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A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-C (SMALL FARMERS' AREA) CAYMANAS AREA, ST. CATHERINE PLAINS

A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-C (SMALL FARMERS' AREA) CAYMANAS AREA, ST. CATHERINE PLAINS

By:

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INTRODUCTION

The Crop Diversification and Irrigation Project (CDI) started functioning officially from October 1985, to reinforce the institutional capacity of Agro-21 Corporation Limited to promote and develop private commercial agricultural investment in Jamaica. One of the activities of the CDI project was to rehabilitate and construct irrigation infrastructure such as wells, canals, pumping stations, fencing and storage facilities. On the reorganization of the activities of the Agro-21 Corporation Limited, with effect from April 1, 1989, the CDI project was merged with the National Irrigation Commission. The area of activity is a part of the St. Catherine Plains mostly on the western outskirts of Kingston where it is divided into five (5) sub-areas which are designated as Project - A, Project - B, Project - C (Horticulture), Project-C (small farmers' area) and Project-E. Other areas of small farmer activity include Hill-Run, and Bushy Park. The Hydrogeologist working with the project executed the programme of rehabilitating the old wells and constructing the new ones and also carried out other hydrogeological activities all of which are indicated below:

a) Three old wells in Project-A were rehabilitated in late 1985.

b) Fourteen (14) wells were constructed in Projects - A, B, C (Horticulture) and E during the period September, 1985 to February, 1988.

c) Six (6) old wells in Project-E and two (2) old wells in Project-C (small farmers' area) were tested for their yield and quality of water during the period April, 1987 to February, 1988.

d) Four (4) observation wells were constructed in coastal area to the east, south-east and south of the project areas and one in the Hill-Run area to monitor the quality of groundwater.

e) Two (2) exploratory wells were drilled in the Hill-Run area tapping the limestone aquifer.

f) Water levels and quality of groundwater in the general area were monitored.

As specified in the project document, environmental monitoring of the project activities will be the responsibility of the Underground Water Authority which will include monitoring of:

a) Water quality with respect to both salinity and contamination by pesticides and other pollutants.

b) Groundwater extraction.

Monitoring of groundwater levels is necessary to relate any changes in the quality of groundwater with extraction. Monitoring of water levels and the quality of groundwater and preparation of respective project reports were done in collaboration with Underground Water Authority.

Major hydrological work carried out has been described in the following reports:

1. Ramanamurty, D.V. December, 1988. A report on the groundwater resources of horticulture Project-C, Caymanas area, St. Catherine Plains. Land Utilization Department, Agro-21 Corporation Limited, Kingston.

Contains reports on the construction, development and testing of two wells viz. Watson Grove #3 and Riversdale #1 and the recommended rates of extraction of groundwater from these wells. Describes the chemical characteristics of water required for use in horticulture and the suitability of groundwater in the area for this purpose.

2. Ramanamurty, D.V., and B. Fernandez. March, 1989. A report on the salinity of and groundwater in the alluvial aquifer in parts of Bernard Lodge and Caymanas Areas and the adjoining coastal area, St. Catherine Plains. Land Utilization Department, Agro-21 Corporation Limited, Kingston.

Contains chemical analyses data of groundwater from 38 wells in the area; historical data from 1963 to 1982 and recent data from 1985 to 1988; shows areas of groundwater contamination with sea water and other pollutants.

3. Ramanamurty, D.V. May, 1989. A report on the groundwater resources of Project-A, Bernard Lodge area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on testing of one old well, Half Way Tree #6, reconstruction, development and testing of three old wells, Half Way Tree #4, #5 and Cookson #3 and construction, development and testing of five new wells, Half Way Tree #2, Cookson #4, Newlands #2, #2A and #3, recommended rates of groundwater extraction from the wells, chemical characteristics of water required for irrigation and the suitability of groundwater for this purpose.

4. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-B, Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on the construction development and testing of wells, Cowpark-A, North Syndicate #2, South Syndicate #2, Naggo Head and Guinep Pen and testing of old well, Cedar Grove #2, recommended rates of groundwater extraction from the wells, chemical characteristics of water for irrigation and suitability of groundwater in the area for this purpose.

5. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-E, Bernard Lodge area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on the construction, development and testing of three new wells Goshen #3A, Clifton #B, and Clifton #5 and testing of 6 old wells, Limetree #1, Government Park, Clifton #3 Congrieve Park #4, Salt Pond #7, and Reidspen #1, recommended rates of groundwater extraction from the wells, chemical characteristics of water required for irrigation and suitability of groundwater in the area for this purpose.

6. Ramanamurty, D.V. July, 1989. A report on the groundwater resources of Project-C (small farmers area), Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains reports on testing of two old wells, Phoenix Park #1 and #3 and drilling of five coreholes, Lawrencefield, Riversdale #2 and #3 Cowpark B and C.

7. Ramanamurty, D.V., K. Mulchansingh and B. Fernandez. July, 1989. A report on the ground water levels in parts of Bernard Lodge and Caymanas areas and adjoining coastal area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains water level data and hydrographs for 27 wells and descriptions on the fluctuations in water levels.

8. Ramanamurty, D.V., and B. Fernandez. July, 1989. A note on the salinity of and groundwater from Riversdale #1 well, Caymanas area, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains chemical analyses results of water samples collected from Riversdale #1 well from August, 1986 to March 1989 and description on the changes in the quality of groundwater with pumping time. Attempts to explain the unusually high concentrations of sodium and chloride in water just at the beginning of pumping.

9. Ramanamurty D.V.and B. Fernandez. July, 1989. A note on the water levels and quality of groundwater from the observation well at Hill-Run, St. Catherine Plains. National Irrigation Commission, Kingston.

Contains water level data, hydrographs and chemical analyses results of water samples from the Hill-run observation well.

Reports on the construction of five (5) observation wells along the coast and in the Hill-Run area, and on the drilling of two (2) exploratory wells tapping the limestone Aquifer in the Hill-Run area and on the organic contamination of groundwater in parts of Bernard Lodge area have been issued by the Underground Water Authority under the titles listed below:

1. Fernandez, B. January, 1988. The drilling of monitoring wells, South St. Catherine. Underground Water Authority, Kingston.

The Crop Diversification Project on the South St. Catherine alluvial plains, required high quality groundwater, necessitating the replacement of older sand pumping wells. The quality of groundwater must remain high and the monitoring well network is one early warning system put in place to detect any changes in groundwater quality. The five monitoring wells are aligned in a crescent between the well field and the sea. Multi-level (piezometers) and single level completion using 3" O pvc have been constructed.

2. Fernandez, B. July, 1988. Well completion report, Hill-Run Drive #1, exploratory Well, South St. Catherine. Underground Water Authority, Kingston.

Contains drilling, and testing information. The hole was drilled down to 200 ft. Groundwater from the well was highly saline in the deep zone and moderately saline in the top zone. The well was abandoned.

3. Fernandez, B. August 1988. Well completion report, Pepper Pot Drive exploratory well #2, Hill Run area, St. Catherine. Underground Water Authority, Kingston.

Contains drilling and testing information. The hole was drilled down to 80 ft. Testing could not be completed due to caving of the hole and it was abandoned.

4. Fernandez, B. and D.V. Ramanamurty. July 1989. Groundwater monitoring for organic contamination. Bernard Lodge, St. Catherine Plains. Underground Water Authority, Kingston.

Six water samples one each from six wells in and around the project areas were analysed. Concentration of organophosphorous pesticides in the groundwater were below the detectable limit. Concentration of organochlorine pesticides were also less than the detectable limit except in one sample.

Facilities extended by Agro-21 Corporation Limited, Underground Water Authority and National Irrigation Commission Limited, in furtherance of the work and in the preparation of the reports are gratefully acknowledged.

A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-C (SMALL FARMERS' AREA) CAYMANAS AREA, ST. CATHERINE PLAINS

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A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-C (SMALL FARMERS' AREA) CAYMANAS AREA - ST. CATHERINE PLAINS

1. INTRODUCTION

The small farmers' area of Project-C is about acres in extent. It is south of Rio Cobre river and bounded on the south by the Spanish Town/Kingston railway line. A map showing the location of the area and the wells in and around it is enclosed.

There are 8 wells in and around the area viz: Cow Park #1, Riversdale #1, Watson Grove #3, Cumberland Pen, Phoenix Park #1, 2, 3 and 4. Cow Park #1 well is in the western part of the area and is being used by the Pioneer Seed Farm for irrigation. Riversdale #1 and Watson Grove #3 are new wells and owned by National Irrigation Commission Limited and supply water for Horticulture Park. Cumberland Pen well is in the east and privately owned. Phoenix Park #1, 2, 3 and 4 are old wells and lie in the eastern part of the area.

2. REHABILITATION OF THE OLD WELLS

The four old wells were not in use for a long time. In January 1988, a survey of the wells was made. It was found that Phoenix Park #1 and #3 wells are in usable condition. Phoenix Park #2 well was filled with stones almost to the water level and was not in a fit condition for rehabilitation. Phoenix Park #4 well was also filled with stones upto the top and the area around the well is sunk. It was decided to clean and test Phoenix Park #1 and #3 wells. There was a pump on Phoenix Park #3 well.

2.1 Cleaning and Testing of the Old Wells

The cleaning and testing operations were conducted by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10, in January-February, 1988. A percussion rig was used to conduct these operations.

The wells were first cleaned down to the original depth by bailing the material with a bailer and then cleaning the well with compressed air. A step-drawdown test and time drawdown test were then conducted with a turbine pump. A description of the cleaning and testing operations carried out is given in the following sections:

2.1.1 Phoenix Park #3 Well

The pump house was demolished and the existing pump was removed. The well was cleaned down to 97 ft. The static water level was 14.2 ft. below ground level (bgl). A step-drawdown test was conducted on January 26, 1988, with discharge rates of 600, 812 and 1000 USgpm and the pumping water levels were around 30 ft., 39 ft., and 46 ft. respectively. The test data is given in Table-1 and the data plot is given in Fig 1. Calculation of formation loss, well loss and well efficiency are shown in Table-2. A long duration pumping test was conducted on January 27-29, 1988, for a period of 48 hours at a discharge rate of 700 USgpm. The pumping water level stabilized around 38 ft. b.g.l. The test data is given in Table-3 and the time vs drawdown graph and t/t' vs residual drawdown graph are given as Fig 2 and 3 respectively. The transmissivity of the formation works out to 57 x 10^3 USgpd/ft. and 28 x 10^3 USgpd/ft. by drawdown and recovery methods respectively. Historical abstraction rate from the well was about 580 USgpm. Therefore the well can be put to use at 600 USgpm. The average sand content in water during the long duration pumping test was 0.1 mg/l. At a pumping rate of 600 USgpm the sand content is expected to be less than 0.1 mg/l.

2.1.2 Phoenix Park #1 Well

The pump house was demolished and the well was cleaned down to the original depth of 56 ft. The static water level was 15.66 ft. below ground level. A step drawdown test was conducted on February 16, 1988, at discharge rates of 346, 548 and 700 USgpm and the pumping water levels were around 22 ft., 28 ft. and 32 ft. respectively. The test data is given as Table-4 and the data plot is given at Fig 4. Calculations of formation loss, well loss and well efficiency are shown in Table-5. A long duration pumping test was conducted for a period of 48 hours on February 18-20, 1988 at a discharge rate of 500 USgpm and the test data is given in Table-6. The pumping water level stabilized around 27 ft.

The drawdown vs time and residual drawdown vs t/t' graphs are given as Fig 5 and 6 respectively. The transmissivity of the formation works out to 82 x 10^3 USgpd/ft. and 60 x 10^3 USgpd/ft. by the drawdown and recovery methods respectively.

Historical abstraction rate from the well was 810 USgpm but the test data indicates that the well can be pumped at 500 USgpm taking into consideration the sand content in well water and the pumping water level.

The sand content in water during the first two hours of step-drawdown test at the rate of 346 USgpm was 20 mg/litre. This reduced reduced to 5 mg/l subsequently. During this time-drawdown test, sand content in water in the first hour was 2 mg/l and subsequently it varied from 0.25 mg/l 0.8 mg/l.

3. QUALITY OF GROUNDWATER

Chemical analyses results of three water samples from each of the two wells, collected during the time draw-down test are given in Tables-7 and 8. Water quality guidelines for irrigation are given in Table-9.

The pH of the water ranges from 7.5 to 7.9. Specific conductance varies from 530 t0 628 µ-mhos/cm. Sodium is less than 32 mg/l, chloride is less than 27 mg/l, boron is less than 0.2 mg/l and SAR is less than 1. A comparison of the quality of water with the water quality guidelines for irrigation indicates that the groundwater does not create any problem with respect to salinity, permeability and toxicity of specific ions to sensitive crops.

Bicarbonate in the groundwater, however, is more than 40 mg/l and in waters draining a limestone terrain bicarbonate is bound to be high. If any miscellaneous problems occur due to high bicarbonate content, remedial measures may be adopted.

4. NEW WELLS

In order to select sites suitable for constructing wells, coreholes of 2" diameter were initially drilled at five locations. Core samples were collected at 2ft. intervals. The core samples so obtained were examined and depths at which aquifer zones occur were identified.

Locations of the coreholes are shown in the enclosed map and the particulars of the corehole drilling are given in Table-10.

Table 10: Particulars of Corehole drilling in Project-C (Small Farmers' Area)

Location	Depth Drilled (ft.)	Dates of Drilling	Drilling Company
1. Lawrencefield	110	Sept. 5-10, 1985	Caribbean Boring & Diamond Drilling Limited 1 Hillview Ave, Kingston 10
2. Riversdale #2	104	Aug. 28 to Sept. 3, 1985	
3. Riversdale #3	122	Oct. 4-10 1988	Geotech Engineering Services Limited, Hope Road, Kingston 10
4. Cow Park B	122	Oct. 19-27, 1988	
5. Cow Park C	122	Oct. 31 to Nov. 7, 1988	

Lithological logs of the coreholes are given in Tables 11-15. An examination of the core samples showed that good aquifer zones occur at two locations viz: Riversdale #2 and Cow Park B. At the former location two zones occur at depths 42 ft. to 52 ft. and 82 ft. to 100 ft. and at the latter location also two zones occur at depths 50 ft. to 60 ft. and 100 ft. to 122 ft. Sieve analyses results of 6 aquifer samples from Riversdale #2 corehole and 12 samples from Cow Park B corehole are given in Tables 16 and 17. Cow Park B is centrally located, the aquifer zones here are thick and the aquifer material is coarse. Construction of a well at this location may be considered. Sieve analyses curves for Cow Park B corehole samples are given as Figure-7 and design for a proposed well is given as Fig 8.

Slot size of the well screens and specification of the gravel pack material were worked out from the sieve analyses data and are given below:

	Slot size of well screen	Specifications of the the gravel pack material
Upper aquifer	0.040"	0.033" - 0.066" - 55% 0.066" - 0.187" - 45%
Lower aquifer	0.100"	0.094" - 0.132" - 40% 0.132" - 0.250" - 35% 0.250" - 0.375" - 25%

REFERENCES

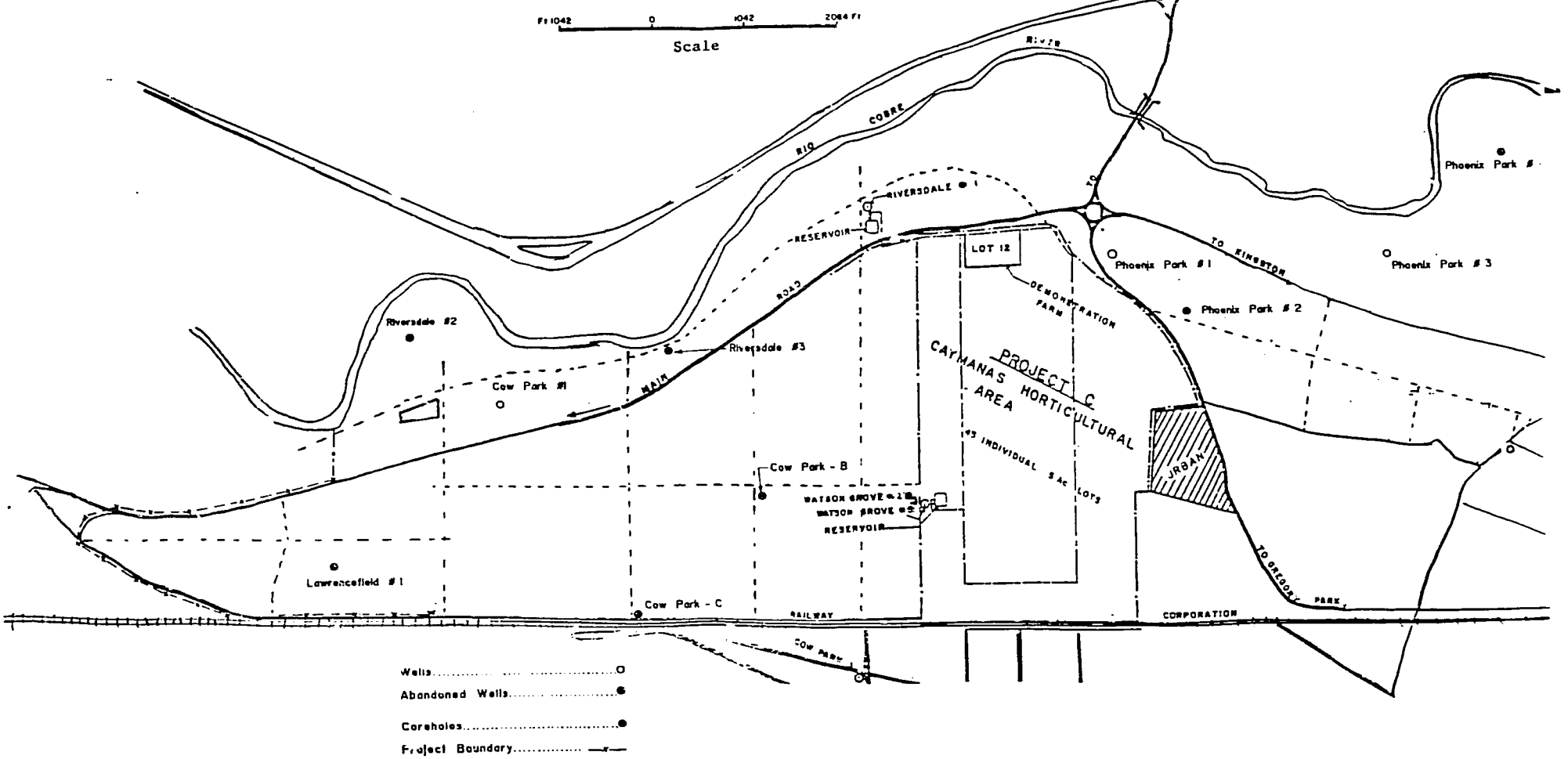
Johnson Division, UOP, Inc. 1982. Groundwater and Wells, Saint Paul, Minnesota.

John Hem. 1971. Study and Interpretation of Chemical Characteristics of Natural Water. USGS Water Supply Paper, 1473. Washington D.C.

Keith E. Anderson (Editor). 1979, Waterwell Handbook, Missouri Waterwell and Pump Contractors Association Inc. Belle.

Todd D.K. 1980, Groundwater Hydrology, John Wiley & Sons Inc., New York.

Map Of Project - C (Small Farmers Area)
Caymanas Area. St. Catherine Plains



St. Catherine Plains

Step-Drawdown Test Data

Location: PHOENIX PARK #3 **Area:** CAYMANAS PROJECT 'C'

Diameter- Discharge Pipe - 10" Orfice - 7 INCHES

Static Water Level - 14.20 FT. BELOW GROUND LEVEL

DATE 1	TIME (HOURS) 2	TIME SINCE PUMPING STARTED (MINUTES) 3	DEPTH TO WATER (FT) 4	DRAWDOWN (FT) 5	MONOMETER READING (INCHES) 6	DISCHARGE (US GPM) 7	REMARKS 8
26-1-88	10:18	S T E P	T E S T	S T A R T E D			
			STEP 1		8	600	
	10:20	2	23.41	9.20	-DO-	-DO-	
		3	24.78	10.58	-DO-	-DO-	
		4	25.11	10.91	-DO-	-DO-	
		5	25.61	11.41	-DO-	-DO-	
		6	25.99	11.79	-DO-	-DO-	
		7	25.99	11.79	-DO-	-DO-	
		8	26.32	12.12	-DO-	-DO-	
		9	26.61	12.41	-DO-	-DO-	
	10:33	15	27.28	13.08	-DO-	-DO-	
		20	27.74	13.54	-DO-	-DO-	
	10:43	25	27.90	13.70	-DO-	-DO-	
		30	28.15	13.95	-DO-	-DO-	
	10:53	35	28.30	14.10	-DO-	-DO-	
		40	28.45	14.25	-DO-	-DO-	
	11:03	45	28.53	14.33	-DO-	-DO-	
		50	28.65	14.45	-DO-	-DO-	
	11:13	55	28.78	14.58	-DO-	-DO-	
		60	28.86	14.66	-DO-	-DO-	
	11:28	70	29.07	14.87	-DO-	-DO-	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: PHOENIX PARK #3

1	2	3	4	5	6	7	8
26-1-88							
			STEP 1				
		80	29.20	15.00	8	600	
		90	29.36	15.16	"	"	
		100	29.42	15.22	"	"	
		110	29.88	15.68	"	"	
	12:18	120	29.64	15.44	"	"	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: PHOENIX PARK #3

1	2	3	4	5	6	7	8
26-1-88			STEP 2				
	12:19	1			15	812	
	:20	2	35.41	21.21	"	"	
	:22	4	35.62	21.42	"	"	
	:23	5	35.78	21.58	"	"	
	:24	6	35.88	21.68	"	"	
	:25	7	35.98	21.78	"	"	
	:26	8	36.10	21.90	"	"	
	:27	9	36.16	21.96	"	"	
	:28	10	36.26	22.06	"	"	
	:33	15	36.54	22.34	"	"	
	:38	20	36.80	22.60	"	"	
	:43	25	36.96	22.76	"	"	
	:48	30	37.06	22.86	"	"	
	:53	35	37.16	22.96	"	"	
	:58	40	37.30	23.10	"	"	
	13:08	50	37.66	23.46	"	"	
	13:18	60	37.68	23.48	"	"	
	:38	80	37.90	23.70	"	"	
	:48	90	38.04	23.84	"	"	
	:58	100	38.20	24.00			
	14:08	110	38.24	24.04			
	14:18	120	38.28	24.08	"	"	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: PHOENIX PARK #3

1	2	3	4	5	6	7	8
26-1-88			STEP 3				
	2:19	1			23	1001	
	:20	2		28.70			
	:21	3	42.90	28.70	"	"	
	:22	4	43.38	29.18			
	:23	5	43.48	29.28			
	:24	6	43.60	29.40			
	:25	7	43.66	29.46			
	:26	8	43.76	29.56			
	:27	9	43.86	29.66			
	:28	10	43.90	29.70			
	:33	15	44.48	30.24			
	2:38	20	44.26	30.06			
	:43	25	44.80	30.0			
	:48	30	44.62	30.42			
	:53	35	44.76	30.56			
	:58	40	44.84	30.64			
	3:08	50	44.94	30.74			
	3:18	60	45.20	31.00			
	:28	70	45.26	31.06			
	:38	80	45.38	31.18			
	:48	90	45.46	31.26			
	:58	100	45.50	31.30			
	4:08	110	45.66	31.46			
	4.18	120	45.70	31.0	"	"	

Fig. 1

PHOENIX PARK #3

St. Catherine Plains

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'

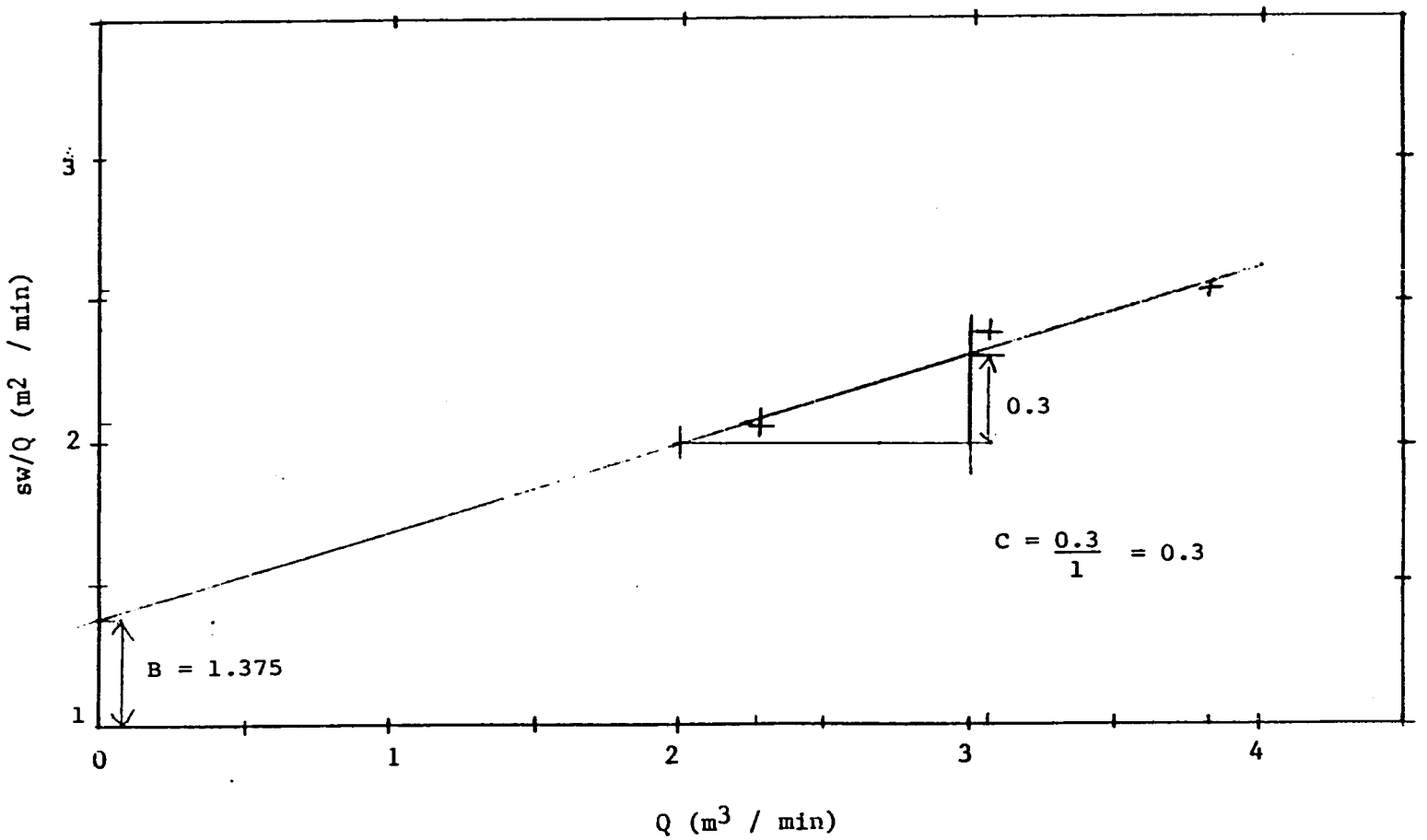


TABLE 2

ST. CATHERINE PLAINS

PHOENIX PARK #3

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q)		Drawdown (SW)		SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
	USgpm	m^3/min	Ft.	m						
1	600	2.27	15.44	4.70	2.07	3.12	1.55	4.67	66	39
2	812	3.07	24.08	7.34	2.39	4.22	2.83	7.05	60	38
3	1001	3.79	31.46	9.59	2.53	5.21	4.31	9.52	55	32

From the Graph (Figure)

Formation loss coefficient (B) = 1.375

Well loss coefficient (C) = 0.30

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Location: PHOENIX PARK #3 **Area:** CAYMANAS - PROJECT 'C'

Diameter- Discharge Pipe 10 INCHES **Orfice** 7 INCHES

Static Water Level 14.21 FT. BELOW GROUND LEVEL

DATE 1	TIME (HOURS) 2	TIME SINCE PUMPING STARTED (MINUTES) 3	DEPTH TO WATER (FT) 4	DRAWDOWN (FT) 5	MONOMETER READING (INCHES) 6	DISCHARGE (US GPM) 7	REMARKS 8
27/1/88	1501	1	-	-	11.5	713	
		4	25.62	11.41	11.5	713	
	1507	7	28.50	14.29		713	
	1515	15	31.88	17.67		713	
	1520	20	32.88	18.67			
		25	33.00	18.79			
	1530	30	33.26	19.05			
		35	33.48	19.27			
		40	33.70	19.49			
		45	33.80	19.59			
	1600	60	34.18	19.97	11.00	698	
	1615	75	34.50	20.29			
	1630	90	34.74	20.53			
		105	35.00	20.79			
	1700	120	35.00	20.79			
	1800	180	35.98	21.77			
	1900	240	36.20	21.99			
	2000	300	36.42	22.21			
		360	36.54	22.33			
	2200	420	36.68	22.47			

St. Catherine Plains

Pumping Test Data (Continued)

Location: PHOENIX PARK #3

1	2	3	4	5	6	7	8
		480	36.74	22.53	11	698	
28/1/88	00.00	540	36.88	22.67			
		600	36.96	22.75			
		660	37.22	23.01			
	03.00	720	37.48	23.27	11	698	
28/1/88		780	37.58	23.37	11	698	
		840	37.64	23.43			
	06.00	900	37.72	23.51	11	698	
		960	37.70	23.49	"	"	
		1020	37.70	23.49	"	"	
	09.00	1080	37.70	23.49	"	"	
		1140	37.70	23.49	"	"	
		1200	37.72	23.51	"	"	
	12.00	1260	37.70	23.49	"	"	
		1320	37.70	23.49	"	"	
		1380	37.72	23.51	"	"	
	15.00	1440	37.72	23.51	"	"	
		1500	37.74	23.53	"	"	
		1560	37.76	23.55	"	"	
	18.00	1620	37.80	23.59	"	"	
		1680	37.80	23.59	"	"	
		1740	37.84	23.63	"	"	
	21.00	1800	37.86	23.65	"	"	
		1860	37.88	23.67	"	"	

St. Catherine Plains

Test Data (Continued)

Location: PHOENIX PARK #3

1	2	3	4	5	6	7	8
		1920	38.00	23.79	11	698	
29/1/88	00.00	1980	38.02	23.81	"	"	
		2040	38.04	23.83	"	"	
		2100	38.06	23.85	"	"	
	03.00	2160	38.08	23.87	"	"	
		2220	38.10	23.89	"	"	
		2280	38.12	23.91	"	"	
	06.00	2340	38.18	23.98	"	"	
	..	2400	38.14	23.93	"	"	
		2460	38.18	23.98	"	"	
	09.00	2520	38.18	23.98	"	"	
		2580	38.18	23.98	"	"	
		2640	38.10	23.89	"	"	
	12.00	2700	38.04	23.83	"	"	
		2760	38.10	23.89	"	"	
		2820	38.12	23.91	"	"	
	03.00	2880	38.12	23.91	"	"	
	..						

Pumping Test Data (Continued)

Location: PHOENIX PARK #3 **Recovery Data:**

DATE (1)	TIME (HOUR) (2)	TIME SINCE PUMPING STARTED - t (MINUTES) (3)	TIME SINCE PUMPING STOPPED - t' (MINUTES) (4)	DEPTH TO WATER (FT.) (5)	RESIDUAL DRAWDOWN (FT.) (6)	t/t' (7)
		RECOVERY DATA				
		2881	1	29.80	15.59	2881.0
		2882	2	27.20	12.99	1441.0
		2883	3	26.94	12.73	961.0
		2884	4	26.80	12.59	721.0
		2885	5	26.74	12.53	577.0
		2886	6	26.04	11.83	481.0
		2887	7	25.05	10.84	412.4
		2888	8	—	—	
		2889	9	—	—	
		2890	10	24.45	10.24	289.0
	3:15pm	2895	15	23.20	8.99	193.0
		2900	20	23.01	8.80	145.0
		2905	25	22.03	7.82	116.2
	3:30	2910	30	21.06	6.85	97.0
		2915	35	20.92	6.71	83.3
		2920	40	—	—	
		2925	45	19.32	5.11	65.0
		2930	50	19.00	4.79	58.6
	4:00pm	2940	60	18.04	3.83	49.0
		2950	70	18.04	3.83	42.1
		2960	80	17.82	3.61	37.0
		2970	90	17.01	2.80	33.0

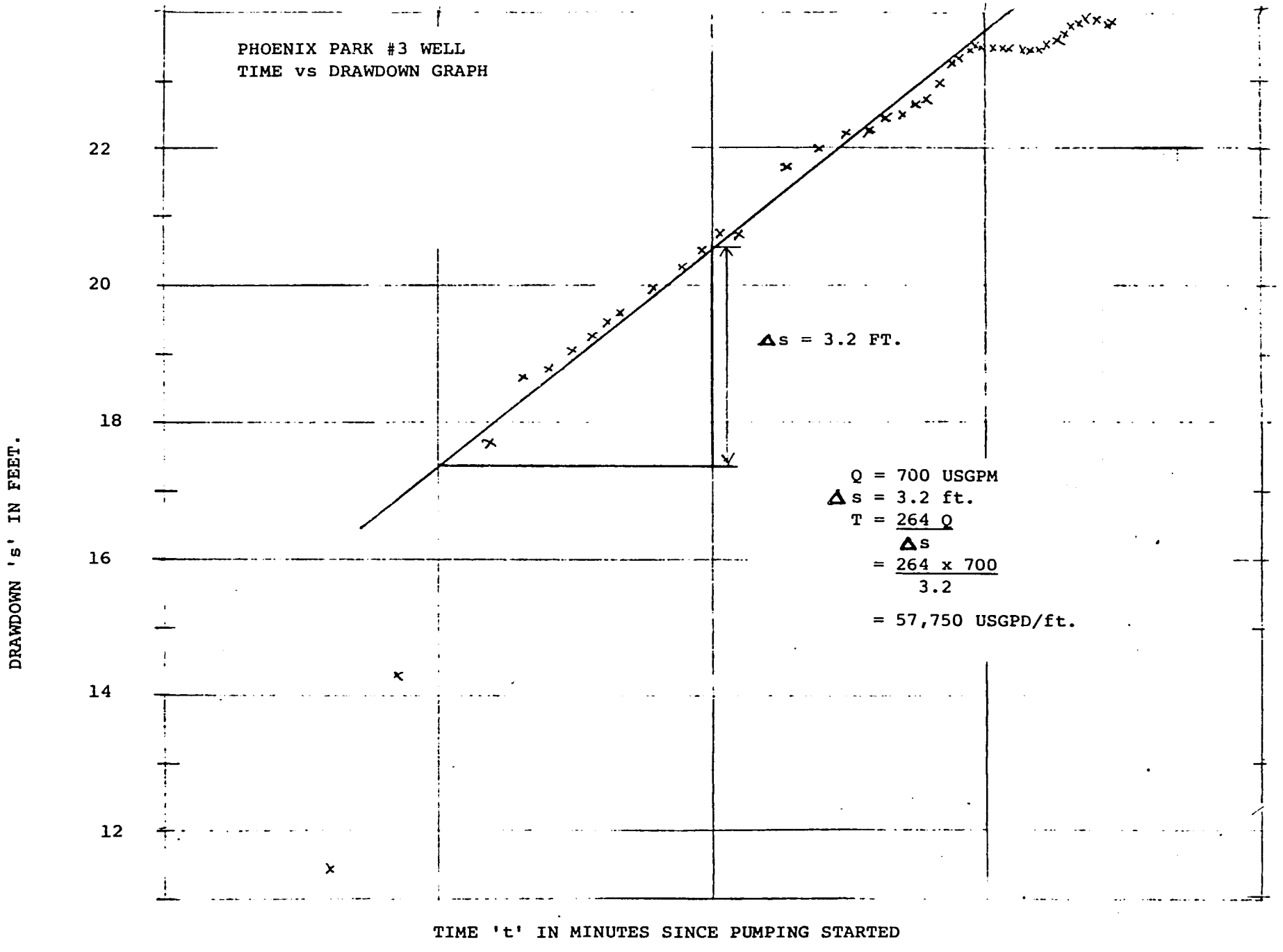
Pumping Test Data (Continued)

Location: PHOENIX PARK#3 **Recovery Data:**

DATE (1)	TIME (HOUR) (2)	TIME SINCE PUMPING STARTED - t (MINUTES) (3)	TIME SINCE PUMPING STOPPED - t' (MINUTES) (4)	DEPTH TO WATER (FT.) (5)	RESIDUAL DRAWDOWN (FT.) (6)	t/t' (7)
		RECOVERY DATA				
		2980	100	16.84	2.63	29.8
		2990	110	16.01	1.80	27.2
	5:00 pm	3000	120	17.84	3.63	25.0
		3015	135	17.61	3.40	22.3
		3030	150	16.41	2.20	20.2
		3045	165	16.40	2.19	18.4
	6:00 pm	3060	180	16.01	1.80	17.0
	6:30 pm	3090	210	15.04	0.83	14.7
	7:00 pm	3120	240	14.71	0.50	13.0
	7:30 pm	3150	270	14.70	0.49	11.7

CAYMANAS AREA

Fig. 2



CAYMANAS AREA

PHOENIX PARK #3 WELL
t/t' vs residual drawdown graph

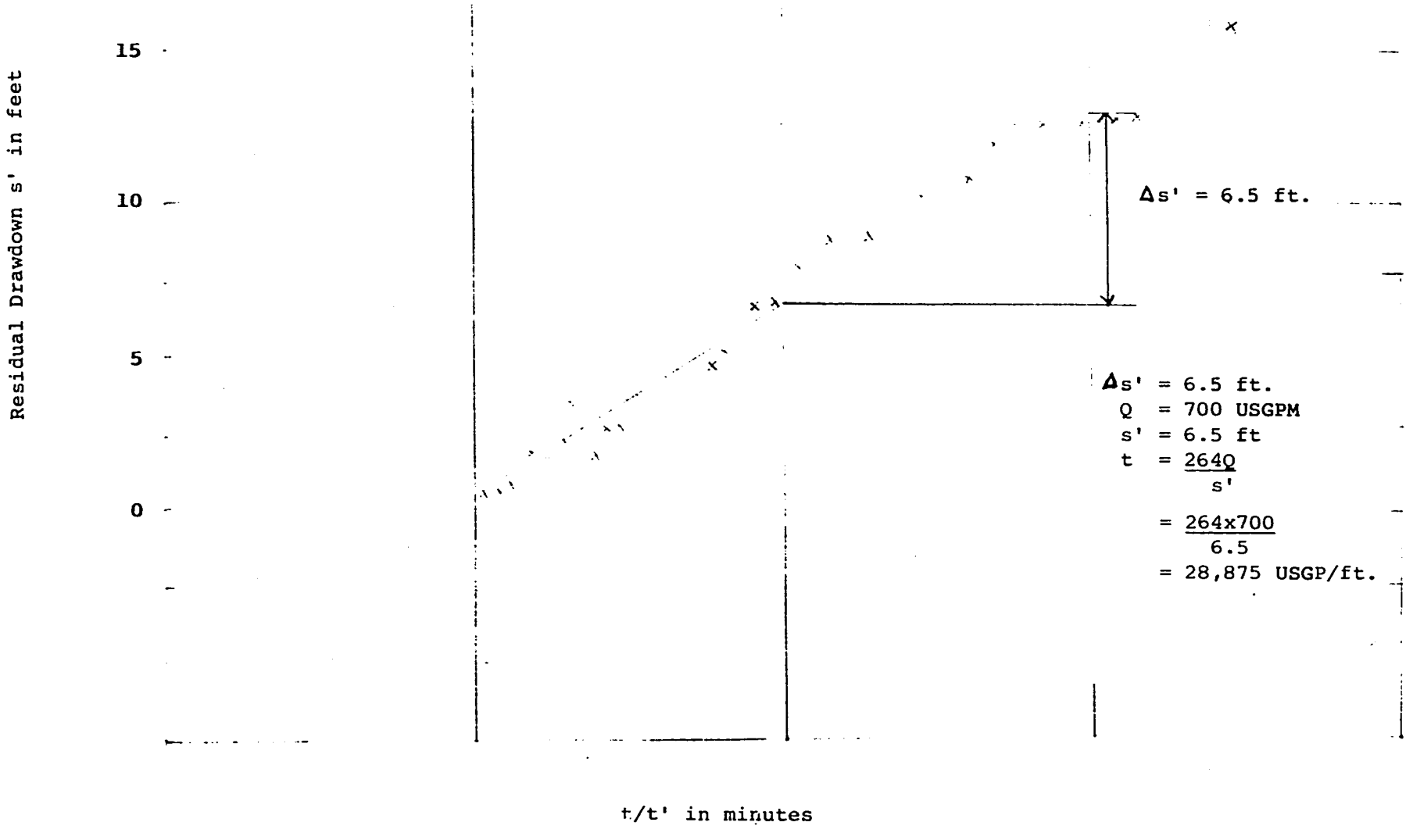


Table-4

(1)

St. Catherine Plains

Step-Drawdown Test Data

Location: PHOENIX PARK #1 Area: CAYMANAS PROJECT 'E'

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 17.26 FT. BELOW M.P. WHICH IS 2 FT. ABOVE G.L.

DATE 1	TIME (HOURS) 2	TIME SINCE PUMPING STARTED (MINUTES) 3	DEPTH TO WATER (FT) 4	DRAWDOWN (FT) 5	MONOMETER READING (INCHES) 6	DISCHARGE (US GPM) 7	REMARKS 8
16-2-88	1006	STEP	TEST	STARTED - STEP-1			
		1	22.27	5.01	12.5	346	
		2	22.32	5.06	"	"	
		3	21.80	4.54	"	"	
		4	22.06	4.80	"	"	
		5	22.28	5.02	"	"	
		6	22.40	5.14	"	"	
		7	23.18	5.92	"	"	
		8	22.76	5.50	"	"	
		9	22.76	5.50	"	"	
		10	23.96	6.70	"	"	
		15	24.32	7.06	"	"	
		20	23.36	6.10	"	"	
		30	23.52	6.26	"	"	
		40	23.56	6.30	"	"	
		50	23.66	6.40	"	"	
		60	23.84	6.58	"	"	
		75	23.86	6.60	"	"	
		90	23.92	6.66	"	"	
		105	23.94	6.68	"	"	
		120	24.16	6.90	"	"	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: PHOENIX PARK #1

1	2	3	4	5	6	7	8
16.2.88	1206		STEP - 2				
		1	26.26	9.00	31.5	548	
		2	26.82	9.56	"	"	
		3	27.16	9.90	"	"	
		4	27.46	10.20	"	"	
		5	27.66	10.40	"	"	
		6	27.80	10.54	"	"	
		7	27.94	10.68	"	"	
		8	28.04	10.78	"	"	
		9	28.12	10.86	"	"	
		10	28.24	10.98	"	"	
		25	28.86	11.60	"	"	
		30	28.76	11.50	"	"	
		40	28.96	11.70	"	"	
		50	29.08	11.82	"	"	
		60	28.86	11.60	"	"	
		75	29.22	11.96	"	"	
		90	29.42	12.16	"	"	
		105	29.40	12.14	"	"	
		120	29.42	12.16	"	"	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: PHOENIX PARK #1

1	2	3	4	5	6	7	8
16.2.88	1406		S T E P - 3				
		1	31.34	14.08	52	700	
		2	31.90	14.64	"	"	
		3	31.96	14.70	"	"	
		4	32.06	14.80	"	"	
		5	32.26	15.00	"	"	
		6	32.44	15.18	"	"	
		7	32.56	15.30	"	"	
		8	32.66	15.40	"	"	
		9	32.66	15.40	"	"	
		10	32.76	15.50	"	"	
		15	32.96	15.70	"	"	
		20	33.12	15.86	"	"	
		25	33.18	15.92	"	"	
		30	33.24	15.98	"	"	
		40	33.32	16.06	"	"	
		50	33.42	16.16	"	"	
		60	33.60	16.34	"	"	
		75	33.68	16.42	"	"	
		90	33.80	16.54	"	"	
		105	33.58	16.32	"	"	
		120	33.78	16.52	"	"	

Fig. 4

PHOENIX PARK #1

St. Catherine Plains

Step - Drawdown Test Data Plot
Determination of 'B' and 'C'

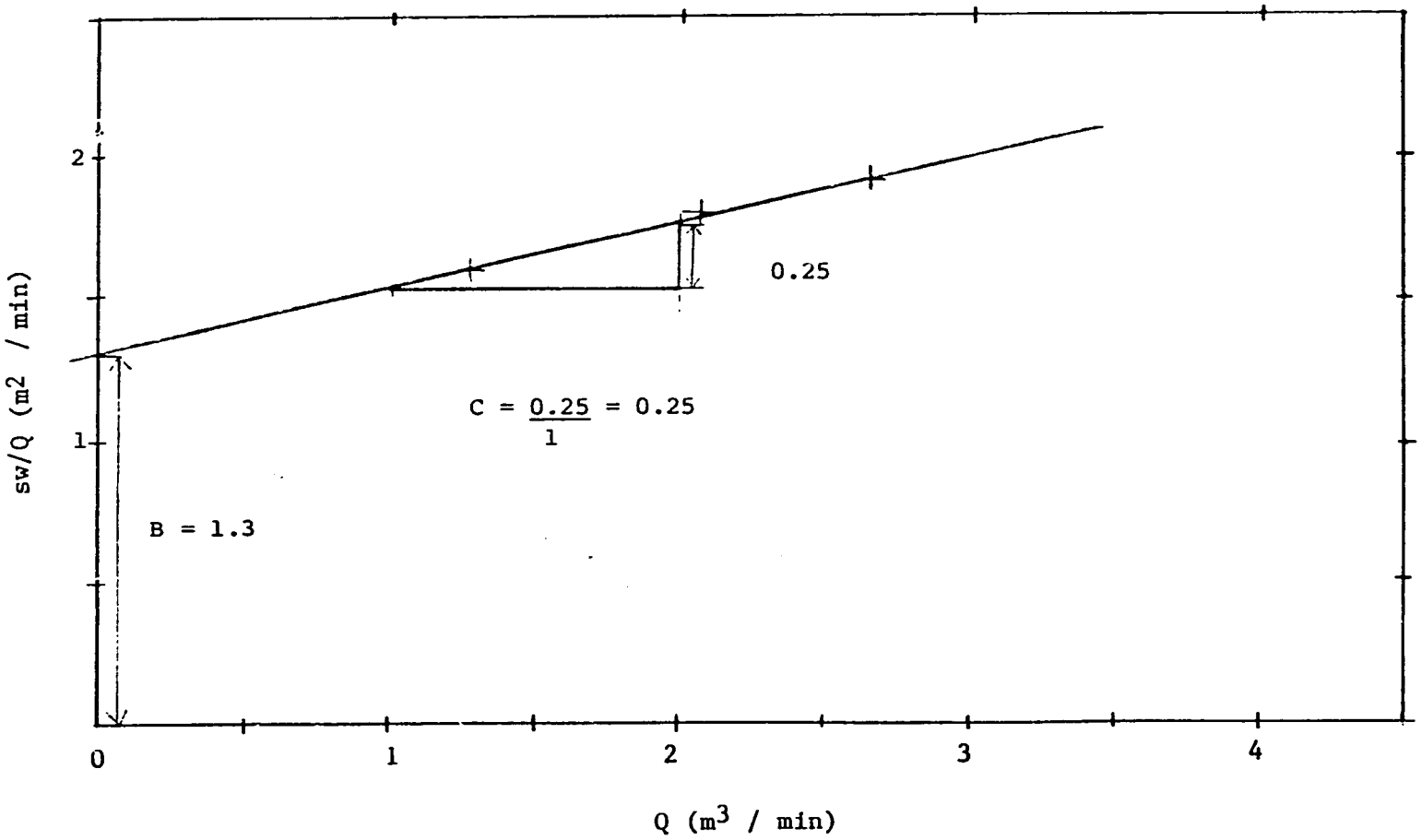


TABLE 5

ST. CATHERINE PLAINS

PHOENIX PARK #1

Calculation of Formation Loss, Well Loss and Well Efficiency from Step-Drawdown Test Data

Step No.	Discharge (Q)		Drawdown (SW)		SW/Q	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity
	USgpm	m^3/min	Ft.	m	(m^2/min)					(USgpm/ft)
1	346	1.31	6.90	2.10	1.60	1.70	0.43	2.13	80	50
2	548	2.07	12.16	3.70	1.79	2.70	1.07	3.77	72	45
3	700	2.65	16.52	5.03	1.90	3.45	1.76	5.21	66	42

From the Graph (Figure 4)

Formation loss coefficient (B) = 1.3

Well loss coefficient (C) = 0.25

Well efficiency = $\frac{BQ}{SW} \times 100$

St. Catherine Plains

Pumping Test Data

Location: PHOENIX PARK #1 Area: CAYMANAS - PROJECT 'C'

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 17.66 FT. BELOW M.P. WHICH IS 2 FT. ABOVE G.L.

DATE 1	TIME (HOURS) 2	TIME SINCE PUMPING STARTED (MINUTES) 3	DEPTH TO WATER (FT) 4	DRAWDOWN (FT) 5	MONOMETER READING (INCHES) 6	DISCHARGE (US GPM) 7	REMARKS 8
.8 2/88	1400	PUMPING TEST STARTED					
		1	21.66	4.00	25.5	500	
		2	22.84	5.18	"	"	
		3	23.64	5.98	"	"	
		4	24.18	6.52	"	"	
		5	24.64	6.98	"	"	
		6	24.92	7.26	"	"	
		7	25.22	7.56	"	"	
		8	25.44	7.78	"	"	
		9	25.66	8.00	"	"	
		10	25.82	8.16	"	"	
		15	26.30	8.64	"	"	
		20	26.62	8.96	"	"	
		25	26.84	9.18	"	"	
		30	27.00	9.34	"	"	
		40	27.24	9.58	"	"	
		50	27.38	9.72	"	"	
	1500	60	27.50	9.84	"	"	
		75	27.64	9.98	"	"	
		90	27.74	10.08	"	"	
		105	27.82	10.16	"	"	

St. Catherine Plains

Pumping Test Data (Continued)

Location: PHOENIX PARK #1

1	2	3	4	5	6	7	8
18.2.88	1600	120	27.90	10.24	25.5	500	
		150	28.00	10.34	"	"	
		180	28.08	10.42	"	"	
		210	28.10	10.44	"	"	
	1800	240	28.16	10.50	"	"	
		300	28.24	10.58	"	"	
		360	28.32	10.66	"	"	
		420	28.36	10.70	"	"	
	2200	480	28.40	10.74	"	"	
		540	28.40	10.74	"	"	
19.2.88	0000	600	28.42	10.76	"	"	
		660	28.42	10.76	"	"	
		720	28.44	10.78	"	"	
		780	28.46	10.80	"	"	
	0400	840	28.46	10.80	"	"	
		900	28.46	10.80	"	"	
		960	28.46	10.80	"	"	
		1020	28.38	10.72	"	"	
	0800	1080	28.36	10.70	"	"	
		1140	28.38	10.72	"	"	
		1200	28.38	10.72	"	"	
		1260	28.36	10.70	"	"	
	1200	1320	28.36	10.70	"	"	

St. Catherine Plains

Pumping Test Data (Continued)

Location: PHOENIX PARK #1

1	2	3	4	5	6	7	8
19.2.88	1300	1380	28.36	10.70	25.5	500	
	1400	1440	28.16	10.50	"	"	
		1500	28.26	10.60	"	"	
	1600	1560	28.26	10.60	"	"	
		1620	29.66	12.00	"	"	
		1680	28.22	10.56	"	"	
		1740	28.22	10.56	"	"	
	2000	1800	28.20	10.54	"	"	
		1860	28.36	10.70	"	"	
		1920	28.34	10.72	"	"	
		1980	28.36	10.70	"	"	
20.2.88	0000	2040	28.32	10.72	"	"	
		2100	28.30	10.76	"	"	
		2160	28.18	10.52	"	"	
		2220	28.18	10.52	"	"	
	0400	2280	28.16	10.50	"	"	
		2340	28.16	10.50	"	"	
		2400	27.88	10.22	"	"	
		2460	27.90	10.24	"	"	
	0800	2520	27.80	10.14	"	"	
		2580	27.86	10.20	"	"	
		2640	27.90	10.24	"	"	
		2700	27.82	10.16	"	"	
	1200	2760	28.06	10.40	"	"	
		2820	28.02	10.36	"	"	
	1400	2880	28.76	11.10	"	"	

Pumping Test Data (Continued)

Location: PHOENIX PARK #1 **Recovery Data:**

DATE (1)	TIME (HOUR) (2)	TIME SINCE PUMPING STOPPED - t' (MINUTES) (3)	TIME SINCE PUMPING STARTED - t (MINUTES) (4)	DEPTH TO WATER (FT.) (5)	RESIDUAL DRAWDOWN (FT.) (6)	t/t' (7)
		RECOVERY DATA				
20.2.88	1403	3	2883	21.46	3.80	961
		4	2884	21.06	3.40	721
		5	2885	20.62	2.96	577
		6	2886	20.44	2.78	481
		7	2887	20.18	2.52	412
		8	2888	19.24	1.58	361
		9	2889	19.76	2.10	321
		10	2890	19.64	1.98	289
		15	2895	19.16	1.50	193
		20	2900	18.80	1.14	145
		25	2905	18.66	1.00	116
	1430	30	2910	18.49	0.83	97
		40	2920	18.29	0.63	73
		50	2930	18.18	0.52	58
	1500	60	2940	18.08	0.42	49
		75	2955	17.98	0.32	39
		90	2970	17.79	0.13	33
		105	2985	17.78	0.12	28
	1600	120	3000	17.76	0.10	25
		150	3030	17.68	0.02	20
	1700	210	3090	17.66	0.00	14

Fig. 5

CAYMANAS AREA

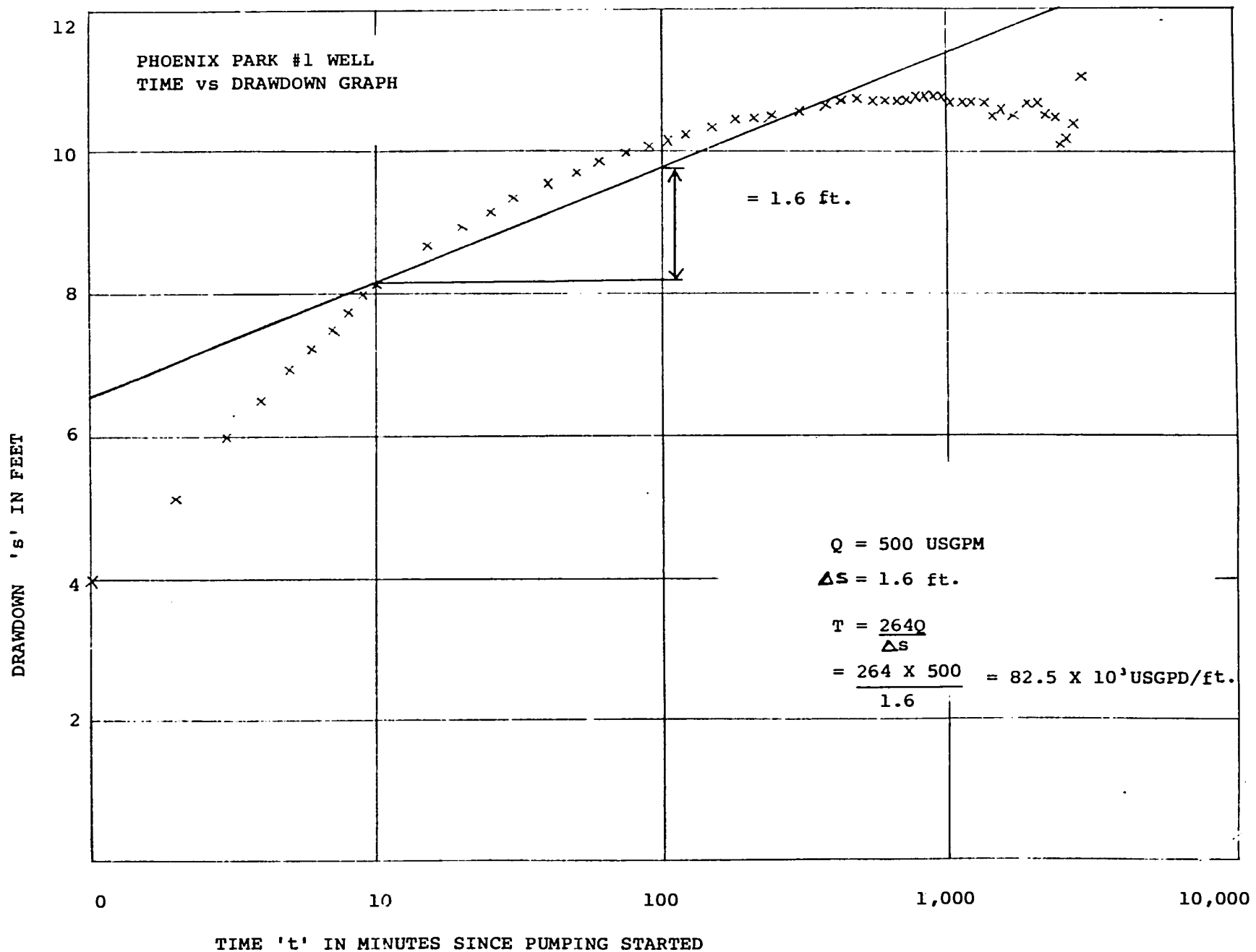
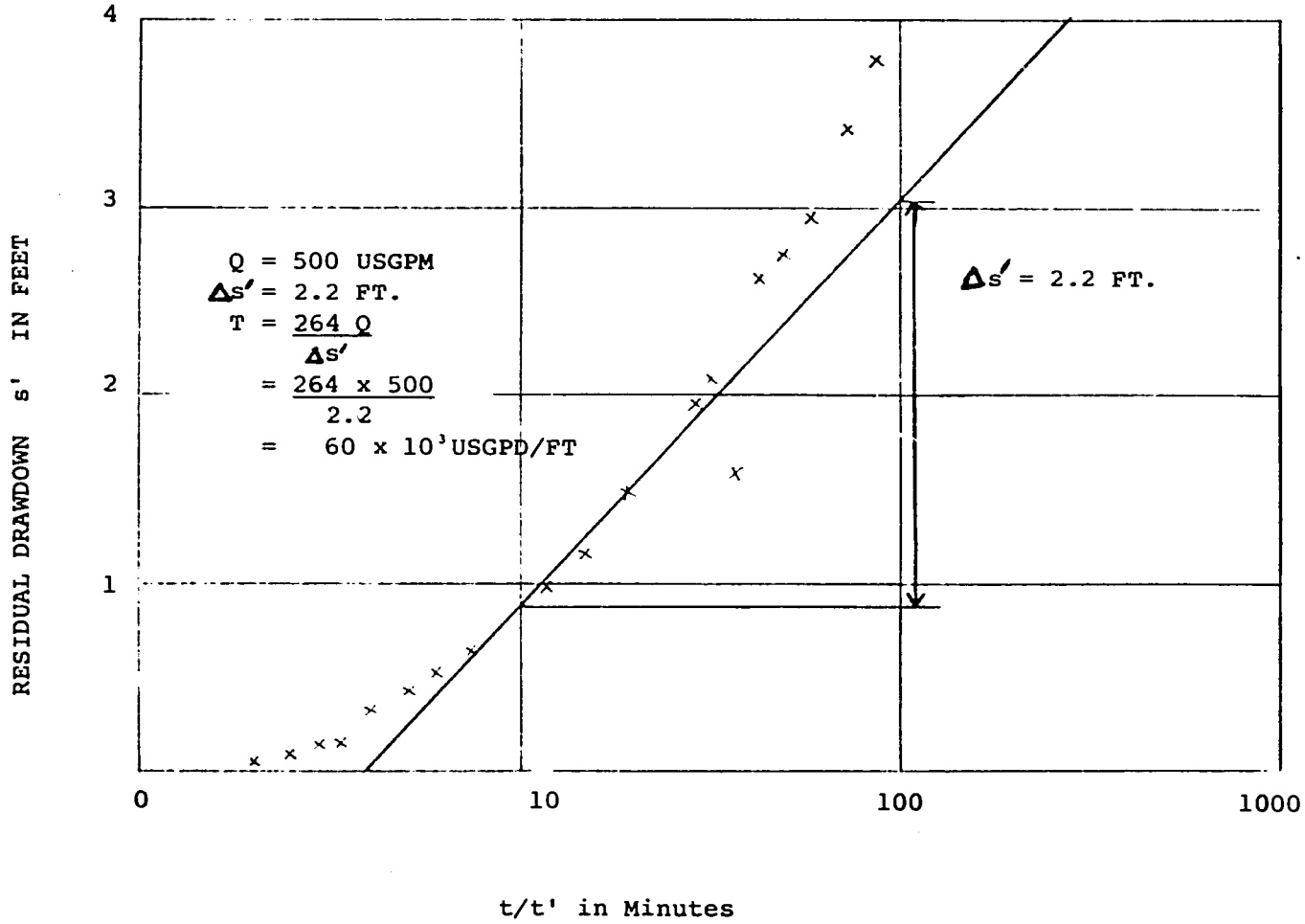


Fig. 6

CAYMANAS AREA

PHOENIX PARK #1 WELL
t/t' vs RESIDUAL DRAWDOWN GRAPH



St. Catherine Plains

Table-7

Chemical Analysis of Water Samples

Location: PHOENIX PARK #1

Area: CAYMANAS

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR
				←						PPM	→									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	18 $\frac{2}{88}$	7.5	621	394.6	92.6	18.0	26.3	0.86	0.06	26.8	19.0	0.09	-	-	-	229.3	14.4	243.7	306	0.65
2	19 $\frac{2}{88}$	7.5	628	397.0	93.8	18.7	26.0	0.85	0.05	24.8	24.5	0.11	-	-	-	229.9	16.8	246.7	312	0.64
3	20 $\frac{2}{88}$	7.7	617	393.6	64.9	19.2	25.8	0.80	0.07	21.7	33.3	0.12	-	-	-	232.3	14.4	246.7	242	0.72

@/µ/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Table-8

Chemical Analysis of Water Samples

Location: PHOENIX PARK #3

Area: CAYMANAS - PROJECT 'C'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR
				← PPM →																
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	27 1/88	7.6	550	339.0	73.7	18.0	31.0	0.9	0.21	21.5	8.8	0.07	-	-	-	281.6	-	281.6	259.0	0.84
2	28 1/88	7.9	530	316.0	74.5	14.9	31.0	0.9	0.03	20.9	10.8	0.11	-	-	-	268.1	-	268.1	248.0	0.86
3	29 1/88	7.8	530	320.0	69.7	17.3	31.0	0.9	0.04	21.3	10.8	0.07	-	-	-	237.3	-	237.3	246.0	0.86

@/µmhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

WATER QUALITY GUIDELINES FOR IRRIGATION[1]

Type of Problem	Degree of Problem		
	None	Increasing	Severe
Salinity			
EC (mmho/cm) or	Less than 0.75	0.75-3.0	More than 3.0
TDS (mg/liter)	Less than 480	480-1920	More than 1,920
Permeability			
Low EC (mmho/cm) or	More than 0.5	0.5-0	Less than 0.2
Low TDS (mg/liter)	More than 320	320-0	—
SAR	Less than 6.0	6.0-9.0	More than 9.0
Toxicity of Specific Ions to Sensitive Crops			
Related to soil			
Sodium (evaluated by SAR)	SAR less than 3	3-9	More than 9
Chloride			
meq/liter	Less than 2	2-10	More than 10
mg/liter	Less than 70	70-345	More than 345
Boron (mg/liter)	1.0	1.0-2.0	2.0-10.0
Related to Foliar Adsorption (Sprinkler Irrigated)			
Sodium			
meq/liter	Less than 3.0	More than 3	—
mg/liter	Less than 70	70	—
Chloride			
meq/liter	Less than 3.0	More than 3	—
mg/liter	Less than 100	100	—
Miscellaneous			
NH_4 and NO_3-N (mg/liter)	Less than 5	5-30	More than 30
HCO_3			
meq/liter	Less than 1.5	1.5-8.5	More than 8.5
mg/liter	Less than 40	40-520	More than 520
pH	Normal range: 6.5-8.4	—	—

Adapted from D. S. Farnham, R. S. Ayers, and R. F. Hasek, Water Quality, University of California Division of Agricultural Science Leaflet 2995 (1977)

[1] Interpretation is related to type of problem and its severity, but is modified by circumstances of soil, crop, and locality.

ST. CATHERINE PLAINS

CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE LAWRENCEFIELD #1

Depth (ft)	Thickness (ft.)	Description
0 - 4	4	Dark silty top soil
4 - 19	15	Brown, fine silty sand, clayey, with coarse sand at the bottom 8".
19 - 30	11	Brown silty, sandy clay
30 - 34	4	Fine to coarse grained silty sand with some clay
34 - 38	4	Brown fine to medium sand
38 - 48	10	Brown silty sandy clay
48 - 52	4	Stiff brown clay
52 - 58	6	Brown fine silty sand with sandy, silty clay on the top 8"
58 - 72	14	Reddish brown silty clay and silty sandy clay
72 - 82	10	Dark brown clay
82 - 88	6	Yellowish brown to dark brown silty clay with a little fine to coarse sand
88 - 90	2	Dark brown silty sand and clay
90 - 100	10	Brown and silty clay
100 - 108	8	Brown silty sandy clay with some layers of silty sand
108 - 110	2	Brown grey silty sandy clay with gravel

St. Catherine Plains
Caymanas Area
Lithological Log of Corehole
Riversdale #2

Depth Range (ft)	Thickness (ft)	Description
0-6	6	Light brown silty top soil.
6-10	4	Light brown silty fine sand.
10-11	1	Stiff dark brown clay.
11-19	8	Brown medium to coarse grained angular sand with a little gravel and clay.
19-30	11	Brown to dark brown silty, fine sand.
30-32	2	Brown medium to coarse grained sand.
32-40	8	Brown fine silty sand with a little angular coarse sand.
40-42	2	A mixture of fine silty sand, coarse sand and gravel.
42-44	2	Fine to very coarse sand with about 40 percent of gravel (upto 0.5 inch in size) and a little silt.
44-52	8	Fine to very coarse sand with about 20 percent of gravel (upto 0.25 inch in size) and a little silt.
52-60	8	Brown silty clay with a little sand.
60-72	12	Stiff brown silty clay with a little coarse sand, weathered limestone pebbles and gravel.
72-76	4	Brown fine sand with some silty clay and a little gravel
76-82	6	Brown silty clay, with a little sand.

Depth Range (ft)	Thickness (ft)	Description
82-100	18	Brown fine to very coarse grained sand and gravel (upto 0.5 inch in size) with a little silt and clay; the gravel content reduces from about 40 percent in the top to about 20 percent in the bottom.
100-104	4	Brown, silty clay with some fine to medium grained sand.

ST. CATHERINE PLAINS
CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE: RIVERSDALE #3

Depth (ft.)	Description
0 - 8	Dark brown silt, clayey
8 - 10	Brown, silty fine sand
10 - 12	Very fine to very coarse angular brown sand with a little gravel up to 1 inch in size
12 - 14	Brown silt, clayey
14 - 16	Stiff brown silty clay, slightly sandy
16 - 24	Stiff brown clay with loose, fine to coarse grained sand lenses
24 - 26	Stiff brown clay
26 - 28	Fine to very coarse grained brown sand, slightly clayey
28 - 32	Stiff dark brown clay
32 - 39	Silty fine to medium grained sand, clayey
39 - 44	Light brown hard clay
44 - 52	Light brown, stiff clay, slightly sandy
52 - 58	Brown, soft, silty clay with a little angular gravel
58 - 60	Brown soft clay, slightly sandy
60 - 62	Light brown soft, silty clay with some fine sand
62 - 64	Light brown, medium to coarse grained sand, clayey
64 - 66	Light brown silty clay
66 - 80	Light brown, silty fine to medium grained sand, slightly clayey
80 - 84	Hard brown clay, slightly sandy
84 - 88	Hard brown clay with silt and very coarse sand
88 - 96	Light brown stiff clay with a little gravel
96 - 100	Soft brown silty sandy clay with a little fine angular gravel
100 - 102	Silty fine sand and clay
102 - 108	Dark brown, fine to very coarse grained sand with a little clay
108 - 116	Light brown, very fine to medium grained sand with a little clay
116 - 122	Brown, very fine to coarse grained sand with a little gravel up to 1.5 inches in size

ST. CATHERINE PLAINS - CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE COW PARK B

DEPTH (FT.)	DESCRIPTION
0 - 6	Black to dark brown silty clay
6 - 8	Brown, very fine to coarse silty sand
8 - 10	Very fine to coarse sand with a little silt
10 - 18	Very fine to very coarse sand and gravel with some silt
18 - 20	As above, with a higher silt content
20 - 26	Dark brown, stiff clay, silty
26 - 30	Very fine to very coarse silty sand, clayey
30 - 32	As above, with a higher content of medium and coarse grained sand
32 - 34	Very fine coarse silty sand
34 - 40	Fine to very coarse clean sand with a little gravel
40 - 42	As above, with some thin clay lenses
42 - 46	Fine to very coarse sand, silty with a little clay
46 - 48	As above, with a higher clay content
48 - 50	As above, but containing gravel up to 3/4 inch in size
50 - 60	Fine to very coarse sand, silty and clayey with gravel upto 1 1/2" in size and forming upto 25% of the material - except between 52'-54' where it is mostly fine to medium grained sand, silty and clayey

DEPTH (FT.)	DESCRIPTION
60 - 62	Mostly fine to medium grained sand with silt and soft clay layers
62 - 68	Soft silty clay, dark brown in colour
68 - 70	Silty fine sand with soft clay
70 - 76	Dark brown, stiff silty clay
76 - 78	Fine to medium grained silty sand with some clay
78 - 82	Stiff dark brown clay with a little silt
82 - 84	As above, with a higher silt content
84 - 86	Stiff dark brown clay with a little silt
86 - 88	Stiff dark brown clay with a little silt and coarse sand
88 - 92	Fine to very coarse grained angular clean sand
92 - 96	Fine to medium grained silty sand with a little clay
96 - 98	Fine to very coarse grained, clean, angular sand and gravel up to ¼ inch in size
	to
98 - 100	Fine/coarse grained sand, silty and clayey with a little gravel
100 - 122	Clean brown angular, fine to very coarse grained sand with angular gravel up to 3/4 inch in size and forming upto 50% of the material

ST. CATHERINE PLAINS
CAYMANAS AREA

LITHOLOGICAL LOG OF COREHOLE: COWPARK C

Depth (ft)	Description
0 - 4	Brown silty clay
4 - 6	Brown silty fine sand
6 - 12	Brown stiff silty clay
12 - 16	Brown silty fine sand
16 - 18	Brown silty clay
18 - 20	Brown silty fine sand - clayey
20 - 26	Brown, stiff silty clay, slightly sandy
26 - 30	Light brown stiff clay with some calcareous material
30 - 46	Brown soft, stiff silty clay
46 - 62	Fine to very coarse, brown sand, slightly clayey at intervals and containing little gravel
62 - 66	Brown soft silty clay
66 - 68	Light brown, fine to coarse grained sand, clayey
68 - 76	Brown, soft, silty, sandy clay
76 - 78	Brown stiff silty clay
78 - 82	Brown, soft, silty fine sandy clay
82 - 90	Light brown, stiff, silty clay
90 - 92	Light brown, silty fine sandy clay
92 - 94	Brown, fine to very coarse grained sandy clay with a few angular pebbles
94 - 98	Light brown silty clay
98 - 104	Brown, fine to very coarse grained sand, clayey, with some fine angular gravel
104 - 106	Brown, soft silty clay
106 - 108	Brown, silty fine sand
108 - 120	Brown, silty fine sandy clay with some fine to coarse grained sand
120 - 122	Brown, silty fine sand clay with some calcareous material

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: RIVERSDALE # 2 Area:

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 42'-44'			44'-46'			48'-50'			82'-84'		
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	—	—	—	—	—	—	—	—	—	—	—	—
2.	3/8"	0.375	16.6	16.6	14.5	—	—	—	—	—	—	—	—	—
3.	4	0.187	13.4	30.0	26.2	7.1	7.1	7.0	6.0	6.0	5.3	5.4	5.4	4.0
4.	10	0.078	13.1	43.1	37.6	16.0	23.1	22.8	13.5	19.5	17.2	8.7	14.1	10.6
5.	16	0.047	9.0	52.1	45.5	6.4	29.5	29.1	6.8	26.3	23.2	4.4	18.5	13.9
6.	30	0.023	15.6	67.6	59.1	7.0	36.5	36.0	12.0	38.3	33.7	20.3	38.8	29.1
7.	50	0.012	16.3	84.0	73.4	12.9	49.4	48.7	19.2	57.5	50.7	43.7	82.5	61.8
8.	80	0.007	12.6	96.6	84.4	32.3	81.7	80.6	33.9	91.4	80.5	24.4	106.9	80.1
9.	100	0.006	4.1	100.7	87.9	5.1	86.8	85.6	5.8	97.2	85.6	6.6	113.5	85.1
10.	200	0.003	10.4	111.1	97.0	10.8	97.6	96.3	13.5	110.7	97.5	15.2	128.7	96.4
11.	PAN	--	3.4	114.5	100.0	3.8	101.4	100.0	2.8	113.5	100.0	4.8	133.5	100.0

@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A - weight retained (grams)
B - cumulative weight retained (grams)
C - cumulative percentage retained

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: RIVERSDALE # 2 Area:

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 90'–92'			98'–100'								
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	—	—	—	—	—	—						
2.	3/8"	0.375	13.2	13.2	8.1	10.8	10.8	7.0						
3.	4	0.187	8.7	21.9	13.4	23.4	34.2	22.3						
4.	10	0.078	14.3	36.2	22.2	26.8	61.0	39.8						
5.	16	0.047	8.9	45.1	27.6	16.2	77.2	50.3						
6.	30	0.023	24.0	69.1	42.3	20.2	97.4	63.5						
7.	50	0.012	38.8	107.9	66.1	16.1	113.5	74.0						
8.	80	0.007	26.6	134.5	82.4	14.3	127.8	83.3						
9.	100	0.006	10.0	144.5	88.5	5.9	133.7	87.2						
10.	200	0.003	15.6	160.1	98.1	13.6	147.3	96.0						
11.	PAN	--	3.1	163.2	100.0	6.1	153.4	100.0						

@ U.S.S. Sieve Series
(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A - weight retained (grams)
B - cumulative weight retained (grams)
C - cumulative percentage retained

ST. CATHERINE PLAINS
SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: Cow Park B

AREA: Project 'C' - Caymanas Area

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE(FT.)								
			50 - 52			52 - 54			58 - 60		
			A	B	C	A	B	C	A	B	C
1	3/8"	0.375	-			-	-	-	18.8	18.8	8.9
2	6	0.132	34.4	34.4	19.1	0.3	0.3	0.2	20.8	39.6	18.9
3	8	0.094	12.9	47.3	26.2	0.9	1.2	0.7	9.3	48.9	23.3
4	12	0.066	12.1	59.4	33.0	0.4	1.6	0.9	9.4	58.3	27.8
5	16	0.047	15.1	74.5	41.4	1.7	3.3	1.9	13.4	71.7	34.1
6	20	0.033	13.3	87.8	48.8	1.8	5.1	3.0	17.1	88.8	42.3
7	30	0.023	12.8	100.6	55.9	4.2	9.3	5.5	20.8	109.6	52.2
8	40	0.016	16.8	117.4	65.2	15.2	24.5	14.4	30.0	139.6	66.5
9	50	0.012	13.9	131.3	72.9	32.9	57.4	33.8	21.8	161.4	76.8
10	70	0.0 8	12.2	143.5	79.7	27.2	84.6	49.9	17.5	178.9	85.2
11	100	0.006	9.3	152.8	84.9	46.4	131.0	77.1	10.9	189.8	90.4
12	PAN	-	27.2	180.0	100	39.0	170.0	100	20.2	210.0	100

* U.S.S. Sieve Series

(Analysed by D.V. Ramanamurty and Kerry Mulchansingh)

A = Weight retained (grams)
B = Cummulate weight retained (")
C = Cummulative percentage retained

ST. CATHERINE PLAINS
SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: Cow Park B

AREA: Project 'C' - Caymanas Area

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE(FT.) 90 - 92			94 - 96			98 - 100		
			A	B	C	A	B	C	A	B	C
1	3/8"	0.375									
2	6	0.132	-	-	-	-	-	-	3.8	3.8	2.1
3	8	0.094	-	-	-	0.2	0.2	0.1	3.2	7.0	3.8
4	12	0.066	0.9	0.9	0.6	0.4	0.6	0.3	3.7	10.7	5.9
5	16	0.047	3.6	4.5	3.0	1.5	2.1	1.0	8.0	18.7	10.4
6	20	0.033	14.0	18.5	12.3	4.1	6.2	3.1	10.4	29.1	16.2
7	30	0.023	26.6	45.1	30.0	9.3	15.5	7.7	12.0	41.1	22.8
8	40	0.016	38.2	83.3	55.5	21.1	36.6	18.3	19.3	60.4	33.5
9	50	0.012	23.4	106.7	71.1	28.6	65.2	32.6	19.3	79.7	44.3
10	70	0.0 8	17.5	124.2	82.8	39.3	104.5	52.2	34.0	113.7	63.2
11	100	0.006	8.3	132.5	88.3	43.2	147.7	73.8	39.9	153.6	85.3
12	PAN		17.5	150.0	100.0	52.3	200.0	100.0	26.4	180.0	100.0

* U.S.S. Sieve Series

(Analysed by D.V. Ramanamurty and Kerry Mulchansingh)

A = Weight retained (grams)
B = Cummulate weight retained (")
C = Cummulative percentage retained

ST. CATHERINE PLAINS
SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: Cow Park B

AREA: Project 'C' - Caymanas Area

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE(FT.)								
			100 - 102			104 - 106			116 - 118		
			A	B	C	A	B	C	A	B	C
1	3/8"	0.375	-	-	-	-	-	-	-	-	-
2	6	0.132	21.6	21.6	12.6	12.9	12.9	6.8	21.4	21.4	10.9
3	8	0.094	9.5	31.1	18.1	8.7	21.6	11.3	9.4	30.8	15.7
4	12	0.066	13.6	44.7	26.0	9.9	31.5	16.5	10.5	41.3	21.0
5	16	0.047	20.3	65.0	37.6	21.8	53.3	27.9	19.5	60.8	30.9
6	20	0.033	21.3	86.3	50.3	28.8	82.1	43.0	27.5	88.3	44.9
7	30	0.023	25.8	112.1	65.3	30.2	112.3	58.8	40.5	128.8	65.5
8	40	0.016	27.8	193.9	81.5	41.9	154.2	80.7	36.5	165.3	84.1
9	50	0.012	16.3	156.2	91.0	20.2	174.4	91.3	17.7	183.0	93.1
10	70	0.0 8	9.2	165.4	96.3	10.1	184.5	96.6	8.2	191.2	97.3
11	100	0.006	4.4	169.8	98.9	4.6	189.1	99.0	3.5	194.7	99.0
12	PAN		1.9	171.7	100.0	2.0	119.1	100.0	1.8	196.6	100.0

* U.S.S. Sieve Series

(Analysed by D.V. Ramanamurty and Kerry Mulchansingh)

A = Weight retained (grams)
B = Cummulate weight retained (")
C = Cummulative percentage retained

ST. CATHERINE PLAINS
SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: Cow Park B

AREA: Project 'C' - Caymanas Area

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE(FT.) 106 - 108			114 - 116			120 - 122		
			A	B	C	A	B	C	A	B	C
1	3/8"	0.375	7.8	7.8	3.9	-	-	-	8.5	8.5	4.7
2	6	0.132	67.1	74.9	37.4	33.8	33.8	15.4	16.6	25.1	13.9
3	8	0.094	30.3	105.2	52.6	18.1	51.9	23.6	9.3	34.4	19.1
4	12	0.066	26.4	131.6	65.8	18.7	70.6	32.1	9.6	44.0	24.4
5	16	0.047	30.6	162.2	81.1	33.5	104.1	47.3	22.4	66.4	36.9
6	20	0.033	15.6	177.8	88.9	36.2	140.3	63.8	32.4	98.8	54.9
7	30	0.023	10.2	188.0	94.0	27.3	167.6	76.2	28.1	126.9	70.5
8	40	0.016	6.1	194.1	97.0	26.4	194.0	88.2	25.1	152.0	84.4
9	50	0.012	2.4	196.5	98.2	13.2	207.2	94.2	13.5	165.5	91.9
10	70	0.0 8	1.8	198.3	99.1	6.5	213.7	97.1	8.3	173.8	96.5
11	100	0.006	0.7	199.0	99.5	3.1	216.8	98.5	4.0	177.8	98.7
12	PAN		1.0	200.0	100.0	3.2	220.0	100.0	2.2	180.0	100.0

* U.S.S. Sieve Series

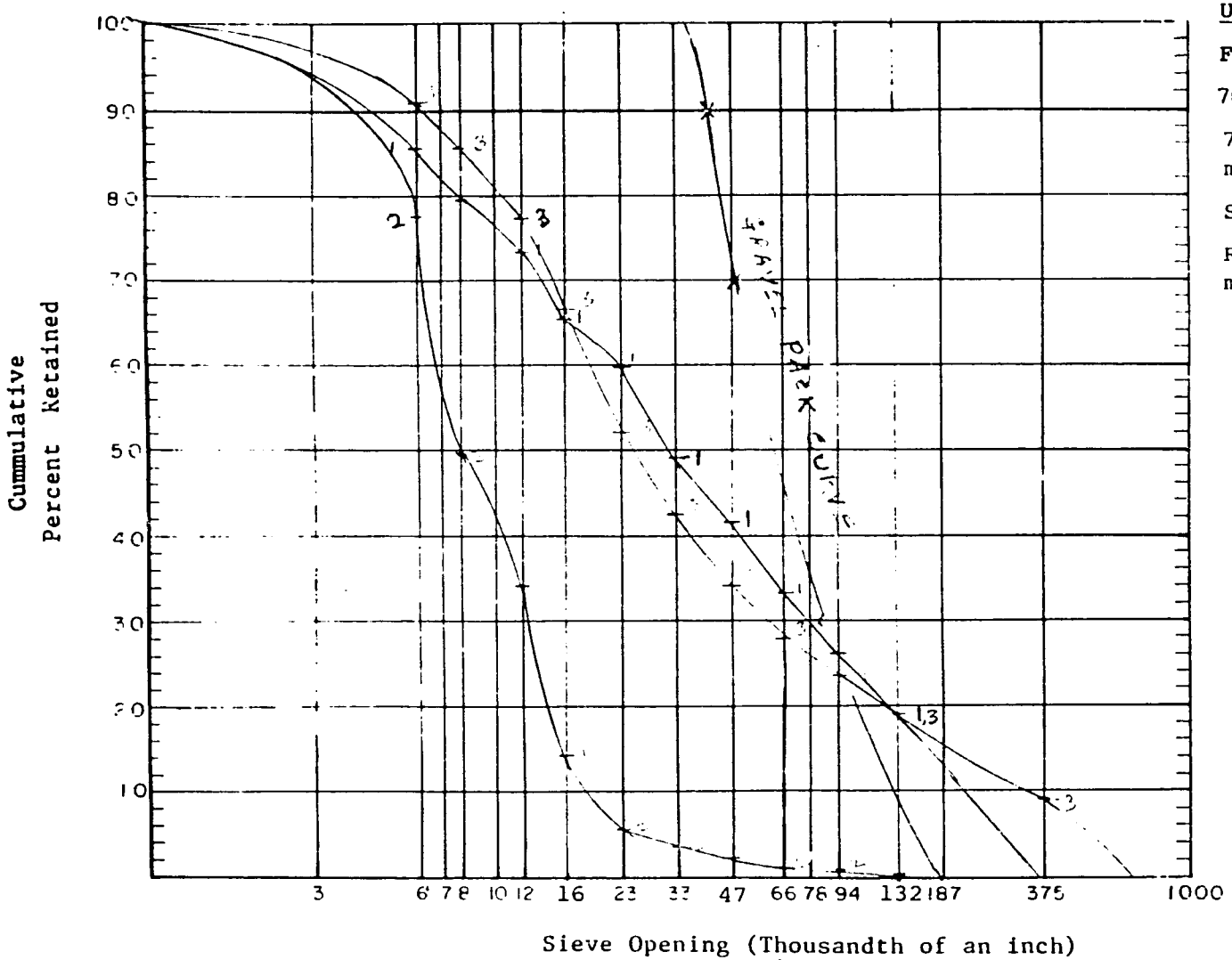
(Analysed by D.V. Ramanamurty and Kerry Mulchansingh)

A = Weight retained (grams)
B = Cummulate weight retained (")
C = Cummulative percentage retained

SIEVE ANALYSES CURVES

Location: Cow Park B

Depth Range: (ft.) 1) 50 - 52
2) 52 - 54
3) 58 - 60



UPPER AQUIFER

Finest sample is #2

70% retention size of sample = 0.006"

70% retention size of gravel pack material = 8x0.006 = 0.048"

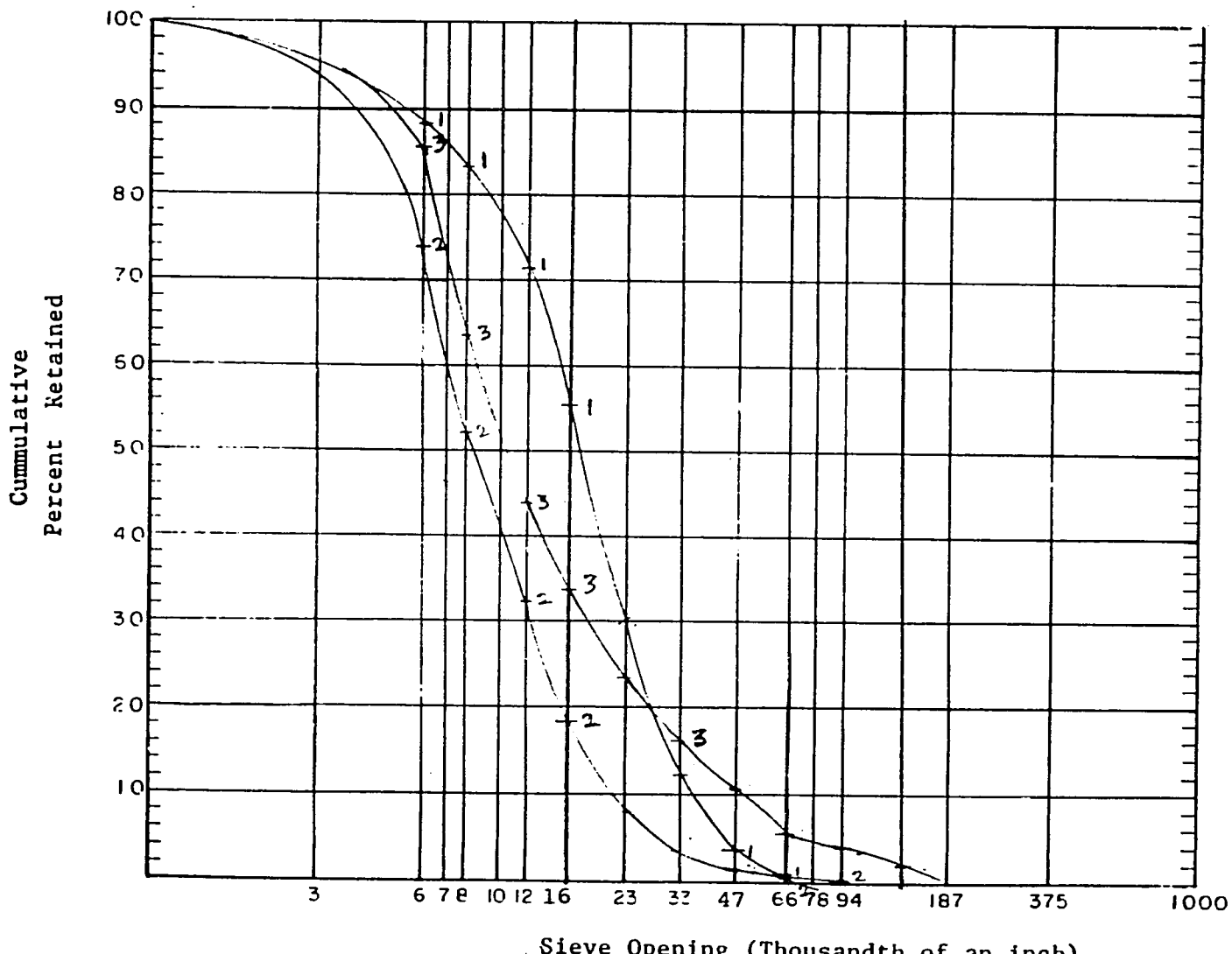
Slot size of the well screen = 90%

Retention size of the gravel pack material = 0.040"

SIEVE ANALYSES CURVES

Location: Cow Park B

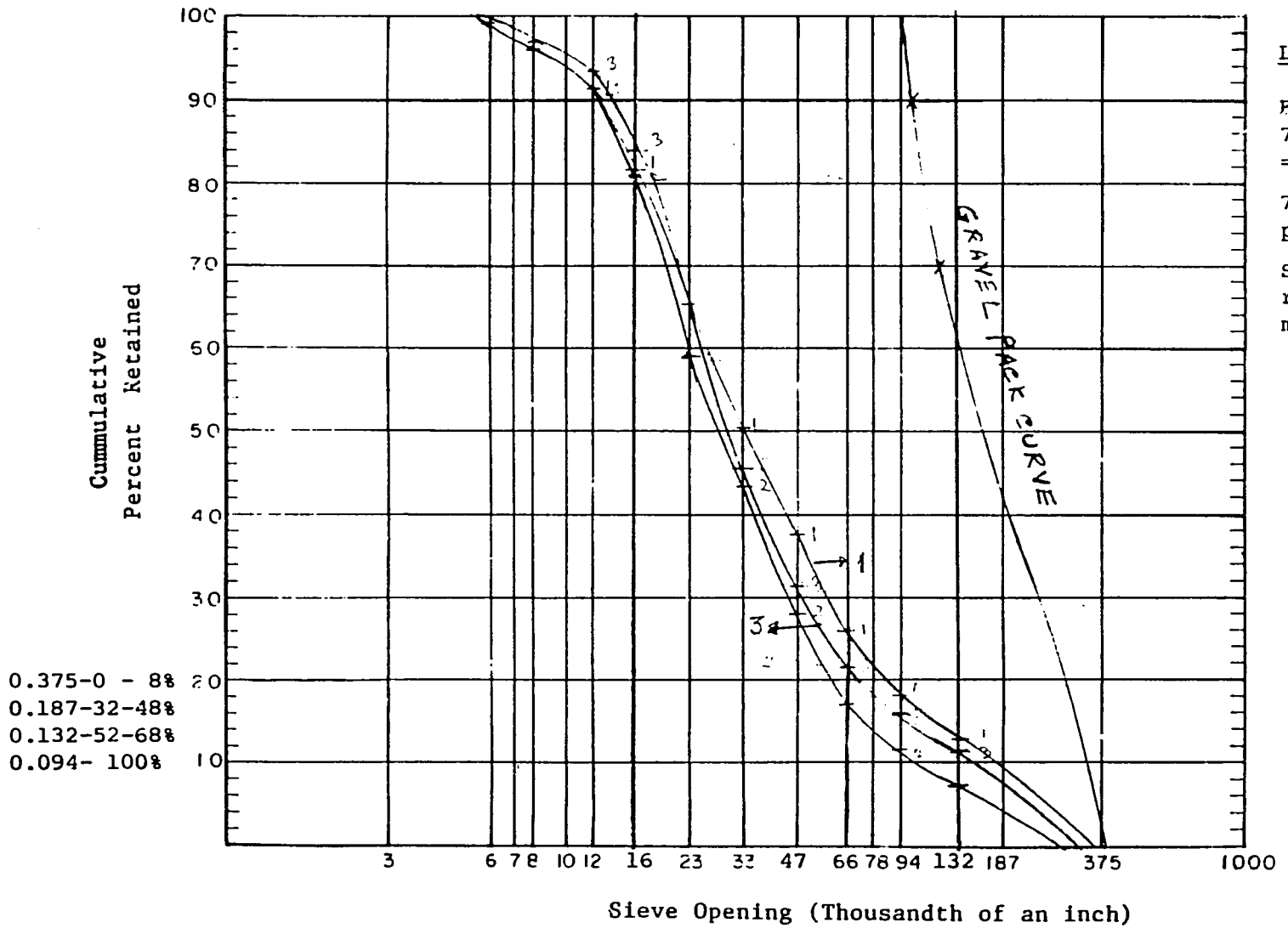
Depth Range: (ft.) 1) 90 - 92
2) 94 - 96
3) 98 - 100



SIEVE ANALYSES CURVES

Location: Cow Park B

Depth Range: (ft.) 1) 100 - 102
2) 104 - 106
3) 116 - 118



LOWER AQUIFER

Finest sample is #2
70% retention size of the sample = 0.020"

70% retention size of the gravel pack material is 6 x 0.020" = 0.120"

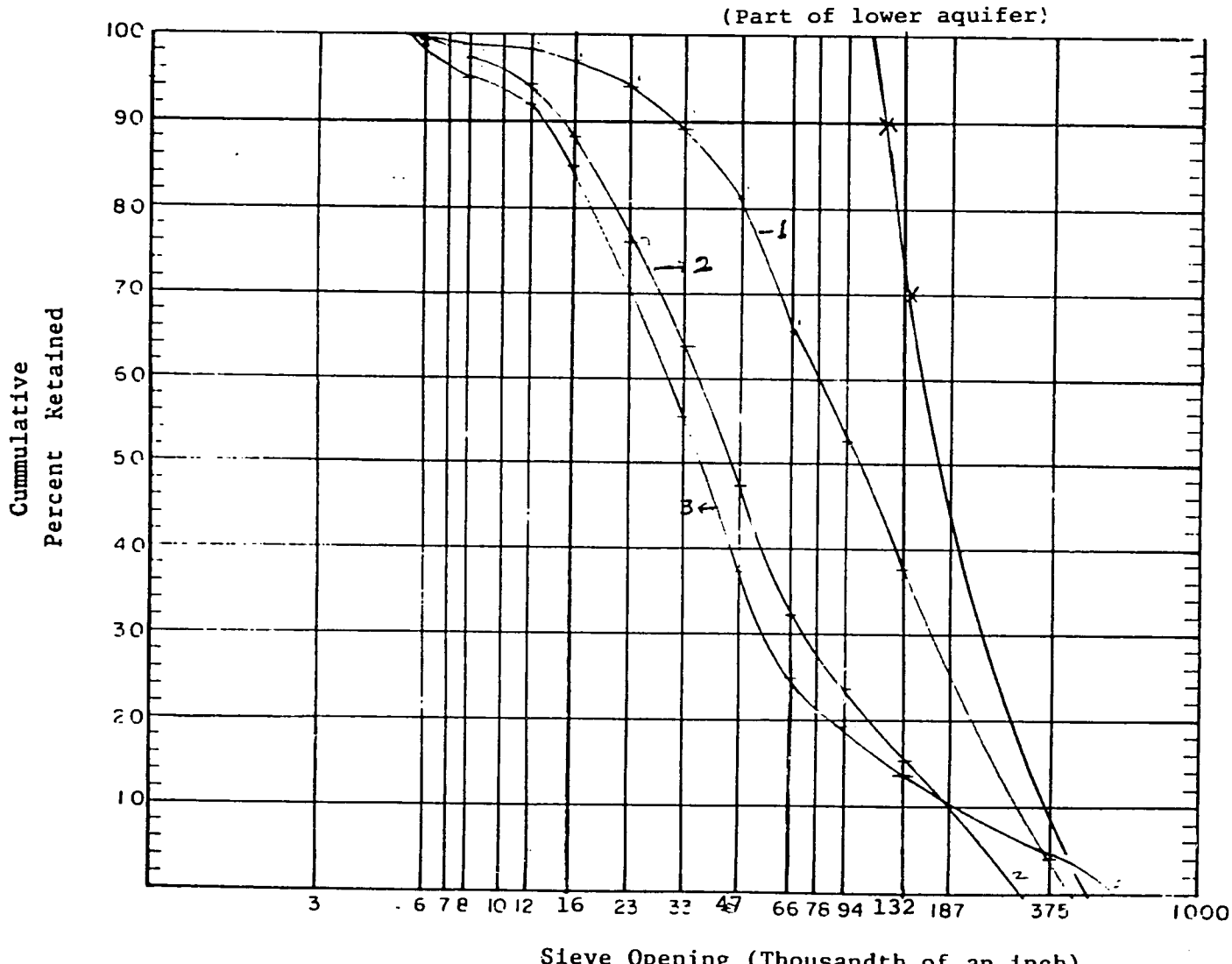
Slot size of the well screen = 90% retention size of the gravel pack material = 0.100"

Gravel 94 - 250 -75%
250 - 375 -25%

SIEVE ANALYSES CURVES

Location: Cow Park B

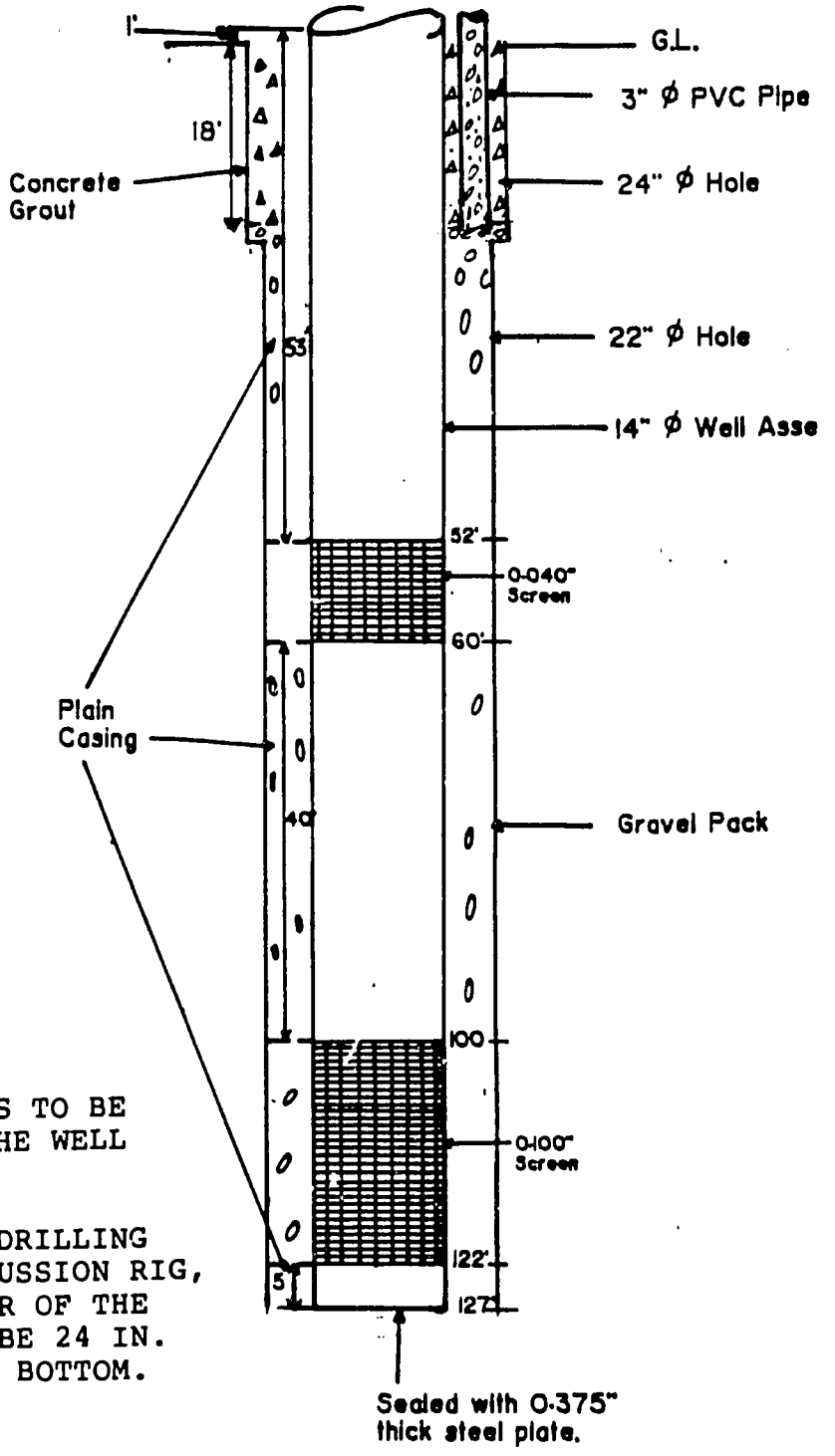
Depth Range: (ft.) 1) 106 - 108
2) 114 - 116
3) 120 - 122
(Part of lower aquifer)



ST. CATHERINE PLAINS

CAYMANAS AREA - PROJECT 'C'

WELL DESIGN COWPARK-B



NOTES:

1. WELL SCREENS TO BE WELDED TO THE WELL CASING

2. IN CASE OF DRILLING WITH A PERCUSSION RIG, THE DIAMETER OF THE HOLE WOULD BE 24 IN. FROM TOP TO BOTTOM.

DRAWING NO. A-987
FEBRUARY '89

Vertical Scale 1" = 20 ft.