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MUNICIPAL WATER SUPPLY INVESTIGATION
GROUNDWATER SOURCE
MAPLE RIDGE AQUIFER COMPLEX

PREPARED FOR

THE ONTARIO MINISTRY OF THE ENVIRONMENT

AND

VILLAGE OF CHESTERVILLE

BY
WATER AND EARTH SCIENCE ASSOCIATES LIMITED

REVISED MARCH 1988

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1.0 INTRODUCTION

Water and Earth Science Associates Ltd.(WESA) was retained by Totten Sims Hubicki Associates Ltd. on behalf of the Ontario Ministry of the Environment (MOE) and the Village of Chesterville to conduct a review of groundwater supply alternatives for the Village of Chesterville.

Chesterville is located in the United Counties of Stormont, Dundas and Glengarry, in the Township of Winchester at the intersection of Highway 43 and the South Nation River.

Three previous studies (McLaren Engineering Ltd, 1981; WESA, 1982; WESA, 1986) have been undertaken to search for new groundwater supplies in the area. For economic reasons this initial work concentrated on finding a new supply in the immediate vicinity of the Village. This work was not successful. Consequently, the present study expands the target area to a 5 km radius of the Village. A brief summary of the previous work is outlined in Section 2.0 of this report.

2.0 BACKGROUND INFORMATION

Three previous groundwater studies have been completed in the Chesterville area. The initial study was undertaken by McLaren Engineering Ltd.(1981) and focused on the existing groundwater development and well field. The existing two-well system is completed in a river connected gravel aquifer located in a bedrock depression west of the village. Little reliable information was available on the construction of the wells, their efficiency, or the aquifer into which they were developed.

The drilling program conducted by WESA (1982) indicated that significant thicknesses of sand and gravel existed in the area of the well field, however the effect of the South Nation River on recharge or the limits of the sand and gravel deposit were poorly defined. The study also investigated the potential of bedrock aquifers in the immediate vicinity of the village core and determined that bedrock derived groundwater was observed to be of relatively poor quality and in most cases aquifers were not well defined or showed poor continuity. The study concluded that the bedrock aquifer is an unreliable source of groundwater at the scale proposed for municipal water supply expansion.

WESA (1986) reported the findings of a test drilling and aquifer testing program implemented to test the hydraulic continuity of the sand and gravel aquifer in the vicinity of Well #1 and the degree to which well interference would affect a proposed well field. This program was designed to assess the feasibility of further expanding production in the existing well field and aquifer. Recharge from the South Nation River was also to be evaluated. Results of this testing showed that the sand and gravel aquifer was already pumped at very nearly its maximum yield, and that the expansion of the existing system was not feasible. The report also pointed out that there were colour, odour and turbidity problems with groundwater in the existing aquifer.

The WESA (1986) study also indicated that a yield on the order of 15.15 l/sec (200 IGPM) is required for the existing commercial and residential population base. It was projected that additional supplies would be required for the continued industrial and residential development of the municipality. A freeze on development had been placed on the community.

Background information prepared by Totten Sims Hubicki Associates prior to this present investigation indicated that a production yield on the order of 22.73 l/sec (300 IGPM) would be appropriate to meet the long term supply requirements for Chesterville as well as provide for an adequate supply to accommodate development over the foreseeable future.

The successful development of municipal water supplies from glaciofluvial complexes in Eastern Ontario is well documented. Unconfined sand and gravel aquifers have large storage capacities and, in areas where the materials are permeable, are capable of yielding in excess of 500 IGPM to a single screened gravel packed well. Water quality in these complexes is usually excellent with the only treatment required being chlorination. A number of glaciofluvial complexes are shown on base mapping of the region (Richard, 1982). The municipality of Embrun is currently using one such deposit with great success. Investigations are currently underway in Vars and Crysler on similar deposits with both showing significant potential. Given the success of these other programs and the failure of other less expensive closer alternatives, it was deemed appropriate that the search for communal water supply sources for Chesterville be expanded to include outlying areas within a 5 km radius of the village including one part of the Maple Ridge glaciofluvial complex lying northwest of the village.

There is some development of bedrock supplies in eastern Ontario. Winchester and Manotick obtain groundwater from bedrock wells. The Winchester system however does have certain quality problems. These problems are treatable however, but require constant attention. The Manotick supply is obtained from a much more transmissive bedrock unit brought closer to surface by faulting.

3.0 METHOD OF STUDY

3.1 Terms of Reference

The Terms of Reference for this type of study has been established by the Ontario Ministry of the Environment Land Use and Planning Branch and the Water Resources Branch. This work program was designed to fulfill the following objectives:

- Define the stratigraphy, extent, and configuration of the aquifer(s) present.
- Provide detailed quantitative information regarding the aquifer parameters of transmissivity, storativity, basin yield, and the safe perennial yield.
- Provide projections of the long term water quality expected from a pumping system developed into the aquifer. These projections would be submitted with a detailed list of site specific natural and anthropogenic influences.
- Provide the design information for the construction of one or several production wells.

3.2 The Work Program

The study area has been limited to a 5 kilometre radius of the village of Chesterville. One hundred and forty one well records were compiled and plotted (Figure 1 and Appendix A). Working plots of bedrock topography and overburden thickness were produced. Recently published surficial geology maps (Richard, 1982) were examined and well record stratigraphy was studied to identify all areas where thick granular deposits, whether confined or unconfined, are present. This investigation also included the location and characteristics of any high producing (greater than 3.78 l/sec (50 IGPM)) bedrock wells that were located in the study area. Work included preliminary field visits to high yielding wells. Exposures in gravel pits, roadside ditches and fields were also examined during our appraisal of the surficial geology.

Drilling in the identified target areas was phased. The descriptions of the two phases follows.

Phase I - Hollowstem Drilling

The background information was used to site locations for the hollowstem drilling program. These sites are shown on Figure 1. In total, 20 holes were drilled in an effort to determine the lateral distribution and vertical thickness of the buried sand and gravel aquifer(s). In all but two of the boreholes piezometers were installed and used to monitor water

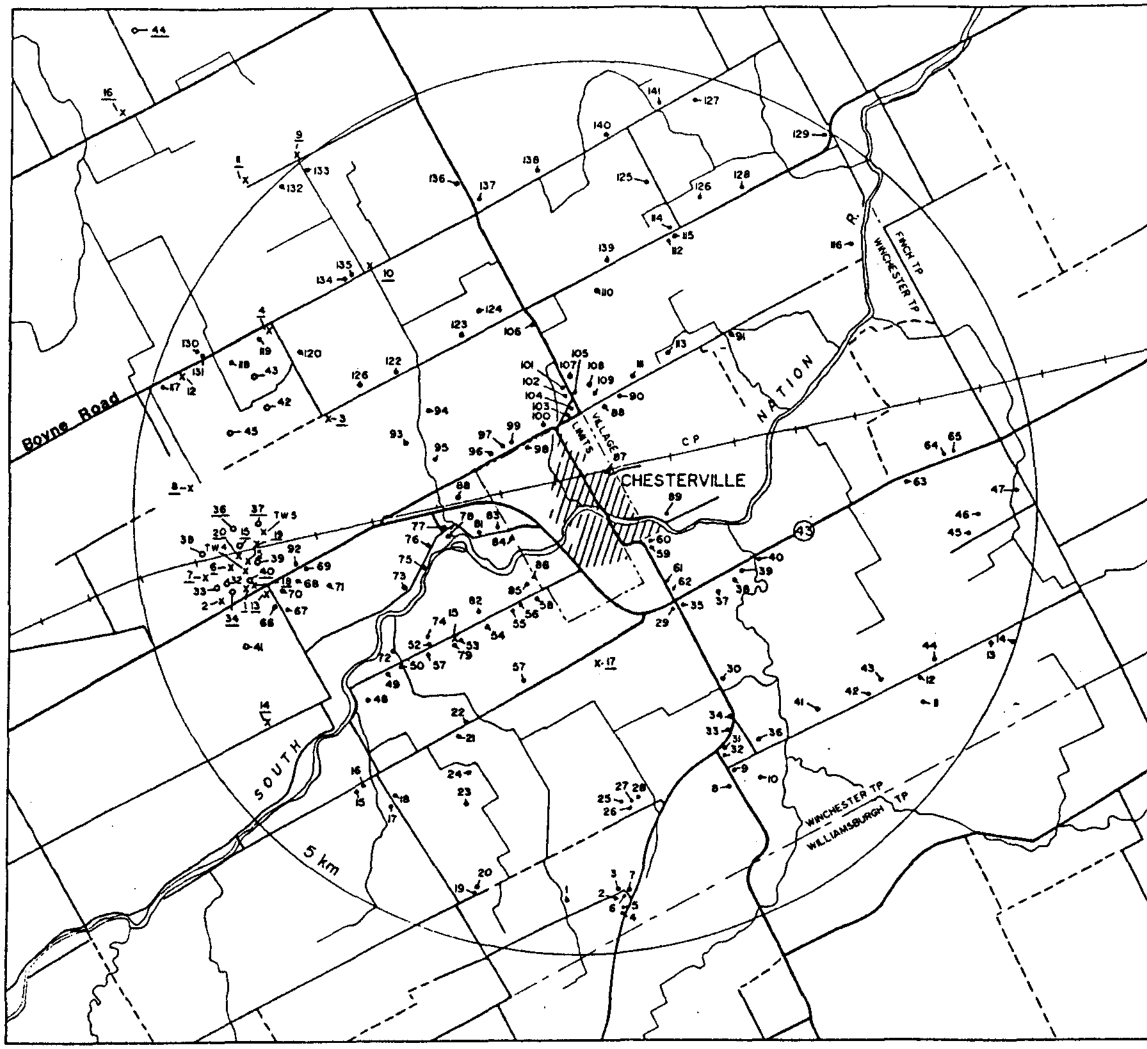

FIGURE 1

DRILLHOLE LOCATION MAP

CHESTERVILLE, ONTARIO
WINCHESTER TOWNSHIP

LEGEND

- •90 WATER WELL LOCATION AND NUMBER
- x WESA
- 1 HOLE NUMBER AND PIEZOMETER INSTALLED
- 12 HOLE NUMBER WITH NO PIEZOMETER INSTALLED
- o MNR
- TW 4 TEST WELL NUMBER

0 0.5 1 2 km

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levels and to obtain water samples. (Geological conditions were not favourable in those two holes). Detailed well logs are included in Appendix A.

Further hollowstem drilling was carried out by the Ministry of Natural Resources (MNR) as part of their study of buried aggregate of Eastern Ontario. Although the focus of the MNR drilling was different than this study, the geological information obtained assisted in determining shallow sand and gravel thicknesses and continuity. Well logs from the MNR study (Gorrell, in prep.) are included in Appendix B.

The above drilling programs, MOE well records, air photo interpretation, and all pertinent background information were used to site locations for Phase II test well drilling.

Phase IIa - Test Well Drilling

Three site locations were chosen for Phase II drilling. Sites 1 and 2 located north and south of one another are separated by the Canadian Pacific Rail right-of-way and are part of the Maple Ridge glaciofluvial complex. Both exhibited the three hydrogeological conditions necessary to meet the supply demands of Chesterville:

- There is sufficient sand and gravel deposit to afford storage and transmission to a well.
- Water can be extracted by conventional well design.
- There is a large recharge area to keep the well in operation.

Site 1 was the preferred site since it is located south of the railway tracks and closer to Highway 43. Site 3 is located on the Boyne Road north of Chesterville but was considered a secondary site for reasons of supply accessibility.

A 20 cm (8") test well (TW4) was drilled at Site 1 to a depth of 15.2 m (50 ft.). Four metres (13 ft.) of saturated gravel found at the bottom of the well allowed for the installation of 3 m (10 ft.) 50 slot screen. However, a step-drawdown test performed on the well indicated a maximum yield of 6.06 to 7.5 l/sec (80 to 100 IGPM). Since this yield did not meet the required yield, a second test well (TW5) was drilled at Site 2.

At TW5 4.3 m (14 ft.) of saturated sand and gravel material was intersected. The gravel was much coarser at TW5 than at TW4, thus enabling more than 6.06 l/sec (80 IGPM) to be bailed from the then undeveloped, unscreened borehole. The well design is shown in Figure 2 with the screen consisting of 1.2 m (4 ft.) of 100 slot screen above 2.7 m (9 ft.) of 80 slot screen.

FIGURE 2. RECORD OF TEST HOLE

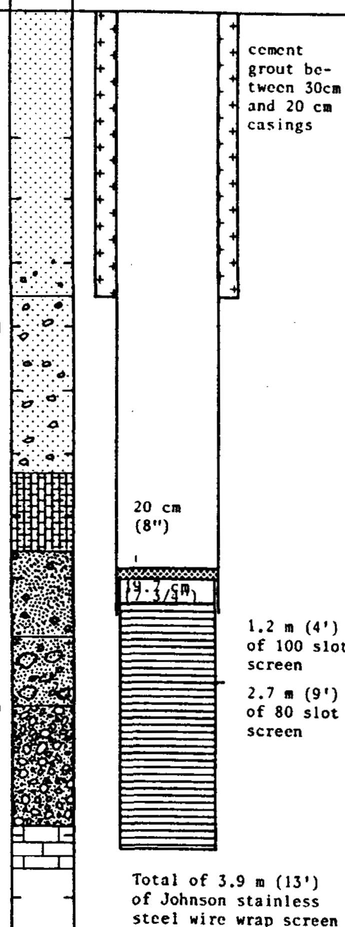
TWS

PROJECT CHESTERVILLE WATER SUPPLY
PROJECT NO. 1500

DRILLING METHODS CABLE TOOL
SUPERVISOR I. MACDONALD
DRILLING CONTRACTOR OLYMPIC DRILLING

DEPTH METRES	ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY
1–4		Sand: light brown, fine grained sand mixed with 20% silt and 5% rounded 5-10 mm coarse sand to fine gravel granules - granules increase in amount with depth 4.6 m
5–7		Sand and gravel: light brown, fine grained sand to silt matrix with subangular to angular gravel clasts up to 3 cm 7.3 m
8		Silty clay: grey clay mixed with fine grained brown silt 8.5 m
9–10		Sand and gravel: dark grey/black, coarse grained sand mixed with 40% angular to subangular gravel up to 5 cm; water produced 9.8 m
10–11		Gravel: dark grey gravel rounded to sub-angular up to 10 cm with a coarse sand matrix - a lot of water produced 11.0 m
12		Gravel: cobble to boulder gravel with a dark grey coarse sand matrix - water produced 12.8 m
13–14		Bedrock: 0.5 m socket 13.3 m

LOG / INSTRUMENTATION



SAMPLING TYPE	INTERVAL	N VALUE

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Johnson, stainless steel wire wrap screen was used. Following screen installation, the well was developed for 16 hours with compressed air surging techniques.

Phase IIb - Aquifer and Well Testing

In order to determine the long range yield of the aquifer, a 72 hour constant discharge test followed by a 24 hour recovery test was performed. The pumping rate for the 72 hour test was determined by first conducting a step-drawdown test. In the step-drawdown test the well was pumped in incremental discharges of 9.47, 15.15, 22.72, 30.3 and 34.39 l/sec (125, 200, 300, 400, and 452 IGPM). Near steady state drawdown conditions in the pumping wells were attained within 5 minutes for each step and maintained for the 30 minutes of pumping at each step. Data and calculations are shown in Appendix C, but the result of the test showed that TW5 could be pumped at a constant discharge rate of greater than 22.72 l/sec (300 IGPM) for 72 hours.

Well efficiency was calculated by drawdown/recovery comparisons of transmissivity in the pumping well and by the Jacob/Rorabaugh method.

The 72 hour aquifer test was performed from May 4 to May 7 with the recovery test immediately following. Drawdown and recovery was monitored in the pumping well (TW5), 3 shallow MNR mini-piezometers (M1-3), 8 piezometers (P1,2,5,6,7,13,19,20) and the test well at Site 1 (TW4). All the piezometers were developed prior to the test using a surge block and pumping technique to ensure connection to the aquifer. An additional piezometer, P18, could not be developed. All monitoring points are shown in Figure 3.

During the test, water samples were collected every 12 hours for major ion and trace metal analyses and every 24 hours for pesticide, volatile and non-volatile organic, radionuclide, phenol, and bacterial analyses. Water temperature, conductivity, and ambient air pressure measurements were taken every hour, and Eh and pH measurements were taken at intervals throughout the test.

Discharge from the aquifer tests was carried by pipeline 200 metres to the south, where it emptied into a ditch which drains to the South Nation River. Test pits dug into the ditch bottom revealed that it lies in silty clay and that no significant infiltration of pumped water would occur.

4.0 RESULTS

4.1 Geology and Hydrogeology

The Maple Ridge glaciofluvial complex consists of a band of sands and gravels that run from south of Highway 43 near Maple Ridge and trend north/northeast towards Morewood. South of Highway 43, the deposit is comprised largely of fine to medium grained sand. The complex narrows northward through Sites 1 and 2 and also increases in gravel content. North of Site 2 the complex can be traced north of the Boyne Road, although the detailed drilling performed near the test well has not been carried out in this area. It is believed that the complex can be traced further north to connect with the Morewood complex. In the vicinity of the test well the aquifer is flanked on both sides by a clay/till unit that is approximately 12 m thick. South of the test well the till unit is also present between the underlying bedrock and the overlying sands and gravel.

TW5 intersects 12.8 m (42 ft.) of overburden material with the bottom 3.7 m (12 ft.) consisting of coarse sand to boulder gravel that yields in excess of 22.73 l/sec (300 IGPM) of groundwater to a properly constructed well. The aquifer was originally thought to be confined due to the presence of a silty clay layer at the test drilling locations but, as shown below, the aquifer responds hydraulically in an unconfined manner. The water table is 0.5 to 1.0 m (1.6 to 3 ft.) below ground surface in the vicinity of the test wells.

4.2 Aquifer Test Results

Steady state conditions were obtained in the pumping well (TW5) almost immediately after pump start up. After three minutes of pumping a drawdown of 2.71 m (8.9 ft.) occurred. By the end of the test only an additional 0.26 m (0.85 ft.) of drawdown was observed.

Four monitoring points (M1,P19,P5,TW4) within 255 m of the pumping well showed a consistent total drawdown of 0.43 - 0.49 m, indicating good hydraulic connection. M2 is located 105 m away from TW5 but the drawdown of 0.055 m reflects its location within the clay/till unit that flanks the aquifer. P20, 270 m radial distance, is hydraulically connected to the aquifer but is located at the transition between the sand and gravel material and the clay/till unit. P7 and P13 also show hydraulic connection to the aquifer, but their radial distances, 728 m and 690 m respectively, account for the slight drawdown observed (<10 cm). Finally, the last four monitoring points, P1,P2, P3,P6, show fluctuations in water levels that are not due to the test well pumping. Only P6 appears to be hydraulically affected by the test but all seem to be affected by the pumping of private

300m - 3.9cm
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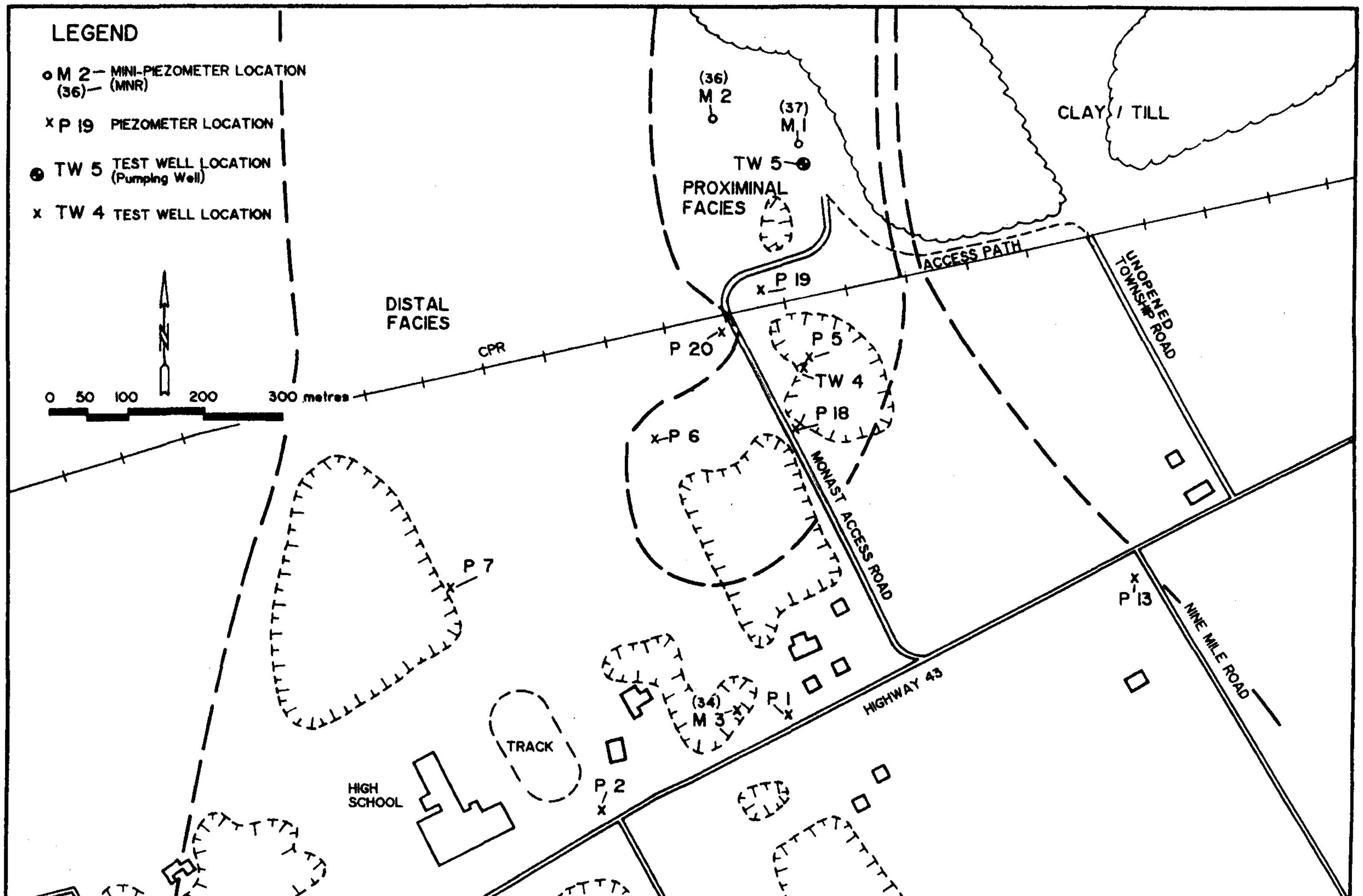

FIGURE 3:

DETAILED WELL SITE MAP

CHESTERVILLE, ONTARIO

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wells along Highway 43. The water level in P2 fluctuates throughout the test and there is no apparent recovery.

The recovery in the pumping well occurred instantaneously with 90% recovery observed within the first minute after the pump was turned off. Water levels in TW5 continued to rise very slowly with 95% recovery attained at the end of the 24 hour test. Recovery was not as rapid in the five closest hydraulically connected monitoring points (M1,P5,P19,P20,TW4) with a final recovery of 35 to 51% observed. Recovery was observed to continue well after the formal conclusion of the test.

The data was analyzed using the methods of Neuman and Jacob for drawdown and Theis for recovery. The calculated transmissivities and storativities (Appendix D) are summarized below.

TABLE 1 CALCULATED AQUIFER PARAMETERS

Monitoring Point	Radial Distance(m)	Stora-tivities (unitless)	Transmissivities (m^2/day) Jacob	Neuman	Theis
P5	250	0.0091	817		2054
P7	728	0.018	4180		--
P13	690	0.0095	1383		--
P19	210	0.0082	946		3210
P20	270	0.012	1089		6536
M1	10	--	1123	244-1116	719
TW4	255	0.0092	808		2947
TW5	0	--	2996		3595
M2	105	0.267	8170		

The drawdown data cannot be analyzed using the Theis/-Neuman method at any location other than M1. An early time transmissivity of 1116 m^2/day and a late time transmissivity of 244 m^2/day was calculated.

4.3 Well Efficiency

The Jacob/Rorabough method yielded an efficiency of 89% by comparing the calculated theoretical drawdown in the pumping well with the actual drawdown observed during the aquifer test. This method assumes that the aquifer has reached steady-state conditions at the time of maximum actual drawdown.

4.4 Water Quality Results

The following water samples were sent to the indicated labs for analysis.

Bondar Clegg and Company Ltd., Ottawa

- major ions: 12,24,48,72 hour
- trace metals: 24,72 hour
- phenols: 12,24,48,72 hour
- radionuclides: 72 hour

KOPP Clinical Laboratories, Ottawa

- bacteria: 12,36,48,72 hour

Zenon Environmental Inc., Burlington

- volatile and non-volatile organics, pesticides, USEPA 624,625 priority pollutants: 72 hour

Ministry of Environment, Kingston

- nuisance bacteria (Fe, SO_4 reducing bacteria): 48 hour

Groundwater chemistry results are shown below.

TABLE 2: GROUNDWATER CHEMISTRY RESULTS

Bacteria

	12 hour	36 hour	48 hour	72 hour
Total Count	0 col/ml	0 col/ml	0 col/ml	0 col/ml
Total Coliform	0 col/100ml	0 col/100ml	0 col/100ml	0 col/100ml
Faecal Coliform	absent	absent	absent	absent
Faecal Strept	absent	absent	absent	absent

Nuisance Bacteria

Fe bacteria	absent
SO_4 reducers	<9.0 MPN/100 ml

Radionuclides	72 hour
^{137}Cs	<0.5 Bq/L
^{131}I	<1.0 Bq/L
^{226}Ra	0.1 Bq/L
^{3}H	<100 Bq/L
^{90}Sr	<1.0 Bq/L

Pesticides, Volatile and Non-volatile Organics

All of these parameters were at concentrations less than detectable limits with the exception of bis(2-ethylhexyl)phthalate which was present at a typical background concentration of 1.7 ug/L. The complete Zenon report is in Appendix E.

Major Ions and Trace Metals

Parameter	12 hour	24 hour	48 hour	72 hour
Ca	64	65	59	59
Mg	19	19	18	19
Na	6	4	4	3
K	2	2	2	2
Cl	7	7	6	6
SO_4	54	54	52	52
Alk	192	186	185	186
N-NO_3	<0.10	<0.10	<0.10	<0.10
N-NO_2		<0.10		<0.10
N tot		<0.10		<0.10
H_2S				<0.10
Fe tot	0.08	0.13	0.13	0.13
Mn		<0.01		<0.01
As		<0.01		<0.01
Ba		<0.01		<0.01
B		0.03		<0.01
Cd		<0.001		<0.001
Cr		<0.01		<0.01
CN^-				<0.10
F		0.09		0.09
Pb		<0.01		<0.01
Hg		<0.1		<0.1
Se		<0.01		<0.01
Ag		0.01		0.08
U		<0.01		<0.01
Cu		<0.01		<0.01
Zn		0.01		0.11
phenol	<0.002	<0.002	<0.002	<0.002
TDS		141		218
turbidity(JCU)		1.0		1.0
colour(UNT)		6.0		6.0

Field conductivity measurements remained constant throughout the test at 175 to 210 umhos. Temperature varied from 10 to 12.5^0 C, pH from 7.3 to 8.1, and Eh between -1 and +20 mV.

5.0 INTERPRETATION OF RESULTS

5.1 Physical Hydrogeology

The Maple Ridge glaciofluvial complex forms a narrow northeast and southwest trending aquifer that can be traced from south of Highway 43 to west of Morewood. The aquifer exhibits the three hydrogeological conditions necessary to meet the water supply demands of Chesterville.

- there is sufficient local transmissivity to provide sufficient flow of groundwater to a well.
- water can be extracted by conventional well design
- there is sufficient recharge area to prevent mining of the aquifer over the long term.

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Given that the annual recharge rate is estimated at ~~10.9~~ mm/a (Charron, 1978), an area of 650 Ha (1620 acres) would be required to support a perennial yield of 300 IGPM without groundwater mining. The dimensions of the esker complex are such that adequate recharge to the aquifer is ensured, particularly since infiltration in this granular body is almost certainly more than two times higher than Charron's average of 10.9 mm/a.

The deposit is capable of producing a short term yield in excess of 34.09 l/sec (450 IGPM) as demonstrated by the step discharge test. Although boundary effects were observed during testing, the available drawdown in the pumping well and the minimal effects on monitoring points greater than 700 m from the pumping well indicates that a safe basin yield in excess of 22.73 l/sec (300 IGPM) is possible.

Theoretical calculations on long term aquifer yields (Appendix F) reveal that greater than 22.73 l/sec (300 IGPM) could be produced. Given the representative aquifer parameters transmissivity of 1000 m^2/day and a storativity of 0.009, the 20 year predicted yield with available drawdown to the top of the screen in TW5 is approximately 52.27 l/sec (690 IGPM). This would result in a drawdown of 8.5 m in the pumping well. This valued is theoretical and should not be used for design purposes. For full utilization up to this level it would be recommended that additional testing and aquifer definition work be conducted. Observation of the water levels in the aquifer to longer term pumping at a rate of 22.73 l/sec (300 IGPM) could also provide an indication of the long term ultimate basis yield of the aquifer.

5.2 Well Interference

Long term drawdown effects at any radial distance away from the pumping well can be calculated (Appendix F). The aquifer appears to be capable of theoretically producing a maximum design yield of 52.27 l/sec (690 IGPM) for 20 years, which is more than double the required yield. Pumping at 22.73 l/sec (300 IGPM) would produce less than 3 m of drawdown in the pumping well, 1.78 m at a distance of 100 m, and 1.14 m at 800 m. If the discharge rate was increased to 37.89 l/sec (500 IGPM) a drawdown of 1.89 m would occur at 800 m distance.

The Theis equation used to derive these figures assumes that the aquifer is homogeneous and isotropic; however, these assumptions cannot be made in this case since, during the pump test, the effect of the aquifer boundaries was felt. To accommodate this fact, the transmissivity values used were calculated using the late-time data and reflect the presence of these negative boundaries.

The calculated drawdowns are not foreseen to be a significant problem to those households that are located along Highway 43 and therefore within an 800 m radius of the final production well. Minor well interference problems do sometimes accentuate existing problems in substandard wells. These problems can not be forecast and guarantees cannot be given that they will not occur since they are as much a function of the well design as the interference problem itself. They are however easily corrected. The above calculations assume that the production well is pumped continuously, which is unlikely, and more importantly, that homogeneous, isotropic hydrogeologic conditions exist everywhere. The main core of the aquifer is not thought to be present along Highway 43 and, therefore, any hydraulic connection would be reduced. This hypothesis is substantiated by 72 hour pump test data. Also, local recharge will occur between the production well and the points of possible interference in question. Recharge will greatly reduce the impact of interference, damping out effects on a seasonal basis.

5.3 Groundwater Quality

The geochemical data listed in Table 2 are all well within MOE drinking water standards, except for the elevated colour readings of 6.0 UNT and the turbidity value of 1 JCU. These are not unusual readings for a newly completed well: the elevated turbidity is a result of high fluid entrance velocities through naturally developed coarse material in TW5. These velocities will be reduced when a specially sized, artificial gravel pack is used in the production well construction. The high colour values are probably created by interference from the sample's turbidity.

Results in Table 2 indicate that the water is very hard. This is characteristic of groundwaters obtained from this type of glaciofluvial deposit. The use of domestic water softeners for wash water is not out of the ordinary in Ontario and is an option that the individual home owner or end point user may wish to consider. From an operational perspective, the calcium and magnesium hardness must be considered in the maintenance program for the well. Calcium and magnesium carbonate scales that form on the well screen will result in an eventual slow plugging of the screen. An adaption of a equilibrium based groundwater speciation model was used to determine the corrosivity or scale potential of the pumped waters based on the 72 hour data. The results of the run are contained in Appendix E. A run of this computer model indicates that the water is mildly corrosive with a Ryznar Index of 7.3. The model also indicates that pumped waters are slightly supersaturated in calcium carbonate and that scale formation on the well screen over the long term is probable.

It is not likely that the water is both corrosive and capable of producing scale. Scale production is not out of the ordinary for similar wells and groundwaters. Screen material and the installation of an artificial gravel pack must therefore be considered in the final well design in order that periodic acidification of the well will not adversely affect the construction. These points are discussed in greater detail in the next section.

A review of potential conflicting land uses was undertaken during the course of the investigation. Features such as landfills, sewage lagoons and major transportation routes were identified as potential contaminant sources.

Some concern has been voiced by Chesterville Council concerning the apparent proximity of the Winchester Township landfill, which is located a little over 3 km from the proposed production site. This landfill is also presently considering accepting fill (non-hazardous industrial waste classification) from a site on Lees Avenue in Ottawa (Interra, 1988).

An examination of the geology of the area shows that the landfill is situated on a low-permeability clay till plain in a separate drainage basin from the proposed production site. The landfill does not lie on or close to the recharge area of the aquifer complex.

The presence of two major transportation corridors, the rail line and Highway 43, do not pose an immediate contamination problem; however, it is imperative that if a spill occurs along these routes where they intersect the recharge area of the aquifer (a distance of approximately some 200 to 500 metres either side of the crest of the ridge) that they are immediately reported, contained and groundwater contamination prevented at all costs. The risks of such contamination are small and the lag times for entry of a contaminant into the water supply would be measured in years. Interception and removal of such a contaminant is technically feasible and most easily accomplished in the early stages of migration.

5.4 Aggregate Extraction from Adjacent Property

A gravel pit is located in the esker complex near the proposed production well site. This operation is currently only licensed to extract granular materials from above the water table (MNR, 1988), but may at a later date apply for a license to excavate below the water table in the future.

WESA foresees no difficulty in operating a municipal water supply well in the vicinity of such an operation, provided that the guidelines outlined in The Pits and Quarries Control Act. 1971, along with the following special conditions, are followed. Three main areas of concern exist: water quality degradation; lowering of the groundwater table; and slope stability.

Water quality degradation might be caused by refueling or dust control. Refuelling of equipment should on no account take place on the pit floor, and should be restricted to areas underlain by clays, to the west of the pit. Dust control compounds such as waste oil contain hazardous components which are mobile in this geologic media, and may even include highly toxic contaminants such as PCB's. Lowering of the water table by draining of surficial water or groundwater pumping will significantly reduce the supply potential of the municipal well. Such a draining operation is in contravention of The Pits and Quarries Act and the Ontario Water Resources Act unless special provision has been made.

Lastly, drag line operations may be expected to induce a significant amount of turbidity in water close to the quarry. The Ontario Pits and Quarries Act states that "no pit or quarry excavation shall be closer than 50 feet from any property boundary". If this setback distance were to be doubled to 30 metres (100 feet), a minimum separation distance of 75 metres between the production well and quarry activities would be achieved. No turbidity problems are foreseen given this separation: further, the pit bank should not encroach onto the neighbouring property, given a setback distance of 30 metres and an angle of repose of less than 42^{o} for the unconsolidated material.

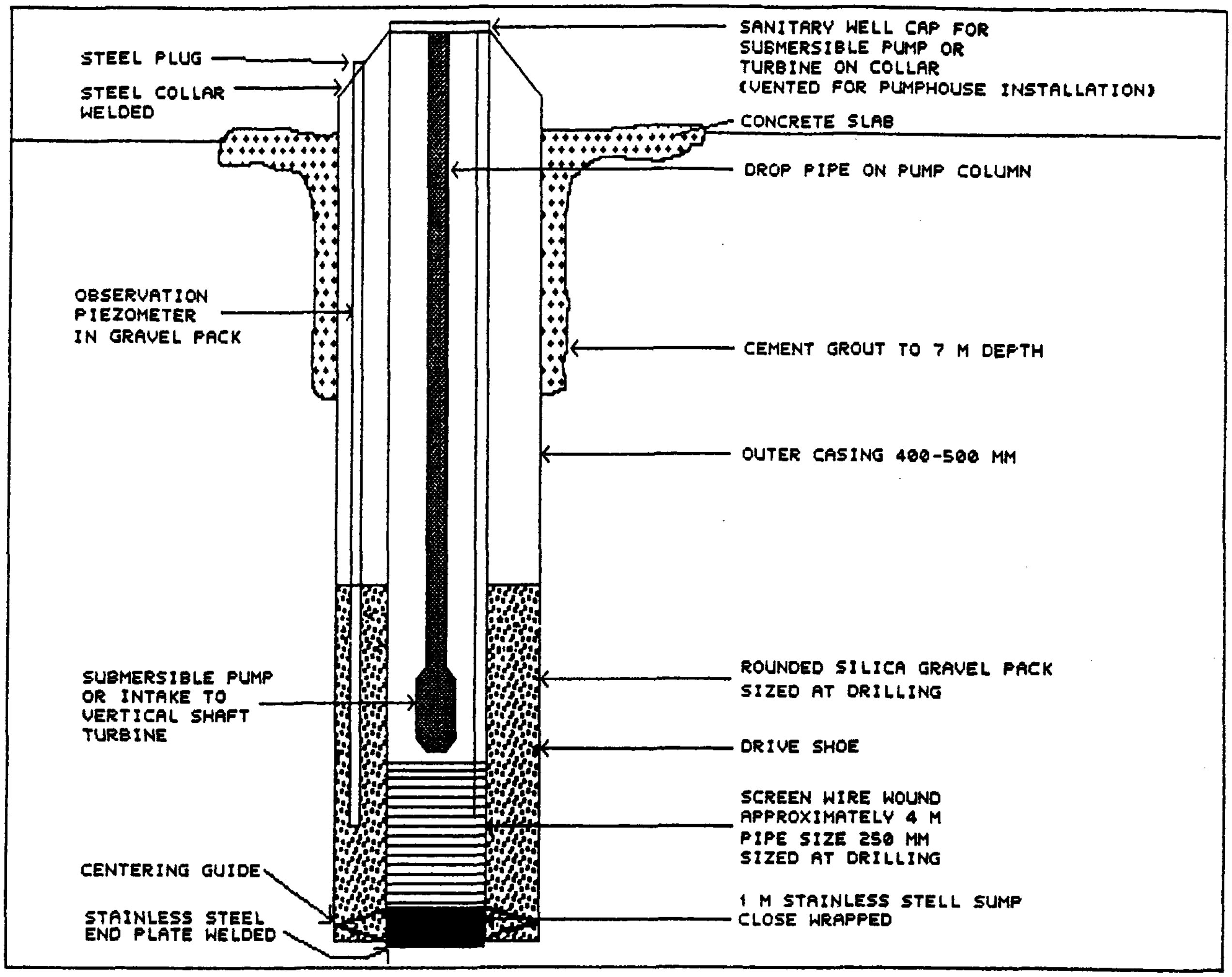

FIGURE 4

PROPOSED WELL DESIGN

CHESTERVILLE, ONTARIO

5.5 Production Well Design

The drilling and testing of the test well has provided information that may be applied to the final production well design.

The test well was a naturally developed well and required 16 hours of developing to obtain a well efficiency of 89% at a pumping rate of 22.73 l/sec (300 IGPM). However, for the production well a large diameter (500 x 250 mm) artificial gravel pack well is preferred. Such a design incorporates a rounded silica gravel pack, sized to the formation, between the 500 mm hole and the 250 mm stainless steel screen. Such a design would be capable of producing in excess of 22.73 l/sec (300 IGPM) and at a lower operation and maintenance costs than a natural gravel pack well. The higher cost of installation is also offset by lower well development costs.

The proposed well design is included on Figure 4. Note that the well design may be encorporated into a pump house with a shaft line turbine pump and surface motor or used as a stand alone facility if completed with electrical submersible pump, pitless adapter and above ground vented well head. Baker manufactures such a protective well cap. The latter option will allow the well to be completed outside of the pump house, an advantage from a maintenance point of view (especially for acidification), but a disadvantage operationally. The use of an airline water level measurement system is more difficult in this type of design and winter access to the well head for electric tape measurement (a preferred and more accurate method) somewhat restricted. The 250 mm well casing diameter will allow for both pump options and is the norm for production well design at this scale. Aquifer materials are such that a 200 mm diameter well would be possible but the cost increase with the increased diameter, especially in gravel packed designs, is marginal.

Design of the gravel pack and well screen is dependent on the geology of the production site. This information is only available at the time of drilling.

Water chemistry and bacteriology results indicate that in-well chlorination or treatment will not be necessary. Chlorination, if recommended, may be undertaken in the pump house.

Maintenance for the production well will most likely include the periodic acidification of the screen and gravel pack to remove calcium and magnesium scale or other mineral precipitates. These precipitates will, with time, accumulate and reduce overall performance and efficiency of the well. Maintenance should be undertaken by a qualified well driller/pump installer and the schedule based on records of well efficiency and specific capacity obtained during the weekly record of drawdown in the production well and proximinal piezometers. Examination of the groundwater chemistry speciation model indicates that scale formation will not be rapid and that maintenance on a yearly or less frequent schedule may be all that is required. The production of a maintenance schedule will be more possible at the conclusion of the first year of operation. Measurement of well drawdown should ideally be conducted at the same time of the day and on the same day, preferably on a Friday, in order that pumping induced fluctuations of water level may be minimized.

The test well should be modified for use as a standby production well.

6.0 CONCLUSIONS

The following conclusions have been derived from the work conducted in this study:

1. An unconfined sand and gravel aquifer is present 4 km west of the Village of Chesterville. A successfully completed test well is located north of Highway 43 and the CPR line and east of the high school.

2. The aquifer consists of a narrow band of glaciofluvial sands and gravels that run from south of Highway 43 to north of the Boyne Road. A clay/till unit flanks both sides of the aquifer. Recharge occurs mainly along the length of the aquifer.

3. The aquifer has demonstrated an ability to produce in excess of 300 IGPM to a test well screened over 4.0 m (13 ft.) of its thickness. A theoretical safe perennial yield of 550-600 IGPM is possible.

4. Minor well interference occurs at the site of any major groundwater withdrawal scheme. The interference at the Maple Ridge site will be small, seasonal and will most likely be unmeasurable at a discharge of 22.7 l/sec over the long term. The low levels of interference anticipated will not result in a "no water" situation at the domestic or school water production sites. If well and aquifer factors combine to drop water levels below pump efficiencies or intakes the condition may be easily corrected with the installation of a submersible or positive displacement pump, or by deepening the well.

5. Water quality in the aquifer is very good. MOE drinking water standards are met for all parameters.

6. Any continued gravel pit operations outside of a reasonable buffer (on the order of 75 metres) should not interfere with aquifer yield and water quality as long as those operations are in accordance with the Pits and Quarries Control Act and do not involve the draining or the addition of contaminants to the groundwater regime. If saturated materials are sought after, a drag line operation conforming to the Ontario Pits and Quarries Act should pose no problems. Water contamination from an operating pit is unlikely if the pit is operated in a manner conforming with the Ontario Pits and Quarries Act.

7. There does not appear to be any potential groundwater contamination sources in the immediate vicinity of the proposed production site. The municipal landfill site located on the Boyne Road, 3 km west of the site, should not pose any problem given its hydrogeologic situation and its position outside of the recharge area. This status should be monitored in the future and any spills or potential conflicts reported immediately. Highway 43 most likely forms the single largest potential spill source. A provincial system for the immediate reporting of spills already exists and should serve as an early warning system for the well field.

7.0 RECOMMENDATIONS

The following recommendations have been formulated based on the results of the study:

1. The aquifer should be used to meet the long term needs for the Village of Chesterville.

2. A 500 x 250 mm artificial gravel pack production well should be installed close to the test well. The well could produce the required 300 IGPM and if necessary produce more if the need arises. The test well should be modified for use as a standby production facility.

3. In the event of any perceived interference problem, the situation should be dealt with immediately and the situation rectified. Rural based water supplies in other municipalities have been subjected to substantial criticism and their ultimate potential reduced due to public opposition and perceived conflicts. The cost of repairing and even replacing allegedly affected water supplies is small in comparison to operating in a disruptive atmosphere of mistrust.

Respectfully submitted,

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COPY

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8.0 REFERENCES

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APPENDIX A

MOE WELL LOGS (Locations on Figure 1)

WESA TEST HOLES

WELL	CON	LOT	EASTING NORTHING	SURFACE ELEV	DRILL DATE	CSG DIA	KIND OF WATER	WATER FOUND	STATIC LEVEL	PUMPED LEVEL	TEST RATE	TEST TIME	WATER USE	OWNER	GEOLOGIC LOG
1	1	14	481586 4989854	260	12/60	4	FR	100	14	54	8	1	st	DEJONG, S	GRVL CLAY BLDR 15 LMSN 108
2	1	15	482050 4989800	270 270	11/77	5	FR FR	30 42	2	35	5	1	DO	SHORT, BURNIS	HPAN 15 LMSN 45
3	1	15	482148 4989722	270	11/74	6	FR	237	22	90	5	1	DO	HOOGEVEEN, HENRY	BRWN TPSL 1 GREY CLAY BLDR 12, GREY LMSN 245
4	1	15	482150 4989700	270 270	10/78	6	FR FR	42 75	12	65	10	1	DO	HOOGEVEEN, HENRY	HPAN 17 LMSN 81
5	1	15	482150 4989700	270 270	10/78	5	FR FR	40 48	15	30	6	1	DO	HOOGEVEEN, HENRY	HPAN 17, LMSN 53
6	1	15	482167 4989939	275	11/53		FR	45	20	20	10	5	ST	SHORT, B	PRDG 20,GREY LMSN 4
7	1	15	482232 4989974	275	12/64	5	FR	45	9	25	10	1	ST DO	HOOGEVEEN, H	HPAN 16 LMSN 53
8	1	18	483300 4991200	275 275	5/78	5	FR FR	45 47	15	35	5	1	DO	SULLIVAN, JAMES	HPAN 4 LMSN 53
9	1	18	483360	260	4/53	4	FR	35	15	15	2	1	DO	GRAHAM,A.	HPAN 5, GRVL STNS
10	1	18	483690 4991040	273	5/71	5	FR	50 72	5	12	2	2	ST	RACINE, A	HPAN 4 LMSN 25, BL LMSN 75
11	1	21	485410 4992098	280	4/73	5	FR	75	16	20	15	2	ST DO	SYBREN DE JONG	HPAN 4, LMSN 70, BL ROCK 80
12	1	22	485363 4992247	277	11/51	5	FR	68	20	20	8	1	ST	MOORE, E.B.	GRVL 8, HPAN 25, LMSN 69
13	1	23	486199 4992699	265	11/79	6	SU	180	20	180	5	1.5	DO	JOHNSON, G.	HPAN 10, LMSN 186
14	1	23	486400 4992800	275	7/77	6	FR	355	18	365	2	1		JOHNSON, GORDON	TPSL 1, CLAY BLDR 5 GREY LMSN 365
15	2	12	479234 4991036	235	8/75	5	FR	52	12	18	20	1	ST DO	DWAYNE MUNROE	HPAN 20,WHIT SAND 4 HPAN 47,LMSN 56
16	2	12	479294 4991082	240	11/57	4	FR	32	15	15	9	10	DO	MUNROE, H.	HPAN 26,LMSN 36
17	2	12	479621 4990848	240	1/65	5	FR	50	12	18	20	1	DO	MUNROE, D.	PRDG 19,CLAY GRVL MSND 46,LMSN 56
18	2	13	479640 4990983	240	8/55	5	FR	57	9	30	10	1	ST DO	SHAY, A.	TPSL 4,CLAY MSND 57
19	2	13	480550 4989920	250	11/70	5	FR	50	8	30	2	2	ST DO	MERKLEY,J.H.	HPAN 40,FSND 42, LMSN 53
20	2	13	480589 4989978	260 260	9/74	5	FR FR	40 58	7	15	15	2	ST	MERKLEY,G.	HPAN 38,LMSN 63
21	2	14	480380 4991690	255	12/60	5	FR	80	15	60	6	2	ST DO	MERKLEY,H.	PRDG 22,BLDR HPAN 4 GREY LMSN 90
22	2	14	480450 4991750	250	10/70	5	FR	43	12	25	10	2	ST DO	MERKLEY,J.H.	HPAN 40,GRVL 43
23	2	14	480481 4990909	258	12/60	5	FR	71	15	35	21	1	ST DO	DERK,M.	PRDG 30,BLDR HPAN 4 GREY LMSN 81
24	2	16	480450 4991250	250	9/78	6	FR	53	8	50	10	1	DO	BRUGMANS,G.	FILL LOOS 10,HPAN 4 BRWN GRVL 53,LMSN 6

25	2	16	482100 4990850	265	12/78	6	FR	93	18	35	10	1	DO	DORHERTY,B.	TILL LOOS 7,LMSN 103
26	2	16	482201 4990771	270	12/64	5	FR	50	18	27	20	1	ST DO	DROPPO,F.	FRDG 15,LMSN 60
27	2	16	482231 4990816	270	7/59	4	FR	45	9	20	7	1	DO	MARTEL,J.	HPAN 10,LMSN 50
28	2	17	482399 4990899	275 275	3/81	6	FR FR	35 61	3	22	6	1	DO	SULLIVAN,R.	HPAN 3,LMSN 65
29	2	18	482716 4993080	240	5/53	5	FR	97	1	10	6	1	DO	DROPPO,A.	CLAY BLDR 50,LMSN 9[illegible]
30	2	18	483220 4992320	255 255	5/72	5	FR FR	50 55	5	30	10	2	DO	CROSS,B.	HPAN 21,LMSN 58
31	2	18	483250 4991500	270	8/78	5	FR	61	10	50	6	1	DO	SULLIVAN,A.	HPAN 15,LMSN 65
32	2	18	483260 4991370	270	5/69	6	FR	145	12	18	17	1	DO	SULLIVAN,BROS.	BLDR CLAY 12,LMSN 151
33	2	18	483302 4991646	270	9/59	4	FR	59	18	50	3	1	ST	MORAN,J.	HPAN 10 LMSN 70
34	2	18	483350 4991725	265 265	6/72	5	FR FR	39 60	5	20	2	1	ST	MORAN,P.B.	HPAN 5,ROCK 10 LMSN 65
35	2	19	482806 4993135	240	6/64	4	FR	64	4	29	5	2	DO	SHORT,B.	HPAN 45,GRVL 59 LMSN 65
36	2	19	483699 4991599	250	9/80	5	FR	40	10	35	6	1	DO	PATENAUDE,H.	HPAN 29,LMSN 45
37	2	20	483224 4993302	245 245	6/74	5	FR FR	35 45	5	20	20	1	DO	WILBURN ROBINSON	HPAN 32,GRVL 34 LMSN 50
38	2	20	483400 4993400	248	4/71	6	FR	133	8	21	17	1	IN	CARL-DON EQUIP.	GRVL CLAY MSND 39 GREY LMSN 140
39	2	20	483485 4993476	240	8/57	4	FR	56	25	25	10	2	ST	KELLY,N.	FRDG 16,HPAN 29 LMSN 60
40	2	20	483629 4993587	239	8/67	4	FR	56	10	20	10	1	DO	COUNTRYMAN,G.	HPAN 35, LMSN 59
41	2	20	484285 4991957	260	11/49	4	FR	48	7	12		2	ST	UNKNOWN	HPAN 42,GRVL 48 LMSN 49
42	2	21	484850 4992100	275	8/69	5	FR	52	6	15	14	2	ST DO	SYBREN	CLAY 20,HPAN 28, LMSN 55
43	2	21	485000 4992250	275 275	10/77	6	FR FR	57 60	18	35	10	1	ST	DE JONG SYBREN	HPAN 24,SAND GRVL 4[illegible] LMSN 67
44	2	22	485557 4992458	275	4/65	6	FR	105	21	45	17	1	ST DO	DEJONG,S.	CLAY GRVL BLDR 17 LMSN114
45	2	23	485950 4993900	255	10/78	6	FR	80	50	110	1	1	DO	MOORE,E. BERTRAM	HPAN 10,GREY LMSN HARD 110
46	2	24	486062 4994108	255 255	9/73	5	FR FR	35 66	10	50	6	2	ST	DOUNDRA, JOHN	HPAN 4,LMSN 55 LMSN 70
47	2	24	486401 4994259	249	5/49	4	FR					1	ST	CLEMENT,B.	CLAY 18,GRVL 20
48	3	13	479300 4992010	225 225	10/70	5	FR FR	69 70	16	30	7	2	ST	BALL,B.	HPAN 42,FSND 56 LMSN 75
49	3	14	479523 4992335	235	10/65	4	FR	40	15	25	8	2	DO	BALL,B.	CLAY 25,HPAN 39 GRVL 40
50	3	14	479690 4992431	240 240	9/75	5	SU SU	55 66	30	40	10	1	ST DO	FORWARD,W.T.	HPAN 50,GRVL 53 LMSN 68
51	3	14	480050 4992620	250	8/68	4	FR	58	27	29	15	1	ST	BALL,B.	HPAN 42, LMSN 60
52	3	14	480050 4992620	250 250	8/68	4	FR FR	50 54	20	40	5	1	ST DO	BALL,B.	HPAN 47,HPAN 55

53	3	15	480350 4992700	250	1/71	5	FR	55	15	20	7	2	ST	EARL CROSS	HPAN 18,MSND 40 LMSN 58
54	3	16	480648 4992884	245	10/74	5	FR	60	20	50	7	1	DO	DUBOIS,J.	HPAN 30,BLDR 40 GRVL 57 LMSN 63
55	3	16	480925 4993027	249	10/64	4	FR	53	22	35	10	1	ST DO	SHAY,S	HPAN 52,LMSN 54
56	3	16	481000 4993100	250 250	5/72	5	FR FR	60 62	15	40	10	2	ST DO	MAXWELL,J.J.	HPAN 36,GRVL 58 LMSN 65
57	3	16	481085 4992262	250 250	5/74	5	FR FR	65 68	2	25	20	1	DO	BYNELDS,J.A.	HPAN 41,GRVL 52 LMSN 70
58	3	16	481199 4993199	250	4/79	5	FR	46	14	32	10	1	DO	MURIEL,M.	PRDR 27 LMSN 50
59	3	19	482450 4993720	225 225	5/72	6	FR FR	50 55	5	16	20	2	ST DO	VANDENBOSCH,J.&SONS	HPAN 30,LMSN 60
60	3	19	482453 4993725	230	4/67	4	FR	46	8	20	6	1	ST DO	VANDENBOSCH,J.	HPAN 30 LMSN 48
61	3	19	482661 4993283	235	1/50	10	SU	42	10	47	27	1	MU	OWRC	CLAY TPSL 4,MSND GRVL 15,CLAY MSND BLDR 33,SHLE 38 LMSN 85
62	3	19	482733 4993225	245	6/73	5	FR	75	18	35	12	2	DO	VANDENBOSCH & SONS	HPAN 31,LMSN 80
63	3	23	485200 4994550	230 230	6/78	6	FR SU	35 94	20	75	20	1	DO	LYNCH,F.	HPAN 18,LMSN 96
64	3	24	485686 4994750	230	6/58	4	FR	18	7	7	8	1	DO	CLEMENT,A.	HPAN 5,LMSN 20
65	3	24	485756 4994755	230	6/62	4	FR	33	9	25	15	1	DO	CLEMENT,P.	HPAN 22,LMSN 40
66	4	12	478302 4993141	270	4/65	6	FR	80	12	23	17	1	DO	SULLIVAN,J.	MSND CLAY GRVL 52 LMSN 90
67	4	13	478438 4993067	265	10/57	4	FR	38	12	33	5	2	ST	BALL,S.	PRDG 12,HPAN 35 LMSN 42
68	4	13	478606 4993423	260	5/58	4	FR	44	12	12	10	5	DO	CROSS,W.	HPAN 41,LMSN 46
69	4	13	478681 4993574	260	6/61	4	FR	47	18	25	20	1	DO	LANTHIER,R.	HPAN 45,GRVL 47
70	4	13	478399 4093299	250	11/80	5	FR	70	16	40	12	1	DO	BOLTEN,B.	HPAN 53,LMSN 73
71	4	14	478927 4993365	260	5/49	5	FR	66	8	20	5		ST DO	CROSS,I.	MSND 25,CLAY 50 LMSN 74
72	4	14	479642 4992527	235	10/74	6	FR	51	12	25	10	1	DO	SMITH,B.	GREY CLAY 10,GREY CLAY BLDR 30,CLAY GRVL 39,LMSN 60
73	4	14	479759 4993263	235	11/66	4	FR	70	10	18	12	2	ST DO	WEREN,H.	HPAN 34,LMSN 75
74	4	14	479953 4992628	250	6/61	4	FR	45	15	20	10	1	ST	SMITH,E.	HPAN 34,LMSN 50
75	4	15	479903 4993565	240	12/66	6	FR	75	22	30	17	1	ST DO	MERKLEY,P.	PRDG 16,BLDR CLAY MSND 44,LMSN 84
76	4	15	480027 4993781	235	12/54	5	FR	80	10	30	10	1	DO	ROADS RESURFACING CO	WHIT 4,HPAN 34, LMSN 86
77	4	15	480121 4993985	230	5/75	5	FR	57	10	18	20	1	ST DO	SHAY,EDWIN	HPAN 30,GRVL SAND 6
78	4	15	480200 4993960	245	5/69	6	FR	105	5	50	17	1	CO	QUEENSWAY TANK LTD	CLAY 10,BLDR CLAY GRVL 20,GRVL CLAY MSND 29,LMSN 111

79	4	15	480280 4992700	250 9/74	5 FR	48	18	25	10	2 DO	JOHNSTON,M.E.	HPAN 26,LMSN 52
80	4	16	480250 4994280	250 12/70 250	5 FR FR	36 55	3	12	10	2 IN	BRACKVILLE CHEMICAL	HPAN 27, LMSN 70
81	4	16	480542 49938132	240 1/61	4 FR	70	25	45	10	1 DO	GAIN,A.	HPAN 67,LMSN 70
82	4	16	480550 4993000	250 8/72	5 FR	70	16	50	15	2 ST DO	VANDELST,T.	HPAN 40,SAND 42 GRVL 44,LMSN 65
83	4	16	480700 4993950	250 5/78	5 FR	68	25	50	12	1 DO	FYKE,A.	HPAN 50,BRWN SANI GRVL 68,LMSN 69
84	4	16	480899 4993899	250 9/80	6 FR	63	20	55	6	1 DO	DROPPO,K.	HPAN 50,LMSN 67
85	4	16	481060 4993250	260 10/68	5 FR	55	9	12	20	4 DO	CRAIG,H.	CLAY 49,GRVL 51 BLCK LMSN 56
86	4	16	481140 4993250	250 10/75	6 FR	52	25	45	10	1 DO	KENNEDY,K.B.	CLAY BLDR 22,CLA CSND GRVL 49,LMSI
87	4	19	481919 4994660	245 5/56	5 FR	48	11	19	18	1 IN	MARCELLUS,L.	TPSL 2,CLAY GRVL MSND 535,LMSN 51
88	4	19	481950 4995290	245 8/68	5 FR	165	20	60	7	8 ST DO	BALL,R.	CLAY 4,HPAN BLDR GREY LMSN 167
89	4	19	482612 4994048	227 10/62	4 FR	35	15	25	15	2 ST DO	CASSELMAN,E.	HPAN 30,LMSN 58
90	4	20	482058 4995410	255 5/57	4 FR	56	12	35	3	2 DO	EDGERTON,A	PRDG 18,GREY LMSI
91	4	22	483366 4996131	240 11/60	4 FR	45	17	25	20	1 DO	FROATS,R.	HPAN 22,GREY LMSI
92	5	13	478570 4993543	240 10/57	4 FR	33	9	20	4	5 DO	McCOLL,C.	HPAN 32,GRVL 33
93	5	16	479746 4994957	250 11/50	4 FR	45	10	15	8	5 DO	SMITH,A.	CLAY 20,HPAN,43 GRVL 48,LMSN 55
94	5	16	479990 4995289	245 11/59	4 SU	55 FLW		15	8	2 ST	SMITH,G.	HPAN 13,LMSN 63
95	5	17	480686 4994750	255 8/63	4 FR	30	14	16	8	2 DE	SMITH,A.	HPAN 30,LMSN 31
96	5	17	480695 4994810	255 11/50	FR	85	15			ST	GRAHAM,C.	PRDG 15,LMSN 85
97	5	17	480800 4994900	255 8/77 255	6 FR FR	45	15	60	12	1 ST	SMITH CARL	HPAN 39,LMSN 92
98	5	17	481033 4994949	255 6/57	4 FR	46	16	30	6	2 DO	SMITH,A.	HPAN 43,GREY LMSI
99	5	18	480890 4994900	255 10/68	5 FR	40	18	40	15	2 ST DO	SMITH,A.	HPAN 39,LMSN75
100	5	18	481251 4995071	255 6/62	4 FR	45	5	35	5	1 DO	HAMILTON,W.B.	HPAN 33,LMSN 50
101	5	18	481457 4995522	255 4/58	4 FR	30	10	10	12	2 DO	STEWART,D.	HPAN 22 LMSN
102	5	18	481497 4995437	255 9/59	4 FR	30	12	30	12	1 DO	SHARKEY,J.	HPAN 20,LMSN 38
103	5	18	481500 4995200	255 6/69 255	5 FR FR	38 75	20	55	4	1 DO	McCADDEN,A.	HPAN 36 LMSN 77
104	5	18	481532 4995217	255 6/73 255	5 FR FR	65 85	18	25	12	2 DO	WHITTEKER,R.	HPAN 20,GRVL 34 LMSN 90
105	5	18	481560 4995261	255 6/73 255	5 FR FR	60 63	12	40	12	2 DO	BASIN,T.R.	HPAN 28,LMSN 65
106	5	19	481159 4996276	255 5/59	4 FR	43	7	18	15	2 DO	MARCILLES,J.	HPAN 25,LMSN 43

107	5	19	481529													
			4995678	255	4/62	4	FR	45	9	40	7	1	DO		BYERS,S.D.	HPAN 34,LMSN 50
108	5	19	481601	255	7/52	5	FR	40	9	9	8	5	ST		SMITH,A	HPAN 30,LMSN 43
			4995376													
109	5	19	481811	255	12/73	5	FR	40	1	30	3	2	DO		BYERS STUART	HPAN 20,FSND 31
			4995404	255			FR	52								UNKN 54
110	5	20	481870	251	12/56	4	FR	82	27	50	8	1	DO		WYLICK,F.V.	HPAN 34,LMSN 90
			4996595													
111	5	20	482250	250	8/68	5	FR	94	20	35	7	6	ST	DO	MOFFATT,M.	CLAY 15,HPAN 25
			4995610													GREY LMSN 95
112	5	21	482630	245	6/70	5	FR	42	16	50	6	2	ST	DO	VAN WYLICK,F.	HPAN 40,LMSN 55
			4997150	245			FR	60								
113	5	21	482680	245	5/73	5	FR	50	2	7	12	2	DO		SMITH,D.	HPAN 12,LMSN 55
			4995877													
114	5	21	482699	250	11/79	6	FR	70	6	25	10	1	DO		VAN WYLICK,C.	HPAN 43,LMSN 75
			4997299													
115	5	21	482702	240	7/67	4	FR	80	7	80	4	2	ST	DO	WYLICK,F.V.	HPAN 35,FSND 125
			4997184	240			FR	100								
116	5	24	484637	230	10/60	4	FR	49	25	36	12	1	ST		WHEELER,E.	HPAN 48,GRVL 49
			4997007													
117	6	12	477050	250	11/78	6	FR	53	15	45	3	1	ST		VOLK,J.	BRWN HPAN 14,ROCK
			4995600													LYRD 23,LMSN 63
118	6	14	477773	248	6/51	5	FR	82	1	10	8		ST		RICHIE,E.	MSND 28,GRVL 31
			4995839													LMSN 83
119	6	14	478100	250	11/77	5	FR	46	7	25	20	1	DO		DAYZIN,R.	HPAN 20,SAND ROCK
			4996050													LMSN 50
120	6	15	478574	245	1/63	4	FR	52	20	30	16	1	ST	DO	DURANT,G.	HPAN 51 LMSN 52
			4995948													
121	6	15	479200	250	6/78	6	FR	42	8	15	35	1	DO		DURANT,G.J.	SAND PCKD 20,GRVL
			4995550													SAND CLAY 33,CGVL
																CSND 42
122	6	16	479617	250	8/59	4	FR	55	15	30	15	1	ST		MERKLEY,H.E.	HPAN 17,LMSN 60
			4995688													
123	6	18	480350	250	8/70	5	FR	40	18	22	10	2	DO		CHAMBERS,L.	HPAN 37,LMSN 45
			4996100													
124	6	18	480555	252	12/64	4	FR	39	18	30	12	1	ST	DO	CHAMBERS,L.	HPAN 24,LMSN 43
			4996326													
125	6	21	482400	255	8/69	5	FR	42	15	25	14	2	ST	DO	KELLY,J.	HPAN 35 LMSN 50
			4997800	255			FR	45								
126	6	22	482948	240	7/56	4	FR	36	7	7	8	2	DO		CHAMBERS,S.	HPAN 27,GRVL 31
			4997603													LMSN 36
127	6	23	482900	250	6/78	5	FR	50	15	25	10	1	DO		COYNE,J.	HPAN 38,LMSN 65
			4998750	250			FR	62								
128	6	23	483450	250	12/76	5	FR	40	10	28	10	1	ST		MERKLEY,D.	HPAN 35,LMSN 50
			4997750	250			FR	48								
129	6	24	484360	230	12/75	5	FR	50	2	10	20	2	ST		WHEELER,M.	HPAN 30,GRVL 31
			4998290													LMSN 55
130	7	13	477399	275	9/80	6	FR	70	10	48	15	1	ST		STOOP,W.	HPAN STNS 31
			4995999													LMSN STNS 80
131	7	13	477477	250	8/58	4	FR	39	10	10	8	4	DO		DARLING,J.W.	MSND 31,LMSN 41
			4995893													
132	7	16	478276	260	4/73	5	FR	48	10	25	12	2	DO		LEFEBRE,F.	HPAN 20,SAND GRVI
			4997819													LMSN 50
133	7	16	478549	251	7/52	4	FR	49	12	15	3	10	ST		LEFEVRE,E.	HPAN 40,GRVL 49
			4997967													

134	7	16	479041 4996757	240	5/51	5 FR	57	20	25	8	1 DO	BARNEY,T.	HPAN 43,GRVL 49 LMSN 58
135	7	16	479050 4996750	245 245	6/70	5 FR FR	50 62	6	15	5	1 ST	STOOP,W.	HPAN 20,GRVL 35 LMSN 66
136	7	18	480313 4997820	248	10/62	5 FR	45	8	52	8	1 DO	TYMS,B.	GRVL CLAY 25,LMSN 52
137	7	19	480510 4997650	250 250	3/76	6 FR FR	40 59	20	50	8	1 ST DO	VAN WYLICK,H.	HPAN 31,LMSN 65
138	7	20	481198 4997910	248	12/66	6 FR	89	7	45	17	1 DO	TASSELAAR,E.	BLDR CLAY MSND 27 LMSN 96
139	7	20	481950 4996970	250 250	8/71	5 FR FR	45 60	16	30	10	2 ST	MASTERSON,L.	HPAN 27 LMSN 62
140	7	21	481907 4998271	240	11/51	5 FR	111	20	25	8	1 DO	MASTERSON,H.	PRDG 25,HPAN 38 LMSN 112
141	7	22	482546 4998691	240	6/59	4 FR	85	5	60	5	3 ST	SERVAGE,T.	HPAN 24,LMSN 90

FIGURE

RECORD OF TEST HOLE

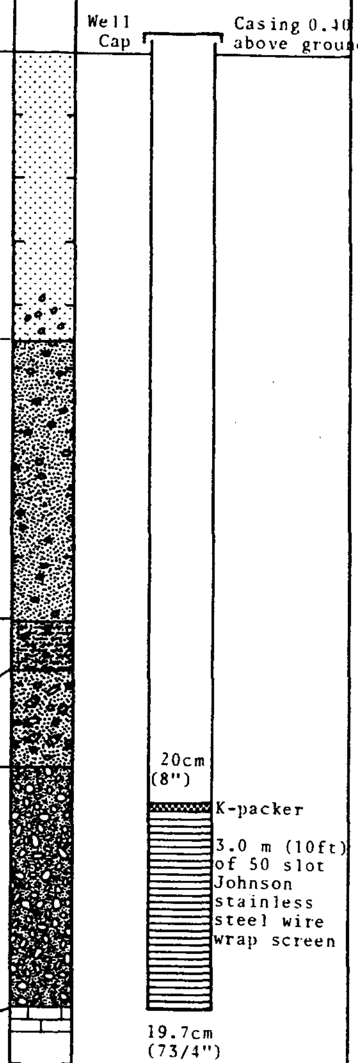
TW4 | 27 March 1986

PROJECT Chesterville Water Supply
PROJECT NO. W1500

DRILLING METHODS Cable Tool
SUPERVISOR I. Macdonald
DRILLING CONTRACTOR Olympic Drilling

DEPTH METRES	ELEVATION METRES	STRATIGRAPHY & HYDROSTRATIGRAPHY
0 – 4.6m		Sand: light brown, fine to medium grained with 5% coarse sand to fine gravel -1 to 3 mm - gravel increases in percentage and size with depth - at 4.6 m gravel is 15% and 10 mm in diameter
4.6m – 9.1m		Gravel and sand: light brown to dark grey gravel with clasts up to 5 cm in a medium to coarse grained sand matrix
9.1m – 9.7m		Clay: dark grey plastic clay with 20% coarse sand and fine gravel
9.7m – 11.2m		Sand and gravel: dark grey/black fine grained sand with 30% fine gravel 2 to 5 mm
11.2m – 15.2m		Gravel: coarse grained, subrounded to sub-angular gravel and cobbles up to 12 cm in a dark grey, coarse sand matrix - <2% clay fillings adhering to the gravel - most gravel 4- 7 cm in diameter
15.2m –		Bedrock

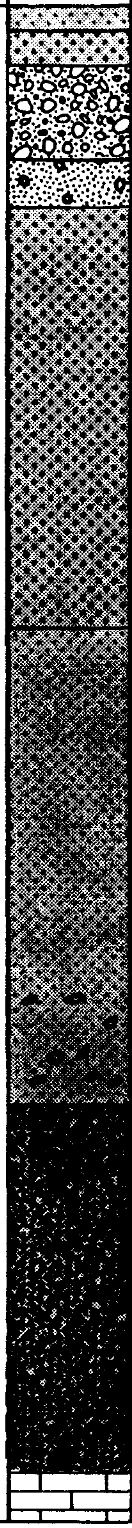
LOG / INSTRUMENTATION



SAMPLING		
TYPE	INTERVAL	N VALUE

WATER AND EARTH SCIENCE ASSOCIATES LTD.

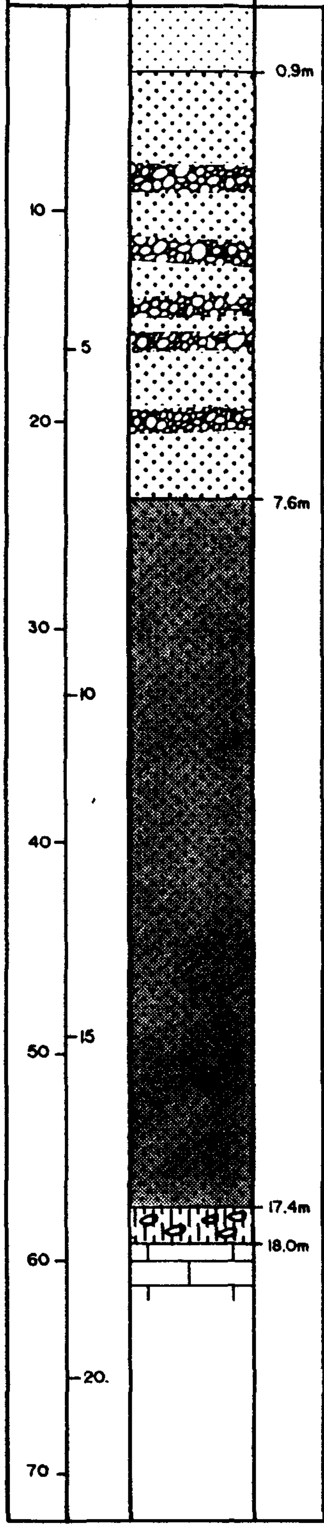
FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 1

DEPTH ft	DEPTH m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
			0.15m	SAND: med. grained, dark brown, organic rich, roots	3.18cm (1¼") PVC PIPE 0.46cm (1½") SCREEN WITH NYTEX WRAP TIP AT 24.1m (79'2")
			0.91m	SAND: med. to coarse grained, dark brown	
			2.4m	GRAVEL: cobble to boulder with coarse sand matrix	
10			3.3m	GRAVEL: pebble to cobble with caorse sand matrix	
20	5		10.6m	SAND: coarse, dark brown, homogeneous and very cohesive	
30, 40, 50	10, 20		18.0m	SAND: medium, dark grey, occasional clasts up to 2cm (.75") in the bottom sections	
60, 70	30		24.5m	TILL: silty dark grey matrix with gravel clasts up to 5cm (2")	
80				BEDROCK	

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 2

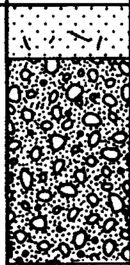
DEPTH (ft / m)	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
0 – 0.9m		SAND; fine to medium grained; light brown organic rich	3.18cm (1¼") PVC PIPE 0.46m (1½') SCREEN WITH NYTEX WRAP. TIP AT 18.0m (59')
0.9m – 7.6m		SAND & GRAVEL: coarse grained, dark brown sand interbedded with cobble to boulder size gravel. Gravel decreases in size and bed thickness in lower sections	
7.6m – 17.4m		SAND: medium grained, dark brown to grey; easy drilling - no gravel clasts	
17.4m – 18.0m		SILT & GRAVEL: fine grained silt with pebble gravel clasts	
18.0m –		BEDROCK	



WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 3

DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER



Depth	Geologic log	Piezometer
0 – 0.6m	SAND: fine to medium grained, light brown, some roots	3.18cm (1¼") PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP. TIP AT 3.8m (12')
0.6m – 3.6m	SAND AND GRAVEL: coarse sand matrix with cobble to boulder gravel	
3.6m	BOULDER OR BEDROCK: refusal at 3.6m (12')	

Depth scale — ft: 10, 20, 30, 40, 50, 60, 70; m: 5, 10, 15, 20

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 4

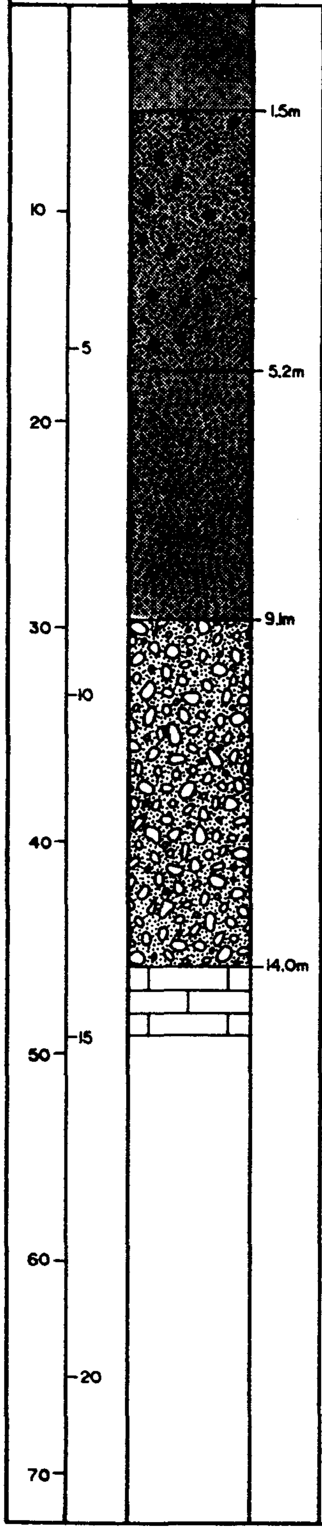
DEPTH ft m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
0			SAND: medium grained, light brown, few roots	1.2cm (1/2") PVC PIPE
		0.6m	SAND & GRAVEL: coarse sand matrix with gravel up to 10cm in diameter. Hole caved in at 3.4m (11')	10cm (4") SCREEN WITH NYTEX WRAP. TIP AT 2.4m (8')
20 ft		6.2m	BOULDER OR BEDROCK: refusal at 6.2m (20')	

Depth scale: ft 10, 20, 30, 40, 50, 60, 70; m 5, 10, 15, 20

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 5

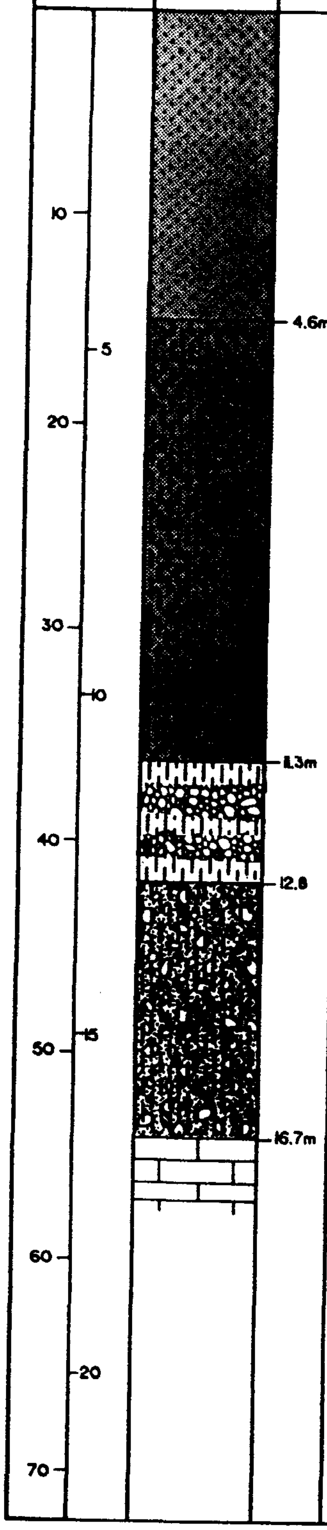
DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
		SAND: medium grained dark brown, no organics	3.18cm (1½") PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP TIP AT 12.0m (39'6")
1.5m		SAND & GRAVEL: medium grained, dark brown sand with 2.5cm (1") to 5.1cm (2") pebble gravel layers	
5.2m		SAND: very coarse grained, dark grey/black; 2.4m (8') ran up the augers	
9.1m		SAND & GRAVEL: coarse sand interbedded with 15.2cm (6") to 20.3cm (8") beds of cobble to boulder gravel	
14.0m		BEDROCK	



WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 6

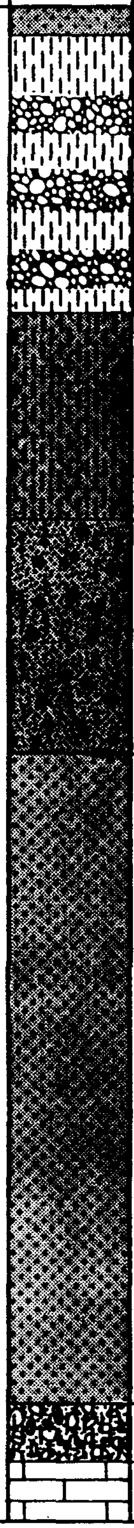
DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
		SAND: fine to medium grained, dark grey / brown, very wet	3.18cm (1¼") PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP TIP AT 16.6m (54'6")
4.6m		SAND & SILT: fine grained sand, dark brown/grey mixed with grey silt	
11.3m		SILT & GRAVEL: silt interbedded with 5.1cm (2") to 10.2cm (4") gravel beds	
12.8		TILL: silt, sand and pebble clasts	
16.7m		BEDROCK	



WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 7

DEPTH ft m | **DRILLERS LOG** | **GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE** | **PIEZOMETER**



Depth (base)	Geologic Log and Well Completion Technique
0.5m	SAND: fine grained, dark brown organic rich
5.2m	SILT & GRAVEL: silt interbedded with 5.1cm (2") to 10.2cm (4") gravel beds; gravel beds decrease in thickness in lower sections
7.6m	SAND & SILT: fine grained sand mixed with silt, dark brown
11.0m	SAND & GRAVEL: medium grained sand, dark brown, with some silt mixed with a pebble gravel
20.4m	SAND: coarse grained, dark grey/black
21.8m	TILL: grey silt with up to 5cm (2") gravel clasts
	BEDROCK

PIEZOMETER

3.18cm (1¼") PVC PIPE

0.3cm (⅛") SCREEN WITH NYTEX WRAP

TIP AT 20.7m (66'10")

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 8

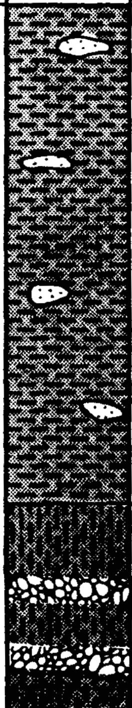
DEPTH ft m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
10, 5, 20			CLAY: grey mottled with light brown fine grained sand lenses	3.18cm (1¼") PVC PIPE 0.3cm (r) SCREEN WITH NYTEX WRAP TIP AT 10m (32'10")
30, 10		7.0m	SILT & GRAVEL: fine silt, dark grey with 5.1cm (2") to 7.6cm (3") pebble gravel beds; could be till	
40, 15, 50, 60, 20, 70		10.0m	BOULDER OR BEDROCK: refusal at 10.0m (32.8')	

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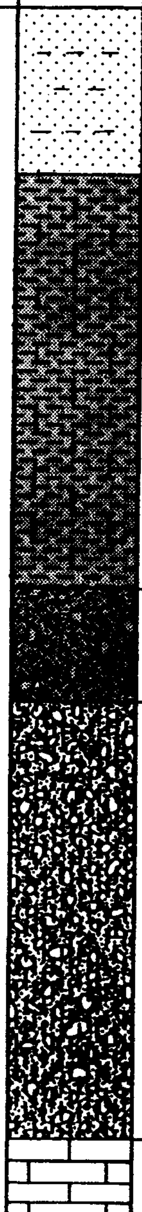
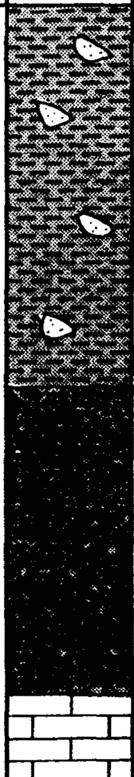
FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 14

DEPTH ft m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
			SAND: fine grained, light brown with <1cm (0.4") lenses of grey clay	3.18cm (1¼") PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP TIP AT 11.0m (36')
10 ft; 5 m; 20 ft		2.4m	SILT & CLAY light brown silt mixed with dark grey clay	
30 ft		8.2m	GRAVEL: medium gravel within a coarse sand dark brown matrix	
10 m; 40 ft; 15 m; 50 ft		10.0m	TILL: fine grained sand and silt mixed with boulders up tp 25cm (10") in diameter; very wet for a till	
60 ft; 20 m; 70 ft		16.5m	BEDROCK	



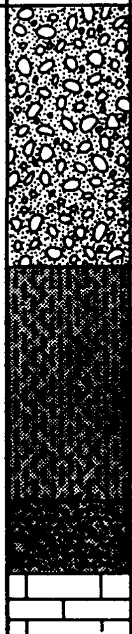
WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 15

DEPTH ft m	DRILLERS LOG		GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
ft: 10, 20, 30, 40, 50, 60, 70 m: 5, 10, 15, 20			CLAY: dark grey clay with <1cm (0.4") lenses of light brown fine sand	NO PIEZOMETER
		5.5m	TILL: dark grey clay with pebble to cobble gravel mixed in	
		10.0	BEDROCK	

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 16



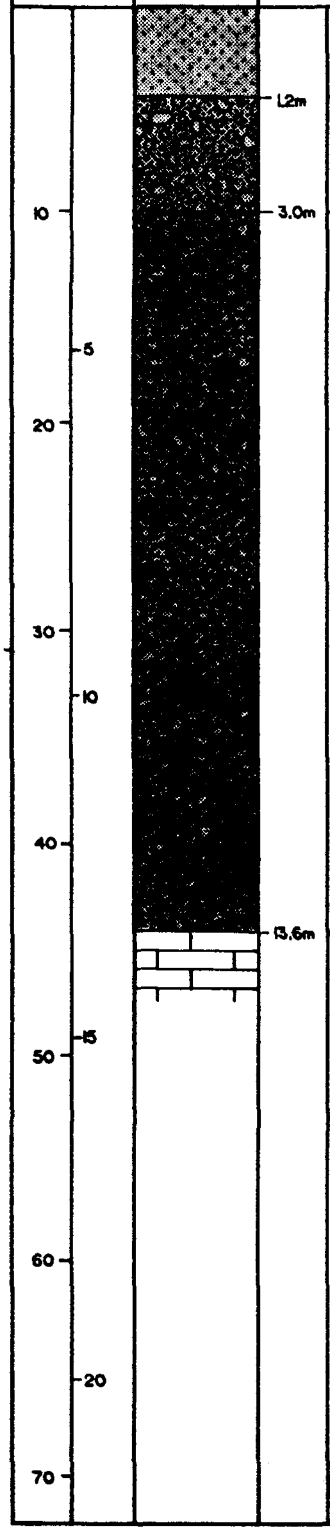
DEPTH ft	DEPTH m	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
0–3.7m		SAND & GRAVEL: fine grained brown sand and silt mixed with gravel clasts up to 5cm (2") in diameter	3.18cm (1¼") PVC PIPE 0.3cm ($\frac{1}{8}$") SCREEN WITH NYTEX WRAP TIP AT 7.0m (23')
3.7m–7.0m		SAND: fine grained silty sand, dark brown	
7.0m–8.2m		TILL: grey clay with sand layers mixed with pebble gravel clasts	
8.2m		BEDROCK	

Depth scale: ft 10, 20, 30, 40, 50, 60, 70; m 5, 10, 15, 20

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 17

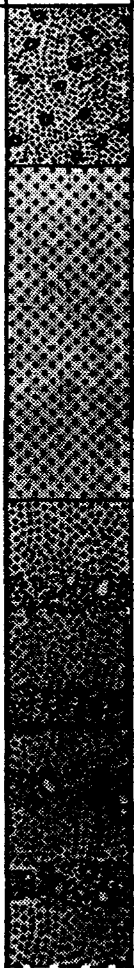
DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
0		**SAND:** medium grained, black, very organic rich bottom 0.7m (2'3") a dark brown	3.18cm (1¼") PVC PIPE 0.6m (2') SCREEN WITH NYTEX WRAP TIP AT 6.0m (20')
1.2m		**SAND & GRAVEL:** medium grained, dark brown sand with pebble gravel (35%) very dry	
3.0m		**TILL:** dark grey clay matrix with cobble to boulder size clasts	
13.6m		**BEDROCK**	



WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 18

DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER



Depth scale: 10, 20, 30, 40, 50, 60, 70 ft; 5, 10, 15, 20 m

2.2m

7.6m

14.3m

SAND & GRAVEL: dark brown, medium grained sand with 2.5cm (1") gravel layers

SAND: dark brown, medium to coarse grained, homogeneous sand

SAND & GRAVEL: dark grey/black coarse sand with 2.5cm (1") to 5.1cm (2") gravel layers. Stopped at 14.3m (47') due to sand running up augers

3.18cm ($1\frac{1}{4}$") PVC PIPE

0.3m (1') SCREEN WITH NYTEX WRAP

TIP AT 14.2m (46'6")

WATER AND EARTH SCIENCE ASSOCIATES LTD.

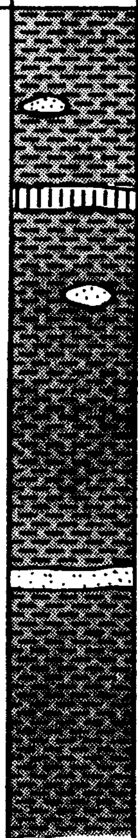
FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 19

DEPTH ft	DEPTH m	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
0–10	0–3.0m	SAND: dark brown, medium grained homogeneous sand	3.18cm (1¼) PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP TIP AT 7.8m (25'7")
10–20	3.0m–6.1m	SAND & GRAVEL: dark brown, medium grained sand with gravel up to 2cm (.75") mixed throughout	
20–30	6.1m–9.1m	SAND & GRAVEL: dark grey /black coarse grained sand with 2.5cm (1") gravel layers; sand up augers and rods always stuck; pulled augers at 9.1m	

Depth scale: ft 10, 20, 30, 40, 50, 60, 70; m 5, 10, 15, 20

WATER AND EARTH SCIENCE ASSOCIATES LTD.

FIGURE	RECORD OF TEST HOLE	ELEVATION	DRILLHOLE 20

DEPTH ft m	DRILLERS LOG	GEOLOGIC LOG AND WELL COMPLETION TECHNIQUE	PIEZOMETER
10, 20, 30, 40, 50, 60, 70 (ft); 5, 10, 15, 20 (m)		CLAY: dark grey plastic clay with occasional sand lense and sand or silt layer augers pulled at 12.2m (40')	3.18cm (1¼") PVC PIPE 0.3m (1') SCREEN WITH NYTEX WRAP TIP AT 11.8m (38'7")
40		12.2m	

WATER AND EARTH SCIENCE ASSOCIATES LTD.

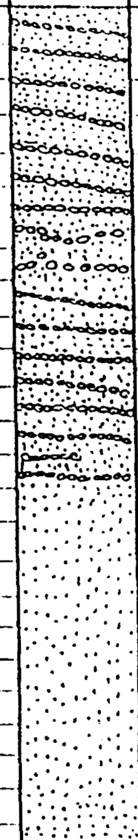
APPENDIX B

MNR BOREHOLE LOGS

DATE Nov/11/86 DRILL HOLE # 32 DRILL TYPE H.S. RECORDER G.G.

STATION Maple Ridge area. Osgoode Pit, east side where foresets are found. UTM 4778 49933 7.0 m face

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data: Sample #	Blows	Depth
0-1	small layers of snd and grvl, clasts 3-5 cm. snd 200-16					
1-2	ditto					
2-3	ditto					
3-4	+25% stn, clasts 2-10cm watertable at 4.0 m					
4-5	fgrvl and fmsnd layers, snd 200-30 grvl < 5cm					
5-6	ditto					
6-7	layered mfsnd and fgrvl, < 5%stn, snd 200-50 some 30 clasts <5cm					
7-8	very dense fsnd, 200-100 some 50					
8-9	ditto					
9-10	vfsnd, 200-100					
10-11	ditto					
11-12	ditto, slightly coarser snd. 200-50 pulled augers at 12.2m					



DATE Nov/11/86 DRILL HOLE # 33 DRILL TYPE H.S. RECORDER G.G.

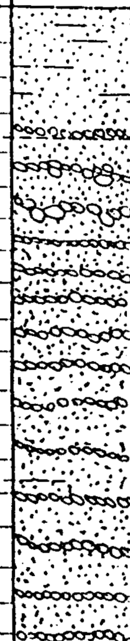
STATION Maple Ridge Body. Osgoode pit, west side, by stockpile.
4 metres has been removed. UTM 4776 49933

DEPTH	DESCRIPTION(Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	rhythmites of fsnd and silty-clay watertable at 0.9m					
1-2	ditto					
2-3	ditto, snd 200-100, layers 2-6cm.					
3-4	ditto					
4-5	ditto					
5-6	ditto to 5.2m then layered cmsnd and fgrvl, snd 100-16, clasts < 5cm					
6-7	ditto, layers 5-25cm.			1	8-38-29	6.1
7-8	layered msnd and fgrvl, <15% stn, snd 100-30, clasts <5cm.					
8-9	ditto to 8.2m, then layered msnd and fsnd, 100-30 and 200-100					
9-10	ditto			2	5-11-11	9.1
10-11	ditto to 10.7 and then saturated fsnd 200-50, some 30					
11-12	coarser snd, 100-16, small layers of fgrvl, clasts <5mm					
12-13	ditto, layers 5-15cm.			3	5-11-14	12.2
13-14	ditto					
14-15	ditto to 14.3, then till					
15-16	till			4	7-2-19	15.2
16-17	till					
17-18	ditto to 17.7m, then rfsl, probably bedrock			5	------	17.2

DATE Nov/12/86 DRILL HOLE # 34 DRILL TYPE H.S. RECORDER G.G.

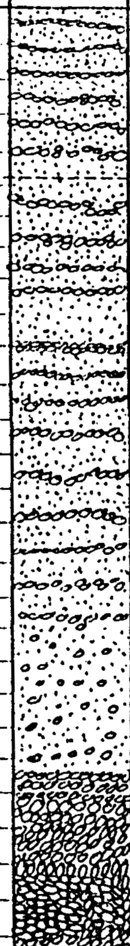
STATION Maple Ridge Body. Osgoode Pit, bottom of front east portion, east of scales, 6.5m face UTM 4778 49932

DEPTH	DESCRIPTION(Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	silty-sand					
1-2	ditto to 1.5m then +20% grvl and csnd,					
	in layers, snd 100-16, clasts to 10cm					
2-3	ditto, but clasts are larger, up to 25cm.					
3-4	vcsnd and fgrvl in layers, snd 100-16 clasts 5-15cm, layers 5-30cm					
4-5	ditto, +20% grvl, layers 5-30cm.					
				1	5-40-4	4.6
5-6	ditto					
6-7	ditto to 6.1m them <10% stn and msnd					
	layers, snd 200-30	P				
7-8	ditto					
				2	11-24-40	7.6
8-9	ditto, pulled augers at 9.1m					
	piezometer installed at 6.7m					



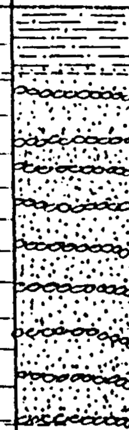
DATE Nov/12/86 DRILL HOLE # 35 DRILL TYPE H.S. RECORDER G.G.

STATION Maple Ridge Body. Monast Pit, north of tracks, just west of trees, on pit floor(south side of pit), 1.5m face UTM 4778 499385

DEPTH	DESCRIPTION(Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data Sample #	Blows	Depth
0-1	+35%stn, and vcsnd in layers, snd 100-16, clasts 2-5cm, snd coarsenes downw.					
1-2	ditto, but clasts are larger 2-20cm. layers 5-30cm					
2-3	ditto, water table at 2.4m.					
3-4	ditto					
4-5	ditto to 4.3m. then msnd, 200-30, some 16 grvl layers at 5.0m			1	3-5-22	4.6
5-6	Layered +25% grvl and csnd, layers 5-25cm, clasts 2-8cm, snd 100-16					
6-7	layered csnd and fgrvl, clasts <5mm and snd 100-16					
7-8	ditto to 7.6m , then layered msnd and fgrvl, <10% stn, clast<1cm, 200-16 snd			2	8-9-13	7.6
8-9	ditto, layers 5-20 cm.					
9-10	<5 stn, fmsnd 200-30 some 16, clasts <5mm					
10-11	ditto			3	2-2-7	10.7
11-12	ditto to 11.1 then grvl layers					
12-13	ditto					
13-14	ditto to 13.7 and then pulled augers					

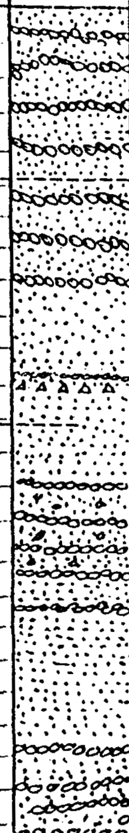
DATE Nov/13/86 DRILL HOLE # 36 DRILL TYPE H.S. RECORDER G.G.

STATION Maple Ridge Body. Monast property, north of pit in unopened area, just south of the fence line. UTM 4777 49939

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	rhythmites of clayey-silt to 0.9m.,					
	then layered +25% grvl, clasts 2-8cm					
1-2	ditto, layered snd and grvl, clasts 2-					
	8cm cmsnd 100-16, layers 5-25cm.					
2-3	ditto					
3-4	ditto					
4-5	ditto					
5-6	ditto, pulled augers at 6.1m.					
		p				
	piezometer installed at 6.1m.					

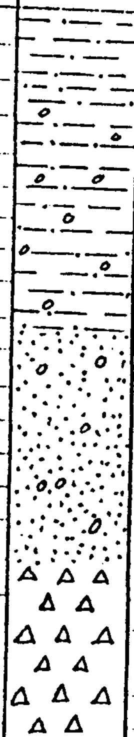
DATE Nov/13/86 DRILL HOLE # 37 DRILL TYPE H.S. RECORDER G.G.

STATION Maple Ridge Body. Property east of Monast's property, north of tracks, within trees. On pit floor UTM 47795 49939

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	layered msnd and +25% grvl, snd 200-30					
	clasts 2-5cm., layers 5-25cm.					
1-2	ditto					
2-3	ditto, water table at 2.4m.					
3-4	ditto except the grvl is +20%					
4-5	ditto to 4.1m. then msnd, 200-30					
5-6	ditto to 5.2m then layered +20% grvl					
	and msnd layers to 5.5m, then sm. till					
6-7	fsnd layers to 6.7m., 200-100; then	p		1	17-41-	6.1
	csnd and fgrvl layers, 100-16 and <5cm				39	
7-8	vcsnd and fgrvl layers, snd 100-16 and					
	clasts <2.5cm, layers 2-10cm.					
8-9	ditto					
9-10	mainly msnd and vcsnd layers, 200-30			2	11-45-	9.1
	and 100-16, layers 5-25cm (c. thicker)				53	
10-11	ditto to 10.7m. then layered +20%					
	fgrl and csnd layers, 100-16, stns<2.5cm					
11-12	ditto					
12-13	ditto, pulled augers at 12.2m.					
	piezometer installed at 6.1m					

DATE Nov/13/86 DRILL HOLE # 38 DRILL TYPE H.S. RECORDER G.G.

STATION Monast Property, Maple Ridge. North of tracks, west portion of property. 50 m north of CPR tracks. UTM 4774 49937

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	clayey-silt					
1-2	ditto, few stns, < 5cm					
2-3	ditto					
3-4	ditto,					
4-5	ditto to 4.7m, then vfsnd 200-100 with occasional stn., clasts < 5cm.					
5-6	ditto					
6-7	ditto			1	18-25-32	6.1
7-8	ditto					
8-9	ditto to 8.5m. then till					
9-10	till					
10-11	clayey-silt till to 10.7 and then pulled augers			2	39-72-rfsl	10.7

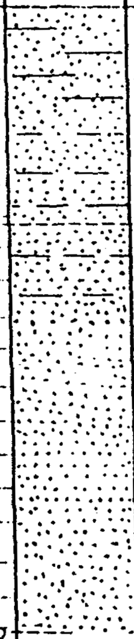
[illegible] 39 DRILL TYPE H.S. RECORDER G.G.

STATION Monast Property, Maple Ridge. Front pit, east side, 3-4 m. removed. East of pit access road. UTM 4779 49936

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	silty-clay, occasional stn, clasts <5cm					
1-2	ditto, few stn. layers which are <2.5cm.					
2-3	ditto, water table at 2.9m.					
3-4	layered fsnd and mcsnd; fsnd 200-100 csnd 100-16, layers 5-15cm.					
4-5	ditto					
5-6	ditto			1	15-24-30	4.6
6-7	ditto					
7-8	layered fsnd and csnd, fsnd 200-100 csnd 100-16,					
8-9	ditto to 8.2m. the fsnd, 200-100 some 50			2	4-3-2	7.6
9-10	ditto					
10-11	ditto to 10.7, then fmsnd 200-30					
11-12	ditto			3	5-6-12	10.7
12-13	ditto to 12.2 and then pulled augers			4	3-8-12	12.2

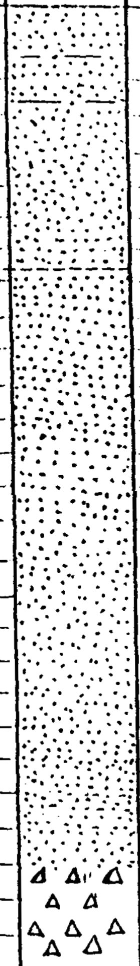
DATE NOV/13/80 DRILL HOLE # 40 DRILL TYPE H.S. RECORDER G.G.

STATION Monast Property, Maple Ridge. Southwest corner, just north of barn; 3.5-4m. face. UTM 4778 499325

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	silty-sand; 200-100					
1-2	ditto to 1.5m., the basically the same except for small silt layers					
2-3	ditto, silt layers < 1cm.					
3-4	ditto, water table at 3.2m.					
4-5	ditto to 4.6m., then fsnd 200-100 some 50, 30			1	13-23-22	4.6
5-6	ditto, occasional stn. <5 cm.					
6-7	ditto					
7-8	ditto			2	1-1-10	7.6
8-9	ditto to 9.1m and then pulled augers			3	7-9-3	9.1
		P				
	piezometer installed at 9.1m.					

STATION Maple Ridge Body, pit south of Highway # 43. Middle, west portion of Pit, 3m. face. UTM 4~~17~~775 49930

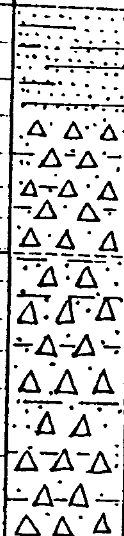
DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data Sample #	Blows	Depth
0-1	fsnd, 200-100; type B ripples, few smallsilt layers (drapes) <1.5cm.					
1-2	ditto, except that there are a few small csnd layers, <1cm 100-16					
2-3	ditto					
3-4	ditto, water table at 3.8m.					
4-5	ditto			1	4-8-11	4.6
5-6	ditto					
6-7	ditto					
7-8	ditto			2	5-16-29	7.6
8-9	ditto					
9-10	ditto					
10-11	ditto			3	6-1-3	10.7
11-12	ditto					
12-13	ditto to 12.5m. then till					
13-14	ditto to 13.7 and then pulled augers			4	69-110	13.7



DRILL TYPE ______ RECORDER

STATION North of the Maple Ridge Body. On farmers access road, south of Boyd, just south of the farm to the west. UTM 4777 499485

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	tpsl, silty sand, 200-100					
1-2	ditto to 1.4 m., then till sandy-silt till					
2-3	ditto					
3-4	ditto, water table at 3.6m.					
4-5	ditto					
5-6	ditto,					
6-7	ditto					
7-8	ditto, pulled augers at 7.6m.					

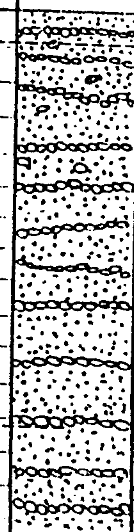


STATION North of the Maple Ridge Body. On the farmers access road, south of Boyd, west (south(?)) of the farm to the west. UTM 4777 499485, 200n of DH 42

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	silty sand to 0.8 then sandy silt till					
1-2	till					
2-3	ditto					
3-4	ditto					
4-5	ditto to 4.6m. and then pulled augers					

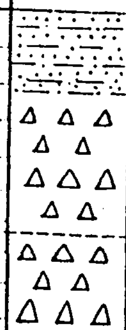
BOREHOLE # 44 DRILL TYPE H.S. RECORDER G.G.

STATION Provost Pit, south of Morewood. UTM 4766 49999.6m removed

DEPTH	DESCRIPTION(Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	+30% layered mfgrvl and csnd, snd 100-16, clasts 2-8cm.;wt at 0.4m.					
1-2	ditto, layers 5-30 cm.					
2-3	ditto					
3-4	ditto					
4-5	ditto					
5-6	ditto					
6-7	ditto	P				
7-8	ditto to 7.6m. and then pulled augers					
	piezometer installed at 6.1m.					

[illegible] G.G.

STATION Farm east of the Winchester dump, west of Boyd.
UTM 4771 49948

DEPTH	DESCRIPTION (Colour, Texture, Moisture, etc.)	WT	Material Diagram	Hollow Stem Data		
				Sample #	Blows	Depth
0-1	rhythmites of fsnd and silt, snd 200-100, layers 1-3cm.					
1-2	ditto to 1.2m. then a sandy-silt till					
2-3	till					
3-4	ditto, watertable at 3.2m.					
4-5	ditto to 4.6 m. and then pulled augers					
				1	50-69	4.6

APPENDIX C

STEP-DRAWDOWN DATA AND CALCULATIONS

AQUIFER TEST DATA WELL#: TW5

Type of aquifer test: step drawdown
How Q Measured: orifice weir
Distance from pumping well: 0.10 m
Meas. point for w. l.'s: 1.07 m
Elevation of Measuring Pt.:
Static Water Level: 1.58

Well type: pumping
Data type: pumping
Depth pump: 9.1 m
Pump on: 12:30 30-04-87
Pump off: 15:00 30-04-87
Discharge rate: various

	Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Drawdown
Q=125 IGPM	1	1	2.55	0.97
	2	2	2.57	0.99
	3	3	2.59	1.01
	4	4	2.59	1.01
	5	5	2.60	1.02
	6	6	2.60	1.02
	7	7	2.60	1.02
	8	8	2.60	1.02
	9	9	2.60	1.02
	10	10	2.60	1.02
	12	12	2.60	1.02
	14	14	2.61	1.03
	16	16	2.61	1.03
	18	18	2.61	1.03
	20	20	2.61	1.03
	25	25	2.61	1.03
	30	30	2.61	1.03
Q=200 IGPM	1	31	3.24	1.66
	2	32	3.27	1.69
	3	33	3.27	1.69
	4	34	3.27	1.69
	5	35	3.28	1.70
	6	36	3.29	1.71
	7	37	3.29	1.71
	8	38	3.29	1.71
	9	39	3.29	1.71
	10	40	3.29	1.71
	12	42	3.29	1.71
	14	44	3.29	1.71
	16	46	3.30	1.72
	18	48	3.30	1.72
	20	50	3.30	1.72
	25	55	3.31	1.73
	30	60	3.31	1.73
Q=300 IGPM	1	61	4.20	2.62
	2	62	4.20	2.62
	3	63	4.21	2.63
	4	64	4.22	2.64
	5	65	4.23	2.65
	6	66	4.23	2.65

AQUIFER TEST DATA WELL#: TW5

Type of aquifer test:	step drawdown	Well type:	pumping
How Q Measured:	orifice weir	Data type:	pumping
Distance from pumping well:	0.10 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on: 12:30	30-04-87
Elevation of Measuring Pt.:		Pump off:15:00	30-04-87
Static Water Level:	1.58	Discharge rate:	various

	Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Drawdown
	7	67	4.23	2.65
	8	68	4.23	2.65
	9	69	4.23	2.65
	10	70	4.23	2.65
	12	72	4.23	2.65
	14	74	4.23	2.65
	16	76	4.23	2.65
	18	78	4.23	2.65
	20	80	4.24	2.66
	25	85	4.24	2.66
	30	90	4.24	2.66
Q=400 IGPM	1	91	5.15	3.57
	2	92	5.18	3.60
	3	93	5.20	3.62
	4	94	5.20	3.62
	5	95	5.21	3.63
	6	96	5.21	3.63
	7	97	5.21	3.63
	8	98	5.22	3.64
	9	99	5.22	3.64
	10	100	5.23	3.65
	12	102	5.23	3.65
	14	104	5.23	3.65
	16	106	5.23	3.65
	18	108	5.24	3.66
	20	110	5.24	3.66
	25	115	5.24	3.66
	30	120	5.24	3.66
Q=452 IGPM	1	121	5.61	4.03
	2	122	5.61	4.03
	3	123	5.62	4.04
	4	124	5.63	4.05
	5	125	5.64	4.06
	6	126	5.64	4.06
	7	127	5.64	4.06
	8	128	5.64	4.06
	9	129	5.64	4.06
	10	130	5.64	4.06
	12	132	5.64	4.06
	14	134	5.64	4.06

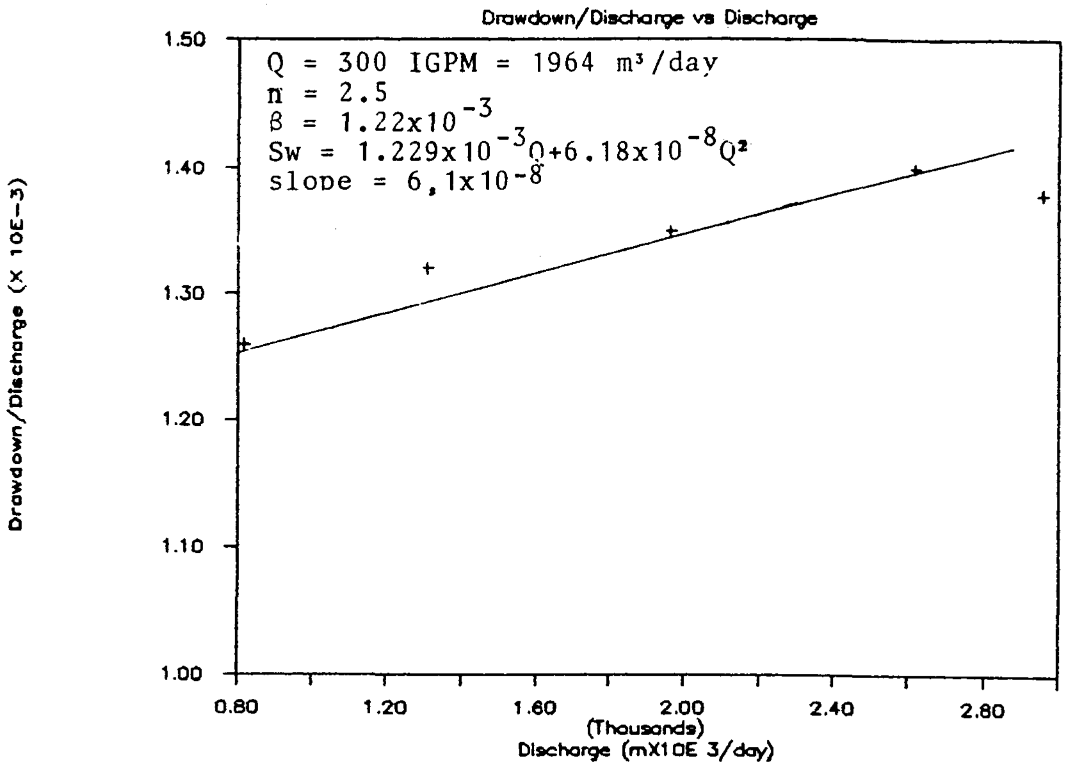
AQUIFER TEST DATA WELL#: TW5

Type of aquifer test: step drawdown
How Q Measured: orifice weir
Distance from pumping well: 0.10 m
Meas. point for w. l.'s: 1.07 m
Elevation of Measuring Pt.:
Static Water Level: 1.58

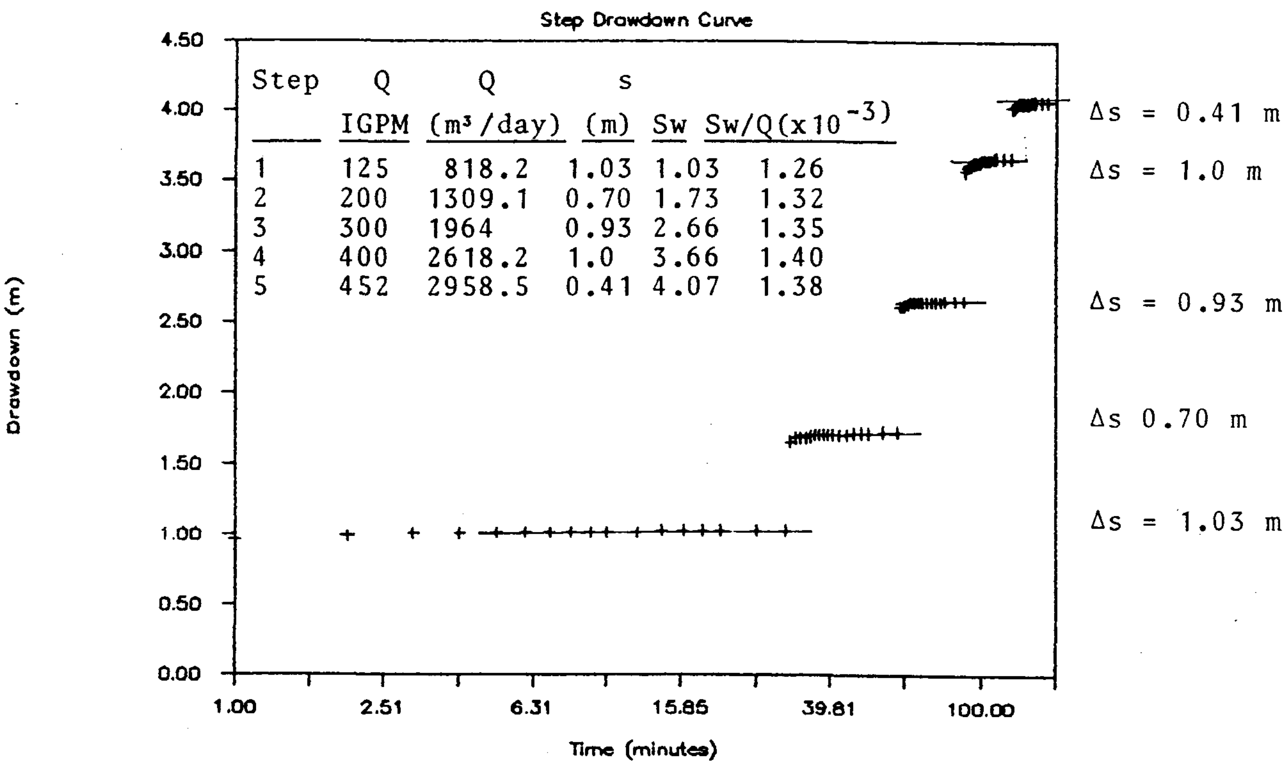
Well type: pumping
Data type: pumping
Depth pump: 9.1 m
Pump on: 12:30 30-04-87
Pump off: 15:00 30-04-87
Discharge rate: various

Time minutes for each step	Time minutes total	Water Level Data w.l. (m)	Drawdown
16	136	5.65	4.07
18	138	5.65	4.07
20	140	5.65	4.07
25	145	5.65	4.07
30	150	5.65	4.07

TW5 Step−Drawdown



TW 5



Sw (theoritical) = $1.229 \times 10^{-3} Q + 6.18 \times 10^{-8} Q^2$

at Q = 300 IGPM

= 1964 m^3/day

= $1.229 \times .10^{-3} (1964) + 6.18 \times 10^{-8} (1964)^2$

= 2.65 m

Sw actual) = 2.97 m (from the 72 hour test)

W.E. = $\frac{\text{Sw (theoritical)}}{\text{Sw (actual)}}$

= $\frac{2.65}{2.97}$

= 89%

AQUIFER TEST DATA JOB#1500 WELL#: P2

Type of aquifer test:	COST. Q	Well type:	OBSERVAT.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	900 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.54 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:3[illegible]
Static Water Level:	9.28	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
64	9.63	0.35
173	9.55	0.27
297	9.43	0.15
411	9.31	0.03
547	9.18	-0.1
653	9.1	-0.18
827	9.05	-0.23
883	8.99	-0.29
1012	8.99	-0.29
1193	9.07	-0.21
1295	9.21	-0.07
1418	9.36	0.08
1536	9.38	0.1
1673	9.25	-0.03
1731	9.22	-0.06
1850	9.18	-0.1
1974	9.11	-0.17
2093	9.06	-0.22
2209	9.02	-0.26
2325	8.98	-0.3
2455	8.98	-0.3
2567	9	-0.28
2678	9.17	-0.11
2796	9.35	0.07
2901	9.4	0.12
3037	9.28	0
3176	9.49	0.21
3304	9.31	0.03
3546	9.12	-0.16
3780	9.03	-0.25
4020	9.05	-0.23
4235	9.33	0.05

AQUIFER TEST DATA JOB#1500 WELL#: P13

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	690 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.29 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	2.47	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
108	2.47	0
168	2.47	0
291	2.47	0
405	2.49	0.02
535	2.48	0.01
645	2.48	0.01
823	2.48	0.01
891	2.48	0.01
1021	2.51	0.04
1178	2.5	0.03
1283	2.49	0.02
1406	2.49	0.02
1522	2.49	0.02
1663	2.5	0.03
1722	2.5	0.03
1842	2.5	0.03
1965	2.51	0.04
2085	2.53	0.06
2204	2.53	0.06
2315	2.53	0.06
2445	2.53	0.06
2561	2.52	0.05
2673	2.52	0.05
2791	2.52	0.05
2901	2.52	0.05
3030	2.53	0.06
3171	2.53	0.06
3299	2.53	0.06
3540	2.53	0.06
3784	2.54	0.07
4012	2.56	0.09
4230	2.56	0.09

AQUIFER TEST DATA JOB#1500 WELL#: P18

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:		Depth pump:	9.1 m
Meas. point for w. l.'s:	0	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	4.03	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
20	4.02	-0.01
57	4.02	-0.01
117	4.01	-0.02
304	4.01	-0.02
419	4.01	-0.02
558	4.01	-0.02
682	4.01	-0.02
840	4.01	-0.02
894	4.01	-0.02
1176	3.99	-0.04
1279	3.99	-0.04
1403	3.99	-0.04
1517	3.99	-0.04
1660	3.99	-0.04
1741	4	-0.03
1982	4	-0.03
2104	4.01	-0.02
2332	4.01	-0.02
2460	4.01	-0.02
2575	4.01	-0.02
2697	4.01	-0.02
2807	4.01	-0.02
2917	4.01	-0.02
3045	4.01	-0.02
3181	4.01	-0.02
3311	4.02	-0.01
3789	4.01	-0.02
4026	4.01	-0.02

AQUIFER TEST DATA JOB#1500 WELL#: P19

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	210 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.95 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	3.09	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
12.5	3.21	0.12
25	3.21	0.12
34	3.22	0.13
48	3.23	0.14
77	3.25	0.16
138	3.26	0.17
185	3.27	0.18
238	3.28	0.19
312	3.29	0.2
359	3.3	0.21
427	3.31	0.22
496	3.32	0.23
559	3.33	0.24
605	3.33	0.24
672	3.34	0.25
775	3.34	0.25
841	3.34	0.25
905	3.35	0.26
963	3.36	0.27
1033	3.38	0.29
1090	3.37	0.28
1197	3.38	0.29
1264	3.39	0.3
1324	3.39	0.3
1389	3.4	0.31
1503	3.41	0.32
1645	3.41	0.32
1751	3.43	0.34
1795	3.43	0.34
1870	3.43	0.34
1993	3.44	0.35
2115	3.45	0.36
2225	3.45	0.36
2346	3.47	0.38
2474	3.47	0.38
2525	3.47	0.38
2586	3.48	0.39
2706	3.49	0.4
2816	3.49	0.4
2926	3.5	0.41
3052	3.5	0.41
3190	3.51	0.42
3320	3.51	0.42

AQUIFER TEST DATA   JOB#1500   WELL#: P19

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	210 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.95 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	3.09	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
3416	3.52	0.43
3561	3.53	0.44
3800	3.55	0.46
3912	3.55	0.46
4036	3.57	0.48
4147	3.57	0.48
4255	3.58	0.49

AQUIFER TEST DATA JOB#1500 WELL#: P20

Type of aquifer test: CONST. Q Well type: OBSERV.
How Q Measured: ORIF.WEIRData type: PUMPING
Distance from pumping well:270 m Depth pump: 9.1 m
Meas. point for w. l.'s: 0.6 m Pump on: 04-05-87 13:30
Elevation of Measuring Pt.: Pump off: 07-05-87 13:30
Static Water Level: 2.61 Discharge rate: 300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
14.5	2.63	0.02
27	2.64	0.03
50	2.66	0.05
75	2.67	0.06
150	2.68	0.07
183	2.69	0.08
236	2.7	0.09
310	2.7	0.09
357	2.7	0.09
425	2.71	0.1
487	2.71	0.1
559	2.71	0.1
602	2.72	0.11
672	2.72	0.11
767	2.72	0.11
847	2.72	0.11
904	2.74	0.13
961	2.75	0.14
1033	2.76	0.15
1095	2.76	0.15
1165	2.76	0.15
1200	2.76	0.15
1270	2.76	0.15
1328	2.77	0.16
1396	2.77	0.16
1508	2.78	0.17
1652	2.79	0.18
1748	2.8	0.19
1793	2.8	0.19
1867	2.8	0.19
2114	2.81	0.2
2222	2.81	0.2
2342	2.82	0.21
2473	2.83	0.22
2524	2.83	0.22
2585	2.83	0.22
2703	2.84	0.23
2814	2.84	0.23
3050	2.85	0.24
3188	2.86	0.25
3319	2.86	0.25
3414	2.87	0.26
3559	2.88	0.27

AQUIFER TEST DATA JOB#1500 WELL#: P20

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	270 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.6 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	2.61	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
3808	2.89	0.28
3910	2.89	0.28
4033	2.9	0.29
4141	2.9	0.29
4256	2.91	0.3

AQUIFER TEST DATA JOB#1500 WELL#: M1

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	10 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.10 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	0.59	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
0.5	0.6	0.01
1	0.6	0.01
2	0.605	0.015
3	0.62	0.03
4	0.63	0.04
5	0.64	0.05
6	0.65	0.06
7	0.65	0.06
8	0.66	0.07
9	0.66	0.07
10	0.67	0.08
12	0.68	0.09
14	0.69	0.1
16	0.7	0.11
18	0.71	0.12
20	0.72	0.13
25	0.73	0.14
30	0.74	0.15
35	0.75	0.16
40	0.76	0.17
47	0.77	0.18
50	0.78	0.19
70	0.785	0.195
80	0.785	0.195
105	0.79	0.2
187	0.805	0.215
214	0.805	0.215
327	0.815	0.225
362	0.82	0.23
434	0.825	0.235
468	0.83	0.24
565	0.835	0.245
611	0.835	0.245
645	0.84	0.25
781	0.85	0.26
853	0.855	0.265
917	0.865	0.275
967	0.865	0.275
1107	0.875	0.285
1212	0.875	0.285
1303	0.885	0.295
1427	0.895	0.305
1553	0.905	0.315

AQUIFER TEST DATA JOB#1500 WELL#: M1

Type of aquifer test: CONST. Q Well type: OBSERV.
How Q Measured: ORIF.WEIRData type: PUMPING
Distance from pumping well: 10 m Depth pump: 9.1 m
Meas. point for w. l.'s: 0.10 m Pump on: 04-05-87 13:30
Elevation of Measuring Pt.: Pump off: 07-05-87 13:30
Static Water Level: 0.59 Discharge rate: 300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
1640	0.905	0.315
1726	0.92	0.33
1800	0.925	0.335
1882	0.925	0.335
2005	0.925	0.335
2049	0.925	0.335
2125	0.93	0.34
2228	0.94	0.35
2355	0.95	0.36
2485	0.95	0.36
2530	0.955	0.365
2595	0.955	0.365
2723	0.96	0.37
2826	0.96	0.37
2931	0.965	0.375
3070	0.97	0.38
3191	0.98	0.39
3328	0.99	0.4
3420	0.995	0.405
3565	1	0.41
3807	1.01	0.42
3916	1.015	0.425
4097	1.03	0.44
4212	1.04	0.45
4329	1.04	0.45

AQUIFER TEST DATA JOB#1500 WELL#: M2

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	105 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.11 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	0.47	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
45	0.445	-0.025
102	0.445	-0.025
324	0.445	-0.025
429	0.46	-0.01
677	0.49	0.02
853	0.49	0.02
909	0.49	0.02
1034	0.49	0.02
1152	0.5	0.03
1267	0.5	0.03
1393	0.505	0.035
1648	0.51	0.04
1746	0.51	0.04
1875	0.52	0.05
1999	0.52	0.05
2119	0.51	0.04
2171	0.51	0.04
2348	0.51	0.04
2588	0.515	0.045
2710	0.51	0.04
2818	0.51	0.04
2925	0.51	0.04
3055	0.51	0.04
3191	0.51	0.04
3323	0.51	0.04
3563	0.51	0.04
3802	0.51	0.04
4035	0.51	0.04
4261	0.525	0.055

AQUIFER TEST DATA JOB#1500 WELL#: M3

Type of aquifer test:	COST. Q	Well type:	OBSERVAT.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	728 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.10 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.89	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
96	1.89	0
178	1.89	0
301	1.89	0
423	1.88	-0.01
550	1.88	-0.01
660	1.88	-0.01
840	1.88	-0.01
887	1.88	-0.01
1015	1.88	-0.01
1184	1.88	-0.01
1289	1.88	-0.01
1410	1.88	-0.01
1527	1.88	-0.01
1667	1.88	-0.01
1735	1.88	-0.01
1855	1.88	-0.01
1978	1.88	-0.01
2097	1.88	-0.01
2341	1.88	-0.01
2455	1.88	-0.01
2570	1.88	-0.01
2692	1.845	-0.045
2804	1.845	-0.045
2913	1.865	-0.025
3040	1.845	-0.045
3180	1.845	-0.045
3307	1.885	-0.005
3548	1.885	-0.005
3793	1.88	-0.01
4034	1.88	-0.01
4240	1.875	-0.015

AQUIFER TEST DATA JOB#1500 WELL#: TW4

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	255 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.40 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.25	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
16.5	1.3	0.05
29	1.3	0.05
52	1.31	0.06
73	1.31	0.06
142	1.33	0.08
181	1.33	0.08
233	1.34	0.09
308	1.35	0.1
355	1.36	0.11
423	1.37	0.12
477	1.38	0.13
556	1.38	0.13
593	1.39	0.14
668	1.39	0.14
770	1.41	0.16
833	1.42	0.17
899	1.42	0.17
958	1.43	0.18
1027	1.43	0.18
1099	1.44	0.19
1169	1.45	0.2
1203	1.45	0.2
1274	1.45	0.2
1332	1.46	0.21
1399	1.47	0.22
1512	1.48	0.23
1654	1.49	0.24
1745	1.5	0.25
1792	1.51	0.26
1865	1.51	0.26
1990	1.53	0.28
2038	1.54	0.29
2107	1.54	0.29
2215	1.55	0.3
2338	1.56	0.31
2470	1.56	0.31
2520	1.57	0.32
2580	1.57	0.32
2699	1.58	0.33
2812	1.59	0.34
2922	1.59	0.34
3049	1.6	0.35
3184	1.61	0.36

AQUIFER TEST DATA JOB#1500 WELL#: TW4

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	255 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.40 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.25	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
3316	1.62	0.37
3412	1.62	0.37
3557	1.64	0.39
3793	1.65	0.4
3907	1.66	0.41
4029	1.66	0.41
4134	1.67	0.42
4253	1.68	0.43

AQUIFER TEST DATA JOB#1500 WELL#: TW5

Type of aquifer test:	CONST. Q	Well type:	PUMPING
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	0	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.63	Discharge rate:	300 IGPM

Time minutes	Water Level Data w.l. (m)	Drawdown
0.25	4.48	2.85
0.5	4.48	2.85
1	4.53	2.9
1.5	4.38	2.75
2	4.38	2.75
2.5	4.36	2.73
3	4.34	2.71
4	4.34	2.71
5	4.34	2.71
6	4.34	2.71
7	4.34	2.71
8	4.34	2.71
9	4.34	2.71
10	4.34	2.71
12	4.34	2.71
14	4.34	2.71
16	4.34	2.71
18	4.34	2.71
20	4.34	2.71
25	4.34	2.71
30	4.34	2.71
35	4.37	2.74
40	4.37	2.74
45	4.37	2.74
50	4.37	2.74
55	4.37	2.74
60	4.37	2.74
70	4.37	2.74
80	4.37	2.74
90	4.34	2.71
100	4.34	2.71
120	4.34	2.71
150	4.34	2.71
180	4.34	2.71
210	4.36	2.73
240	4.36	2.73
300	4.36	2.73
360	4.36	2.73
420	4.36	2.73
480	4.37	2.74
540	4.37	2.74
600	4.38	2.75
660	4.38	2.75

AQUIFER TEST DATA   JOB#1500   WELL#: TW5

Type of aquifer test:	CONST. Q	Well type:	PUMPING
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	0	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.63	Discharge rate:	300 IGPM

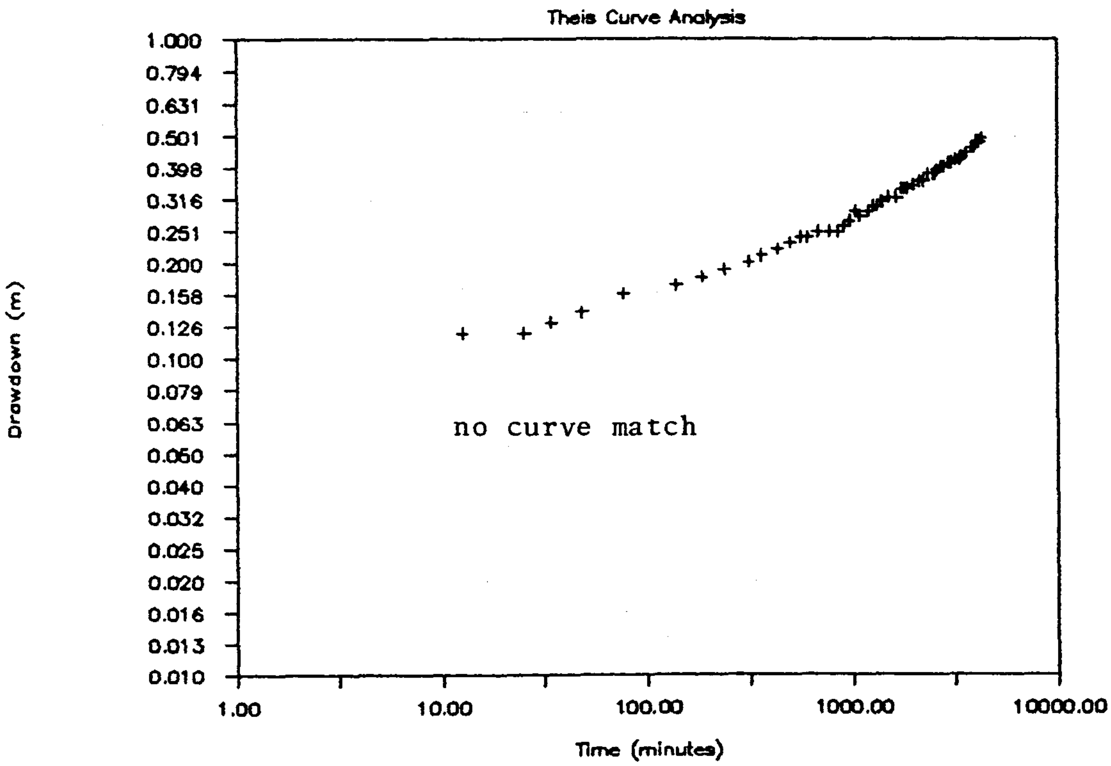
Time minutes	Water Level Data w.l. (m)	Drawdown
720	4.38	2.75
780	4.39	2.76
840	4.39	2.76
900	4.39	2.76
960	4.4	2.77
1020	4.41	2.78
1080	4.45	2.82
1140	4.46	2.83
1200	4.46	2.83
1260	4.46	2.83
1320	4.43	2.8
1380	4.44	2.81
1440	4.44	2.81
1500	4.44	2.81
1560	4.44	2.81
1620	4.44	2.81
1680	4.48	2.85
1740	4.46	2.83
1800	4.46	2.83
1860	4.46	2.83
1920	4.46	2.83
1980	4.47	2.84
2040	4.47	2.84
2100	4.47	2.84
2160	4.47	2.84
2220	4.46	2.83
2280	4.47	2.84
2340	4.48	2.85
2400	4.49	2.86
2460	4.5	2.87
2520	4.51	2.88
2580	4.51	2.88
2640	4.52	2.89
2700	4.53	2.9
2760	4.53	2.9
2820	4.54	2.91
2880	4.55	2.92
2940	4.55	2.92
3000	4.56	2.93
3060	4.56	2.93
3120	4.56	2.93
3180	4.61	2.98
3240	4.56	2.93

AQUIFER TEST DATA JOB#1500 WELL#: TW5

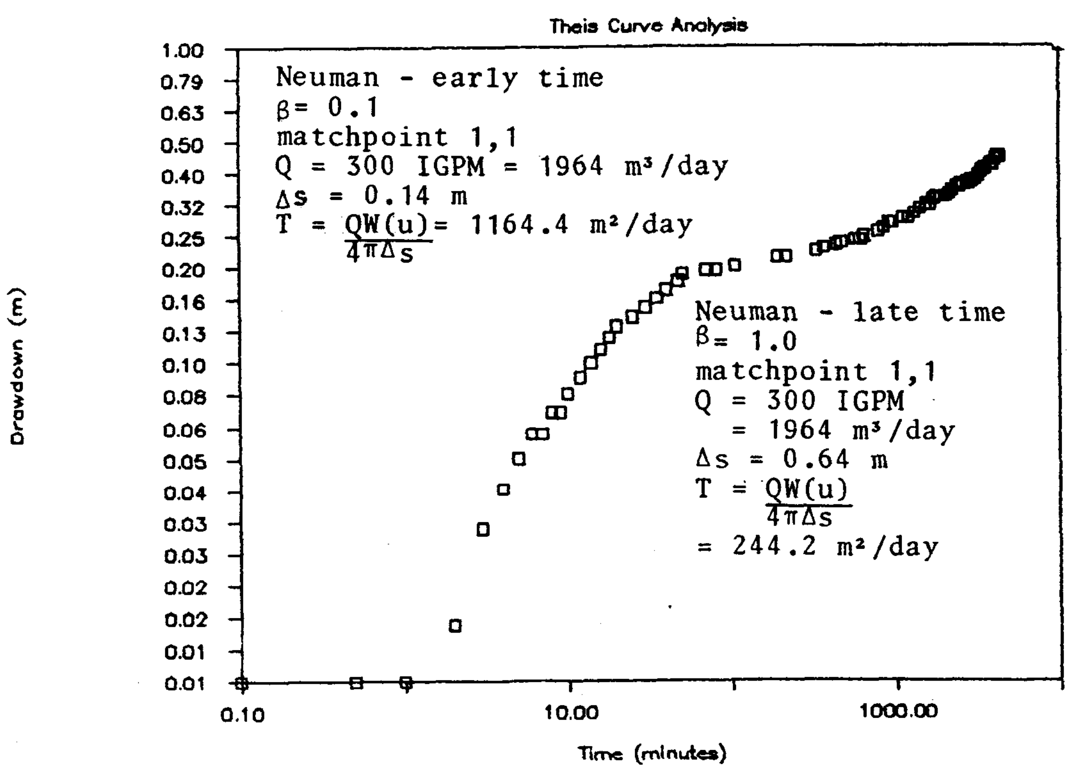
Type of aquifer test:	CONST. Q	Well type:	PUMPING
How Q Measured:	ORIF.WEIR	Data type:	PUMPING
Distance from pumping well:	0	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.63	Discharge rate:	300 IGPM

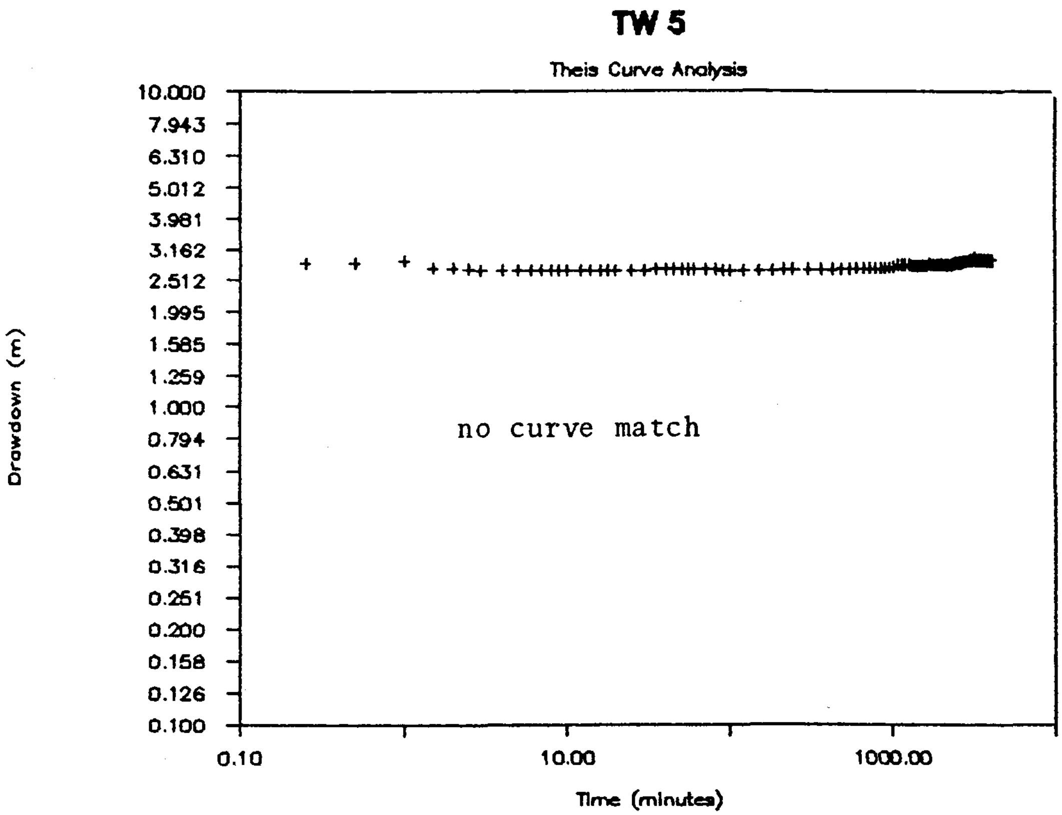
Time minutes	Water Level Data w.l. (m)	Drawdown
3300	4.56	2.93
3360	4.56	2.93
3420	4.57	2.94
3480	4.56	2.93
3540	4.56	2.93
3600	4.56	2.93
3660	4.56	2.93
3720	4.56	2.93
3780	4.56	2.93
3840	4.56	2.93
3900	4.56	2.93
3960	4.56	2.93
4020	4.57	2.94

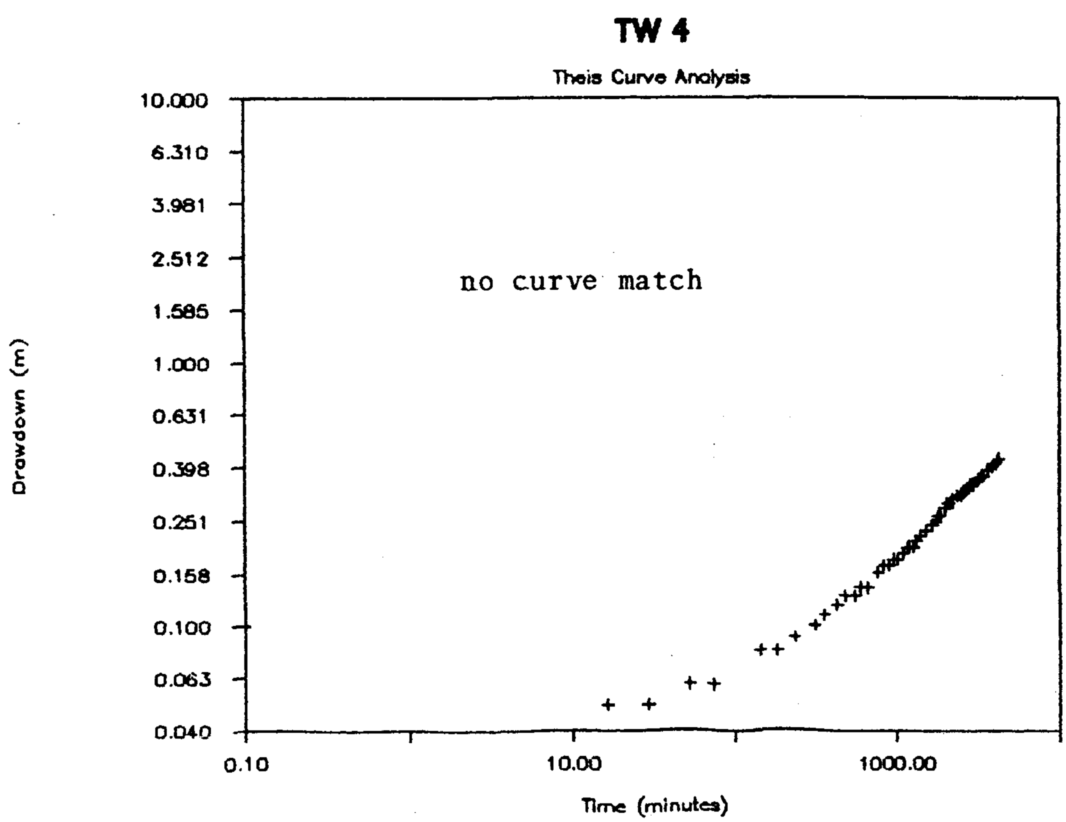
P 19

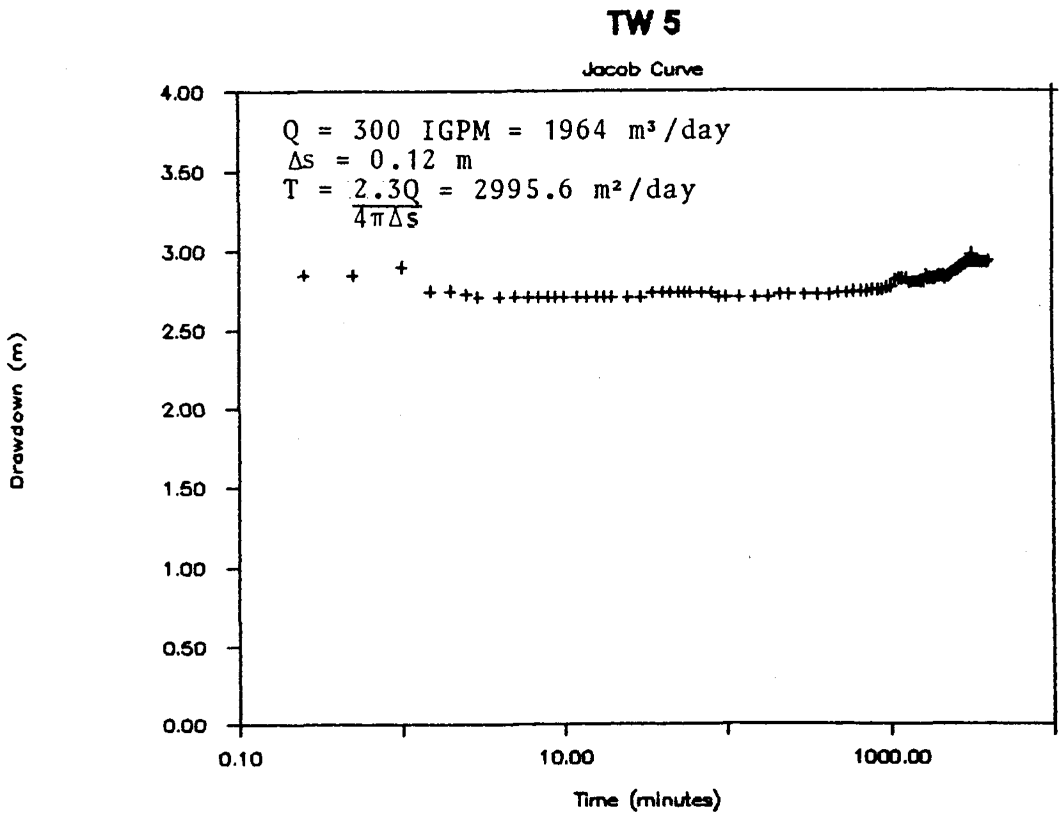

Theis Curve Analysis
Drawdown (m)
1.000
0.794
0.631
0.501
0.398
0.316
0.251
0.200
0.158
0.126
0.100
0.079
0.063
0.050
0.040
0.032
0.025
0.020
0.016
0.013
0.010
no curve match
1.00
10.00
100.00
1000.00
10000.00
Time (minutes)

M1

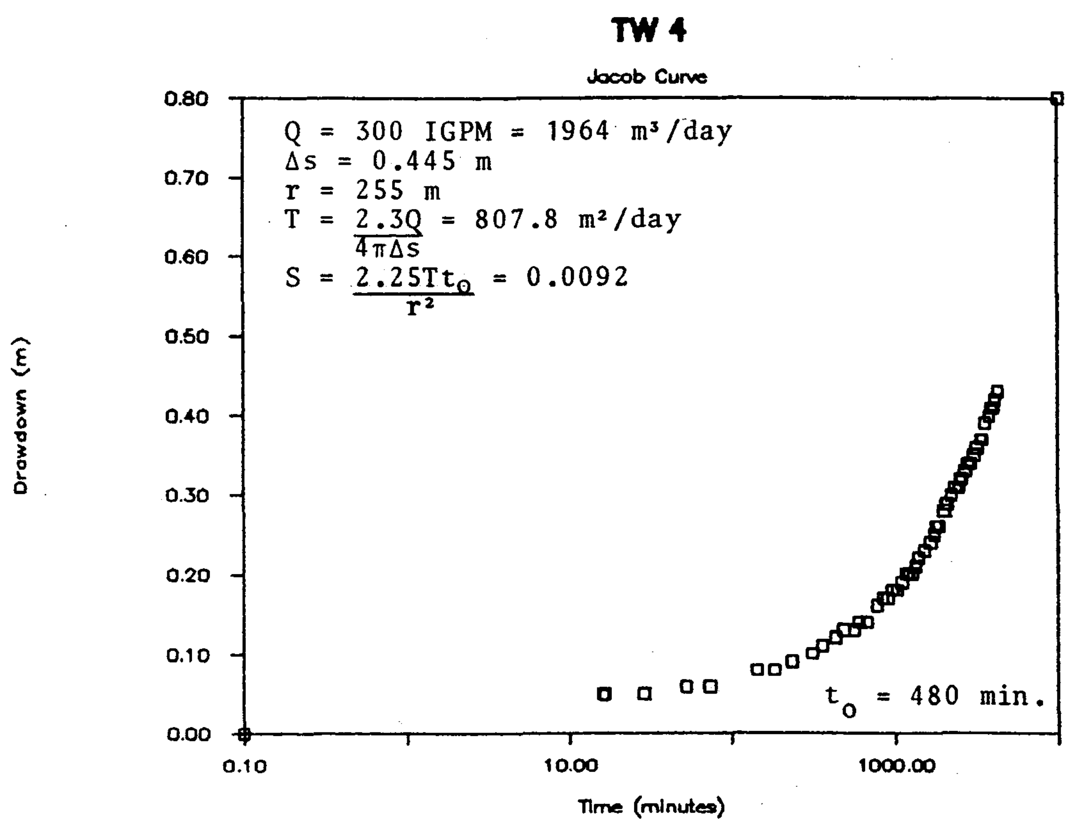

Theis Curve Analysis
Drawdown (m)
1.00
0.79
0.63
0.50
0.40
0.32
0.25
0.20
0.16
0.13
0.10
0.08
0.06
0.05
0.04
0.03
0.03
0.02
0.02
0.01
0.01
Neuman - early time
β= 0.1
matchpoint 1,1
Q = 300 IGPM = 1964 m³/day
Δs = 0.14 m
T = QW(u)/4πΔs = 1164.4 m²/day
Neuman - late time
β= 1.0
matchpoint 1,1
Q = 300 IGPM
= 1964 m³/day
Δs = 0.64 m
T = QW(u)/4πΔs
= 244.2 m²/day
0.10
10.00
1000.00
Time (minutes)


TW 5
Theis Curve Analysis
10.000
7.943
6.310
5.012
3.981
3.162
2.512
1.995
1.585
1.259
1.000
0.794
0.631
0.501
0.398
0.316
0.251
0.200
0.158
0.126
0.100
Drawdown (m)
no curve match
0.10
10.00
1000.00
Time (minutes)


TW 4
Theis Curve Analysis
10.000
6.310
3.981
2.512
1.585
1.000
0.631
0.398
0.251
0.158
0.100
0.063
0.040
Drawdown (m)
no curve match
0.10
10.00
1000.00
Time (minutes)

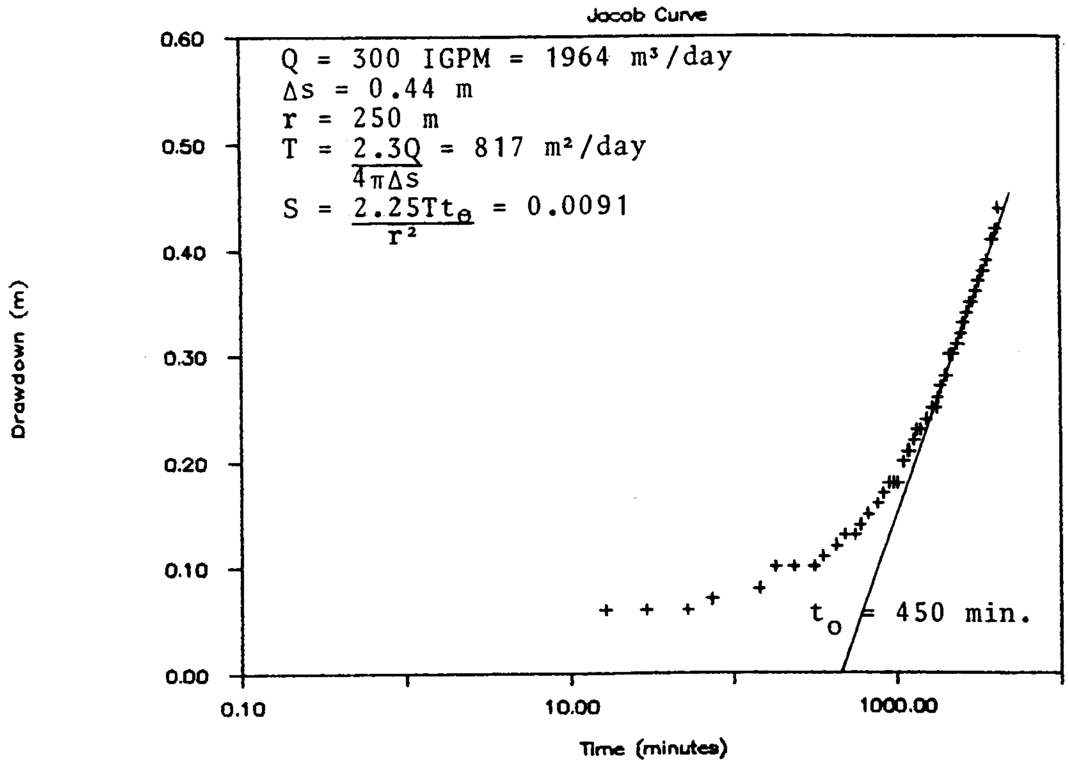


TW 5
Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.12 m
T = 2.3Q / 4πΔs = 2995.6 m²/day
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Drawdown (m)
0.10
10.00
1000.00
Time (minutes)

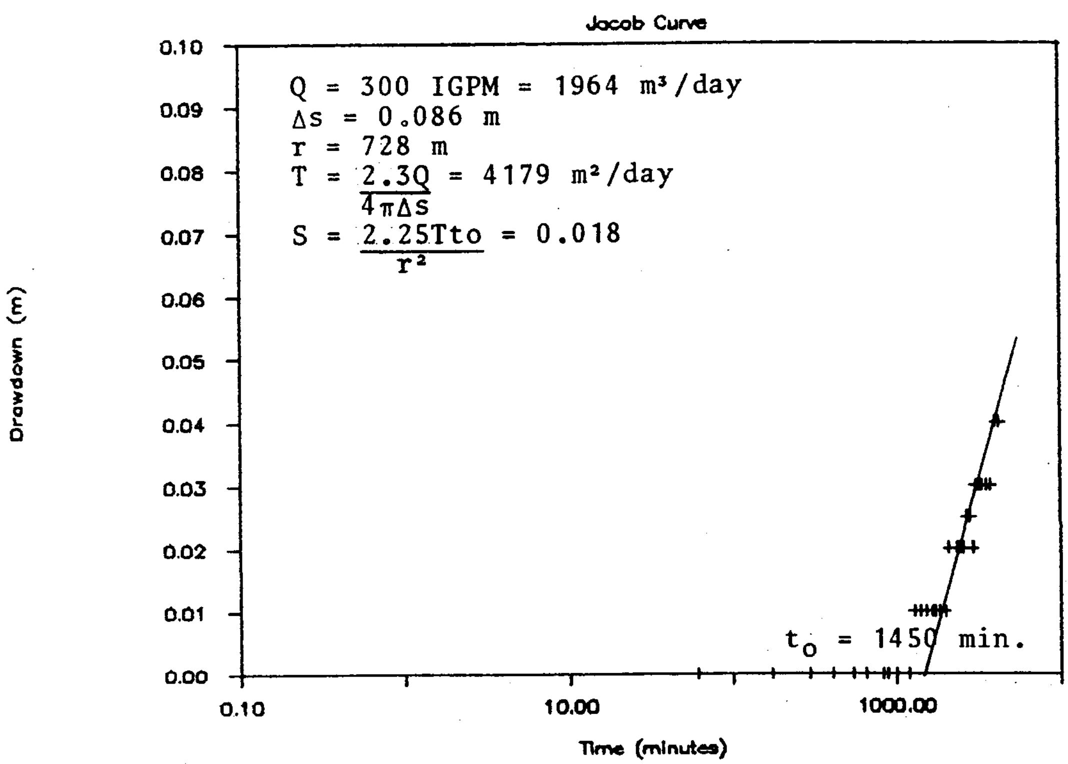


TW 4
Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.445 m
r = 255 m
T = 2.3Q / 4πΔs = 807.8 m²/day
S = 2.25Tt0 / r² = 0.0092
t0 = 480 min.
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Drawdown (m)
0.10
10.00
1000.00
Time (minutes)

P 5

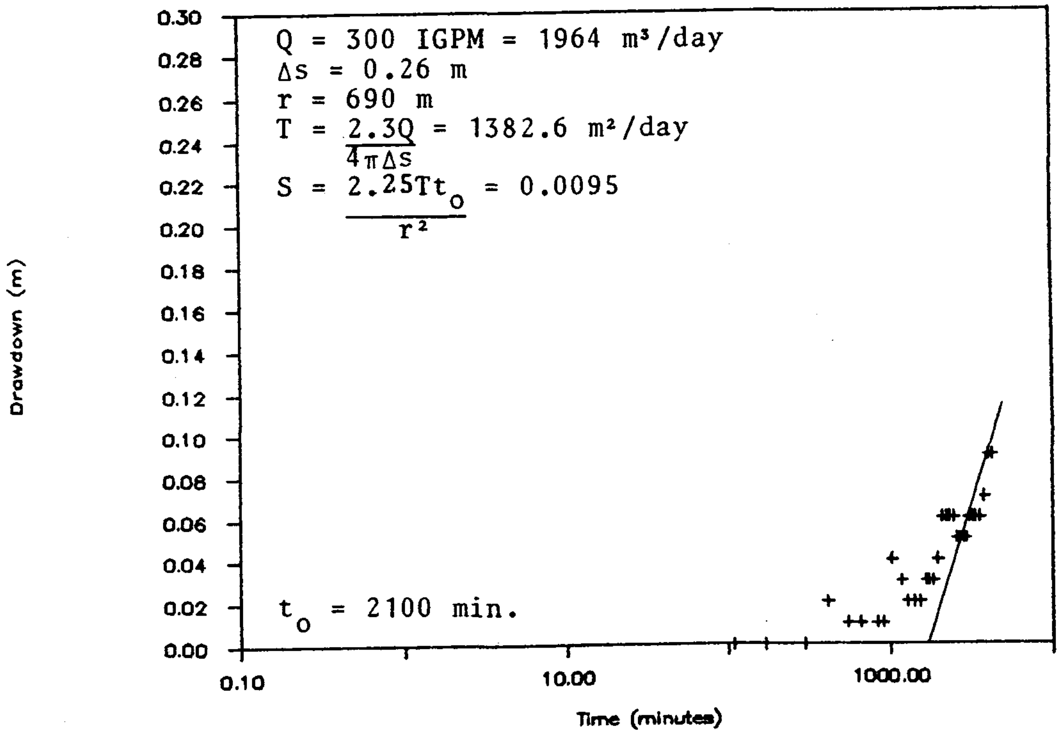

Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.44 m
r = 250 m
T = 2.3Q / 4πΔs = 817 m²/day
S = 2.25Tt₀ / r² = 0.0091
t₀ = 450 min.
Drawdown (m)
Time (minutes)
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.10
10.00
1000.00

P 7


Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.086 m
r = 728 m
T = 2.3Q / 4πΔs = 4179 m²/day
S = 2.25Tto / r² = 0.018
t₀ = 1450 min.
Drawdown (m)
Time (minutes)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.10
10.00
1000.00

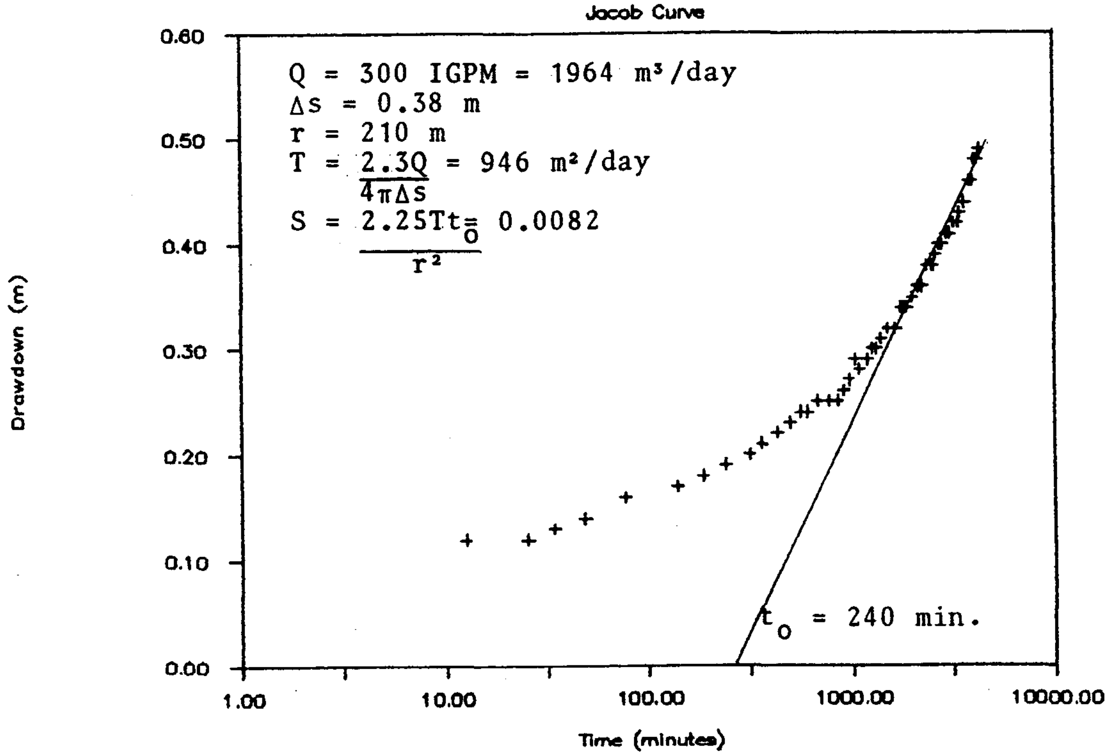
P 13

Jacob Curve

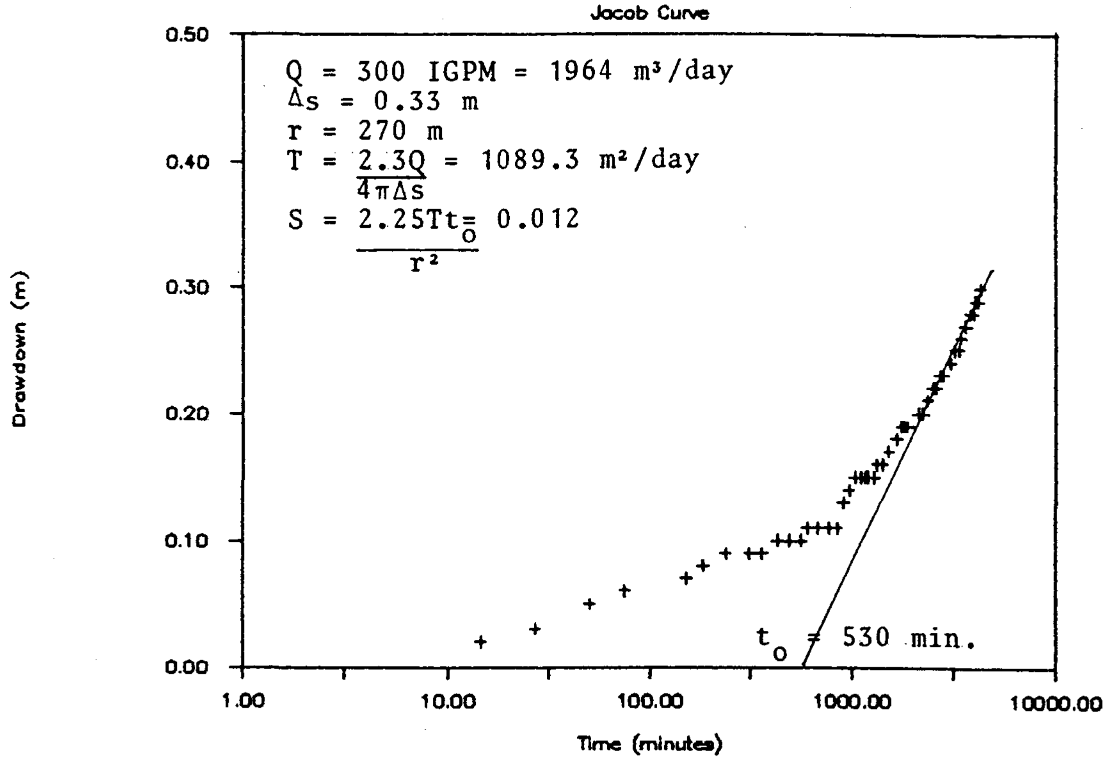


P 19

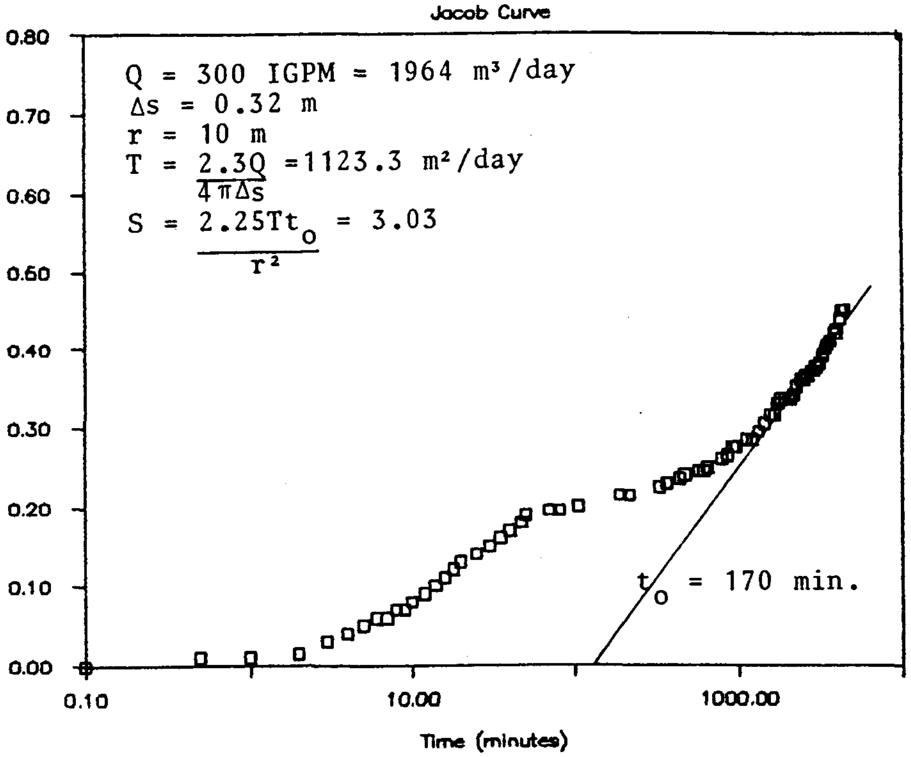
Jacob Curve



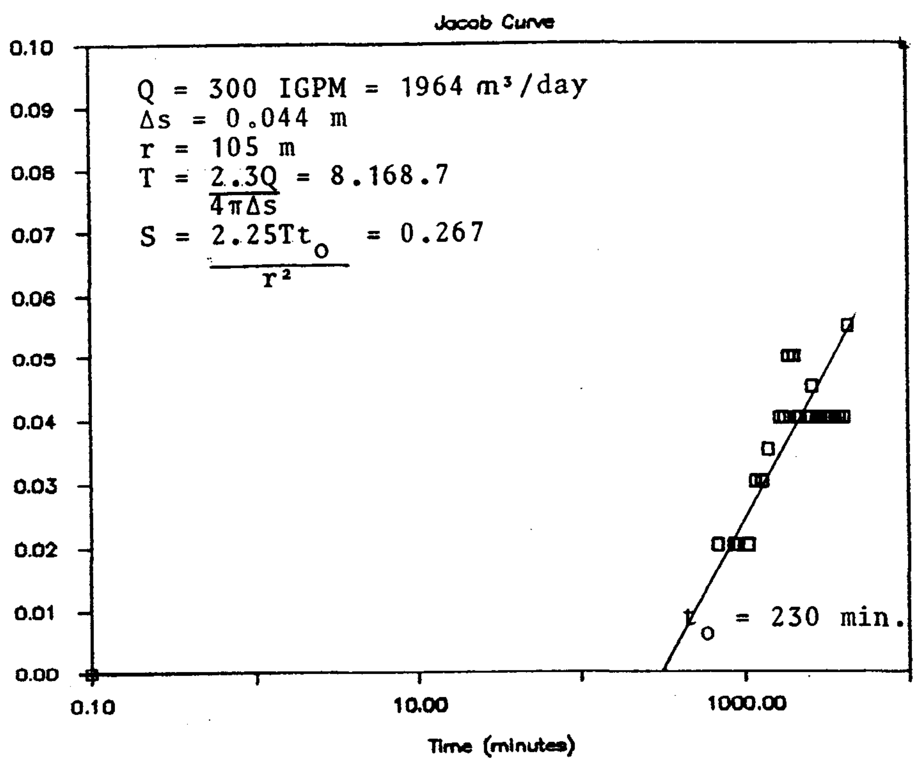
P 20


Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.33 m
r = 270 m
T = 2.3Q / 4πΔs = 1089.3 m²/day
S = 2.25Tt_o / r² = 0.012
t_o = 530 min.
0.50
0.40
0.30
0.20
0.10
0.00
Drawdown (m)
1.00
10.00
100.00
1000.00
10000.00
Time (minutes)

M1


Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.32 m
r = 10 m
T = 2.3Q/4πΔs =1123.3 m²/day
S = 2.25Tt₀/r² = 3.03
t₀ = 170 min.
Drawdown (m)
Time (minutes)
0.80
0.70
0.60
0.60
0.40
0.30
0.20
0.10
0.00
0.10
10.00
1000.00

M 2


Jacob Curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.044 m
r = 105 m
T = 2.3Q/4πΔs = 8.168.7
S = 2.25Tt₀/r² = 0.267
t₀ = 230 min.
Drawdown (m)
Time (minutes)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
0.10
10.00
1000.00

AQUIFER TEST DATA JOB#1500 WELL#: TW4

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	255 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.40 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.25	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
65	67.46153	1.62	0.37
85	51.82352	1.62	0.37
124	35.83870	1.61	0.36
185	24.35135	1.6	0.35
220	20.63636	1.6	0.35
275	16.70909	1.59	0.34
341	13.66862	1.59	0.34
365	12.83561	1.58	0.33
560	8.714285	1.56	0.31
801	6.393258	1.55	0.3
1024	5.21875	1.53	0.28
1212	4.564356	1.52	0.27
1445	3.989619	1.52	0.27

AQUIFER TEST DATA JOB#1500 WELL#: TW5

Type of aquifer test:	CONST. Q	Well type:	PUMPING
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	0.1 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	1.63	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
0.5	8641	2.22	0.59
1	4321	2.1	0.47
2	2161	2.04	0.41
2.5	1729	2.03	0.4
3	1441	2.02	0.39
3.5	1235.285	2.02	0.39
4	1081	2.01	0.38
4.5	961	2	0.37
5	865	2	0.37
6	721	1.99	0.36
7	618.1428	1.98	0.35
8	541	1.98	0.35
9	481	1.97	0.34
10	433	1.95	0.32
12	361	1.95	0.32
14	309.5714	1.95	0.32
16	271	1.97	0.34
18	241	1.97	0.34
20	217	1.96	0.33
25	173.8	1.95	0.32
30	145	1.95	0.32
35	124.4285	1.95	0.32
40	109	1.95	0.32
45	97	1.94	0.31
50	87.4	1.94	0.31
55	79.54545	1.94	0.31
60	73	1.93	0.3
70	62.71428	1.93	0.3
80	55	1.92	0.29
90	49	1.91	0.28
100	44.2	1.91	0.28
110	40.27272	1.91	0.28
120	37	1.91	0.28
150	29.8	1.91	0.28
180	25	1.91	0.28
210	21.57142	1.9	0.27
240	19	1.9	0.27
270	17	1.9	0.27
300	15.4	1.9	0.27
330	14.09090	1.9	0.27
360	13	1.89	0.26
390	12.07692	1.89	0.26
538	9.029739	1.88	0.25

AQUIFER TEST DATA JOB#1500 WELL#: TW5

Type of aquifer test:	CONST. Q	Well type:	PUMPING
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	0.1 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.07 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	1.63	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
790	6.468354	1.86	0.23
1037	5.165863	1.85	0.22
1190	4.630252	1.85	0.22
1440	4	1.84	0.21

AQUIFER TEST DATA JOB#1500 WELL#: P1

Type of aquifer test: CONST. Q
How Q Measured: ORIF.WEIR
Distance from pumping well: 728 m
Meas. point for w. l.'s: 0.65 m
Elevation of Measuring Pt.:
Static Water Level: 9.84

Well type: OBSERV.
Data type: RECOVERY
Depth pump: 9.1 m
Pump on: 04-05-87 13:30
Pump off: 07-05-87 13:30
Discharge rate: 300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
140	31.85714	8.31	-1.53
198	22.81818	8.3	-1.54
287	16.05226	8.3	-1.54
379	12.39841	8.28	-1.56
555	8.783783	8.26	-1.58
807	6.353159	8.22	-1.62
1015	5.256157	8.21	-1.63
1220	4.540983	8.24	-1.6
1458	3.962962	8.24	-1.6

AQUIFER TEST DATA JOB#1500 WELL#: P2

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	900 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.54 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	9.28	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
135	33	9.42	0.14
196	23.04081	9.32	0.04
284	16.21126	9.24	-0.04
376	12.48936	9.18	-0.1
550	8.854545	9.13	-0.15
813	6.313653	9.04	-0.24
1013	5.264560	9.01	-0.27
1225	4.526530	9.15	-0.13
1451	3.977257	9.15	-0.13

AQUIFER TEST DATA JOB#1500 WELL#: P5

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	250 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.58 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	1.55	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
65	67.46153	1.93	0.38
85	51.82352	1.93	0.38
124	35.83870	1.92	0.37
185	24.35135	1.91	0.36
220	20.63636	1.91	0.36
275	16.70909	1.9	0.35
341	13.66862	1.89	0.34
365	12.83561	1.89	0.34
560	8.714285	1.88	0.33
801	6.393258	1.85	0.3
1024	5.21875	1.84	0.29
1212	4.564356	1.83	0.28
1449	3.981366	1.82	0.27

AQUIFER TEST DATA WELL#: P6

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOV.
Distance from pumping well:	458 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.93 m	Pump on:	04-05-87 13:30:00
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30:00
Static Water Level:	2.06	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
67	65.47761	2.31	0.25
86	51.23255	2.31	0.25
127	35.01574	2.31	0.25
187	24.10160	2.33	0.27
218	20.81651	2.34	0.28
227	20.03083	2.35	0.29
338	13.78106	2.34	0.28
367	12.77111	2.34	0.28
558	8.741935	2.31	0.25
803	6.379825	2.27	0.21
1020	5.235294	2.25	0.19
1215	4.555555	2.24	0.18
1455	3.969072	2.23	0.17

AQUIFER TEST DATA WELL#: P7

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOV.
Distance from pumping well:	728 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.35 m	Pump on:	04-05-87 13:30:00
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30:00
Static Water Level:	10.32	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
133	33.48120	10.36	0.04
194	23.26804	10.37	0.05
285	16.15789	10.37	0.05
374	12.55080	10.37	0.05
547	8.897623	10.36	0.04
810	6.333333	10.36	0.04
1010	5.277227	10.36	0.04
1229	4.515052	10.36	0.04
1460	3.958904	10.36	0.04

AQUIFER TEST DATA WELL#: P13

Type of aquifer test:	CONST.Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOV.
Distance from pumping well:	690 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	1.29 m	Pump on:	04-05-87 13:30:00
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30:00
Static Water Level:	2.47	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
130	34.23076	2.53	0.06
191	23.61780	2.56	0.09
280	16.42857	2.56	0.09
370	12.67567	2.56	0.09
543	8.955801	2.55	0.08
815	6.300613	2.55	0.08
1017	5.247787	2.55	0.08
1231	4.509341	2.56	0.09
1453	3.973158	2.56	0.09

AQUIFER TEST DATA JOB#1500 WELL#: P18

Type of aquifer test: CONST. Q Well type: OBSERV.
How Q Measured: ORIF.WEIRData type: RECOVERY
Distance from pumping well: Depth pump: 9.1 m
Meas. point for w. l.'s: 0 m Pump on: 04-05-87 13:30
Elevation of Measuring Pt.: Pump off: 07-05-87 13:30
Static Water Level: 4.03 Discharge rate: 300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
144	31	4.01	-0.02
208	21.76923	4.01	-0.02
282	16.31914	4.02	-0.01
301	15.35215	4.02	-0.01
804	6.373134	4.02	-0.01
1018	5.243614	4.02	-0.01
1462	3.954856	4.02	-0.01

AQUIFER TEST DATA JOB#1500 WELL#: P19

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	210 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.95 m	Pump on:	04-05-87 13:30
Elevation of Measuring Pt.:		Pump off:	07-05-87 13:30
Static Water Level:	3.09	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
63	69.57142	3.44	0.35
81	54.33333	3.43	0.34
121	36.70247	3.43	0.34
181	24.86740	3.42	0.33
210	21.57142	3.41	0.32
275	16.70909	3.4	0.31
333	13.97297	3.4	0.31
361	12.96675	3.41	0.32
555	8.783783	3.37	0.28
797	6.420326	3.35	0.26
1028	5.202334	3.34	0.25
1199	4.603002	3.34	0.25
1438	4.004172	3.33	0.24

AQUIFER TEST DATA JOB#1500 WELL#: P20

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	270 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.60 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	2.61	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
69	63.60869	2.87	0.26
88	50.09090	2.87	0.26
122	36.40983	2.86	0.25
183	24.60655	2.85	0.24
217	20.90783	2.83	0.22
295	15.64406	2.83	0.22
335	13.89552	2.83	0.22
364	12.86813	2.84	0.23
553	8.811934	2.82	0.21
809	6.339925	2.81	0.2
1026	5.210526	2.81	0.2
1210	4.570247	2.81	0.2
1440	4	2.8	0.19

AQUIFER TEST DATA JOB#1500 WELL#: M1

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	10 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.1 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	0.59	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
7	618.1428	1.01	0.42
10	433	0.99	0.4
11	393.7272	0.98	0.39
12	361	0.975	0.385
14	309.5714	0.965	0.375
17	255.1176	0.965	0.375
19	228.3684	0.945	0.355
21	206.7142	0.945	0.355
23	188.8260	0.935	0.345
26	167.1538	0.92	0.33
31	140.3548	0.915	0.325
36	121	0.91	0.32
41	106.3658	0.9	0.31
46	94.91304	0.89	0.3
51	85.70588	0.89	0.3
56	78.14285	0.885	0.295
61	71.81967	0.885	0.295
71	61.84507	0.875	0.285
81	54.33333	0.87	0.28
90	49	0.87	0.28
100	44.2	0.865	0.275
110	40.27272	0.865	0.275
120	37	0.865	0.275
150	29.8	0.86	0.27
180	25	0.855	0.265
210	21.57142	0.855	0.265
240	19	0.855	0.265
270	17	0.85	0.26
300	15.4	0.85	0.26
330	14.09090	0.85	0.26
360	13	0.85	0.26
390	12.07692	0.85	0.26
537	9.044692	0.83	0.24
789	6.475285	0.83	0.24
1036	5.169884	0.82	0.23
1236	4.495145	0.82	0.23
1435	4.010452	0.81	0.22

AQUIFER TEST DATA JOB#1500 WELL#: M2

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	105 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.11 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	0.47	Discharge rate:	300 IGPM

At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
145	30.79310	0.52	0.05
200	22.6	0.52	0.05
295	15.64406	0.52	0.05
568	8.605633	0.515	0.045
808	6.346534	0.52	0.05
1031	5.190106	0.515	0.045
1203	4.591022	0.515	0.045
1463	3.952836	0.515	0.045

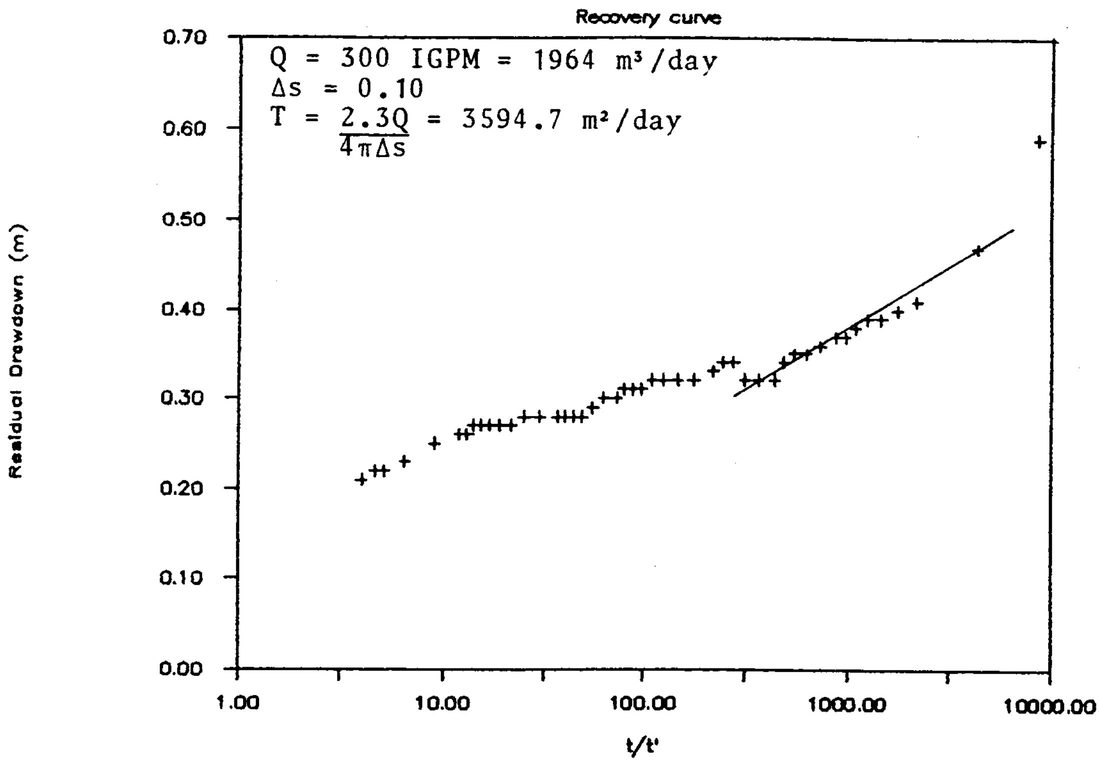
AQUIFER TEST DATA JOB#1500 WELL#: M3

Type of aquifer test:	CONST. Q	Well type:	OBSERV.
How Q Measured:	ORIF.WEIR	Data type:	RECOVERY
Distance from pumping well:	728 m	Depth pump:	9.1 m
Meas. point for w. l.'s:	0.10 m	Pump on:	04-05-87
Elevation of Measuring Pt.:		Pump off:	07-05-87
Static Water Level:	1.89	Discharge rate:	300 IGPM

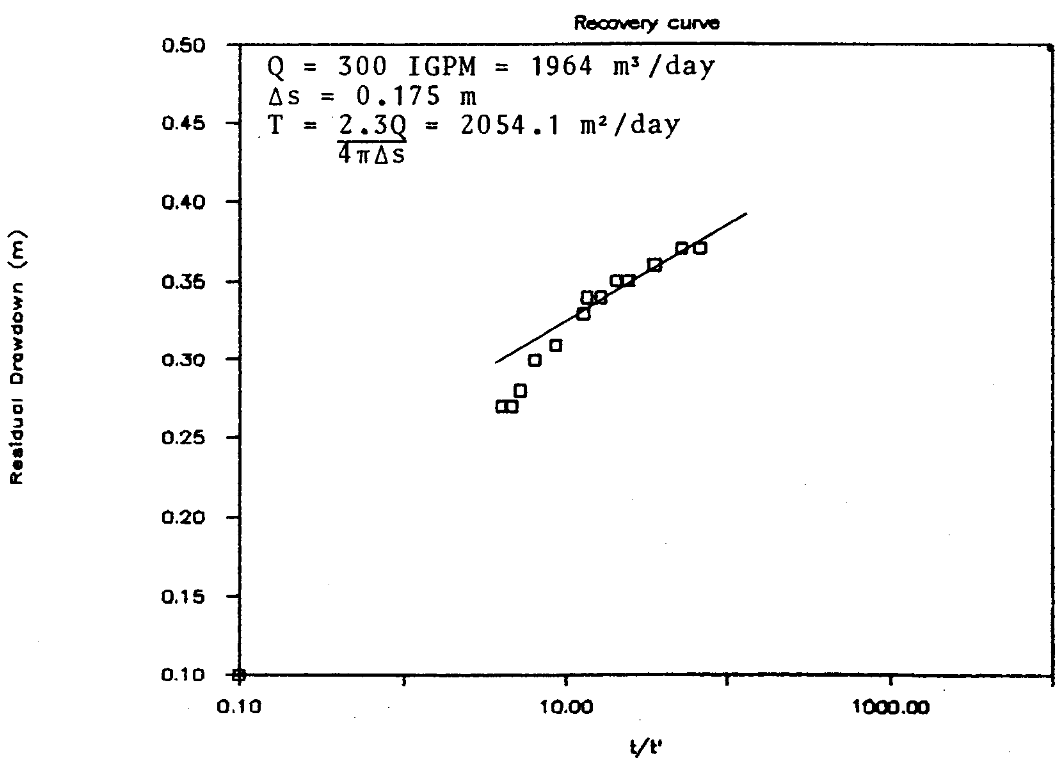
At t' = 0, t = 4320 Water Level Data

Time minutes	t/t'	w.l. (m)	Residual Drawdown
139	32.07913	1.89	0
196	23.04081	1.89	0
289	15.94809	1.89	0
379	12.39841	1.89	0
553	8.811934	1.89	0
809	6.339925	1.89	0
1014	5.260355	1.89	0
1225	4.526530	1.89	0
1454	3.971114	1.89	0

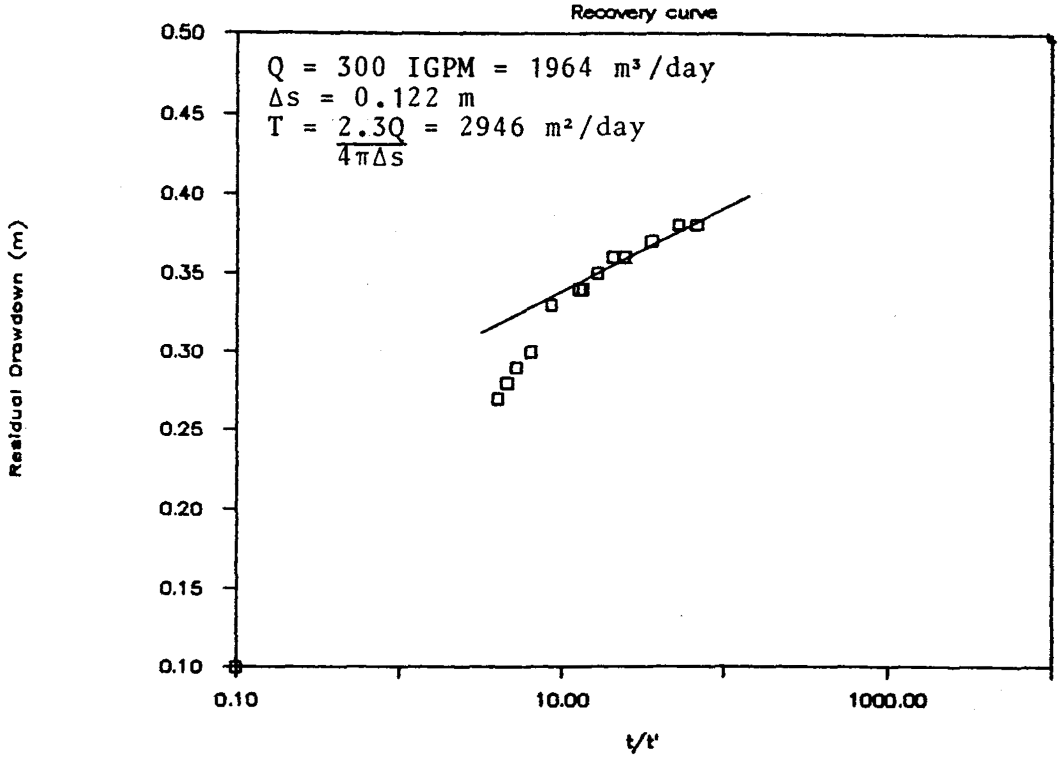
TW 5



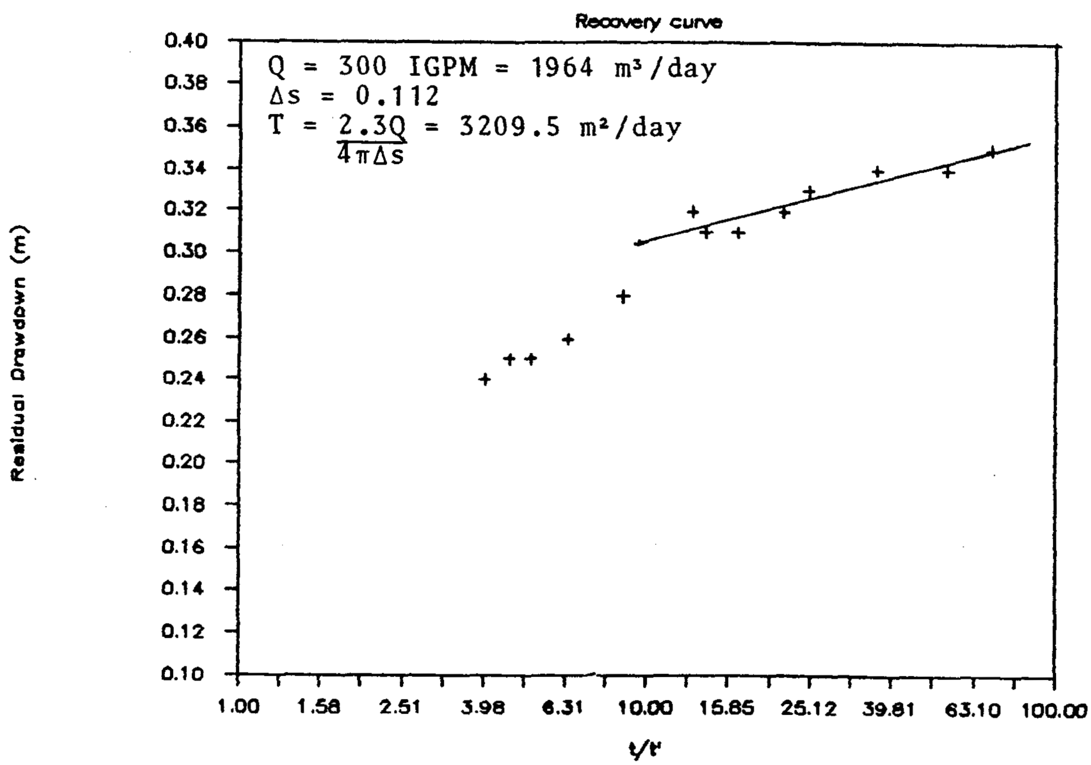
RECOVERY DATA FOR TW4



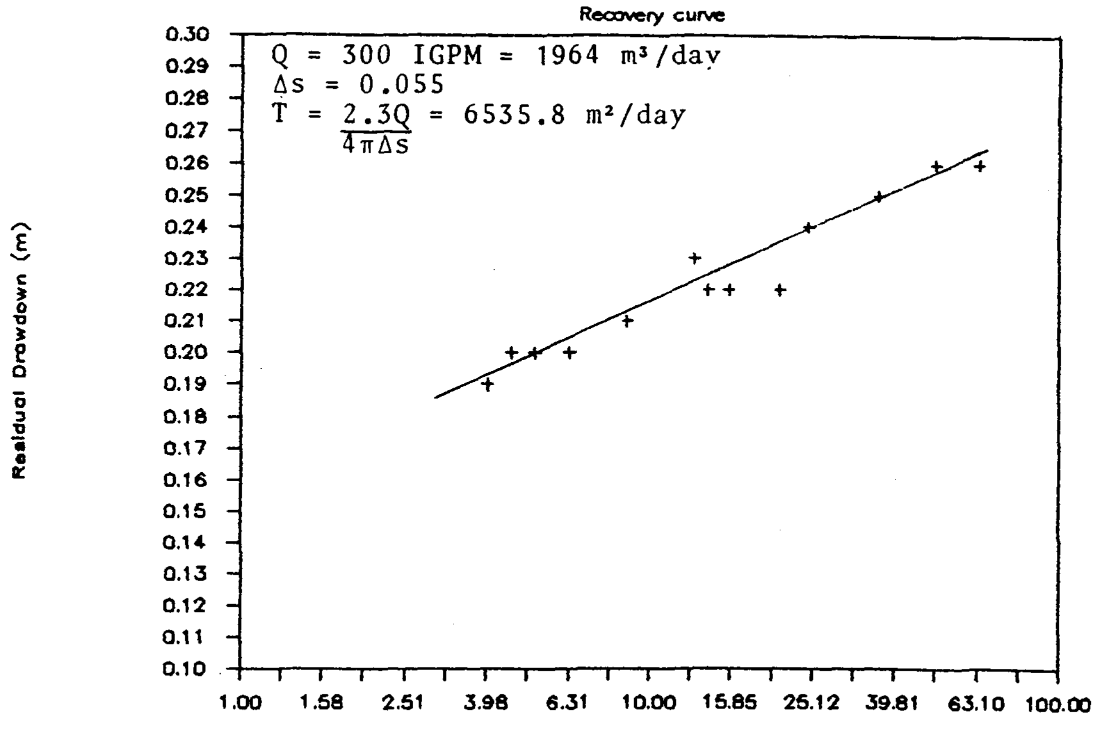
RECOVERY DATA FOR P5



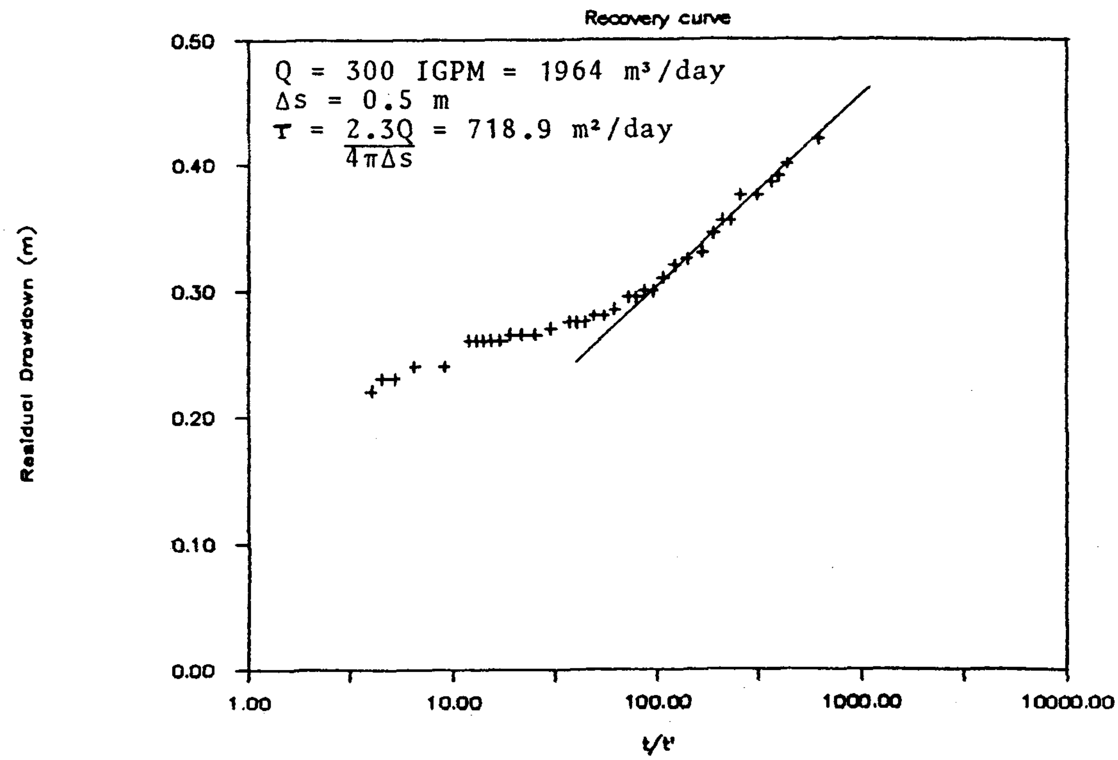
P 19



P 20


Recovery curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.055
T = 2.3Q / 4πΔs = 6535.8 m²/day
Residual Drawdown (m)
0.30
0.29
0.28
0.27
0.26
0.25
0.24
0.23
0.22
0.21
0.20
0.19
0.18
0.17
0.16
0.15
0.14
0.13
0.12
0.11
0.10
1.00
1.58
2.51
3.98
6.31
10.00
15.85
25.12
39.81
63.10
100.00
t/t'

M 1


Recovery curve
Q = 300 IGPM = 1964 m³/day
Δs = 0.5 m
T = 2.3Q / 4πΔs = 718.9 m²/day
Residual Drawdown (m)
0.50
0.40
0.30
0.20
0.10
0.00
1.00
10.00
100.00
1000.00
10000.00
t/t'

APPENDIX E

GROUNDWATER QUALITY DATA

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

W1500

WATER & EARTH SCIENCES
MR. ROGER WOELLER
P.O. BOX 430
CARP, ONTARIO.
K0A 1L0

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
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Phone: (613) 749-2220
Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-1964 (COMPLETE)

REFERENCE INFO: 1500

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: S.SZOJKA
DATE PRINTED: 1-JUN-87

ORDER	ELEMENT		NUMBER OF ANALYSES	LOWER DETECTION LIMIT	EXTRACTION	METHOD
1	Phen	Phenols -Assay	4	0.001 PPM		
2	SPEC	TYPED ASSAY REPORTS	0			
3	As	Arsenic -Assay	2	0.01 PPM		
4	Ba	Barium -Assay	2	0.1 PPM		
5	B	Boron -Assay	2	0.01 PPM		
6	Cd	Cadmium	2	0.001 PPM		
7	Cr	Chromium -Assay	2	0.01 PPM		
8	CN-	Cyanide -Assay	1	0.01 PPM		
9	F	Fluorine -Assay	2	0.01 PPM		
10	Pb	Lead -Assay	2	0.01 PPM		
11	Hg	Mercury -Assay	2	0.1 PPB		
12	N-NO3	Nitrate Nitrogen	4	0.01 PPM		
13	N-NO2	Nitrite Nitrogen	2	0.01 PPM		
14	SPEC	TYPED ASSAY REPORTS	0			
15	Se	Selenium -Assay	2	0.01 PPM		
16	Ag	Silver -Assay	2	0.01 PPM		
17	Turb	Turbidity	2	0.1 JCU		
18	U	Uranium -Assay	2	0.01 PPM		
19	Cl	Chloride -Assay	4	1 PPM		
20	Color	Colour -Assay	2	0.1 UNT		
21	Cu	Copper -Assay	2	0.01 PPM		
22	Fe tot	Iron (total)	4	0.01 PPM		
23	Mn	Manganese -Assay	2	0.01 PPM		
24	N tot	Nitrogen (total)	2	0.01 PPM		
25	SO4	Sulphate -Assay	4	1 PPM		
26	H2S	Hydrogen Sulphide	1	0.01 PPM		
27	TDS	Tot. Diss. Solids	2	1 PPM		
28	Zn	Zinc -Assay	2	0.01 PPM		
29	Ca	Calcium -Assay	4	1 PPM		
30	Mg	Magnesium -Assay	4	1 PPM		
31	K	Potassium -Assay	4	1 PPM		
32	Na	Sodium -Assay	4	1 PPM		
33	Alk	Alkalinity	4	1 PPM		

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Ottawa, Ontario,
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BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-1964 (COMPLETE)

REFERENCE INFO: 1500

CLIENT: WATER & EARTH SCIENCES
PROJECT: NONE

SUBMITTED BY: S.SZOJKA
DATE PRINTED: 1-JUN-87

SAMPLE TYPES	NUMBER	SIZE FRACTIONS	NUMBER	SAMPLE PREPARATIONS	NUMBER
WATER	4	AS RECEIVED	4	AS RECEIVED, NO SP	4

REMARKS: RADIONUCLIDES:
CS-137 <0.5 Bq/L
I-131 <1.0 Bq/L
Ra-226 0.1 Bq/L
H-3 <100 Bq/L
~~Sr-90 <1.0 Bq/L~~

REPORT COPIES TO: MR. ROGER WOELLER

INVOICE TO: MR. ROGER WOELLER

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
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REPORT: 417-1964

PROJECT: NONE PAGE 1A

SAMPLE NUMBER	ELEMENT UNITS	Phen PPM	SPEC	As PPM	Ba PPM	B PPM	Cd PPM	Cr PPM	CN- PPM	F PPM	Pb PPM	Hg PPB
1500-12		<0.002										
1500-24		<0.002		<0.01	<0.1	0.03	<0.001	<0.01	IS	0.09	<0.01	<0.1
1500-48		<0.002										
1500-72		<0.002		<0.01	<0.1	<0.01	<0.001	<0.01	<0.10	0.09	<0.01	<0.1

Chief Chemist

Bondar-Clegg & Company Ltd.
5420 Canotek Rd.,
Ottawa, Ontario,
Canada K1J 8X5
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Telex: 053-3233

BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-1964

PROJECT: NONE PAGE 1B

SAMPLE NUMBER	ELEMENT UNITS	N-NO3 PPM	N-NO2 PPM	SPEC	Se PPM	Ag PPM	Turb JCU	U PPM	Cl PPM	Color UNT	Cu PPM	Fe tot PPM
1500-12		<0.10							7			0.08
1500-24		<0.10	<0.10		<0.01	0.01	1.0	<0.01	7	6.0	<0.01	0.13
1500-48		<0.10							6			0.13
1500-72		<0.10	<0.10		<0.01	0.08	1.0	<0.01	6	6.0	<0.01	0.13

Chief Chemist

Bondar-Clegg & Company Ltd.
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BONDAR-CLEGG

Certificate of Analysis

REPORT: 417-1964

PROJECT: NONE PAGE 1C

SAMPLE NUMBER	ELEMENT UNITS	Mn PPM	N tot PPM	SO4 PPM	H2S PPM	TDS PPM	Zn PPM	Ca PPM	Mg PPM	K PPM	Na PPM	Alk PPM
1500-12				54				64	19	2	6	192
1500-24		<0.01	<0.10	54	IS	141	0.01	65	19	2	4	186
1500-48				52				59	18	2	4	185
1500-72		<0.01	<0.10	52	<0.10	218	0.11	59	19	2	3	186

Chief Chemist

Clinical Laboratories

MICROBIAL MONITORING REPORT

INSTITUTION WATER & EARTH SCIENCE
DATE COLLECTED set up 7-5-87
DATE REPORTED May 11, 1987
TECH SIGNATURE K Reid
PHONED

NO	SITE DESCRIPTION	LABORATORY REPORT					NOTES
	WATER ANALYSIS as per drinking water standards	TOTAL COUNT	TOTAL COLIFORM	FAECAL COLIFORM	FAECAL STREPT		
WESA #1	12 hr-1500-05-05-87	0col/ml	0col/100ml	absent	absent		
WESA #2	48hr-1500-05-06-87	0col/ml	0col/100ml	absent	present		

KEY:
NG = No Growth
NSG = No Significant Growth
NFL = Normal Flora

CC = Colony Count
NP = Non pathogenic
PP = Potential pathogen
MG = Mixed growth non-pathogenic and potential pathogens

DRINKING WATER: TT = Total Count
TC = Total Coliform
FC = Faecal Coliform
FS = Faecal Strept.

The results contained in this report are only representative of the sample(s) received by our laboratory.
Interpretation of the results should include a consideration of the integrity of both the sampling technique and protocol.

Form MMR 5 83

c/o Suzanne Szajka

Clinical Laboratories

MICROBIAL MONITORING REPORT

INSTITUTION Water & Earth Sciences
DATE COLLECTED set up 8-5-87
DATE REPORTED May 11, 1987
TECH SIGNATURE K. R.
PHONED

NO	SITE DESCRIPTION	LABORATORY REPORT					NOTES
	WATER ANALYSIS as per drinking water standards	TOTAL COUNT	TOTAL COLIFORM	FAECAL COLIFORM	FAECAL STREPT		
WESA #3	36-1500-06-05-87	0col/ml	0col/100ml	absent	absent		
WESA #4	72-1500-07-05-87	0col/ml	0col/100ml	absent	absent		

KEY:
NG = No Growth
NSG = No Significant Growth
NFL = Normal Flora
CC = Colony Count
NP = Non pathogenic
PP = Potential pathogen
MG = Mixed growth non-pathogenic and potential pathogens

DRINKING WATER: TT = Total Count
TC = Total Coliform
FC = Faecal Coliform
FS = Faecal Strept.

The results contained in this report are only representative of the sample(s) received by our laboratory.
Interpretation of the results should include a consideration of the integrity of both the sampling technique and protocol.

Form MMR 5-83

MAIL ADDRESS
MINISTRY OF THE ENVIRONMENT
LABORATORY BRANCH
P.O. BOX No. 213
REXDALE, ONTARIO

MINISTRY OF THE ENVIRONMENT
LABORATORIES

EXPRESS ADDRESS:
RESOURCES ROAD
HIGHWAY 401 & ISLINGTON AVE.
TORONTO, ONTARIO

Municipality:
Source: Region:
Program:
Date sampled: by: Suzanne Szeika
Date analysed: MAY 11 1987 Date reported: JUN 1 1987

Report to: Water + Earth Science Assoc.
Address: Box 430
Carp, Ont
K0A 1L0
613-831-1883

C | Bi | Ba

LAB. NUMBER	SENDER'S NUMBER	SAMPLING POINT LOCATIONS AND TIME	NATURE OF SAMPLE, DANGEROUS CONSTITUENTS, PRESERVATIVES USED, COMPOSITING DATA, ETC.	✓CHECK BELOW IF CHLORINE PRESENT
08228		48-1500-05-06-87	iron + SO_4 reducers	

SEE DIRECTIONS OVER

LAB. NUMBER		Sulphate reducers per 100 mls (MPN)
08228	No iron bacteria seen in the sample.	< 9.0

FOR LAB USE ONLY

PRELIMINARY REPORT
Sulfate reducing bacteria
to follow
Date: MAY 12 1987

FINAL REPORT
Date: JUN 1 1987

0951-M3 (03/84)

ANALYSIS OF ORGANIC PARAMETERS

IN WATER SAMPLE

72hr 1500-08-04-87

Prepared for:

WATER AND EARTH SCIENCES

P.O. Box 430

Carp, Ontario

Prepared by:

ZENON ENVIRONMENTAL INC.

845 Harrington Court

Burlington, Ontario

L7N 3P3

June 18, 1987

File No: AN878093

Zenon Environmental Inc.
845 Harrington Court, Burlington, Ontario L7N 3P3 Canada Telephone: (416) 639-6320 Telex: 061-8734

File No: AN878093

June 18, 1987

Suzanne Szojka
Water and Earth Sciences
Carp Road
West of City of Ottawa
1 Mile North of Queensway
(Behind Ottawa Ford Tractor Sales)
Carp, Ontario
K0A 1L0

Dear Ms. Szojka:

Please find enclosed, our report entitled, "Analysis of Organic Parameters in Water Sample 72hr 1500-08-04-87".

Should any questions arise, please do not hesitate to contact me.

Yours truly,

Ronald A. McLeod

Ronald A. McLeod
Senior Chemist

RAM/jas

Encl.

1.0 INTRODUCTION

1.0 INTRODUCTION

One water sample was submitted to ZENON Environmental Inc. for analysis of EPA priority pollutant lists 624 and 625, selected chlorinated organic pesticides, selected herbicides and PCB.

This report details the methodologies, the analytical results and the quality assurance procedures of these analyses.

2.0 METHODOLOGY

2.0 METHODOLOGY

2.1 Volatiles Analysis

The volatiles were analysed by a purge and trap technique using an Enviroclean UNICON Series 810 sample concentrator system coupled with a Hewlett Packard MSD GC/MS. An aliquot of the sample (5 mL) was placed in the sparging vessel along with 1 uL of a methanolic solution of surrogate standards of toluene - $^2H_8$, dichloroethane - $^2H_4$, chlorobenzene - $^2H_5$ and 4-bromofluorobenzene. Instrument conditions are given in Sections 2.1.1 and 2.1.2 below. A standard of EPA volatile organics was analysed in the same manner as the sample and indicated a detection limit of 1.0 ug/L for most of the components.

2.1.2 GC/MS Analysis of Volatiles

A Hewlett Packard MSD was used for the analysis of voltile organics.

The gas chromatographic conditions are listed below:

Column Head Pressure:	7 psi
Column:	30M DB-5 x 0.25 mm ID
Temp. Program:	-40°C for 2 minutes
	-40°C for 120°C at 15°C/min.
	120°C to 200°C at 20°C/min.
Injection Mode:	Direct column injection

The mass spectrometer conditions used in the analysis are as follows:

Electron Impact mode, scanning 45-300 a.m.u. each second

Electron Energy	70 eV
EM Voltage	2000 eV
Emission Current	0.5 A

The U.S. EPA standard mixture prepared by Radian Corporation was used for quantification and confirmation of the presence of volatile organics. The GC/MS was calibrated with PFTBA (FC-43).

2.1.1 Enviroclean Unicon Series 810

The Enviroclean instrument conditions are listed below:

Sparge Flow:	45 mL/min He
Trap to Trap Flow:	60 mL/min He
Sparge Time:	10 min
Secondary Carrier Flow Time:	5 min.
Trap to Trap Transfer Time:	2 min.
Primary Trap Temp. (cool):	50°C
Primary Trap Temp. (heat):	210°C
Secondary Trap Temp (cool):	50°C
Secondary Trap Temp (heat):	200°C
Transfer Line Temp:	220°C

Quantification was performed using the external standard method, as detailed in the Federal Register, on peak areas from reconstructed ion plots for the quantification ions listed in the EPA Federal Register. Assurance of correct identification was performed uisng the secondary ions and the case of higher level determination, using the full scan spectra.

2.2 **Extraction for EPA 625 Priority Pollutants**

The volume of the sample was measured in a 1L graduated cylinder and poured into a 2L separatory funnel. 10mL of methylene chloride was used to rinse the cylinder and this was transferred into the funnel, together with an additional 100 mL of methylene chloride. The pH of the aqueous portion was adjusted to 12 with 6N KOH and it was spiked with a deuterated surrogate standard, $^2H_{10}$ anthracene, $^2H_3$ dichlorophenol and $^2H_{12}$ benzo(a)pyrene to monitor recovery in the procedure.

The sample was shaken vigorously for 1 minute and when the phases had separated the methylene chloride extract was drained through a 1.5 inch anhydrous Na_2SO_4 column in an Allihn filter. The aqueous portion was reextracted twice as above with 75 mL of methylene chloride. After the third extraction, the pH of the sample was adjusted to approximately 2 with 6N H_2SO_4 and was extracted as above 3 times with 75 mL methylene chloride. 20mL of methylene chloride was used to wash the walls of the Allihn filter and suction was applied to recover all traces of the extract. The extract was then rotary evaporated to approximately 2mL and quantitatively transferred to a calibrated centrifuge tube and concentrated to a final volume of 1.0

analysis. Immediately prior to instrumental analysis, the sample is spiked with a deuterated internal standard $^{2}H_{10}$ phenanthrene to compensate for variations in injection volume, instrument conditions etc.

2.2.1 GC/MS Analysis of Extractables

A Finnigan 4510 GC/MS system was used for gas chromatographic/mass spectrometric analysis. The EPA consent decree base/neutral and acid extractable standards were used to establish instrumental sensitivity and to provide identification criteria for sample analysis. The conditions employed were as follows.

Gas Chromatography

Injection Mode - On-column

Column - 30 m DB5 x 0.32 mm ID

Column Flow - He @ 20cm/sec.

Oven Temperature Profile

60°C - 2 min. --

60°C -- 270°C @ 10°/min. hold 15 min.

GC/MS Interface - Direct Couple

Transfer Area - 270°

Mass Spectrometry

Ionization Mode	- Electron Impact
Electron energy	- 70 eV
Filament Emission	- 0.5A
Electron Multiplier	- 1200V @ 1 x 10^6 Gain
Ionizer Temperature	- 170°C
Scan	45-550 a.m.u. @ .95S-.05S Bottom Hold

Quantification was carried out by comparing mass spectrometric responses of selected ions to those of external standards. Calculations were based on 1 liter samples and no correction has been made for recovery of deuterated surrogate spikes.

The criteria used for the identification of the organics required:

a) the presence of appropriate secondary ions in the mass spectrum
b) signal to noise of at least 3 to 1
c) retention time within 2% of reference standard

2.3 Herbicide Analysis

The volume of the sample was measured in a 1L graduated cylinder and poured into a 2L separatory funnel. 10mL of methylene chloride was used to rinse the cylinder and this was transferred into the funnel, together with an additional 100 mL of methylene chloride. The sample was spiked with deuterated surrogate standard. $^2H_{12}$ benzo(a)pyrene to monitor recovery in the procedure.

The sample was shaken vigorously for 1 minute and when the phases had separated the methylene chloride extract was drained through a 1.5 inch anhydrous Na_2SO_4 column in an Allihn filter. The aqueous portion was reextracted twice as above with 75 mL of methylene chloride. 20mL of methylene chloride was used to wash the walls of the Allihn filter and suction was applied to recover all traces of the extract. The extract was then rotary evaporated to approximately 2mL and quantitatively transferred to a calibrated centrifuge tube. The extract was carefully evaporated to dryness under a gentle stream of nitrogen and redissolved in approximately 3 mL of ether. The solution was treated with excess diazomethane and after standing for 30 min, the ether and excess diazomethane were removed during a solvent exchange to 1.0 mL of isooctane. Immediately prior to GC/MS analysis, the sample is spiked with a deuterated internal standard $^{2}H_{10}$ phenanthrene to compensate for variations in injection volume, instrument conditions etc.

2.3.1 **GC/MS Analysis**

The extracts were analysed on a Finnigan 4510 GC/MS with Incos data system. Instrumental conditions are listed below:

GC/MS Analysis

Gas Chromatography

Injection Mode	On Column
Column	30 m DB5 x 0.25 mm ID
Column Flow	He @ 20 cm/sec.
Oven Temp. Profile	

100°C - 2 min.;

80°C — 210°C @ 12°/min; 210°C —— 290°C @ 20°C/min.

hold 3 min.

Mass Spectrometry

Ionization Mode	Electron Impact
Electron Energy	70 eV
Filament Emission	0.5 A
Electron Multiplier	1600 V
Scan	Stepped ion MID

2.3.2 Quantification

The compounds of interest and the quantification ions used are presented below with the secondary ion given in brackets.

Compound	Quantification Ion	Secondary Ion
2,4-D	199	234,236
Silvex	196	284
Diazinon	179	304
Methyl Parathion	263	109,125
Carbaryl	144	115
Parathion	291	97,137

Quantification was carried out by comparing mass spectrometric responses of selected ions to those of external standards. Calculations were based on a final volume of 1 mL and no correction has been made for recovery of deuterated surrogate spikes.

The criteria used for the identification of the organics required:

a) the presence of appropriate secondary ions in the mass spectrum

b) signal to noise of at least 3 to 1

c) retention time within 2% of reference standard

2.4 PCB/Organochlorine Analysis

The volume of a the sample was measured in a 1 L graduated cylinder and poured into a 2 L separatory funnel. 10 mL of methylene chloride was used to rinse the cylinder and this was transferred into the funnel, together with an additional 100 mL of methylene chloride. The sample was shaken vigorously for 1 minute and when the phases had separated the methylene chloride extract was drained through a 1.5 inch anhydrous Na_2SO_4 column in an Allihn filter. The aqueous portion was re-extracted twice as above with 75 mL methylene chloride. After the third extraction 20 mL of methylene chloride was used to wash the walls of the Allihn filter and suction was applied to recover all traces of the extract. The extract was rotary evaporated and solvent exchanged into isooctane to a final volume of 1 mL.

The 1 mL extract of isooctane was placed onto a 1.5 cm ID x 40 cm chromatography column packed with 10 cm of 3% water deactivated silica gel. The centrifuge tube was rinsed several times with 2 mL of hexane. These rinses were also applied to the column. The column was eluted with 60 mL of hexane. This eluant is fraction A. An additional 50 mL of benzene was collected in a separate flask as fraction B. The cleaned up extract was rotary evaporated to 1 mL isooctane, quantitatively transferred to a calibrated centrifgue tube and volume adjusted to 1.0 mL for GC/ECD analysis. A method blank and spike of organochlorines and PCB were also carried out to avoid misidentification and to ensure PCB and organochlorines native to the sample would be recovered through the methodology employed.

2.4.1 Instrumental Conditions - PCB/OC Analysis

2.4.1.1 High Resolution Gas Chromatography

Column	30 M x .25 mm ID DB5;
	30 M x .25 mm ID OV 1701
Injector Temp.	250°C
Carrier	He @ 30 cm/sec.
Injection Mode	Splitless 30 sec.
Split	30 mL/min.
Septum Flush	4 mL/min.
Oven Temp.	80°C - 2 min. — 160°C @ 10°/min.
	-- 260°C @ 4°/min, Hold
Detector Temp.	300°C
Detector Makeup	30 mL/min. Argon/Methane 95/5

3.0 ANALYTICAL RESULTS

3.0 ANALYTICAL RESULTS

The data for the analysis of EPA 624 and 625 priority pollutants, herbicides and chlorinated organics are presented in Tables 3.1 through 3.4 respectively. The only determined contaminant was bis(2-ethylhexyl)phthalate at a typical background level.

TABLE 3.1: EPA624 Priority Polutants (µg/L)

PARAMETER	Detection Limit	Method Blank	72 hr 1500-08-04-87 Zenon ID#: 872755
Benzene	20	ND	ND
Bromodichloromethane	1.0	ND	ND
Bromoform	1.0	ND	ND
Bromoethane	1.0	ND	ND
Carbon Tetrachloride	1.0	ND	ND
Chlorobenzene	1.0	ND	ND
Chloroethane	1.0	ND	ND
2-Chloroethylvinylether	1.0	ND	ND
Chloroform	5.0	ND	ND
Chloromethane	1.0	ND	ND
Dibromochloromethane	1.0	ND	ND
1,1-Dichloroethane	1.0	ND	ND
1,2-Dichloroethane	1.0	ND	ND
1,1-Dichloroethylene	1.0	ND	ND
trans-1,2-Dichloroethylene	1.0	ND	ND
cis-1,3-Dichloropropylene	1.0	ND	ND
1,2-Dichloropropane	1.0	ND	ND
trans-1,3-Dichloropropylene	1.0	ND	ND
Ethylbenzene	1.0	ND	ND
Methylene chloride	5.0	ND	ND
1,1,2,2-Tetrachloroethane	1.0	ND	ND
Tetrachloroethylene	1.0	ND	ND
Toluene	5.0	ND	ND
1,1,1-Trichloroethane	1.0	ND	ND
1,1,2-Trichloroethane	1.0	ND	ND
Trichloroethylene	1.0	ND	ND
Trichlorofluoromethane	1.0	ND	ND
Vinyl chloride	2.5	ND	ND
SURROGATE RECOVERY %			
d4-Dichloroethane		95	98
d8-Toluene		89	90
d5-Chlorobenzene		114	126
4-Bromofluorobenzene		108	101

ND = Not Detected

TABLE 3.2 EPA 625 Priority Pollutants (μg/L)

PARAMETER	Detection Limit (μg/L)	Method Blank	72hr 1500-08-04-87 Zenon ID#:872755
Acenaphthylene	1	ND	ND
Acenaphthene	1	ND	ND
Anthracene	1	ND	ND
Aldrin	1	ND	ND
Benzidine	1	ND	ND
Benzo(a)anthracene	1	ND	ND
Benzo(b)fluoranthene	1	ND	ND
Benzo(k)fluoranthene	1	ND	ND
Benzo(a)pyrene	1	ND	ND
Benzo(ghi)perylene	1	ND	ND
Benzylbutyl phthalate	1	ND	ND
alpha-BHC	1	ND	ND
beta-BHC	1	ND	ND
gamma-BHC	1	ND	ND
Bis(2-chloroethyl)ether	1	ND	ND
Bis(2-chloromethyl)methane	1	ND	ND
Bis(2-ethylhexyl)phthalate	1	ND	1.7
Bis(2-chloroisopropyl)ether	1	ND	ND
4-Bromodiphenylether	1	ND	ND
Chlordane	1	ND	ND
4-Chlorodiphenylether	1	ND	ND
Chrysene	1	ND	ND
p,p'-DDD	1	ND	ND
p,p'-DDE	1	ND	ND
p,p'-DDT	1	ND	ND
Dibenzo(a,h)anthracene	1	ND	ND
Di-n-butyl phthalate	1	ND	ND
Di-n-octyl phthalate	1	ND	ND
1,2-Dichlorobenzene	1	ND	ND
1,3-Dichlorobenzene	1	ND	ND
1,4-Dichlorobenzene	1	ND	ND
3,3'-Dichlorobenzidine	1	ND	ND
Dieldrin	1	ND	ND
Diethyl phthalate	1	ND	ND
Dimethyl phthalate	1	ND	ND
2,4-Dinitrotoluene	10	ND	ND
2,6-Dinitrotoluene	10	ND	ND
Endosulfan I	1	ND	ND
Endosulfan II	1	ND	ND
Endosulfan Sulfate	10	ND	ND
Endrin	1	ND	ND
Endrin aldehyde	1	ND	ND
Fluoranthene	1	ND	ND
Fluorene	1	ND	ND
Heptachlor	1	ND	ND

TABLE 3.2 EPA 625 Priority Pollutants (μg/L)

PARAMETER	Detection Limit	Method Blank	72hr 1500-08-04-87 Zenon ID#:872755
Heptachlor epoxide	1	ND	ND
Hexachlorobenzene	1	ND	ND
Hexachlorobutadiene	1	ND	ND
Hexachlorocyclopentadiene	1	ND	ND
Hexachloroethane	1	ND	ND
Indeno(1,2,3-cd)pyrene	1	ND	ND
Isophorone	1	ND	ND
Naphthalene	1	ND	ND
Nitrobenzene	1	ND	ND
N-Nitrosodi-N-Propylamine	1	ND	ND
N-Nitrosodimethylamine	1	ND	ND
N-Nitrosodiphenylamine	1	ND	ND
PCB-1016	20	ND	ND
PCB-1221	20	ND	ND
PCB-1232	20	ND	ND
PCB-1242	20	ND	ND
PCB-1248	20	ND	ND
PCB-1254	20	ND	ND
PCB-1260	20	ND	ND
Phenanthrene	1	ND	ND
Pyrene	1	ND	ND
Toxaphene	100	ND	ND
1,2,4-Trichlorobenzene	1	ND	ND
4-Chloro-3-methylphenol	5	ND	ND
2-Chlorophenol	5	ND	ND
2,4-Dichlorophenol	5	ND	ND
2,4-Dimethylphenol	5	ND	ND
2,4-Dinitrophenol	5	ND	ND
2-Methyl-4,6-dinitrophenol	5	ND	ND
2-Nitrophenol	5	ND	ND
4-Nitrophenol	5	ND	ND
Pentachlorophenol	5	ND	ND
Phenol	5	ND	ND
2,4,6-Trichlorophenol	5	ND	ND
2,4-D	5	ND	ND
Silvex	5	ND	ND
SURROGATE RECOVERY %			
d3-Dichlorophenol		93	92
d10-Anthracene		88	73
d12- Benzo(a)pyrene		102	96

ND =Not Detected

TABLE 3.3: HERBICIDE ANALYSIS (μg/L)

Herbicides	Detection Limit (μg/L)	Method Blank	72hr 1500-08-04-87 Zenon ID#:872755
2,4-D	0.1	ND	ND
2,4,5-TP(Silvex)	0.1	ND	ND
Diazinon	0.1	ND	ND
Methyl Parathion	0.1	ND	ND
Parathion	0.1	ND	ND
Carbaryl	0.1	ND	ND
SURROGATE RECOVERY %			
d-12 Benzo (a)pyrene		135	92

Table 3.4: Chlorinated Organics (μg/L)

CHLORINATED ORGANICS	Detection Limits (μg/L)	Method Blank	72hr 1500-08-04-87 Zenon ID#:872755	Spike Recoveries (%)
HEXACHLOROBENZENE	0.01	ND	ND	96
a-BENZENEHEXACHLORIDE	0.01	ND	ND	-
LINDANE	0.01	ND	ND	89
HEPTACHLOR	0.01	ND	ND	109
ALDRIN	0.01	ND	ND	82
HEPTACHLOR EPOXIDE	0.01	ND	ND	90
g-CHLORDANE	0.01	ND	ND	91
a-ENDOSULFAN	0.01	ND	ND	90
a-CHLORDANE	0.01	ND	ND	94
p,p'-DDE	0.01	ND	ND	101
DIELDRIN	0.01	ND	ND	-
ENDRIN	0.01	ND	ND	92
b-ENDOSULFAN	0.01	ND	ND	96
p,p'-DDD	0.01	ND	ND	105
o,p'-DDT	0.01	ND	ND	92
p,p'-DDT	0.01	ND	ND	90
PHOTOMIREX	0.01	ND	ND	-
METHOXYCHLOR	0.02	ND	ND	100
MIREX	0.01	ND	ND	-
TOXAPHENE	0.01	ND	ND	-
TOTAL PCB		ND	ND	111

ND = Not detected

4.0 QUALITY ASSURANCE

4.0 QUALITY ASSURANCE

Quality control measures were taken in the work for organic parameters for the sample preparation, gas chromatographic and mass spectrometric areas and are as follows:

i) Samples were received and immediately refrigerated to preserve sample integrity.

ii) Mass assignments for ions generated by GC/MS were determined from a calibration of an FC43 perfluorohydrocarbon mixture.

iii) The analysis of volatile organics was performed within two weeks in order to ensure sample integrity.

iv) Purge and trap performance was monitored on each sample by the addition of a deuterated internal standards (d_8 toluene, d_4-dichloroethane, d_5 chlorobenzene and 4-bromofluorobenzene) into each sample just prior to analysis.

v) False or high biased positive identifications due to internal contamination were avoided by performing a purge and trap system blank prior to analysis.

vi) Surrogate spikes were added for base/neutral/acid extractables analysis prior to extraction.

Extractables - anthracene $^2H_{10}$

- benzo(a)pyrene $^2H_{12}$
- dichlorophenol $^2H_3$

vii) Addition of internal standards to samples or sample extracts just prior to GC/MS analysis.

eg. extractables - phenanthrene - $^{2}H_{10}$

volatiles - d_8 toluene

- d_4 dichloroethane
- d_5 chlorobenzene
- 4-bromofluorobenzene

viii) Method blank performed for all analyses to correct for laboratory contamination.

I1: 'CALCULATION OF IONIC STRENGTH SHEET

1	CALCULATION OF IONIC STRENGTH					
2						
3	Parameter	mg/L	molality	Activity Coef.	Z	I
4						
5	NA	3	1.30E-04	0.908	+1	
6	K	2	5.11E-05	0.905	+1	
7	CA	59	1.47E-03	0.684	+2	
8	MG	19	7.82E-04	0.687	+2	
9	FE	0.13	2.33E-06	0.688	+2	
10	MN	0	0.00E+00	0.644	+2	0.0076
11	CL	6	1.69E-04	0.905	-1	
12	SO4	52	5.41E-04	0.681	+2	
13	HS	0	0.00E+00	0.905	-1	
14	N-NO3	0	0.00E+00	0.904	-1	
15	N-NO2	0	0.00E+00	0.896	-1	
16	NH4 (N-NH3)	0	0.00E+00	0.903	+1	
17	ALK.(CaCO3)	186	3.72E-03	0.910	-1	
18	PH	7.7				
19	COND.(UMHOS)	190	! Debye Huckel	A = 0.5461		
20	TEMP.(C)	11	! Parameters	B = 0.3364		

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O1: 'CHARGE BALANCE CALCULATIONS SHEET

1	CHARGE BALANCE CALCULATIONS			
2	Parameter			
3		mg/L		meq/L
4				
5	NA	3		0.13
6	K	2		0.05
7	CA	59		2.94
8	MG	19		1.56
9	FE	0.13		.00
10	MN	0		0.00
11	CL	6		0.17
12	SO4	52		1.08
13	ALK.(CaCO3), (HCO3-)	186	226.92 Corrected HCO3 ->	3.46
14	NO3	0		0.00
15	NO2	0		0.00
16	NH4 (NH3)	0		0.00
17	HS	0		0.00
18	PH	7.7		0.02
19	CHARGE BALANCE ERROR		-2.67%	
20	(based on correction to HCO3)		-6.95%	

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Y1: (F2) 'CALCULATION OF THE RYZNAR STABILITY INDEX AND rH SHEET

CALCULATION OF THE RYZNAR STABILITY INDEX AND rH

Adapted from Persons and Hart (1980) and Hasselbarth and Ludeman (1972)

Parameter	Value		Ryznar Parameter	Value	PHs
TDS (mg/L)	123.50		A	0.10	
Hardness (CaCO3)	225.36		C	1.96	7.52
Alk. (CaCO3)	186.00		D	2.28	
Temperature (C)	11.00	0	B	2.35	
PH	7.70				
FE	0.13				
MN	0.00				
EH	0				

scale 6<(R.I.>7 corrosion -------> Ryznar Index = 7.3

rH = 15.40

Biological Incrus. if:
1) FE> 0.3 mg/L,
2) EH>-10mV +/- 20mV,
3) rH> 14.5 +/- 1

These conditions apply to a well being pumped

MAIN>

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AF1: 'CALCULATION OF THE CARBONATE EQUILIBRIUM SHEET

CALCULATION OF THE CARBONATE EQUILIBRIUM

Parameter *= calc'd	Activities		After dol precip.	After cal precip.	Mass Precip. mg/L
CA	1.01E-03		1.01E-03	8.60E-04	
MG	5.37E-04		5.37E-04	5.37E-04	Dolomite
PCO2(atm)*	3.80E-03		3.80E-03	3.80E-03	0
ALK.(HCO3)	3.38E-03		3.38E-03	3.19E-03	
pH	7.70		7.70	7.67	Calcite
TEMP.(K)	284	%ER	-1.3%	.0%	21
-LOG(K1)*	7.75				
-LOG(K2)*	-2.11				
-LOG(K3)*	-4.24				

adj. T(C)=	0
adj. PCO2=	0.00E+00
SI(DOL) =	-5.3E-02
pH(s) =	7.73
SI(CAL) =	1.2E-01
pH(s) =	7.58

PCO2(atm)=3.16E-4

Model good for 6.4<pH<10.3

CO2(g) + H2O = H+ + HCO3-: K1

CaCO3(s) + H+ = Ca++ + HCO3-: K2

CaMg(CO3)2(s) + 2H+ = Ca++ + Mg++ + 2HCO3-: K3

MAIN>

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A01: 'CALCULATION OF THE SULFATE AND FLUORIDE SOLUBILITY EQUILIBRIA   SHEET

```
1   CALCULATION OF THE SULFATE AND FLUORIDE SOLUBILITY EQUILIBRIA
2
3   Parameter    mg/L   molalities   Activity       Activities   Ionic
4                                    Coefficients                Strength
5   ---------------------------------------------------------------------
6   CA             59    1.47E-03          0.684    1.01E-03
7   MG             19    7.82E-04          0.687    5.37E-04    0.0076
8   SO4            52    5.41E-04          0.681    3.69E-04
9   F               0    0.00E+00          0.905    0.00E+00
10  TEMP (C)       11
11  ---------------------------------------------------------------------
12                                                               mg/L
13  SI(CaF2)=     ERR
14  SI(MgF2)=     ERR                Mass gypsum precipitate          0.0
15  SI(gyps)=    -1.8
16  ---------------------------------------------------------------------
17
18  CaF2 = Ca2+ + 2F-  K1            -LOG(K1)=          10.3 Source: Stumm &
19  MgF2 = Mg2+ + 2F-  K2            -LOG(K2)=           8.1 Morgan, pg.232
20  CaSO4(s) = Ca2+ + SO4--  K3      -LOG(K3)=           4.6
                                                                     MAIN>
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APPENDIX F

THEORETICAL AQUIFER YIELD AND WELL INTERFERENCE CALCULATIONS

THEORETICAL AQUIFER YIELD AND WELL INTERFERENCE CALCULATIONS

Theoretical Aquifer Yields

The theoretical aquifer yield can be calculated using the following formula:

$$Q_{max} = \frac{4\pi T\ \Delta s_{max}}{W(u)}$$

where Q_{max} = maximum discharge [m³/day]

T = transmissivity [m²/day]

$\Delta smax$ = maximum allowable drawdown [m]

W(u) = well function [\\]

The well function is derived by means of well function tables that are based on the following:

$$u = \frac{r^2 S}{4Tt}$$

where r = radial distance from pumping well [m]

S = storativity [\\]

t = time since pumping began [days]

Tests done on the test well revealed the following aquifer parameters:

T = 1000 m²/day S = 0.009 $\Delta smax$ = 8.5 m

For a 10 year design period the calculations are:

$$u = \frac{(0.1)(0.009)}{4(1000)(3650)}$$

$$= 6.16\text{x}10^{-11}$$

W(u) = 22.93

$$Q_{max} = \frac{4\ \pi(1000)(8.5)}{22.93} = 4.658 \text{ m}^3/\text{day} = 712 \text{ IGPM}$$

For a 20 year design period the calculations are:

$$u = \frac{(0.1)(0.009)}{4(1000)(7300)} = 3.08 \times 10^{-11}$$

W(u) = 23.625

$$Q_{max} = \frac{4\pi(1000)(8.5)}{23.625}$$

$= 4521\ m^3/day$

$= 691$ IGPM

Well Interference

The same equations used to calculate aquifer yield can also be used to determine theoretical well interference data. Here, however, Q is kept constant and the drawdown is calculated.

example calculation:

$r = 1$ m $\quad Q = 300$ IGPM $= 1964\ m^3/day \quad T = 1000\ m^2/day \quad S = 0.009$

$t = 10$ years $= 3650$ days

$$u = \frac{(1)^2(0.009)}{4(1000)(3650)}$$

$= 1 \times 10^{-9}$

$W(u) = 20.146$

$$\Delta s = \frac{1964(20.146)}{4\pi(1000)}$$

$= 3.15$ m

The following table shows the drawdown data for various radial distances and pumping rates.

radius (m)	u	W(u)	Δs(m) 300 IGPM	400 IGPM	500 IGPM
1	1×10^{-9}	20.146	3.15	4.20	5.25
20	2.47×10^{-7}	14.63	2.29	3.05	3.81
50	1.54×10^{-6}	12.80	2.00	2.67	3.33
100	6.16×10^{-6}	11.40	1.78	2.38	2.97
200	2.47×10^{-5}	10.03	1.57	2.09	2.61
500	1.54×10^{-4}	8.20	1.28	1.71	2.14
800	3.9×10^{-4}	7.27	1.14	1.51	1.89