STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN FOR THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN IN THE REPUBLIC OF NAMIBIA

Japan International Cooperation Agency

Pacific Consultants International

BOREHOLE FINAL REPORT

Borehole

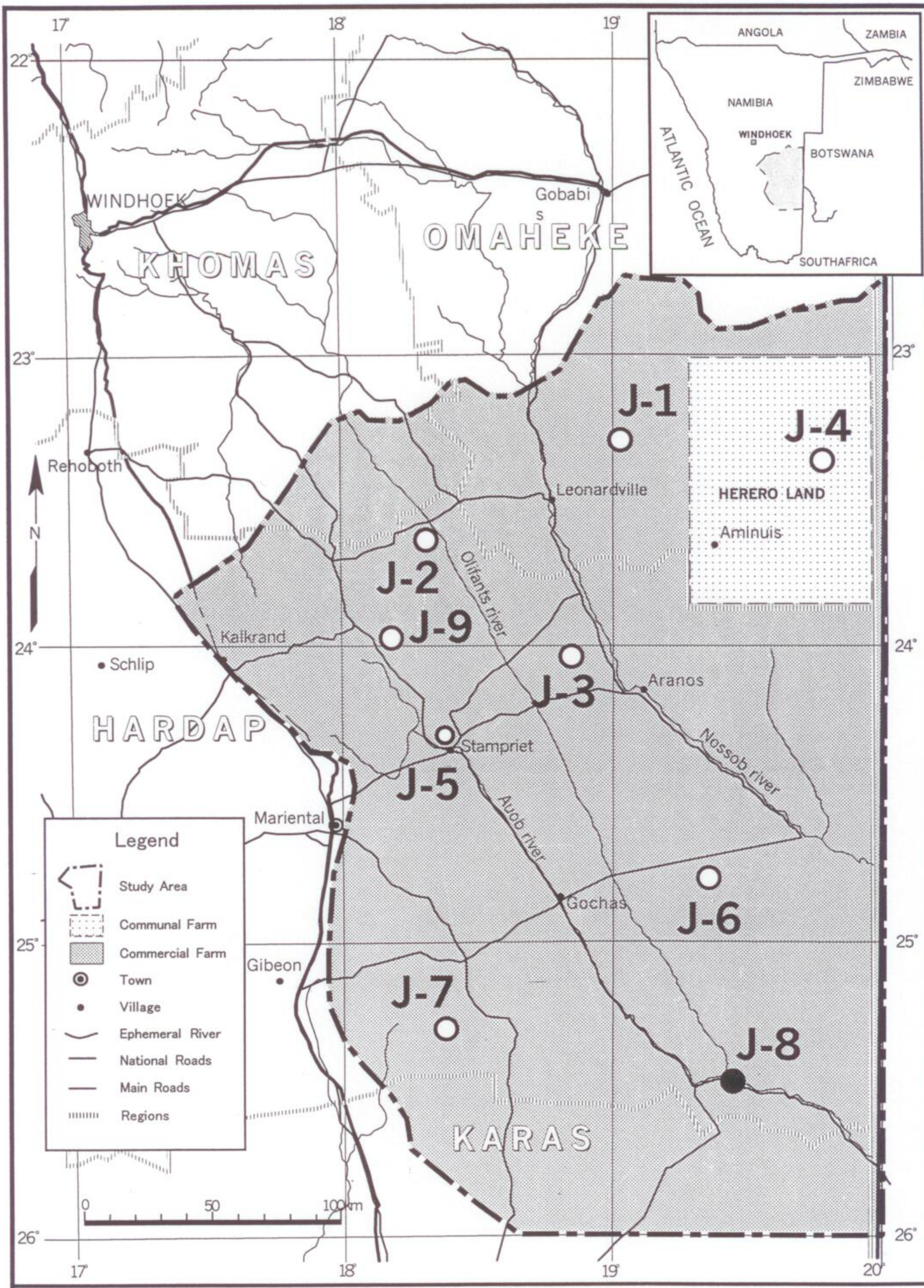
J8-N (WW 39856)

Twee Reviere R481

METZGER PM DRILLING
P.O.Box 11733
Windhoek
Namibia

Windhoek

December 2000



Location Map of Test Boreholes

THE STUDY ON THE GROUNDWATER IN THE STAMPRIET ARTESIAN BASIN	JICA

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

Introduction

The Joint Venture Contractors **Metzger-PM Drilling** were appointed by **Pacific Consultants International** to conduct a drilling investigation in the Stampriet Artesian Basin.

A total of 19 boreholes were constructed successfully on nine different localities. All boreholes were geophysically logged and pumping tests have been conducted.

The following Drilling Rigs were used during this operation:

1. **Schramm 685**: Used for all drilling and grouting as well as large diameter casing installation.
2. **Jaswell J 3500**: Used for installation of final casing, placement of filters and filter gravel. This rig was also used for developing boreholes by double tube airlift and pumping test operations.
3. **Hotline**: Only used for conducting pumping tests.
4. **Steyns Cable Tool Rig**: Used for developing and conducting slug tests.

Drilling started on the 10th of April 2000 and was completed on the 16th August 2000. The drilling method employed was mostly Mud-rotary, but the air rotary method was also employed throughout the programme.
Due to supply problems, the final pumping test by pressure probe on the free flowing boreholes could only be conducted and the results evaluated during November 2000.

The data collected at each borehole is presented in a separate report. This report details the results and interpretation for borehole **J 8 N at Twee Reviere.**

Contents per Chapter

1. Geological Borehole Log

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

GEOLOGICAL BOREHOLE LOG

Farm Twee Reviere
Jica Reference: J 8 N
Date completed: 27 July 2000

WW 39856
S 25.46148°
E 19.43324°
Collar elev. : 1015 m

Depth below surface (m)	Section (m)	Lithology	Stratigraphy
0 - 3	3	Calcrete, moderately karsted. Shallow cover of pale orange sand. Karst cavities filled with orange to pale red sand.	
3 - 12	9	Pinkish calcretized conglomerate. Matrix is a fine to medium grained pinkish grey calcareous sandstone, with pebbles and boulders of grey and brown quartzite and sandstone.	
12 - 14	2	Very light grey to white sandy calcrete.	**KALAHARI**
14 - 19	5	Pale grey to pale brown sandy calcrete. Drill-cuttings recovered in a clayey mass. Saline encrustations on dry cuttings. (= sulphate ?)	
19 - 30	11	Pale grey to white sandy calcrete with minor clayey horizons at 23, 28 m. At 21 m red sandstone pebbles in calcareous sandstone matrix.	
30 - 36	6	Sandstone very pale brown, mostly fine grained unsorted, calcareous. Grains sub-rounded. Saline coating on dry drill cuttings.	
36 - 141	105	Sandstone, generally pale reddish brown, gradually changing to reddish brown at depth. Grain-size unsorted very fine to medium, with generally finer grained at 135 to 141 m. Aquifer (aline!) Collected drill cuttings when dried before washing all develop a white saline coating.	
141 - 142	1	Sandstone, reddish brown, hard, unsorted fine to medium grained. Major FeO-staining.	
142 - 152	10	Light greyish brown sandstone, medium grained, sub-rounded and porous. Disseminated gypsum from 148 to 150 m. Moderately calcareous, but very calcareous at 149 to 152 m.	
152 - 155	3	Sandstone, gradually changing to quartzite, purplish to dark brown fine to medium grained, poorly porous.	**AUOB A 5**
155 - 156	1	Dark purplish brown quartzite. Non-porous. Very thin horizon of basalt (only one positively identified chip!) Calcareous.	
156 - 157	1	Quartzite / very hard baked calcareous sandstone, purplish brown.	
157 - 164	7	Sandstone, calcareous, purplish brown, medium to coarse grained.	
164 - 172	8	Sandstone with minor intercalated red shale layers,	

		sandstone purplish brown, calcareous, coarse grained.	
172 - 176	4	Lost sample due to cross over to air-rotary as requested for collection of water samples.	**AUOB A 5**
176 - 183	7	Sandstone, purplish to purplish-brown with abundant muscovite. Sandstone increasingly laminated with depth. FeO staining on laminations. Slightly feldspathic.	
183 - 191	8	Intercalated laminated sandstone / shale, purplish. Laminations in sandstone well developed. Muscovite in sample.	
191 - 194	3	Shale, black/dark grey, intercalated with dark purplish sandstone. Shale is sandy and micaceous.	**AUOB A 4**
194 - 209	15	Dark grey well laminated shale. Minor calcite at 207 m. Regular pyrite in cuttings. Pyrite occurs in thin laminae of piritiferous sandstone.	
209 - 221	12	Grey sandstone with intercalations of darker grey siltstone, apparently cyclic. Muscovite on laminations. Sandstone fine to medium grained. Abundant pyrite at 214 m.	**AUOB A 3**
221 - 233	12	Grey to dark grey laminated shale with minor piritiferous sandstone horizons.	**AUOB A 2**
233 - 241	8	Medium grained pale grey sandstone, non-calcareous. Sandstone laminated with muscovite.	**AUOB A 1**
241 - 266	25	Intercalations of pale grey siltstone/shale.	**MUKOROB**
266 - 319	53	Shale, grey with minor horizons of light grey. Below 298 m the shale is dark grey.	
319 - 324	5	Medium to fine grained pale grey to white sandstone.	**NOSSOB**
324 - 328	4	Grey hard medium grained sandstone	
328 - 330	2	Light grey fine grained sandstone, intercalated with thin laminated grey shale	
330 - 331	1	Grey shale	
331 - 337	6	Finegrained light grey sandstone, with increasing laminated shale in depth. Shale grey.	
337 - 342	5	Grey shale	**DWYKA**
342 – 346 EOH	4	Pale grey shale/mudstone with drop-stones at 344 m.	

REMARKS:

1. Up to a depth of 172 m, drilling was done by the mud-rotary method, with resulting highly ground drill cuttings.
2. Below 172 m, up to a depth of 319 m, drilling was done by air-rotary method, resulting in a better quality drill cutting collected.
3. From 319 m to 346 m again the drilling method employed was the mud-rotary method.
4. Penetration rates are also totally dependent on the drilling method employed. Generally, the up-hole velocity achieved during air-rotary drilling is much higher than during the mud-rotary method, resulting in not only a better penetration rate, but also in the recovery of a higher quality of drill cuttings.

This borehole was logged by F. Bockmuhl.

2. Penetration Record

	Penetration Record J 8 N			
Depth (m)	**Pen. Rate (min/m)**	**Time**	**Date**	**Remarks**
1				
5				
	3.65			
	4			
	5.55			
10	8.6			
	5.6			
	4.15			
	5.45			
	5.4			
	5.75			
	4.35			
	5.75			
	6.15			
	9.1			
20	6.65			
	9.6			
	8.2			
	7.25			
	7.8			
	5.7			
	9.9			
	7.7			
	7.1	Time 18:20	Date 10/7/00	
	7			
30	6			
	7.4			
	6.6			
	7.5			
	9.9			
	8.55			
	8.1			
	8.25			
	8.2			
	7.1			
40	7			
	8.1			
	8.85			
	11.6	Time 08:20	Date 11/7/00	
	7.65			
	7.75			
	7.75			
	8			
	7			
	9.35			
50	10.6			
	9.55			
	10.6			
	10.25			
	9.2			

	10.3			
	9.75			
	9.25			
	9.6			
	8.6			
60	8.75			
	10.8			
	9.65			
	9.8			
	9.45			
	8.8			
	9			
	9.3			
	9.3			
	8.85			
70	9.4			
	10.7			
	9.35			
	8.5			
	7.2			
	9.8			
	10.75			
	8.85			
	9.25			Stop, change to air rotary drilling
	6.8	Time 14:32	Date 11/7/00	Start air rotary
80	8.85			
	4.9			
	3.95			
	9.45			
	4.7			
	6.2			
	4.7			
	6.8			
	3.75			
	7.85			
90	7.3			
	9.25			
	4.45			
	2.1			Water loss
	5.7			
	4.1			
	1.75			Water loss
	2.5			
	3.6			
	4.25			
100	3.25			
	2.25			
	2.05			
	2.1			
	2.9			
	2.65			
	3.3			
	2.7			
	2.9			
	2.45			
110	4.25			

	4.3			
	4.75			
	3.95			
	4.7			
	4.45			
	4.3			
	6.1			
	3.85			
	7.75			
120	6.85			
	4.45			
	4			
	4.7			
	10.05			
	4.7			
	3.95			
	3.25			
	3.15			
	3.7			
130	5.05			
	4.5			
	3.95			
	4.75			
	4.45			
	4.9			
	3.35			
	5.5			
	6.1			
	2.95			
140	4			
	11.85		Date 12/7/00	Mud rotary drilling
	21.4	Time 08:25		
	12			
	12.45			
	13.35			
	16.9			
	19			
	16.9			
	15.2			
150	13.25			
	18.9			
	13.25			
	11.7			
	11.75			
	24.45			
	37.6	Time 12:55		
	21.15			
	21.2			
	20.3			
160	15.45			
	9.25			
	11.65			
	11.65			
	12.95			
	12.95			
	13.35			

	13.35			
	15.05			
	11.3	Time 16:30		Add second pump
170	12.4			
	16.55			
	10.5	Time 17:25		End of 311 mm drilling
	2.75	Time 08:35	Date 15/7/00	Air rotary drilling 200 mm
	3.6			
	4.45			
	3.75			
	3.95			
	2.15			
180	3.35			
	2.5			
	1.55			
	1.4			
	1.5			
	2.05			
	1.75			
	2.45			
	2.35			
	2.4			
190	2.4			
	1.95			
	1.4			
	1.95			
	1.7			
	1.85			
	2.05			
	2.15	Time 09:54		
	1.55			
	2			
200	2.1			
	2			
	2			
	1.6			
	1.8			
	2.5			
	1.9			
	2.15			
	2.3			
	2.2			
210	2			
	1.7			
	2			
	1.85			
	1.8			
	1.7			
	1.8			
	1.4			
	1.6			
	2.35			
	2.7			
	2			
	1.35			

	1.3			
	1.25			
	1.45			
	1.5			
	1.55			
	1.5			
	1.55			
	2			
	2.15			
	1.6			
	1.95			
	1.65			
	1.8			
	2			
	1.9			
	1.8			
	0.9			
	1.45			
	1.75			
	1.55			
	1.65			
	1.4			
	1.8			
	1.25			
	1.15			
	1.95			
	2			
	1.75			
	1.9			
	1.85			
	1.7			
	1.7			
	1.95			
	2.05			
	1.5			
	1.7			
	1.8			
	1.6			
	1.9	Time 12:30		
	2.6		Date 18/7/00	Air rotary drilling 200 mm
	3.1			
	3.1			
	2.6			
	2.65			
	2.75			
	2.6			
	1.85			
	2.6			
	2.25			
	2.4			
	2.85			
	2.6			
	3			
	2.75			

	2.85			
	2.45			
	2.45			
	2.55			
	2.4			
	2.5			
	2.65			
	2.9			
	2.8			
	3.1			
	3.5			
	3.25			
	2.4			
	2.75			
	3.3			
	2.55			
	2.4			
	2.5			
	2.45			
	2.9			
	2.5			
	2.45			
	2.55			
	2.5			
	2.4			
	2.35			
	2.5			
	2.5			
	2.5			
	2.65			
	2.2			
	2.9			
	2.8			
	2.5			
	2.3			
	2.75			
	2.6			
	2.5			
	2.25			
	2.15			
	2.4			
	4.2			
	6.25			
	6.3			
	6.25			
	6			
	22.9	Time 19:50	Date 18/7/00	End air rotary drilling
			Date 19/7/00	Start mud rotary drilling 200 mm
	49.2			
	20.4			
	14			
	14.65			
	15.3			
	15.15			
	13.25			
	13.6			

	14.95			
	16.25			
	14.55			
	13.95			
	14.15			
	14.5			
	14.15			
	16.25			
	23.45			
	19.2			
	19.3			
	22.65			End of borehole

j8npen

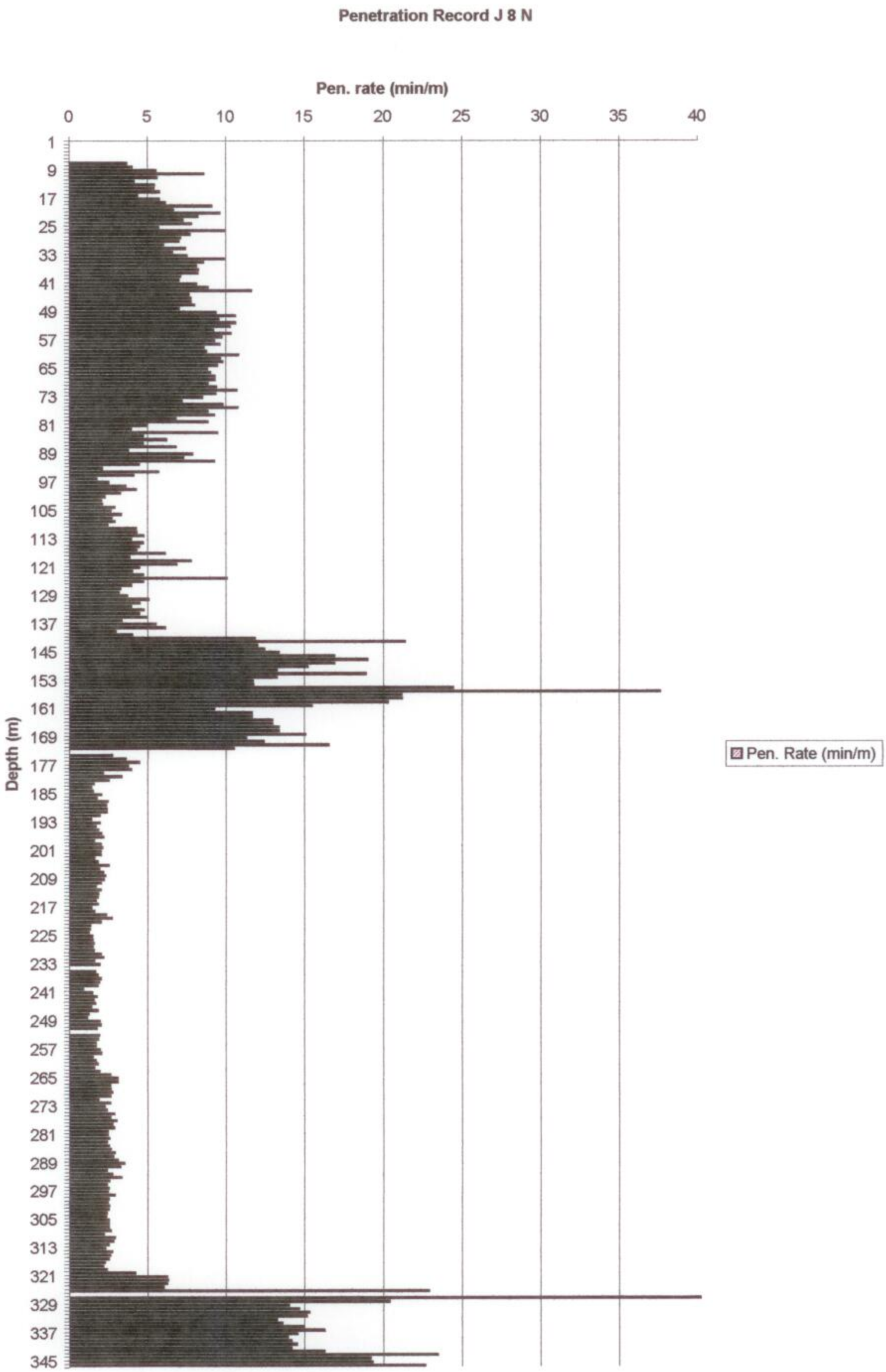


Chart1

3. Mud Rotary Drilling Log

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

MUD ROTARY DRILLING LOG

JICA REFERENCE: J 8 N LOCALITY: Twee Reviere R 481 WW 39856 DATE: July 2000

TIME	DEPTH mbgl	MARSH FUNNEL TEST 1000 ml	MARSH FUNNEL TEST 500 ml	E. C. MS/cm	DENSITY	PH	TEMPERATURE ° C	COMMENT
(10/07)	42	39	26	7.25		9		
(11/07)	141	35	24			9		
18:10 (12/07)	*172*	*35*	*24*	*4.52*		*9*	*24.7*	*Before logging the 311 mm borehole, measurements at the end of drilling*
		29	19	4.69		9	14.9	Water used for mixing
13:07 (15/07)	*263*	*29*	*19*	*5.83*		*9*	*27.8*	*Air rotary drill fluid + water from borehole, measured before logging*
		29	19	4.43		9	15.9	Water used for drilling air rotary
(19/07)	*346*	*29*	*18*	*6.75 to* ***5.04****	*<1.16*	*9*	*23.5*	*Air rotary assisted drilling with drillfluid + water from borehole Before logging*
		29	19	4.7 and **2.94***		9	14.7	Water used for drilling air rotary

* At Twee Reviere it was difficult to find water for drilling. Water from different sources was used esp. at the end of drilling. The bold data was measured immediately after the drill-string was removed from the borehole.

5. Borehole Development Data

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

BOREHOLE DEVELOPMENT DATA

JICA REFERENCE: J 8 N LOCALITY: Twee Reviere R 481 WW 39856 DATE: 23/07/2000 (starting)

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
08:00						Date 23/07/00: Install airlift pipes. Introduce 25 kg STPP.
17:00	317					Date 24/07/00. Start to airlift, re-circulate water in order to effectively distribute STPP throughout borehole.
07:30						Date 25/07/00. Start normal pumping by airlift after 14.5 hours re-circulation.
08:00	317				54.09	
09:00		30			56.23	
10:00		20			66.30	
14:00		<10				
17:00		<10		2340	164	Stop
07:30					126	Date 26/07/00. No airlifting.
08:00				2850		**Date 28/07/00: Cable tool data.** Bailing and plunging.
17:00					56	Bail 68 bailers @ 35 l
15:00					73.15	Date 29/07/00. Plunge.
17:00						Bail: 45bailers @ 35 l
08:00				5030		Date 30/07/00. Bailing
17:00						Bailing

TIME (actual)	P.I.D. (mbsu)	½ 90° V-Notch (mm)	Yield (m^3/h)	E.C. (mS/m)	Water Level (mbsu)	Remarks
08:00				5030	86	Date 31/07/00.
17:00						Bail 86 bailers @ 35 l.
08:00					96	Date 1/8/00: Bailing and plunging.
17:00						Bailing.
08:00					92	Date 2/8/00.
17:00				>1999		Bailing and plunging.
08:00					90	Date 3/8/00.
17:00						End developing by cable tool.

Remarks:

1. This low yielding borehole was not developed by electrical submersible pump.

6. Evaluation of Pumping Test

1. EVALUATION OF SLUG TEST

Borehole **J8-N** was tested using a 3 m long slug. The first test was done after the slug was lowered (**See Figures 1 and 2**), while the second test was done after the slug was pulled out of the borehole (**See Figures 3 and 4**).

The Cooper Bredenhoeft-Papadopulos (type curve) and Bouwer-Rice (straight line) solutions for confined aquifers were used to evaluate the transmissivity and hydraulic conductivity of the sandstone aquifer (**See Table 1**).

Table 1: Solutions for slug test J8-N

Test	Solution	T [m^2/day]	K [cm/sec]	Y_0 [m]	S* [--]
Lower Slug	Cooper-Bredehoeft-Papadopulos	0.005			0.1
	Bouwer-Rice		5.4×10^{-7}	0.64	
Pull Slug	Cooper-Bredehoeft-Papadopulos	0.02			1.8×10^{-6}
	Bouwer-Rice		8.8×10^{-7}	0.72	

* estimated

T = transmissivity [m^2/day]
K = hydraulic conductivity [cm/sec]
Y_0 = original displacement [m]
S* = estimated storativity [--]

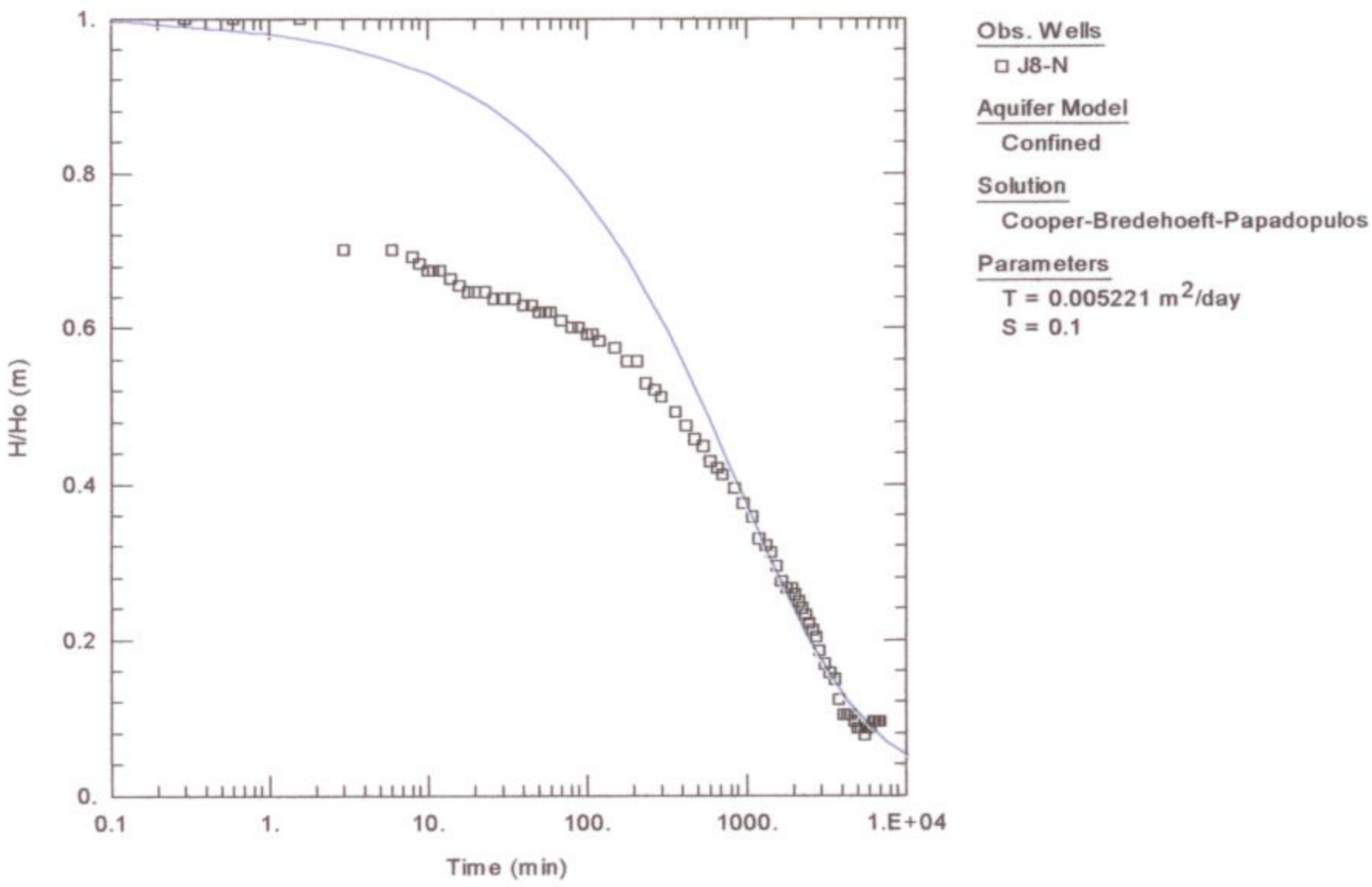


Figure 1: Lower slug; Cooper-Bredehoeft-Papadopulos Solution

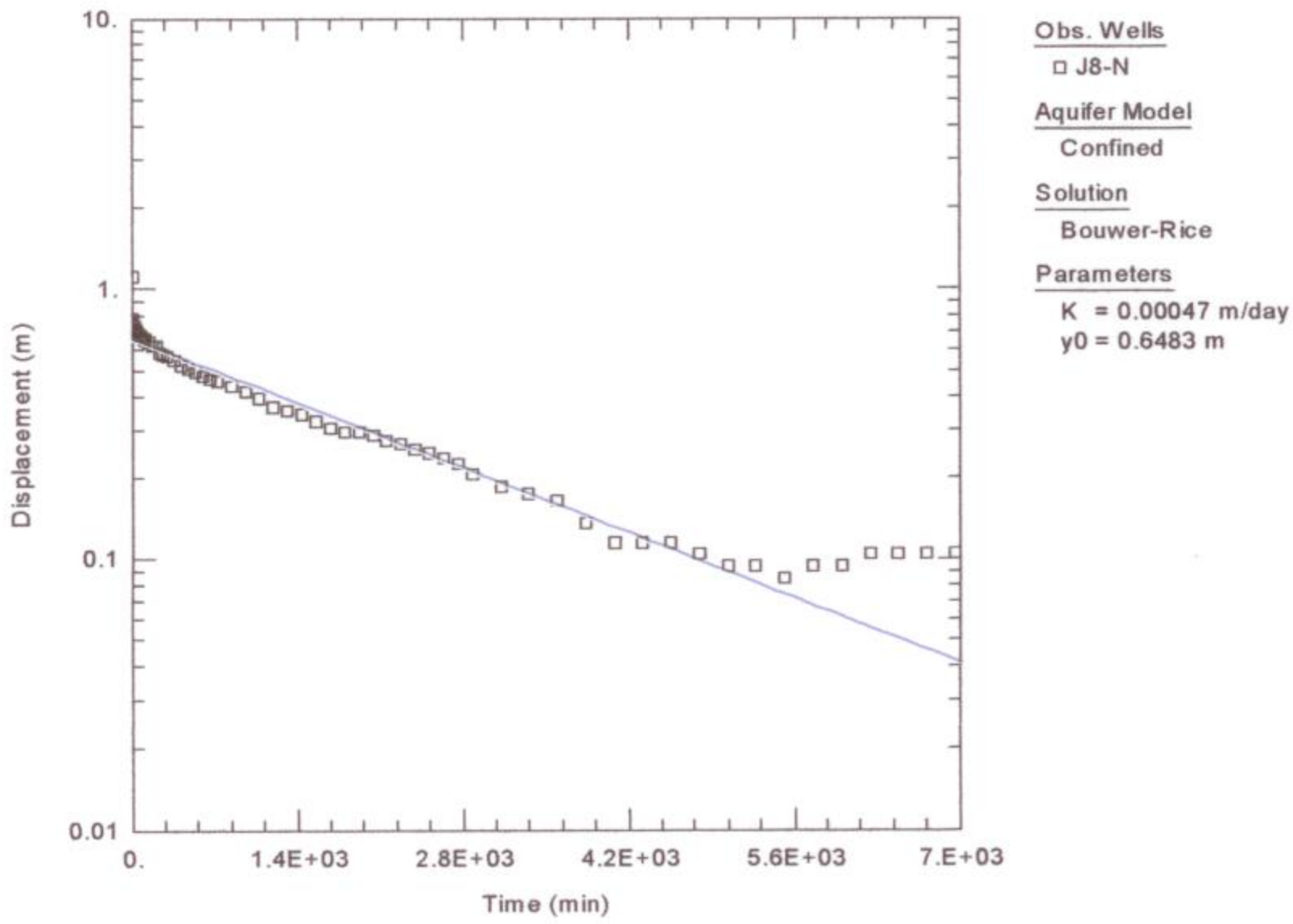


Figure 2: Lower slug; Bouwer-Rice Solution

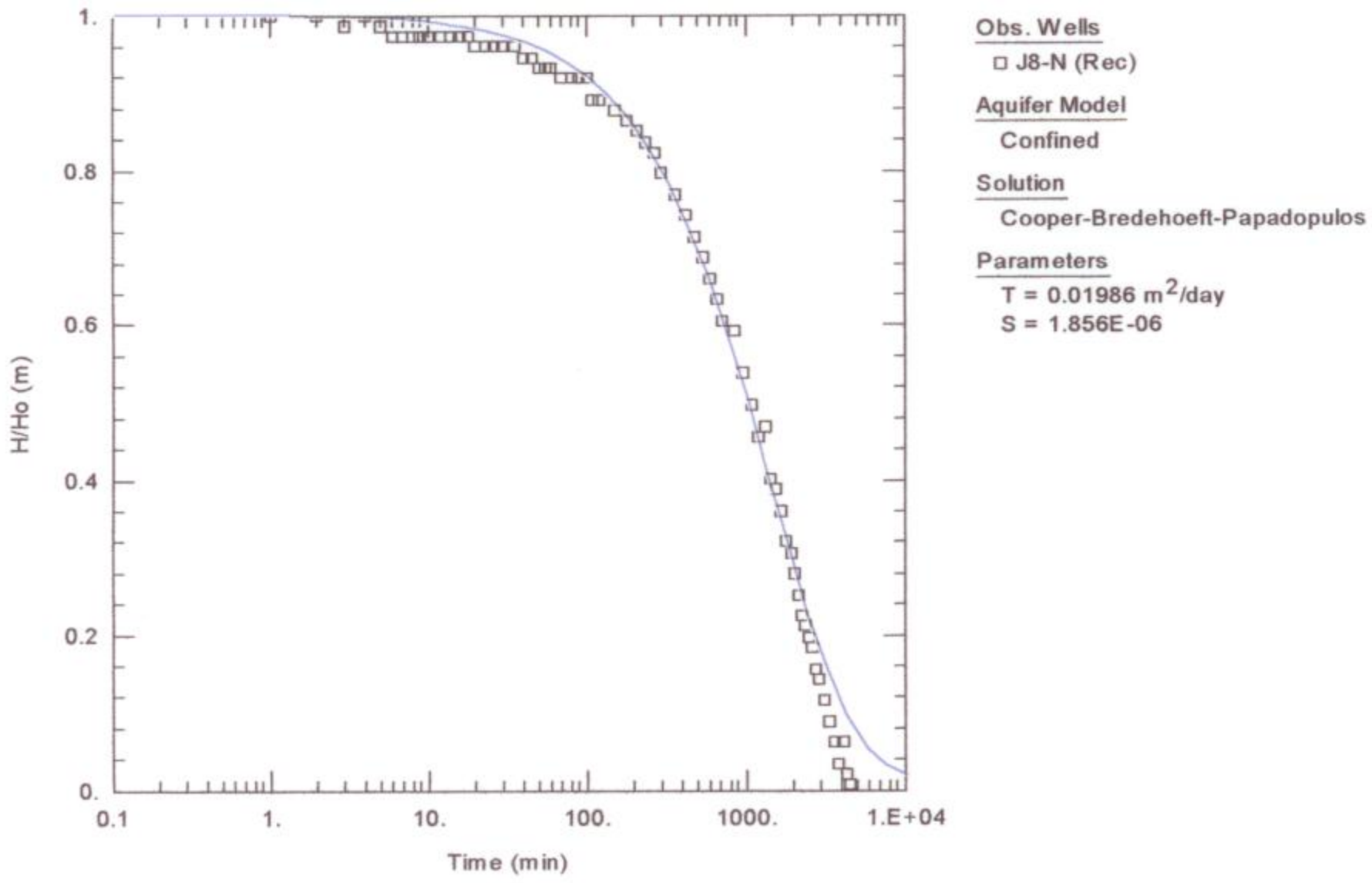


Figure 3: Pull slug; Cooper-Bredehoeft-Papadopulos Solution

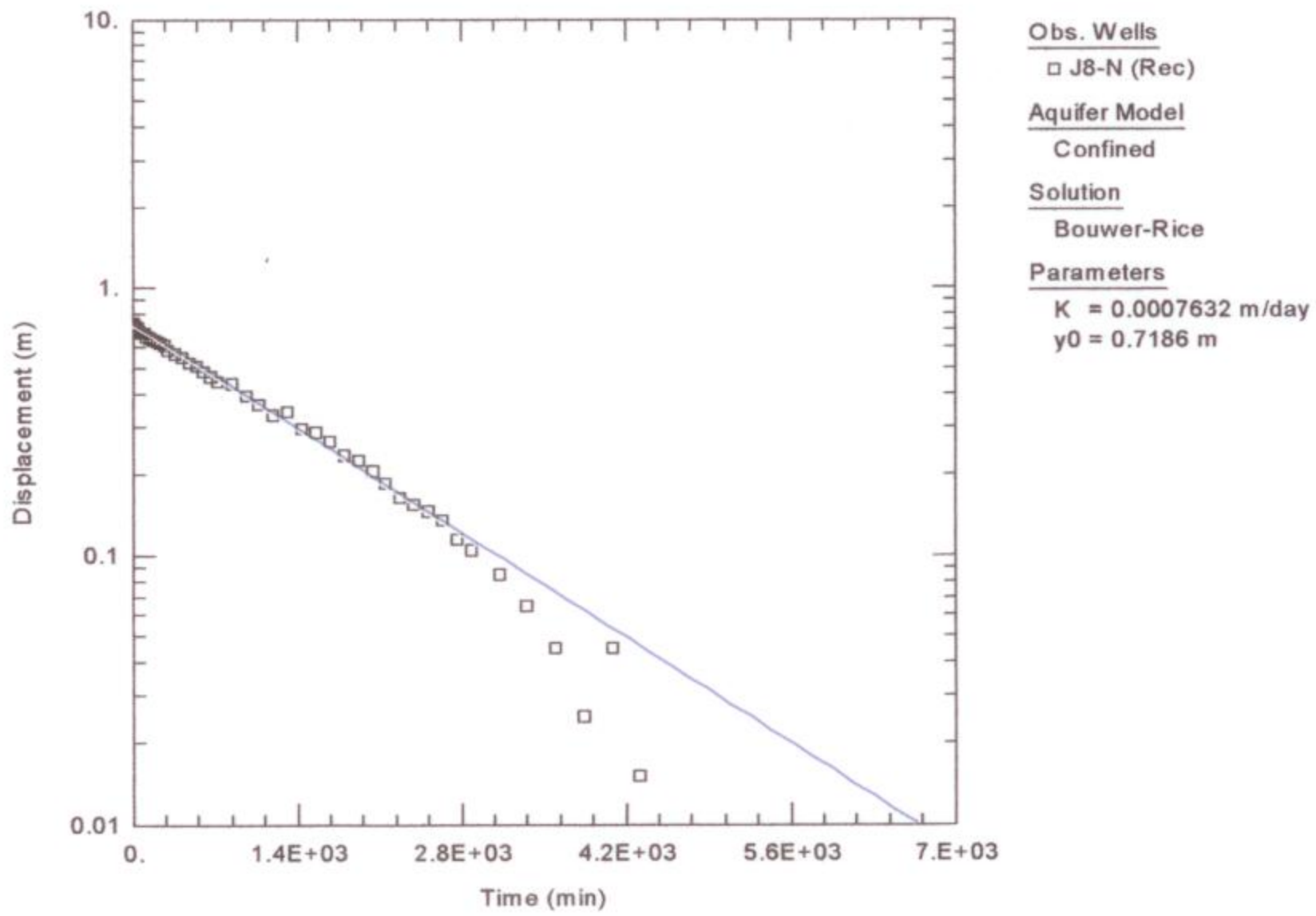


Figure 4: Pull slug; Bouwer-Rice Solution

7. Water Level Recorder Installation

THE STUDY ON THE GROUNDWATER POTENTIAL EVALUATION AND MANAGEMENT PLAN IN THE SOUTHEAST KALAHARI (STAMPRIET) ARTESIAN BASIN

INSTALLATION OF SEBA FLOATERS

JICA REFERENCE: J 8 N LOCALITY: Twee Reviere R 481

WW 39856

1. **Serial Number of floater**:
2. **Date installed**: 04/10/00
3. **Rest Water Level when installed**: 21.83 m
4. **Distance from stick-up to logger**: 13.00 m
5. **Distance from logger to water level**: 8.83 m
6. **Cut off**: 13.0 m (12.11 + 0.91 m)