty clay, grey with sand and boulders, coal chips
15	-	20	Silty clay, grey with sand and 2" boulders, coal chips
20	-	25	Silty clay, grey with sand and with boulders, coal chips
25	-	35	Silty clay, grey with boulders
Bedrock			
35	-	40	Sandstone-siltstone, hardspot at 36'
40	-	50	Brown, grey very fine grain hard, brittle with coal chips
50	-	55	Brown, coal seam at 52-53 1/2 feet
55	-	60	Brown grey
60	-	80	Brown grey medium grey
80	-	85	Sandstone, bentonitic with coal seams light grey very fine grain
85	-	95	Sandstone, bentonitic with coal seams medium hard
95	-	100	Sandstone, bentonitic more coal
100	-	115	Shale brown, dark grey with sandstone layers
115	-	120	Sandstone medium grey very fine grain
120	-	125	Coal seam and sandstone light grey, bentonitic very fine grain
125	-	135	Sandstone with multiple coal seams grey medium grain
135	-	140	Sandstone with multiple coal seams light grey bentonitic
140	-	145	Sandstone with multiple coal seams
145	-	150	Sandstone hard sandstone at 147-149 feet
		150	Bottom of Hole
	-		Hole E-logged

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 1

PILOT WELL #2 (Drift)

Location: NW 17-44-21-W4M

Owner: Eldon Graff

Driller: Schmidt Drilling

Date: Oct. 17, 1978

Est. rate of Production: 1.2 igpm (Airlift)

0	-	15	Till, greyish brown mixture of sand, silt clay with some boulders and coal chips, very fine grained
15	-	25	Clay brown grey with some silt and sand
25	-	45	Clay brown dark grey very fine grain
45	-	50	Clay more sandy layers hard spot at 48' aquifer?
50	-	60	Weathered sandstone, rusty-buff very fine grain
60	-	65	Weathered sandstone, buff coloured
65	-	73	Weathered sandstone, buff coloured
		73	Bottom of Hole

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 3

PILOT WELL #3 BOH (Bedrock Open Hole)

195	-	200	Shale brown
200	-	205	Sandstone medium hard fine grain light grey argillaceous, bentonitic
205	-	220	Sandstone medium hard fine grain with brown siltstone layers
220	-	225	Shale dark brown grey, with brown siltstone layers
225	-	260	Shale dark brown with sandstone layer at 250-252', light grey, bentonitic, some coal
		260	Total Depth of Hole

- 4 1/2" casing installed to 140.5' and then driven to 142 ft, 1 1/2 ft into the shale

- (Oct. 23, 1978)
Hole first drilled to 230 ft after E-logging reaming, casing installation and airlift tests (at 40' intervals decided to go deeper to 260' Estimated rate of production not more than 1-2 igpm (Airlift)

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 3

PILOT SITE #3

Location: SE-25-44-21-W4M

Owner: Noah Toews

Driller: Schmidt Drilling

Date: Oct. 18, 1978

Drilling Started: 15.40

Drilling Finished: 18.00

Water Level: 1.71m (Oct. 23/78)

Drift			
0	-	20	Till, brown silt, clayey and sandy rock chips
20	-	25	Sandy silty clay, grey, with pebbles
25	-	40	Sandy silty clay, grey, with pebbles, trace of coal chips
40	-	65	Sandy clay, to medium grained grey, clayey with coal chips
65	-	80	Sandy clay (more sand) to medium grained grey, clayey with coal chips
80	-	90	Sandy with clayey layers and coal chips
90	-	95	Sandy (more sandy layers) with clayey layers and coal chips
			Gravel Starts at 99 feet
99	-	116	Gravel quartz, felds, with trace of coal chips loosely cemented cobbles up to 2-3"
116	-	130	Sandstone, light grey, ash very fine grained argillaceous with occasional pebbles
130	-	134	Gravel (as of 99-116) very fine grained argillaceous
Bedrock			
134	-	140	Sandstone grey, very fine grained, bentonitic

- This well intended to be a bedrock slotted casing hole (BSC), reaming the hole from 4 1/2" to 6 3/4" to 120' 5 1/2" blank casing installed, drilling from 122' to 140' 5 1/8" RB. Because of 4 ft thick gravel found below the sandstone, casing removed hole abandoned.

- E-logged

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 3

PILOT WELL #3 DN (Drift North)

Location: SE 25-44-21-W4M

Date: Oct. 18, 1978

Owner: Noah Toews

Driller: Schmidt Drilling

Est. rate of Production: 25-30 igpm (Airlift)

Drift			
0	-	5	Till, silt, brown, sandy and clayey, pebbles
5	-	10	Till, silt, brown, sandy and clayey, pebbles, some coal chips
10	-	20	Till, silt, greyish brown, sandy and more clayey, pebbles, some coal chips
25	-	40	Clay, brownish grey to grey silty and sandy with some pebbles and coal chips
40	-	90	Sandy silty clay, grey with plenty of sand medium to course grain, pebbles and coal chips
90	-	100	Sandstone (as a piece of bedrock greenish grey, very fine grain, hard)
100	-	105	Coarse sand
105	-	126	Gravel, very coarse gravel 1-3" size, loose, chert, quartz felds with coal chips
Bedrock			
126	-	128	Sandstone - Bedrock: light grey, fine to medium grain argillaceous bentonitic
		128	Bottom of Hole

- Hole E-logged
- Reamed the hole from 4 1/2" to 6 3/4"
- Drilling mud additive "magcogel" used during the drilling
- 126 ft of 5 1/2" casing installed (12 ft slotted casing at the bottom included)
- Drilling started at 10:30, finished at 15:30
- Airlift production rate 25-30 igpm
- Measured depth of well = 125.60 ft (38.28m)
- Water sample taken for chemical analyses

NEW NORWAY SEISMIC PROJECT

EXPLORATION SITE 3

PILOT WELL #3 DN (Drift North)

Water Level Measurements

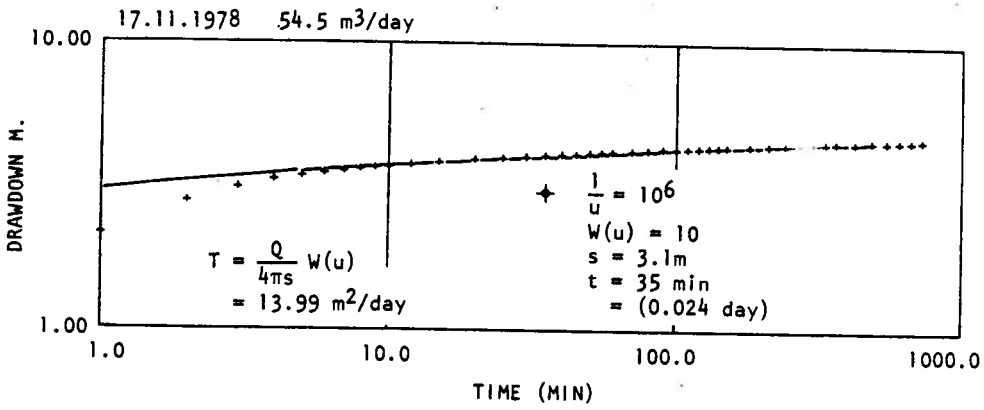
Date	Time	Water Level (m)
Oct. 18/78	3.55	9.63
Oct. 19/78	8.35	6.41
Oct. 19/78	9.35	6.23
Oct. 19/78	10.35	6.08
Oct. 19/78	11.40	6.08
Oct. 19/78	13.50	5.62
Oct. 19/78	14.50	5.65
Oct. 19/78	16.05	5.63
Oct. 20/78	8.30	5.74
Oct. 23/78	9.20	5.63
Oct. 24/78	11.15	5.58

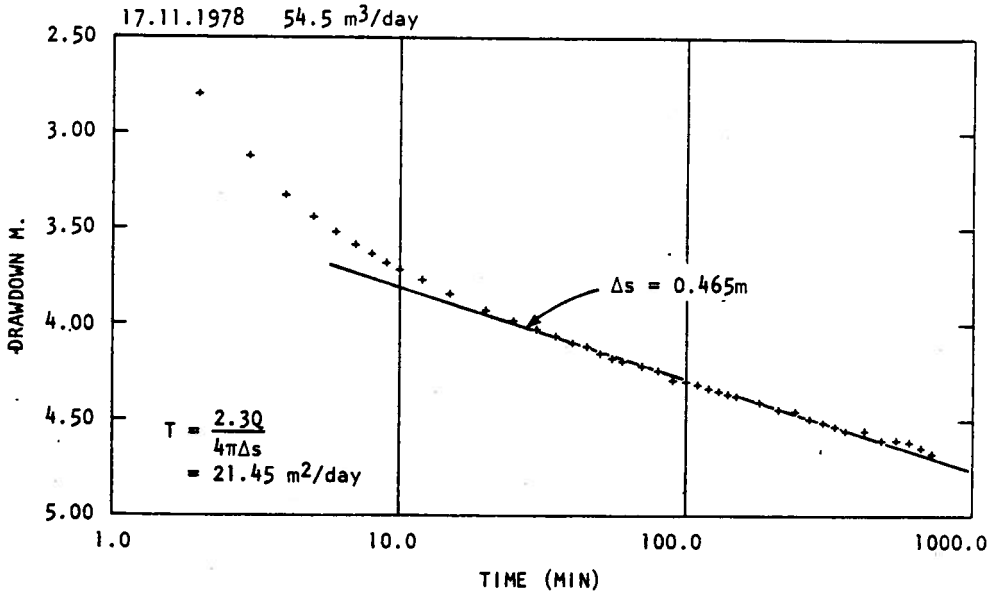
Appendix B

PRE-DETONATION AQUIFER AND WELL PERFORMANCE TESTS

DSAT 1

PUMPING WELL

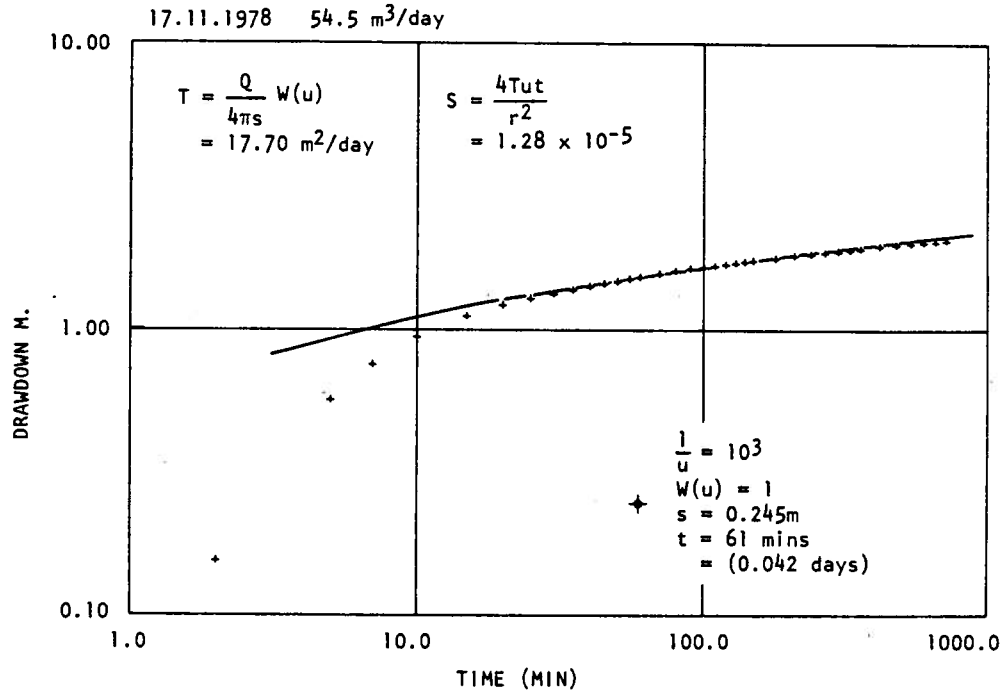


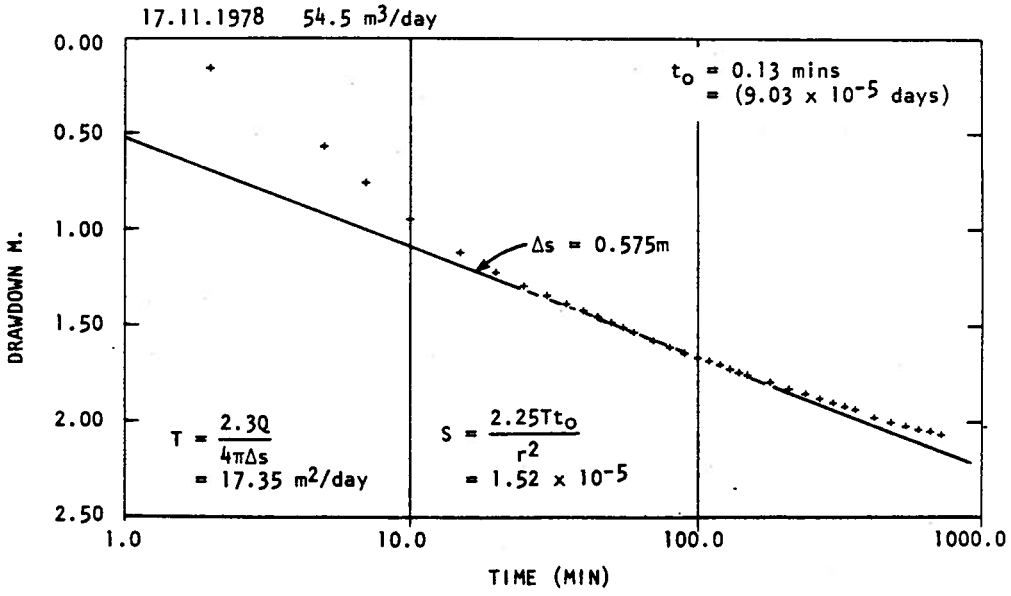


DSAT 1

OBSERVATION WELL

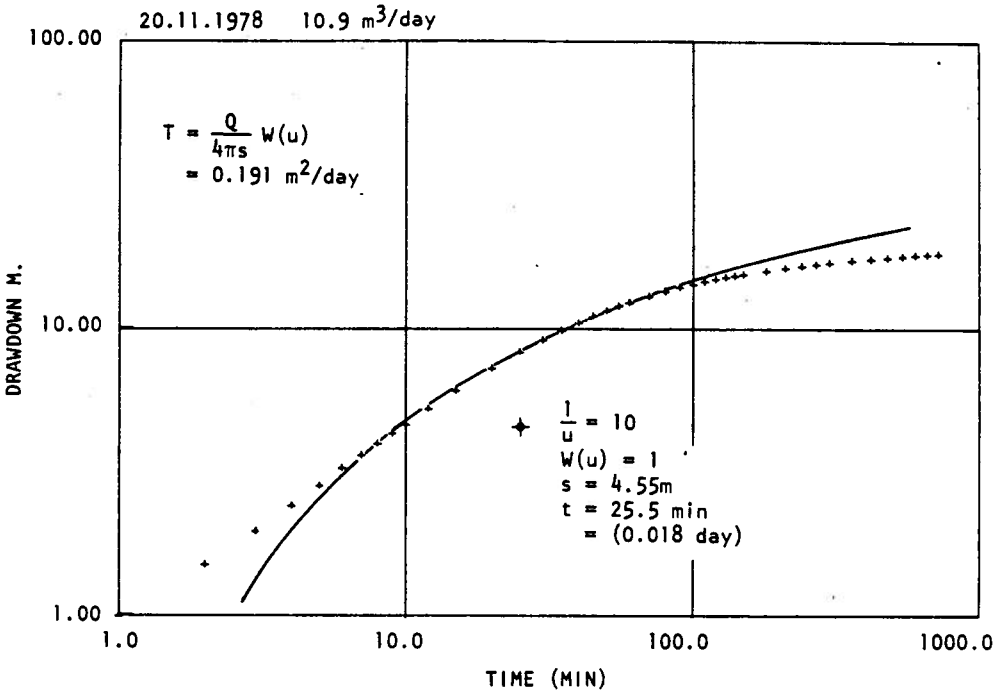
R = 15.239 m

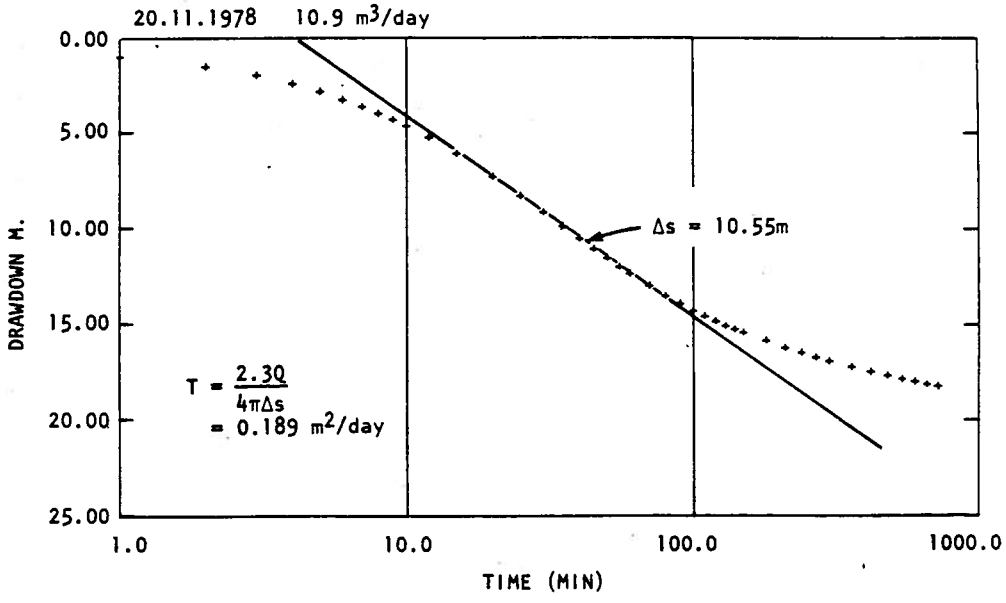




BOHAT 1

PUMPING WELL

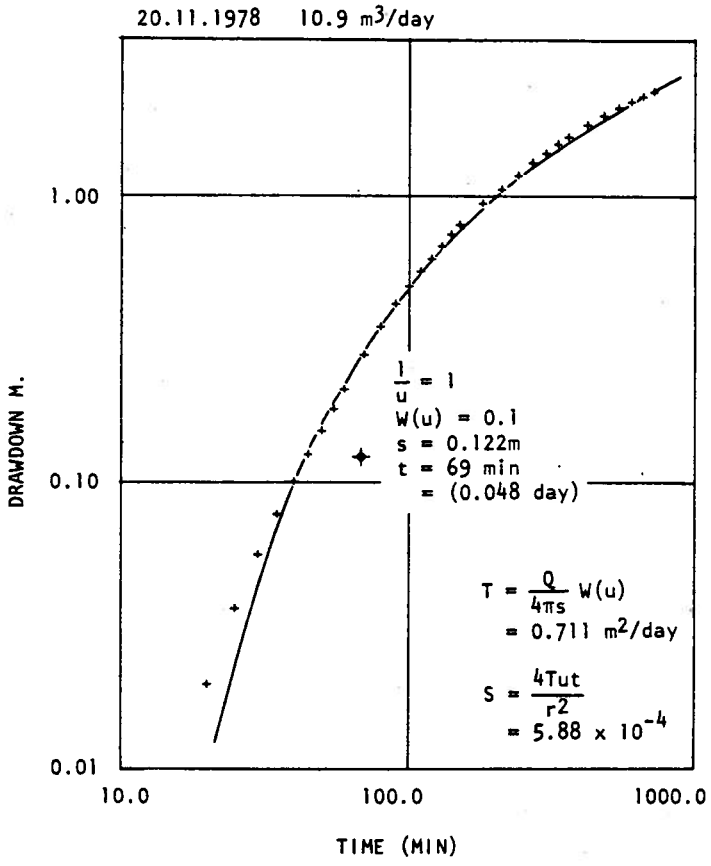


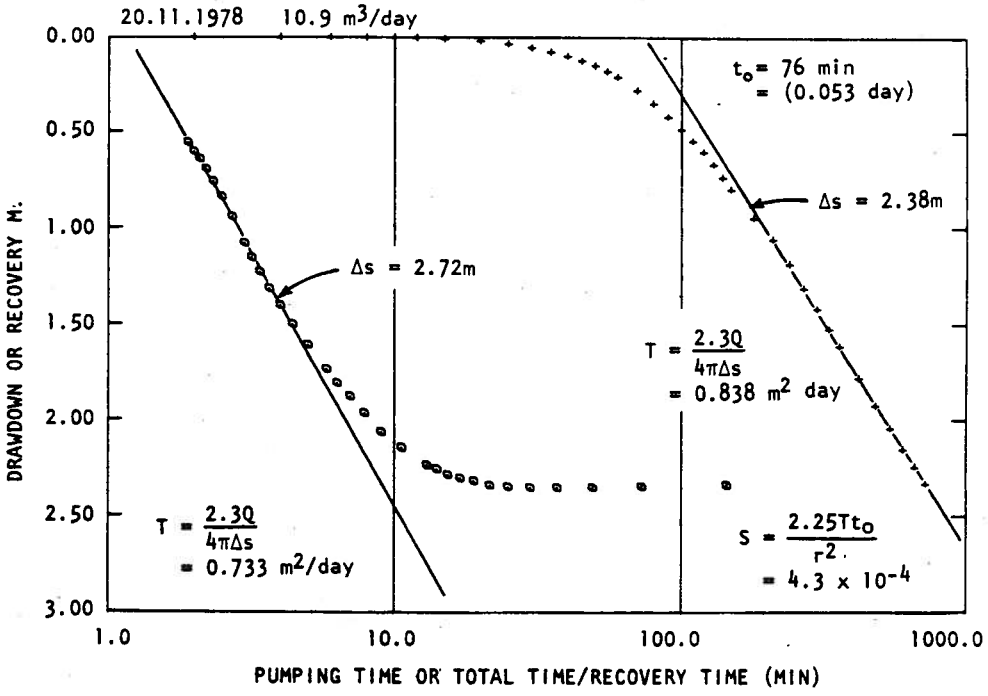


BOHAT 1

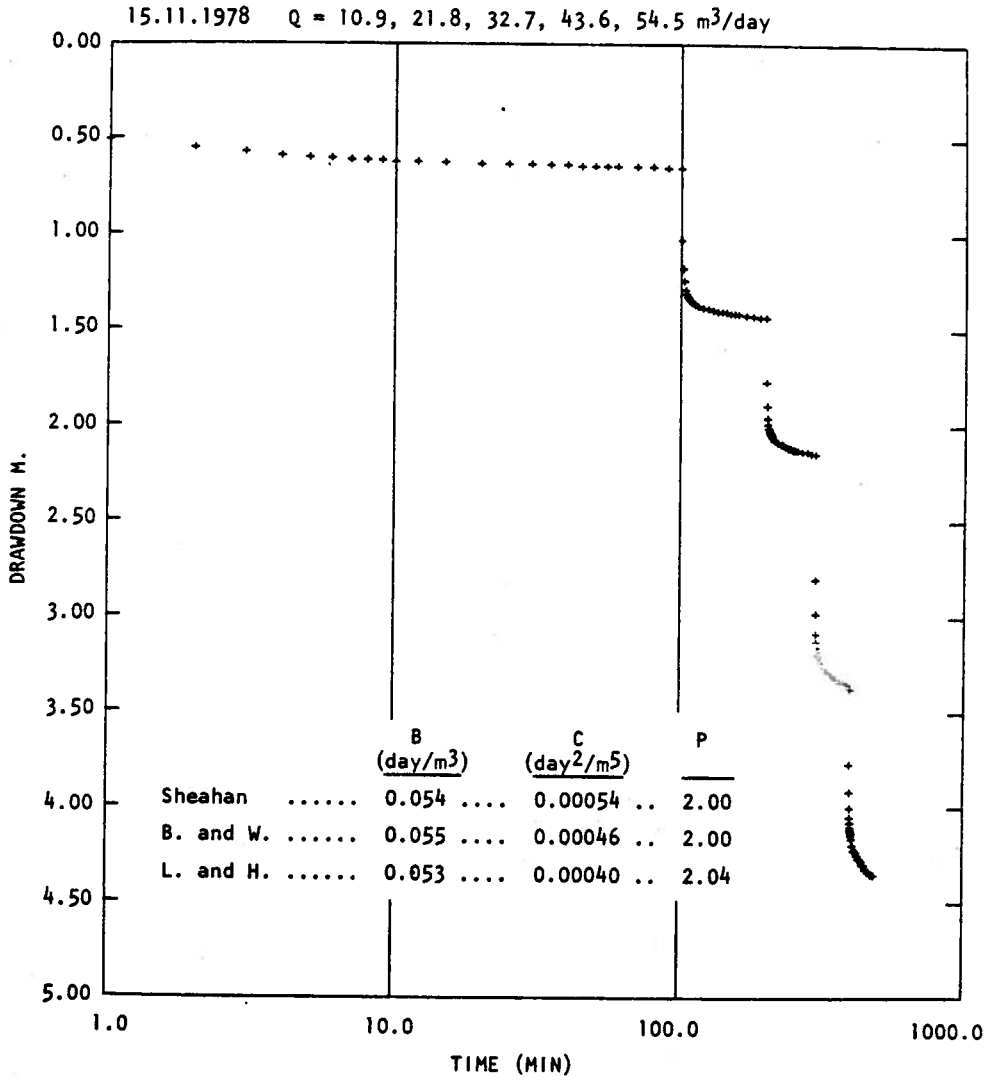
OBSERVATION WELL

R = 15.239 m

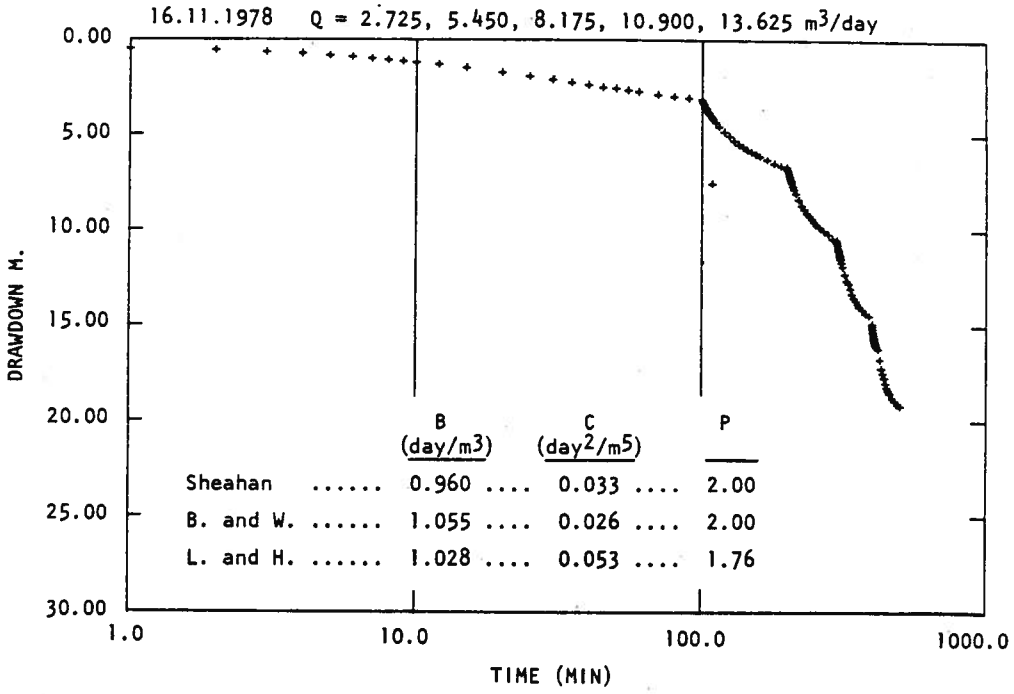




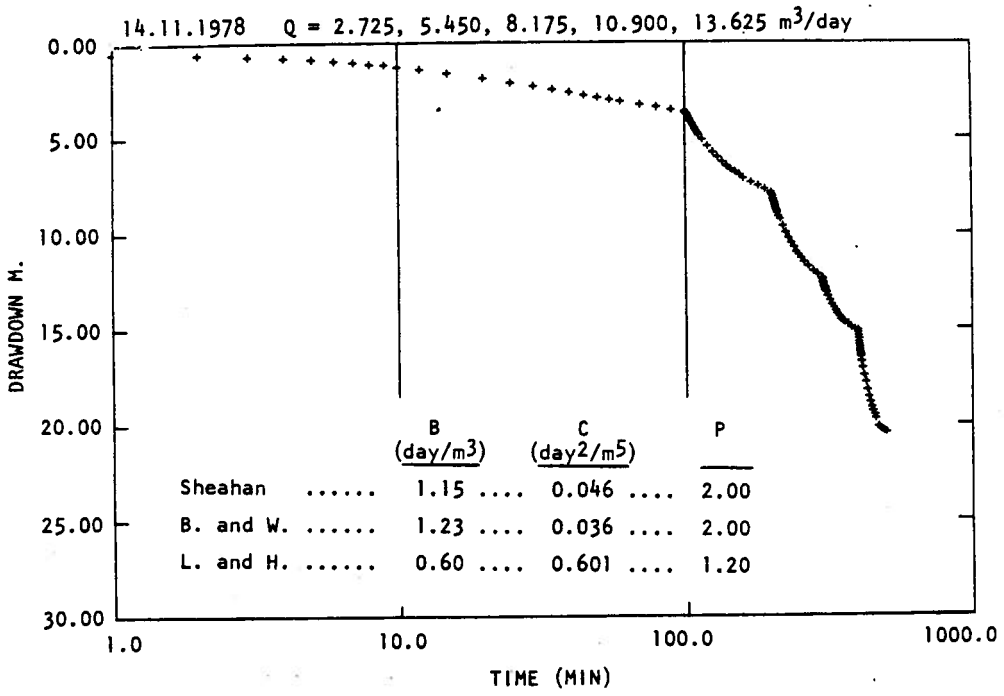
DSWT 1


15.11.1978 Q = 10.9, 21.8, 32.7, 43.6, 54.5 m3/day
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.054 .... 0.00054 .. 2.00
B. and W. ..... 0.055 .... 0.00046 .. 2.00
L. and H. ..... 0.053 .... 0.00040 .. 2.04

BOHWT 1


16.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.960 .... 0.033 .... 2.00
B. and W. ..... 1.055 .... 0.026 .... 2.00
L. and H. ..... 1.028 .... 0.053 .... 1.76

BSCWT 1

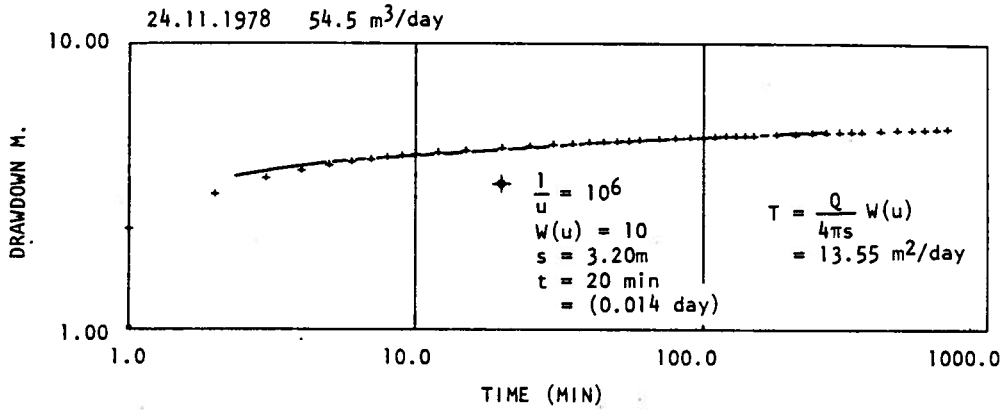

14.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 1.15 .... 0.046 .... 2.00
B. and W. ..... 1.23 .... 0.036 .... 2.00
L. and H. ..... 0.60 .... 0.601 .... 1.20

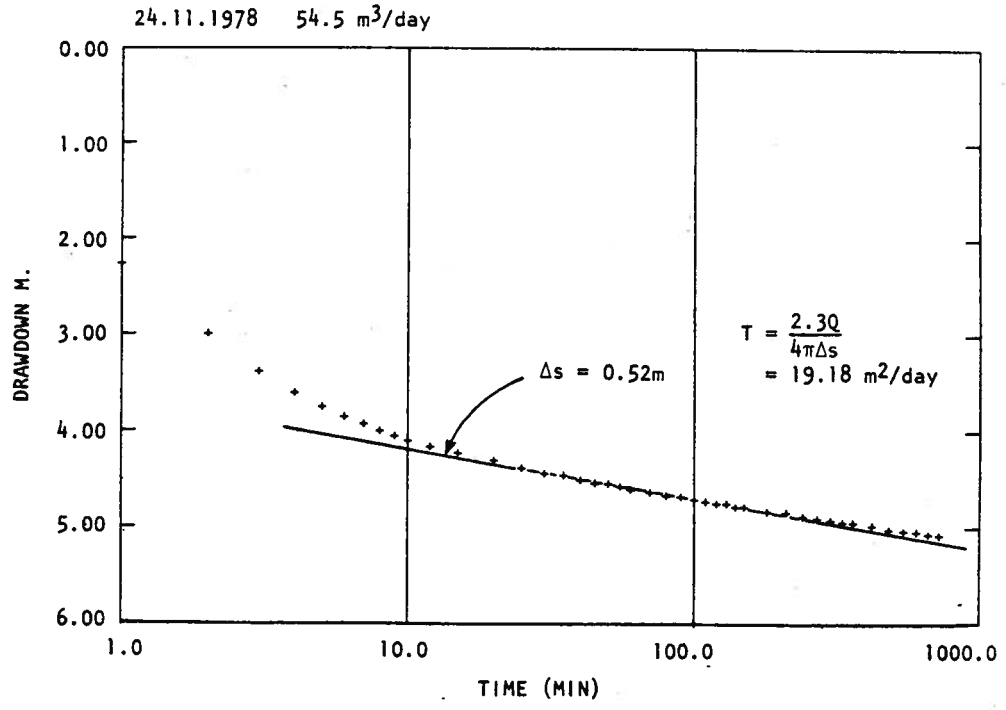
Appendix C

POST-DETONATION AQUIFER AND WELL PERFORMANCE TESTS

DSAT 2

PUMPING WELL

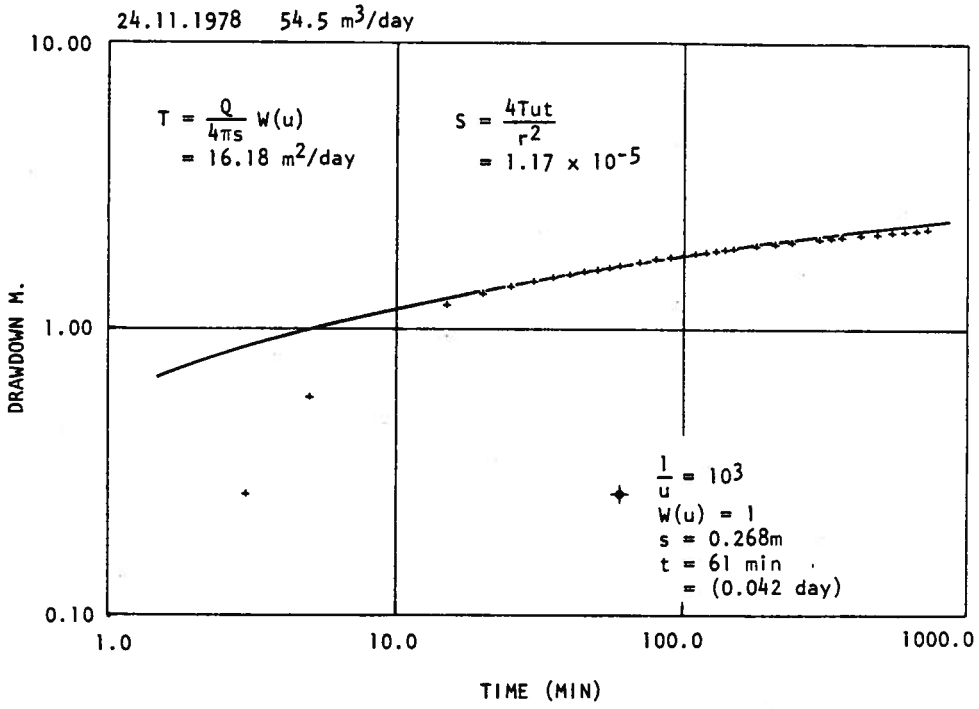


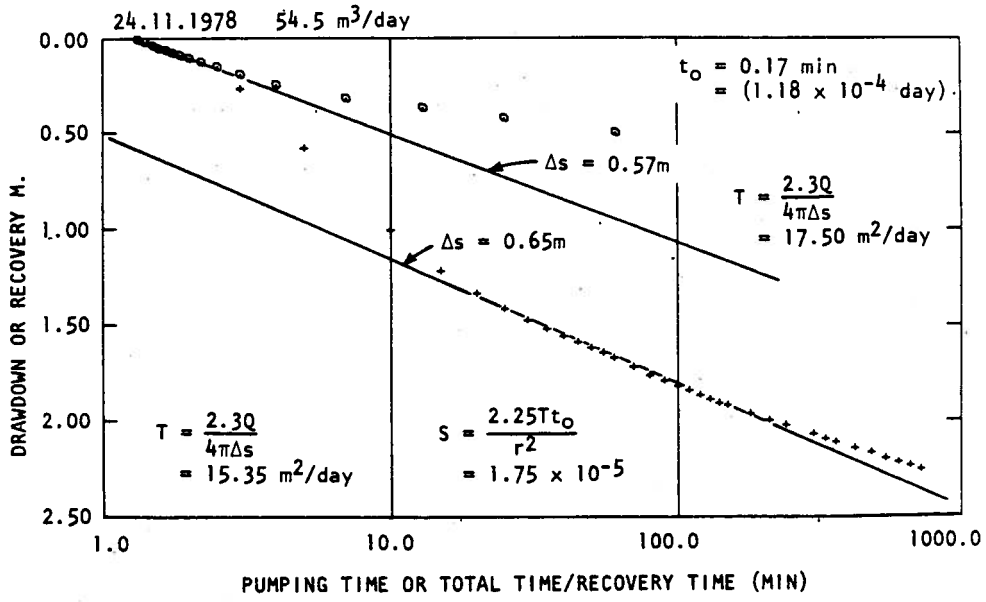


DSAT 2

OBSERVATION WELL

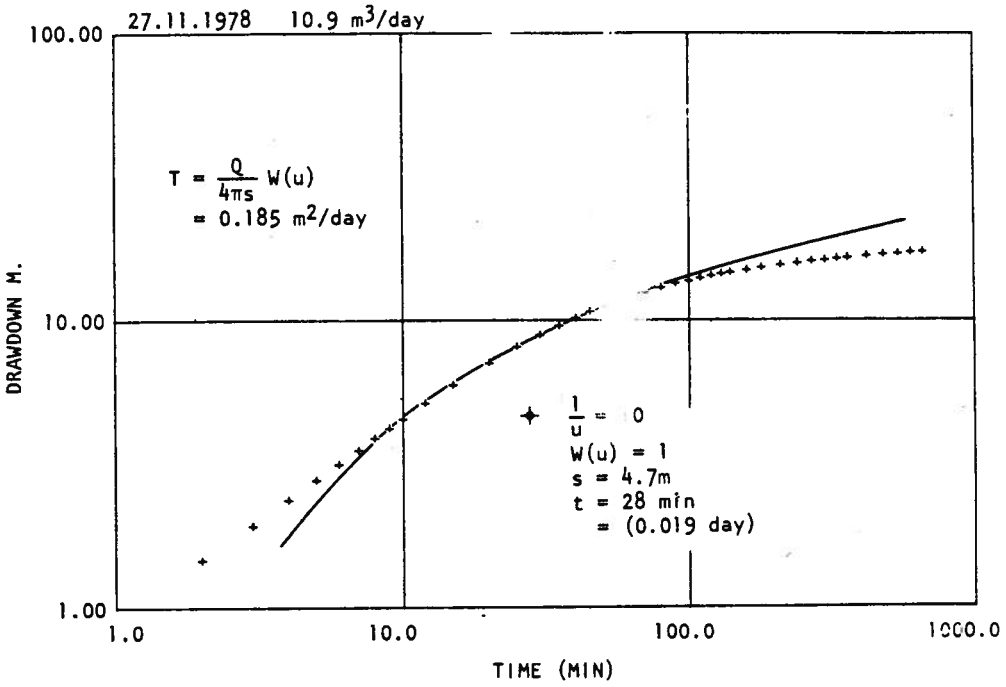
R = 15.239 m

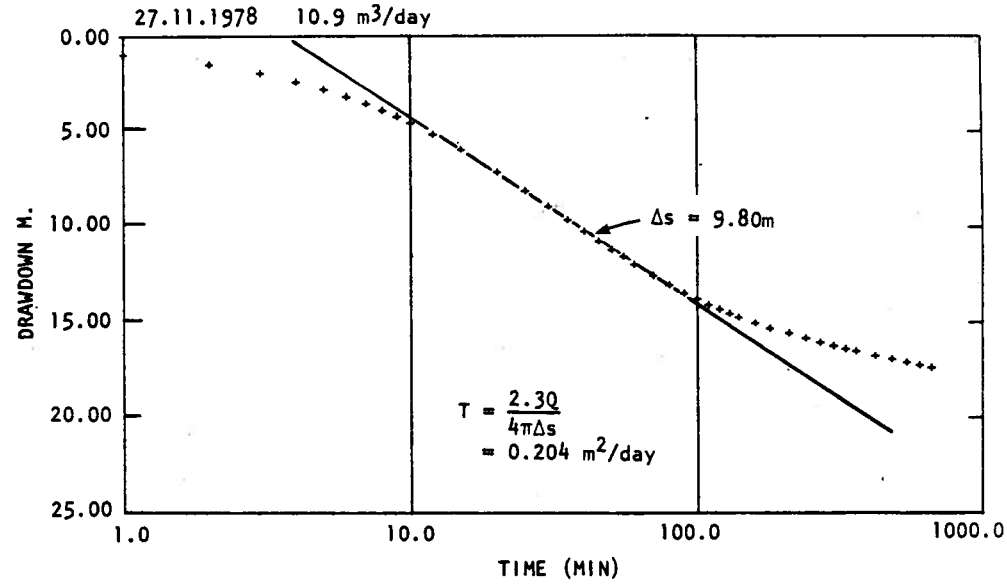




BOHAT 2

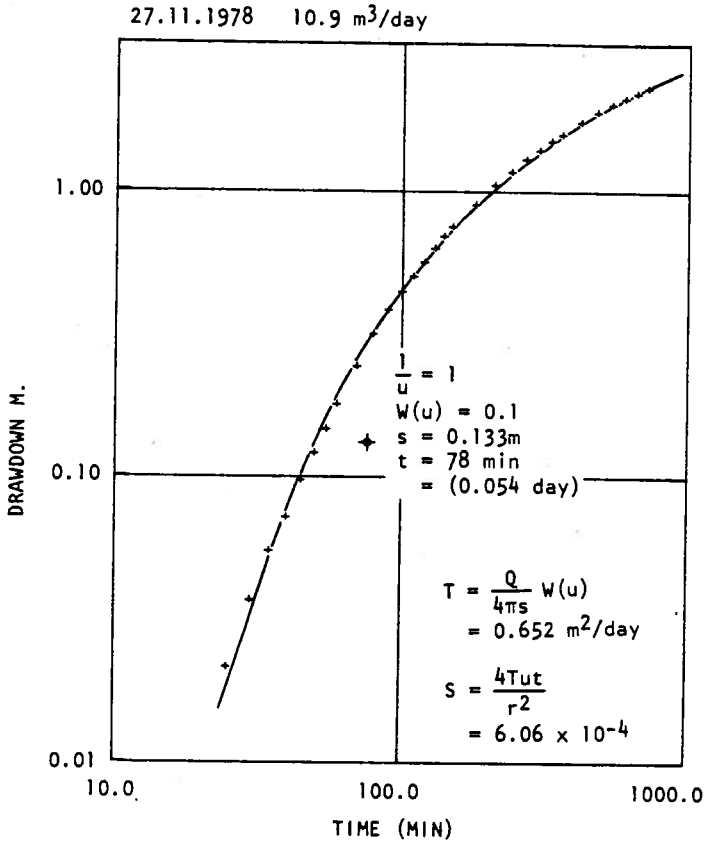
PUMPING WELL

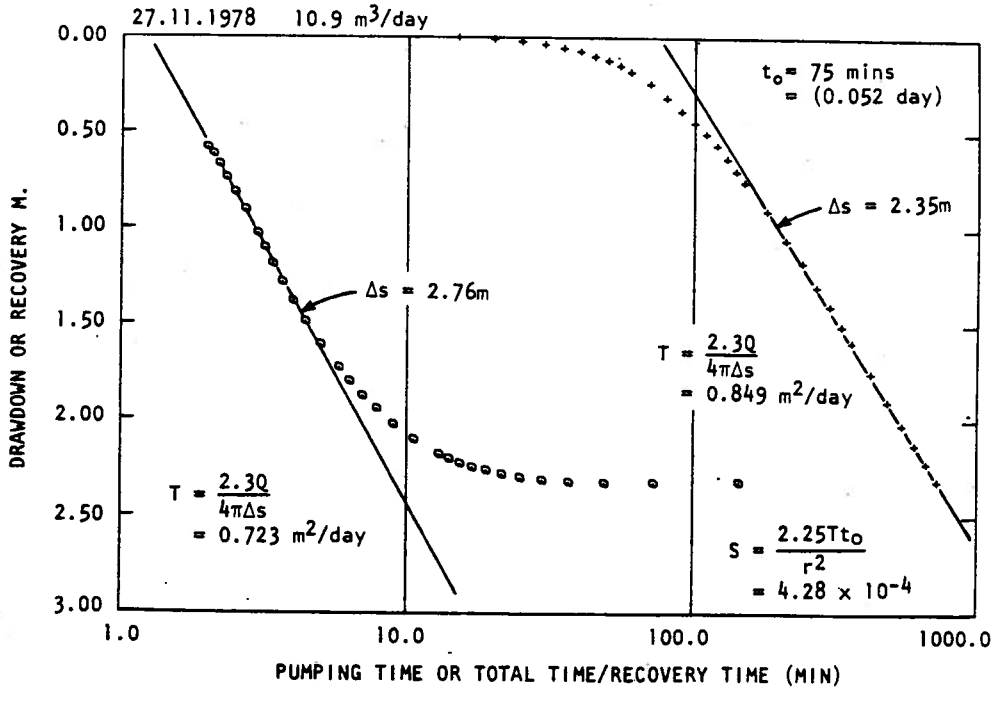




BOHAT 2

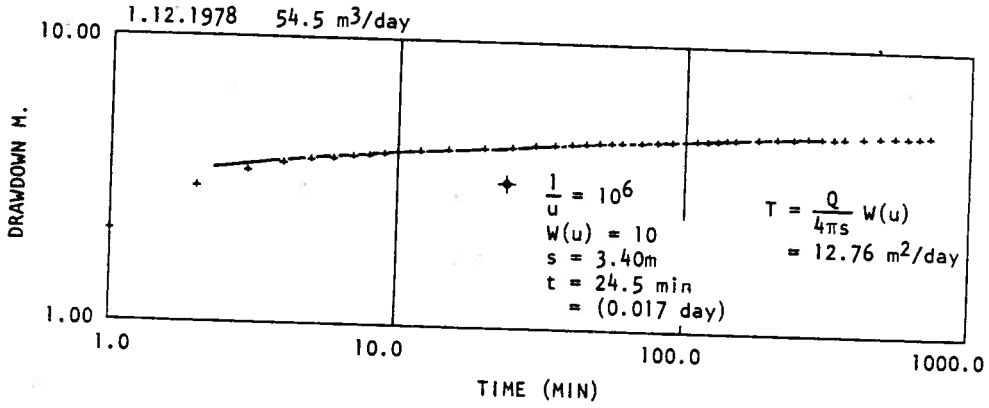
OBSERVATION WELL

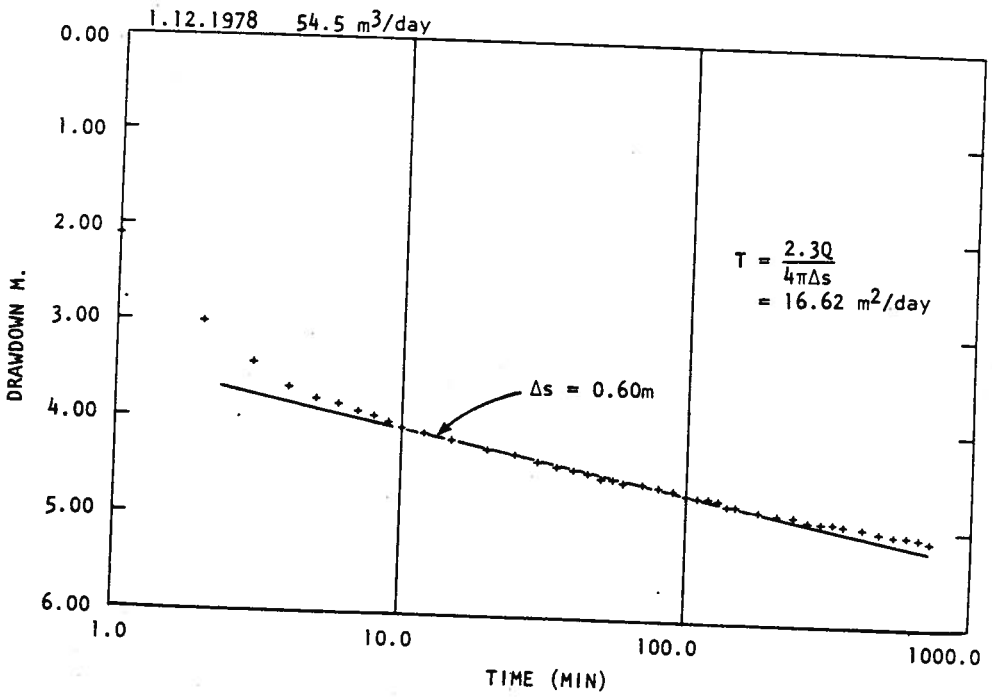




DSAT 3

PUMPING WELL

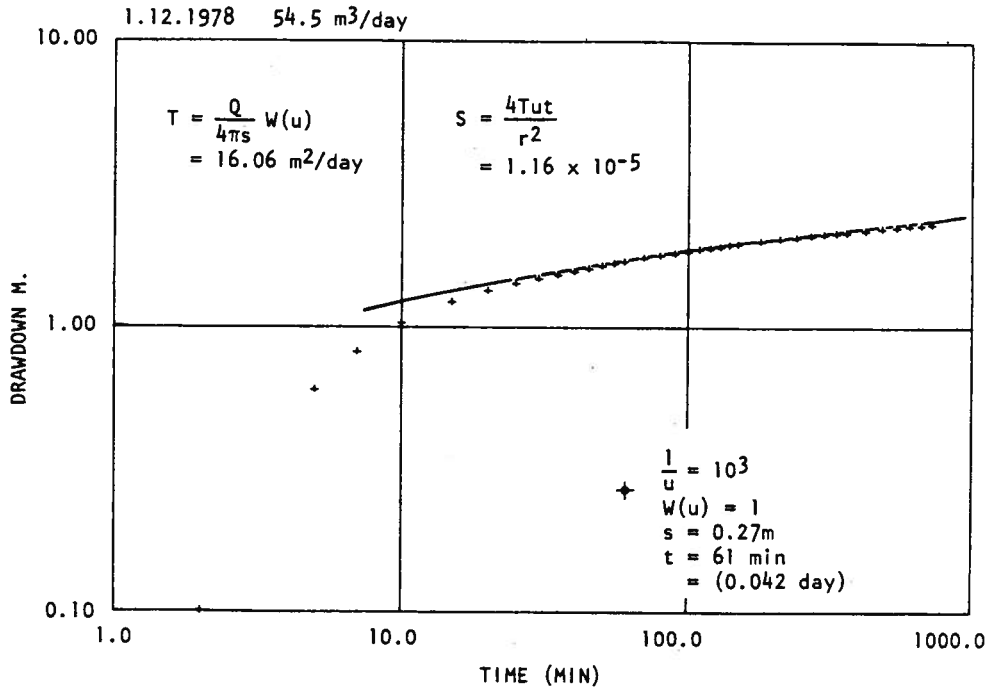


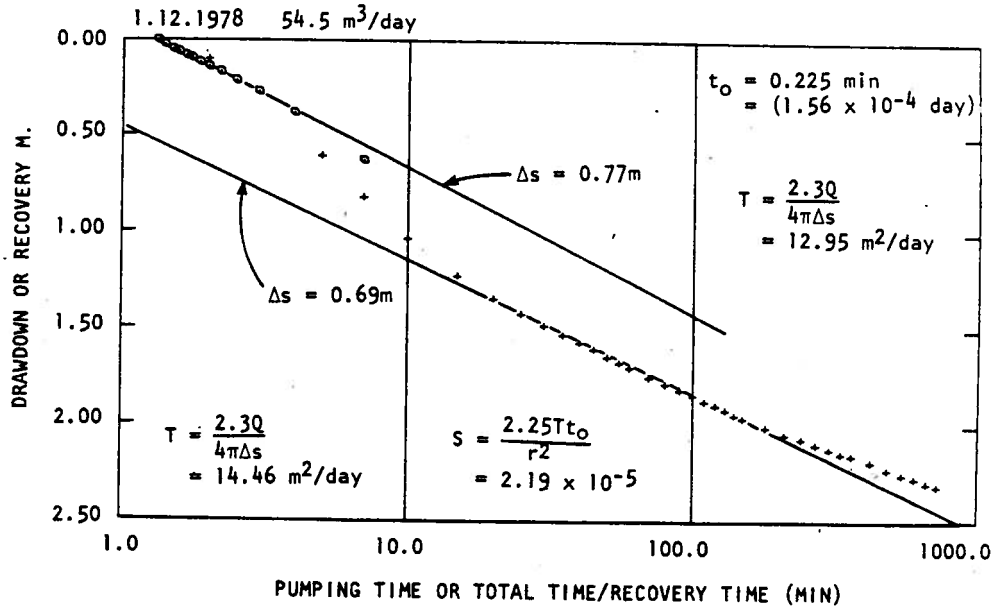


DSAT 3

OBSERVATION WELL

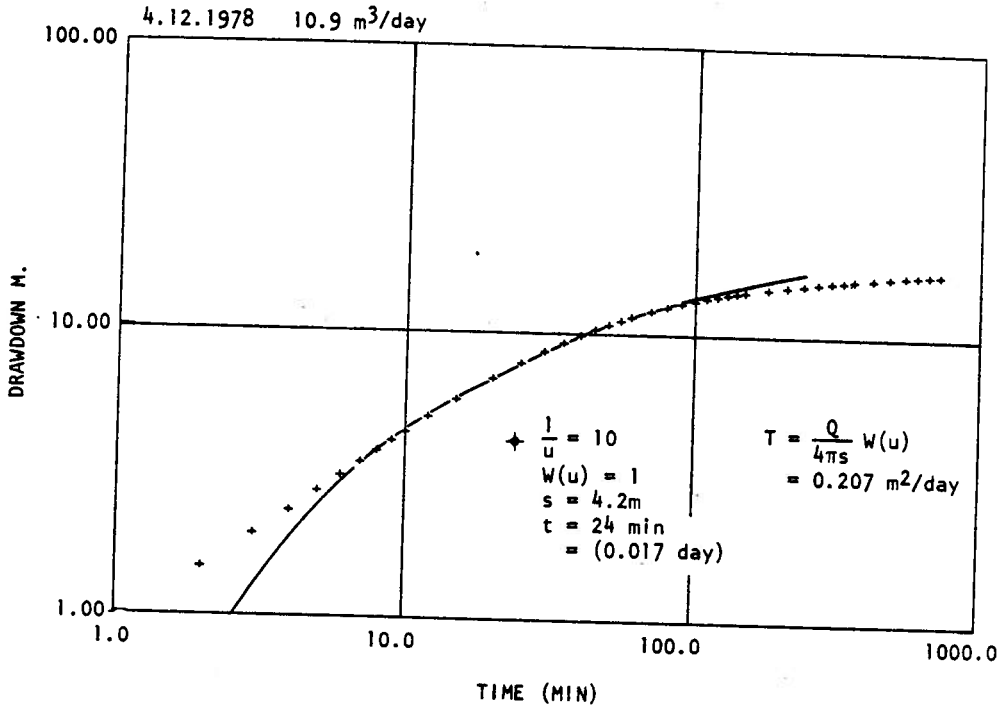
R = 15.239 m

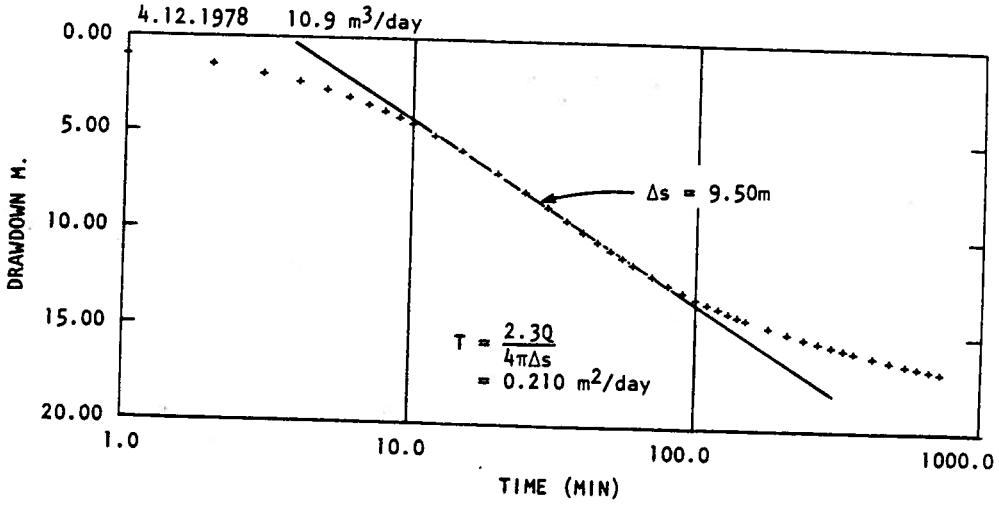




BOHAT 3

PUMPING WELL

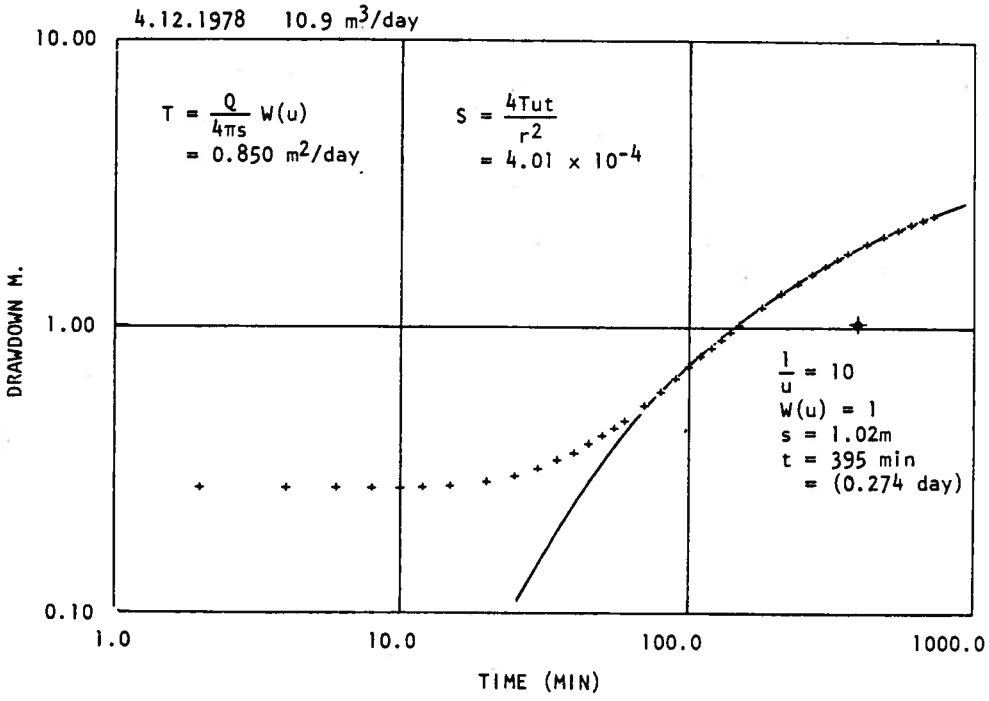


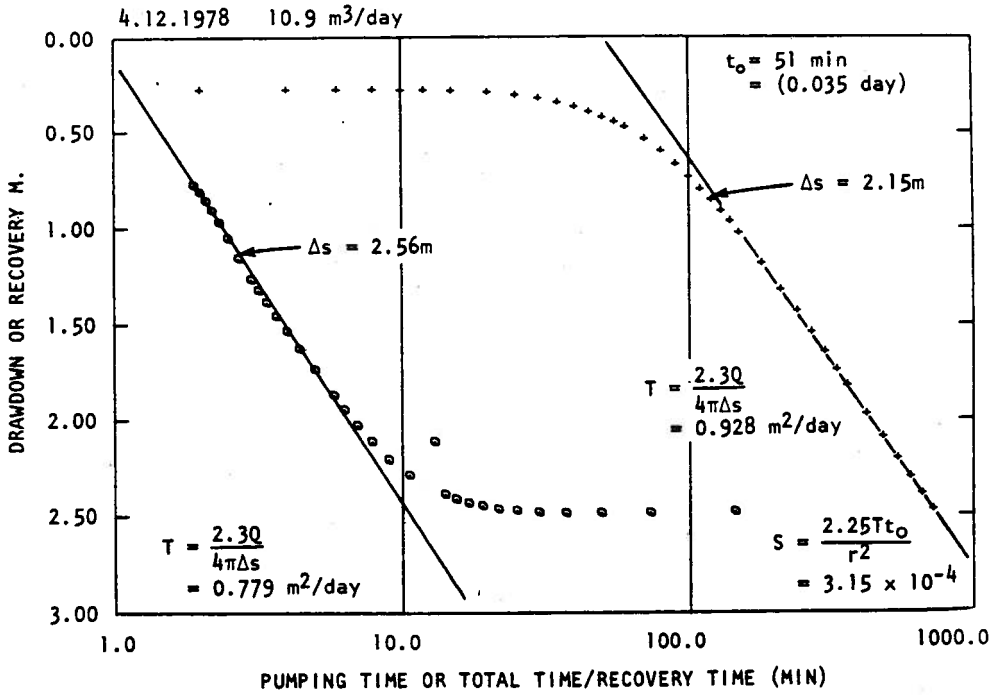


BOHAT 3

OBSERVATION WELL

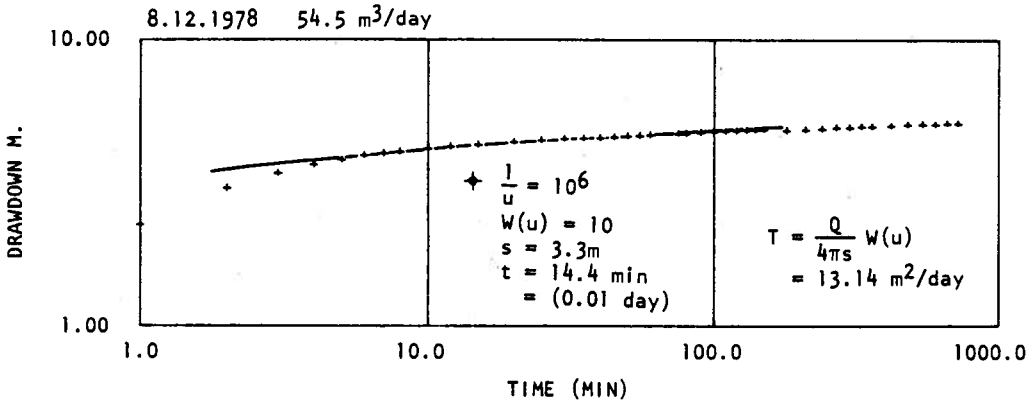
R = 15.239 m

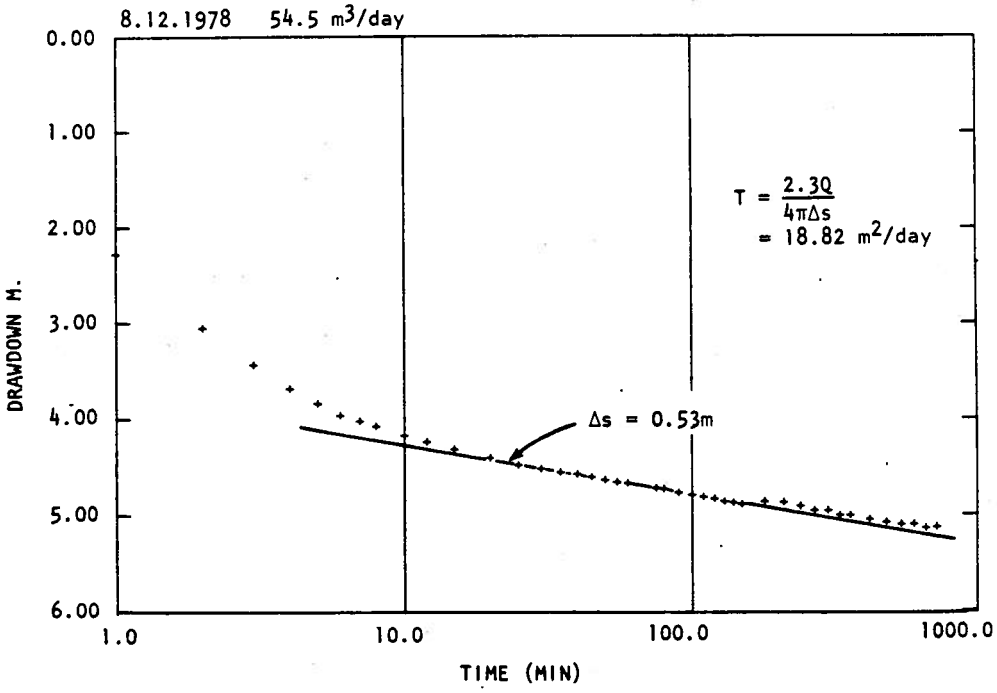




DSAT 4

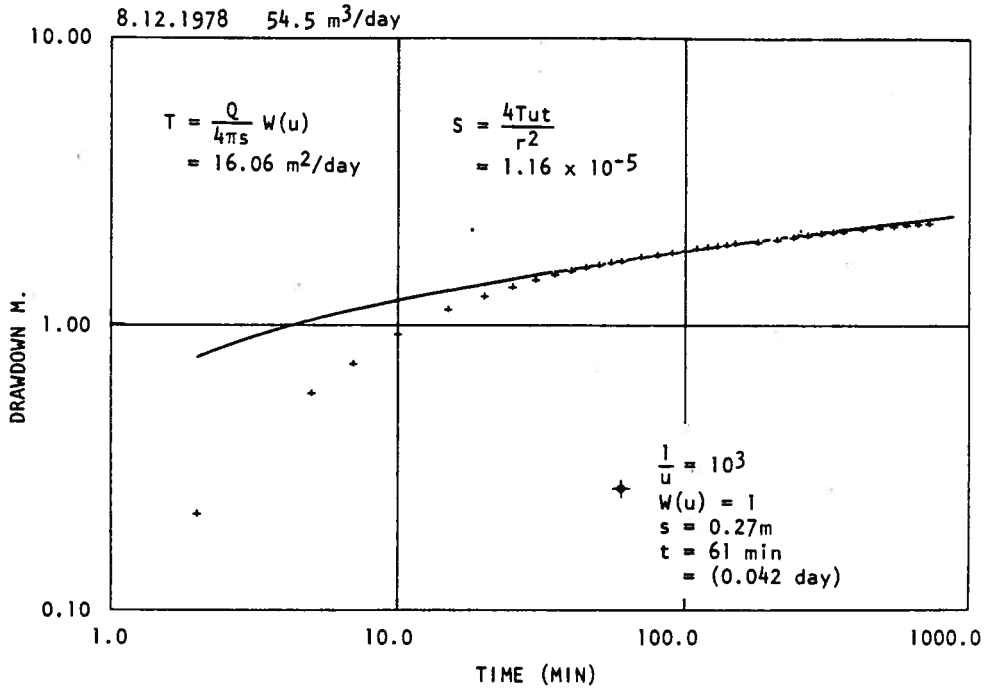
PUMPING WELL

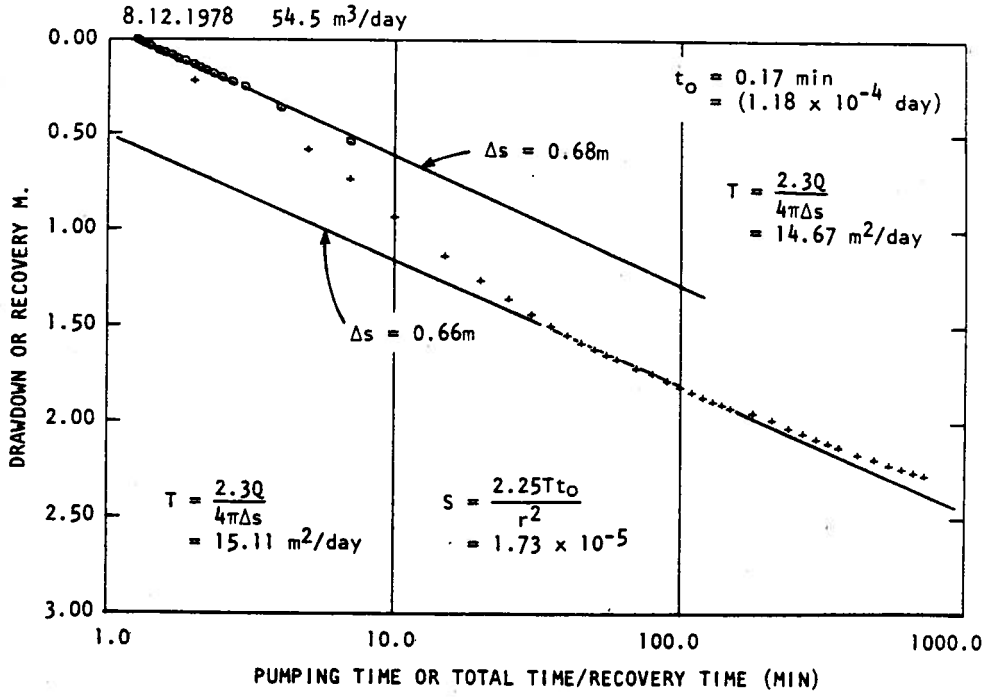




DSAT 4

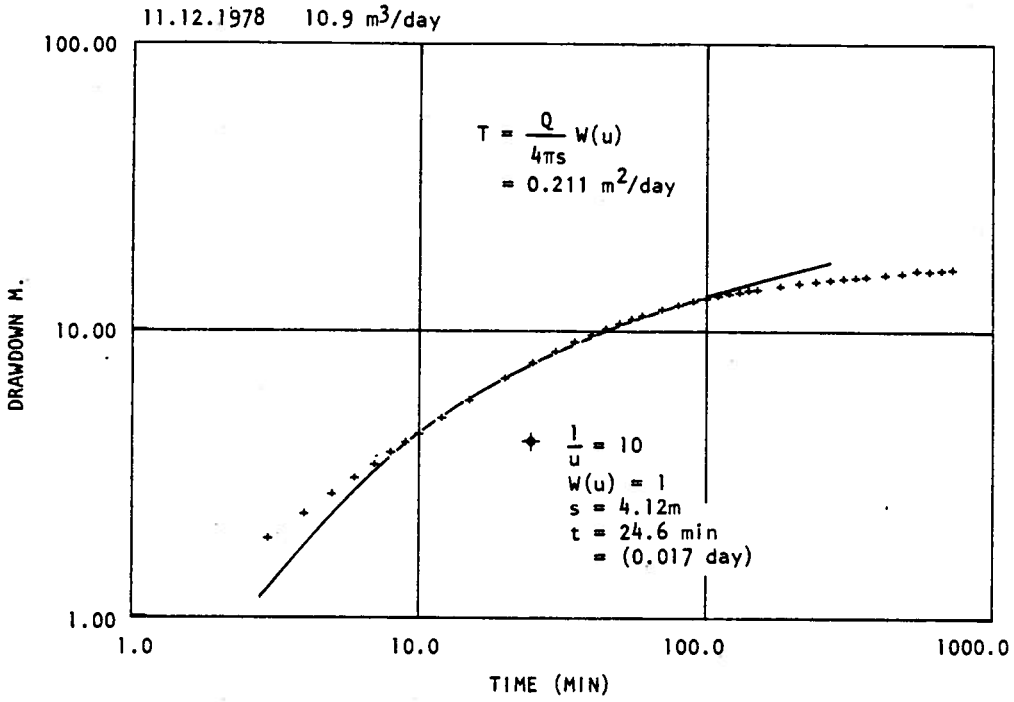
OBSERVATION WELL

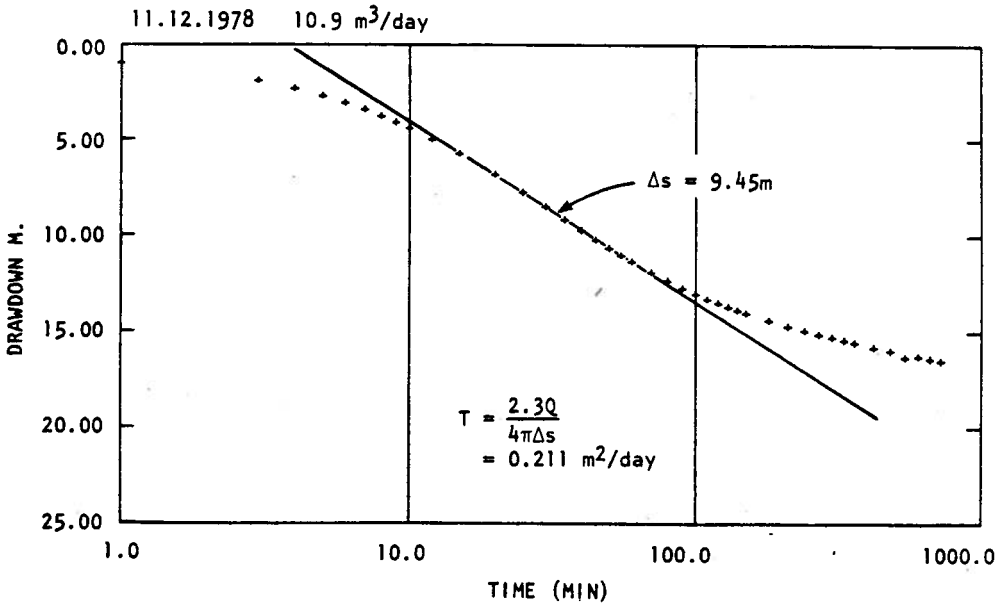




BOHAT 4

PUMPING WELL

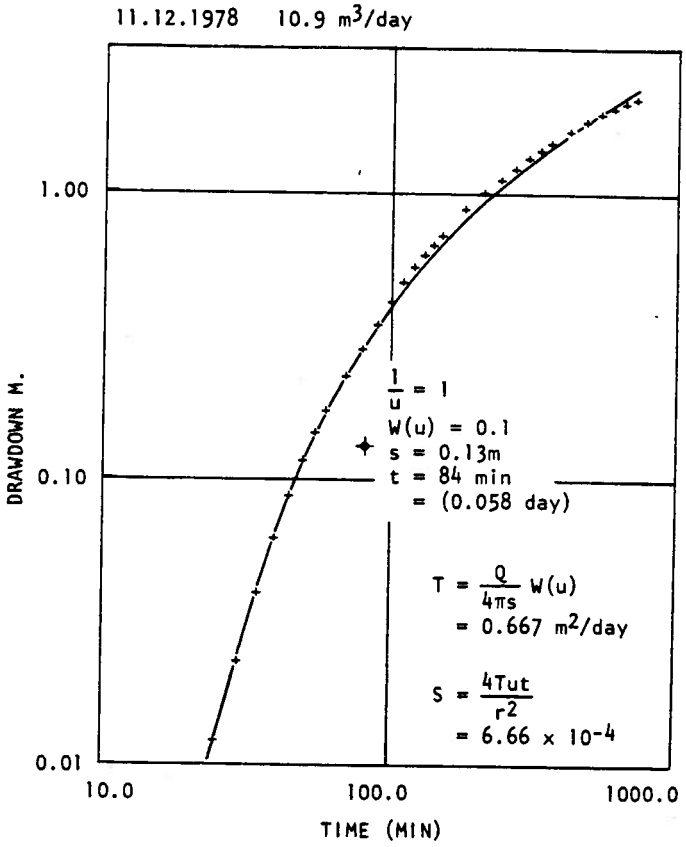


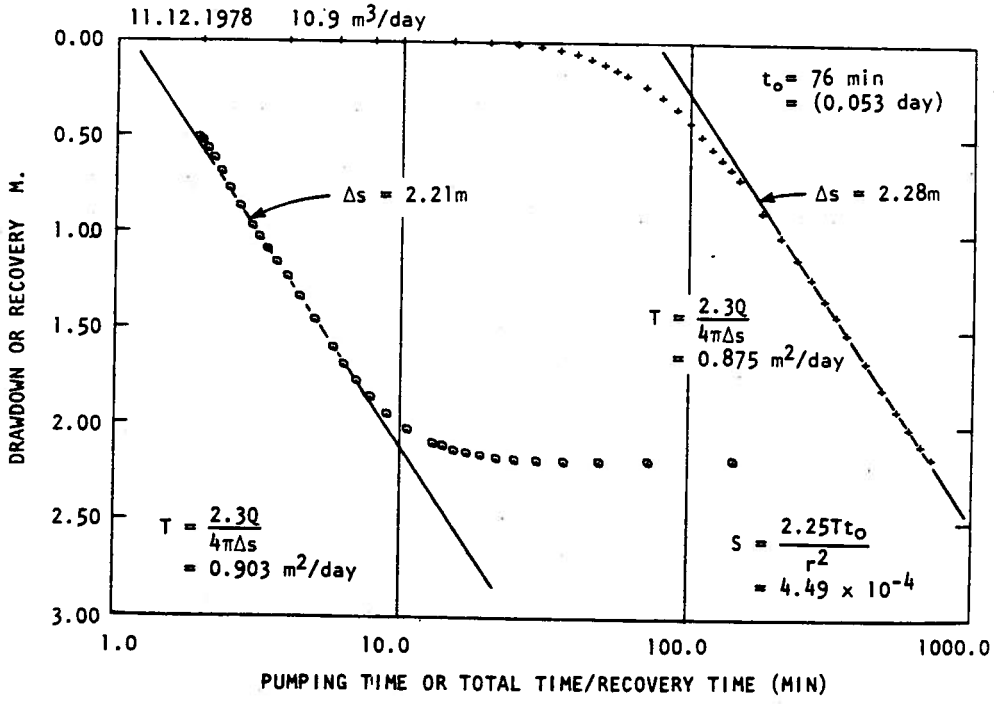


BOHAT 4

OBSERVATION WELL

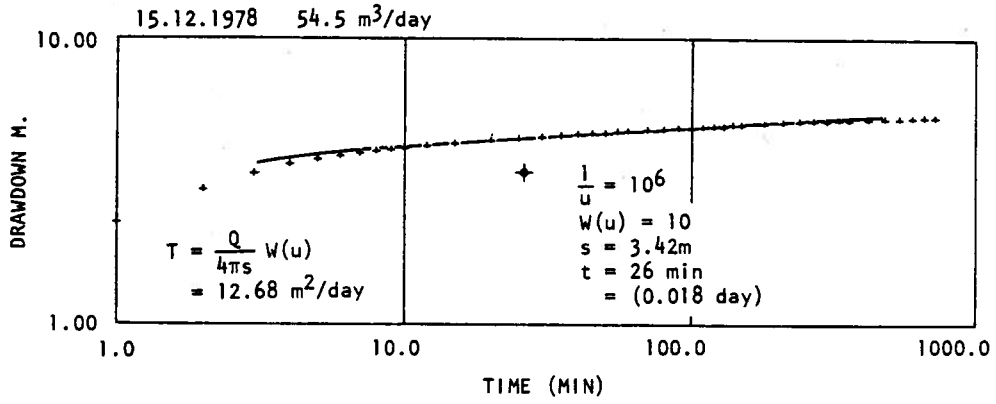
R = 15.239 m

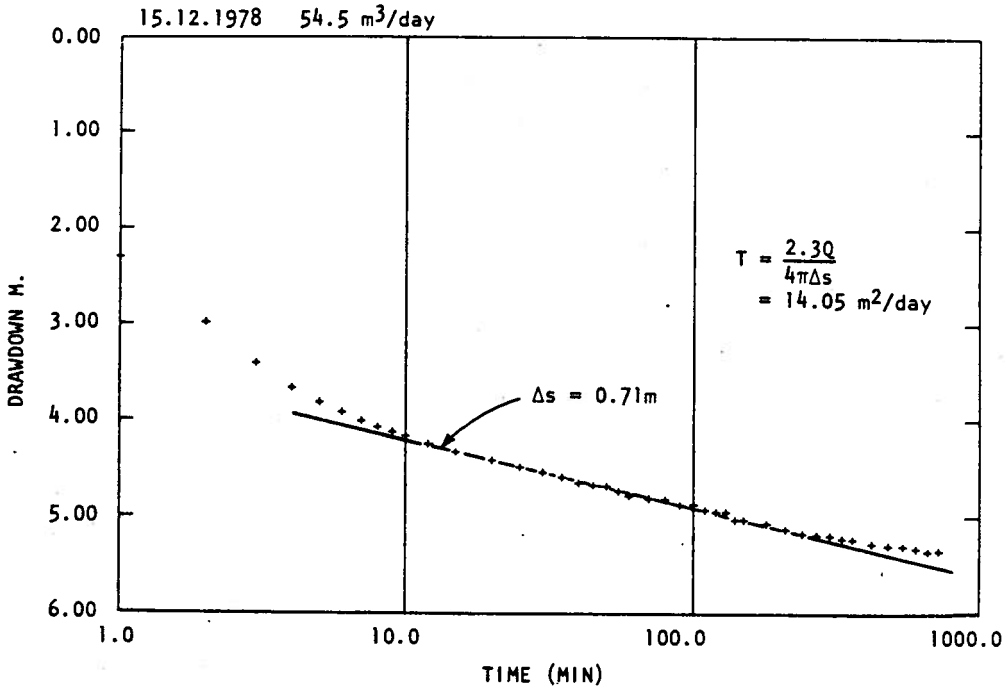




DSAT 5

PUMPING WELL

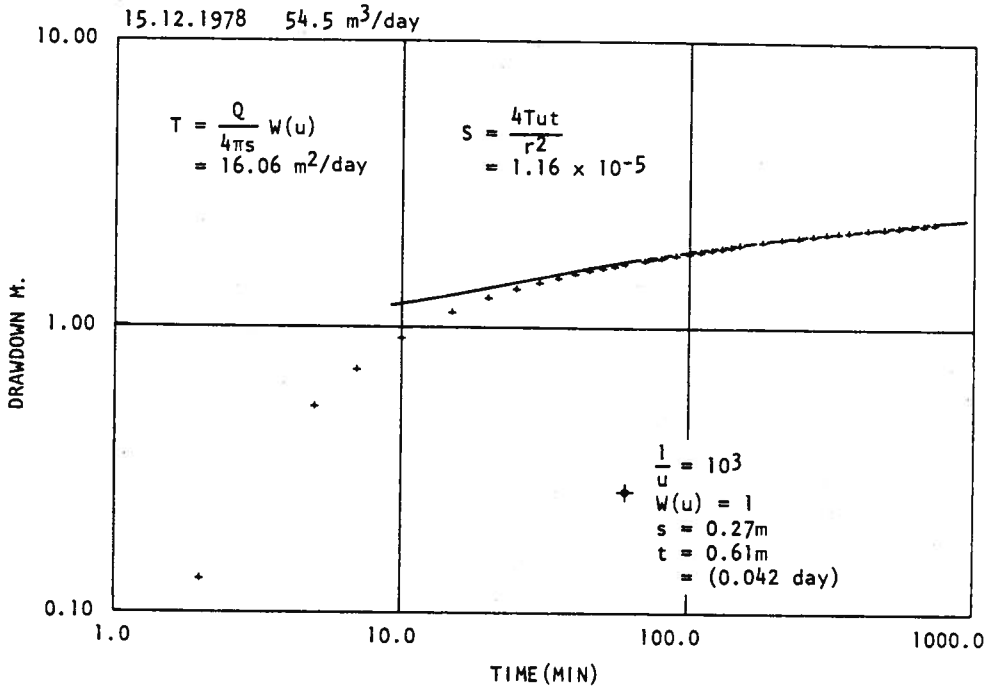


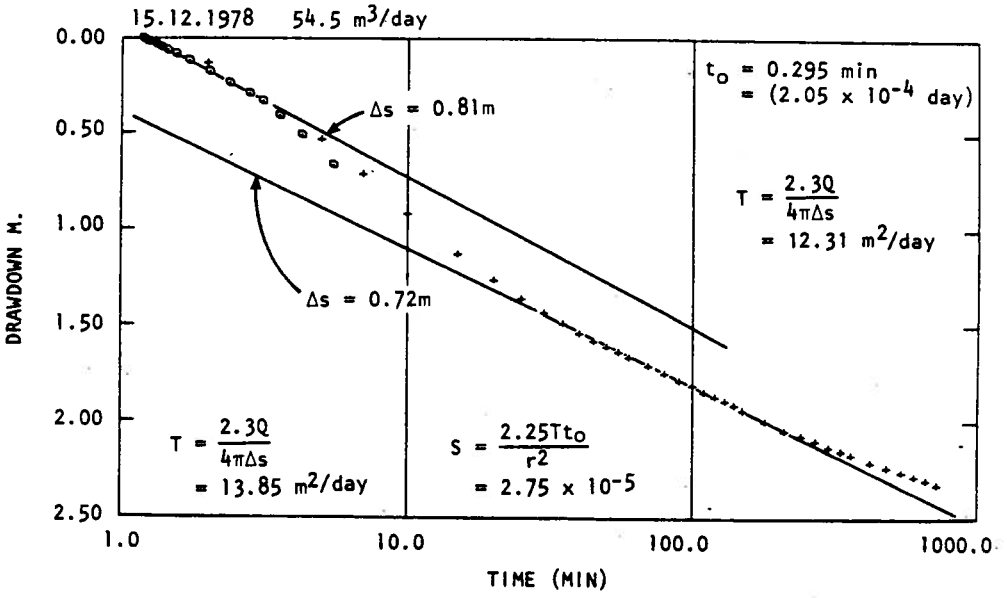


DSAT 5

OBSERVATION WELL

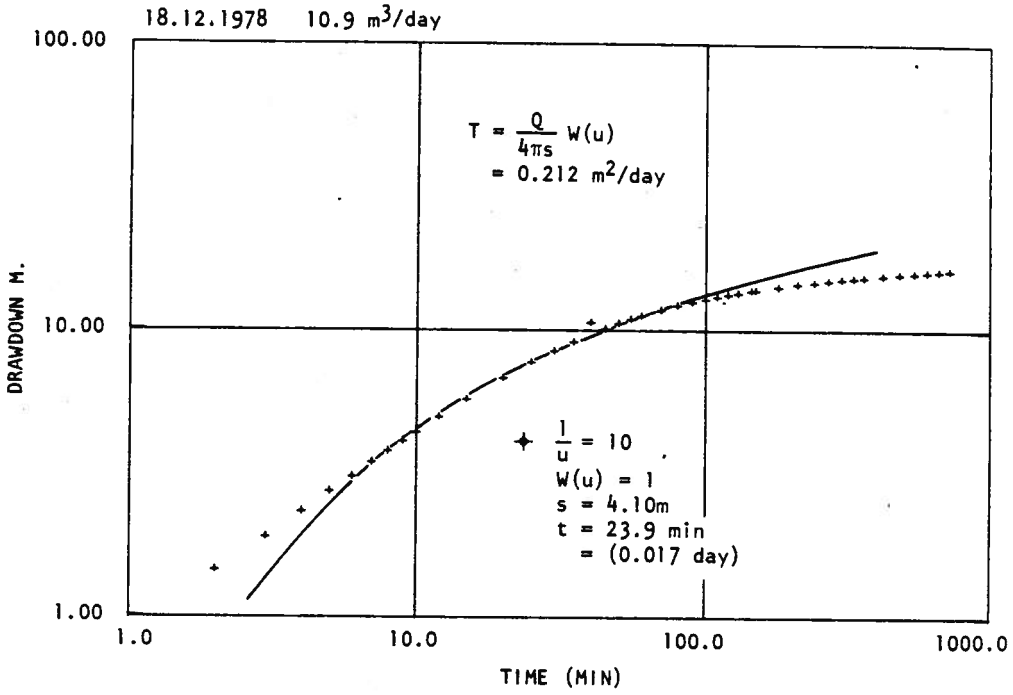
R = 15.239 m

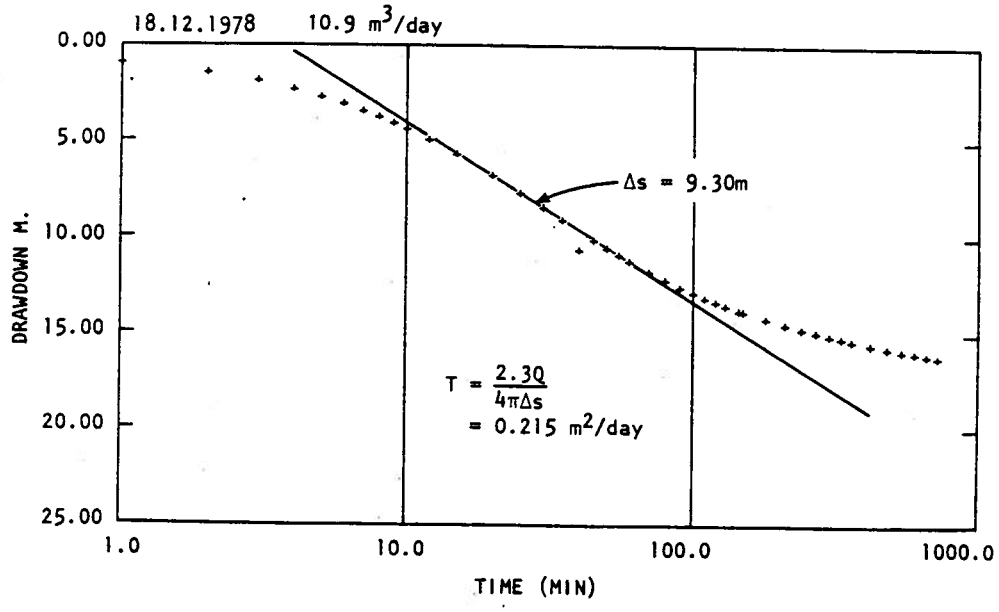




BOHAT 5

PUMPING WELL

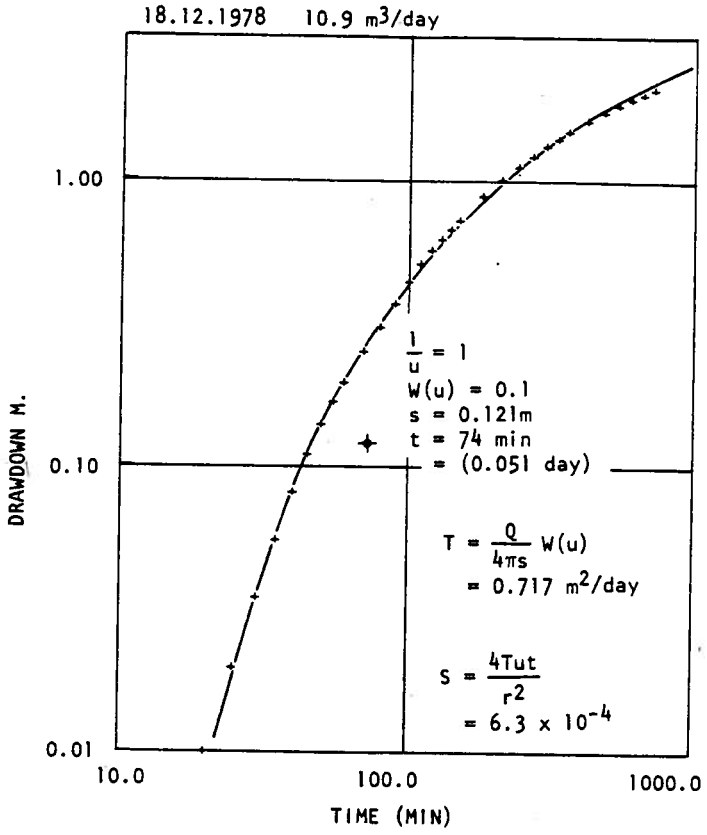


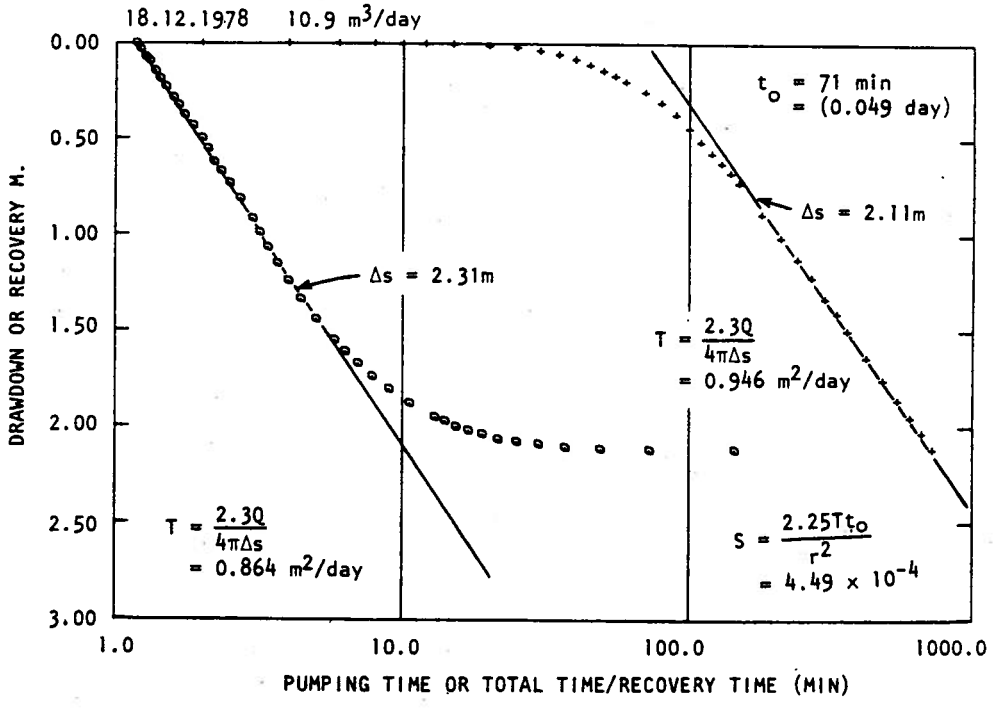


BOHAT 5

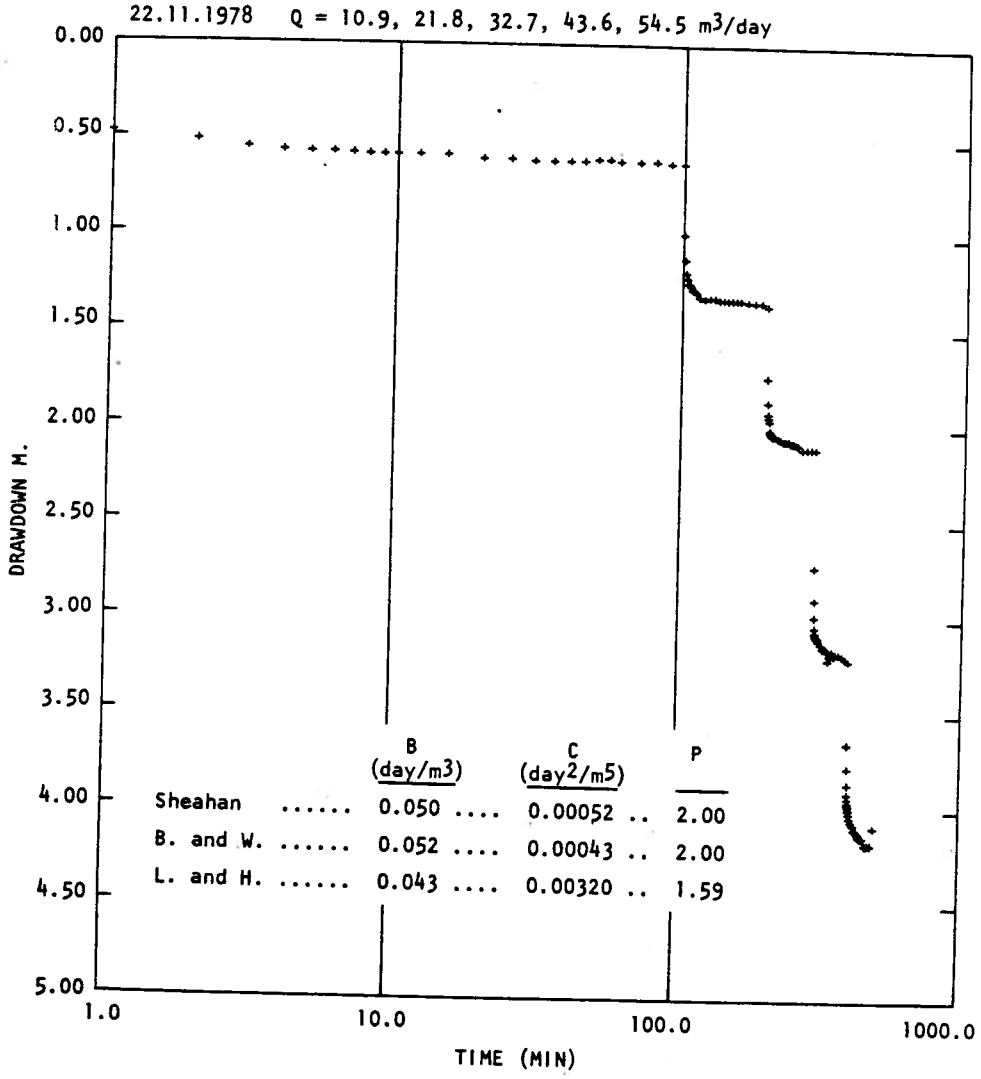
OBSERVATION WELL

R = 15.239 m

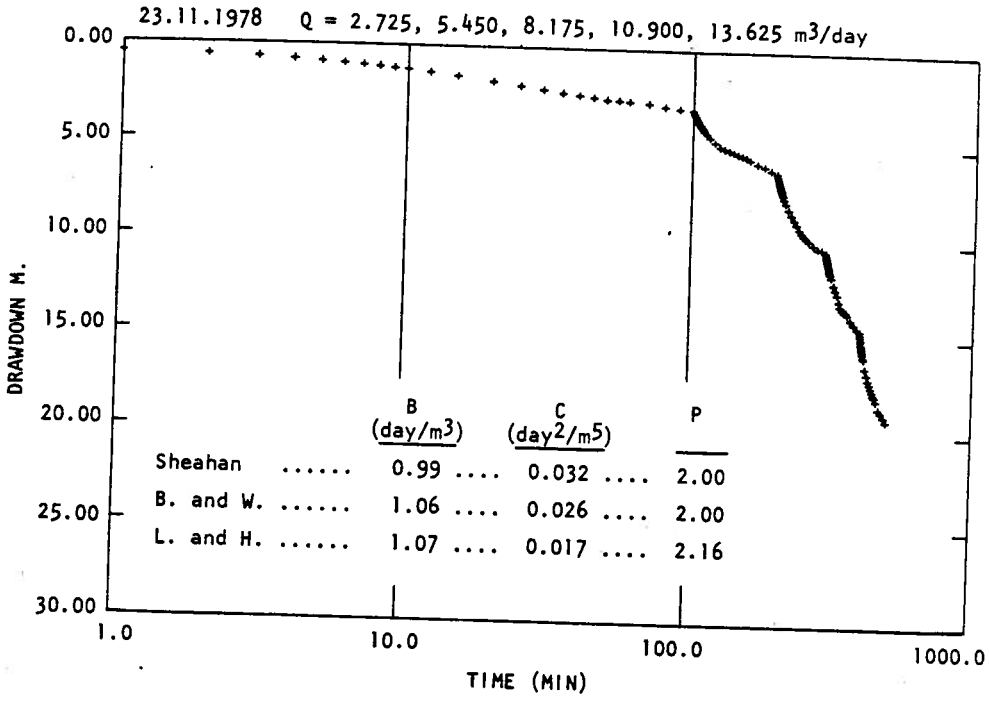




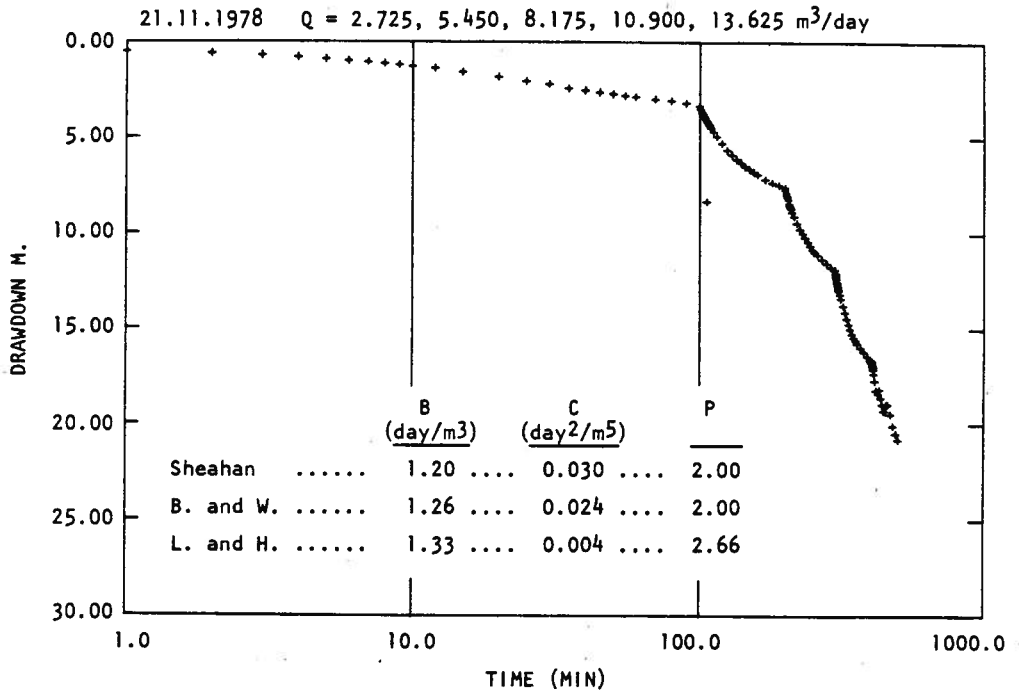
DSWT 2


22.11.1978 Q = 10.9, 21.8, 32.7, 43.6, 54.5 m3/day
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.050 .... 0.00052 .. 2.00
B. and W. ..... 0.052 .... 0.00043 .. 2.00
L. and H. ..... 0.043 .... 0.00320 .. 1.59

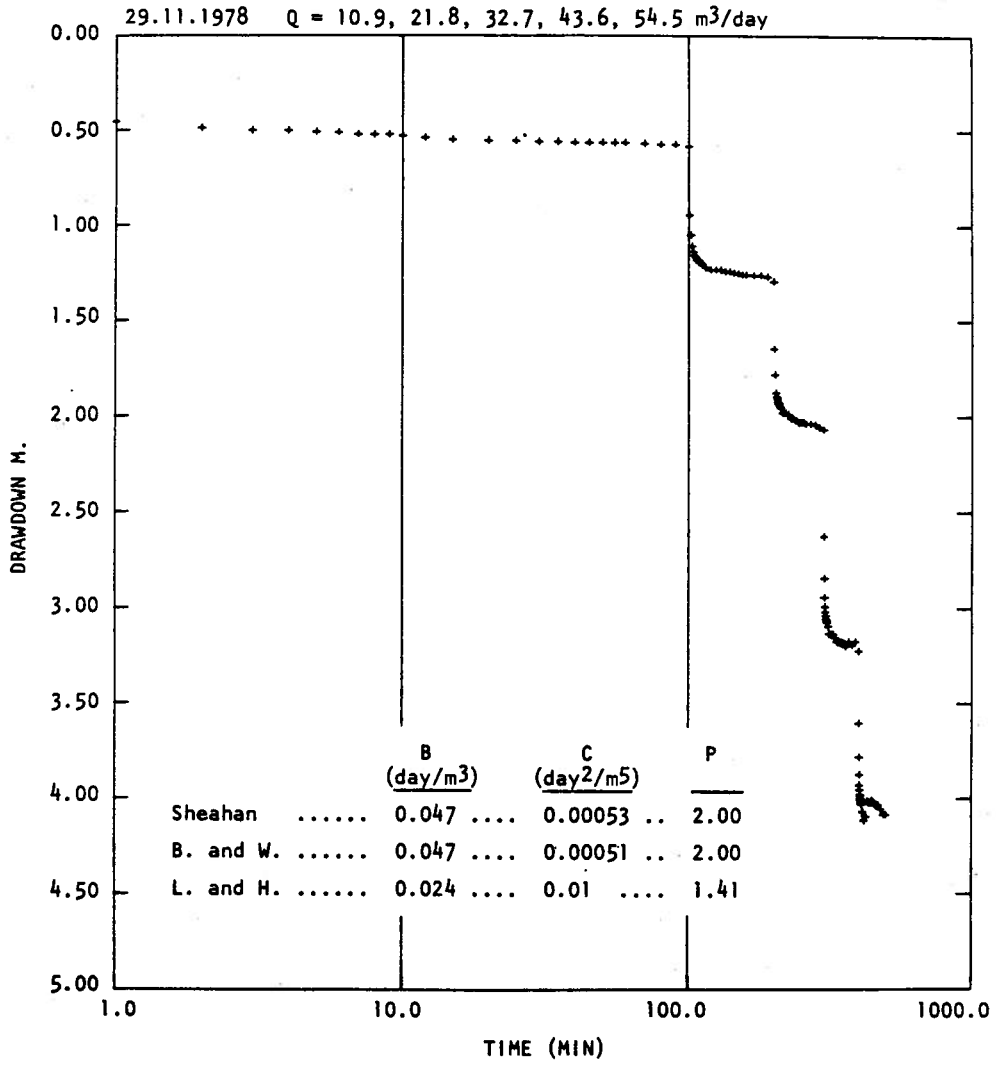
BOHWT 2


23.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.99 .... 0.032 .... 2.00
B. and W. ..... 1.06 .... 0.026 .... 2.00
L. and H. ..... 1.07 .... 0.017 .... 2.16

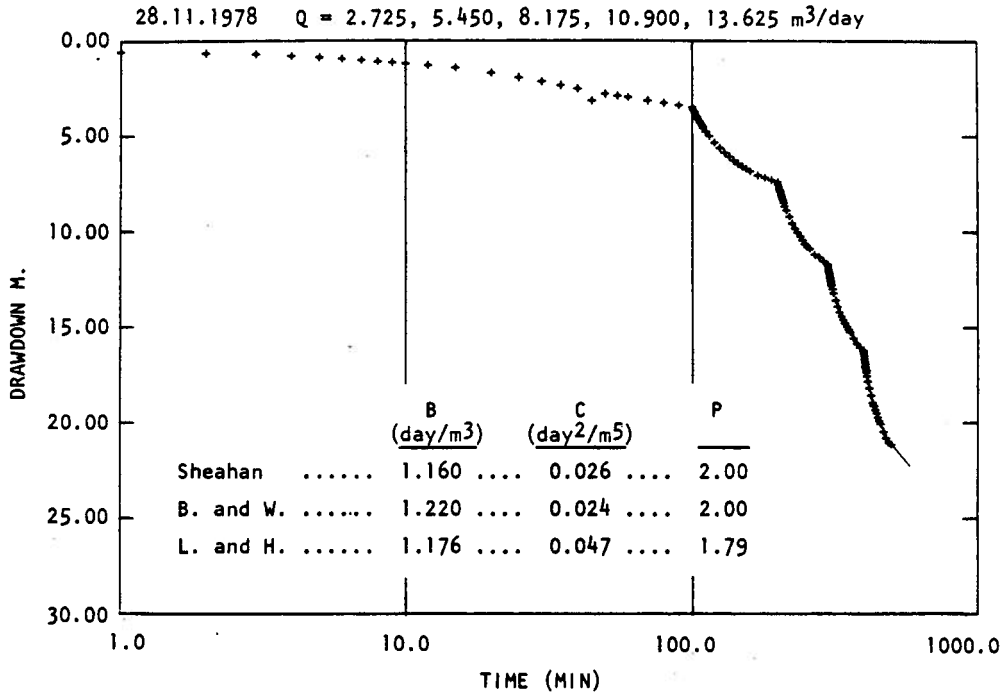
BSCWT 2


21.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 1.20 .... 0.030 .... 2.00
B. and W. ..... 1.26 .... 0.024 .... 2.00
L. and H. ..... 1.33 .... 0.004 .... 2.66

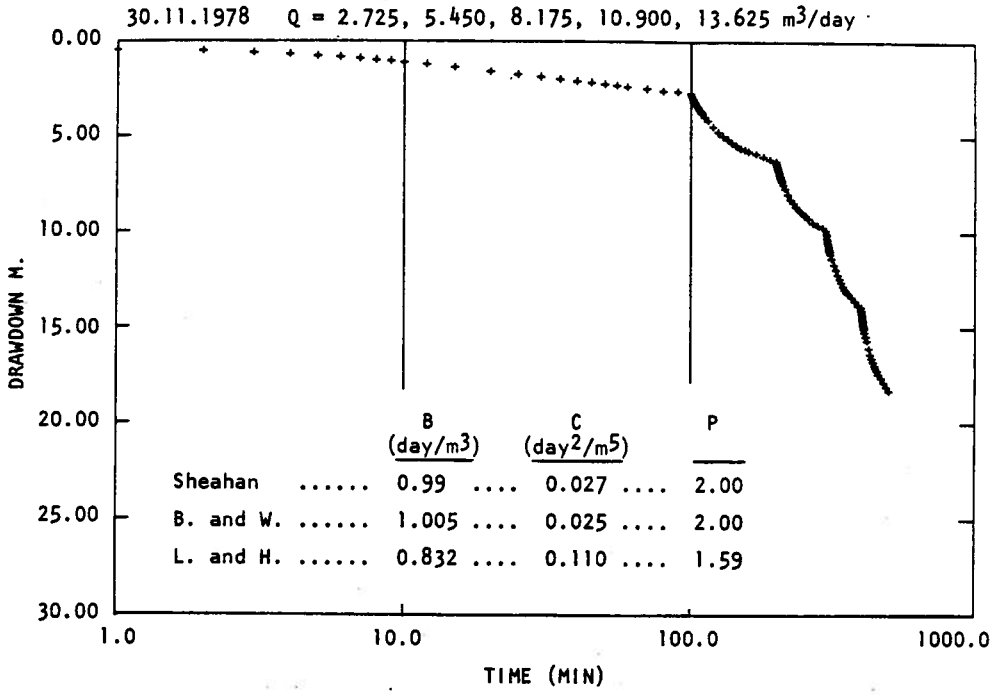
DSWT 3


29.11.1978 Q = 10.9, 21.8, 32.7, 43.6, 54.5 m3/day
DRAWDOWN M.
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.047 .... 0.00053 .. 2.00
B. and W. ..... 0.047 .... 0.00051 .. 2.00
L. and H. ..... 0.024 .... 0.01 .... 1.41

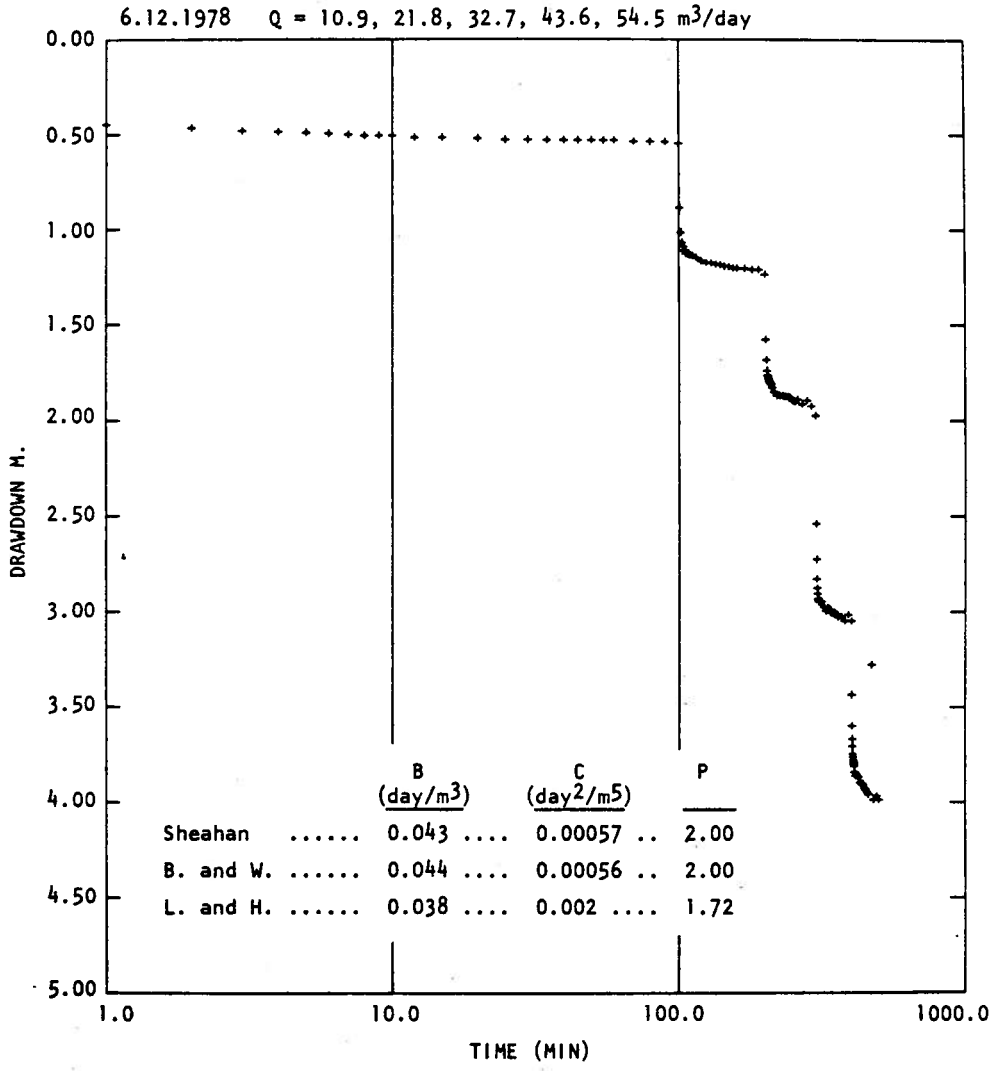
BSCWT 3


28.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 1.160 .... 0.026 .... 2.00
B. and W. ..... 1.220 .... 0.024 .... 2.00
L. and H. ..... 1.176 .... 0.047 .... 1.79

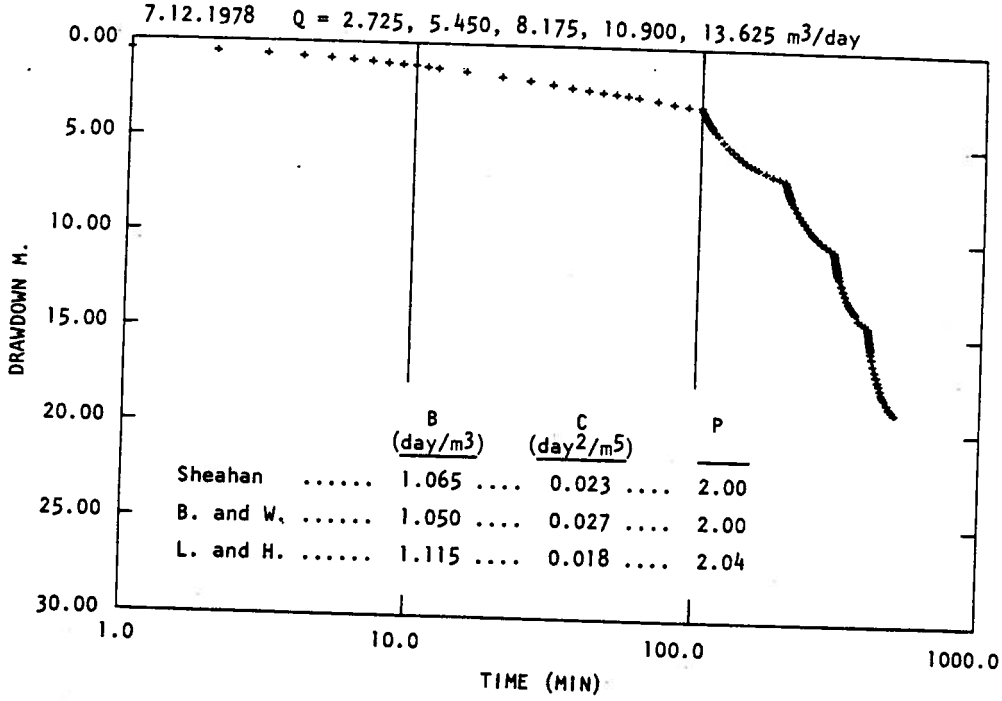
BOHWT 3


30.11.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.99 .... 0.027 .... 2.00
B. and W. ..... 1.005 .... 0.025 .... 2.00
L. and H. ..... 0.832 .... 0.110 .... 1.59

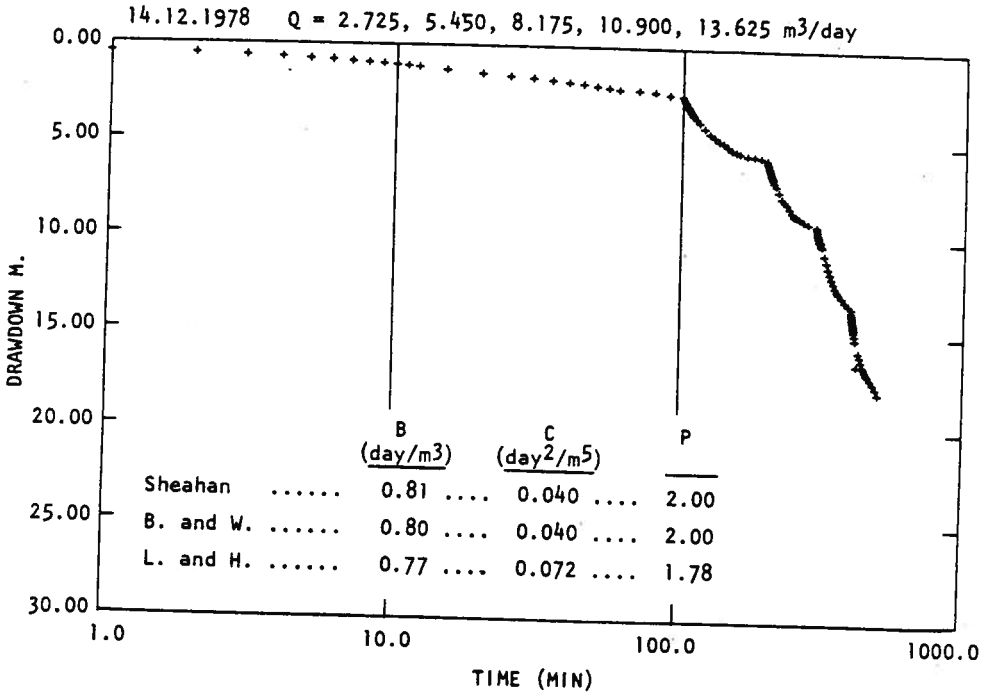
DSWT 4


6.12.1978 Q = 10.9, 21.8, 32.7, 43.6, 54.5 m3/day
DRAWDOWN M.
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.043 .... 0.00057 .. 2.00
B. and W. ..... 0.044 .... 0.00056 .. 2.00
L. and H. ..... 0.038 .... 0.002 .... 1.72

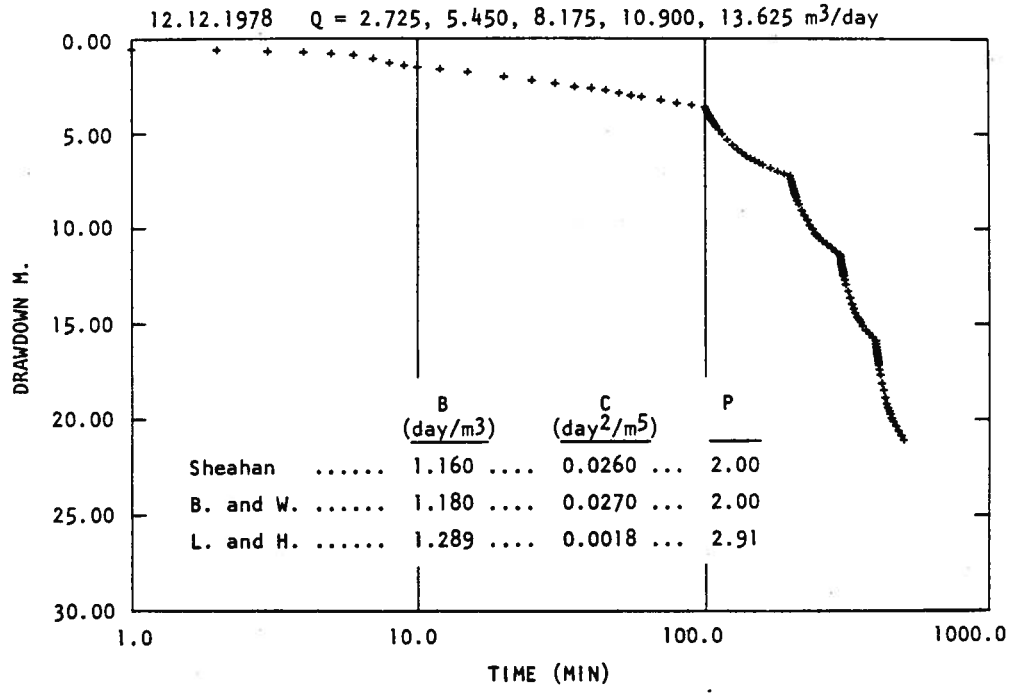
BOHWT 4


7.12.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
DRAWDOWN M.
0.00
5.00
10.00
15.00
20.00
25.00
30.00
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 1.065 .... 0.023 .... 2.00
B. and W. ..... 1.050 .... 0.027 .... 2.00
L. and H. ..... 1.115 .... 0.018 .... 2.04

BOHWT 5


14.12.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 0.81 .... 0.040 .... 2.00
B. and W. ..... 0.80 .... 0.040 .... 2.00
L. and H. ..... 0.77 .... 0.072 .... 1.78

BSCWT 5


12.12.1978 Q = 2.725, 5.450, 8.175, 10.900, 13.625 m3/day
0.00
5.00
10.00
15.00
20.00
25.00
30.00
DRAWDOWN M.
1.0
10.0
100.0
1000.0
TIME (MIN)
B (day/m3)
C (day2/m5)
P
Sheahan ..... 1.160 .... 0.0260 ... 2.00
B. and W. ..... 1.180 .... 0.0270 ... 2.00
L. and H. ..... 1.289 .... 0.0018 ... 2.91

Appendix D

HYDROCHEMICAL DATA - SUMMARIES AND ANALYSES

	DSAT									
	DSAT-1		DSAT-2		DSAT-3		DSAT-4		DSAT-5	
	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm
TDS	1732	1738	1662	1694	1758	1826	1046	1636	1628	1646
Alk.	504.0	515.2	443.2	17.6	544.8	566.4	562.4	520.8	454.4	509.6
Hard.	846.7	836.8	807.6	794.0	888.4	916.5	939.0	899.1	838.3	885.7
pH	7.6	7.8	7.7	7.8	7.8	7.6	7.4	7.6	7.6	7.5
Na	179.0	178.0	184.0	183.0	184.0	185.0	190.0	189.0	186.0	186.0
K	7.1	6.7	7.9	7.1	7.9	7.9	6.7	6.7	5.4	5.4
Ca	214.0	215.0	200.0	193.0	234.0	242.0	251.0	235.0	209.0	228.0
Mg	76.0	73.0	75.0	76.0	74.0	76.0	76.0	76.0	77.0	77.0
Cl	4.0	6.0	4.0	2.0	20.0	4.0	4.0	4.0	4.0	4.0
SO_4	643.0	600.0	688.0	687.0	698.0	679.0	723.0	673.0	758.0	742.0
NO_3	1.5	0.2	1.6	0.0	0.8	0.0	0.3	0.1	2.8	0.0
$HCO_3 + CO_3$	630.0	644.0	554.0	522.0	681.0	708.0	703.0	651.0	568.0	637.0

	DSWT									
	DSWT-1		DSWT-2		DSWT-3		DSWT-4		DSWT-5	
	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm
TDS	1560	1604	1800	1792	1682	1598	1720	1602	1598	1726
Alk.	332.0	396.0	566.4	550.4	394.4	340.0	544.8	468.8	513.6	569.6
Hard.	766.7	823.2	901.6	880.0	801.6	745.9	875.3	798.7	883.4	952.2
pH	7.5	7.6	7.6	7.5	7.9	7.7	7.8	7.8	7.8	7.5
Na	174.0	179.0	178.0	179.0	184.0	185.0	188.0	188.0	188.0	188.0
K	6.7	7.5	7.5	7.5	7.1	7.1	6.7	6.3	6.7	5.8
Ca	177.0	198.0	236.0	229.0	191.0	167.0	237.0	203.0	232.0	253.0
Mg	79.0	80.0	76.0	75.0	79.0	80.0	69.0	71.0	74.0	78.0
Cl	4.0	4.0	6.0	4.0	2.0	2.0	6.0	8.0	4.0	4.0
SO_4	668.0	692.0	613.0	699.0	778.0	778.0	748.0	778.0	728.0	743.0
NO_3	4.5	2.8	0.0	3.0	0.3	2.6	0.1	0.3	0.2	0.3
$HCO_3 + CO_3$	415.0	495.0	708.0	688.0	493.0	425.0	681.0	586.0	642.0	712.0

	BSCWT									
	BSCWT-1		BSCWT-2		BSCWT-3		BSCWT-4		BSCWT-5	
	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm
TDS	1456	1394	1474	1348	1586	1308	1704	1282	1474	1262
Alk.	587.2	611.2	616.8	599.2	572.0	528.8	584.0	482.0	628.8	624.8
Hard.	134.9	289.1	203.4	317.3	251.5	229.3	218.0	175.2	228.0	313.2
pH	8.1	7.7	7.0	7.2	7.2	7.8	7.6	8.5	7.7	7.5
Na	470.0	365.0	475.0	365.0	453.0	371.0	476.0	381.0	465.0	390.0
K	2.5	2.9	2.9	2.9	1.7	2.1	4.2	3.3	2.9	2.5
Ca	30.0	73.0	53.0	81.0	66.0	49.0	61.0	29.0	65.0	81.0
Mg	14.6	26.0	17.3	28.0	21.1	26.0	16.0	25.0	16.0	27.0
Cl	10.0	10.0	4.0	8.0	8.0	8.0	10.0	10.0	14.0	10.0
SO_4	448.0	391.0	520.0	428.0	512.0	502.0	564.0	450.0	563.0	437.0
NO_3	1.8	2.0	0.0	2.5	0.0	0.1	0.1	0.0	0.1	0.1
$HCO_3 + CO_3$	734.0	764.0	771.0	749.0	715.0	661.0	730.0	587.4	786.0	781.0

	BOHWT									
	BOHWT-1		BOHWT-2		BOHWT-3		BOHWT-4		BOHWT-5	
	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm
TDS	1512	1302	1234	1242	1422	1262	1338	1258	1260	1206
Alk.	636.0	607.2	630.4	507.9	615.2	630.4	601.6	628.8	634.4	628.8
Hard.	80.9	203.7	136.7	144.7	187.3	256.1	170.3	277.7	193.1	269.0
pH	7.8	7.9	7.8	8.4	8.1	8.1	7.4	7.7	7.6	7.7
Na	520.0	379.0	430.0	381.0	436.0	381.0	439.0	385.0	429.0	379.0
K	2.5	2.9	1.7	3.3	3.8	2.9	1.7	2.9	1.7	2.5
Ca	24.0	49.0	36.0	25.0	49.0	68.0	45.0	75.0	51.0	60.0
Mg	5.1	19.8	11.4	20.0	15.8	21.0	14.1	22.0	16.0	29.0
Cl	14.0	14.0	36.0	6.0	20.0	16.0	22.0	14.0	24.0	14.0
SO_4	500.0	311.0	383.0	383.0	398.0	334.0	375.0	348.0	368.0	362.0
NO_3	0.0	2.4	0.1	1.4	0.0	0.0	0.2	0.2	0.3	0.0
$HCO_3 + CO_3$	795.0	759.0	788.0	622.0	769.0	788.0	752.0	786.0	793.0	786.0

	BOHAT									
	BOHAT-1		BOHAT-2		BOHAT-3		BOHAT-4		BOHAT-5	
	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm	30 Mins ppm	End ppm
TDS	1414	1256	1472	1181.3	1370	1270	1378	1212	1258	1258
Alk.	634.4	626.4	638.4	558.4	566.3	628.8	636.0	634.4	634.4	626.4
Hard.	157.9	226.6	228.7	161.3	139.4	233.8	229.6	247.0	250.2	262.6
pH	7.9	7.9	8.1	8.3	8.4	7.8	7.7	7.7	7.8	8.0
Na	443.0	373.0	454.0	384.0	454.0	384.0	449.0	390.0	443.0	384.0
K	2.5	2.9	2.9	2.5	2.5	4.2	2.5	2.1	2.1	1.3
Ca	42.0	56.0	60.0	30.0	29.0	64.0	64.0	66.0	64.0	64.0
Mg	12.9	21.1	19.2	21.0	16.3	18.0	17.0	20.0	22.0	25.0
Cl	18.0	18.0	12.0	12.0	12.0	20.0	14.0	16.0	14.0	4.0
SO_4	408.0	322.0	469.0	379.0	463.0	360.0	464.0	331.0	484.0	339.0
NO_4	0.5	0.0	0.0	0.0	0.0	0.4	0.2	0.2	0.0	0.0
HCO_3 + CO_3	793.0	783.0	798.0	698.0	695.0	786.0	795.0	793.0	793.0	783.0

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781029	Date sampled	17 11 78
Index no.	DSAT 1	Date submitted	20 11 78
well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	700MIN
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	836.8
TDS(mg/l)	1738.0	Alkalinity(as CaCO3)	515.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2050
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	215.0	10.73	43.5
Magnesium(Mg)	73.0	6.01	24.4
Sodium(Na)	178.0	7.74	31.4
Potassium(K)	6.7	0.17	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	644.0	10.56	45.5
Sulphate(SO4)	600.0	12.49	53.8
Chloride(Cl)	6.0	0.17	0.7
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.8	Total anions(epm)	23.220
Calcium(Acid)	235.0	Total cations(epm)	24.651
Magnesium(Acid)	75.0	Ion balance error(%)	3.
Calculated TDS	1405.4	TDS balance error(%)	-19.

MINOR CONSTITUENTS

Iron 7.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.50 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781054	Date sampled	D M Y 24 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	83.0	Date analysed(major)	5 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	83.0	Sample Source	DSAT2
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	807.6
TDS(mg/l)	1662.0	Alkalinity(as CaCO3)	443.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1850
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	200.0	9.98	41.0
Magnesium(Mg)	75.0	6.17	25.3
Sodium(Na)	184.0	8.00	32.9
Potassium(K)	7.9	0.20	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	554.0	9.08	38.6
Sulphate(SO4)	688.0	14.32	60.8
Chloride(Cl)	4.0	0.11	0.5
Nitrate(NO3)	1.6	0.03	0.1
Hydroxide(OH)			
Silica(SiO2)	14.7		
Calcium(Acid)	230.0	Total anions(epm)	23.543
Magnesium(Acid)	73.0	Total cations(epm)	24.358
Calculated TDS	1447.6	Ion balance error(%)	2.
		TDS balance error(%)	-13.

MINOR CONSTITUENTS

Iron 8.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.18 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781055	Date sampled	24 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	83.0	Date analysed(major)	5 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGEL
Bottom open interval(ft)	82.0	Sample Source	DSAT2
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	794.3
TDS(mg/l)	1694.0	Alkalinity(as CaCO3)	417.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1850
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	193.0	9.63	40.1
Magnesium(Mg)	76.0	6.26	26.0
Sodium(Na)	183.0	7.96	33.1
Potassium(K)	7.1	0.18	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	522.0	8.56	37.3
Sulphate(SO4)	687.0	14.30	62.4
Chloride(Cl)	2.0	0.06	0.2
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	14.6	Total anions(epm)	22.916
Calcium(Acid)	231.0	Total cations(epm)	24.027
Magnesium(Acid)	68.0	Ion balance error(%)	2.
Calculated TDS	1419.4	TDS balance error(%)	-16.

MINOR CONSTITUENTS

Iron 5.6 ppm

OTHER MEASUREMENTS

Fluoride(F) 0.00 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781060	Date sampled	1 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	84.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	OSAT3
Altitude(ft)		Owners name	30 MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	888.4
TDS(mg/l)	1758.0	Alkalinity(as CaCO3)	544.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2000
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	234.0	11.68	45.0
Magnesium(Mg)	74.0	6.09	23.4
Sodium(Na)	184.0	8.00	30.8
Potassium(K)	7.9	0.20	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	681.0	11.16	42.5
Sulphate(SO4)	698.0	14.53	55.3
Chloride(Cl)	20.0	0.56	2.1
Nitrate(NO3)	0.8	0.01	0.0
Hydroxide(OH)			
Silica(SiO2)	14.5	Total anions(epm)	26.272
Calcium(Acid)	245.0	Total cations(epm)	25.973
Magnesium(Acid)	75.0	Ion balance error(%)	1.
Calculated TDS	1568.0	TDS balance error(%)	-11.

MINOR CONSTITUENTS

Iron 7.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.90 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781061	Date sampled	1 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	84.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSAT3
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	916.5
TDS(mg/l)	1826.0	Alkalinity(as CaCO3)	566.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1000
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	242.0	12.08	45.4
Magnesium(Mg)	76.0	6.26	23.5
Sodium(Na)	185.0	8.05	30.3
Potassium(K)	7.9	0.20	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	708.0	11.60	44.9
Sulphate(SO4)	679.0	14.14	54.7
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	14.5	Total anions(epm)	25.854
Calcium(Acid)	235.0	Total cations(epm)	26.580
Magnesium(Acid)	72.0	Ion balance error(%)	1.
Calculated TDS	1556.5	TDS balance error(%)	-15.

MINOR CONSTITUENTS

Iron 5.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.90 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781070	Date sampled	8 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	83.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSAT4
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	939.0
TDS(mg/l)	1046.0	Alkalinity(as CaCO3)	562.4
Field Cond(micromhos/cm)		Cond(micromhos/cme25C)	2070
Field pH		Lab pH	7.4

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	251.0	12.52	46.0
Magnesium(Mg)	76.0	6.26	23.0
Sodium(Na)	190.0	8.26	30.4
Potassium(K)	6.7	0.17	0.6
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	703.0	11.52	43.2
Sulphate(SO4)	723.0	15.05	56.4
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	0.3	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	15.1	Total anions(epm)	26.693
Calcium(Acid)	234.0	Total cations(epm)	27.216
Magnesium(Acid)	77.0	Ion balance error(%)	1.
Calculated TDS	1611.8	TDS balance error(%)	54.

MINOR CONSTITUENTS

Iron 10 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.00 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781071	Date sampled	8 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	83.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSAT4
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	899.1
TDS(mg/l)	1636.0	Alkalinity(as CaCO3)	520.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2020
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	235.0	11.73	44.5
Magnesium(Mg)	76.0	6.26	23.7
Sodium(Na)	189.0	8.22	31.2
Potassium(K)	6.7	0.17	0.6
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	651.0	10.67	43.0
Sulphate(SO4)	673.0	14.01	56.5
Chloride(Cl)	4.0	0.11	0.5
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	17.0	Total anions(epm)	24.797
Calcium(Acid)	239.0	Total cations(epm)	26.374
Magnesium(Acid)	73.0	Ion balance error(%)	3.
Calculated TDS	1520.9	TDS balance error(%)	-7.

MINOR CONSTITUENTS

Iron 6.9 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.60 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781091	Date sampled	15 12 78
Index no.	404522	Date submitted	04 01 79
Well depth(ft)	83.0	Date analysed(major)	10 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSAT 5
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	838.3
TDS(mg/l)	1628.0	Alkalinity(as CaCO3)	454.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1940
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	209.0	10.43	41.7
Magnesium(Mg)	77.0	6.34	25.4
Sodium(Na)	186.0	8.09	32.4
Potassium(K)	5.4	0.14	0.6
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	568.0	9.31	36.9
Sulphate(SO4)	758.0	15.78	62.5
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	2.8	0.05	0.2
Hydroxide(OH)			
Silica(SiO2)	13.4	Total anions(epm)	25.250
Calcium(Acid)	245.0	Total cations(epm)	24.995
Magnesium(Acid)	78.0	Ion balance error(%)	1.
Calculated TDS	1534.9	TDS balance error(%)	-6.

MINOR CONSTITUENTS

Iron 12 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.00 Fluoride(F) 0.20 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781092	Date sampled (D M Y)	15 12 78
Index no.	404522	Date submitted	04 01 79
Well depth(ft)	83.0	Date analysed(major)	10 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSAT 5
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	885.7
TDS(mg/l)	1646.0	Alkalinity(as CaCO3)	509.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1990
Field pH		Lab pH	7.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	228.0	11.38	43.9
Magnesium(Mg)	77.0	6.34	24.4
Sodium(Na)	186.0	8.09	31.2
Potassium(K)	5.4	0.14	0.5
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	637.0	10.44	40.2
Sulphate(SO4)	742.0	15.45	59.4
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	14.8		
Calcium(Acid)	225.0	Total anions(epm)	26.002
Magnesium(Acid)	68.0	Total cations(epm)	25.943
Calculated TDS	1570.4	Ion balance error(%)	0.
		TDS balance error(%)	-5.

MINOR CONSTITUENTS

Iron 7.1 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.60 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781022	Date sampled	D M Y 1 11 78
Index no.	D8	Date submitted	20 11 78
Well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	PILOT
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	636.1
TDS(mg/l)	1418.0	Alkalinity(as CaCO3)	189.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1700
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	123.0	6.14	29.3
Magnesium(Mg)	80.0	6.58	31.4
Sodium(Na)	184.0	8.00	38.2
Potassium(K)	8.3	0.21	1.0
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	237.0	3.88	19.7
Sulphate(SO4)	752.0	15.66	79.2
Chloride(Cl)	6.0	0.17	0.9
Nitrate(NO3)	3.5	0.06	0.3
Hydroxide(OH)			
Silica(SiO2)	6.5		
Calcium(Acid)	301.0	Total anions(epm)	19.767
Magnesium(Acid)	105.0	Total cations(epm)	20.938
Calculated TDS	1279.8	Ion balance error(%)	3.
		TDS balance error(%)	-10.

MINOR CONSTITUENTS

Iron 38 ppm

OTHER MEASUREMENTS

Fluoride(F) 0.00 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781028	Date sampled	D M Y 15 11 78
Index no.	DSWT 1	Date submitted	20 11 78
Well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	30 MIN
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	766.7
TDS(mg/l)	1560.0	Alkalinity(as CaCO3)	332.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1860
Field pH		Lab pH	7.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	177.0	8.83	38.3
Magnesium(Mg)	79.0	6.50	28.2
Sodium(Na)	174.0	7.57	32.8
Potassium(K)	6.7	0.17	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	415.0	6.80	32.6
Sulphate(SO4)	668.0	13.91	66.6
Chloride(Cl)	4.0	0.11	0.5
Nitrate(NO3)	4.5	0.07	0.3
Hydroxide(OH)			
Silica(SiO2)	9.9		
Calcium(Acid)	255.0	Total anions(epm)	20.896
Magnesium(Acid)	74.0	Total cations(epm)	23.074
Calculated TDS	1327.2	Ion balance error(%)	5.
		TDS balance error(%)	-15.

MINOR CONSTITUENTS

Iron 17.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 8.50 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781027	Date sampled	D M Y 15 11 78
Index no.	DSWT 1	Date submitted	20 11 78
Well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	500MIN
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	823.2
TDS(mg/l)	1604.0	Alkalinity(as CaCO3)	396.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1920
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	198.0	9.88	40.4
Magnesium(Mg)	80.0	6.58	26.9
Sodium(Na)	179.0	7.79	31.9
Potassium(K)	7.5	0.19	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	495.0	8.11	35.8
Sulphate(SO4)	692.0	14.41	63.5
Chloride(Cl)	4.0	0.11	0.5
Nitrate(NO3)	2.8	0.05	0.2
Hydroxide(OH)			
Silica(SiO2)	9.9		
Calcium(Acid)	227.0	Total anions(epm)	22.679
Magnesium(Acid)	74.0	Total cations(epm)	24.442
Calculated TDS	1416.6	Ion balance error(%)	4.
		TDS balance error(%)	-12.

MINOR CONSTITUENTS

Iron 8.1 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781032	Date sampled	22 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	DSWT2
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	901.6
TDS(mg/l)	1800.0	Alkalinity(as CaCO3)	566.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2110
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	236.0	11.78	45.4
Magnesium(Mg)	76.0	6.26	24.1
Sodium(Na)	178.0	7.74	29.8
Potassium(K)	7.5	0.19	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	708.0	11.60	47.3
Sulphate(SO4)	613.0	12.76	52.0
Chloride(Cl)	6.0	0.17	0.7
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.2		
Calcium(Acid)	227.0	Total anions(epm)	24.537
Magnesium(Acid)	72.0	Total cations(epm)	25.966
Calculated TDS	1474.8	Ion balance error(%)	3.
		TDS balance error(%)	-18.

MINOR CONSTITUENTS

Iron 11.4 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.00 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781033	Date sampled	D M Y 22 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	83.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	DSWT2
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	880.0
TDS(mg/l)	1792.0	Alkalinity(as CaCO3)	550.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2080
Field pH		Lab pH	7.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	229.0	11.43	44.7
Magnesium(Mg)	75.0	6.17	24.1
Sodium(Na)	179.0	7.79	30.4
Potassium(K)	7.5	0.19	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	688.0	11.28	43.4
Sulphate(SO4)	699.0	14.55	56.0
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	3.0	0.05	0.2
Hydroxide(OH)			
Silica(SiO2)	10.4		
Calcium(Acid)	235.0	Total anions(epm)	25.991
Magnesium(Acid)	74.0	Total cations(epm)	25.578
Calculated TDS	1545.2	Ion balance error(%)	1.
		TDS balance error(%)	-14.

MINOR CONSTITUENTS

Iron 7.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.70 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781051	Date sampled	29 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	83.0	Date analysed(major)	5 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWT3
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	801.6
TDS(mg/l)	1682.0	Alkalinity(as CaCO3)	394.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1800
Field pH		Lab pH	7.9

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	191.0	9.53	39.4
Magnesium(Mg)	79.0	6.50	26.8
Sodium(Na)	184.0	8.00	33.0
Potassium(K)	7.1	0.18	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	493.0	8.08	33.2
Sulphate(SO4)	778.0	16.20	66.5
Chloride(Cl)	2.0	0.06	0.2
Nitrate(NO3)	0.3	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	13.2		
Calcium(Acid)	231.0	Total anions(epm)	24.340
Magnesium(Acid)	69.0	Total cations(epm)	24.218
Calculated TDS	1497.0	Ion balance error(%)	0.
		TDS balance error(%)	-11.

MINOR CONSTITUENTS

Iron 10.2 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.80 Fluoride(F) 0.00 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781052	Date sampled	D M Y 29 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	83.0	Date analysed(major)	5 1 79
Water level(ft)	28.5	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	R VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWTJ
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	745.9
TDS(mg/l)	1598.0	Alkalinity(as CaCO3)	340.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1750
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	167.0	8.33	36.0
Magnesium(Mg)	80.0	6.58	28.4
Sodium(Na)	185.0	8.05	34.8
Potassium(K)	7.1	0.18	0.8
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	425.0	6.97	29.9
Sulphate(SO4)	778.0	16.20	69.6
Chloride(Cl)	2.0	0.06	0.2
Nitrate(NO3)	2.6	0.04	0.2
Hydroxide(OH)			
Silica(SiO2)	14.2		
Calcium(Acid)	228.0	Total anions(epm)	23.263
Magnesium(Acid)	68.0	Total cations(epm)	23.146
Calculated TDS	1444.9	Ion balance error(%)	0.
		TDS balance error(%)	-10.

MINOR CONSTITUENTS

Iron 6.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.38 Fluoride(F) 0.00 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781066	Date sampled	D M Y 6 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	84.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWT4
Altitude(ft)		Owners name	30 MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	875.3
TDS(mg/l)	1720.0	Alkalinity(as CaCO3)	544.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2070
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	237.0	11.83	45.7
Magnesium(Mg)	69.0	5.68	22.0
Sodium(Na)	188.0	8.18	31.6
Potassium(K)	6.7	0.17	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	681.0	11.16	41.5
Sulphate(SO4)	748.0	15.57	57.9
Chloride(Cl)	6.0	0.17	0.6
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	17.4		
Calcium(Acid)	216.0	Total anions(epm)	26.907
Magnesium(Acid)	72.0	Total cations(epm)	25.854
Calculated TDS	1607.0	Ion balance error(%)	2.
		TDS balance error(%)	-7.

MINOR CONSTITUENTS

Iron 11 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781067	Date sampled	D M Y 6 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	84.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWT4
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	798.7
TDS(mg/l)	1602.0	Alkalinity(as CaCO3)	468.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1970
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	203.0	10.13	41.7
Magnesium(Mg)	71.0	5.84	24.0
Sodium(Na)	188.0	8.18	33.6
Potassium(K)	6.3	0.16	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	586.0	9.60	36.9
Sulphate(SO4)	778.0	16.20	62.2
Chloride(Cl)	8.0	0.23	0.9
Nitrate(NO3)	0.3	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	13.9		
Calcium(Acid)	244.0	Total anions(epm)	26.034
Magnesium(Acid)	70.0	Total cations(epm)	24.312
Calculated TDS	1656.6	Ion balance error(%)	3.
		TDS balance error(%)	-3.

MINOR CONSTITUENTS

Iron 6.4 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.40 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781077	Date sampled	13 12 78
Index no.	404522	Date submitted	15 12 78
Well depth(ft)	83.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWT5
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	883.4
TDS(mg/l)	1598.0	Alkalinity(as CaCO3)	513.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1980
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	232.0	11.58	44.5
Magnesium(Mg)	74.0	6.09	23.4
Sodium(Na)	188.0	8.18	31.4
Potassium(K)	6.7	0.17	0.7
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	642.0	10.52	40.8
Sulphate(SO4)	728.0	15.16	58.8
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	14.0		
Calcium(Acid)	228.0	Total anions(epm)	25.796
Magnesium(Acid)	76.0	Total cations(epm)	26.016
Calculated TDS	1562.6	Ion balance error(%)	0.
		TDS balance error(%)	-2.

MINOR CONSTITUENTS

Iron 11.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.78 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781078	Date sampled	13 12 78
Index no.	404522	Date submitted	15 12 78
Well depth(ft)	83.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	72.0	Sampled by	VOGWILL
Bottom open interval(ft)	82.0	Sample Source	DSWT5
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	952.2
TDS(mg/l)	1726.0	Alkalinity(as CaCO3)	569.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2080
Field pH		Lab pH	7.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	253.0	12.62	46.1
Magnesium(Mg)	78.0	6.42	23.5
Sodium(Na)	188.0	8.18	29.9
Potassium(K)	5.8	0.15	0.5
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	712.0	11.67	42.8
Sulphate(SO4)	743.0	15.47	56.8
Chloride(Cl)	4.0	0.11	0.4
Nitrate(NO3)	0.3	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	14.0		
Calcium(Acid)	236.0	Total anions(epm)	27.257
Magnesium(Acid)	75.0	Total cations(epm)	27.370
Calculated TDS	1636.2	Ion balance error(%)	0.
		TDS balance error(%)	-5.

MINOR CONSTITUENTS

Iron 8.3 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.40 Fluoride(F) 0.10 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781030	Date sampled	14 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	BSCWT1
Altitude(ft)		Owners name	35MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	134.9
TDS(mg/l)	1456.0	Alkalinity(as CaCO3)	587.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2040
Field pH		Lab pH	8.1

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	30.0	1.50	6.5
Magnesium(Mg)	14.6	1.20	5.2
Sodium(Na)	470.0	20.44	88.1
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	734.0	12.03	55.5
Sulphate(SO4)	448.0	9.33	43.0
Chloride(Cl)	10.0	0.28	1.3
Nitrate(NO3)	1.8	0.03	0.1
Hydroxide(OH)			
Silica(SiO2)	6.4		
Calcium(Acid)	50.0	Total anions(epm)	21.669
Magnesium(Acid)	15.3	Total cations(epm)	23.206
Calculated TDS	1344.2	Ion balance error(%)	3.
		TDS balance error(%)	-8.

MINOR CONSTITUENTS

Iron 9.1 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781031	Date sampled	14 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	BSCWT1
Altitude(ft)		Owners name	450MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	289.1
TDS(mg/l)	1394.0	Alkalinity(as CaCO3)	611.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1870
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	73.0	3.64	16.8
Magnesium(Mg)	26.0	2.14	9.8
Sodium(Na)	365.0	15.88	73.1
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	764.0	12.52	59.7
Sulphate(SO4)	391.0	8.14	38.8
Chloride(Cl)	10.0	0.28	1.3
Nitrate(NO3)	2.0	0.03	0.2
Hydroxide(OH)			
Silica(SiO2)	7.8		
Calcium(Acid)	71.0	Total anions(epm)	20.978
Magnesium(Acid)	25.0	Total cations(epm)	21.733
Calculated TDS	1253.4	Ion balance error(%)	2.
		TDS balance error(%)	-10.

MINOR CONSTITUENTS

Iron 3.1 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781037	Date sampled	D M Y 21 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
r) Water level(ft)	30.0	Date analysed mino	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	BSCWT2
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	203.4
TDS(mg/l)	1474.0	Alkalinity(as CaCO3)	616.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2080
Field pH		Lab pH	7.0

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	53.0	2.64	10.7
Magnesium(Mg)	17.3	1.42	5.7
Sodium(Na)	475.0	20.66	83.3
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	771.0	12.64	53.6
Sulphate(SO4)	520.0	10.83	45.9
Chloride(Cl)	4.0	0.11	0.5
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.3		
Calcium(Acid)	57.0	Total anions(epm)	23.577
Magnesium(Acid)	17.9	Total cations(epm)	24.804
Calculated TDS	1461.6	Ion balance error(%)	3.
		TDS balance error(%)	-1.

MINOR CONSTITUENTS

Iron 0.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.25 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781038	Date sampled	21 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	4 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)		Sampled by	VOGWILL
Bottom open interval(ft)		Sample Source	BSCWT2
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	317.3
TDS(mg/l)	1348.0	Alkalinity(as CaCO3)	599.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1880
Field pH		Lab pH	7.2

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	81.0	4.04	18.1
Magnesium(Mg)	28.0	2.30	10.3
Sodium(Na)	365.0	15.88	71.2
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	[illegible]	[illegible]	0.0
Bicarbonate(HCO3)	749.0	12.28	57.2
Sulphate(SO4)	428.0	8.91	41.5
Chloride(Cl)	8.0	0.23	1.1
Nitrate(NO3)	2.5	0.04	0.2
Hydroxide(OH)			
Silica(SiO2)	9.7	Total anions(epm)	21.454
Calcium(Acid)	79.0	Total cations(epm)	22.297
Magnesium(Acid)	27.0	Ion balance error(%)	2.
Calculated TDS	1293.4	TDS balance error(%)	-4.

MINOR CONSTITUENTS

Iron 2.2 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.50 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781049	Date sampled	D M Y 28 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	4 1 79
Water level(ft)	31.6	Date analysed(minor)	
Top open interval(ft)	97.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BSCWT3
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	251.5
TDS(mg/l)	1586.0	Alkalinity(as CaCO3)	572.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2120
Field pH		Lab pH	7.2

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	66.0	3.29	13.3
Magnesium(Mg)	21.1	1.74	7.0
Sodium(Na)	453.0	19.70	79.5
Potassium(K)	1.7	0.04	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	715.0	11.72	51.8
Sulphate(SO4)	512.0	10.66	47.2
Chloride(Cl)	8.0	0.23	1.0
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.5		
Calcium(Acid)	63.0	Total anions(epm)	22.605
Magnesium(Acid)	21.1	Total cations(epm)	24.778
Calculated TDS	1421.9	Ion balance error(%)	5.
		TDS balance error(%)	-10.

MINOR CONSTITUENTS

Iron 8.8 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.60 Fluoride(F) 0.40 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781050	Date sampled	D M Y 28 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	4 1 79
Water level(ft)	31.6	Date analysed(minor)	
Top open interval(ft)	97.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	RSCWT3
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	229.3
TDS(mg/l)	1308.0	Alkalinity(as CaCO3)	528.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1820
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	49.0	2.45	11.8
Magnesium(Mg)	26.0	2.14	10.3
Sodium(Na)	371.0	16.14	77.7
Potassium(K)	2.1	0.05	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	661.0	10.83	50.4
Sulphate(SO4)	502.0	10.45	48.6
Chloride(Cl)	8.0	0.23	1.0
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.6		
Calcium(Acid)	78.0	Total anions(epm)	21.513
Magnesium(Acid)	25.0	Total cations(epm)	20.776
Calculated TDS	1291.8	Ion balance error(%)	2.
		TDS balance error(%)	-1.

MINOR CONSTITUENTS

Iron 3.4 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.40 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781064	Date sampled	D M Y 5 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BSCWT4
Altitude(ft)		Owners name	30 MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	218.0
TDS(mg/l)	1704.0	Alkalinity(as CaCO3)	584.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2060
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	61.0	3.04	12.1
Magnesium(Mg)	16.0	1.32	5.2
Sodium(Na)	476.0	20.70	82.2
Potassium(K)	4.2	0.11	0.4
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	730.0	11.97	49.9
Sulphate(SO4)	564.0	11.74	48.9
Chloride(Cl)	10.0	0.28	1.2
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.5	Total anions(epm)	23.992
Calcium(Acid)	61.0	Total cations(epm)	25.173
Magnesium(Acid)	16.0	Ion balance error(%)	2.
Calculated TDS	1499.7	TDS balance error(%)	-12.

MINOR CONSTITUENTS

Iron 7.3 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.20 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781065		D M Y
Index no.	404522	Date sampled	5 12 78
Well depth(ft)	240.0	Date submitted	8 12 78
Water level(ft)	30.0	Date analysed(major)	5 1 79
Top open interval(ft)	30.0	Date analysed(minor)	
Bottom open interval(ft)	240.0	Sampled by	VOGWILL
Altitude(ft)		Sample Source	BSCWT4
Bedrock elevation(ft)		Owners name	END
TDS(mg/l)	1282.0	Hardness(as CaCO3)	175.2
Field Cond(micromhos/cm)		Alkalinity(as CaCO3)	482.3
Field pH		Cond(micromhos/cm@25C)	1710
		Lab pH	8.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	29.0	1.45	7.2
Magnesium(Mg)	25.0	2.06	10.2
Sodium(Na)	381.0	16.57	82.2
Potassium(K)	3.3	0.08	0.4
Carbonate(CO3)	14.4	0.48	2.5
Bicarbonate(HCO3)	573.0	9.39	48.1
Sulphate(SO4)	450.0	9.37	48.0
Chloride(Cl)	10.0	0.28	1.4
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.0		
Calcium(Acid)	79.0	Total anions(epm)	19.523
Magnesium(Acid)	25.0	Total cations(epm)	20.162
Calculated TDS	1203.4	Ion balance error(%)	2.
		TDS balance error(%)	-6.

MINOR CONSTITUENTS

Iron 2.3 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.20 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781074	Date sampled	12 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGHILL
Bottom open interval(ft)	240.0	Sample Source	BSCWT5
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	228.0
TDS(mg/l)	1474.0	Alkalinity(as CaCO3)	628.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2090
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	m	meq/l	% of total anion or cation
Calcium(Ca)	65	3.24	13.0
Magnesium(Mg)	16	1.32	5.3
Sodium(Na)	465.0	20.23	81.4
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	786.0	12.88	51.5
Sulphate(SO4)	563.0	11.72	46.9
Chloride(Cl)	14.0	0.39	1.6
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.4	Total anions(epm)	25.001
Calcium(Acid)	66.0	Total cations(epm)	24.861
Magnesium(Acid)	21.0	Ion balance error(%)	0.
Calculated TDS	1522.9	TDS balance error(%)	3.

MINOR CONSTITUENTS

Iron 8.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.20 Fluoride(F) 0.40 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781076	Date sampled	12 12 78
Index no.	404522	Date submitted	15 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BSCWT5
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	313.2
TDS(mg/l)	1262.0	Alkalinity(as CaCO3)	624.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1920
Field pH		Lab pH	7.5

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	81.0	4.04	17.4
Magnesium(Mg)	27.0	2.22	9.5
Sodium(Na)	390.0	16.96	72.8
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	781.0	12.80	57.7
Sulphate(SO4)	437.0	9.10	41.0
Chloride(Cl)	10.0	0.28	1.3
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.5		
Calcium(Acid)	79.0	Total anions(epm)	22.183
Magnesium(Acid)	26.0	Total cations(epm)	23.292
Calculated TDS	1342.1	Ion balance error(%)	2.
		TDS balance error(%)	6.

MINOR CONSTITUENTS

Iron 3.1 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.50 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781023	Date sampled	D M Y 31 10 78
Index no.	BOH	Date submitted	20 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	PILOT
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	22.2
TDS(mg/l)	1214.0	Alkalinity(as CaCO3)	490.3
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1720
Field pH		Lab pH	8.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	6.1	0.30	1.6
Magnesium(Mg)	1.7	0.14	0.7
Sodium(Na)	419.0	18.23	97.1
Potassium(K)	4.2	0.11	0.6
Carbonate(CO3)	19.2	0.64	3.6
Bicarbonate(HCO3)	573.0	9.39	53.2
Sulphate(SO4)	337.0	7.02	39.7
Chloride(Cl)	16.0	0.45	2.6
Nitrate(NO3)	10.1	0.16	0.9
Hydroxide(OH)			
Silica(SiO2)	2.4		
Calcium(Acid)	314.0	Total anions(epm)	17.662
Magnesium(Acid)	99.0	Total cations(epm)	18.777
Calculated TDS	1097.4	Ion balance error(%)	3.
		TDS balance error(%)	-10.

MINOR CONSTITUENTS

Iron 59 ppm

OTHER MEASUREMENTS

Fluoride(F) 0.80 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781021		D M Y
Index no.	BOH	Date sampled	1 11 78
Well depth(ft)	240.0	Date submitted	20 11 78
Water level(ft)	29.3	Date analysed(major)	3 1 79
Top open interval(ft)	90.0	Date analysed(minor)	
Bottom open interval(ft)	240.0	Sampled by	R VOGWILL
Altitude(ft)		Sample Source	90 MIN
Bedrock elevation(ft)		Owners name	NEWSTED
TDS(mg/l)	1256.0	Hardness(as CaCO3)	186.8
Field Cond(micromhos/cm)		Alkalinity(as CaCO3)	458.4
Field pH		Cond(micromhos/cm@25C)	1800
		Lab pH	8.1

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	32.0	1.60	7.7
Magnesium(Mg)	26.0	2.14	10.3
Sodium(Na)	388.0	16.88	81.5
Potassium(K)	3.8	0.10	0.5
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	573.0	9.39	50.0
Sulphate(SO4)	438.0	9.12	48.5
Chloride(Cl)	8.0	0.23	1.2
Nitrate(NO3)	3.9	0.06	0.3
Hydroxide(OH)			
Silica(SiO2)	5.9		
Calcium(Acid)	83.0	Total anions(epm)	18.800
Magnesium(Acid)	30.0	Total cations(epm)	20.711
Calculated TDS	1187.3	Ion balance error(%)	5.
		TDS balance error(%)	-5.

MINOR CONSTITUENTS

Iron 9.3 ppm

OTHER MEASUREMENTS

Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781024	Date sampled	16 11 78
Index no.	BOHWT1	Date submitted	20 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	30 MIN
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	80.9
TDS(mg/l)	1512.0	Alkalinity(as CaCO3)	636.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2150
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	24.0	1.20	4.9
Magnesium(Mg)	5.1	0.42	1.7
Sodium(Na)	520.0	22.62	93.1
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	795.0	13.03	54.7
Sulphate(SO4)	500.0	10.41	43.7
Chloride(Cl)	14.0	0.39	1.7
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	6.7	Total anions(epm)	23.836
Calcium(Acid)	25.0	Total cations(epm)	24.300
Magnesium(Acid)	6.0	Ion balance error(%)	1.
Calculated TDS	1463.2	TDS balance error(%)	-3.

MINOR CONSTITUENTS

Iron 2.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.30 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781025	Date sampled	D M Y 16 11 78
Index no.	BOHWT1	Date submitted	20 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	END
Altitude(ft)		Owners name	NEWSTED
Bedrock elevation(ft)		Hardness(as CaCO3)	203.7
TDS(mg/l)	1302.0	Alkalinity(as CaCO3)	607.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1800
Field pH		Lab pH	7.9

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	49.0	2.45	11.8
Magnesium(Mg)	19.8	1.63	7.9
Sodium(Na)	379.0	16.49	79.9
Potassium(K)	2.9	0.07	0.4
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	759.0	12.44	64.3
Sulphate(SO4)	311.0	6.48	33.5
Chloride(Cl)	14.0	0.39	2.0
Nitrate(NO3)	2.4	0.04	0.2
Hydroxide(OH)			
Silica(SiO2)	5.8	Total anions(epm)	19.349
Calcium(Acid)	58.0	Total cations(epm)	20.634
Magnesium(Acid)	21.6	Ion balance error(%)	3.
Calculated TDS	1157.1	TDS balance error(%)	-11.

MINOR CONSTITUENTS

Iron 6.8 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.50 Fluoride(F) 0.70 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781036	Date sampled	23 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	97.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT2
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	136.7
TDS(mg/l)	1234.0	Alkalinity(as CaCO3)	630.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1830
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	36.0	1.80	8.4
Magnesium(Mg)	11.4	0.94	4.4
Sodium(Na)	430.0	18.70	87.1
Potassium(K)	1.7	0.04	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	788.0	12.92	59.0
Sulphate(SO4)	383.0	7.97	36.4
Chloride(Cl)	36.0	1.02	4.6
Nitrate(NO3)	0.1	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.6	Total anions(epm)	21.907
Calcium(Acid)	38.0	Total cations(epm)	21.482
Magnesium(Acid)	12.3	Ion balance error(%)	1.
Calculated TDS	1295.3	TDS balance error(%)	5.

MINOR CONSTITUENTS

Iron 6.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.00 Fluoride(F) 0.80 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781058	Date sampled	D M Y 23 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT2
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	144.7
TDS(mg/l)	1242.0	Alkalinity(as CaCO3)	507.9
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1630
Field pH		Lab pH	8.4

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	25.0	1.25	6.4
Magnesium(Mg)	20.0	1.65	8.4
Sodium(Na)	381.0	16.57	84.8
Potassium(K)	3.3	0.08	0.4
Carbonate(CO3)	12.0	0.40	2.2
Bicarbonate(HCO3)	610.0	10.00	53.9
Sulphate(SO4)	383.0	7.97	43.0
Chloride(Cl)	6.0	0.17	0.9
Nitrate(NO3)	1.4	0.02	0.1
Hydroxide(OH)			
Silica(SiO2)	9.1	Total anions(epm)	18.564
Calcium(Acid)	63.0	Total cations(epm)	19.550
Magnesium(Acid)	19.0	Ion balance error(%)	3.
Calculated TDS	1140.7	TDS balance error(%)	-8.

MINOR CONSTITUENTS

Iron 2.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.00 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781053	Date sampled	D M Y 30 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	92.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT3
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	187.3
TDS(mg/l)	1422.0	Alkalinity(as CaCO3)	615.2
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1810
Field pH		Lab pH	8.1

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	49.0	2.45	10.7
Magnesium(Mg)	15.8	1.30	5.7
Sodium(Na)	436.0	18.96	83.2
Potassium(K)	3.8	0.10	0.4
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	769.0	12.60	58.7
Sulphate(SO4)	398.0	8.29	38.6
Chloride(Cl)	20.0	0.56	2.6
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.3	Total anions(epm)	21.455
Calcium(Acid)	77.0	Total cations(epm)	22.808
Magnesium(Acid)	15.0	Ion balance error(%)	3.
Calculated TDS	1310.0	TDS balance error(%)	-8.

MINOR CONSTITUENTS

Iron 6.5 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.30 Fluoride(F) 0.70 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781059	Date sampled	30 11 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT3
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	256.1
TDS(mg/l)	1262.0	Alkalinity(as CaCO3)	630.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1760
Field pH		Lab pH	8.1

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	68.0	3.39	15.6
Magnesium(Mg)	21.0	1.73	7.9
Sodium(Na)	381.0	16.57	76.1
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	788.0	12.92	63.6
Sulphate(SO4)	334.0	6.95	34.2
Chloride(Cl)	16.0	0.45	2.2
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.9		
Calcium(Acid)	65.0	Total anions(epm)	20.321
Magnesium(Acid)	20.0	Total cations(epm)	21.768
Calculated TDS	1219.3	Ion balance error(%)	3.
		TDS balance error(%)	-3.

MINOR CONSTITUENTS

Iron 1.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.90 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781068	Date sampled	D M Y 7 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT4
Altitude(ft)		Owners name	30 MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	170.3
TDS(mg/l)	1338.0	Alkalinity(as CaCO3)	601.6
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1840
Field pH		Lab pH	7.4

MAJOR CONSTITUENTS

	mg/l	meq/	% of total anion or cation
Calcium(Ca)	45.0	2.25	10.0
Magnesium(Mg)	14.1	1.16	5.1
Sodium(Na)	439.0	19.10	84.7
Potassium(K)	1.7	0.04	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	752.0	12.33	59.4
Sulphate(SO4)	375.0	7.81	37.6
Chloride(Cl)	22.0	0.62	3.0
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.0	Total anions(epm)	20.757
Calcium(Acid)	45.0	Total cations(epm)	22.545
Magnesium(Acid)	14.0	Ion balance error(%)	4.
Calculated TDS	1276.8	TDS balance error(%)	-5.

MINOR CONSTITUENTS

Iron 3.4 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.50 Fluoride(F) 0.70 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781069	Date sampled	D M Y 7 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT4
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	277.7
TDS(mg/l)	1258.0	Alkalinity(as CaCO3)	628.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1790
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	75.0	3.74	16.7
Magnesium(Mg)	22.0	1.81	8.1
Sodium(Na)	385.0	16.75	74.8
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	786.0	12.88	62.8
Sulphate(SO4)	348.0	7.25	35.3
Chloride(Cl)	14.0	0.39	1.9
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.8	Total anions(epm)	20.527
Calcium(Acid)	67.0	Total cations(epm)	22.374
Magnesium(Acid)	22.0	Ion balance error(%)	4.
Calculated TDS	1243.4	TDS balance error(%)	-1.

MINOR CONSTITUENTS

Iron 2.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.90 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781079	Date sampled	D M Y 14 12 78
Index no.	404522	Date submitted	15 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT5
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	193.1
TDS(mg/l)	1260.0	Alkalinity(as CaCO3)	634.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1880
Field pH		Lab pH	7.6

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	51.0	2.54	11.3
Magnesium(Mg)	16.0	1.32	5.8
Sodium(Na)	429.0	18.66	82.7
Potassium(K)	1.7	0.04	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	793.0	13.00	60.9
Sulphate(SO4)	368.0	7.66	35.9
Chloride(Cl)	24.0	0.68	3.2
Nitrate(NO3)	0.3	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.1		
Calcium(Acid)	50.0	Total anions(epm)	21.341
Magnesium(Acid)	17.3	Total cations(epm)	22.566
Calculated TDS	1290.0	Ion balance error(%)	3.
		TDS balance error(%)	2.

MINOR CONSTITUENTS

Iron 4.7 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.30 Fluoride(F) 0.70 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781088	Date sampled	D M Y 14 12 78
Index no.	404522	Date submitted	04 01 79
Well depth(ft)	240.0	Date analysed(major)	10 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	92.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHWT5
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	269.0
TDS(mg/l)	1206.0	Alkalinity(as CaCO3)	628.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1770
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	60.0	2.99	13.7
Magnesium(Mg)	29.0	2.39	10.9
Sodium(Na)	379.0	16.49	75.2
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	786.0	12.88	61.9
Sulphate(SO4)	362.0	7.54	36.2
Chloride(Cl)	14.0	0.39	1.9
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.1		
Calcium(Acid)	66.0	Total anions(epm)	20.815
Magnesium(Acid)	25.0	Total cations(epm)	21.930
Calculated TDS	1242.1	Ion balance error(%)	3.
		TDS balance error(%)	3.

MINOR CONSTITUENTS

Iron 2.2 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.18 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781035	Date sampled	20 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	97.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT1
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	157.9
TDS(mg/l)	1414.0	Alkalinity(as CaCO3)	634.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1980
Field pH		Lab pH	7.9

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	42.0	2.10	9.3
Magnesium(Mg)	12.9	1.06	4.7
Sodium(Na)	443.0	19.27	85.7
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	793.0	13.00	59.1
Sulphate(SO4)	408.0	8.49	38.6
Chloride(Cl)	18.0	0.51	2.3
Nitrate(NO3)	0.5	0.01	0.0
Hydroxide(OH)			
Silica(SiO2)	6.8	Total anions(epm)	22.008
Calcium(Acid)	40.0	Total cations(epm)	22.491
Magnesium(Acid)	12.4	Ion balance error(%)	1.
Calculated TDS	1323.6	TDS balance error(%)	-6.

MINOR CONSTITUENTS

Iron 3.2 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.10 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781034	Date sampled	20 11 78
Index no.	404522	Date submitted	27 11 78
Well depth(ft)	240.0	Date analysed(major)	3 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	97.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHATI
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	226.6
TDS(mg/l)	1256.0	Alkalinity(as CaCO3)	626.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1820
Field pH		Lab pH	7.9

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	56.0	2.79	13.4
Magnesium(Mg)	21.1	1.74	8.3
Sodium(Na)	373.0	16.22	77.9
Potassium(K)	2.9	0.07	0.4
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	783.0	12.83	64.0
Sulphate(SO4)	322.0	6.70	33.4
Chloride(Cl)	18.0	0.51	2.5
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.1		
Calcium(Acid)	55.0	Total anions(epm)	20.046
Magnesium(Acid)	20.4	Total cations(epm)	20.830
Calculated TDS	1186.1	Ion balance error(%)	2.
		TDS balance error(%)	-6.

MINOR CONSTITUENTS

Iron .6 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.58 Fluoride(F) 0.70 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781056	Date sampled	27 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT2
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	228.7
TDS(mg/l)	1472.0	Alkalinity(as CaCO3)	638.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1960
Field pH		Lab pH	8.1

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	60.0	2.99	12.3
Magnesium(Mg)	19.2	1.58	6.5
Sodium(Na)	454.0	19.75	80.9
Potassium(K)	2.9	0.07	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	798.0	13.08	56.4
Sulphate(SO4)	469.0	9.76	42.1
Chloride(Cl)	12.0	0.34	1.5
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.5		
Calcium(Acid)	57.0	Total anions(epm)	23.183
Magnesium(Acid)	12.0	Total cations(epm)	24.396
Calculated TDS	1418.0	Ion balance error(%)	3.
		TDS balance error(%)	-4.

MINOR CONSTITUENTS

Iron 4.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.70 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781057	Date sampled	27 11 78
Index no.	404522	Date submitted	01 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT2
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	161.3
TDS(mg/l)	1202.0	Alkalinity(as CaCO3)	558.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1640
Field pH		Lab pH	8.3

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	30.0	1.50	7.5
Magnesium(Mg)	21.0	1.73	8.6
Sodium(Na)	384.0	16.70	83.5
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	698.0	11.44	58.2
Sulphate(SO4)	379.0	7.89	40.1
Chloride(Cl)	12.0	0.34	1.7
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	9.6	Total anions(epm)	19.670
Calcium(Acid)	57.0	Total cations(epm)	19.992
Magnesium(Acid)	14.0	Ion balance error(%)	1.
Calculated TDS	1181.3	TDS balance error(%)	485.

MINOR CONSTITUENTS

OTHER MEASUREMENTS

Field Temp(C)	7.40	Fluoride(F)	0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781062	Date sampled	4 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT3
Altitude(ft)		Owners name	30 MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	139.4
TDS(mg/l)	1370.0	Alkalinity(as CaCO3)	566.3
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1880
Field pH		Lab pH	8.4

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	29.0	1.45	6.4
Magnesium(Mg)	16.3	1.34	5.9
Sodium(Na)	454.0	19.75	87.4
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	12.0	0.40	1.9
Bicarbonate(HCO3)	683.0	11.19	51.9
Sulphate(SO4)	463.0	9.64	44.7
Chloride(Cl)	12.0	0.34	1.6
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.8	Total anions(epm)	21.573
Calcium(Acid)	53.0	Total cations(epm)	22.600
Magnesium(Acid)	14.0	Ion balance error(%)	2.
Calculated TDS	1333.4	TDS balance error(%)	-3.

MINOR CONSTITUENTS

Iron 2.4 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.30 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781063	Date sampled	4 12 78
Index no.	404522	Date submitted	8 12 78
Well depth(ft)	240.0	Date analysed(major)	5 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT3
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	233.8
TDS(mg/l)	1270.0	Alkalinity(as CaCO3)	628.8
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1760
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	64.0	3.19	14.9
Magnesium(Mg)	18.0	1.48	6.9
Sodium(Na)	384.0	16.70	77.7
Potassium(K)	4.2	0.11	0.5
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	786.0	12.88	61.5
Sulphate(SO4)	360.0	7.50	35.8
Chloride(Cl)	20.0	0.56	2.7
Nitrate(NO3)	0.4	0.01	0.0
Hydroxide(OH)			
Silica(SiO2)	9.7	Total anions(epm)	20.949
Calcium(Acid)	61.0	Total cations(epm)	21.485
Magnesium(Acid)	17.0	Ion balance error(%)	1.
Calculated TDS	1246.8	TDS balance error(%)	-2.

MINOR CONSTITUENTS

Iron .6 ppm

OTHER MEASUREMENTS

Field Temp(C)	6.25	Fluoride(F)	0.60 ppm

DTS

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781072	Date sampled	11 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT4
Altitude(ft)		Owners name	30MINS
Bedrock elevation(ft)		Hardness(as CaCO3)	229.6
TDS(mg/l)	1378.0	Alkalinity(as CaCO3)	636.0
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	2030
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total ion or cation
Calcium(Ca)	64.0	3.19	13.2
Magnesium(Mg)	17.0	1.40	5.8
Sodium(Na)	449.0	19.53	80.7
Potassium(K)	2.5	0.06	0.3
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	795.0	13.03	56.4
Sulphate(SO4)	464.0	9.66	41.8
Chloride(Cl)	14.0	0.39	1.7
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.0	Total anions(epm)	23.089
Calcium(Acid)	60.0	Total cations(epm)	24.187
Magnesium(Acid)	16.0	Ion balance error(%)	2.
Calculated TDS	1411.6	TDS balance error(%)	2.

MINOR CONSTITUENTS

Iron 4 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.38 Fluoride(F) 0.40 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

			D M Y
Lab no.	781073	Date sampled	11 12 78
Index no.	404522	Date submitted	13 12 78
Well depth(ft)	240.0	Date analysed(major)	9 1 79
Water level(ft)	30.0	Date analysed(minor)	
Top open interval(ft)	90.0	Sampled by	VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT4
Altitude(ft)		Owners name	END
Bedrock elevation(ft)		Hardness(as CaCO3)	247.0
TDS(mg/l)	1212.0	Alkalinity(as CaCO3)	634.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1780
Field pH		Lab pH	7.7

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	66.0	3.29	15.0
Magnesium(Mg)	20.0	1.65	7.5
Sodium(Na)	390.0	16.96	77.3
Potassium(K)	2.1	0.05	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	793.0	13.00	63.9
Sulphate(SO4)	331.0	6.89	33.9
Chloride(Cl)	16.0	0.45	2.2
Nitrate(NO3)	0.2	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	10.0	Total anions(epm)	20.344
Calcium(Acid)	62.0	Total cations(epm)	21.957
Magnesium(Acid)	18.0	Ion balance error(%)	4.
Calculated TDS	1225.2	TDS balance error(%)	1.

MINOR CONSTITUENTS

Iron 8.6 ppm

OTHER MEASUREMENTS

Field Temp(C) 7.18 Fluoride(F) 0.60 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781089	Date sampled	D M Y 18 12 78
Index no.	404522	Date submitted	04 01 79
Well depth(ft)	240.0	Date analysed(major)	10 1 79
Water level(ft)	29.3	Date analysed(minor)	
Top open interval(ft)	92.0	Sampled by	R VOGWILL
Bottom open interval(ft)	240.0	Sample Source	BOHAT5
Altitude(ft)		Owners name	30 MIN
Bedrock elevation(ft)		Hardness(as CaCO3)	250.2
TDS(mg/l)	1258.0	Alkalinity(as CaCO3)	634.4
Field Cond(micromhos/cm)		Cond(micromhos/cm@25C)	1980
Field pH		Lab pH	7.8

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	64.0	3.19	13.1
Magnesium(Mg)	22.0	1.81	7.4
Sodium(Na)	443.0	19.27	79.2
Potassium(K)	2.1	0.05	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	793.0	13.00	55.4
Sulphate(SO4)	484.0	10.08	42.9
Chloride(Cl)	14.0	0.39	1.7
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.9		
Calcium(Acid)	62.0	Total anions(epm)	23.470
Magnesium(Acid)	21.0	Total cations(epm)	24.327
Calculated TDS	1427.9	Ion balance error(%)	2.
		TDS balance error(%)	14.

MINOR CONSTITUENTS

Iron 2.9 ppm

OTHER MEASUREMENTS

Field Temp(C) 5.00 Fluoride(F) 0.50 ppm

ALBERTA RESEARCH COUNCIL
WATER ANALYSIS REPORT

Mer 4 Tp 45 Rge 22 Sec 14 Lsd 11

Lab no.	781090		D M Y
Index no.	404522	Date sampled	18 12 78
Well depth(ft)	240.0	Date submitted	04 01 79
Water level(ft)	29.3	Date analysed(major)	10 1 79
Top open interval(ft)	92.0	Date analysed(minor)	
Bottom open interval(ft)	240.0	Sampled by	R VOGWILL
Altitude(ft)		Sample Source	BOHAT5
Bedrock elevation(ft)		Owners name	END
TDS(mg/l)	1258.0	Hardness(as CaCO3)	262.6
Field Cond(micromhos/cm)		Alkalinity(as CaCO3)	626.4
Field pH		Cond(micromhos/cm@25C)	1760
		Lab pH	8.0

MAJOR CONSTITUENTS

	mg/l	meq/l	% of total anion or cation
Calcium(Ca)	64.0	3.19	14.5
Magnesium(Mg)	25.0	2.06	9.4
Sodium(Na)	384.0	16.70	76.0
Potassium(K)	1.3	0.03	0.2
Carbonate(CO3)	0.0	0.00	0.0
Bicarbonate(HCO3)	783.0	12.83	64.2
Sulphate(SO4)	339.0	7.06	35.3
Chloride(Cl)	4.0	0.11	0.6
Nitrate(NO3)	0.0	0.00	0.0
Hydroxide(OH)			
Silica(SiO2)	8.9		
Calcium(Acid)	57.0	Total anions(epm)	20.005
Magnesium(Acid)	25.0	Total cations(epm)	21.987
Calculated TDS	1211.2	Ion balance error(%)	5.
		TDS balance error(%)	-4.

MINOR CONSTITUENTS

Iron 1 ppm

OTHER MEASUREMENTS

Field Temp(C) 6.18 Fluoride(F) 0.60 ppm