A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-A BERNARD LODGE AREA ST. CATHERINE PLAINS

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A REPORT ON THE GROUNDWATER RESOURCES OF PROJECT-A, BERNARD LODGE AREA ST. CATHERINE PLAINS

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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.

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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 tne 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.

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9	Lithological logs of coreholes Cookson #2, Newlands #1 and Newlands #4 and sieve analyses results of samples from Newlands #1.

Map

1	Map of Bernard Lodge East Area showing the locations of wells - Project-A.

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1. Location and Extent

The Project A in Bernard Lodge east area has an extent of about 1000 acres. It is bounded by the Naggo Head-Bernard Lodge road on the south, the Naggo Head and Newlands villages on the east, Project B of Agro-21 Corporation Limited on the north and the Stud Farms on the north west and west. It is an alluvial plain sloping gently eastward. The elevation of the land surface varies from about 45 ft. above sea level in the west to about 25 ft. a.s.l. in the east.

2. Groundwater Resources

2.1 Background Information

The area was under sugarcane cultivation before Agro-21 Corporation Limited took it up for implementing the Crop Diversification Programme. The water supply to the area was partly through wells and partly through Cumberland Pen Canal. A list of seven wells which operated in the area is given below:

(a)	Half Way Tree #2	-	dug well
(b)	Cookson #2	-	dug well
(c)	Cookson #1	-	dug well
(d)	Cookson #3	-	tube well
(e)	Half Way Tree #4	-	tube well
(f)	Half Way Tree #5	-	tube well
(g)	Half Way Tree #6	-	tube well

The dug wells used to pump sand, and collapsed in course of time. The tube wells were constructed with perforated casing, the perforations being 0.5" in diameter and coarse gravel with the result that they also used to pump sand. Except Cookson #3, the other three wells were not in operation when Agro-21 Corporation Limited took charge of the area in 1985, for providing the necessary infrastructure including the rehabilitation of the water supply structures. There were also no pumps on these three tube wells.

2.2 Cleaning and Testing of Old Wells

In order to assess the yield and quality of water from these four old wells which were filled to some extent with sand they were cleaned and tested. These operations were carried out in July-August, 1985, by Hood Daniel Well Company Limited, Spur Tree, (for Cookson #3, Half Way Tree #5 and Half Way Tree #6 wells) and by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10 (for Half Way Tree #4 well). A cable tool rig was used for conducting these operations, which included cleaning of the wells down to the original depths with a bailer and testing for yield with a turbine pump. In case of Half Way Tree #4 well, an air compressor was used to clean the well and test it for yield. The results obtained from the cleaning and testing operations are given below:

(a) Cookson #3

The well was cleaned down to the original depth and tested for yield with a turbine pump on July 17, 1985. The static water level was 20.4 ft. and the yield was 950 USgpm for a drawdown of 17.6 ft. indicating a specific capacity of 54 USgpm/ft. The well discharge was accompanied by much sand.

(b) Half Way Tree #5

The well was cleaned down to the original depth and tested for yield with a turbine pump on July 11, 1985. The static water level was 21.16 ft. and the yield was 950 USgpm for a drawdown of 17.5 ft. indicating a specific capacity of 54 USgpm/ft. The well discharge was accompanied by much sand. The land surface around the well began to sink after 6 hours of testing due perhaps to sand pumping.

(c) Half Way Tree #4

The well was cleaned down to the original depth and tested for yield with air compressor on August 12, 1985. The static water level was 23 ft. The yield was 300 USgpm for a pumping water level of 29 ft. indicating a specific capacity of 50 USgpm/ft The well discharge was accompanied by some sand.

(d) Half Way Tree #6

The well was cleaned down to the original depth and tested for yield with a turbine pump on July 9, 1985. The static water level was 16.83 ft. The yield was 350 USgpm for a pumping water level of 50.5 ft. The well discharge was accompanied by a little sand (all the water levels mentioned are from top of the casing).

2.3 Reconstruction of Old Wells

Based on the results obtained from the cleaning and testing of the wells, it was decided to reconstruct the wells Half Way Tree #4, Half Way Tree #5 and Cookson #3 by installing a 14 inch diameter well assembly consisting of plain casing and well screens of required slot opening and length in the old wells which are 20" in diameter and gravel packing the annular space with proper size gravel. Such a reconstructed well would pump almost sand free water but the yield will be less than that of the old well.

Sand accompanying the well discharge during the testing of the wells was collected and subjected to sieve analyses. Slot size of the well screens and specifications for the gravel pack material were worked out using the sieve analyses curves. Lengths of the well screens and the plain casing which together formed the well assembly were worked out taking into consideration lithologs of the old wells and the anticipated pumping water levels (about 40 ft. below ground level). The well construction reports are given as Appendices 1-3.

Half Way Tree #6 well yielded about 350 USgpm for a pumping water level of 50.5 ft. It was decided to use the well in the same condition as a reconstructed well would yield much less than 350 USgpm. The well particulars are given as Appendix-4.

2.4 New Wells

Table-1 shows the historical and entitled abstraction rates of the seven old wells in Project-A area (from the records of Underground Water Authority)

Table-1 Historical and Entitled Abstraction Rates of Seven Wells in Project-A

Sl No.	Well	Well Production (mil. imp. gal./day) 1963/66	1972/74	1980/84	Entitlement (MIG/D)
1	Half Way Tree #2	0.87	0.76	0.70	0.87
2	Half Way Tree #4	1.00	0.86	0.60	1.00
3	Half Way Tree #5	0.71	0.84	0.83	0.71
4	Half Way Tree #6	-	0.76	0.84	1.20 *
5	Cookson #1	0.97	-	0.90	0.97
6	Cookson #2	0.44	0.34	0.40	0.44
7	Cookson #3	-	0.83	0.69	0.83
					6.02

(* Licensed in 1970)

In order to obtain as much groundwater as possible within the entitled quantity, three new wells were constructed in 1985 as replacements for the three old wells and one more new well was constructed in 1987. The three new wells Half Way Tree #2, Newlands #3 and Cookson #4 were constructed as replacement wells for Half Way Tree #2, Cookson #1 and Cookson #2 respectively. The other new well constructed in 1987 is Newlands #2A.

Reports on the construction of these four new wells are given as Appendices 5 to 8.

In all, seven coreholes of 2" diameter were drilled to obtain information on the lithology at the locations. These were drilled at locations - Half Way Tree #2, Cookson #1, Cookson #4, Newlands #1, Newlands #2, Newlands #3 and Newlands #4 which are shown in Map-1. New wells were constructed at the four favourable locations mentioned above. No good water bearing zones were encountered at Cookson #1 and Newlands #4. Favourable zones were encountered at Newlands #1 but as this location is close to the Radar Station, no well was constructed. Lithological logs of the abandoned coreholes and the sieve analyses results of aquifer samples from Newlands #1 are given as Appendix-9.

2.5 Rate of Abstraction

The old well, the reconstructed wells and the new wells have all been in operation since 1985 (Newlands #2A since 1987). Long duration pumping tests were conducted on three wells viz - Half Way Tree #2, Half Way Tree #5 and Newlands #2A. Based on the results of pumping tests and the performance of the wells during the years 1986 to 1988, the maximum possible abstraction rates have been worked. The licensed capacity and the recommended maximum abstraction rate for each of the wells are given in Table-2.

Table 2: Licensed capacity and recommended maximum abstraction for the wells

Sl No.	Well	Licensed Capacity		Recommended Max. Abstraction	
		MIG/D	USG/MIN	MIG/D	USG/MIN
1	Half Way Tree #2	0.72	600	0.60	500
2	Half Way Tree #4	0.43	360	0.30	250
3	Half Way Tree #5	0.58	480	0.48	400
4	Half Way Tree #6	0.43	360	0.30	250
5	Cookson #3	0.43	360	0.36	300
6	Cookson #4	0.86	720	0.48	400
7	Newlands #2A	0.96	800	0.48	400
8	Newlands #3	0.72	600	0.48	400
		5.13	4280	3.48	2900

It is seen from the above Table that out of the entitled abstraction rate of 6.02 MIG/D the recommended maximum abstraction rate for all the eight wells in the project area put together is 3.48 MIG/D.

Summarized account of the well construction particulars and performance of the wells are given in Table-3.

2.6 Sand Content in Well Waters

Sand content in water from the old well, reconstructed wells and the new wells (except Newlands #2A) was visually estimated at the time of testing these wells in 1985. Subsequently, a 'Rossum' sand content tester was fitted to the discharge pipes of the wells and tests were conducted to determine the sand content in the water from all these wells. That in the water from Newlands #2A well was determined during the testing in 1987 with the help of the sand content tester. The data collected during the tests is given in Table-4 and a summary of the test results is given below:

Half Way Tree #2

Test was conducted for 6 hours and there was no trace of any sand in water.

Half Way Tree #4

The sand content in the water was 2.6 mg/l in the first 20 minutes after pumping started and 0.015 mg/l in the subsequent 18 hours 42 minutes indicating that the well pumps a little sand immediately after pumping starts but the sand content decreases with increase in pumping time.

Half Way Tree #5

The sand content in the water was 0.3 mg/l in the first 16 minutes after pumping started and 0.0036 mg/l for about 19 hours of pumping indicating that the sand content decreases with increase in pumping time.

Newlands #3

The sand content which was 0.86 mg/l in the first 30 minutes of pumping decreased to 0.08 mg/l in the next 4 hours 30 minutes and then to 0.018 mg/l in the next 19 hours 30 minutes. It may ultimately become much less with prolonged pumping.

Cookson #4

The sand content in the water was 0.025 mg/l in the first 18 hours of pumping which reduced to 0.01 mg/l in the next 6 hours 30 minutes. From the above, it is seen that the well water contains a little sand immediately after the pumping starts but the sand content decreases with increase in pumping period.

Half Way Tree #6

The sand content in the water was 0.77 mg/l for the test period of 5 hours (16 minutes after pumping started) for a discharge rate of 360 gpm and it was 0.29 mg/l for 3 hours since pumping started for a discharge rate of 180 gpm.

Cookson #3

The test conducted for 10 minutes at the well discharge rate of 540 gpm indicated that the sand content in the water was 120 mg/l. Further test could not be conducted as the pumping was stopped due to much sand in water which choked the filters.

Newlands #2A

Sand content in water was estimated during the long duration pumping test. It was 0.013 to 0.014 mg/l from 31 hours after the pumping started to the end of the pumping test.

Sand content in water from the wells Cookson #3 and Half-Way-Tree #6 was found to increase in course of time and the filters at the drip irrigation station used to get choked frequently. Therefore sand separators were installed on these two wells. Tests were conducted again on these wells to determine the sand content in the water coming out of the sand separators.

A test was conducted on Cookson #3 well for a period of 71 hours from January 23-26, 1987, when the well was pumping at the rate of 300 USgpm and the results of the test are given in Table-4. It is seen from the results that the sand content decreased with increased pumping time.

A test was conducted on Half-Way-Tree #6 well for a period of 24 hours from March 24-25, 1988, when the well was pumping at the rate of 150 to 200 USgpm. The average sand content in the water was 0.1 mg/l.

2.7 Quality of Water

Chemical analyses results of water samples collected from the wells from time to time are given in Tables 5-12. Water quality guidelines for irrigation are given in Table-13.

PH is mostly within the range of 6.5 to 8.4. Specific conductance of the water is less than 0.75 milli-mhos/cm and mostly more than 0.5 milli-mhos/cm. Chloride is less than 70 mg/l and boron is less than 1 mg/l. Sodium adsorption ratio is less than 3. According to the water quality guidelines, the water does not create any problem of salinity, permeability and toxicity of specific ions to crops.

However, bicarbonate is more than 40 mg/l and nitrate is also high. In water draining a limestone area bicarbonate is bound to be high. Therefore if bicarbonate and nitrate happen to create any problem for irrigation, necessary remedial measures may have to be implemented.

3. Recommendations

Groundwater abstraction from the wells may be limited to the recommended rate. Quality of groundwater and water levels from the wells may be monitored periodically to detect any deterioration in the quality of water well in time so that remedial measures could be adopted to prevent further deterioration.

References

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

2. John Hem , 1971. Study and interpretation of chemical characteristics of natural water. USGS water supply paper, 1473, Washington, D.C.

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

4. Todd, D.K. 1982. Groundwater Hydrology. John Wiley & Sons Inc., New York

Summary of Well Construction Particulars and Performance of Wells in Project "A"

Sl No.	Well Name	Depth (ft.)	Diameter (inches)	Screen Setting (ft.)	Slot Size of Screens (inches)	Date of Test	Static Water Level (ft.)	Pumping Water Level (ft.)	Yield (USgpm)	Licensed Abstraction (USgpm)	Recommended Abstraction (USgpm)	Anticipated Pumping Water Level (ft.)
1	Half-Way-Tree #2	103	16	42 - 54 82 - 100	0.030 0.030	Dec. '85	22.42	51.92	402	600	500	45
2	Half-Way-Tree #4	76	14	46 - 76	0.040	* Oct. '85	23.60	33.35	400	360		35 - 40
3	Half-Way-Tree #5	72	14	40 - 64	0.030	Sep. '85	21.79	37.08	400	480	400	36
4	Half-Way-Tree #6	100	20	Perforated pipe from the top		* July '85	16.83	50.50	350	360	-	40
5	Cookson #3	76	20/14	46 - 76	0.040	* Nov. '85	20.40	35.00	400	360	300	30 - 32
6	Cookson #4	110	16	37 - 42 76 - 104	0.040 0.030	Dec. '85	15.00	68.00	600	720	'00	40 - 45
7	Newlands #2A	110	14	30 - 38 92 - 106	0.100 0.100	April '87	12.08	42.30	400	800	400	42
8	Newlands #3	94	16	36 - 46 55 - 60 80 - 92	0.050 0.060 0.060	* Dec. ' 85	20.0	40.0	360	600	400	45 - 47

(Depths, depths to water levels etc. are from ground level for Sl. # 1, 6, 7 and 8 and below the top of the casing for other wells).

* No time-drawdown test was conducted. Data based on results obtained during development.

CONTENT IN WELL WATER

BERNARD LODGE EAST AREA - PROJECT A

SI No.	DATE	LOCATION	TIME OF TEST FROM	TIME OF TEST TO	TIME OF TEST TOTAL TIME	FLOW THROUGH TESTER RATE (USgpm)	FLOW THROUGH TESTER QUANTITY (USG)/ LITRES	SAND CONTENT mg	SAND CONTENT mg/l	WELL DISCHARGE (USgpm)	REMARKS
1	5.11.86	Half-Way-Tree #2	8:45 a.m.	2:45 p.m.	6 hrs	0.5	180/680	NIL		360	
2	5.11.86	Half-Way-Tree #5	3:22 p.m.	10-12 a.m. (6.11.86)	18 hrs 50 mts	0.5	565/2135	7.7*	0.0036	360	The well discharge was 480 USgpm from 3:22 p.m. to 4:30 p.m. Test conducted from 12 mts. after pumping started
3	6.11.86	Half-Way-Tree #5	10:21 a.m.	10:37 a.m.	16 mts	0.5	8/30	9.1*	0.3	360	Test conducted for 16 mts. immediately after pumping started.
4	6.11.86	Half-Way-Tree #6	3:55 p.m.	8:55 p.m.	5 hrs	0.5	150/567	436*	0.77	360	A few fine iron flakes and sand were pumped initially. Test conducted from 16 mts. after pumping started.
5	7.11.86	Half-Way-Tree #6	10:45 a.m.	1:45 p.m.	3 hrs	0.5	90/340	100	0.29	180	Test conducted since pumping started.
6	7.11.86	Half-Way-Tree #4	1:55 p.m.	2:15 p.m.	20 mts	0.5	10/37.8	100	2.6	360	Test conducted since pumping started.
7	7.11.86	Half-Way-Tree #4	2:16 p.m.	8:58 a.m. (8.11.86)	18 hrs 42 mts	0.5	561/2120	32	0.015	300	Test conducted from 21 mts. after pumping started.
8	15.11.86	Newlands #3	8:30 a.m.	9:00 a.m.	30 mts	0.5	15/56.7	48.8*	0.86	360	First half hour of test since pumping started.
9	15.11.86	Newlands #3	12:30 p.m.	5:00 p.m.	4 hrs 30 mts	0.5	135/510	42*	0.08	360	Test for 4 1/2 hrs. 30 mts. after pumping started.
10	15.11.86	Newlands #3	5:00 p.m.	12:30 p.m. (16.11.86)	19 hrs. 30 mts	0.5	585/2211	41*	0.018	360	Test for 19 1/2 hrs., 5 hrs. after pumping started
11	21.11.86	Cookson #4	3:30 p.m.	9:30 a.m. (22.11.86)	18 hrs.	0.5	540/2041	50	0.025	360	Test conducted since pumping started.

Sl No.	DATE	LOCATION	TIME OF TEST			FLOW THROUGH TESTER		SAND CONTENT		WELL DISCHARGE (USgpm)	REMARKS
			FROM	TO	TOTAL TIME	RATE (USgpm)	QUANTITY (USG) LITRES	mg	mg/l		
12	22.11.86	Cookson #4	9:30 a.m.	4:00 p.m.	6 hrs 30 mts	0.5	195/737	8*	0.01	360	Test conducted from 18 hrs. after pumping started.
13	22.4.87	Newlands #2A	5:15 p.m.	10:45 a.m. (23.4.87)	17 hrs 30 mts	0.5	525/1984	26.7*	0.013	400	Time drawdown test for 72 hrs. started at 10:00 a.m. on 21.4.87
14	23.1.87	Newlands #2A	11:00 a.m.	10:00 a.m. (24.4.87	23 hrs	0.5	690/2608	37.4*	0.014	400	
15	23.1.87	Cookson #3	1:30 p.m.	12:30 p.m. (24.1.87)	23 hrs	0.5	690/2608	1680	0.65	390	
16	24.1.87	Cookson #3	12:30 p.m.	12:30 p.m. (25.1.87)	24 hrs	0.5	720/2721	840	0.30	300	Test conducted from the beginning of pumping the well.
17	25.1.87	Cookson #3	12:30 p.m.	12:30 p.m. 26.1.87	24 hrs	0.5	720/2721	420	0.15	300	

(* Sand content weight obtained by weighing. In other cases measured in cc and converted to milligrams)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: Half Way Tree #2

Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.12.85	8.7	645	377	76.2	19.84	26.0	1.0	-	17.12	-	-	-	-		212.6	62.53	275.13	273	0.7/1.6
2	3.12.85	8.7	626	373	74.2	21.0	26.0	1.0	-	16.64	-	-	-	-		187.6	100.06	287.66	273	0.7 /1.7
3	28.2.86	8.24	534	362.5	76.95	14.40	26.0	1.15	-	17.23	2.94	-	-	-		268.69	0	268.69	252	0.7/1.7
4	14.5.86	8.22	520	320	79.16	15.24	27.5	1.2	0.40	17.74	13.73	-	-	-		271.46	0	271.46	261	0.7/1.7
		(7.16)	(560)	- on the spot measurements																
5	16.7.86	8.07	418	351.4	77.35	15.84	27.5	1.3	-	19.00	9.81	-				271.46	0	271.46	259	0.7/1.7
6	9.2.87	7.88	570	354.0	78.56	15.60	25.23	1.0	0.18	19.99	2.94	0.13	0.02	0.0	293.49	259.0	13.85	272.9	261.00	0.7/1.6
7	5.3.87	7.04	537	-	-	-	-	-	-	19.30	-	-	-	-	-	-	-	-	-	-
8	12.8.87	7.4	564	277.4	57.7	15.1	24.0	0.9	0.14	20.3	0	0.57				233.0	39.0	272.0	207.0	0.7/1.6
9	7.10.87	7.6	558	275.2	81.0	16.1	18.0	0.85	-	17.4	24.5	-	-	-	-	225.1	38.3	263.4	268.5	0.5/1.1
10	5.11.87	7.8	560	346.4	79.4	14.9	26.0	1.1	-	14.0	28.4	-	-	-	-	234.7	38.3	273.0	259.6	0.07/0.2
11	27.11.87	7.9	550	317.0	80.9	22.1	24.5	0.9	0.05	23.9	35.3	0.07	-	-	-	211.0	48.8	259.8	294.0	0.6/1.5
12	8.2.88	7.9	515	316.6	78.2	16.3	28.3	1.0	0.03	19.9	19.6	0.02	-	-	-	274.1	10.0	274.1	263	0.7/1.8
13	8.3.88	7.6	515	-	-	-	29.0	-	-	19.3	-	-	-	-	-	199.9	9.8	209.7	-	-

@/μ/mhos/cm at 25°C * as $CaCo_3$

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: HALF WAY TREE NO. 4 Area: BERNARD LODGE PROJECT 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR/ADJ SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	8 10 85	8.1	595	366.6	71.2	24	21	0.7	-	17.37	-	-	-	-	-	295.7	0	295.7	278	0.5/1.5
2	15 10 85	8.3	610	392.1	67.6	20.40	42	0.7	-	17.37	-	-	-	-	-	322.6	0	322.6	254	1.1/2.8
3	28 2 86	8.3	567	354	76.55	21.1	22.5	0.6	-	23.23	11.77	-	-	-	-	282.54	0	282.54	279	0.6/1.4
4	9 2 87	7.95	605	371.9	79.76	22.08	20.5	0.6	0.20	21.99	10.79	0.26	0.17	14.37	714.3	267.3	11.08	278.4	291.0	0.5/1.2
5	5 3 87	7.06	575	-	-	-	-	-	-	20.78	-	-	-	-	-	-	-	-	-	-
6	12.8.87	7.3	601	315.0	76.2	22.1	20.0	0.6	-	23.7	23.5	0.21	-	-	-	215.9	34.1	250.0	282.0	0.5/1.2
7	3.9.87	8.2	560	419.0	70.50	20.4	17.0	0.38	-	22.4	0	-	-	-	-	222.1	14.4	236.5	259.9	0.5 /1.1
8	15.1.88	7.9	575	457.6	73.8	21.4	23.0	0.5	-	24.8	14.6	-	-	-	-	211.0	43.9	254.9	272.2	0.6 /1.4
9	8.3.88	7.6	557	-	-	-	25.5	-	-	26.7	-	-	-	-	-	198.7	16.8	215.5	-	-

@/µ/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: Half Way Tree #5

Area: Bernard Lodge East - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			Total* Hardness	SAADJ SAR
										mg/l						HCO_3	CO_3	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	6.9.85	7.60	640	338.2	83.60	18.24	21.50	0.80		20.36						284.94	0	284.94	285	0.5/1.3
2	7.9.85	8.3	630	331	83.60	18.00	21.50	0.80		19.86						284.94	0	284.94	284	0.5/1.3
3	8.9.85	7.65	630	328	82.40	19.20	22.00	0.80		19.36						284.94	0	284.94	282	0.5/1.4
4	9.9.85	7.67	640	366	82.40	18.24	22.00	0.80		19.36						284.94	0	284.94	285	0.5/1.4
5	28.2.86	8.00	506	341.3	63.73	18.72	24.0	0.80		13.69	13.73					261.76	13.68	275.44	237	0.7/1.6
6	16.7.86	7.90	460	357.7	50.10	18.00	23.5	0.80		20.49	Nil					277.0		277.0	200.0	0.7/1.6
7	6.11.86	8.10	570	351.1	79.76	18.84	23	0.80	0.32	19.99	25.98					277.75		277.75	277.5	0.6/1.4
8	9.2.87	8.02	563	353	77.76	18.00	20.5	0.70	0.12	19.99	8.82	0.12	0.02	0.0	204.89	250.7	19.39	270.1	269.0	0.5/1.3
9	6.3.87	7.21	540							19.30										
10	27.11.87	7.3	558	-	-	-	-	-	-	20.3	-	-	-	-	-	-	-	-	-	-
11	8.2.88	7.8	580	-	-	-	-	-	-	23.3	-	-	-	-	-	271.1	-	271.1	-	-

@/μ/mhos/cm at 25°C * as $CaCo_3$

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: HALF WAY TREE #6 Area: BERNARD LODGE EAST - PROJECT 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR /AD SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	28 2/86	7.93	579	356.9	74.55	13.73	32.5	0.80	-	18.25	9.81	-	-	-	-	289.46	-	289.46	257	0.9/2.1
2	16 7/86	7.92	399	411.1	49.50	15.60	34.5	0.90	-	19.0	Nil	-	-	-	-	271.46	13.85	285.31	190.5	1.1/2.5
3	23 10/86	8.35	586	354	73.15	6.36	32.0	0.90	0.12	18.74	Nil	0.02	-	-	-	236.83	22.16	258.99	209.0	0.9/1.6
4	6 3/87	6.95	542	-	-	-	-	-	-	18.30	-	-	-	-	-	-	-	-	-	-
5	27.11.87	7.4	540	-	-	-	-	-	-	20.5	-	-	-	-	-	-	-	-	-	-

@/μ/mhos/cm at 25°C * as $CaCo_3$

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: Newlands #2A

Area: Bernard Lodge - Project A

SL NO.	DATE	pH	@ Sp. Conduc-tance	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 /ADJ SAR
										mg/l										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	22.4.87	7.82	665	410.3	77.35	29.52	35	1.35	Trace	21.28	12.76	0.74	0.28		221.50	288.08	30.47	319.55	296.0	0.86/2.0
2	23.4.87	7.45	668	412.4	60.52	24.00	35	1.57	Trace	22.76	0.00	0.25	0.25		276.88	299.92	29.15	329.07	251.0	0.96 /2.3
3	24.4.87	7.73	669	408.3	64.93	21.60	36	1.45	0.010	22.76	78.44	0.14	0.25		293.49	265.20	49.99	315.19	252.0	0.99 /2.4
4	8.3.88	7.5	650	446.4	79.8	25.0	46.0	1.7	0.02	26.4	14.7	0.07	-	-	-	237.1	14.4	251.5	305	1.2 /2.6

@/u/mhos/cm at 25° C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analysis of Water Samples

Location: NEWLANDS #3

Area: BERNARD LODGE – PROJECT 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			Total* Hardness	SAR/ADJ SAR
										mg/l						HCO_3	CO_3	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	24 10/86	8.4	582	358	72.74	1.08	40.1	1.1	0.12	17.99	0	0.59	–	–	–	224.36	27.0	251.36	186.0	1.3/2.8
2	9 2/87	7.93	601	371.8	72.55	15.6	39.0	0.9	0.19	19.99	2.94	0.17	0.02	0.0	132.9	265.9	22.16	288.06	245.0	1.1/2.6
3	6 3/87	7.37	566	–	–	–	–	–	–	18.31	–	–	–	–	–	–	–	–	–	–
4	12.8.87	7.4	593	288.2	46.9	16.6	37.0	0.9	0.12	19.9	0	1.13	–	–	–	259.8	29.3	289.1	186.0	1.2/2.7
5	27.11.87	7.8	571	335.0	75.3	14.9	38.5	0.8	0.10	18.1	5.9	0.11	–	–	–	231.8	51.2	283.0	250	1.0/2.5
6	8.2.88	7.9	556	347.2	74.9	15.1	41.5	0.9	–	18.5	13.7	0.05	0.05	–	–	293.7	0.0	293.7	250	1.1/2.7
7	8.3.88	7.5	553	–	–	–	44.0	–	–	18.5	–	–	–	–	–	208.3	9.6	217.9	–	–

@/µ/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: Cookson #3 Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl mg/l	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR /ADJ SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	17 7/85	8.0	390	471	83.96	17.76	33.50	1.70	-	21.84	-	-	-	-	-	318.66	0.0	318.66	283	0.9/2.1
2	7 11/85	8.85	745	464	85.2	23.4	44.82	1.2	-	24.56	-	-	-	-	-	300.2	25.01	325.21	311	1.1/2.7
3	16 7/86	8.02	516	411.1	52.1	18.0	34.5	1.4	-	25.49	Nil	-	-	-	-	317.16	0	317.16	205	1.0/2.4
4	9 2/87	8.05	647	418.1	88.98	21.36	32.25	1.2	0.17	24.99	14.71	0.21	0.17	24.37	182.74	306.1	11.08	317.19	311	0.8/2.0
5	6 3/87	7.20	656	-	-	-	-	-	-	24.25	-	-	-	-	-	-	-	-	-	-

@/μ/mhos/cm at 25° C * as $CaCo_3$

(Analyses by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains

Chemical Analyses of Water Samples

Location: COOKSON #4

Area: BERNARD LODGE EAST – PROJECT 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			* Total Hardness	SAR /ADJ SAR
										mg/L						HCO	CO	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	29 10/86	7.80	617	397.85	72.94	27.12	36	0.90	0.0	21.49	23.66	0.23	–	–	–	313.7	0	313.7	295	0.9/2.2
2	9 2/87	8.08	607	386.0	70.54	18.00	42.0	0.80	0.10	22.99	8.82	0.44	0.02	0.0	132.9	268.7	19.39	288.09	251	1.1/2.7
3	6 3/87	7.21	578	–	–	–	–	–	–	23.26	–	–	–	–	–	–	–	–	–	–
4	12.8.87	7.4	611	329.0	56.5	18.2	40.0	0.7	0.06	24.2	0	0.21	–	–	–	256.1	24.4	280.5	217.0	1.2/2.7
5	8.2.88	7.8	603	367.2	72.4	18.0	46.0	0.8	0.26	25.4	15.7	0.04	–	–	–	281.6	15.0	296.6	256	1.3 /3.0
6	8.3.88	7.4	591	–	–	–	50.0	–	–	25.2	–	–	–	–	–	216.7	19.2	235.9	–	–

@/μ/mhos/cm at 25°C * as $CaCo_3$

(Analyses 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. Avers, and R. F. Hasek, Water Quality, University of California Division of Agricultural Science Leaflet 2995 (1977)

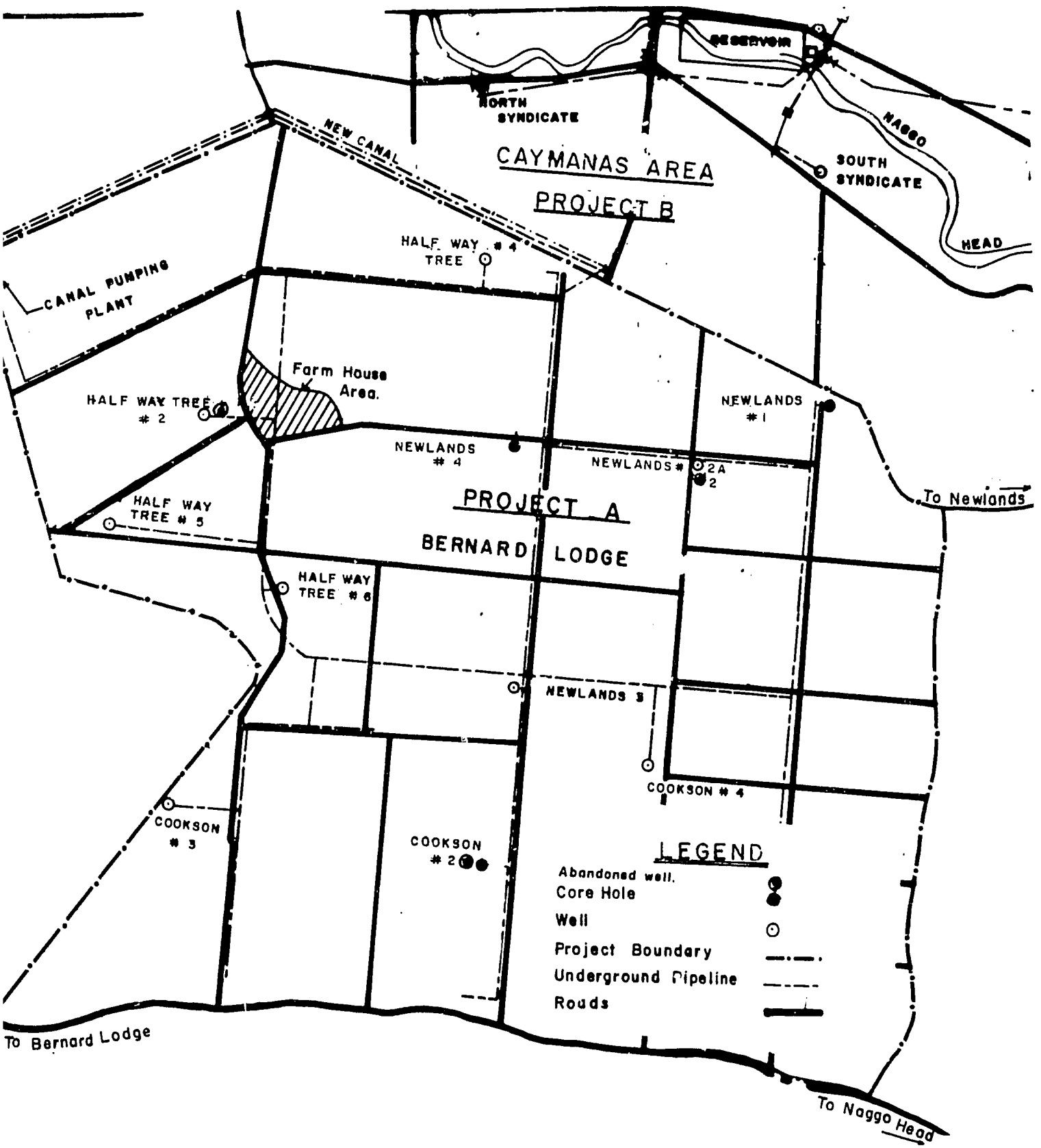
[1] Interpretation is related to type of problem and its severity, but is modified by circumstances of soil, crop, and locality.

ST. CATHERINE PLAINS.

Map of Bernard Lodge East Area Showing The Location of Wells.

(Scale 1:12,500)

Project A



St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well Half-Way-Tree #5

CONTENTS

St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well
Half-Way-Tree #5

1. Introduction

The Half Way Tree #5 Well was constructed in the year 1959 by Water Well Engineering Co., Race Course, for the F.M.L.C., Spanish Town. The construction details of the well as contained in the records of Underground Water Authority (formerly Water Resources Division) are given in Table-1. The yield from the well was 1005 gpm for a pumping water level of 24.4 ft. at the time of construction. As the well was constructed with perforated pipe (20" dia.) and coarse gravel the well discharge was accompanied by sand. The well was not in regular use since a long time.

In order to assess the present yield and quality of water from the well it was proposed to clean the well and then test it for the yield.

2. Cleaning and Testing of the Well

The cleaning and testing operations were carried by Hood Daniel Well Company Limited, Spur Tree P.O., Manchester, in July 1985.

The well was cleaned down to the original depth using a cable tool rig and tested for yield with a turbine pump for seven hours on July 11, 1985. The static water level was 21.16 ft. The yield was 950 gpm for a drawdown of 17.5 ft. The well discharge, however, was accompanied by sand throughout the pumping period. After seven hours of pumping, slight caving took place around the well and further pumping was discontinued. As the specific capacity of the well was 54 gpm/ft. it was decided to reconstruct the well by lowering a properly designed small diameter well assembly into the well and gravel packing the annular space with suitable gravel.

3. Well Design

A sample of sand collected from the well discharge during the testing operations was subjected to sieve analysis and the results are given in Table-2. The sieve analysis curve and the gravel pack composition curve are shown in Fig. 1. Six times the 70% retention size (0.007") of the sand sample was taken as the 70% retention size (0.042") of the gravel pack material. With this point as origin a curve was developed with a uniformity coefficient of nearly 2 to represent the composition of the gravel pack material. 90% retention size (0.030") of the gravel pack material was taken as the slot size of the well screen. The composition of the gravel pack material is given below:

Size of material	Percentage
0.023" - 0.047"	40
0.047" - 0.094"	50
0.094" - 0.125"	10

The well assembly consisted of 50 ft. of 14" dia. (0.375" thick) plain casing and 24 ft. of 14" dia. irrigation type (low carbon steel) well screens of slot size 0.030" (manufactured by Johnson Division, U.S.A.). The bottom of the assembly was sealed with a 0.375" thick steel plate.

The well design is shown in Fig. 2.

The top of the screens was set below the anticipated pumping water level.

4. Well Reconstruction

The well reconstruction, development and testing operations were carried out by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10.

The well assembly was lowered into the existing well on August 30, 1985 and the annular space was packed with graded gravel which consisted of rounded to subrounded hard material like quartz, granite, etc. with a little limestone impurity.

5. Well Development and Testing

The reconstructed well was developed with compressed air (using an air compressor of capacity 150 psi - 160 cfm) for 5 hrs. on August 31. The well discharge was turbid, occasionally accompanied by fine sand. The well was developed with compressed air for a further period of 15 hrs. on September 2 and 3 and for 10 hrs. with a turbine pump on September 4 and 5. The discharge was free from turbidity and sand at the end of the development. It was found during the development that th well could be pumped at 400 gpm. A long duration pumping test was conducted for 72 hrs. from September 6 to 9, at 400 gpm and the pumping test data is given in Table 3. The static water level was 21.79 ft. below the top of the casing and the pumping water level stabilized at 37.08 ft. after 58 hours of pumping. This pumping water level was about 7 ft. above sea level. The specific capacity of the well worked out to 26 gpm/ft. The time vs drawdown graph is given as Fig. 3. The transmissivity of the formation was 45,900 gpd/ft.

6. Quality of Water

Chemical analyses results of two water samples collected during the test are given in Table-4.

7. Rate of Abstraction

Based on the results of long duration pumping test, it is recommended that the well maybe pumped at 400 gpm.

(The measure used in this report is US gallons).

WATER RESOURCES DIVISION — WELL RECORD

LOCATION Half-Way-Tree #5 (See 30)		**WELL NUMBER** E5808 N3892
PARISH St. Catherine	**GRID REFERENCE** E5808 N3892	
OWNER F.M.L.C.	**ADDRESS** Spanish Town	
DRILLER Waterwell Eng. Co.	**ADDRESS** Race Course	**DATE OF COMPLETION** March '59

HOLE SIZE 20 INCHES TO 80 FEET; INCHES TO FEET; INCHES TO FEET	**TYPE OF RIG USED** Cable Tool	**DEPTH OF WELL** 80 FEET	**ELEVATION OF SITE A.S.L.** 42½ FEET
	WATER STRUCK AT FEET	**PRINCIPAL AQUIFER**	**REST WATER LEVEL ON COMPLETION** FEET

CASING

TYPE	Plain	DIAMETER	20 INCHES	LENGTH	10	FEET FROM	0	FEET TO	10 FEET
TYPE	Perf.	DIAMETER	20 INCHES	LENGTH	70	FEET FROM	10	FEET TO	80 FEET
TYPE		DIAMETER	INCHES	LENGTH		FEET FROM		FEET TO	FEET

ORIGIN OF DATA Well Logs.	**COMPILED BY** S.D.	**CHECKED BY**

REMARKS

S.W.L. - 14/10/63 - 2.19 ft.

P.W.L. - 24/9/63 - 15.27 ft.

Yield - 595 G.P.M.

Former Grid Reference
E5816 N3892

TEST PUMPING — DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
0	6	
335	9	3
670	14.3	8.3
1005	24.4	18.3

SKETCH PLAN OF LOCATION

SITED IN FIELD BY — **DATE**

Table 2

ST. CATHERINE PLAINS

SIEVE ANALYSIS RESULT OF AQUIFER SAMPLE

(CUMMULATIVE PERCENT RETAINED)

LOCATION: Half Way Tree #5

AREA: Bernard Lodge - Project 'A'

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE OF SAMPLE (FT.)										
1	3/8"	0.375											
2	4	0.187											
3	10	0.078											
4	16	0.047	0.1										
5	30	0.023	0.3										
6	50	0.012	26.6										
7	80	0.007	69.4										
8	100	0.006	80.4										
9	200	0.003	94.8										

CUMULATIVE PERCENT RETAINED

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

* - Sand sample collected from well discharge

St. Catherine Plains

Pumping Test Data

Table 3

1

Location: Half Way Tree #5 **Area:** Bernard Lodge-Project 'A'

Diameter- Discharge Pipe 8" **Orfice** 5"

Static Water Level 21.79 ft.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
6.9.85	1000	-	21.79	-			
		1	30.83	9.04			
		2	31.75	9.96			
		3	31.08	9.29			
		4	31.08	9.29			
		5	-	-			
		6	31.41	9.62			
		7	31.50	9.71			
		8	31.54	9.75			
		9	31.70	9.91			
		10	31.66	9.87	16"	400	
		12	31.95	10.16			
		14	31.95	10.16			
		18	32.08	10.29			
		20	32.08	10.29			
		22	32.10	10.37			
		25	32.12	10.33			
		26	32.25	10.46			
		28	32.25	10.46			
		30	32.45	10.66			
		33	32.45	10.66			

St. Catherine Plains

Pumping Test Data (Continued) Table 3

2

Location: Half Way Tree #5

1	2	3	4	5	6	7	8
		36	32.45	10.66			
		40	32.45	10.66			
		45	32.54	10.75			
		50	32.79	11.00			
		55	32.75	10.96			
6.9.85	1100	60	32.79	11.00	16" - 16½"	400	
		65	32.83	11.04			
		70	32.92	11.13			
		75	32.92	11.13			
		80	32.96	11.17			
		85	33.0	11.21			
		90	33.0	11.21			
		95	33.16	11.37			
		100	33.16	11.37			
		105	33.16	11.37			
		110	33.29	11.50			
		115	33.29	11.50			
	1200	120	33.29	11.50			
		125	33.29	11.50			
		130	33.33	11.54			
		135	33.54	11.75			
		150	33.58	11.79			
		155	33.62	11.83			

St. Catherine Plains

Pumping Test Data (Continued) Table 3

3

Location: Half Way Tree #5

1	2	3	4	5	6	7	8
6.9.85		160	33.70	11.91			
		170	33.75	11.96			
	1300	180	33.79	12.00			
		190	33.83	12.04			
		210	33.87	12.08			
		225	34.0	12.21			
		240	34.12	12.33			
		255	34.16	12.37			
		270	34.20	12.41	16"-16½"	400	
	1500	300	34.29	12.50			
		315	34.37	12.58			
		330	34.46	12.67			
		345	34.50	12.71			
		360	34.54	12.75			
		375	34.58	12.79			
		390	34.62	12.83			
		405	34.70	12.91			
	1700	420	34.75	12.96			
		480	34.75	12.96			
		495	34.83	13.04			
		510	34.87	13.08			
		525	34.91	13.12			
		540	35.08	13.29			

St. Catherine Plains

Pumping Test Data (Continued) Table 3

4

Location: Half Way Tree #5

1	2	3	4	5	6	7	8
6.9.85		570	35.0	13.21			
		600	35.08	13.29			
6.9.85	2100	660	35.08	13.29			
		690	35.12	13.33			
		720	35.16	13.37			
"		750	35.25	13.46			
		780	35.33	13.54			
		840	35.33	13.54			
7.9.85	0100	900	35.50	13.71			
		960	35.50	13.71			
		1020	35.54	13.75			
7.9.85	0400	1080	35.62	13.83	16"-16½"	400	
		1140	35.70	13.91			
		1200	35.75	13.96			
		1260	35.92	14.13			
		1320	35.83	14.04			
	1000	1440	35.83	14.04			
		1560	35.96	14.17			
		1680	36.0	14.21			
		1800	36.12	14.33			
		1920	36.12	14.33			
		2040	36.25	14.46			
		2160	36.25	14.46			

St. Catherine Plains

Pumping Test Data (Continued) Table 3

5

Location: Half Way Tree #5

1	2	3	4	5	6	7	8
		2280	36.29	14.50			
8.9.85	0200	2400	36.29	14.50			
		2520	36.33	14.54			
		2640	36.42	14.63			
		2760	36.62	14.83			
	1000	2880	36.62	14.83			
		3000	36.62	14.83			
		3120	36.66	14.87			
		3240	36.66	14.87			
		3360	37.00	15.21			
		3480	37.08	15.29			
		3600	37.08	15.29			
		3720	37.08	15.29			
.9.85	0200	3840	37.08	15.29			
	0400	3960	37.08	15.29	16"-16½"	400	
		4080	37.08	15.29			
		4200	37.08	15.29			
	1000	4320	37.08	15.29			

Table 3

Pumping Test Data (Continued)

Location: Half Way Tree #5 **Recovery Data:**

Date	Time (hours)	Time since pumping started (minutes) (t)	Time since pumping stopped (t')	t/t'	Depth to water	Residual Drawdown	Remarks
9.9.85	1001	4321	1	4321	23.66	1.87	
		4322	2	2161	23.31	1.34	
		4323	3	1441	22.98	1.19	
		4324	4	1081	22.70	0.91	
		4325	5	865	22.50	0.71	
		4326	6	721	22.30	0.51	
		4327	7	618.1	22.20	0.41	
		4328	8	541	22.08	0.29	
		4330	10	433	22.04	0.25	
		4332	12	361	21.96	0.17	
		4334	14	309	21.89	0.10	
		4335	15	289	21.85	0.06	
		4336	16	271	21.81	0.02	
		4338	18	241	21.79	0	
		4340	20		21.75		
		4342	22		21.75		
		4345	25		21.70		
		4350	30		21.68		
		4355	35		21.66		
		4360	40		21.62		
		4365	45		21.58		
		4370	50		21.54		
		4375	55		21.54		
		4380	60		21.54		

St. Catherine Plains

Chemical Analyses of Water Samples

Table-4

Location: Half Way Tree #5

Area: Bernard Lodge East - Project 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl ppm	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity total	Total* Hardness	SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	6.9.85	7.60	640	338.2	83.60	18.24	21.50	0.80		20.36						284.94	0	284.94	285	0.5
2	7.9.85	8.3	630	331	83.60	18.00	21.50	0.80		19.86						284.94	0	284.94	284	0.5
3	8.9.85	7.65	630	328	82.40	19.20	22.00	0.80		19.36						284.94	0	284.94	282	0.5
4	9.9.85	7.67	640	366	82.40	18.24	22.00	0.80		19.36						284.94	0	284.94	285	0.5

@/u/mhos/cm at 25°C * as $CaCo_3$

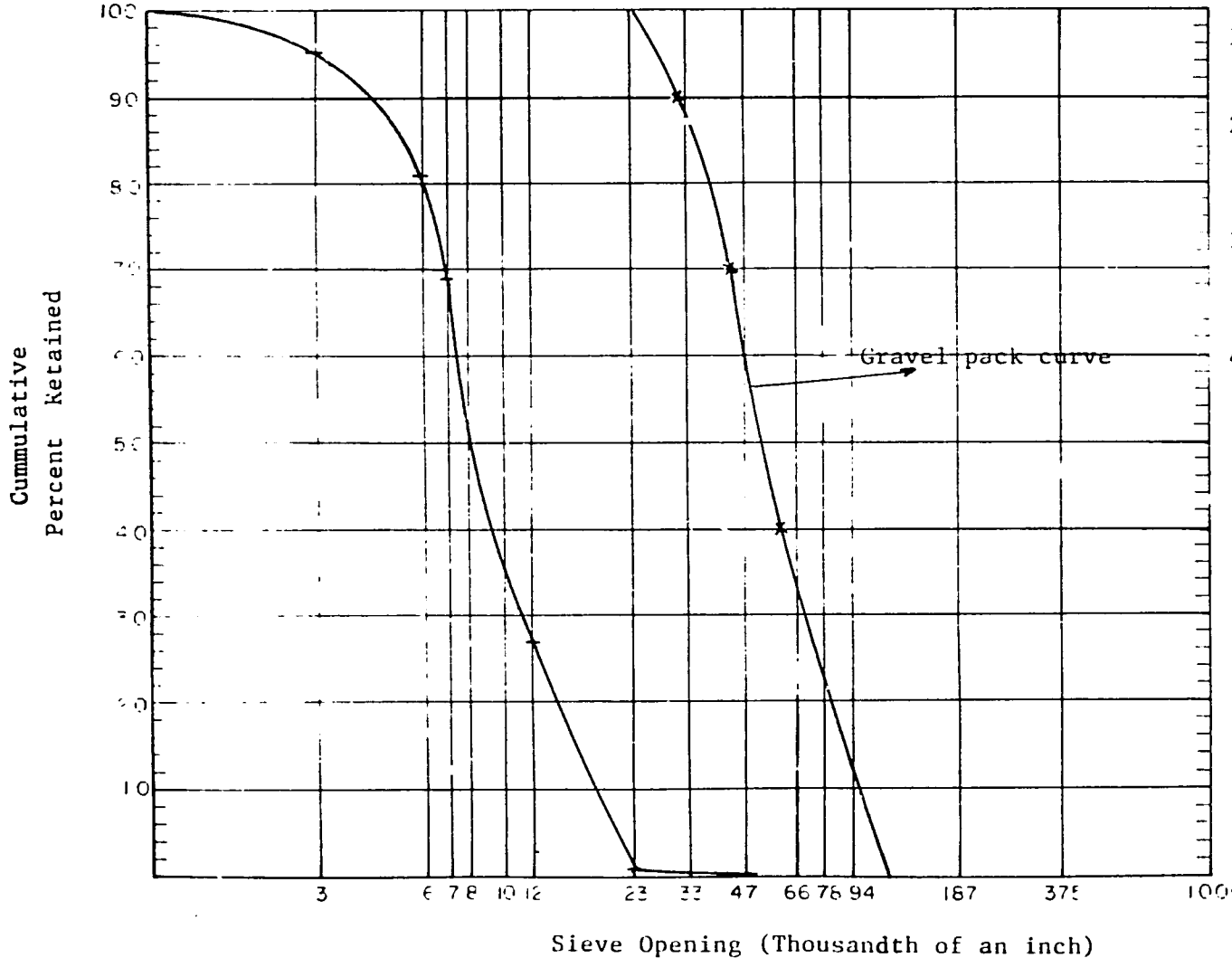
(Analysis by Jamaica Bauxite Institute, Kingston)

SIEVE ANALYSIS CURVE

Fig. 1

Location: Half Way Tree #5 Well

Depth Range: (ft.) Sample from well discharge



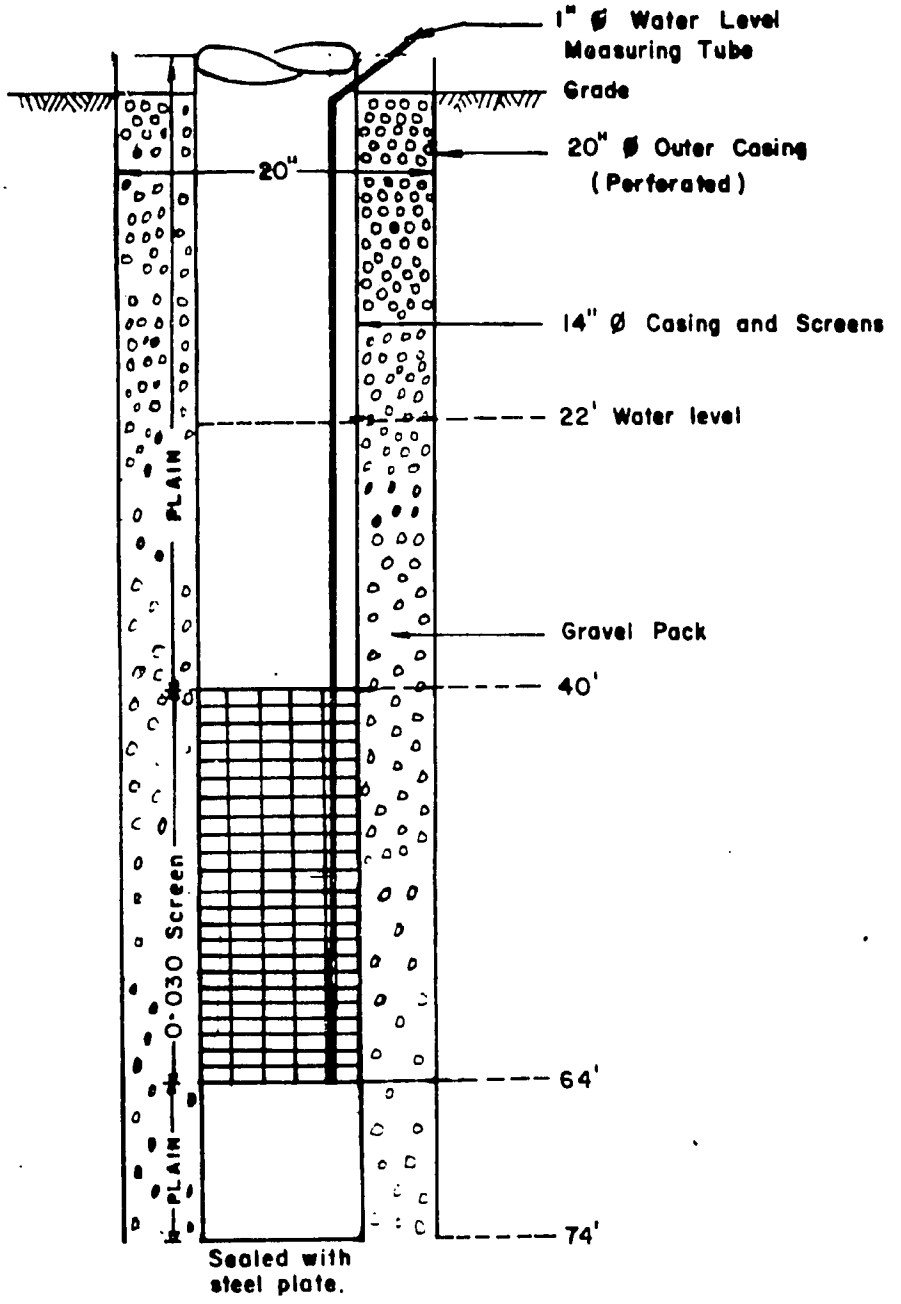
1. 70% retention size of the sample = 0.007".
2. 70% retention size of the gravel pack. = 0.007" x 6
   = 0.042"
3. Slot size of the screen (90% retention size of the gravel pack) = 0.030".
4. Uniformity co-efficient of the sample = 2.5.

ST CATHERINE PLAINS.

Fig. 2

Bernard Lodge Area Project 'A'

Well Design – Half Way Tree # 5.



VERTICAL SCALE

0·8in = 10 ft.

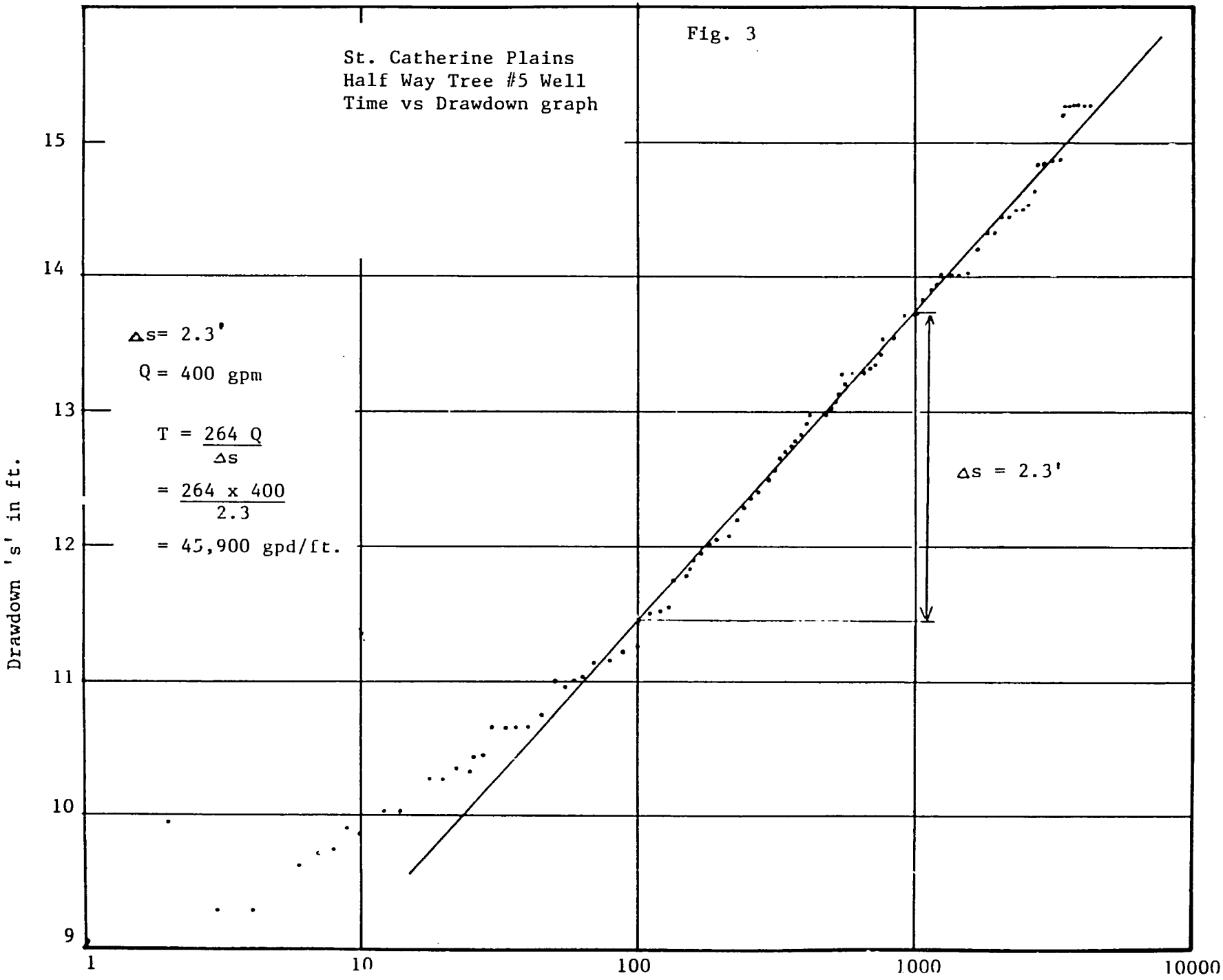


Fig. 3
St. Catherine Plains
Half Way Tree #5 Well
Time vs Drawdown graph
Δs= 2.3'
Q = 400 gpm
T = 264 Q / Δs
= 264 x 400 / 2.3
= 45,900 gpd/ft.
Δs = 2.3'
Drawdown 's' in ft.
15
14
13
12
11
10
9
1
10
100
1000
10000

St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well Half-Way-Tree #4

CONTENTS

St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well Halfway Tree #4

1. Introduction

The Halfway Tree #4 well was constructed in January, 1959, by Waterwell Engineering Co., Race Course, for F.M.L.C., Spanish Town. The construction details of the well as contained in the records of Underground Water Authority (formerly Water Resources Division) are given in Table-1. The yield from the well was 1005 gpm for a pumping water level of 19 ft at the time of construction and 835 gpm for a pumping water level of 18.97 ft on Sept. 24, 1963. As the well was constructed with perforated pipe (20" diameter) and coarse gravel, the well discharge was accompanied by sand. The well was not in regular use since a long time.

In order to assess the present yield and quality of water from the well it was proposed to clean the well and test it for the yield.

2. Cleaning and Testing of the well.

The Cleaning and testing operations were carried out by Jamaica Wells and Services Ltd., 3 Ballater Avenue, Kingston 10.

The well was filled with sand below 65 ft. It was cleaned down to the original depth with compressed air (using an air compressor of capacity 150 psi 160 cfm) on August 8 and 9, 1985, and tested for the yield with compressed air on August, 12. The water level was 23 ft and pumping water level was 29 ft for a discharge of 300 gpm indicating a specific capacity of 50 gpm/ft. which compared favourably with those of other wells in the area. However, the well discharge was accompanied by sand. It was therefore decided to reconstruct the well by lowering a properly designed smaller diameter well assembly and gravel packing the annular space with suitable gravel.

3. Well Design.

A sample of sand collected from the well discharge during the testing operations was subjected to sieve analysis and the results are given in table 2. The sieve analysis curve and the gravel pack material curve are shown in fig.1. Six times the 70% retention size (0.014") of the sand sample was taken as the 70%

retention size of the gravel pack material and with this point as origin a curve was developed with a uniformity coefficient of nearly 2 to represent the composition of the gravel pack material. 90% retention size (0.040") of the gravel pack material was taken as the slot size of the well screen. The composition of the gravel pack material is given below:

Size of material		Percentage
0.033" - 0.047"	-	20%
0.047" - 0.094"	-	50%
0.094" - 0.125"	-	30%

The well assembly consisted of 48 ft of 14" dia. (0.375" thick) plain casing and 30 ft. of 14" dia. irrigation type (low carbon steel) well screens of slot size 0.040" (manufactured by Johnson Division U.S.A.). The bottom of the assembly was sealed with a steel plate.

The well design is shown in fig. 2.

The top of the screens was set below the anticipated pumping water level.

4. Well Reconstruction

The well reconstruction, development and testing operations were carried out by Jamaica Wells and Services Ltd., 3 Ballater Avenue, Kingston 10, using a cable tool rig. The well assembly as described above was lowered into the existing 20" dia. well between Sept. 28 and 30, 1985, and the annular space was packed with graded gravel which consisted of rounded to sub-rounded hard material like quartz, granite etc. with a little limestone impurity.

5. Well Development and Testing.

The well was developed with compressed air (using an air compressor of capacity 150 psi-160 cfm) for 7 hrs. on Oct. 2, and with a turbine pump for 19 hrs. between Oct. 4 and 8. The water level was 23.6 ft. below the top of the casing. At the end of the development operations the yield was 315 gpm for a pumping water level of 47.3 ft. In order to improve the yield, further development using other methods was contemplated and therefore the pump was removed on Oct. 10. The well was back washed by injecting 2000 gallons of water on Oct. 11. Surging with a surge block was done for 4 hrs on Oct. 12. Then the well was developed again with compressed air for a total period of 17 hrs on Oct. 14, 15, and 16.

4 bags of polyphosphate (100 lbs each bag) were used to disperse the clay fractions. At the end of these operations the yield was 300-315 gpm for pumping water levels of 33 ft.-35 ft.

6. Quality of water

Chemical analysis results of two water samples collected during the development of the well are given in table-3.

7. Rate of Abstraction

Based on the results obtained during development of the well and its subsequent performance it is recommended that the abstraction rate may be limited to 250 gpm. Its further performance and changes in the quality of water are to be observed.

(The measure used in this report is US gallons)

Table-1

WATER RESOURCES DIVISION — WELL RECORD

LOCATION Half-Way-Tree 4 (See 30)		**WELL NUMBER** E5842 N3910
PARISH St. Catherine	**GRID REFERENCE** E5842 N3910	
OWNER F.M.L.C.	**ADDRESS** Spanish Town	
DRILLER Waterwell Eng. Co.	**ADDRESS** Race Course	**DATE OF COMPLETION** Jan. 1959

HOLE SIZE 20 INCHES TO 80 FEET; INCHES TO FEET; INCHES TO FEET	**TYPE OF RIG USED** Cable Tool	**DEPTH OF WELL** 80 FEET	**ELEVATION OF SITE A.S.L.** 37.02 FEET
	WATER STRUCK AT FEET	**PRINCIPAL AQUIFER**	**REST WATER LEVEL ON COMPLETION** FEET

CASING

TYPE	Plain	DIAMETER	20 INCHES	LENGTH	10 FEET	FROM +2 FEET	TO	8	FEET
TYPE	Perf.	DIAMETER	20 INCHES	LENGTH	70 FEET	FROM 8 FEET	TO	78	FEET
TYPE		DIAMETER	INCHES	LENGTH	FEET	FROM FEET	TO		FEET

ORIGIN OF DATA Well Logs	**COMPILED BY** D.S.	**CHECKED BY**

REMARKS

S.W.L. - 14/10/63 - 1.40 ft.

P.W.L. - 24/9/63 - 18.97 ft.

Yield - 835 G.P.M.

Pumping for irrigation uses.

Former Grid Reference
E5842 N3913

TEST PUMPING — DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
0	5	-
697	15	10
1005	19	14

SKETCH PLAN OF LOCATION

SITED IN FIELD BY — **DATE**

ST. CATHERINE PLAINS
SIEVE ANALYSIS RESULT OF AQUIFER SAMPLE

LOCATION: HALF WAY TREE # 4 WELL

AREA: BERNARD LODGE PROJECT "A"

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	*DEPTH RANGE (FT.)								
			A	B	C						
1	6	0.132	3.3	3.3	1.8						
2	8	0.094	7.1	10.4	5.8						
3	12	0.066	9.8	20.2	11.3						
4	16	0.047	20.0	40.2	22.5						
5	20	0.033	23.3	63.5	35.5						
6	30	0.023	24.1	87.6	49.0						
7	40	0.016	28.7	116.3	65.1						
8	50	0.012	22.1	138.4	77.5						
9	70	0.008	18.7	157.1	87.9						
10	100	0.006	11.4	168.5	94.3						
11	PAN	-	10.1	178.6	100.0						

*Sand sample collected from well discharge

* U.S.S. Sieve Series

(Analysed by Alex Campos and D.V. Ramanamurty)

A =Weight retained in grams

B =Cummulative weight retained

C =Cummulative percentage retained

St. Catherine Plains

Chemical Analyses of Water Samples

Table-3

Location: HALF WAY TREE NO. 4 Area: BERNARD LODGE PROJECT 'A'

SL NO.	DATE	pH	@ Sp. Conductance	TDS	Ca	Mg	Na	K	Fe	Cl ppm	SO_4	B	F	PO_4	NO_3	* Alkalinity HCO_3	* Alkalinity CO_3	* Alkalinity Total	Total* Hardness	SAR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	8 10 85	8.1	595	366.6	71.2	24	21	0.7	-	17.37	-	-	-	-	-	295.7	0	295.7	278	0.5
2	15 10 85	8.3	610	392.1	67.6	20.40	42	0.7	-	17.37	-	-	-	-	-	322.6	0	322.6	254	1.1

@/µ/mhos/cm at 25°C * as $CaCo_3$

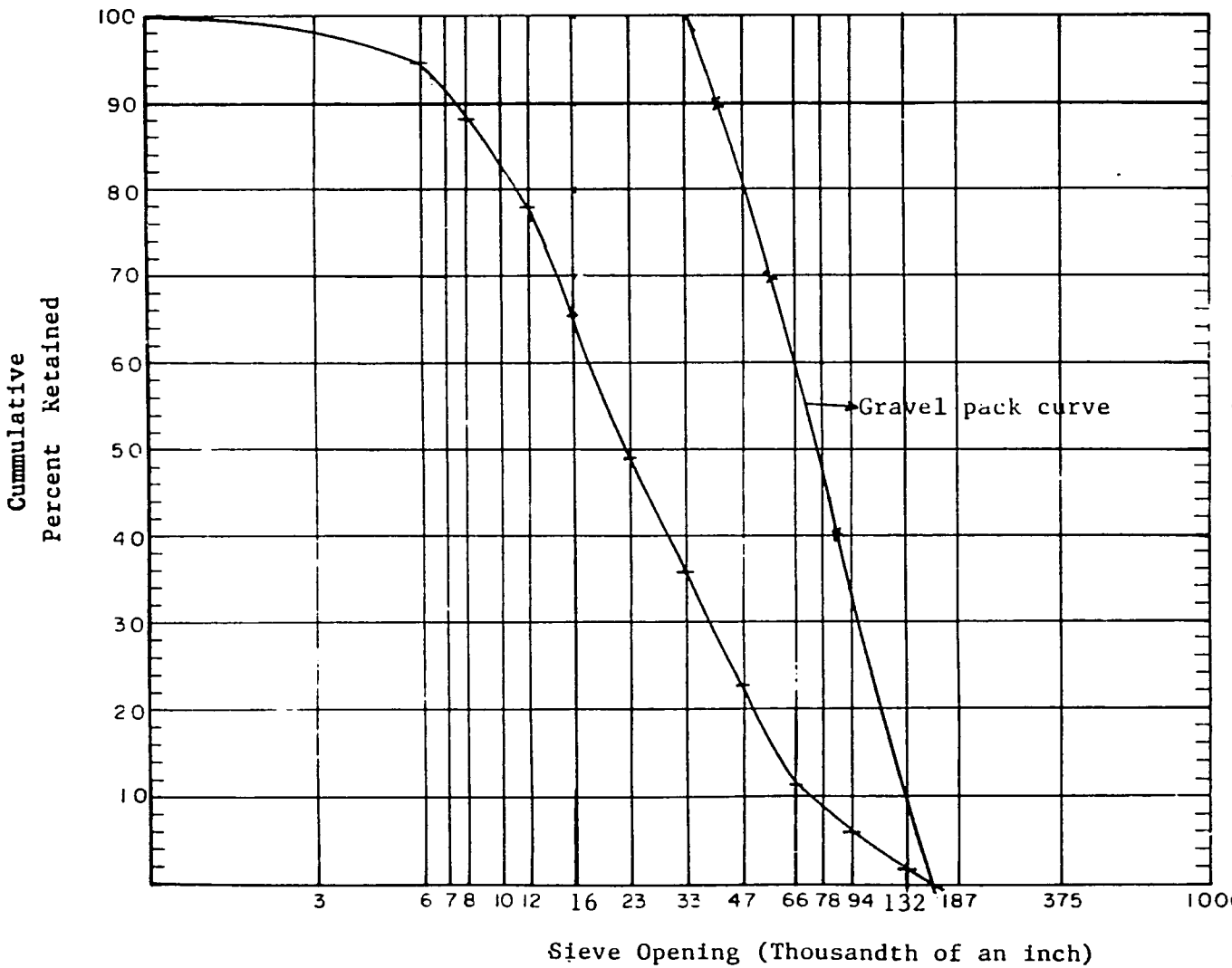
(Analysis by Jamaica Bauxite Institute, Kingston)

Figure 1

SIEVE ANALYSIS CURVE

Location: Half Way Tree #4

Depth Range: (ft.) Sample from well discharge



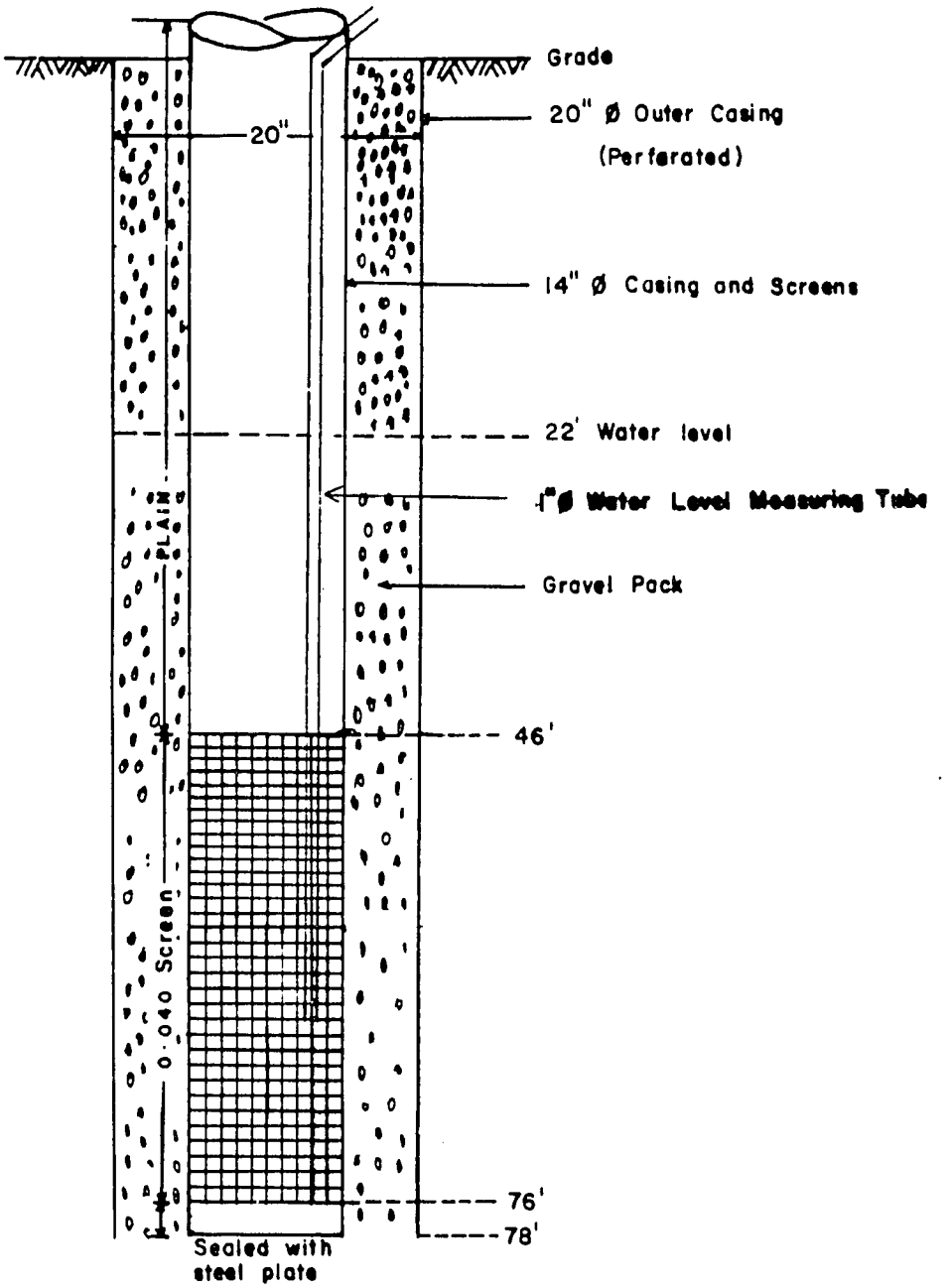
1. 70% retention size of the sample = 0.014".
2. 70% retention size of the gravel pack = 0.014" x 4
   = 0.056"
3. Slot opening of the screen (90% retention size of the gravel pack) = 0.040".
4. Uniformity co-efficient of the sample = 4.

ST CATHERINE PLAINS.

Fig. 2

Bernard Lodge Area Project 'A'

Well Design – Half Way Tree # 4.



VERTICAL SCALE

0·8" = 10 Feet

St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well Cookson #3

CONTENTS

St. Catherine Plains
Bernard Lodge East Area
Report on the Reconstruction of Well Cookson #3

1. Introduction

The Cookson #3 Well was constructed in May, 1962, by Hood Daniel Well Company Limited, Mandeville for F.L.M.C., Spanish Town. The particulars of the well as obtained from the records of Underground Water Authority (formerly Water Resources Division) are given in Table-1. The yield from the well was 1345 gpm for a drawdown of 30.5 ft. at the time of construction. However, as the well was constructed with a perforated pipe (20" dia.) and coarse gravel, the well discharge was accompanied by sand. The well was in intermittent use. In order to test the present yield of the well and the quality of water it was proposed to clean the well and test it for the yield.

2. Cleaning and Testing of the Well

The cleaning and testing operations were carried out by Hood Daniel Well Company Limited, Spur Tree P.O., Manchester, in July 1985, using a cable tool rig. The well was filled below 70 ft. It was cleaned down to the original depth and tested for the yield with a turbine pump on July 17, 1985, for 4 1/2 hrs. The static water level was 20.4 ft. The yield was 950 gpm for a drawdown of 17.6 ft. indicating a specific capacity of 54 gpm/ft. However the well discharge was accompanied by sand throughout the pumping period. The pumping water level stabilized after 2 1/2 hrs. of pumping. As the performance of the well was found to be good, except for sand pumping, it was decided to reconstruct the well by lowering a smaller diameter properly designed well assembly into the well and gravel pack the annular space with suitable size gravel.

3. Well Design

A sample of sand collected from the well discharge during the testing operations was subjected to sieve analysis. The sieve analysis result is given in Table-2 and the sieve analysis curve is shown in Fig. 1. Six times the 70% retention size (0.010") of the sample was taken as the 70% retention size of the gravel pack material.

With this point as origin a curve was developed with a uniformity coefficient of nearly 2, to represent the composition of the gravel pack material. The gravel pack curve is also shown in Fig. 1. 90% retention size of the gravel pack material (0.040") was taken as the slot size of the screen.

The well assembly consisted of 48.6 ft. of 14" dia. plain casing (0.375" thick) and 30 ft. of 14" dia. irrigation type (low carbon steel) well screens of 0.040" slot size (manufactured by Johnson Division, U.S.A.). The bottom of the assembly was sealed with 0.375" thick steel plate. The well assembly as described here was lowered in the old well, but subsequently it had to be pulled due to the reasons stated in paragraph 5 below. Only 30 ft. screens are now in the old well. The well design is shown in Fig. 2.

4. Well Reconstruction

The well reconstruction, development and testing operations were carried out by Hood Daniel Well Company Limited, Spur Tree P.O., Manchester, using a cable tool rig. The well assembly, as described above was lowered into the old well between October 4 and 7, 1985, and gravel packing was done on October 8.

5. Well Development and Testing

The reconstructed well was developed for 7 hrs. with a turbine pump on October 10. The well discharge was slightly turbid and the yield was 300 gpm for a pumping water level of 55 ft. As the performance of the well was considered unsatisfactory, the pump was pulled out on October 14, so that the well could be developed by other methods. Surging with a surge block and bailing operations were carried out on October 15 and 16 for a period of 8 1/2 hrs. The well was then developed with compressed air for 10 hrs. on October 17 and 18. At this stage the well discharge was turbid and the yield was 130 gpm for a pumping water level of 34 ft.-35 ft. It was therefore decided to pull out the assembly and increase the screen length. Attempts were made to pull out the assembly on October 23, but the assembly did not move. In an attempt to make the assembly free, gravel from the annular space was ejected out on October 24, by blowing air through a 1 1/4" pipe inserted in the gravel. However after a few hours of air blowing the land surface around the well started sinking and therefore the operations were suspended and the rig was moved out from the site. The land surface was levelled by filling the caved in portion with rubble and the rig was reset on October 25. Gravel was ejected out again on October 28 and 29.

The gravel level which was 20 ft. below ground level at the start of the operations went down to 36.5 ft. at the end of the operations. Attempts were made to pull out the assembly with a 100 ton jack on October 31, but the casing broke inside the well.

The broken portion of the casing was pulled out on November 1, and it was found out that the casing gave way at the junction with the screens. 46.6 ft. of casing was pulled out. The screens remained in the well and the well got filled with gravel below 64 ft. The gravel was bailed out with a bailer. A small assembly consisting of 20 ft. of 16" dia., 0.050" slot size screen and 26.6 ft. of 14" dia. plain pipe was prepared and lowered into the well on November 5. One foot length of reducer was fitted to the bottom of the 16" dia. screen so that it could be positioned properly on the 14" dia. screen which was in the well. The well was tested with a turbine pump for about 8 hrs. on November 6 and 7. The yield was 400 gpm for a pumping water level of 35 ft. inside the well and 32.7 ft. in between the well assembly and 20" dia. well casing. The annular space was not filled with gravel at this stage.
As the small assembly could not be positioned properly on the screens left out in the well, the former was pulled out.

6. Quality of Water

Chemical analyses results of two water samples one collected during the testing of the well after cleaning operations and the other at the end of the reconstruction operations are given in Table-3.

7. Rate of Abstraction

No long duration pumping test was conducted on the reconstructed well. However based on the data obtained during development and intermittent testing, it is recommended that the well may be pumped at 300 gpm. However, if the well shows improvement in performance in course of time, then the abstraction rate could be increased. The well discharge will be accompanied by some sand.

(The measure used is USgpm. The depth to water indicated is below the top of casing)

Table 1

WATER RESOURCES DIVISION — WELL RECORD

LOCATION Cookson 3		**WELL NUMBER** E5814 N3875
PARISH St. Catherine	**GRID REFERENCE** E5814 N3875	
OWNER F.M.L.C.	**ADDRESS** Spanish	
DRILLER Hood-Danial Well Co.	**ADDRESS** Mandeville	**DATE OF COMPLETION** May, 1962

HOLE SIZE 20 INCHES TO 78 FEET; INCHES TO FEET; INCHES TO FEET	**TYPE OF RIG USED** Cable Tool	**DEPTH OF WELL** 78 FEET	**ELEVATION OF SITE A.S.L.** 41.70 FEET
	WATER STRUCK AT 14 FEET	**PRINCIPAL AQUIFER** Sandy Clay	**REST WATER LEVEL ON COMPLETION** 7.5 FEET

CASING

TYPE Perf	DIAMETER 20 INCHES	LENGTH 80	FEET FROM +2	FEET TO 78 FEET
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO FEET
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO FEET

ORIGIN OF DATA Hood-Daniel Records	**COMPILED BY** B.F.	**CHECKED BY** D.S.

REMARKS

S.WL. - 14/10/63 - 5.48 ft.

Former Grid Reference
E5820 N3880

17.7.85 - Well cleaned and pump tested

TEST PUMPING C/yds/Hr. **DATE** 1962

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
0	7.5	-
100	12	4.5
200	18	10.5
300	26	18.5
400	38	30.5

SKETCH PLAN OF LOCATION

SITED IN FIELD BY **DATE**

ST. CATHERINE PLAINS

SIEVE ANALYSIS RESULT OF AQUIFER SAMPLE

(CUMMULATIVE PERCENT RETAINED)

Table-2

LOCATION: Cookson #3 WELL

AREA: BERNARD LODGE - PROJECT "A"

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	* DEPTH RANGE OF SAMPLE (FT.)										
1	3/8"	0.375											
2	4	0.187											
3	10	0.078	3.0										
4	16	0.047	10.1										
5	30	0.023	35.1										
6	50	0.012	66.3										
7	80	0.007	78.5										
8	100	0.006	85.6										
9	200	0.003	95.4										

@ U.S.S. Sieve Series

(Analysed by Jamaica Engineering & Technical Services Limited, Kingston) * sand sample collected from well discharge

6a

St. Catherine Plains

Chemical Analyses of Water Samples

Table-3

Location: Cookson #3 Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	@ Sp. Conduct-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			Total* Hardness	SAR
										ppm						HCO_3	CO_3	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	17 7/85	8.0	390	471	83.96	17.76	33.50	1.70	-	21.84	-	-	-	-	-	318.66	0.0	318.66	283	0.8
1	7 11/85	8.85	745	464	85.2	23.4	44.82	1.2	-	24.56	-	-	-	-	-	300.2	25.0	325.21	311	1.1

@/μ/mhos/cm at 25 C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

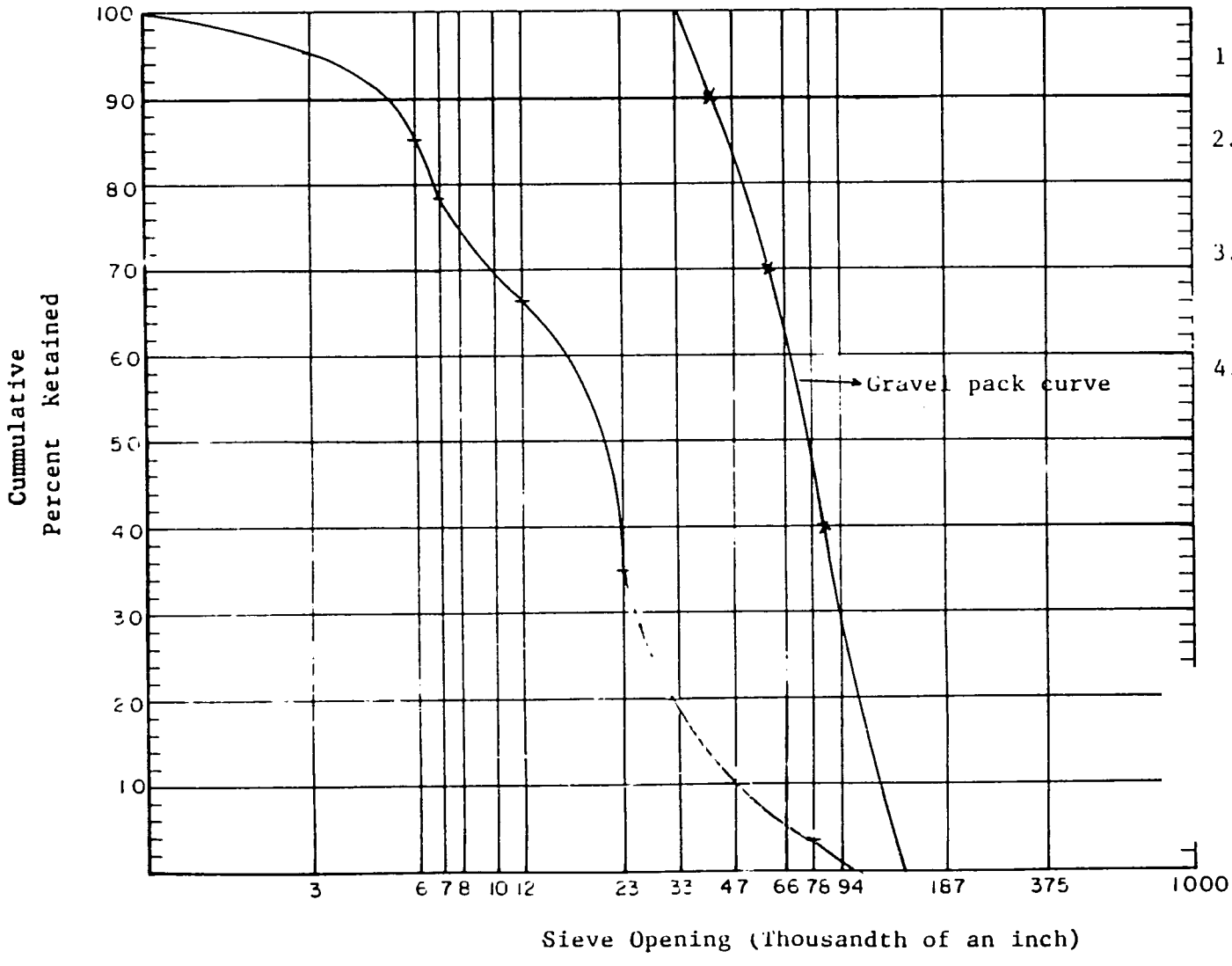
3.

SIEVE ANALYSIS CURVE

Fig. 1

Location: Cookson #3 Well

Depth Range: (ft.) Sample from well discharge



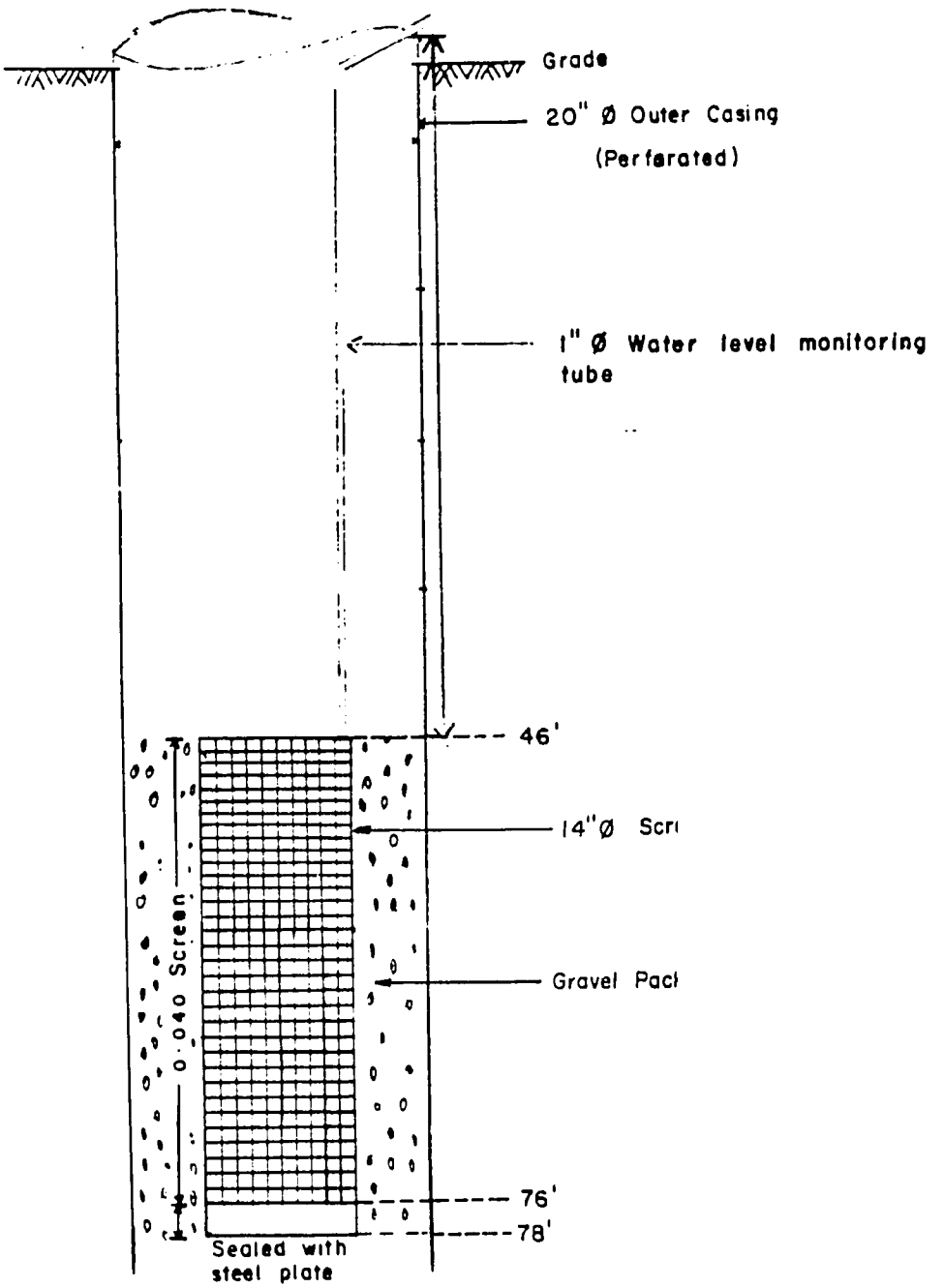
1. 70% retention size of the sample = 0.010".
2. 70% retention size of the gravel pack = $\frac{0.010" \times 6}{0.060"}$
3. Slot opening of the screen (90% retention size of the gravel pack) = 0.040".
4. Uniformity co-efficient of the sample = 4.2.

ST CATHERINE PLAINS.

Fig. 2

Bernard Lodge Area Project 'A'

Well Design – Cookson # 3.



VERTICAL SCALE

0·8 in. = 10 ft.

TABLE 1

WATER RESOURCES DIVISION — WELL RECORD

LOCATION Half-Way-Tree 2		**WELL NUMBER** E5818 N3907
PARISH St. Catherine	**GRID REFERENCE** E5818 N3907	
OWNER F.M.L.C.	**ADDRESS** Spanish Town	
DRILLER	**ADDRESS**	**DATE OF COMPLETION**

HOLE SIZE INCHES TO FEET / INCHES TO FEET / INCHES TO FEET	**TYPE OF RIG USED** Dug	**DEPTH OF WELL** FEET	**ELEVATION OF SITE A.S.L.** 37.6 FEET
	WATER STRUCK AT FEET	**PRINCIPAL AQUIFER** Alluvium	**REST WATER LEVEL ON COMPLETION** FEET

CASING

TYPE	Concrete	DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE		DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET
TYPE		DIAMETER	INCHES	LENGTH	FEET FROM	FEET TO	FEET

ORIGIN OF DATA GSD Records	**COMPILED BY**	**CHECKED BY**

REMARKS

P.W.L. - 12.58 ft. (24.9.63)
Irrigation uses.
Water comes to ground level during heavy rains.
P.W.L. - 15.62 (24.2.60)
Yield 730 G.P.M.
13.00 ft. 10 mins. after pumping

Located in yard.
Small domestic pump also attached to serve houses in area.

Former Grid Reference
E5815 N3903

Replacement well drilled close by

TEST PUMPING DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN

SKETCH PLAN OF LOCATION

SITED IN FIELD BY **DATE**

TABLE 2

St. Catherine Plains
Bernard Lodge East Area
Lithological Log of Corehole
Halfway Tree #2

Depth Range (Ft)	Thickness (Ft)	Description
0-13	13	Light brown silty sand and clay.
13-18	5	Coarse sand with slight clay.
18-22	4	Clay with silt and a little medium to fine grained sand.
22-32	10	Fine to coarse grained sand with some gravel and silty clay.
32-38	6	Clay with silt and fine grained sand.
38-54	16	Mostly fine to very coarse grained sand, clayey, with a little angular gravel (up to 0.375" in size).
54-70	16	Yellowish brown sticky clay, occasionally with some sand and gravel.
70-80	10	Fine to medium grained sand with clay lenses.
80-90	10	Mostly very fine to very coarse grained sand, clayey, with some angular gravel (up to 0.5" in size).
90-100	10	A above (gravel size up to 0.75").
100-103	3	Silty clay.

TABLE 3

ST. CATHERINE PLAINS

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

(CUMMULATIVE PERCENT RETAINED)

LOCATION: HALFWAY TREE # 2 COREHOLE

AREA: BERNARD LODGE EAST -PROJECT

SERIAL NO.	SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE OF SAMPLE (FT.)											
				44-46		48-50		52-54	82-84		88-90		98-100	
1	3/8"	0.375		1		2		3	4		5		6	
2	4	0.187												
3	10	0.078												
4	16	0.047		7.6		13.6		16.5	7.6		4.6		14.3	
5	30	0.023		31.5		45.1		53.5	35.0		21.6		42.7	
6	50	0.012		57.3		67.2		73.2	58.7		46.4		64.0	
7	80	0.007		77.8		80.9		82.5	74.4		68.3		76.9	
8	100	0.006		84.8		85.1		85.9	79.4		75.7		81.4	
9	200	0.003		94.8		93.8		92.7	89.0		88.0		91.3	

CUMULATIVE PERCENT RETAINED

(Analysed by Jamaica Engineering and Technical Services Ltd., Kingston)

TABLE 4

St. Catherine Plains

1

Step-Drawdown Test Data

Location: Halfway Tree #2 Area: Bernard Lodge East

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 24.45 ft.below m.p. which is 3 ft. above g.l.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
1.12.85	0900	TEST STARTED - STEP I					
		2	40.75	16.3	11"	330	Water clear
		3	41.66	17.21			
		4	42.50	18.05			
		5	42.83	18.38			
		6	43.42	18.97			
		7	44.00	19.55			
		8	44.29	19.84			
		9	44.58	20.13			
		10	44.79	20.34			
		12	45.12	20.67			
		14	45.42	20.97			
		16	45.62	21.17			
		18	45.79	21.34			
		20	46.04	21.59			
		22	46.25	21.80			
		24	46.29	21.84			
		26	46.33	21.88			
		28	46.42	21.97			
		30	46.54	22.09			
		32	46.50	22.05			

St. Catherine Plains 2

Step-Drawdown Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
		35	46.71	22.26			
		40	46.92	22.47			
		45	46.96	22.51			
		50	47.00	22.55			
		55	47.12	22.67			
	1000	60	47.12	22.67			
		65	47.17	22.72			
		70	47.08	22.63			
		75	47.16	22.71			
		80	47.12	22.67			
		85	47.12	22.67			
	1029	89	47.12	22.67			
	1030	STEP II			17½"	420	Water clear
	1031	1	52.08	27.63			
		2	53.16	28.71			
		3	53.33	28.88			
		4	53.50	29.05			
		5	53.58	29.13			
		6	53.66	29.21			
		7	53.75	29.30			
		9	53.79	29.34			
		10	53.83	29.38			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
		12	53.87	29.42			
		14	54.00	29.55			
		16	54.00	29.55			
		18	54.12	29.67			
		20	54.12	29.67			
		22	54.20	29.75			
		25	54.16	29.71			
		27	54.29	29.84			
		30	54.29	29.84			
		35	54.29	29.84			
		40	54.37	29.92			
		45	54.37	29.92			
		50	54.37	29.92			
		55	54.50	30.05			
	1130	60	54.54	30.09			
		65	54.54	30.09			
		70	54.54	30.09			
		75	54.58	30.13			
		80	54.54	30.09			
		85	54.58	30.13			
		89	54.58	30.13			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
1.12.85	1200	STEP III			25½"	500	
		1	60.29	35.84			
		4	61.04	36.59			
		6	58.0	33.55			
		7	57.04	32.59			
		8	58.66	34.21			
		9	58.25	33.80			
		10	61.41	36.96			
		13	61.54	37.09			
		15	61.58	37.13			
		18	61.83	37.38			
	1225	25	61.75	37.30			
	1230	30	61.75	37.30			
		35	61.83	37.38			
		40	62.00	37.55			
		45	62.08	37.63			
		50	62.04	37.59			
	1300	60	62.25	37.80			
		64	62.16	37.71			
		70	62.16	37.71			
		75	62.41	37.96			
		80	62.16	37.71			
		85	62.16	37.71			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
		89	62.12	37.67			
	1330		STEP IV		36	584	
		17	68.08	43.63			
		20	70.00	45.55			
		24	71.50	47.05			
		27	71.50	47.05			
		30	71.41	46.96			
		35	71.50	47.05			
		40	71.66	47.21			
		45	71.66	47.21			
		50	71.75	47.30			
		55	71.83	47.38			
		60	72.00	47.55			
		65	72.00	47.55			
		70	71.92	47.47			
		75	72.16	47.71			
		80	72.08	47.63			
		85	72.16	47.71			
	1459	89	72.16	47.71			
	Test over at 1500 hours.						

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
		RECOVERY DATA					
	1501	Time since pumping stopped	Depth of Water	Residual/ DD			
		1	37.16	12.71			
		2	32.04	7.59			
		3	30.92	6.47			
		4	30.00	5.55			
		5	29.41	4.96			
		6	28.92	4.47			
		7	28.50	4.05			
		8	28.25	3.80			
		9	28.00	3.55			
		10	27.75	3.30			
		11	27.50	3.05			
		12	27.25	2.80			
		15	26.92	2.47			
		20	26.33	1.88			
		25	25.92	1.47			
		30	25.66	1.21			

TABLE 5

ST. CATHERINE PLAINS

Halfway Tree #2 Well

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

Step No.	Discharge (Q) USgpm	Discharge (Q) m 3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (US gm/ft)
1	330	1.25	22.67	6.91	5.52	5.57	1.32	6.89	80	14.36
2	420	1.59	30.13	9.18	5.77	7.09	2.14	9.23	77	13.94
3	500	1.89	37.67	11.48	6.07	8.43	3.03	11.46	73	13.27
4	584	2.21	47.71	14.54	6.58	9.85	4.15	14.00	70	12.24

From the Graph (Figure 4)

Formation loss coefficient B = 4.46
Well loss coefficient C = 0.85

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

TABLE 6

St. Catherine Plains 1

Pumping Test Data

Location: Halfway Tree #2 Area: St. Catherine

Diameter- Discharge Pipe 8 in. Orfice 5 inches

Static Water Level 25.42 ft. (Tip of measuring tube which is 3 ft. above gl.)

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRA (	METER ING HES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
2-12-85	1200	Pump Started			16"	402	
		1	45.50	20.08			
"		2	48.25	22.83			
		3	49.83	24.41			
		4	50.42	25.00			
		5	50.62	25.20			
		6	51.00	25.58			
		7	51.50	26.08			
		8	51.75	26.33			
		9	51.83	26.41			
		10	52.08	26.66			
		12	52.20	26.78			
		20	53.50	28.08			
		24	53.42	28.00			
		26	53.33	27.91			
		28	53.56	28.14			
	1230	30	53.58	28.16			
		35	53.58	28.16			
		40	53.83	28.41			
		45	53.92	28.50			
		50	54.00	28.58			

St. Catherine Plains

Pumping Test Data (Continued)

Location: Half Way Tree #2

1	2	3	4	5	6	7	8
		55	54.16	28.74			
		64	53.96	28.54			
		68	54.16	28.42			
		70	54.25	28.83			
	1315	75	54.37	28.95			
	1320	80	54.56	29.14			
	1330	90	54.29	28.87			
		110	54.26	28.84			
		120	54.56	29.14			
		130	54.66	29.24			
		145	54.66	29.24			
		175	54.92	29.50			
		205	54.83	29.41			
		235	54.71	29.29			
		270	54.92	29.50			
	1700	300	55.00	29.58			
		360	54.66	29.54			
		420	54.66	29.54			
		540	54.92	29.50			
		660	54.92	29.50			
3-12-85	0100	780	54.92	29.50			
		900	54.92	29.50			
		1020	54.92	29.50			

St. Catherine Plains

Pumping Test Data (Continued)

Location: Halfway Tree #2

1	2	3	4	5	6	7	8
		1140	55.00	29.58			
	0800	1200	54.83	29.41			
	0855	1255	54.75	29.33			
		Test over at 0900 hrs.					

Pumping Test Data (Continued)

Location: Halfway Tree #2 **Recovery Data:**

DATE	TIME (HOUR)	TIME SINCE PUMPING STARTED - t (MINUTES)	TIME SINCE PUMPING STOPPED - t' (MINUTES)	DEPTH TO WATER (FT.)	RESIDUAL DRAWDOWN (FT.)	t/t'
		RECOVERY DATA				
3.12.85	0901	1261	1	32.25	6.83	1261
		1262	2	30.33	4.91	631
		1263	3	29.64	4.22	421
		1264	4	29.16	3.74	316
		1265	5	28.83	3.41	253
		1266	6	28.50	3.08	211
		1267	7	28.25	2.83	181
		1268	8	28.00	2.58	158
		1269	9	27.83	2.41	141
		1270	10	27.66	2.24	127
		1275	15	27.08	1.66	85
		1280	20	26.70	1.28	64
		1285	25	26.50	1.08	51.4
		1290	30	26.25	0.83	43
		1295	35	26.00	0.58	37
		1300	40	26.00	0.58	32.5
		1311	51	25.92	0.50	25.7
		1320	60	25.66	0.24	22
	1300	1500	240	25.42	0	

TABLE 7

St. Catherine Plains

Chemical Analysss of Water Samples

Location: Half Way Tree #2

Area: Bernard Lodge - Project 'A'

SL NO.	DATE	pH	@ Sp. Conduc-tance	TDS	Ca	Mg	Na	K	Fe	Cl	SO_4	B	F	PO_4	NO_3	* Alkalinity			* Total Hardness	SAR
										ppm						HCO_3	CO_3	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	1.12.85	8.7	645	377	76.2	19.84	26.0	1.0	-	17.12	-	-	-	-		212.6	62.53	275.13	273	0.7
2	3.12.85	8.7	626	373	74.2	21.0	26.0	1.0	-	16.64	-	-	-	-		187.6	100.06	287.66	273	0.7

@/μ/mhos/cm at 25°C * as $CaCo_3$

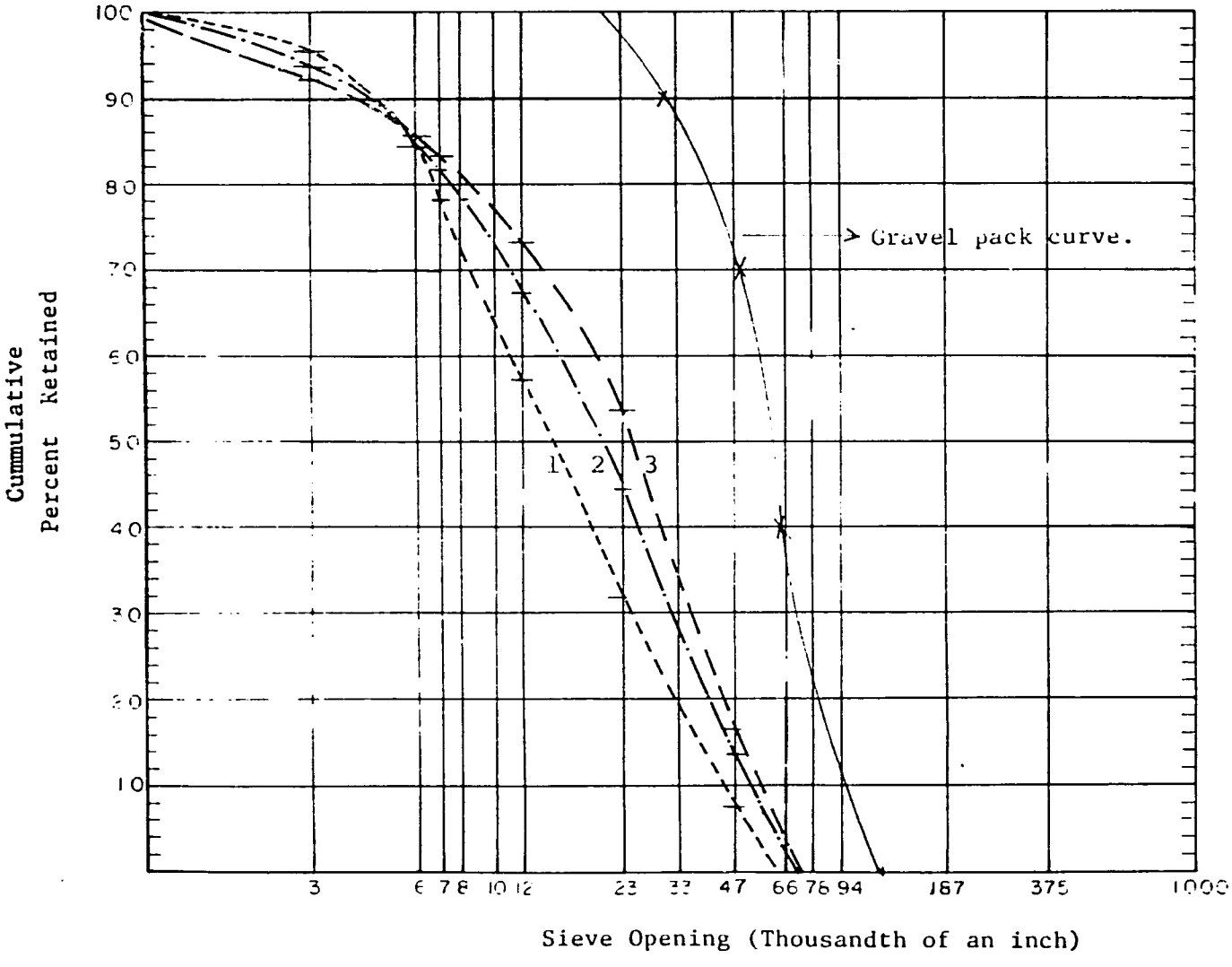
(Analysis by Jamaica Bauxite Institute, Kingston)

Fig. 1

SIEVE ANALYSES CURVES

Location: Half Way Tree #2 Corehole

Depth Range: (ft.)
1) 44-46 (2) 48-50 (3) 52-54 (Upper Aquifer)



1. Finest sample is #1
2. 70% retention size of the sample = 0.008"
3. 70% retention size of the gravel pack material 0.008" x 6 = 0.048"
4. Slot size of the screen = 0.030" (90% retention size of the gravel pack material)
5. Uniformity coefficient of the sample = 4.7

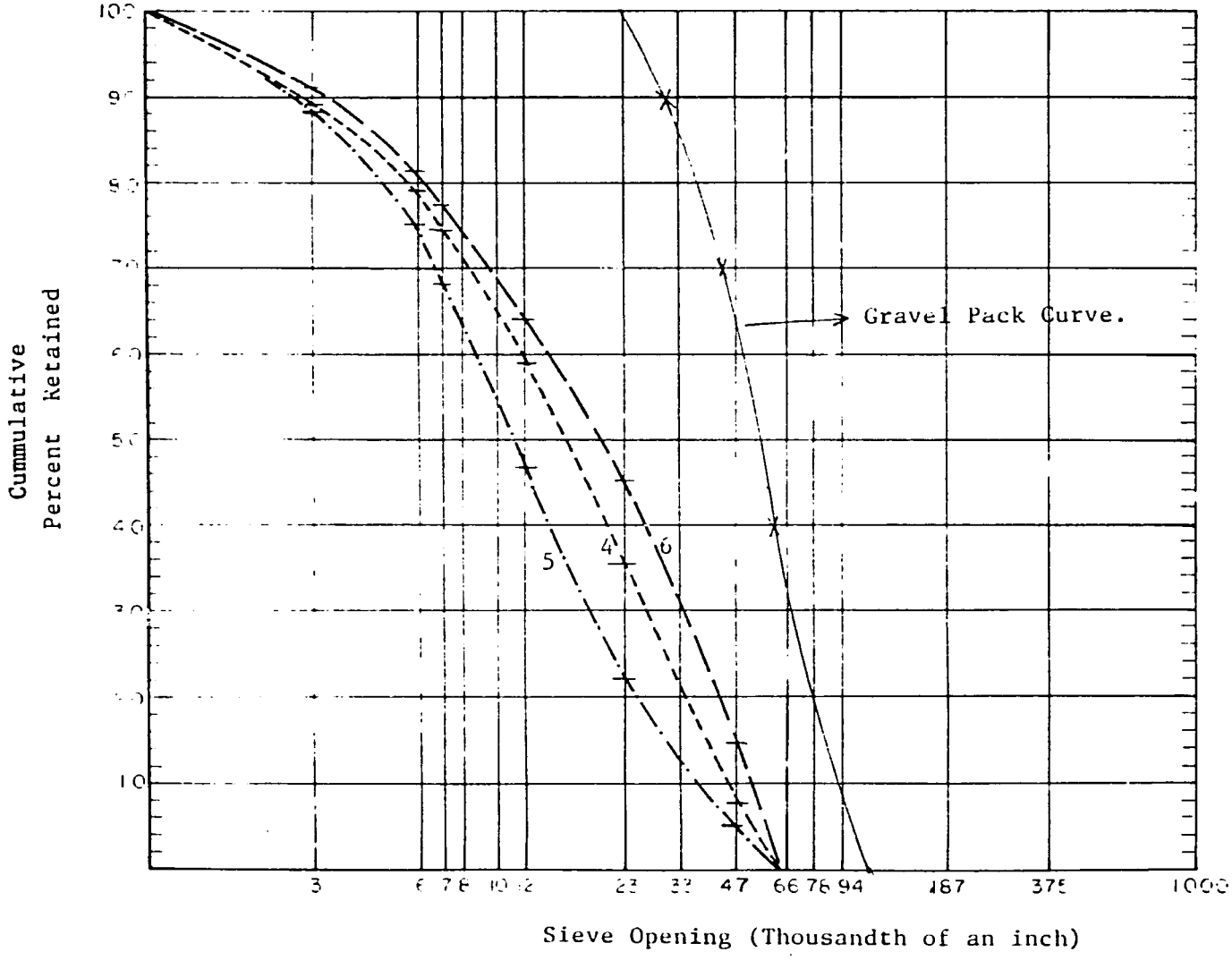
Fig. 2

SIEVE ANALYSES CURVES

Location: Half Way Tree #2 Corehole

Depth Range: (ft.)

4) 82-84 (5) 88-90 (6) 98-100 (Lower Aquifer)



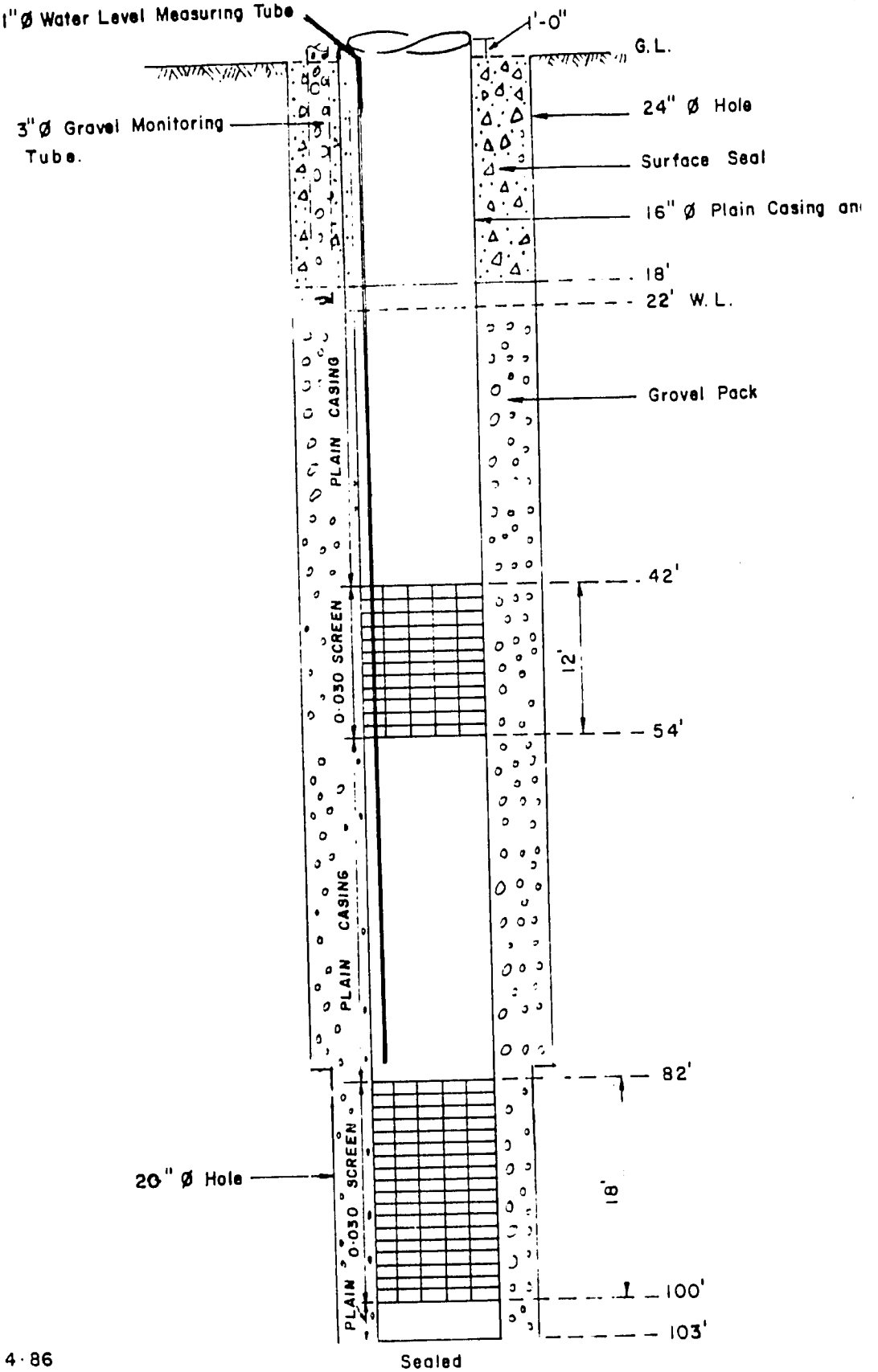
1. Finest sample is #5
2. 70% retention size of the sample = 0.007"
3. 70% retention size of the gravel pack material 0.007" x 6 = 0.042"
4. Slot size of the screen = 0.030" (90% retention size of the gravel pack material)
4. Uniformity coefficient of the sample = 7

ST CATHERINE PLAINS.

Fig. 3

Bernard Lodge Area Project 'A'

Well Design – Half Way Tree # 2



DATE : 10·4·86

DRAWING NO. A-120

BY: D. RAMANAMURTY

VERTICAL SCALE

0·8" = 10 Feet

Fig . 4

St. Catherine Plains

Half Way Tree #2 Well

Step - Drawdown Test Data Plot

Determination of 'B' and 'C'

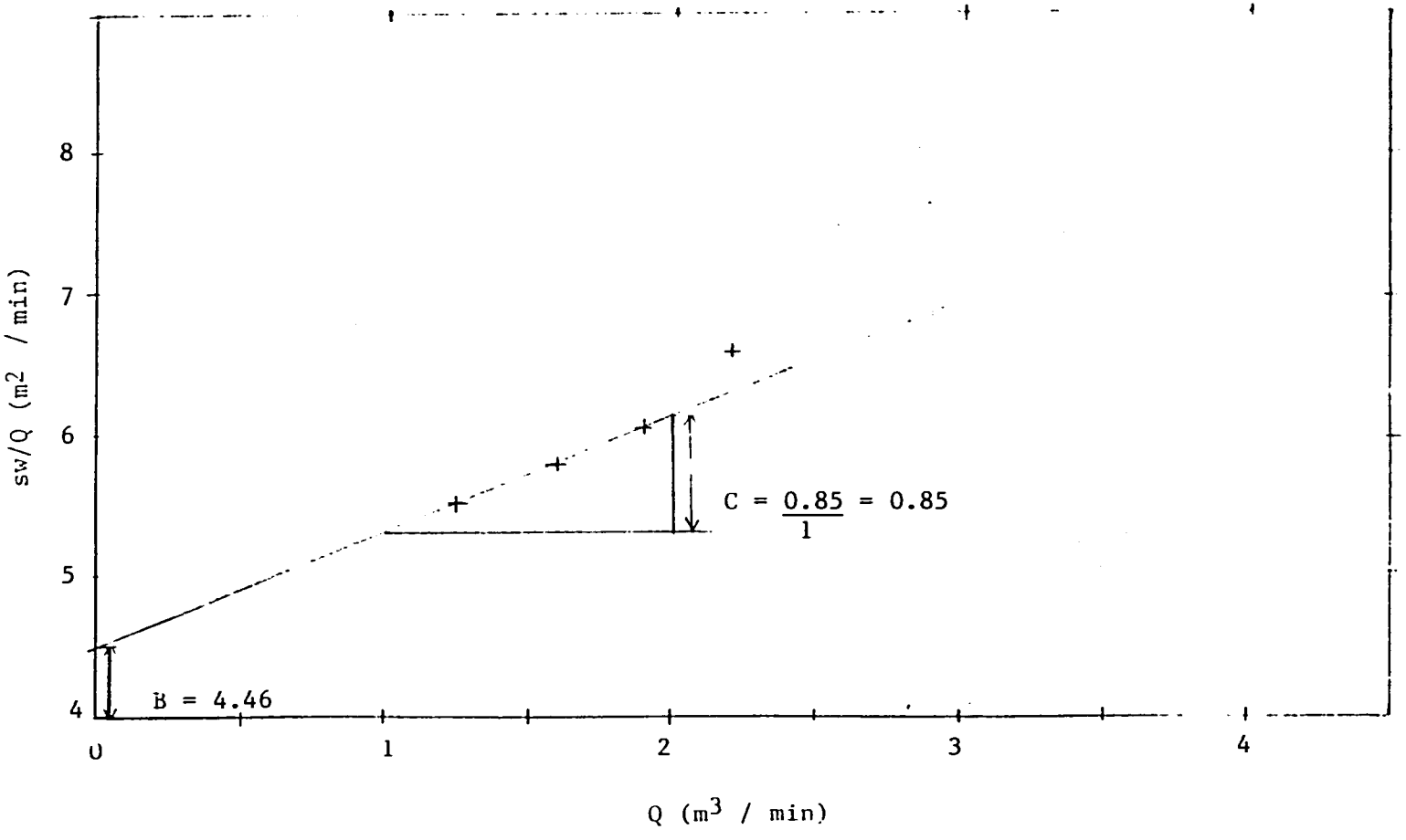
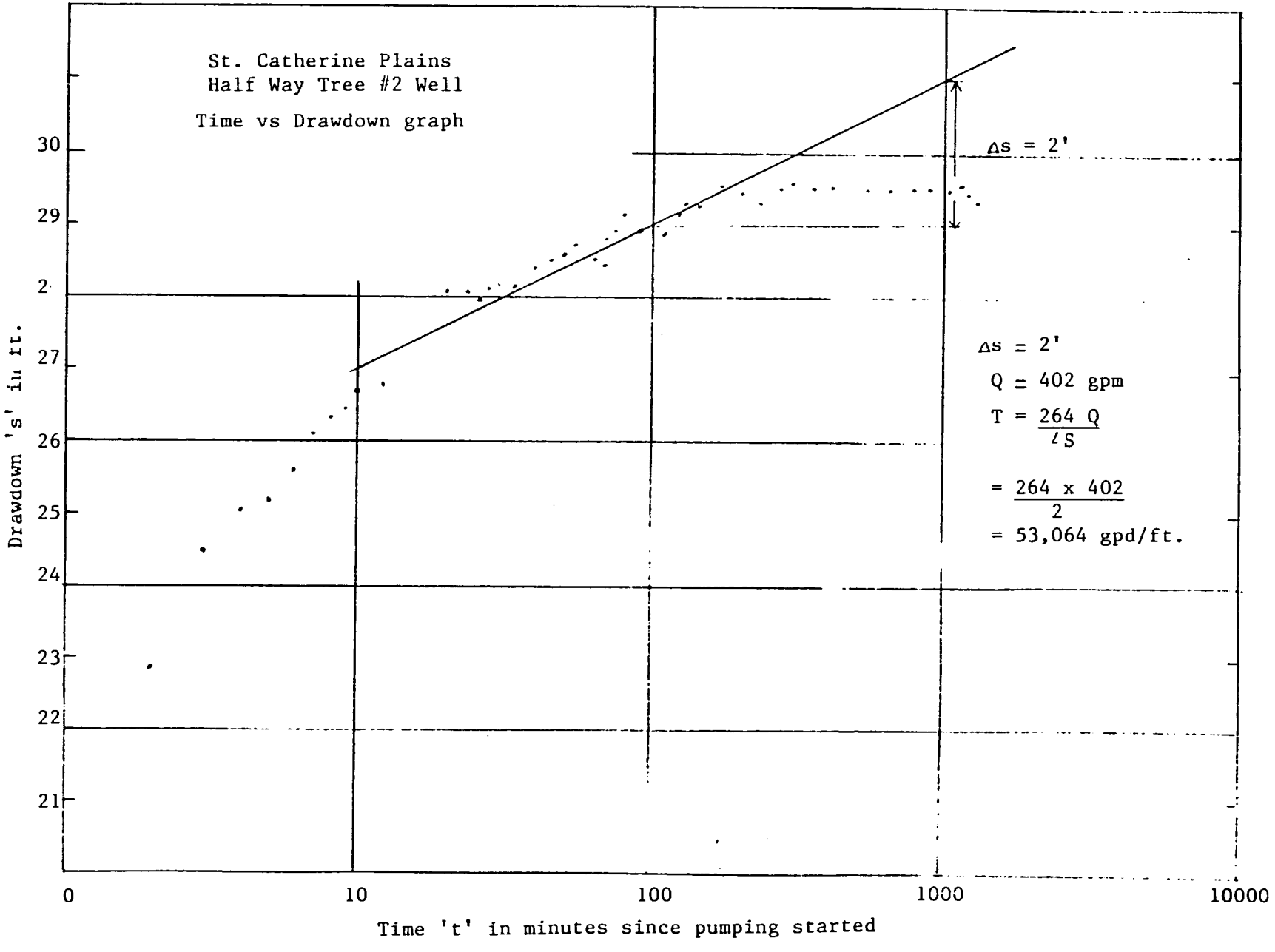
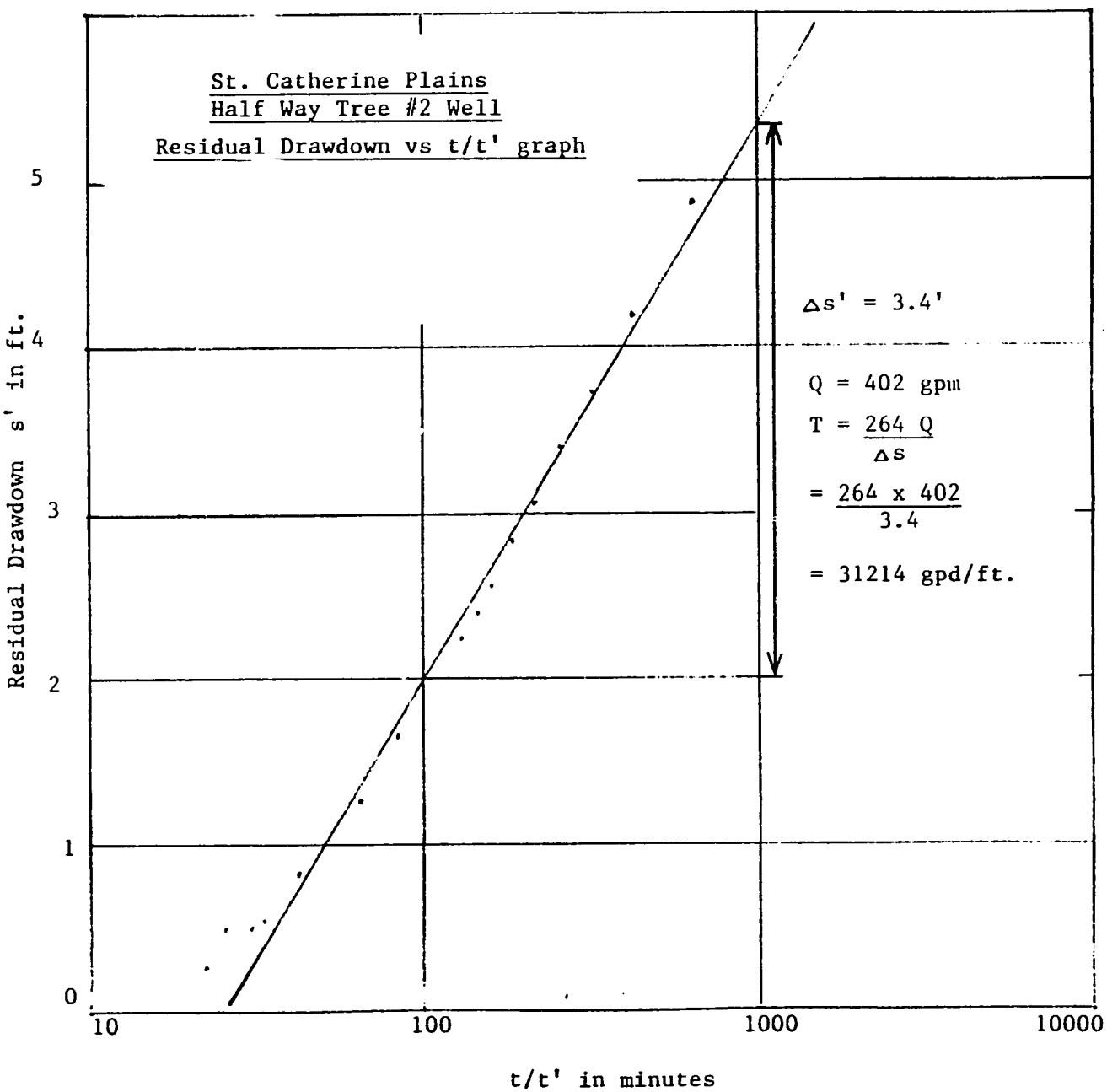


Fig. 5


St. Catherine Plains
Half Way Tree #2 Well
Time vs Drawdown graph
Δs = 2'
Δs = 2'
Q = 402 gpm
T = 264 Q / Δs
= 264 x 402 / 2
= 53,064 gpd/ft.
Drawdown 's' in ft.
30
29
2
27
26
25
24
23
22
21
0
10
100
1000
10000
Time 't' in minutes since pumping started


St. Catherine Plains
Half Way Tree #2 Well
Residual Drawdown vs t/t' graph
Residual Drawdown s' in ft.
0
1
2
3
4
5
10
100
1000
10000
t/t' in minutes
Δs' = 3.4'
Q = 402 gpm
T = 264 Q / Δs
= 264 x 402 / 3.4
= 31214 gpd/ft.

ST. CATHERINE PLAINS
BERNARD LODGE EAST AREA
PERFORMANCE OF HALF WAY TREE #6 WELL (OLD WELL)

A copy of the well record obtained from the Underground Water Authority (formerly Water Resources Division) is enclosed. It is seen from the well record that the well was constructed by Hood Daniel Well Company, Mandeville and that the well is 100 ft deep. No other construction details are known. It is seen on the site that the diameter of the well casing is 20 inches and that the casing is perforated right from the top, the diameter of the perforations being 0.5 inch. Historical abstraction date shows that the average yield from the well was 700 US gpm. The well used to pump some sand and was not in regular use for sometime. When the Agro-21 Corporation Limited took up the task of rehabilitating old wells in the area, there was no pump and motor on the well.

The well was cleaned and tested for the yield in July 1985. The cleaning and testing operations were carried out by Hood Daniel Well Company, Spur Tree, Manchester. A percussion rig was used to conduct these operations. The well was tested with a turbine pump on July 9, 1985 for 6 hours. The static water level was 16.83 ft below the top of the easing and pumping water level was around 55 ft for a discharge of 350 US gpm. The well discharge was accompanied by a little sand.

Reconstructing the well by installing a smaller diameter well assembly consisting of well screens and plain casing in the existing 20" diameter well and gravel packing the annular space with fine gravel would reduce the sand content in well discharge but the yield also would correspondingly decrease. It was therefore decided to use the well in the same condition.

WATER RESOURCES DIVISION — WELL RECORD

LOCATION: Half-Way-Tree 6		WELL NUMBER: E5821 N3890
PARISH: St. Catherine	GRID REFERENCE: E58210 N3890	
OWNER: F.M.L.C.	ADDRESS: Spanish Town	
DRILLER: Hood-Daniel Well Co.	ADDRESS: Mandeville	DATE OF COMPLETION:

HOLE SIZE	TYPE OF RIG USED	DEPTH OF WELL	ELEVATION OF SITE A.S.L.
INCHES TO FEET	Percussion	100 FEET	FEET
INCHES TO FEET	WATER STRUCK AT FEET	PRINCIPAL AQUIFER	REST WATER LEVEL ON COMPLETION FEET
INCHES TO FEET			

CASING

TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO	FEET	
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO	FEET	
TYPE	DIAMETER INCHES	LENGTH	FEET FROM	FEET TO	FEET	

ORIGIN OF DATA	COMPILED BY	CHECKED BY

REMARKS

Pumping for overhead irrigation purposes

Sept. 1985

Well back filled - sand cleaned down to 100 ft. with compressor. Tested with turbine pump. - Yielded 350 USgpm with a 39ft drawdown.

Installed capacity - 200 IGPM.(240US GPM) with a pwl of 35 ft. - 1985 Sept.

swl - 12.86 ft 1/10/86

TEST PUMPING Sept. 85 DATE

U.S.G.P.M.	WATER LEVEL	DRAWDOWN
0	19	-
350	58	39

SKETCH PLAN OF LOCATION

SITED IN FIELD BY DATE

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Well Half-Way-Tree #2

Contents

Figures

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Well
Half Way Tree #2

1. Corehole Drilling

The old well Half Way Tree #2 was a dug well which used to yield about 730 gpm in the initial stages of construction. However it is reported that the yield progressively declined and the well was ultimately abandoned due to poor yield coupled with sand pumping. Some particulars of the well as obtained from the records of Underground Water Authority (formerly Water Resources Division) are given in Table-1.

As a first step towards the construction of a replacement tube well, a corehole of 2" diameter was drilled down to a depth of 100 ft. at a location about 200 ft. to the west of the dug well in order to identify the depths at which aquifer zones occur and to obtain the aquifer material samples for conducting sieve analyses and working out well design. The corehole drilling was done by Caribbean Boring and Diamond Drilling Limited, 1 Hillview Avenue, Kingston 10, with a Boyles-37 Rotary Rig from July 2-5, 1985. Core samples were obtained at every 2 ft. interval during the drilling operations by split-spoon sampling technique.

2. Sieve Analysis of Aquifer Samples

The lithological log of the corehole is given in Table-2. Two aquifer zones were identified one between 38 ft. and 54 ft. and the other between 80 ft. and 100 ft. Sieve analyses results of three aquifer samples from each of the two zones are given in Table-3.

3. Well Design

The sieve analyses curves of the samples from the upper and lower aquifers are shown in Fig. 1 and Fig. 2 respectively. It is seen from the curves that the particle size distribution in the upper and lower aquifers is more of less the same. Six times the 70% retention size of the finest aquifer sample (0.008" for the upper aquifer and 0.007" for the lower aquifer) was taken as the 70% retention size of the gravel pack material. With this point as origin a curve was developed with a uniformity coefficient of nearly 2 to represent the composition of the gravel pack material and 90% retention size of the gravel pack material (0.030") was taken as the slot size of the well screen.

The gravel pack curves are also shown in Fig. 1 and Fig. 2 and the composition of the gravel pack material (both for the upper and lower aquifers) is given below:

Size of the material	Percentage
0.023" - 0.047"	30
0.047" - 0.094"	60
0.094" - 0.125"	10

The well assembly consisted of 74 ft. of 16" dia. (0.375" thick) plain casing and 30 ft. of 16" dia. 304 stainless steel 'v'-shaped, non-clogging type well screens of slot size 0.030" (manufactured by Johnson Division, U.S.A.). The bottom of the assembly was sealed with a steel plate (0.375" thick).

The well design is shown in Fig. 3. It was worked out to tap the maximum thickness of aquifer zones. The top of the screens was set below the anticipated pumping water level.

4. Well Construction

The well was constructed by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10, using a cable tool rig. Drilling of 24" dia. hole was started on September 20, 1985, and progressed down to 60 ft. by October 4, when the drilling operations had to be stopped as the rig got tilted and the mast was damaged. After repairs to the rig, the drilling operations were resumed on October 15 and the hole was drilled down to the targeted depth of 103 ft. by October 26. However, as the temporary well construction casing of 24" dia. did not move down freely, the diameter of the hole was reduced to 20" below 81 ft. Heaving conditions were encountered around 54 ft. and 81 ft. and 'supercol' was used to stop these conditions.

Between October 28, and November 4, the well assembly was lowered and the temporary construction casing was pulled out. Gravel packing of the well was done in stages while the construction casing was being pulled out. 20 feet of the casing (from 1 ft. above g.l. to 19 feet below g.l.) was kept in the well to prevent collapse of the well during development and testing operations which were also done by Jamaica Wells and Services Ltd.

5. Well Development

Development of the well was started on November 5, and completed on November 27. The work commenced with surging and bailing operations which were done for 13 hrs. This was followed by development with compressed air using a 150 psi-160 cfm air compressor for 8 hrs. At this stage the well discharge was turbid and the yield was around 200 gpm.

Surging and bailing operations were repeated for 8 hrs. followed by development with compressed air for 11 hrs. (3 hrs. with small compressor and 8 hrs. with large compressor) by surging and bailing for 32 hrs. and again with compressed air (large compressor) for 24 hrs. The yield at this stage was 400 gpm for a pumping water level of 43 ft.

The well was then developed with a turbine pump for 4 hrs. after which the yield was 500 gpm for a pumping water level of 60 ft. 4 bags of 100 lbs. each of hexametaphosphate were used at different times during the development to disperse the clay fractions.

6. Step-Drawdown Test

A step-drawdown test was conducted on December 1, 1985, with steps of 330, 420, 500 and 584 gpm the duration of every step being 90 mts. The test data is given in Table-4 and the data plot as Fig. 4. Calculations of formation loss, well loss and well efficiency are shown in Table-5. The calculated and observed draw-downs compare well for the first three steps. However the results for the fourth step deviated from the general trend, perhaps due to the reason that the discharge was too high for well to yield. The well loss coefficient of 0.85 min^2/m^5 indicates a mild clogging of the well which can be expected to be cleared in course of time. The well efficiency varies from 80%-73% for the first three steps.

7. Time-Drawdown Test

A time-drawdown test was conducted on December 2-3, for a period of 21 hrs. at the rate of 402 gpm and the test data is shown in Table-6. The static water level was 25.42 ft. below the measuring point which was 3 ft. above the ground level. The pumping water level stabilized at 54.92 ft. after 9 hrs. of pumping resulting in a drawdown of 29.50 ft. The specific capacity worked out to 13.6 gpm/ft.

The time drawdown graph is shown as Fig. 5 and the recovery graph as Fig. 6. The transmissivity of the aquifer works out to 53064 gpd/ft. by drawdown method and 31214 gpd/ft. by recovery method.

8. Quality of Water

Chemical analyses results of two water samples one collected on December 1, during the step-drawdown test and the other collected on December 3, at the end of the time drawdown test are given in Table-7.

9. Rate of Abstraction

The well was tested at 402 gpm and the pumping water level stabilized around 52 ft below the ground level. Pumping tests conducted on old wells Half Way Tree #5 and Cookson 3 showed that the wells yielded about 950 gpm for pumping water levels of 38 to 40 ft below ground level. As Half Way Tree #2 well was constructed with well screens of 0.030" slot size and fine gravel, the pumping water levels are deeper than in old wells which were constructed with perforated pipe and coarse gravel. The performance of the well subsequent to its testing has indicated that the pumping water levels are around 42 to 47 ft (b.g.l.) for a discharge of 500 gpm. The rate of pumping shall be limited to 500 gpm, though the licensed abstraction is 600 gpm and the performance of the well shall be watched.

10. Grouting of the Well

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" dia. and the well assembly was maintained around 17 ft. below ground level. After the long duration pumping test was over, the temporary casing was pulled out and a 3' dia. pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor any sinking of gravel in course of time. The annular space was then grouted with cement concrete.

(Note: The measure used in the report is US gallons)

St. Catherine Plains

Bernard Lodge East Area
Report on the construction of Wells
Newlands #2 and Newlands #2A

CONTENTS

St. Catherine Plains

Bernard Lodge East Area
Report on the construction of Wells
Newlands #2 and Newlands #2A

I. NEWLANDS #2

1. Corehole Drilling

A corehole of 2" diameter was drilled between July 23 and 27, 1985 down to a depth of 110 ft. by Caribbean Boring and Diamond Drilling Limited, Kingston, with a Boyles-37 Rotary Rig. Core samples were obtained at every 2 ft. interval by split spoon sampling method. The lithological log of the corehole is given in Table-1.

2. Sieve Analyses of Aquifer Samples

The lithological log showed that two aquifer zones occur one between 24 ft. and 38 ft. and the other between 90 ft. and 106 ft. separated by a thick clay zone. Sieve analyses results of four aquifer samples from depth ranges 34 ft.-36 ft., 92 ft.-94 ft., 96 ft.-98 ft. and 102 ft.-104 ft are given in Table 2 and the sieve analyses curves are shown in Fig. 1.

3. Well Design

The slot size of the well screens and the specifications of the gravel pack material to be used in the construction of the well were worked out using the sieve analyses data of the aquifer samples.

Five times the 70% retention size of the finest aquifer material (sample #3) was considered as the 70% retention size of the gravel pack material. With this point as origin a curve was drawn with a uniformity co-efficient of nearly 2 to represent the composition of the gravel pack material. 90% retention size of the gravel pack material (0.050 inch) was considered as the slot size of the well screen. Specifications of the gravel pack material are given below:

0.047" - 0.094" - 50%
0.094" - 0.250" - 50%

The well assembly consisted of 78 ft. of 16" dia., 0.375" thick plain casing and 32 ft. of 304-stainless steel v-shaped, non-clogging type, 16" dia. well screens of slot size 0.050". (manufactured by Johnson Division, U.S.A.). The bottom of the assembly was sealed with a steel plate. The gravel pack consisted of rounded to sub-rounded hard material like quartz, granite, etc. with a little limestone. Gravel of size 0.094"-0.250" was only used.

The well design is shown in Fig. 2. The top of the screens was set at the anticipated pumping water level.

4. Well Construction

The well was constructed and developed by Hood Daniel Well Co.Limited, Spur Tree P.O., Manchester, using a Cable Tool Rig. Drilling of a 24" diameter hole was started on October 16, 1985 and completed on November 15, 1985. The well assembly was lowered on November 21. The well was gravel packed with 14 cft. of gravel on November 22. Lifting of the temporary well casing was started on November 26. The casing moved up slowly and by December 13, the bottom of the casing was near about 84 ft below the land surface. However, during these operations the land surface around the well collapsed on December 4 and 12 cu. yds. of rubble was used to fill in the cavity. Subsequently the caving of the land surface occurred from time to time during the lifting operations and a total of about 30 cu. yds. of rubble was used to keep the land surface at level. As there was a collapse of land surface around the well and as the casing did not move during the last few days of the lifting up operations a crane was used on December 18, to pull out the casing. However the casing broke in a joint above the ground level. Two pieces of reinforcement railings were welded to the casing and the crane was used again on December 28, to pull out the casing. This time the casing gave way inside the well. 28.5 ft. of the casing got stuck up in the well. The lower end of the casing was at 82 ft. below ground level. Subsequently 14 ft. 4 in. of the temporary casing was lowered again into the well to prevent the collapse of the top formation. Gravel packing of the well was then completed and development work started.

5. Well Development

Development of the well was started on January 7, 1986, and stopped on February 27. The well was developed by surging with a surge block and bailing for 100 hrs. with compressed air for 77 hrs. and with a turbine pump for 20 hrs. 400 pounds of sodium hexa-metaphosphate was used during the development operations to disperse the clay fractions. In spite of protracted development the well yielded only 30 gpm for a pumping water level of 41 ft. The water level was 14 ft. resulting in a drawdown of 27 ft. Lowering the pumping water level to 92 ft. did not increase the yield.

The well was therefore abandoned.

II. NEWLANDS #2A

Another well Newlands #2A was constructed at a location 36 ft. to the north of the abandoned well, during February-April 1987.

1. Well Design

The sieve analyses results of the same corehole Newlands #2 were used in designing this well.

As the wells constructed in the area with designs worked out on the basis of six times the 70% retention size of the finest aquifer material yielded almost sand free water, the design for Newlands #2A well was worked out on the basis of eight times the 70% retention size of the finest sample. However the lengths of the screens were reduced (by 6 ft. in the upper aquifer and 4 ft. in the lower aquifer). The lengths now used can transmit about 1840 gpm at the optimum entrance velocity.

The gravel pack curve is shown in Fig. 1. The slot size of the screens worked out to 0.100". Specifications of the gravel pack material are given below:

0.080" - 0.250" - 70%
0.250" - 0.375" - 30%

The well assembly consisted of 90 ft. of 14" dia., 0.375" thick plain casing and 22 ft. of 304 stainless steel, v-shaped non-clogging type, 14" dia. well screens of 0.100" slot size. The assembly was sealed at the bottom with a steel plate.

The gravel used was of the above mentioned specifications.

The well design is shown in Fig. 3.

2. Well Construction

The well was constructed, developed and tested, by Underground Water Authority, Kingston, using a Davey - 1500 direct rotary rig.

The drilling operations were started on February 20, 1987. A 24" diameter hole was drilled down to 20 ft. and the construction casing of 24" diameter was lowered down to 19 ft. below ground level on the same day.

Drilling of a 22" diameter hole down to 110 ft. was completed by February 25. The well assembly was lowered on February 26 and gravel packing was done on February 27.

3. Well Development

The well was developed from March 3-6, with compressed air using a 4" diameter eductor pipe and 1 1/4" diameter air pipe. The development was mainly to back wash the well and clear it of drilling mud. The well was further developed between March 9 and April 8, by surging and bailing (40 hrs.) with compressed air using an 8" diameter eductor pipe and a 1 1/4" diameter air pipe (46 hrs.) and with a turbine pump (50 hrs). 400 pounds of sodium hexa-metaphosphate was used during the development operations to disperse the clay fractions.

4. Step-Drawdown Test

A step-drawdown test was conducted on April 8, but as the water marker wire got stuck up in the well the test had to be discontinued.

Another test was conducted on April 14. It consisted of 4 steps of 2 hrs. duration each with discharge rates of 260, 370, 500 and 550 gpm. The test data is given in Table-3, analysis of the data in Table-4 and the data plot as Fig. 4. It is seen from Table-4 that the calculated and observed drawdowns compare well for the first two steps. The observed drawdown was very high for the next two steps. The well loss co-efficient of 1.4 indicates moderate clogging of the well.

5. Time-Drawdown Test

A time-drawdown test was conducted for 72 hrs. starting from 10 a.m. on April 21, at a discharge rate of 420 gpm. The Newlands #2 well was used as an observation well during the test.

The test data for the pumping well and the observation well is given in Table-5 and Table-6 respectively.

The drawdown in the pumping well at the end of the test was 28.22 ft. for a discharge of 400 gpm resulting in a specific capacity of 14.2 gpm/ft. The water level recovered to the original level within 70 minutes after the pumping was stopped.

A maximum drawdown of 3.30 ft. occurred in the observation well after 5.5 hrs. of pumping. The water level started rising after 7.5 hrs. of pumping and at the end of the test the drawdown was 2.40 ft. The rising of water level in the observation well, while the water level in the pumping well was declining could be due to turbulent flow around the well.

The time (t) vs drawdown (s) graph and the t/t' vs residual drawdown (s') graph are shown in Fig. 5 and Fig. 6 respectively. Due to slight variations in discharge the t vs s graph did not form a straight line. The discharge was fairly constant between 300 mts. and 1600 mts. Therefore that portion of the graph pertaining to this period was matched with the remaining part of the graph and the straight line so formed was considered for calculation of the transmissivity of the formation.

The transmissivity of the formation so calculated was 19,600 gpd/ft. By the recovery method, the transmissivity was 19,600 gpd/ft. The (s) vs t/r^2 graph drawn for the observation well is shown in Fig. 7. The transmissivity of the formation calculated by Theis' match curve method was 24,126 gpd/ft. and storage co-efficient worked out by the same method was 0.12. The time (t) vs drawdown (s) graph drawn for the observation well is shown in Fig. 8. The transmissivity and storage co-efficient calculated from this graph were 58666 gpd/ft. and 0.09 respectively (Jacob's Method).

6. Quality of Water

Chemical analysis results of one water sample collected from Newlands #2 well on February 27, 1986, and three water samples collected from Newlands #2A well on April 22, 23 and 24, 1987, during the time-drawdown test are given in Table-7.

7. Rate of Abstraction

Based on the results of the pumping test it is recommended that the abstraction from the well may be limited to 400 gpm and its further performance and any changes in the quality of water be observed.

8. Sand content in well water

A 'ROSSUM' sand content tester was fitted to the discharge pipe and the amount of sand accompanying the well discharge was estimated. The results of the test are given below:

Sl No	Time of the Test			Quantity of water flown through the tester (litres)	Sand collected in the tester (mg)	Sand Content in water (mg/l)
	From	To	No. of hrs.			
1	22.4.87 5:15 pm	23.4.87 10:45 am	17.5	1984	26.7	0.013
2	23.4.87 11 am	24.4.87 10 am	23	2608	37.4	0.014

The sand content in the well water is very low. The limit of sand content in water that can be used for sprinkler irrigation is 10 mg/l.

9. Grouting of the Well

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" dia. and the well assembly was maintained around 17 ft. below ground level. After the long duration pumping test was over, the temporary casing was pulled out and a 3" dia. pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor any sinking of gravel in course of time. The annular space was then grouted with cement concrete.

(The measure used in the report is US gallons)

St Catherine Plains

Bernard Lodge East Area

Lithological Log of Corehole

Newlands #2

Depth Range (ft)	Thickness (ft)	Description
0-4	4	Dark brown top soil
4-16	12	Fine, sandy, silty clay
16-38	22	Mostly fine to very coarse sand and gravel with a few fine sand layers.
38-40	2	Stiff brown and grey clay with a little gravel.
40-52	12	Silty clay with some fine sand.
52-88	36	Stiff brown clay with lenses of fine sand.
88-90	2	Sandy clay
90-106	16	Mostly fine to very coarse sand and gravel.
106-108	2	Gravel and sand (top 6 inches) and tight brown clay.

ST. CATHERINE PLAINS

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: NEWLANDS # 2 COREHOLE

AREA: BERNARD LODGE - PROJECT "A"

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE OF SAMPLE (FT.) 34-36 ft							92-94 ft			
			A	B	C					A	B	C	
1	3/8"	0.375	-	-	-								
2	4	0.187	14.0	14.0	10.4					7.1	7.1	5.5	
3	10	0.078	21.5	35.5	26.4					17.0	24.1	18.7	
4	16	0.047	16.5	52.0	38.7					15.4	39.5	30.7	
5	30	0.023	28.5	80.5	59.9					33.7	73.2	56.9	
6	50	0.012	24.5	105.0	78.1					27.2	100.4	78.0	
7	80	0.007	12.5	117.5	87.4					12.7	113.1	87.9	
8	100	0.006	3.7	121.2	90.1					6.6	119.7	93.0	
9	200	0.003	7.2	128.4	95.5					6.0	125.7	97.7	
10	PAN		6.1	134.5	100.0					3.0	128.7	100.0	

@ U.S.S. Sieve series

(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

A = Weight retained in grams

B = Cummulative weight retained in grams

C = Cummulative percent retained

ST. CATHERINE PLAINS

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: Newlands # 2 COREHOLE

AREA: BERNARD LODGE PROJECT "A".

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE OF SAMPLE (FT.) 96-98						102-104			
				A	B	C				A	B	C	
1	3/8"	0.375		2.9	2.9	1.8				10.0	10.0	6.7	
2	4	0.187		3.0	5.9	3.7				10.6	20.6	13.9	
3	10	0.078		19.8	25.7	16.0				23.2	43.8	29.5	
4	16	0.047		23.0	48.7	30.2				26.1	69.9	47.1	
5	30	0.023		40.2	88.9	55.2				35.7	105.6	71.2	
6	50	0.012		35.0	123.9	76.9				21.4	127.0	85.6	
7	80	0.007		13.5	137.4	85.3				8.8	135.8	91.6	
8	100	0.006		5.8	143.2	88.9				2.6	138.4	93.3	
9	200	0.003		9.3	152.5	94.7				5.6	144.0	97.1	
10	PAN			8.6	161.1	100.0				4.3	148.3	100.0	

@ U.S.S. Sieve series

(Analysed by Jamaica Engineering & Technical Services Ltd., Kingston)

St. Catherine Plains

Step-Drawdown Test Data

Location: Newlands #2A Area: Bernard Lodge, Project 'A'

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 13.70 ft. below m.p. which is 2 ft above g.l.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
14.4.87	0 830		Step Test Started				
			Step-1				Orfice Plate-4"
	8:30	0	13.70				
		1	21.10	7.4	22	279	
		2	21.70	8.0	23	285	
		3	23.10	9.4			
		4	23.40	9.7			
		5	23.65	9.95			
		6	23.75	10.05			
		7	23.75	10.05	20	266	
		8	23.75	10.05			
		9	23.75	10.05			
		10	23.75	10.05	19.5	263	
		12	23.85	10.15			
		14	23.85	10.15	19	260	
		16	23.98	10.28			
		18	23.98	10.28			
		20	23.98	10.28			
		25	24.08	10.38			
	9.00	30	24.20	10.50			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Newlands #2A

1	2	3	4	5	6	7	8
14.4.87		35	24.25	10.55			
		40	24.40	10.70			
		45	24.45	10.75			
		50	24.50	10.80	19		
		55	24.50	10.80	18.5	256	
		60	24.50	10.80			
		70	24.65	10.95	18.5		
		80	25.01	11.31	19.5		
		90	25.21	11.51	19.5		
		100	25.21	11.51			
	10:30	110	25.21	11.51			
	10:30	120	25.21	11.51	19	260	
			Step 2				
	10.31	1	29.51	15.81	15		
		2	-	-	12		
		3	-	-	13		
		4	29.66	15.96	14	376	
		5	29.76	16.06	14		
		6	29.86	16.16			
		7	29.96	16.26			
		8	30.06	16.36			
		9	30.11	16.41			
		10	30.11	16.41	15		

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Newlands 2A

1	2	3	4	5	6	7	8
14.4.87		12	30.76	17.06	14.5		
		14	30.96	17.26	14		
		16	31.04	17.34	14		
		18	31.14	17.44	14		
		20	31.24	17.54	14		
		25	31.44	17.74	14		
	11.00	30	-	-			
		35	31.50	17.80	14		
		40	31.87	18.17	14		
		45	31.92	18.22	14		
		50	31.97	18.27	14		
		55	32.07	18.37	14		
		60	32.17	18.47	14		
		70	32.42	18.72	14		
		80	32.62	18.92	14		
		90	32.72	19.02	14		
		100	32.77	19.07	14		
		110	32.77	19.07	14		
	12:30	120	32.82	19.12			
			Step 3				
	12:31	1	-	-	24	488	
		2	38.22	24.52			
		3	38.62	24.92	25	496	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Newlands 2A

1	2	3	4	5	6	7	8
14.4.87	12:31	4½	38.72	25.02	25		
		5	38.89	25.19	25		
		6	38.94	25.24	25		
		7	39.64	25.94	24		
		8	39.69	25.99	24		
		9	39.88	26.18	24		
		10	40.69	26.99	24		
		12	41.19	27.49	24		
		16	41.39	27.69	23.5		
		20	43.24	29.54	25		
		25	43.69	29.99	25.5	500	
	13:00	30	44.29	30.59	24.5	492	
		35	44.40	30.70	24.5		
		40	44.80	31.10	25		
		45	45.80	32.10			
		50	45.80	32.10			
		55	45.80	32.10			
		60	48.40	34.70			
		70	49.85	36.35			
		80	50.10	36.4			
	14:00	90	50.75	37.05			
		100	51.07	37.37			
		110	51.07	37.37	26	504	

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Newlands 2A

1	2	3	4	5	6	7	8
14.4.87	14:00	120	54.52	40.82			
			Step 4				
	14:31	1	60.72	47.02	31	544	
		2	-	-	34	568	
		2½	62.39	48.69			
		3	-	-			
		3½	62.94	49.24			
		4	62.94	49.24			
		5	62.94	49.24	32	552	
		6	62.94	49.24			
		7	62.94	49.24			
		8	63.59	49.89			
		9	63.59	49.89			
		10	64.47	50.77			
		12	64.74	51.04			
		14	64.74	51.04			
		16	64.98	51.28			
		18	65.41	51.71			
		20	65.76	52.06		544	
		25	66.11	52.41			
		30	69.12	55.42			
		35	70.22	56.52			
		40	70.86	57.16			

St. Catherine Plains

Step-Drawdown Test Data (Continued)

Location: Newlands 2A

1	2	3	4	5	6	7	8
14.4.87	14:31	45	69.40	55.7			
		50	71.31	57.61			
		55	-	-			
		60	69.60	55.9	32	552	
		70	70.55	56.85			
		80	70.68	56.98			
		90	71.00	57.30			
		100	70.65	56.95			
		105	-	-			
		110	71.10	57.40			
	16:30	120	71.10	57.40	32		
			Test over				

ST. CATHERINE PLAINS

Newlands #2A

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

Step No.	Discharge (Q) USgpm	Discharge (Q) m^3/min	Drawdown (SW) Ft.	Drawdown (SW) m	SW/Q (m^2/min)	Formation Loss (BQ)	Well Loss (CQ^2)	Calculated Drawdown ($BQ + CQ^2$)	Well Efficiency	Specific Capacity (USgpm/ft)
1	260	0.98	11.51	3.50	3.56	1.96	1.34	3.3	56.0	22.59
2	376	1.42	19.12	5.83	4.10	2.84	2.82	5.66	48.71	19.66
3	500	1.89	40.82	12.44	6.58	3.78	5.00	8.78	30.39	12.25
4	550	2.08	57.40	17.50	8.40	4.16	6.06	10.22	23.77	9.58

From the Graph (Figure 4)

Formation loss coefficient (B) = 2.0

Well loss coefficient (C) = 1.4

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

St. Catherine Plains

Pumping Test Data

Location: Newlands #2A Area: St. Catherine

Diameter- Discharge Pipe 8" Orfice 5"

Static Water Level 14.08 ft below m.p. which is 2 ft above g.l.

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED (MINUTES)	DEPTH TO WATER (FT)	DRAWDOWN (FT)	MONOMETER READING (INCHES)	DISCHARGE (US GPM)	REMARKS
1	2	3	4	5	6	7	8
21/4	10:00	0	14.08	14.12			
		1	28.20	14.12	24"	488	
		2	29.00	14.92			
		3	29.10	15.02	22"	470	
		5	29.30	15.22	19"	438	
		7	30.00	15.92	16"	402	
		8	30.20	16.12	16"		
		9	30.55	16.47	16"		
		12	31.40	17.32	15"	390	
		14	31.50	17.42	15"		
		15	-	-	15"		
		16	31.60	17.52	15"		
		18	31.65	17.57	16"		
		20	31.80	17.72	18"	426	
		30	33.80	19.72	18"		
		35	33.82	19.74	17.5"	420	
		40	34.00	19.92	17.5"		
		45	34.01	19.93	17.5"		
		50	34.06	19.98	16"		
		55	34.10	20.02	16"		
	11:00	60	34.15	20.07	15.5"	396	

St. Catherine Plains

Pumping Test Data (Continued)

Location: Newlands #2 A

1	2	3	4	5	6	7	8
21/4	11:00	70	34.37	20.29	15.5"		
		80	34.45	20.37	15.5"		
		90	34.82	20.74	15.5"		
		100	35.03	20.95	15.5"		
		110	35.08	21.00	15.5"		
		120	35.22	21.14	15.5"		
		140	35.38	21.30	15.5"		
		150	-	-			
		160	35.63	21.55	15.5"		
	13:00	180	36.88	22.80	17.5"		
		200	37.61	23.53	16.5"	408	
		210	-	-			
		220	37.78	23.70	16.5"		
		240	37.99	23.91	16.5"		
		270	38.13	24.05	16.5"		
		275	-	-			
	15:00	300	38.52	24.44	17.5"		
		330	38.84	24.76	17.5"		
		360	39.04	24.96	17.5"		
		390	39.28	25.20	17.5"		
		420	39.52	25.44	17.5"		
		450	39.92	25.84	17.5"		
	18:00	480	40.30	26.22			

St. Catherine Plains

Pumping Test Data (Continued)

Location: Newlands #2 A

1	2	3	4	5	6	7	8
	18:00	540	39.52	25.44	17.5"		
		600	39.92	25.84	17.5"		
	21.00	660	40.42	26.34	17.5"		
		720	40.32	26.24	17"		
		780	40.02	25.94	17"		
22/4	0000	840	40.02	25.94	17"		
		900	40.12	26.04	17"		
		1050	40.12	26.04	16.5"		
		1170	40.02	25.94	17"		
		1260	39.50	25.42	17"		
	9:00	1380	39.85	25.77	17"		
	11:00	1500	40.16	26.08	17"		
		1620	40.28	26.20	17"		
		1680	40.30	26.22			
		1800	40.48	26.40	16½"		
		1920	40.67	26.59			
		2040	41.07	26.99	17"		
		2160	40.67	26.59	17"		
23/4	0000	2280	40.67	26.59	16.5"		
		2400	40.30	26.22	16.5"		
		2520	40.48	26.40	16.5"		
		2640	40.67	26.59	17"		
		2700	40.30	26.22	16.5"		

St. Catherine Plains

Pumping Test Data (Continued)

Location: Newlands #2A

1	2	3	4	5	6	7	8
		2820	41.40	27.32	18"		
		2880	41.10	27.02	17"		
		2940	40.50	26.42	17"		
	1300	30 60	40.50	26.42	17.5"		
		3180	40.60	26.52			
		3300	40.80	26.72	17"		
		3480	40.94	26.86	17.5"		
		3660	41.09	27.01	17.5"		
24/4	0200	3840	41.23	27.15	17"		
		4020	41.43	27.35			
		4200	41.43	27.35	17.5"		
		4260	42.30	28.22			
		4320	42.30	28.22	17.5"		
	1000						
		Test Over at 10:00 hrs.					

Pumping Test Data (Continued)

Location: Newlands #2A 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				
24.4.87	1002	4322	2	23.80	9.72	2161
		4323	3	23.05	8.97	1441
		4326.5	4.5	21.25	7.17	961
		4325.5	5.5	20.25	6.17	786
		4326.5	6.5	19.35	5.27	665
		4327.5	7.5	18.70	4.62	577
		4328	8	18.45	4.37	541
		4329	9	18.05	3.97	481
		4330	10	17.75	3.67	433
		4332	12	17.30	3.22	361
		4334	14	16.70	2.62	309
		4335	15	-	-	289
		4336	16	16.42	2.34	271
		4338	18	16.21	2.13	241
		4340	20	15.99	1.91	217
		4345	25	15.57	1.49	174
		-	30	-	-	-
		4352	32	15.17	1.09	136
		4356	36	14.87	0.79	121
	1040	4360	40	14.72	0.64	109

Pumping Test Data (Continued)

Location: Newlands #2A 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				
24.4.87	1045	4365	45	14.52	0.44	97
		4370	50	14.42	0.34	87
		4375	55	14.28	0.20	79
		4380	60	14.19	0.11	73
			70	14.04	+0.04	
			80	13.93	+0.15	
			90	13.89	+0.19	
			100	13.73	+0.35	
			110	13.68	+0.40	

PUMPING TEST DATA

OBSERVATION WELL

AREA: Bernard Lodge - Project ' A'

LOCATION OF PUMPING WELL: Newlands #2A

DISTANCE TO OBSERVATION WELL (r): 36 ft.

STATIC WATER LEVEL: 13.60 ft.

TYPE OF OBSERVATION WELL: Tubewell

DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED t - (minutes)	WATER LEVEL (ft.)	DRAWDOWN s (ft.)	$\frac{t}{r^2}$ $\frac{(min)}{(ft.^2)}$	REMARKS
21.4.87	1000	0	13.60	-	-	
		15	13.90	0.30	1.1×10^{-2}	
		70	15.50	1.90	5.4×10^{-2}	
		150	15.82	2.22	1.1×10^{-1}	
		210	16.20	2.60	1.6×10^{-1}	
		270	16.30	2.70	2.0×10^{-1}	
		275	16.40	2.80	2.1×10^{-1}	
		330	16.90	3.30	2.5×10^{-1}	
		390	16.90	3.30	3.0×10^{-1}	
		450	16.50	2.90	3.5×10^{-1}	
		525	16.30	2.70	4.0×10^{-1}	
		1170	16.40	2.80	9.0×10^{-1}	
		1260	16.50	2.90	9.7×10^{-1}	
		1380	16.35	2.75	1.0	
		1500	16.37	2.77	1.15	
		1620	16.37	2.77	1.25	
		1800	16.31	2.71	1.38	
		2040	16.31	2.71	1.57	
		2640	16.25	2.65	2.03	
		2700	16.19	2.59	2.08	
		2820	16.26	2.66	2.17	

PUMPING TEST DATA
OBSERVATION WELL

AREA: Bernard Lodge - Project 'A'

LOCATION OF PUMPING WELL: Newlands #2A

DISTANCE TO OBSERVATION WELL (r): 36 ft.

STATIC WATER LEVEL: 13.60

TYPE OF OBSERVATION WELL: Tubewell

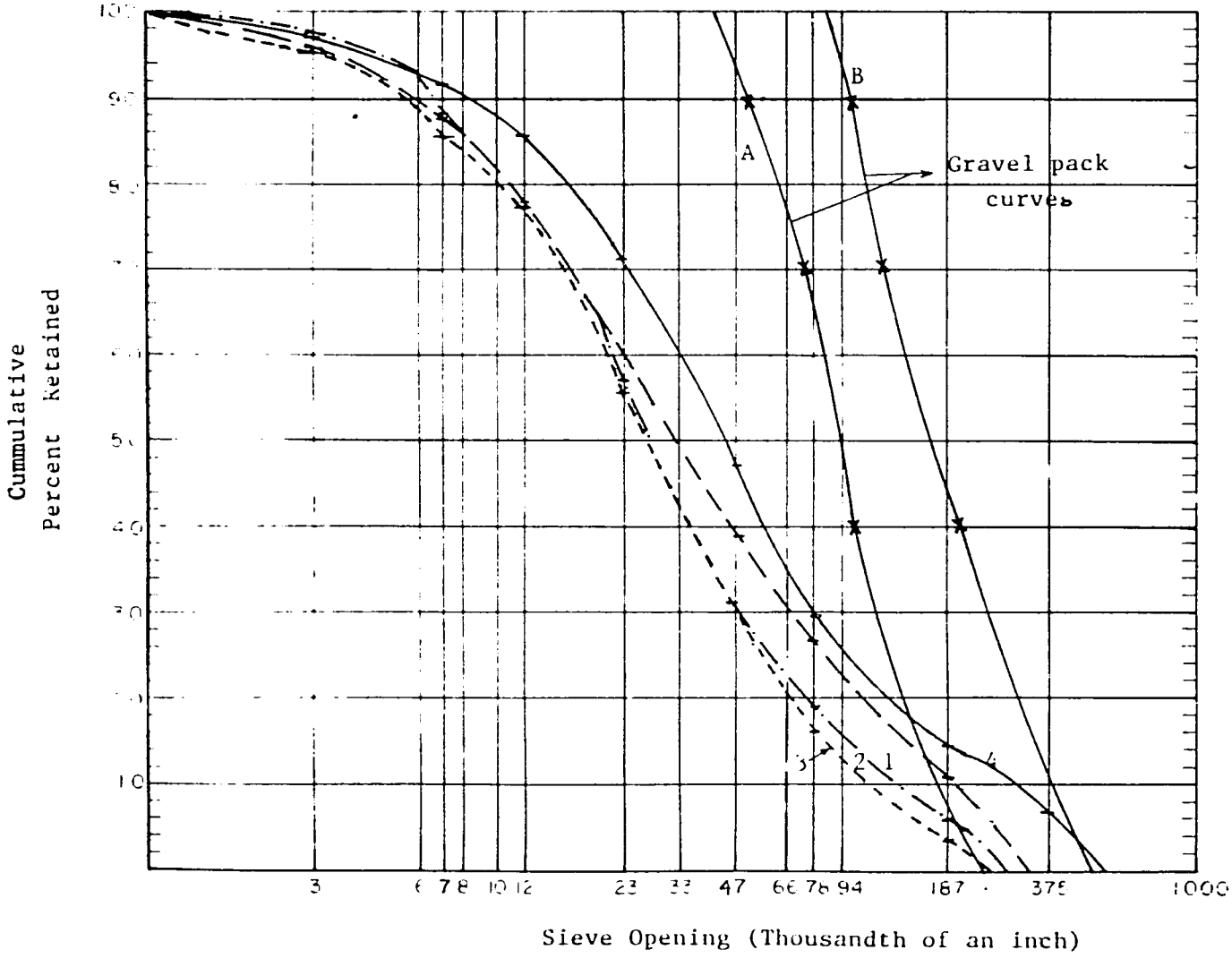
DATE	TIME (HOURS)	TIME SINCE PUMPING STARTED t - (minutes)	WATER LEVEL (ft.)	DRAWDOWN s (ft.)	$\frac{t}{r^2}$ $\frac{(min)}{(ft.^2)}$	REMARKS
23.4.87	1000	2880	16.24	2.64	2.22	
		2940	16.20	2.60	2.27	
		3060	16.21	2.61	2.36	
		3180	16.15	2.55	2.45	
		3300	16.10	2.50	2.55	
		3480	16.13	2.53	2.68	
		3660	16.13	2.53	2.82	
		3840	16.11	2.51	2.96	
		4020	16.08	2.48	3.10	
		4200	16.10	2.50	3.24	
		4320	16.00	2.40	3.33	

SIEVE ANALYSES CURVES

Fig 1

Location: Newlands #2 Corehole

Depth Range: (ft.) (1) 34-36 (2) 92-94 (3) 96-98 (4) 102-104



Finest sample is #3

70% retention size of the sample = 0.015".

A. Newlands #2 Well

1. 70% retention size of the gravel pack = 0.015" x 5 = 0.075.
2. Slot size of the screen = 0.050". (90% retention size of the gravel pack).
3. Uniformity co-efficient of the sample = 6.4.

B. Newlands #2A Well

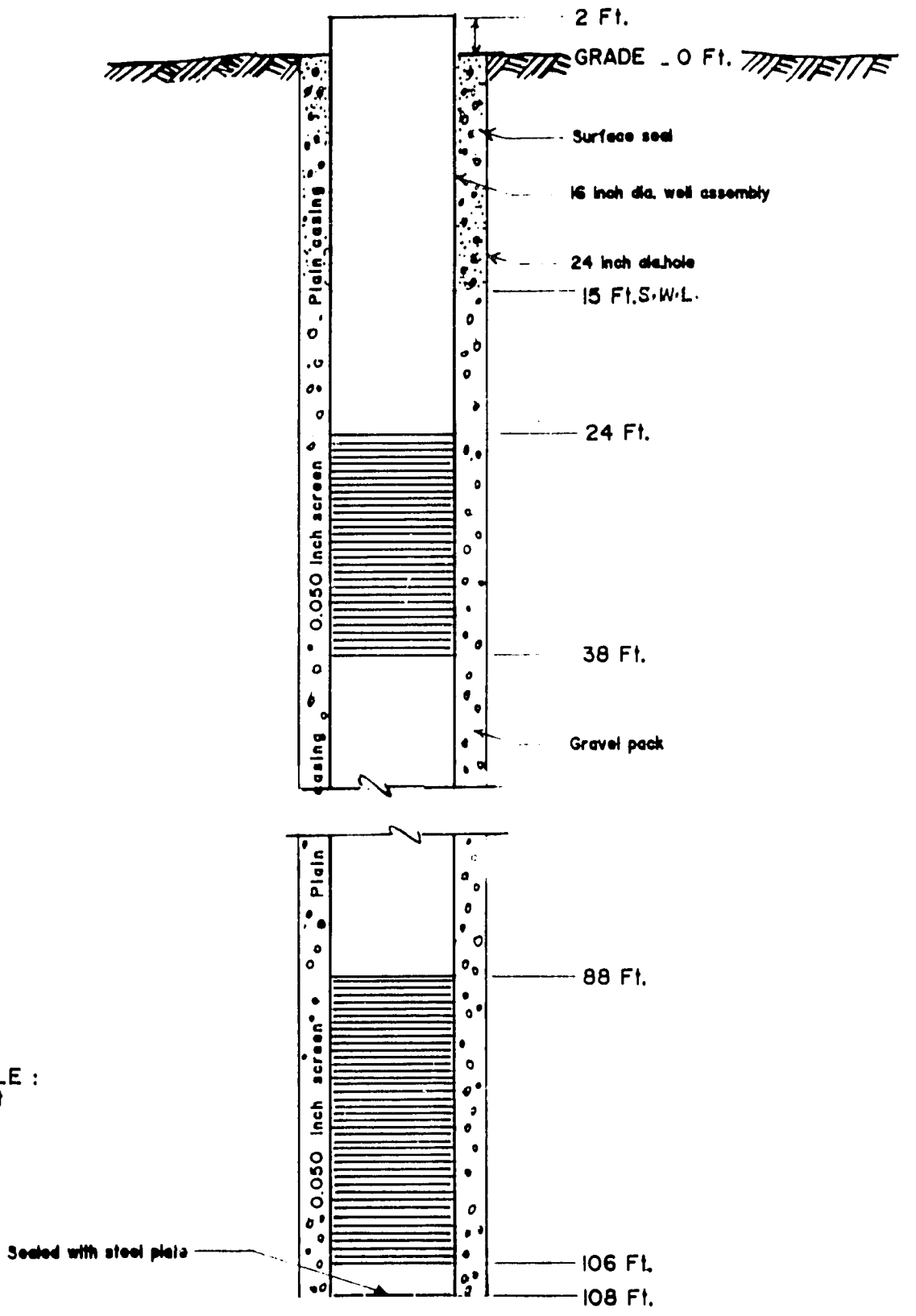
1. 70% retention size of the gravel pack = 0.015 x 8 = 0.120"
2. Slot size of the screen = 0.100" (90% retention size of the gravel pack).

ST. CATHERINE PLAINS

Fig. 2

Bernard Lodge Area Project 'A'

WELL DESIGN - NEWLANDS # 2



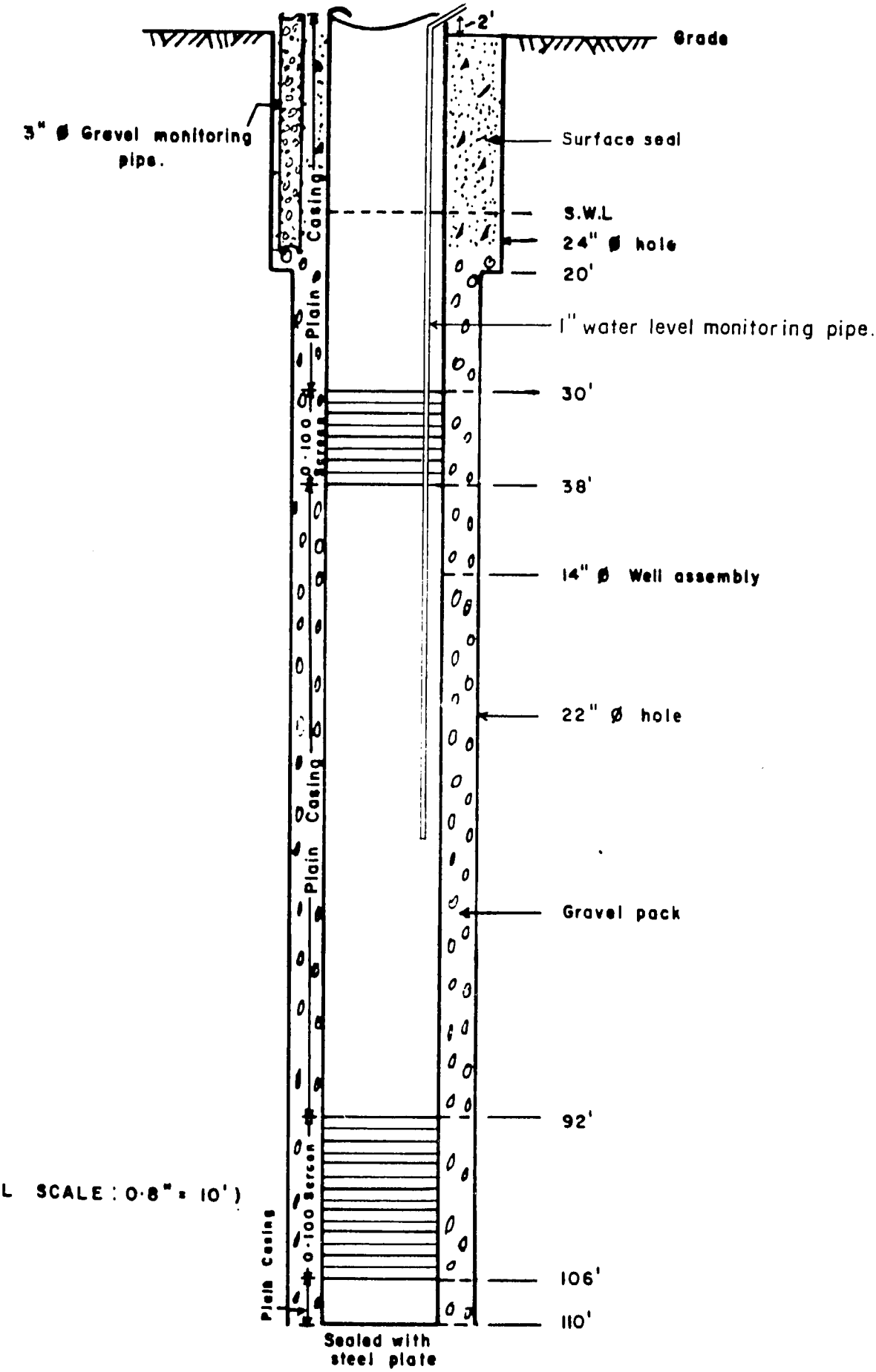
VERTICAL SCALE :
1 inch = 10 feet

ST CATHERINE PLAINS.

Fig. 3

Bernard Lodge Area Project 'A'

Well Design – Newlands # 2. A



(VERTICAL SCALE : 0·8" = 10')

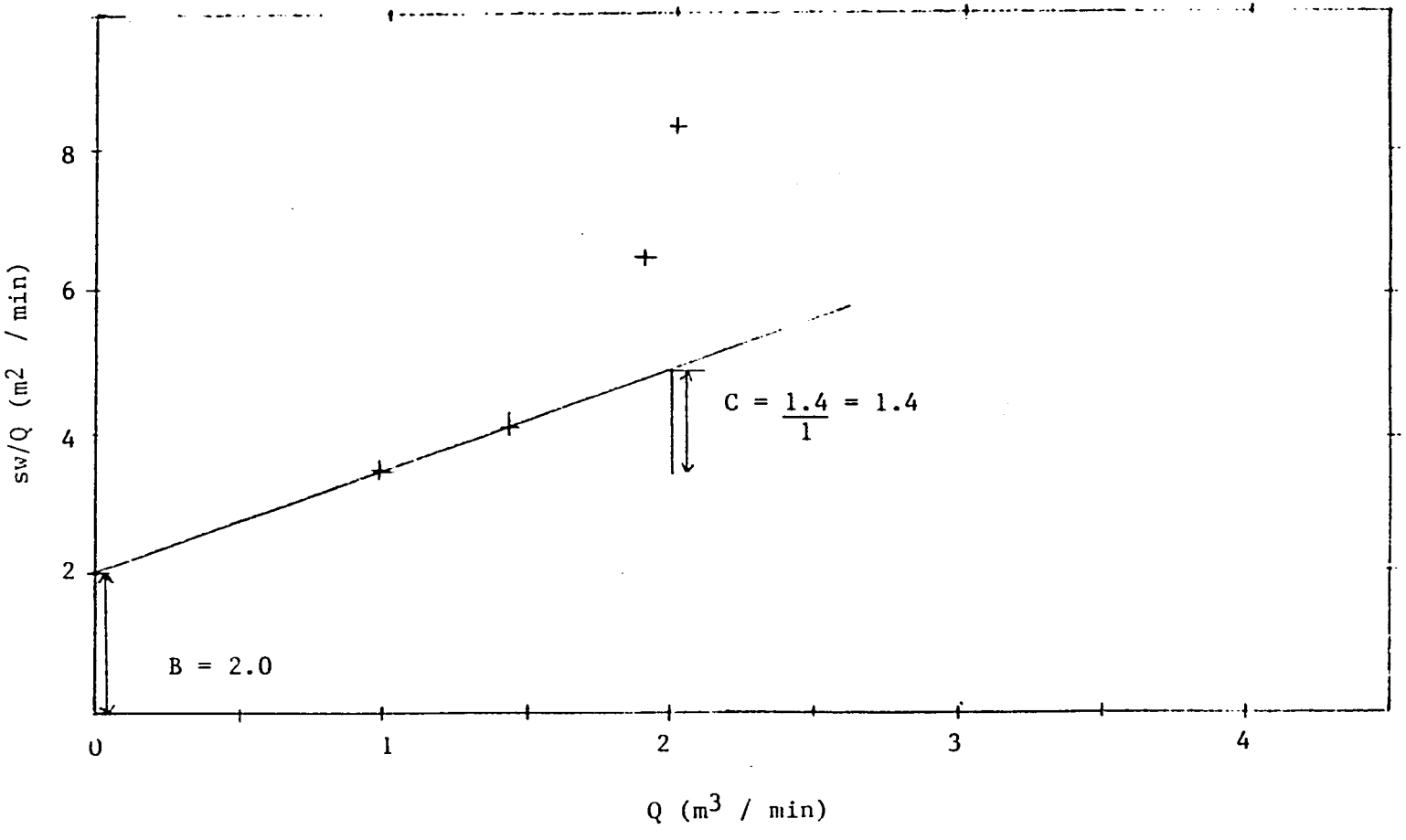
Fig. 4

St. Catherine Plains

Newlands #2A Well

Step - Drawdown Test Data Plot

Determination of 'B' and 'C'



St. Catherine Plains
Newlands #2A Well

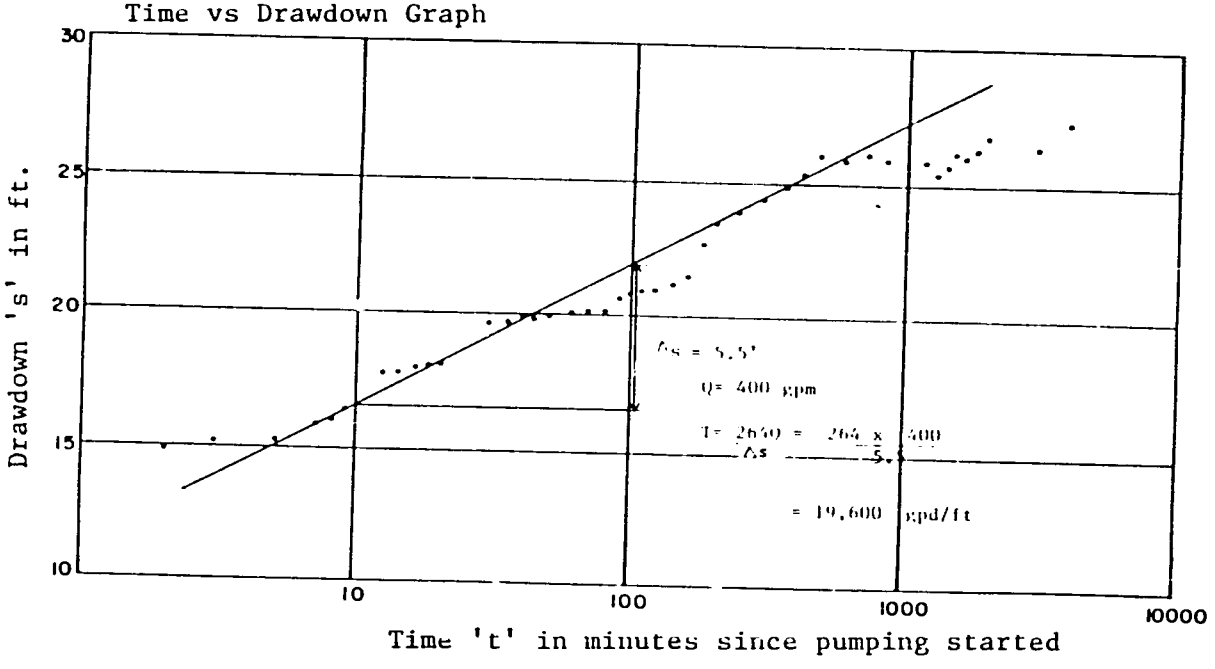


Fig 5

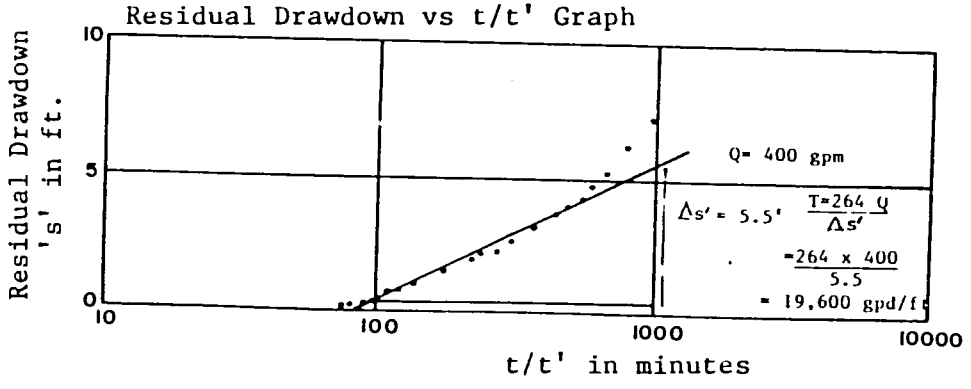
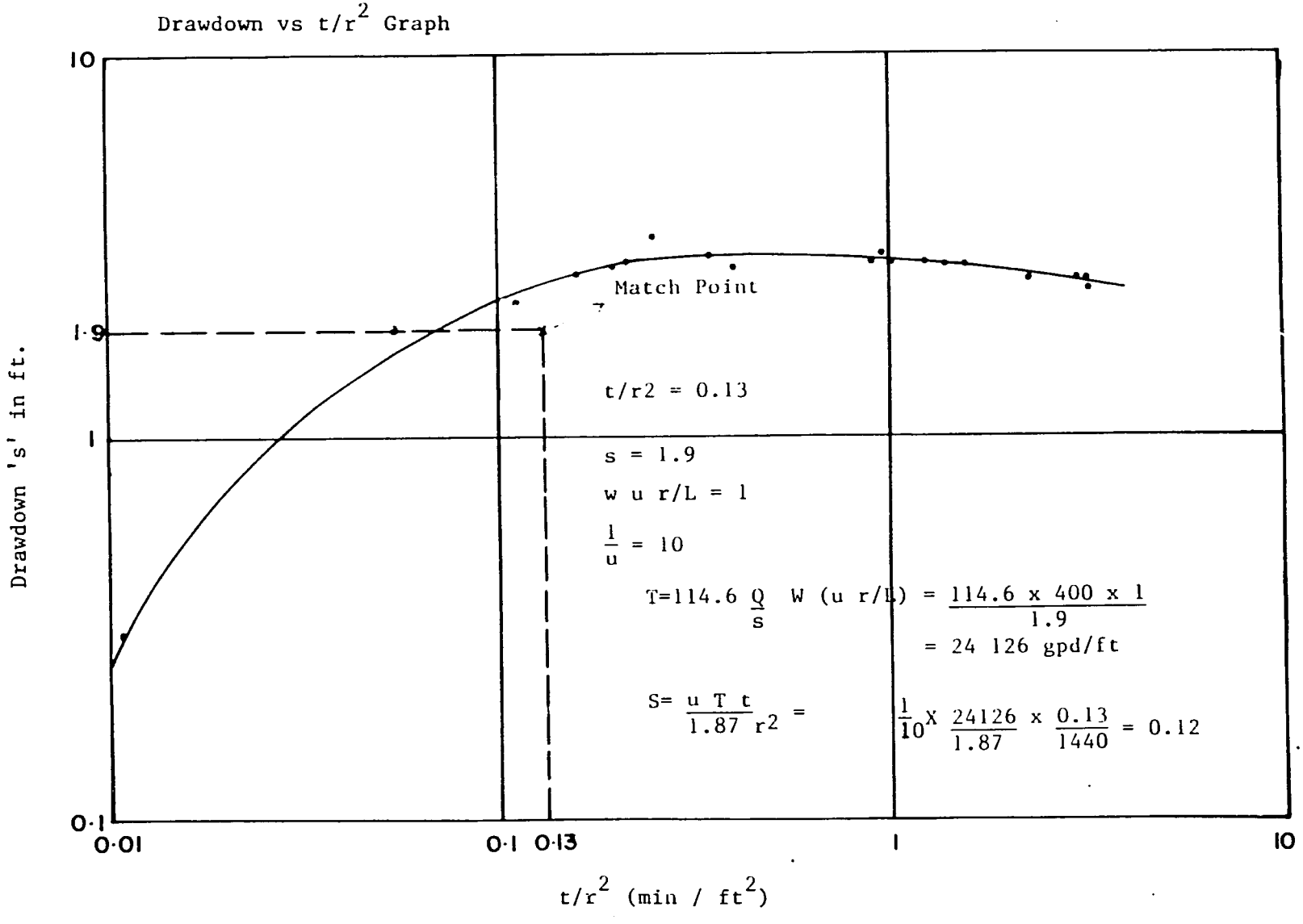


Fig 6

St. Catherine Plains
Newlands #2
Observation Well

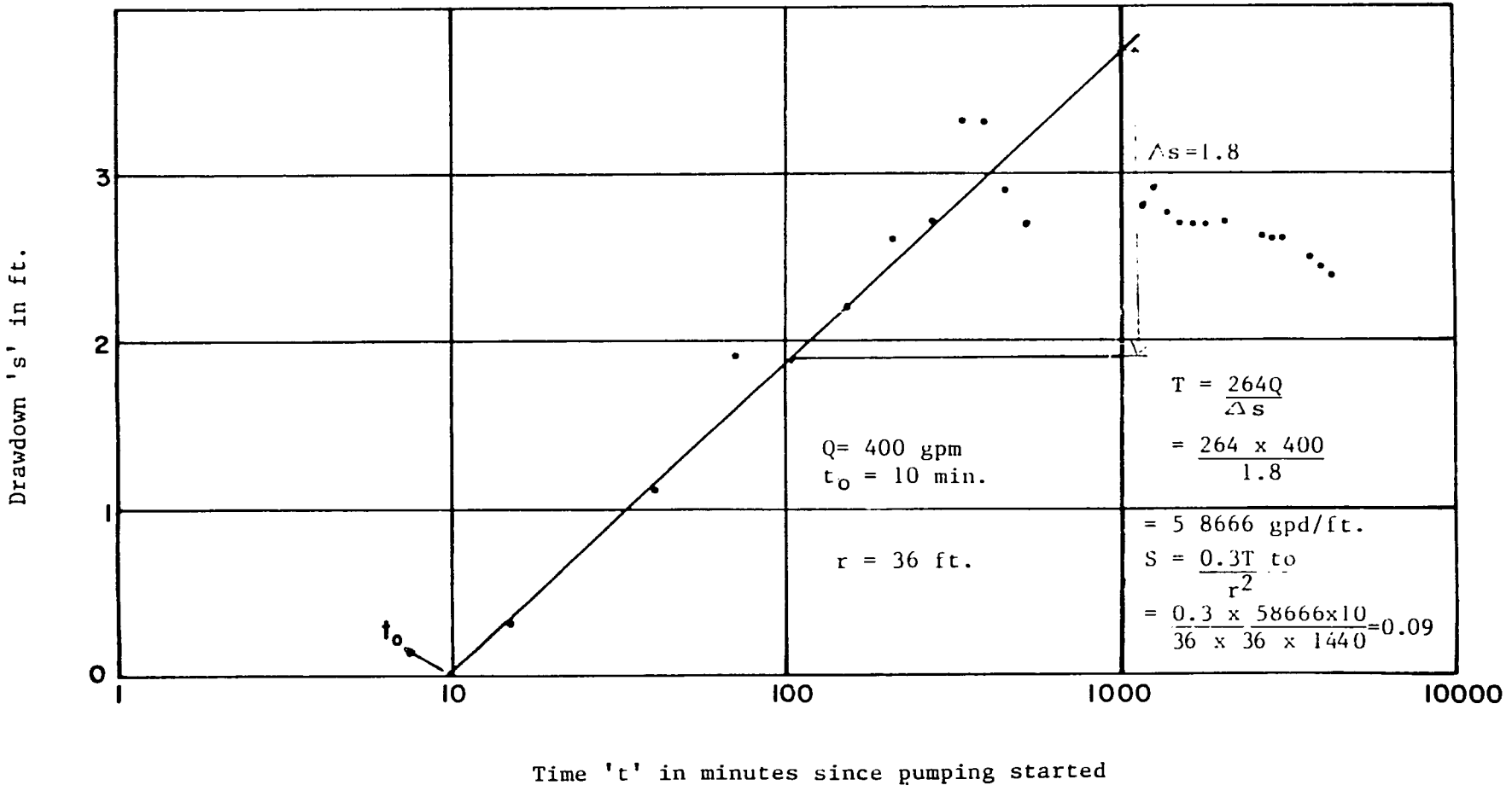
Fig 7



St. Catherine Plains
Newlands #2
Observation Well

Fig 8

Time vs Drawdown Graph



Time 't' in minutes since pumping started

St. Catherine Plains

Chemical Analysis of Water Samples

Table 7

Location: Newlands #2 and Newlands #2A

Area: Bernard Lodge –

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
Newlands #2																				
1	27.2.86	8.51	631	434.4	66.93	27.36	61.0	1.20	–	17.4	16.67	–	–	–	–	331.02	13.68	334.86	281	1.58
Newlands #2A																				
1	22.4.87	7.82	665	410.3	77.35	29.52	35	1.35	Trace	21.28	12.76	0.74	0.28		221.50	288.08	30.47	319.55	296.0	0.85
2	23.4.87	7.45	668	412.4	60.52	24.00	35	1.57	Trace	22.76	0.00	0.25	0.25		276.88	299.52	29.15	329.07	251.0	0.96
3	24.4.87	7.73	669	408.3	64.93	21.60	36	1.45	0.010	22.76	78.44	0.14	0.25		293.49	265.20	49.99	315.19	252.0	0.99

@/u/mhos/cm at 25°C * as $CaCo_3$

(Analysis by Jamaica Bauxite Institute, Kingston)

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Well Newlands #3

CONTENTS

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Newlands #3 Well *

1. Corehole Drilling

A corehole of 2" diameter was drilled between October 9 and 14, 1985 down to a depth of 100 ft. by Caribbean Boring and Diamond Drilling Limited, 1 Hillview Avenue, Kingston 10, with a Boyles rotary rig. Core samples were obtained at 2 ft. intervals by split spoon sampling method. The lithological log of the corehole is given in Table 1.

2. Sieve Analyses of Aquifer Samples

The lithological log showed that aquifer zones occur at depths of 24 ft. - 38 ft., 40 ft. - 42 ft., 55 ft. - 60 ft. and 78 ft. - 92 ft. Sieve analyses results of aquifer samples from depth ranges of 40 ft. - 42 ft., 56 ft. - 58 ft., 80 ft. - 82 ft. and 90 ft. - 92 ft. are given in Table-1 and the sieve analyses curves are shown in Fig. 1.

3. Well Design

The slot size of the well screens and the specifications of gravel pack material were worked out using the sieve analyses data of the aquifer samples. Six times the 70% retention size of the finest sample (0.012") was considered as the 70% retention size (0.072%) of the gravel pack material. With this point as origin a curve was developed with a uniformity coefficient of nearly 2 to represent the composition of the gravel pack material and 90% retention size (0.060") of the material was selected as the slot size of the well screen. Specifications of the gravel pack material are given below:

0.047" - 0.094" - 50%
0.094" - 0.375" - 50%

The well assembly consisted of 68 ft. of 16" diameter plain casing and 27 ft. of 16" diameter 304 stainless steel, v-shaped, non-clogging type well screens (manufactured by Johnson Division, U.S.A.) .17 ft. of the screens were of 0.060" slot size and 10 ft. of 0.050" slot size. It was first proposed to use 2 ft. of 0.060" slot size screen between 40' and 42'. However, it was subsequently decided to use 10 ft. of 0.050" slot size screen, between 36 ft. and 46 ft. so as to expose more thickness of the aquifer zone in the upper section of the well. The bottom of the assembly

* A replacement well for Cookson #1

was sealed with 0.375" thick steel plate. The well design is shown in Fig. 2.

4. Well Construction

The well construction and development operations were carried by the Underground Water Authority, Hope Gardens, Kingston, using a Davey-1500 direct rotary rig.

Drilling of a 22" diameter hole down to 94 ft. was started on November 10 and completed on November 15, 1985. Lowering of the well assembly was started on November 19, but it did not go down smoothly. By the afternoon of November 22, 10 ft. of assembly was yet to go and it appeared that the assembly would not go down any further. This happened probably due to the setting of drill cuttings at the bottom of the hole and narrowing of the hole in the lower reaches. The assembly was therefore pulled out on November 25. The hole was reamed to 24" in diameter and cleared of drill cuttings by November 28. The well assembly was lowered on November 29, and gravel packing was done on the same day.

5. Well Development

Clean water was circulated on December 2, to clear the well of the drilling fluid. Surging with a surge block and bailing operations were done on December 2 and 3, for a total period of 10 hours. The well was then developed with compressed air using a 250 psi. - 600 cfm air compressor, 8" eductor pipe and 1 1/2" air pipe for a total period of 30 hours from December 5 to 8. At the end of the development the yield was around 360 gpm for a pumping water level of 40 ft. the static water level being 20 ft. The specific capacity of the well was 18 gpm/ft. The specific capacity of the well was 18 gpm/ft. The well discharge was clear and almost free from sand.

No step-drawdown test and time-drawdown test were conducted.

6. Rate of Abstraction

No step-draw-down test or time-draw-down test was carried out on this well. Based on the results obtained during the development of the well and its subsequent performance or over two years, it is recommended that the abstraction from the well maybe limited to 400 gpm and its further performance and any changes in the quality of water be observed.

7. Grouting of the Well

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" dia. and the well assembly was maintained around 10 ft. below ground level. After the long duration pumping test was over, the temporary casing was pulled out and a 3" dia. pvc pipe of 12 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor any sinking of gravel in course of time. The annular space was then grouted with cement concrete.

(The measure used in this report is US gallons and the depths indicated are below ground level)

ST. CATHERINE PLAINS

TABLE 2

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: NEWLANDS #3 COREHOLE

AREA: BERNARD LODGE - PROJECT "A"

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	1) 40-42. DEPTH RANGE (FT.)						2) 56-58		
			A	B	C				A	B	C
1	6	0.132	15.8	15.8	9.6				12.8	12.8	9.0
2	8	0.094	15.2	31.0	18.8				4.5	17.3	12.2
3	12	0.066	11.4	42.4	25.7				5.2	22.5	15.8
4	16	0.047	17.4	59.8	36.3				9.7	32.2	22.7
5	20	0.033	15.4	75.2	45.6				12.9	45.1	31.8
6	30	0.023	12.1	87.3	53.0				18.3	63.4	44.7
7	40	0.016	13.7	101.0	61.3				24.8	88.2	62.1
8	50	0.012	14.3	115.3	70.0				17.6	105.8	74.5
9	70	0.008	16.1	131.4	79.8				13.1	118.9	83.8
10	100	0.006	12.7	144.1	87.5				7.5	126.4	89.1
11	PAN		20.6	164.7	100				15.5	141.9	100

* U.S.S. Sieve Series

(Analysed by Alex Campos and D.V. Ramanamurty)

A = Weight retained in grams

B = Cummulative weight retained in grams

C = Cummulative percent retained

ST. CATHERINE PLAINS
SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

LOCATION: NEWLANDS # 3 COREHOLE

AREA: . BERNARD LODGE - PROJECT "A"

SERIAL NO.	* SIEVE NO.	MESH OPENING (INCH)	3) 80-82 DEPTH RANGE (FT.)						4) 90-92		
			A	B	C				A	B	C
1	6	0.132	11.5	11.5	7.7				23.8	23.8	15.7
2	8	0.094	8.4	19.9	13.4				16.5	40.3	26.7
3	12	0.066	9.0	28.9	19.5				17.4	57.7	38.2
4	16	0.047	16.4	45.3	30.5				18.0	75.7	50.1
5	20	0.033	18.3	63.6	42.8				13.7	89.4	59.2
6	30	0.023	17.5	81.1	54.6				11.1	100.5	66.5
7	40	0.016	20.4	101.5	68.4				12.2	112.7	74.6
8	50	0.012	13.3	114.8	77.3				10.1	122.8	81.3
9	70	0.008	10.4	125.2	84.3				9.5	132.3	87.6
10	100	0.006	7.2	132.4	89.2				6.0	138.3	91.5
11	PAN		16.1	148.5	100				12.8	151.1	100

* U.S.S. Sieve Series

(Analysed by Alex Campos and D.V. Ramanamurty)

A = Weight retained in grams

B = Cummulatave weight retained in grams

C = Cummulative percent retained

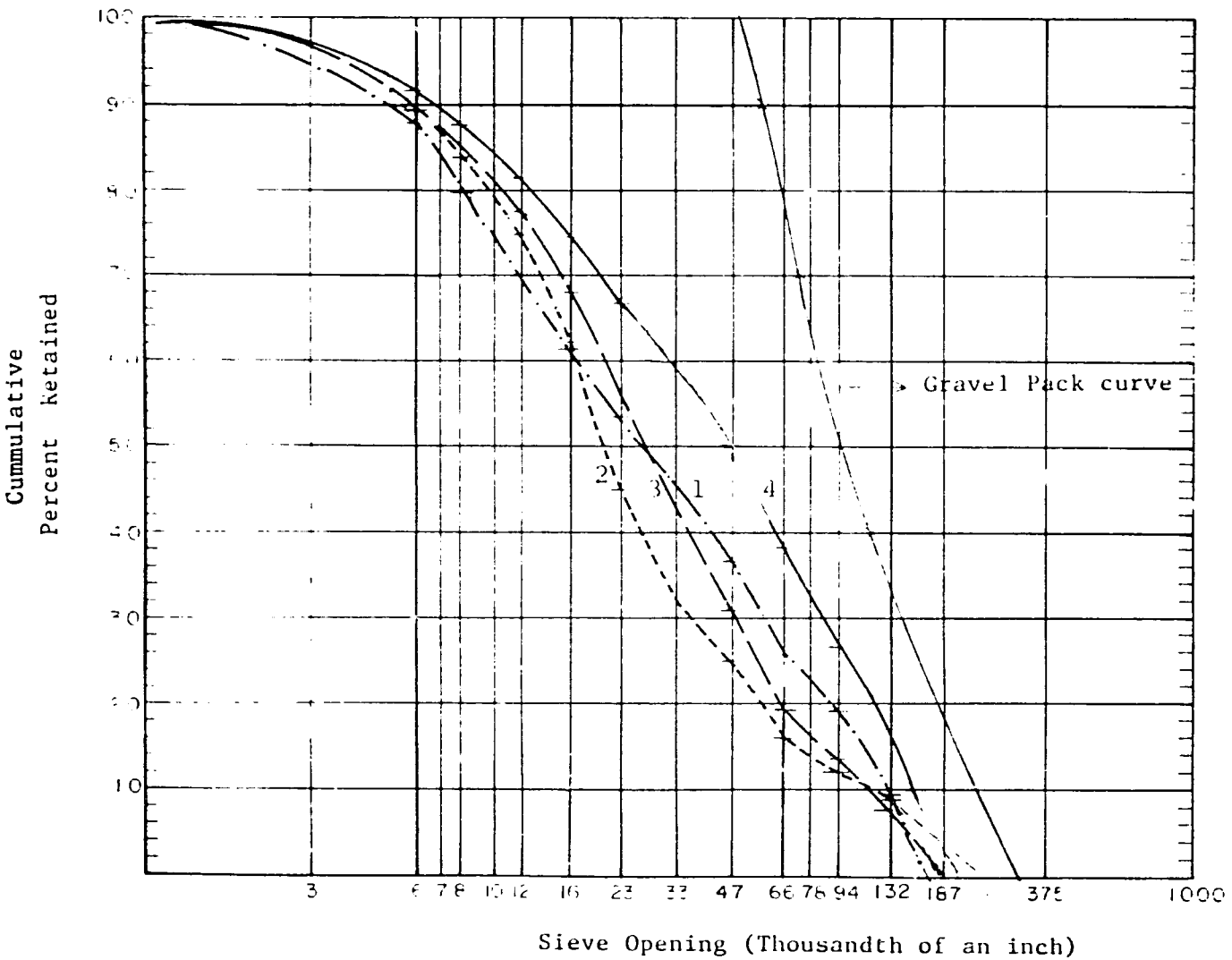
FIG. 1

SIEVE ANALYSES CURVES

Location: Newland #3 Corehole

Depth Range: (ft.)

1) 40-42 (2) 56-58 (3) 80-82 (4) 90-92



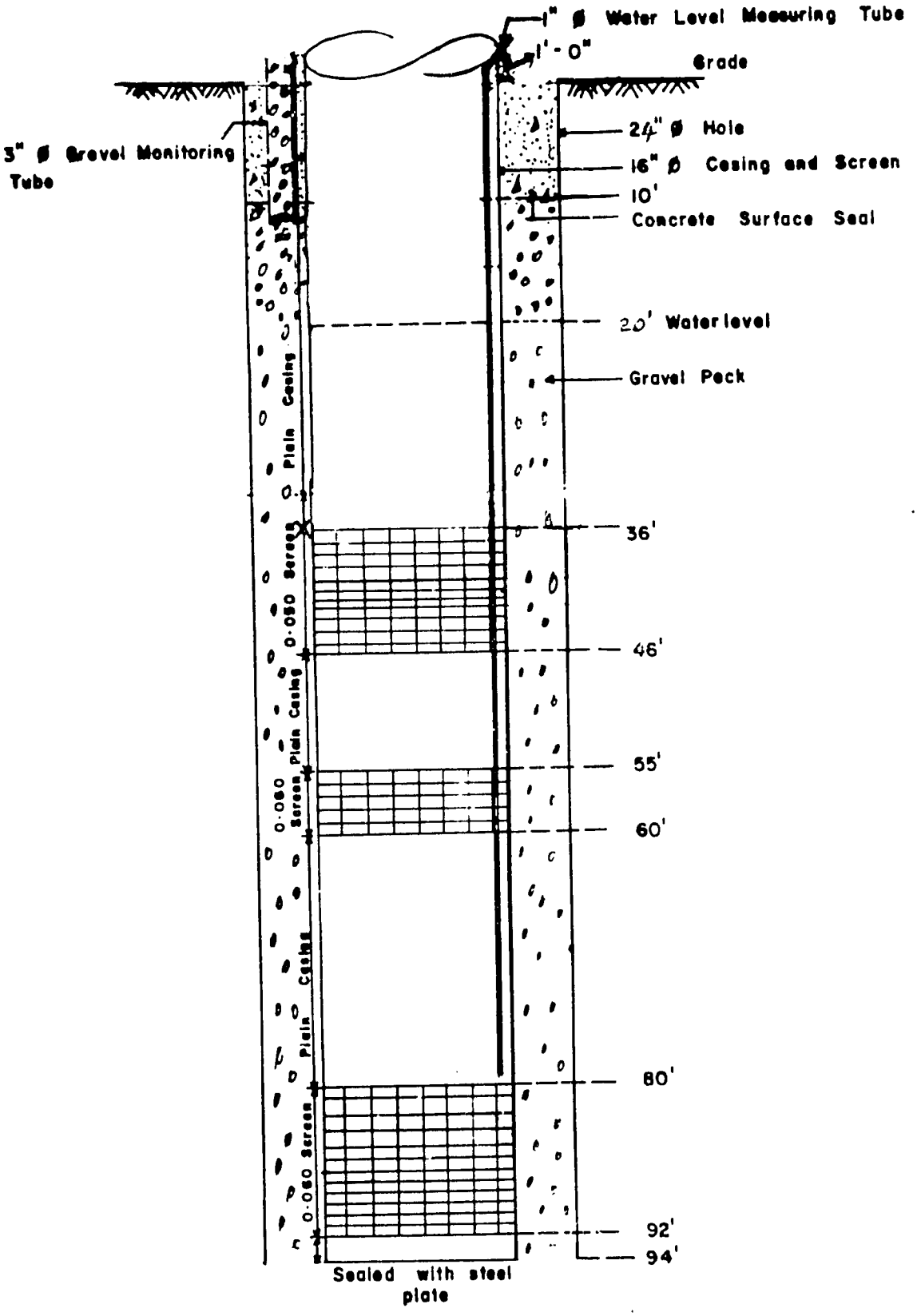
1. Finest Sample is #1
2. 70% retention size of the sample = 0.012"
3. 70% retention size of the gravel pack material 0.012" x 6 = 0.072"
4. Slot size of the screen = 0.060"
5. Uniformity coefficient of the sample = 5

ST CATHERINE PLAINS.

Fig. 2

Bernard Lodge Area Project 'A'

Well Design – Newlands # 3.



VERTICAL SCALE

0·8 in. = 10 ft.

TABLE-1

St. Catherine Plains
Bernard Lodge East Area
Lithological log of corehole - Newlands #3

Depth Range (ft.)	Thickness (ft.)	Description
0 - 4	4	Dark brown, silty, sandy soil
4 - 14	10	Brown fine to coarse grained sand with a little gravel
14 - 18	4	Brown silty sand
18 - 24	6	Brown, fine to coarse grained sand with some silt
24 - 32	8	Silty clay and sand
32 - 34	2	Stiff brown sandy clay
34 - 38	4	Medium to coarse grained sand, clayey, with some angular gravel up to an inch in size
38 - 40	2	Brown silty clay
40 - 42	2	Mostly fine to very coarse grained silty sand with some gravel
42 - 46	4	Grey clay with fine to medium grained sand
46 - 50	4	Fine to medium grained sand with much of silty clay
50 - 55	5	Dark grey clay
55 - 60	5	Mostly fine to very coarse grained sand with some gravel
60 - 64	4	Dark brown soft clay with a little fine to medium grained sand
64 - 78	14	Brown sandy silty clay
78 - 80	2	Brown medium to coarse sand with a little clay
80 - 92	12	Mostly medium to very coarse grained silty sand with a little clay and some gravel.
92- 100	8	Sticky clay

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Well
Cookson #4

CONTENTS

St. Catherine Plains
Bernard Lodge East Area
Report on the Construction of Cookson #4 *

1. Corehole Drilling

A corehole of 2" dia. was drilled down to 108 ft. between July 16, and 18, 1985, by Caribbean Boring and Diamond Drilling Limited, 1 Hillview Avenue, Kingston 10, with a Boyles-37 rotary rig. Core samples were obtained at every 2 ft. interval by split-spoon sampling method. The lithological log of the corehole is given in Table-1.

2. Sieve Analyses of Aquifer Samples

The lithological log showed that two aquifer zones occur one between 37 ft. and 42 ft. and the other between 74 ft. and 104 ft. Sieve analyses results of four aquifer samples taken from depth ranges 40 ft. - 42 ft., 74 ft. - 76 ft., 82 ft. - 84 ft. and 100 ft. - 102 ft. are given in Table-2 and the sieve analyses curves are shown in Fig. 1.

3. Well Design

The slot size of the screens and the specifications of gravel pack material were worked out using the sieve analyses curves. Six times the 70 percent retention size of the finest sample (#3) in case of lower aquifer (and four times in case of the upper aquifer) was taken as the 70% retention size of the gravel pack material and with this point as origin a curve was developed to represent the composition of the gravel pack material. The gravel pack curves are also shown in Fig. 1. 90% retention size of the gravel pack material (0.040" in case of the upper aquifer and 0.030" in case of the lower aquifer) was taken as the slot size of the screen. Specifications of the gravel pack material are given below:

Sizes	Lower Aquifer	Upper Aquifer
0.023" - 0.047"	40%	-
0.033" - 0.047"	-	20%
0.047" - 0.094"	50%	50%
0.094" - 0.250"	10%	30%

* A replacement well for Cookson #2

However, in the well construction, gravel of size 0.094" - 0.250" only was used so as to have a high permeability in the gravel pack zone. The gravel pack material consisted of rounded to sub-rounded hard material like quartz, granite etc. with a little limestone. The well assembly consisted of 78 ft. of 16" dia. 0.375" thick seamless plain casing and 33 ft. of 16" dia. 304 stainless steel v-shaped non-clogging type well screens (5 ft. of 0.040" slot opening and 28 ft. of 0.030" slot opening) manufactured by Johnson Division U.S.A. The bottom of the assembly was sealed with cement concrete. The well design is shown in Fig. 2.

4. Well Construction

The well was constructed by Jamaica Wells and Services Limited, 3 Ballater Avenue, Kingston 10, using a Cable Tool Rig. Drilling of a 24" dia. hole was started on September 27, 1985. The drilling operations were suspended from October 26 to November 4 as the tool broke off in the well and fishing operations were carried out to retrieve the tool. The hole was drilled in 24" dia. down to 70 ft. As the construction casing of 24" did not move freely below 70 ft. the dia. of hole was reduced to 20" between 70 ft. and 110 ft. The well assembly was lowered into the hole on November 15, but it did not go down fully. 7 ft. of the assembly was left above the ground. The assembly was therefore pulled out and the hole was cleaned by bailing. After removing the base plate the assembly was re-lowered on November 17. The construction casings of 20" and 24" dia. were pulled out on November 19 and 20. Gravel packing of the well was down in stages while construction casing was being pulled out. 20 ft. of 24" dia. construction casing was left in the well to prevent any collapse of the formation during development. It was pulled out after the well was completely developed and before the surface seal was installed. The bottom of the well was sealed with cement concrete on November 21.

5. Well Development

The well development was also done by Jamaica Wells and Services Ltd.

The water level in the well was 16 ft. below ground level (b.g.l.) on November 18.

The well was developed by surging with a surge block and bailing for 12 hrs. on November 26, 27 and 28. This was followed by development with an air compressor using an 8" eductor pipe and 1 1/2" air pipe for 22 hrs. from November 30 to December 2. At the end of this development, the water was slightly turbid and the yield was around 300 USgpm for a pumping water level of 40 ft. - 45 ft. The well was further developed with a

turbine pump for 16 hours on December 7 and 8. The water level was 18 ft. b.g.l. and the pumping water level fluctuated between 50 ft. and 60 ft. for a yield of 400 to 450 USgpm. The well discharge was slightly turbid. The pump was therefore removed and further development was done by surging and bailing and with air compressor. Surging and bailing was done for 14 hrs. on December 10 and 11 and development with air compressor was done for about 30 hrs. from December 13 to 19. The yield at the end of the development was about 600 USgpm for a pumping water level of 68 ft. b.g.l., the static water level being 15 ft. b.g.l.

6. Rate of Abstraction

No step-draw-down test or time-draw-down test was carried out on this well. Based on the results obtained during the development of the well and its subsequent performance or over two years, it is recommended that the abstraction from the well maybe limited to 400 gpm and its further performance and any changes in the quality of water be observed.

7. Grouting of the Well

During the development and testing of the well the gravel level in the annular space between the temporary casing of 24" dia. and the well assembly was maintained around 17 ft. below ground level. After the long duration pumping test was over, the temporary casing was pulled out and a 3" dia. pvc pipe of 20 ft. length was installed in the annular space, driven a foot into the gravel and then filled with gravel. The purpose of this pipe is to monitor any sinking of gravel in course of time. The annular space was then grouted with cement concrete.

Table 1

St. Catherine Plains
Bernard Lodge East Area
Lithological log of corehole - Cookson #4

Depth Range (ft)	Thickness (ft)	Description
0 - 2	2	Sandy loam
2 - 8	6	Light brown fine to coarse grained sand with a little gravel
8 - 14	6	Fine silty sand and clay
14 - 20	6	Dark brown clay with a little silt, fine sand and gravel
20 - 30	10	Dark brown silty clay with some fine to coarse grained sand and gravel
30 - 37	7	Clay with fine to very coarse grained sand and silt
37 - 42	5	Brown slightly silty sand, fine to very coarse grained, with some gravel
42 - 74	32	Stiff, dark brown clay, partly silty
74 - 88	14	Brown slightly silty sand, fine to very coarse grained
88 - 104	16	Fine to very coarse grained sand, silty and clayey with some gravel
104 - 108	4	Brown silty clay with a little gravel

ST. CATHERINE PLAINS

SIEVE ANALYSES RESULTS OF AQUIFER SAMPLES

(CUMMULATIVE PERCENT RETAINED)

LOCATION: COOKSON #4 COREHOLE

AREA: BERNARD LODGE -PROJECT "A"

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	UPPER AQUIFER DEPTH RANGE OF SAMPLE (FT.)						LOWER AQUIFER		
			40-42			74-76		82-84		100-102	
1	3/8"	0.375	(1)			(2)		(3)		(4)	
2	4	0.187	4.9								
3	10	0.078	12.4			2.5		2.6		39.8	
4	16	0.047	19.9			3.8		7.7		51.8	
5	30	0.023	42.4			7.2		14		64.8	
6	50	0.012	74.1			39.3		37.6		74.8	
7	80	0.007	89.1			77.8		68.6		81.7	
8	100	0.006	92.3			86.3		79.6		83.5	
9	200	0.003	97.4			95.4		92.9		87.7	

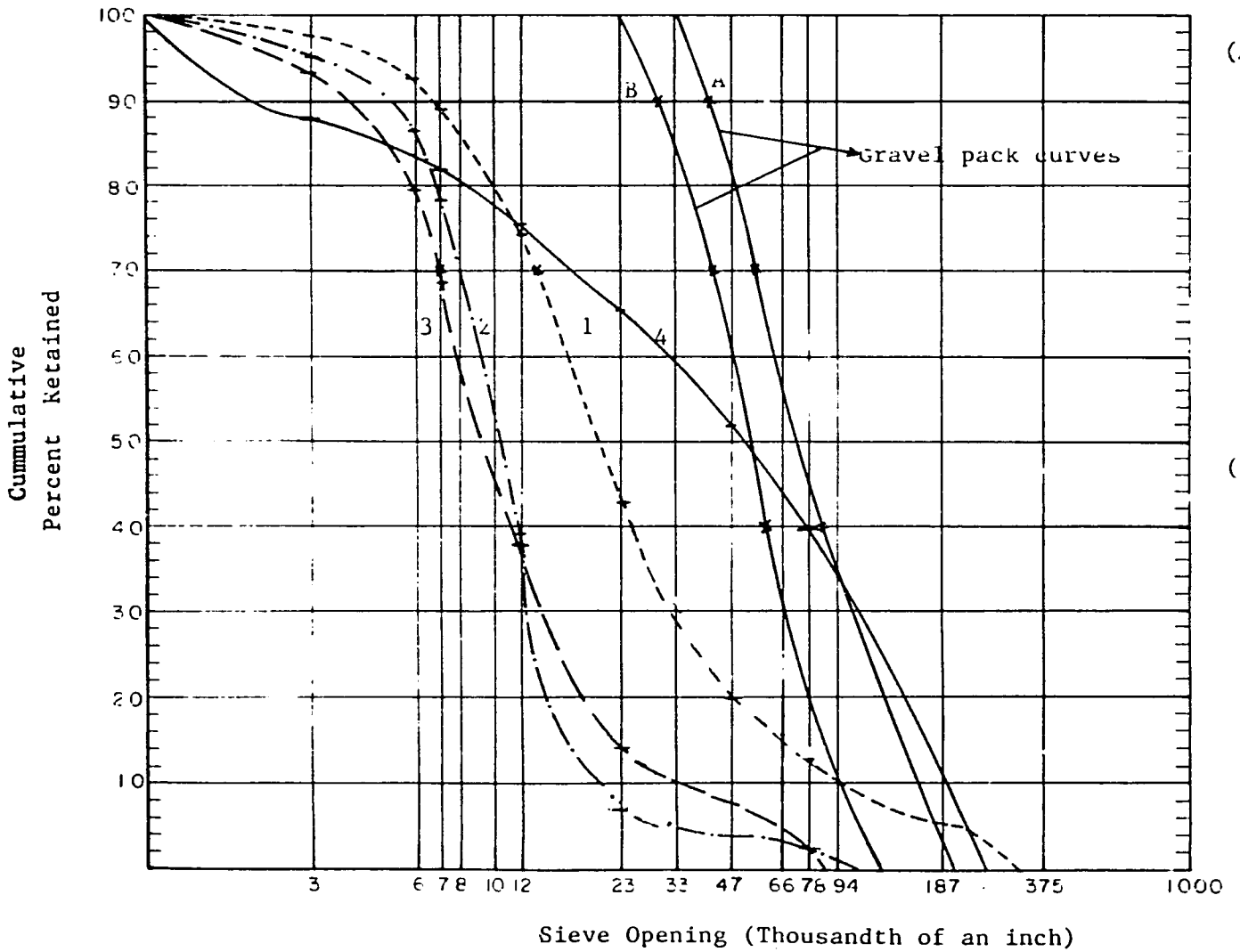
@U.S.S. Sieve Series

(Analysed by Jamaica Engineering & Technical Services Limited, Kingston)

SIEVE ANALYSIS CURVES

Location: Cookson #4 Corehole

Depth Range: (ft.) (1) 40-42 (upper aquifer)
(2) 74-76 (3) 82-84 (4) 100-102 (lower aquifer)



(A) Upper Aquifer

1. 70% retention size of the sample = 0.013".
2. 70% retention size of the gravel pack = 0.013" x 4 = 0.052"
3. Slot opening of the screen (90% retention size of the gravel pack) = 0.040".
4. Uniformity co-efficient of the sample = 3.5.

(B) Lower Aquifer

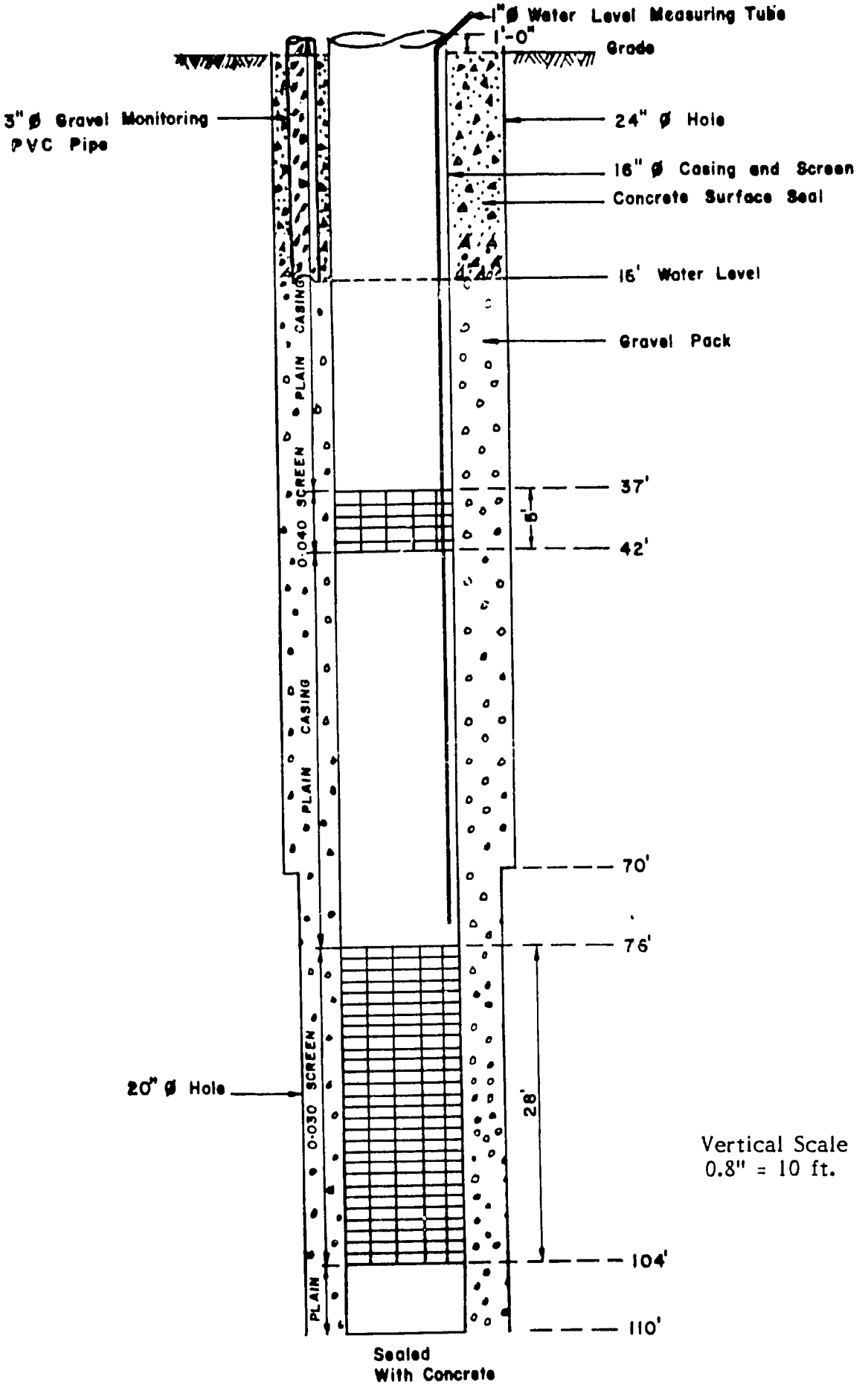
Finest sample is #3

1. 70% retention size of the sample = 0.007".
2. 70% retention size of the gravel pack = 0.007" x 6 = = 0.042".
3. Slot opening of the screen (90% retention size of the gravel pack) = 0.030"
4. Uniformity co-efficient of the sample = 3.

ST CATHERINE PLAINS.

Bernard Lodge Area Project 'A'

Well Design – Cookson # 4.



Vertical Scale
0.8" = 10 ft.

St. Catherine Plains

Bernard Lodge East Area
Lithological Log of Corehole
Cookson #2

Depth Range (ft.)	Thickness (ft.)	Description
0 - 8	8	Brown fine silty sand
8 - 16	8	Silty sandy clay
16 - 24	8	Dark brown, medium to fine sand with some gravel
24 - 32	8	Stiff brown clay, silty and sandy towards the bottom
32 - 35	3	Medium to coarse grained sand
35 - 103	68	Stiff dark drown clay with a few lenses of silty sand and fine gravel
103 - 110	7	Stiff brown clay with lenses (upto 6" in thickness) of silty sand

St. Catherine Plains

Bernard Lodge East Area
Lithological Log of Corehole
Newlands #4

Depth Range (ft.)	Thickness (ft.)	Description
0 - 6	6	Top soil and silty sand
6 - 10	4	Brownish grey coarse sand and gravel with some silty sand
10 - 12	2	Silty, sandy clay
12 - 18	6	Dark grey fine silty sand
18 - 26	8	Brownish grey silty clay
26 - 40	14	Brownish grey fine to medium silty sand with thin layers of clay at the bottom
40 - 72	32	Brown silty, sandy clay with a few thin layers of coarse sand and gravel
72 - 94	22	Brownish grey silty sandy clay with a few thin layers of silty sand
94 - 100	6	Brown silty sandy clay with a few thin layers of coarse sand and gravel

St. Catherine Plains

Bernard Lodge East Area
Lithological Log of Corehole
Newlands #1

Depth Range (ft.)	Thickness (ft.)	Description
0 - 2	2	Dark brown silty soil with a little fine sand
2 - 6	4	Fine to coarse grained sand with a little gravel
6 - 10	4	Fine to medium grained sand with a little silt
10 - 31	21	Stiff yellowish brown clay with a little silt
31 - 38	7	Fine to coarse grained sand, mostly angular
38 - 72	34	Dark brown to yellowish brown silty clay, occasionally very stiff
72 - 75	3	Clay mixed with a little medium grained sand
75 - 78	3	Medium grained sand with a little clay
78 - 98	20	Mostly medium to very coarse grained sand angular to subrounded with some gravel (upto 3/8" in size), the gravel content increasing downwards
98 - 100	2	Clay

St. Catherine Plains

Sieve Analysis Results of Aquifer Samples

Location: NEWLANDS # 1

Area: Bernard Lodge - Project 'A'

SERIAL NO.	@ SIEVE NO.	MESH OPENING (INCH)	DEPTH RANGE (FT.) 78-80			82-86			88-90			92-94		
			A	B	C	A	B	C	A	B	C	A	B	C
1.	½"	0.500	--	--	--	--	--	--	--	--	--	--	--	--
2.	3/8"	0.375	2.5	2.5	2.1	8.8	8.8	6.5	6.0	6.0	4.7	20.6	20.6	13.7
3.	4	0.187	12.6	15.1	12.8	9.5	18.3	13.6	17.6	23.6	18.5	19.6	40.2	26.7
4.	10	0.078	17.2	32.3	27.4	29.9	48.2	35.7	28.8	52.4	41.4	33.1	73.3	48.7
5.	16	0.047	20.2	52.5	44.6	28.6	76.8	56.9	21.3	73.7	57.8	18.9	92.2	61.3
6.	30	0.023	27.7	80.2	68.1	29.3	106.1	78.7	19.6	93.3	73.2	25.9	118.1	78.5
7.	50	0.012	17.6	97.8	83.1	13.4	119.5	88.6	15.9	109.2	85.7	14.2	132.3	88.0
8.	80	0.007	8.2	106.0	90.0	6.4	125.9	93.3	7.5	116.7	91.6	8.2	140.5	93.4
9.	100	0.006	2.3	108.3	91.9	1.8	127.7	94.7	2.3	119.0	93.4	2.2	142.7	94.9
10.	200	0.003	4.8	113.1	96.0	4.0	131.7	97.6	4.8	123.8	97.2	5.6	148.3	98.6
11.	PAN	--	4.7	117.8	100	3.2	134.9	100	3.6	127.4	100	2.1	150.4	100

@ 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

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