Table 6.1-1 Summary of Test Borehole Data

Locality Information							Borehole Structure				Pumping Data									
Location		Borehole Number		Coordination			Depth drilled (m)	Screen Pipe			Static water level			Yield (m^3/h)	Dynamic water level (mbgl)	Specific yield ($m^3/h/m$)	EC (mS/m)	TDS (mg/lit.)	pH	Temp. ℃
No.	Farm Name	JICA Ref. No.	WW No.	Latitude (d:m:s) / Latitude (decimal)	Longitude (d:m:s) / Longitude (decimal)	Elevation (masl)		from (mbgl)	to (mbgl)	Thick-ness (m)	(mbgl)	(masl)	Date							
J1	Christiana	J1A	39839	23°15'14.9" / 23.25415	18°59'12.0" / 18.98668	1331.71	256.00	84.00	180.55	30.55	57.49	1274.22	2000/5/6	8.00	68.29	0.741	85	553	7.62	25.0
J2	Olifantswater West	J2A	39840	23°38'50.9" / 23.64747	18°23'19.4" / 18.38873	1275.26	130.51	95.05	127.51	26.41	16.94	1258.32	2000/3/7	3.40	54.94	0.089	90	585	7.78	25.8
		J2N	39841	23°38'53.1" / 23.64808	18°23'19.4" / 18.38871	1275.60	209.00	181.07	204.47	23.40	39.72	1235.88	2000/2/7	2.90	73.93	0.085	91	592	8.34	30.0
J3	Steynsrus	J3K	39842	24°02'45.3" / 24.04592	18°47'36.2" / 18.7934	1208.05	102.00	44.23	76.90	17.52	19.35	1188.7	2000/10/7	1.50	29.84	0.143	330	2,145	7.17	21.9
		J3A	39843	24°02'52.5" / 24.04792	18°47'35.2" / 18.79312	1205	253.00	121.34	247.74	32.15	15.77	1189.23	2000/4/7	19.88	20.26	4.428	115	771	(7.5)	29.3
		J3N	39844	24°02'54.9" / 24.04858	18°47'46.1" / 18.79614	1205	409.00	336.80	363.40	14.60	-24	1229	2000/7/9	0.15	-	-	461	3,089	8.41	14.4
J4	Okanyama (Aminuis)	J4K	39845	23°24'03.5" / 23.40098	19°37'29.6" / 19.62489	1258.05	53.20	30.00	50.30	20.30	45.1	1212.95	2000/2/10	0.10	50.71	0.018	227	1,476	8.58	29.3
		J4A	39846	23°24'01.8" / 23.40049	19°37'32.8" / 19.62577	1256.39	204.00	59.60	175.97	56.05	59.13	1197.26	2000/8/9	19.70	79.54	0.965	646	2,119	7.47	23.8
		J4N	39847	23°24'03.8" / 23.40105	19°37'34.4" / 19.62621	1256.38	356.00	328.00	351.35	23.35	10	1246.38	2000/10/7	11.80	65.31	0.213	100	650	8.89	30.3
J5	Maritzville	J5N	39848	24°19'41.7" / 24.32824	18°23'52.6" / 18.39794	1168.33	187.00	158.00	179.23	20.46	-20	1188.33	21/8/2000	0.80	26.46	0.017	139.5	904	8.27	31.1
J6	Cobra	J6K	39849	24°48'00.3" / 24.80009	19°20'05.4" / 19.33483	1102.67	168.50	108.50	165.00	17.50	101.98	1000.69	2000/5/8	3.00	122.7	0.145	2,310	15,015	9.09	29.8
		J6A	39850	24°48'02.1" / 24.80059	19°20'06.7" / 19.3352	1102.47	273.00	237.90	264.00	26.10	104.41	998.06	31/7/2000	3.96	128.29	0.166	188	1,216	8.54	26.9
		J6N	39851	24°47'58.7" / 24.79963	19°20'04.5" / 19.33457	1103.18	385.00	350.18	373.58	23.40	-16	1119.18	Oct-00	-	-	-		0		27.8
J7	Jackalsdraai	J7K	39852	25°17'29.9" / 25.29163	18°25'00.4" / 18.41678	1144	55.00	27.60	51.00	23.40	10.04	1133.96	21/8/2000	7.15	19.44	0.761	103	670	7.44	27.0
		J7N	39853	25°17'28.2" / 25.29117	18°24'59.4" / 18.4165	1144	250.00	226.83	241.33	14.50	22.45	1121.55	2000/5/8	0.30	88.33	0.005	431	2,743	9.08	29.1

Locality Information							Borehole Structure				Pumping Data										
Location		Borehole Number		Coordination			Depth drilled (m)	Screen Pipe			Static water level			Yield (m^3/h)	Dynamic water level (mbgl)	Specific yield ($m^3/h/m$)	EC (mS/m)	TDS (mg/lit.)	pH	Temp. ℃
No.	Farm Name	JICA Ref. No.	WW No.	Latitude (d:m:s) / Latitude (decimal)	Longitude (d:m:s) / Longitude (decimal)	Elevation (masl)		from (mbgl)	to (mbgl)	Thick-ness (m)	(mbgl)	(masl)	Date							
J8	Tweerivier	J8K	39854	25°27'40.4" / 25.46122	19°25'57.6" / 19.43266	1021.25	129.00	84.60	114.00	23.40	60.31	960.94	21/7/2000	0.24	75.2	0.016	351	2,282	8.74	27.0
		J8A	39855	25°27'42.3" / 25.46174	19°26'01.4" / 19.43373	1021.13	250.00	234.10	242.80	8.70	172.32	848.81	Oct-00	-	-	-	1,039	6,754	12.19	28.0
		J8N	39856	25°27'41.3" / 25.46148	19°25'59.7" / 19.43324	1021.26	346.00	320.15	337.55	17.40	20.77	1000.49	Oct-00	-	-	-	>5,000	33,500	8.64	21.8
J9	Klein Swart Modder	J9A	39857	24°00'06.5" / 24.00182	18°12'55.0" / 18.21529	1210.16	141.50	65.43	135.33	69.90	2.23	-2.23	30/8/2000	45.00	5.05	15.957	101	656	7.69	28.6

Table 6.1-2 Depth and Thickness of the Each Formation

Locality Information						Geological Formation															
Location		Borehole Number		Elev. (masl)	Drilling Depth (mbgl)	Unit	Kalahari	Kalkrand Basalt	Dolerite	Rietmond		Auob					Mukorob		Nossob	Dwyka	Basement Rock
No.	Farm Name	JICA Ref. No.	WW No.							Upper	Lower	A5	A4	A3	A2	A1	Upper	Lower			
J1	Christiana	J1A	39839	1331.71	256	Dep.(mbgl)	0	-	-	4	21	83.5	117	123.5	145	171	-	198	-	236	253
						Thick.(m)	4	-	-	17	62.5	33.5	6.5	21.5	26	27	-	38	-	17	3+
J2	Olifants-water West	J2A	39840	1275.26	131	Dep.(mbgl)	0	-	-	11	40			90			115				
						Thick.(m)	11	-	-	29	50			25			16+				
		J2N	39841	1275.60	209	Dep.(mbgl)	0	-	-	12	43			90			117	142	181	204	207.5
						Thick.(m)	12	-	-	31	47			27			25	39	23	3.5	1.5+
J3	Steynsrus	J3K	39842	1208.05	102	Dep.(mbgl)	0	-	-	53											
						Thick.(m)	53	-	-	49+											
		J3A	39843	1208.05	253	Dep.(mbgl)	0	-	-	48	-	121	145	151	177	226.5	246				
						Thick.(m)	48	-	-	73	-	24	6	26	49.5	19.5	7+				
		J3N	39844	1208.05	409	Dep.(mbgl)	0	-	-	50	-	118	143	149	176	226.5	246.5	275	336	366	
						Thick.(m)	50	-	-	68	-	25	6	27	50.5	20	28.5	61	30	43+	
J4	Okanyama (Aminuis)	J4K	39845	1258.05	53	Dep.(mbgl)	0	-	14.5												
						Thick.(m)	14.5	-	38.5+												
		J4A	39846	1256.39	204	Dep.(mbgl)	0	-	15.5	-	-	53.5	87.5	95.5	130	155	177.5				
						Thick.(m)	15.5	-	38	-	-	38	8	34.5	25	22.5	26.5+				
		J4N	39847	1256.38	356	Dep.(mbgl)	0	-	16	-	-	57.5	93	96	130	154.5	183	270	329	351	
						Thick.(m)	16	-	41.5	-	-	35.5	3	34	24.5	28.5	87	59	22	5+	
J5	Maritzville	J5N	39848	1168.33	187	Dep.(mbgl)	-	-	-	0	43			53			96	105	158	183	
						Thick.(m)	-	-	-	43	10			43			9	53	25	4+	
J6	Cobra	J6K	39849	1102.67	168	Dep.(mbgl)	0	-	-	158											
						Thick.(m)	158	-	-	10+											
		J6A	39850	1102.47	273	Dep.(mbgl)	0	-	-	158	168	177	209	222	232	236	264				
						Thick.(m)	158	-	-	10	9	32	13	10	4	28	9+				
		J6N	39851	1103.18	385	Dep.(mbgl)	0	-	-	158	168	177	209	222	232	236	264	285	352	380	
						Thick.(m)	158	-	-	10	9	32	13	10	4	28	21	67	28	5+	
J7	Jackalsdraai	J7K	39852	1148.19	55	Dep.(mbgl)	0	-	-	48											
						Thick.(m)	48	-	-	7+											
		J7N	39853	1148.14	250	Dep.(mbgl)	0	-	-	49	-	68.5	89	127	154.5	155	166	175	228	245	
						Thick.(m)	49	-	-	19.5	-	20.5	38	27.5	0.5	11	9	53	17	5+	
J8	Tweerivier	J8K	39854	1021.25	129	Dep.(mbgl)	0														
						Thick.(m)	129+														
		J8A	39855	1021.13	250	Dep.(mbgl)	0	-	-	-	-	141	183	209	221	233	241				
						Thick.(m)	141	-	-	-	-	42	26	12	12	8	9+				
		J8N	39856	1021.26	346	Dep.(mbgl)	0	-	-	-	-	141	183	209	221	233	241	266	319	337	
						Thick.(m)	141	-	-	-	-	42	26	12	12	8	25	53	18	9+	
J9	Klein Swart Modder	J9A	39857	1210.16	141.5	Dep.(mbgl)	-	0	-	-	-			65.5			-	-	-	-	140
						Thick.(m)	-	65.5	-	-	-			74.5			-	-	-	-	1.5+

Note: "Dep.(mbgl)" means the Depth(mbgl) of top of the Formation

Table 6.1-3 The Aquifers which Water Samples are Taken, and the Items Analysed

Locality Information											Sample taken for					
Location		Borehole Number		Kalahari			Auob			Nossob						
No.	Farm Name	JICA Ref. No.	WW No.	Kalahari	Basalt / Dorelite	Upper Rietmond	A5	A3	A1		^{18}O	^{2}H	^{3}H	^{15}N	^{14}C	Chemical Analysis
J1	Christiana	J1A	39839					●			✓	✓	✓	✓	✓	✓
							▲(96m)				✓	✓	✓	-	-	-
J2	Olifantswater West	J2A	39840					●			✓	✓	✓	✓	✓	✓
								▲ (Upper part of Auob,96m)			✓	✓	✓	-	-	✓
		J2N	39841							●	✓	✓	✓	-	✓	✓
J3	Steynsrus	J3K	39842		● (K+R)						✓	✓	✓	✓	✓	✓
		J3A	39843					●			✓	✓	-	-	✓	✓
							▲(122m)				✓	✓	✓	-	-	✓
		J3N	39844							●	✓	✓	-	-	✓	✓
								▲(159m)			✓	✓	✓	-	-	✓
J4	Okanyama (Aminuis)	J4K	39845		●(Dorelite)						✓	✓	✓	✓	✓	✓
		J4A	39846					●			✓	✓	✓	✓	✓	✓
							▲(79m)				✓	✓	✓	-	-	✓
		J4N	39847							●	✓	✓	✓	-	✓	✓
J5	Maritzville	J5N	39848							●	✓	✓	-	-	✓	✓
							▲ (57m)				✓	✓	-	-	-	-
									▲ (158m)		✓	✓	-	-	-	✓
J6	Cobra	J6K	39849		● (K+R)						✓	✓	✓	✓	✓	✓
		J6A	39850						●(A1 only)		✓	✓	-	-	✓	✓
							▲(208m)				✓	✓	-	-	-	✓
		J6N	39851							●	✓	✓	-	✓	✓	✓
J7	Jackalsdraai	J7K	39852		●(K+R)						✓	✓	✓	✓	✓	✓
		J7N	39853							●	✓	✓	-	-	✓	✓
								▲ (A3+A1, 163m)			✓	✓	-	-	-	✓
J8	Tweerivier	J8K	39854	●							✓	✓	✓	✓	✓	✓
		J8A	39855						●(A1 only)		✓	✓	-	✓	✓	✓
				▲(137m)							✓	✓	-	-	-	✓
					▲ (K+A5, 155m)						✓	✓	-	-	-	✓
		J8N	39856							●	✓	✓	-	-	✓	✓
								▲ (A3+A1, 263m)			✓	✓	-	-	-	✓
J9	Klein Swart Modder	J9A	39857					●			✓	✓	-	✓	✓	✓
					▲(B,43m)						✓	✓	-	-	-	✓
							▲ (Basalt+Auob, 115m)				✓	✓	-	-	-	✓

Table 6.1-4 Results of Water Quality and Isotope Analysis of JICA Test Boreholes

Locality Information				Isotope Analysis						Samples			Chemical Contents															
Location		Borehole Number																										
No.	Farm Name	JICA Ref. No.	WW No.	Laboratory Number	^{18}O (o/oo)	^{2}H (o/oo)	^{3}H (TU)	^{14}C (pMC)	^{15}N	Sample Number	Date Sample taken	Date Sample analysed	pH	Conductivity mS/m	Total Dissolved Solids	Sodium as Na	Potassium as K	Sulphate as SO4	Nitrate as N	Nitrite as N	Silicate as SiO2	Fluoride as F	Chloride as Cl	Total Alkalinity as CaCO3	Phenolphthalein Alkalinity as CaCO3	Total Hardness as CaCO3	Calcium as CaCO3	Magnesium as CaCO3
J1	Christiana	J1A	39839	G4972	-7.03	-51	0.0 ± 0.2	14.6 ± 0.3	9.5	DS6838	14-Jun-00	2-Oct-00	8.2	84.1	563	92	11	12	9.8	<0.1	27	0.2	30	356		256	110	146
J2	Olifantswater West	J2A	39840	G4977	-6.65	-50	0.0 ± 0.2	3.0 ± 0.2	13.8	DS6836	20-Jun-00	2-Oct-00	8.1	90.3	605	140	11	35	13.8	0.1	23	0.6	63	300		155	55	100
		J2N	39841	G4976	-6.72	-50	0.0 ± 0.2	4.0 ± 0.2	-	DS6835	11-Jun-00	2-Oct-00	8.3	92.0	616	190	5	97	2.8	0.1	15	1.1	66	274		39	23	17
J3	Steynsrus	J3K	39842	G4992	-6.27	-47	0.0 ± 0.2	55.2 ± 0.6	10.6	DS6832	29-Jun-00	2-Oct-00	7.7	322.0	2,157	300	19	65	176.0	0.1	59	0.6	465	288		912	345	567
		J3A	39843	G4993	-6.99	-50	0.0 ± 0.2	25.5 ± 0.3	-	DS6833	8-Jul-00	2-Oct-00	8.1	115.6	775	145	9	43	23.1	0.5	39	1.2	47	426		269	140	129
		J3N	39844	G5044	-7.41	-52	-	1.4	-	DS7503	9-Oct-00	25-Oct-00	9.1	493.0	3,303	1,020	4	460	<0.5	<0.1	12	3.2	900	460	26.0	53	33	21
J4	Okanyama (Aminuis)	J4K	39845	G4975	-7.21	-50	0.0 ± 0.2	44.1 ± 0.4	-	DS6837	4-Jun-00	2-Oct-00	7.8	221.0	1,481	545	7	210	1.3	3.3	38	0.7	184	748		115	28	88
		J4A	39846	G4973	-7.19	-52	0.0 ± 0.2	60.1 ± 0.5	9.3	DS6834	23-May-00	2-Oct-00	8.0	311.0	2,084	465	18	290	17.5	<0.1	54	0.3	600	482		589	273	317
		J4N	39847	G4974	-7.85	-54	0.0 ± 0.2	0.25 ± 0.2	-	DS6839	31-May-00	2-Oct-00	8.5	99.2	665	230	4	31	<0.5	<0.1	15	0.7	29	448	10.0	7	3	4
J5	Maritzville	J5N	39848	G5037	-6.96	-52	-	1.7	-	DS7176	24-Aug-00	5-Oct-00	8.3	135.7	909	365	4	105	<0.5		15	2.4	45	592		9	5	4
J6	Cobra	J6K	39849	G4994	-5.03	-42	0.0 ± 0.2	6.2 ± 0.2	14.7	DS7177	27-Aug-00	5-Oct-00	9.2	2220.0	14,874	7,400	39	1,850	60.0		30	19.0	4,100	6,520	1,084	7	3	4
		J6A	39850	G4995	-7.07	-52	0.0 ± 0.2	0.9 ± 0.2	-	DS7174	4-Aug-00	5-Oct-00	8.4	186.3	1,248	495	5	125	<0.5		15	1.2	220	592		7	3	4
		J6N	39851																									
J7	Jackalsdraai	J7K	39852	G5038	-6.47	-48	0.0 ± 0.2	50.7	9.5	DS7171	25-Aug-00	5-Oct-00	7.7	97.8	655	121	5	82	14.0		73	0.7	63	316		268	118	150
		J7N	39853	G5039	-6.81	-50	-	10.8	-	DS7173	1-Sep-00	5-Oct-00	8.7	395.0	2,647	1,020	5	840	< 0.5		13	4.5	590	460	16.0	28	20	8
J8	Tweerivier	J8K	39854	G4996	-5.86	-47	0.0 ± 0.2	54.9 ± 0.2	13.0	D7175	15-Aug-00	5-Oct-00	8.7	328.0	2,198	880	12	320	15.0		34	3.7	295	1,068	52.0	13	5	8
		J8A	39855	G5041	-3.56	-36	-	99.3	8.9	DS7501	16-Sep-00	25-Oct-00	11.8	1,026.0	6,874	1,800	20	880	8.4	0.7	22	2.0	1,120	1,630	1,360	17	13	4
		J8N	39856	G5042	-4.52	-41	-	26.5	-	DS7502	16-Sep-00	25-Oct-00	9.0	5,890.0	39,463	17,000	32	8,500	<0.5	<0.1	1	0.8	20,500	118	24.0	406	160	246
J9	Klein Swart Modder	J9A	39857	G5040	-6.76	-51	-	47.5	7.5	DS7172	2-Sep-00	5-Oct-00	7.8	97.3	652	152	5	105	13.3		57	0.9	64	286		184	105	79

Table 6.1-5 Results of Water Quality and Isotope Analysis of Specified Aquifer in JICA Test Boreholes

Locality Information: Location		Locality Information: Borehole Number		Sample Data			Isotope Analysis						Chemical Contents																		
No.	Farm Name	JICA Ref. No.	WW No.	Aquifer	Depth	Date Sample Taken	Laboratory Number	Laboratory*	^{18}O (o/oo)	^{2}H (o/oo)	^{3}H (TU)	^{14}C (pMC)	Laboratory*	Laboratory Number	Date Sample analysed	pH	Conductivity mS/m	Total Dissolved Solids	Sodium as Na	Potassium as K	Sulphate as SO_4	Nitrate as N	Nitrite as N	Silicate as SiO_2	Fluoride as F	Chloride as Cl	Total Alkalinity as $CaCO_3$	Phenolphthalein Alkalinity as $CaCO_3$	Total Hardness as $CaCO_3$	Calcium as $CaCO_3$	Magnesium as $CaCO_3$
J1	Christiana	J1A	39839	A5	96	15-Apr-00	NAM 52	SL	-6.96	-49.4	0.1 ± 0.2	-				-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
J2	Olifantswater West	J2A	39840	Upper part of Auob	96	20-May-00	NAM 53	SL	-5.81	-46.3	0.3 ± 0.2	-	NW	DS6660	18-Jul-00	8.6	90.1	604	146	13	31	13.9	0.2	23	0.4	69	298		143	68	75
		J2N	39841																												
J3	Steynsrus	J3K	39842																												
		J3A	39843	A5	122	15-Jun-00	NAM 54	SL	-7.41	-51.3	0.3 ± 0.2	-	NW	DS6661	18-Jul-00	8.5	116	774	240	3	66	7.2	0.2	24	1.2	49	476		98	53	46
		J3N	39844	A3	159	27-May-00	NAM 55	SL	-5.93	-42.8	0.0 ± 0.2	-	NW	DS6662	18-Jul-00	8.5	88.8	595	114	10	43	18.7	0.1	43	0.5	47	308		214	110	104
J4	Okanyama (Aminuis)	J4K	39845																												
		J4A	39846	A5	79	23-Apr-00	NAM 56	SL	-6.96	-49.2	0.3 ± 0.2	-	NW	DS6663	18-Jul-00	8.1	355	2379	560	16	330	20.5	<0.1	70	0.2	670	558		599	245	354
		J4N	39847																												
J5	Maritzville	J5N	39848	Auob	57	7-Aug-00																									
				Auob	158	9-Aug-00																									
J6	Cobra	J6K	39849																												
		J6A	39850	A5	208		NAM 74	SL	-1.25	-21.1			NW	DS6906	4-Oct-00	9.5	2310	15477	6100	25	1800	33.9	4.2	14	26	4150	6610	1730	15	3	13
		J6N	39851																												
J7	Jackalsdraai	J7K	39852																												
		J7N	39853	A3+A1	163	1-Aug-00																									
J8	Tweerivier	J8K	39854																												
		J8A	39855	Kalahari	137	22-Jul-00			-	-	-	-	NW	DS6907	4-Oct-00	9.1	672	4502	1760	9	900	17.7	0.8	26	5.8	1040	1400	162	15	3	13
				K+A5	155	22-Jul-00			-	-	-	-	NW	DS6908	4-Oct-00	9	536	3591	1290	16	590	0.2	0.3	24	5.4	720	1268	126	19	3	17
		J8N	39856	A3+A1	263	15-Jul-00			-	-	-	-	NW	DS6910	4-Oct-00	9	596	3993	1350	9	730	18.8	13.2	14	5.3	870	1112	140	13	5	8
J9	Klein Swart Modder	J9A	39857	Basalt	43	13-Aug-00																									
				Basalt +Auob	115	14-Aug-00																									

*Note: "SL" = Schonland, "NM" = Namwater

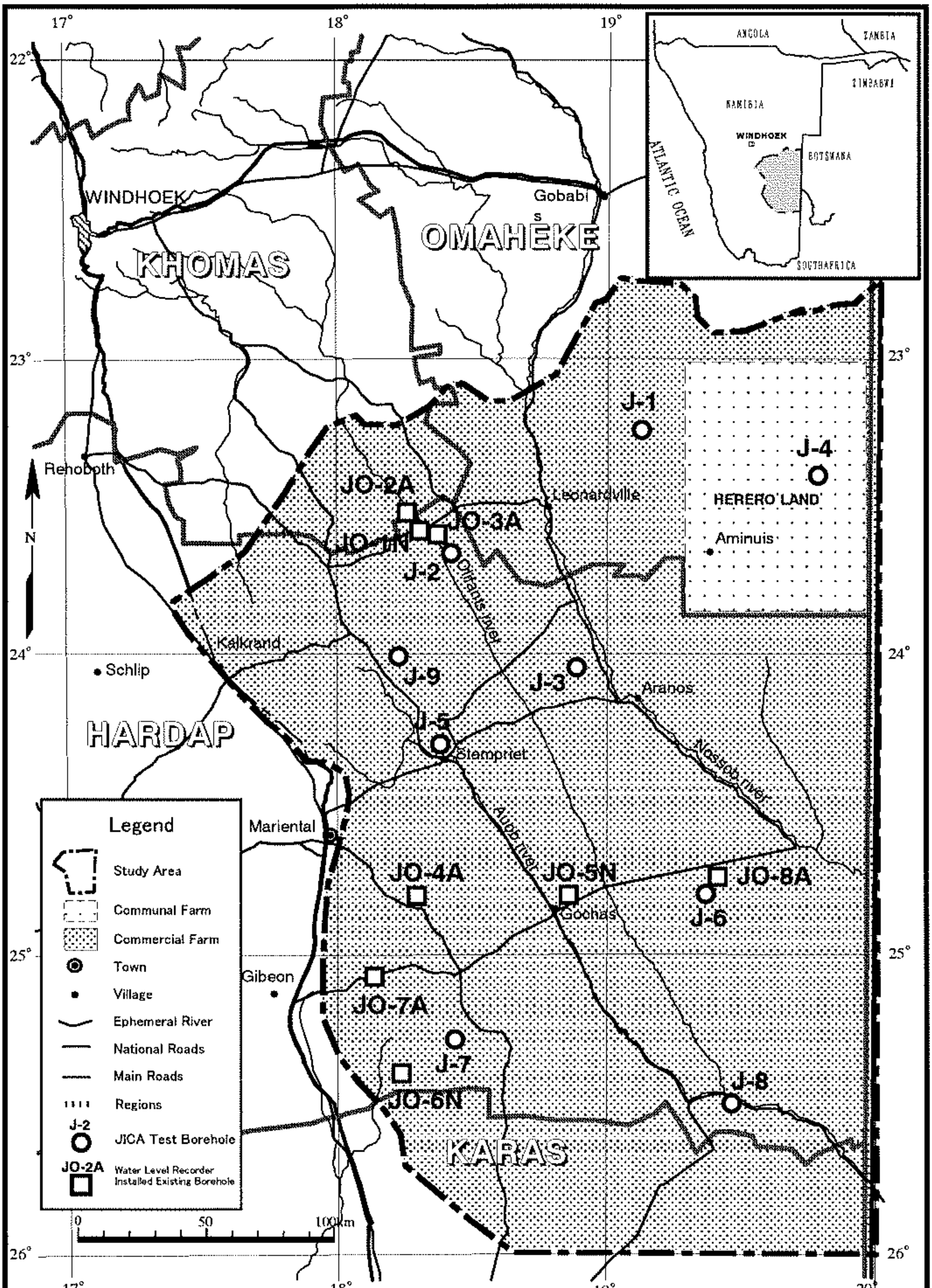

Fig.6.1-1 Location Map of Test Boreholes

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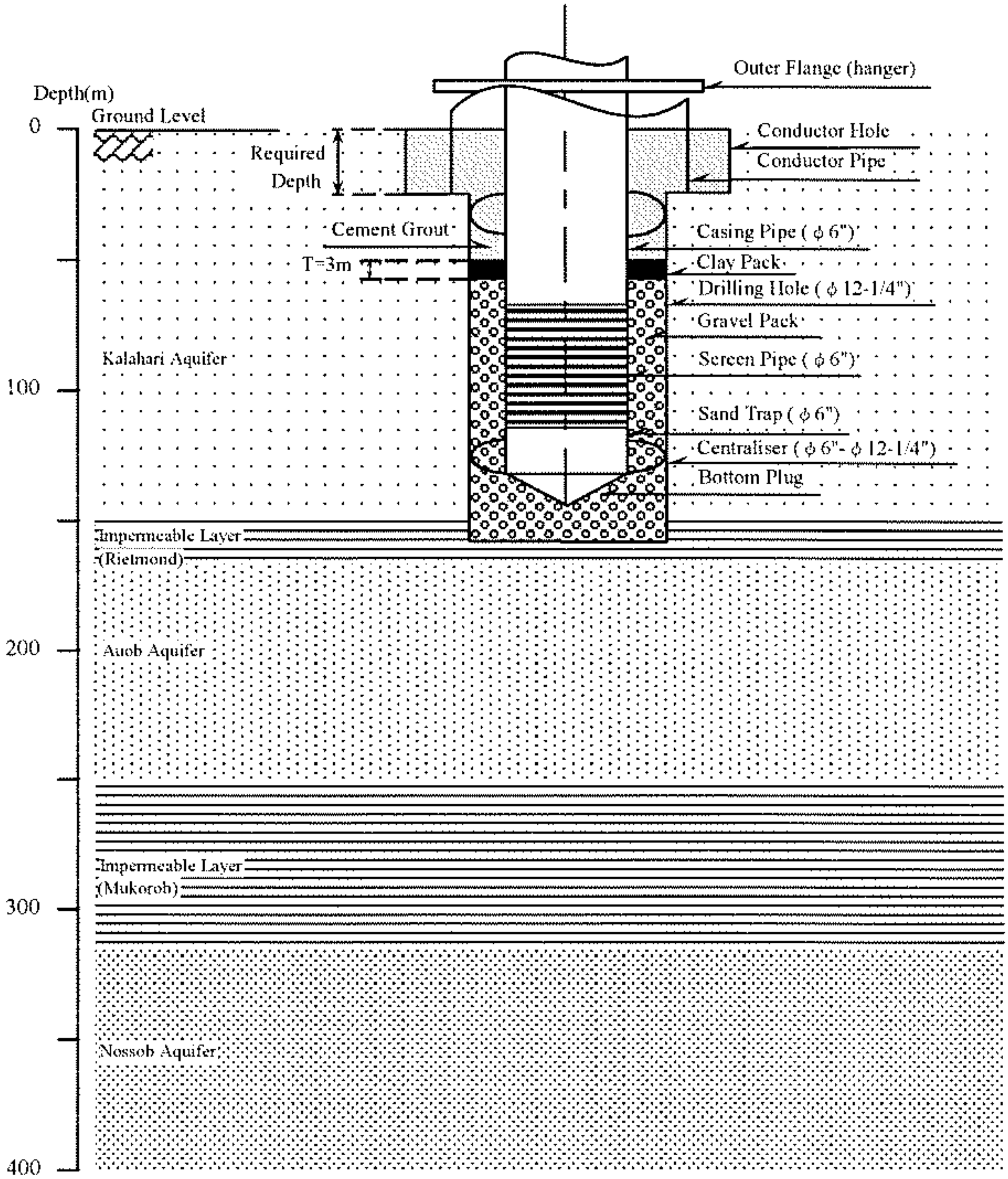

Fig.6.1-2 Standard Design, Kalahari Test Borehole

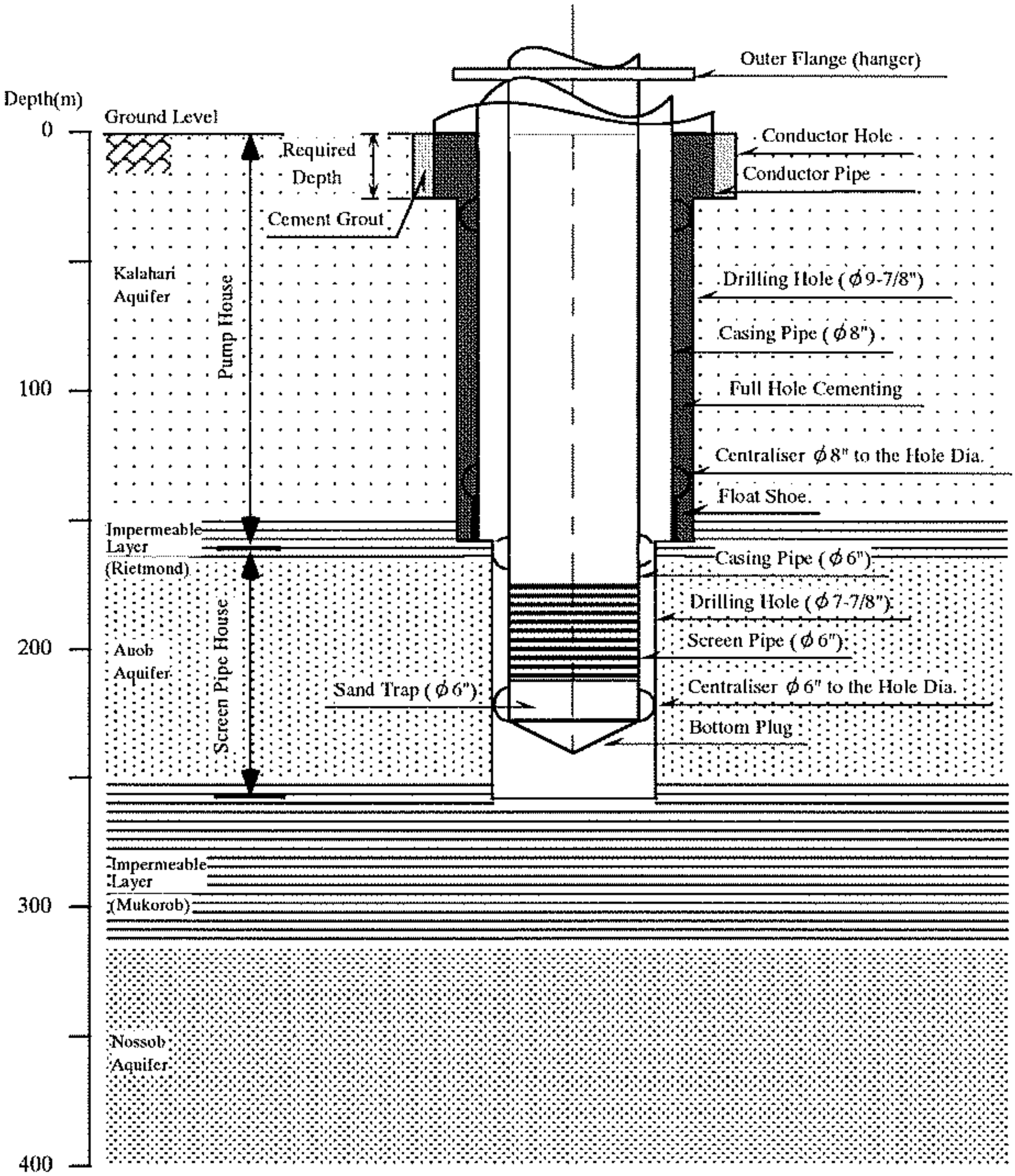

Fig.6.1-3 Standard Design, Auob Test Borehole

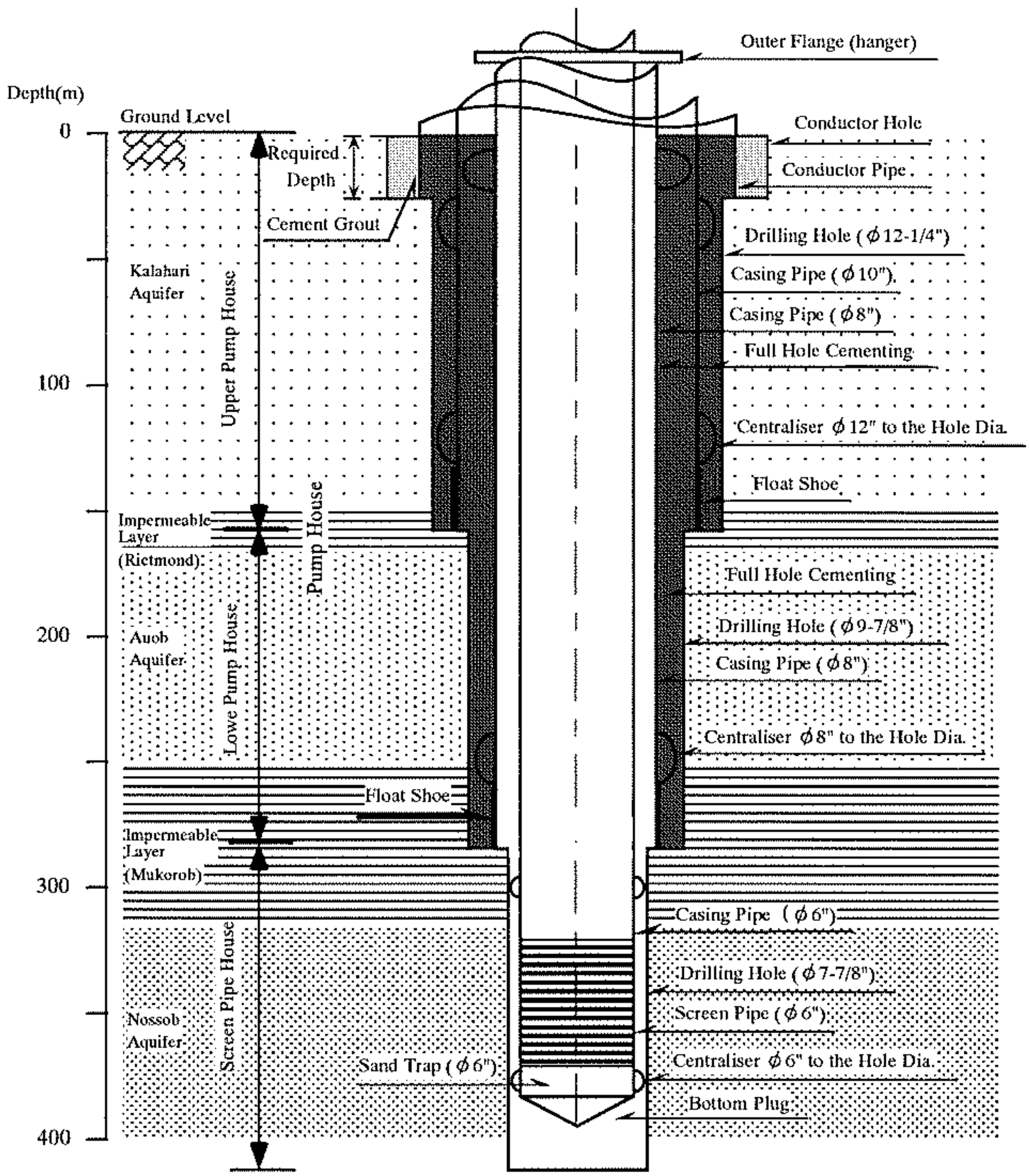

Fig. 6.1-4 Standard Design, Nossob Test Borehole

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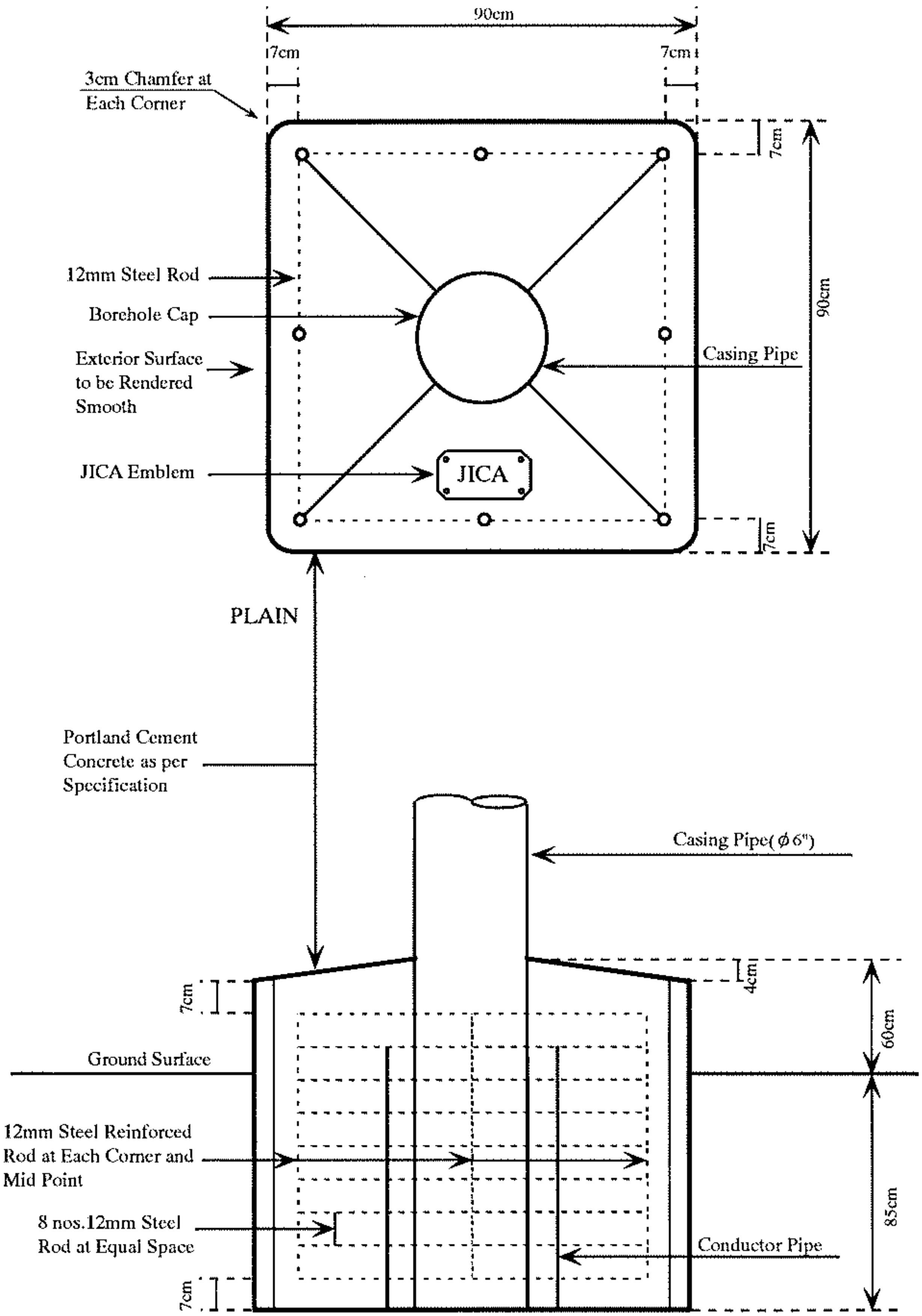


Fig.6.1-5 Concrete Head Block for Test Boreholes

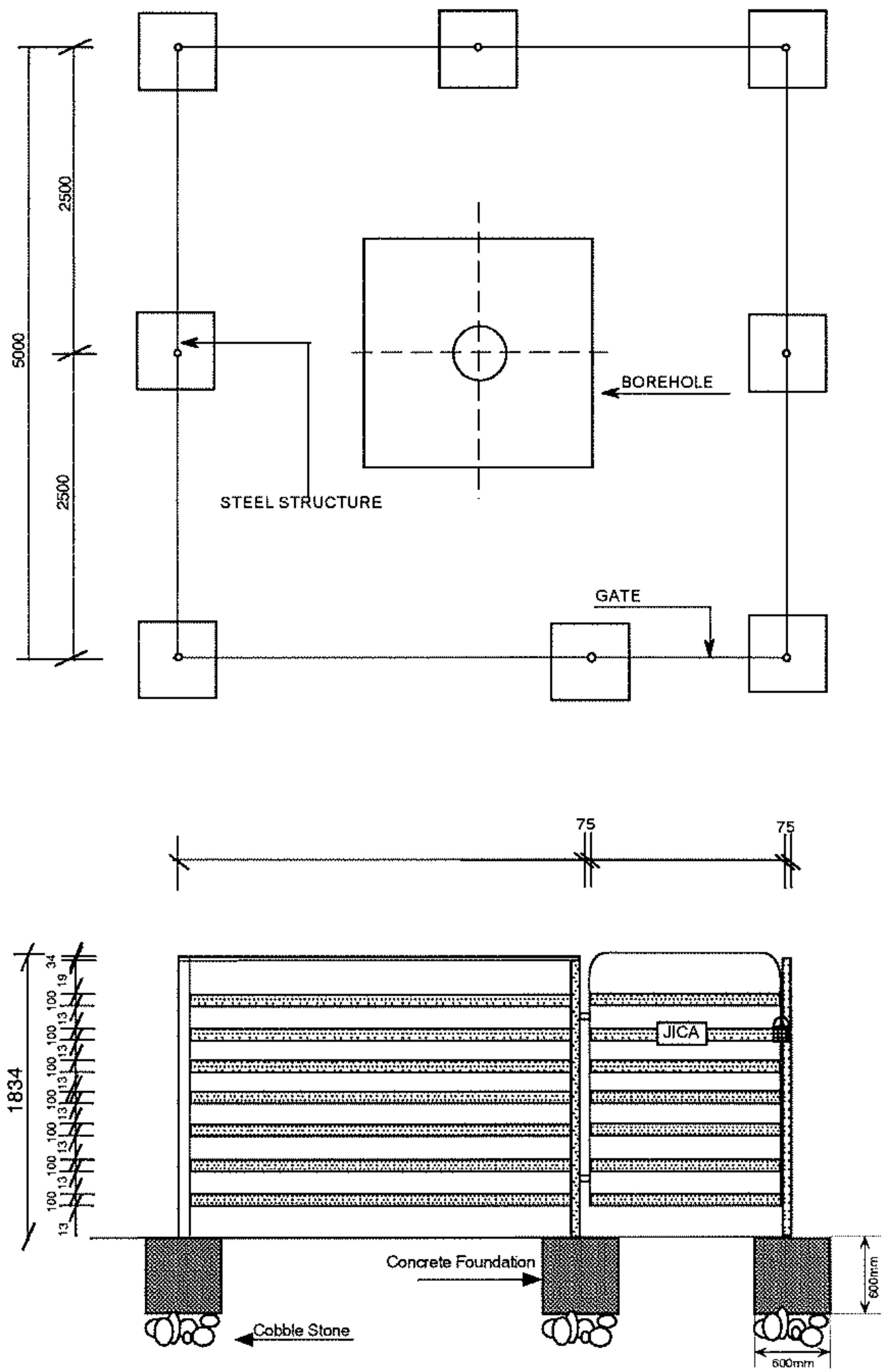


Fig. 6.1-6 Borehole Head Facilities

6.2 Pumping Test

6.2.1 Outline of the Test

The pumping test was carried out by using a submersible pump, except at very low yielding and artesian boreholes. At the boreholes with very low yield, which could not be pumped with the submersible pump, a slug test was applied. The table below shows a summary of the tests carried out. There are three boreholes of J3N, J5N and J6N that are confirmed to yield artesian flow. The tests using a pressure probe were applied at these boreholes. On the borehole at J5N, since the borehole has enough yield for pumping, two tests, using a pressure probe and a submersible pump were carried out.

At the other low yielding boreholes, such as J4K, J6N, J7N, J8K, J8A and J8N, a slug test was applied. On the boreholes at J7N and J8K, both a pumping test and a slug test were carried out. Since these boreholes have slightly better yields, two tests were carried out to prove the reliability of the tests.

BH No.	Test			Remarks
	Method	Pumping	Test item carried out	
J1A	Pumping Test	Submersible pump	SDT, CDT, RT	
J2A	Pumping Test	Submersible pump	SDT, CDT, RT	
J2N	Pumping Test	Submersible pump	SDT, CDT, RT	
J3K	Pumping Test	Submersible pump	SDT, CDT, RT	
J3A	Pumping Test	Submersible pump	SDT, CDT, RT	
J3N	Pumping Test	Pressure Probe	SDT, CDT, RT	Artesian
J4K	Pumping Test	Submersible pump	CDT, RT	Very low yield
	Slug Test	Slug Body	Slug in, Slug out	
J4A	Pumping Test	Submersible pump	SDT, CDT, RT	
J4N	Pumping Test	Submersible pump	SDT, CDT, RT	
J5N	Pumping Test	Submersible pump	SDT, CDT, RT	Artesian
	Pumping Test	Pressure Probe	SDT, CDT, RT	
J6K	Pumping Test	Submersible pump	SDT, CDT, RT	
J6A	Pumping Test	Submersible pump	SDT, CDT, RT	
J6N	Slug Test	Pressure Probe	Slug in, Slug out	Artesian Very low yield
J7K	Pumping Test	Submersible pump	SDT, CDT, RT	
J7N	Pumping Test	Submersible pump	SDT, CDT, RT	Very low yield
	Slug Test	Submersible pump	SDT, CDT, RT	
J8K	Pumping Test	Submersible pump	SDT, CDT, RT	Very low yield
	Slug Test	Slug Body	Slug in, Slug out	
J8A	Slug Test	Slug Body	Slug in, Slug out	Very low yield
J8N	Slug Test	Slug Body	Slug in, Slug out	Very low yield
J9A	Pumping Test	Submersible pump	SDT, CDT, RT	

Remarks: SDT (Step Drawdown Test), CDT (Constant Discharge Test), RT (Recovery Test)

6.2.2 Measurement

1) Tests Carried Out

The following phases were applied to the pumping tests:

Phase 1:Provisional test

A short provisional test was normally done before the commencement of the pumping test. The purpose of the test was to measure the approximate pumping rate and to decide on the number of steps necessary for the step drawdown test, and to adjust the valve-opening rate to achieve the prescribed pumping rate. The discharge and the duration of each test and the number of steps were determined by the results of the provisional test.

Phase 2:Step drawdown test

Normally at least five steps (sometimes more or less) were performed with each step measuring 120 minutes or occasionally shorter in duration.

Phase 3:Constant discharge test

The test was done in most cases 72 hours or occasionally longer or shorter in duration. The test was performed as soon as the water in the borehole had recovered to its static water level after completion of the step drawdown test.

Phase 4:Time recovery test

The test commenced immediately on completion of the constant discharge test and continued until the water level returned to its static water level or occasionally over a shorter period.

2) Method of Measurement

The original static water level in the borehole was always measured before any test pumping commenced. Throughout the duration of each test, the water level in the borehole was measured and recorded following the observation time schedule listed below:

Time from start of pumping or pumping rate increase (minutes)			Time interval between observations (minutes)
0	-	5	0.5
5	-	10	1
10	-	20	2
20	-	30	3
30	-	60	5
60	-	120	10
120	-	240	20
240	-	360	40
360	-	720	60
720	-	2880	120
2880 and longer			240

The flow of all water pumped from the borehole during the pumping test was measured by an approved method using mainly a triangular weir. Discharge rates were recorded during the pumping test at intervals corresponding to those for water level measurements.

Existing boreholes were used for observation boreholes during the test pumping, if they were located near the test borehole and were suitable for that purpose. In addition, where the sites, two or three test boreholes were drilled, namely J-2, J-3, J-4, J-6, J-7 and J-8, boreholes other than test borehole were also used as observation boreholes during the test pumping. The way of water level measurement in the observation boreholes was similar as that of the test borehole.

6.2.3 Method of Analysis

1) Aquifer Constants

The aquifer constants necessary for the hydrogeological evaluation are transmissibility, storage coefficient and permeability. These aquifer constants were analyzed by using the results of constant discharge and recovery tests. The methods used for analysis of the aquifer constants are shown in below.

i) The Theis Method

Theis (1935) solved the non-equilibrium flow equations in radial coordinates. For the specific definition of u given, the integral is known as the well function $W(u)$, and can be represented by an infinite Taylor series. Using this function, the equation becomes:

$$s = \frac{Q}{4pT} W(u)$$

A log/log scale plot of the relationship *W(u)* along the y-axis versus 1/*u* along the x-axis is commonly called the Theis curve. The field measurements are similarly plotted on a log-log plot with t along the x-axis and s along the y-axis. The data analysis is done by matching the observed data to the type curve.

ii) The Cooper & Jacob Method

This solution is valid for greater time and smaller separation distance from the pumping well (smaller u values, i.e. u<0.01). The resulting equation is:

$$T = \frac{2.3Q}{4p\Delta s}$$

$$S = \frac{2.25Tt_0}{r^2}$$

where s is drawdown, Q is the well discharge rate, t is time, r is the radial distance, and S and T are the storativity and transmissivity respectively.

The above equation plots as a straight line on semi-logarithmic plot if the limiting conditions are met. Thus, straight-line plots of drawdown versus time can be produced after sufficient time has elapsed. In pumping tests with multiple observation wells, the closer wells will meet the conditions before the more distant ones. Time is plotted along the logarithmic x-axis and drawdown is plotted along the linear y-axis.

iii) Theis and Jacob Recovery Test Method

The recovery / rebound of the water level in a pumping well can also be used to estimate aquifer transmissivity. Analysis of the recovery can be used to confirm data values obtained using the pumping test data, or it may be the only data available in the case where only a production well is available. In cases where observation well data are not available and it is necessary to estimate aquifer properties with only a production well, water level data during the pumping test cannot be used because they are subject to well losses which cause the drawdown in the well to be significantly greater than the drawdown in the aquifer just outside the well. This can be overcome by measuring the recovery of the water level in the well after the pump has been shut down.

According to Theis (1935), the residual drawdown after pumping has ceased is:

$$s' = \frac{Q}{4pT} W(u) - W(u')$$

where,

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

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

and, Q is the constant discharge rate, T is the transmissivity, r is the distance to the observation well, s' is the residual drawdown, S and S' are the storativity values during pumping and recovery respectively, and t and t' are the time elapsed since the start and ending of pumping respectively.

iv) Hantush Method

Most confined aquifers are not totally isolated from sources of vertical recharge. Less permeable layers, either above or below the aquifer, can leak water into the aquifer under pumping conditions.

The Hantush and Jacob (1955) solution to the above equation is given by:

$$S = \frac{Q}{4pT} W\left(u, \frac{r}{L}\right)$$

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

A log/log plot of the relationship W(u,r/L) along the y-axis versus 1/u along the x-axis is used as the type curve as with the Theis method. The field measurements are plotted as t or t/r2 along the x-axis and s along the y-axis. The data analysis is done by curve matching..

v) Bouwer-Rice Slug Test Method

The Bouwer and Rice (1976) slug test analysis method is designed to more accurately estimate the hydraulic conductivity of the aquifer material by better accounting for the piezometer geometry . In a slug/bail test, a solid "slug" is lowered into/removed from the piezometer instantaneously raising/lowering the water level in the piezometer. The Bouwer and Rice (1976) equation for hydraulic conductivity is:

$$K = \frac{r^2 \ln\left(R_{cont} / R\right)}{2L} \frac{l}{t} \ln\left(\frac{h_0}{h_t}\right)$$

where,
r = piezometer radius
R = radius measured from center of well to undisturbed aquifer material
Rcont = contributing radial distance over which the difference in head, h0, is dissipated in the aquifer
L = the length of the screen
h0 = head in well at *t0* = 0
ht = head in well at t > *t0*

Since the contributing radius of aquifer is seldom known a priori, Bouwer and Rice developed some empirical curves to account for this radius by three coefficients (A,B,C) which are all functions of the ratio of L/R. Coefficients A and B are used for partially penetrating wells whereas coefficient C is used only for fully penetrating wells.

The data are plotted with time on a logarithmic x-axis and ht/ho on a linear y-axis.

2) Borehole Hydraulics

i) Well Efficiency

Well efficiency is given by the following formula;
Well Efficiency (%) E_w=BQ /(BQ +CQ^2)
Where
B = aquifer loss
C = well loss
Q = discharge rate (l/s)

ii) Radius of Influence

The Radius of Influence is given by the following formula after the Theis Equation;

Radius of Influence (m) R=(4Ttu/S)0.5

s=(Q/4πT)W(u)

Where	Q	=Discharge rate (m^3/h)
	T	=Transmissivity (m^2/h)
	s	=drawdown(m)(0.001)
	S	=Effective porosity (0.3)
	W(u)	=Well function of Theis
	t	=Time of pumping operation (h)

6.2.4 Borehole Hydraulics

Borehole hydraulics were evaluated by the results of the step drawdown test data. These include well efficiency, aquifer boundary type and area of influence. At the low yielding boreholes of J4K, J6N, J8A and J8N, however, no step drawdown test was performed.

The evaluation sheets for all boreholes are listed in Appendix A-2, and a summary of results are shown in Table 6.2-1.

1) Well Efficiency

Well efficiency calculated by aquifer loss and well loss, was analyzed using the Jacob method for step drawdown test data. Aquifer parameters used for the calculation of well efficiency were obtained from the evaluation results of the constant discharge test. The well efficiencies at the range of flow rates used during the step drawdown test was calculated.

2) Aquifer Boundary Type

In the most of the step drawdown tests, reverse tests were conducted to evaluate the aquifer boundary. Two types of aquifer boundary, namely a “non-flow boundary type” and a “constant head boundary type” could be presumed by the relation between the discharge rate and the drawdown of both forward and reverse tests. None flow boundary types are defined as “the aquifer has a none flow boundary or a barrier, due to 1) a geological structure such as fault, buried valley, etc., 2) an impermeable barrier, 3) the formation of a conspicuous permeability”. Constant head boundary types are defined as "the aquifer is characterized as 1) a relatively high permeability, 2) a relatively high storage, 3) associated with recharge by surface water and 4) receives induced recharge from the upper formation".

3) Area of Influence

The area of influence at the rates of well efficiency within the following ranges were calculated: 1) less than 50%, 2) 50% to 70%, 3) 70% to 80% and 4) more than 80%. The area of influence is estimated, under the condition that the influenced drawdown is 0.01m within the pumping time from one hour to 8,760 hours.

4) Evaluation of Borehole hydraulics

The table below shows is a summary of the results of the step drawdown tests. The table shows the well efficiency rate (%) at a discharge rate of 5.0 m^3/h with the presumed aquifer boundary type of each borehole.

Aquifer	**Borehole No.**	**Well efficiency rate (%) at a discharge rate of 5.0 m^3/h**	**Presumed aquifer boundary type**
Kalahari	J3K	64	-
	J6K	70	Constant Head Type
	J7K	93	Constant Head Type
	J8K	Less than 10	None Flow Type
Auob	J1A	80	None Flow Type
	J2A	63	None Flow Type
	J3A	95	Constant Head Type
	J4A	65	Constant Head Type
	J6A	93	None Flow Type
	J9A	86	Constant Head Type
Nossob	J2N	87	None Flow Type
	J3N	15	-
	J4N	95	None Flow Type
	J5N	Less than 4	None Flow Type
	J7N	16	-

The factors of well efficiency contributing to excess drawdown in the boreholes can be grouped into two classes. One class comprises those factors related primarily to choices made in the design of borehole and the other class includes factors related to construction. The evaluation of the aquifer, therefore, can not be done by the well efficiency alone. The results however suggest, that the Auob Aquifer shows a relatively high well efficiency overall. On the other hand, the boreholes with extremely low well efficiency are concentrated in the Nossob Aquifer and one in the Kalahari Aquifer. The boreholes drilled into the Nossob Aquifer are also very low yielding.

Most of the boreholes within the Kalahari and Auob are characterized by a "constant head type" aquifer boundary, whereas all Nossob boreholes are "none flow type aquifer boundary". The results suggest that the Nossob Aquifer is characterized as extremely low permeability and an extremely low recharged.

6.2.5 Aquifer Constants

Aquifer constants necessary for the hydrogeological evaluation are transmissibility, storage coefficient and permeability. These aquifer constants were analyzed by using the results of constant discharge and recovery tests.

The evaluation sheets of aquifer constants for all boreholes are listed in Appendix A-2. A summary of results are shown in Table 6.2-2.

1) Specific Yield

The quantity of water that a unit volume of unconfined aquifer gives up by gravity is called its specific yield. Specific yield was calculated by the drawdown and pumping rate at the constant discharge test.

2) Transmissibility

Transmissibility is the rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. The value is given in cubic meters per day through a vertical section of an aquifer one meter wide and extending through the full saturated height of an aquifer under a hydraulic gradient of 1. Both of the constant discharge and recovery tests were used for the analysis.

3) Permeability

Permeability is the property or capacity of an aquifer to transmitting a fluid. It is a measure of the relative ease of fluid flow under unequal pressure. Both the constant discharge and recovery tests were used for the analysis.

4) Storage Coefficient

The storage coefficient is the volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In this project, however, no observation borehole were drilled. Both the constant discharge test and recovery tests were used for the analysis. The presented value of the storage coefficient in this report is therefore an estimated value.

5) Evaluation of Aquifers

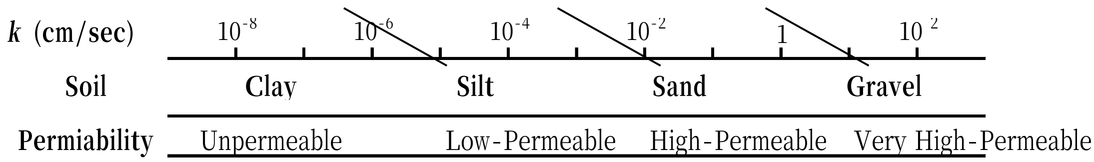
The table below shown is a summary of the results of analyses of the aquifer constants. Specific yield, transmissibility, permeability and storage coefficient for the each borehole is shown. Figure 6.2-1 shows the distribution of aquifer constants within the aquifers.

Aquifer	Borehole No.	Specific Capacity (m^3/h/m)	Transmissibility (m^3/day/m)	Permeability (cm/sec)	Storage coefficient
Kalahari	J3K	0.143	6.42	1.50E-04	1.00E-06
	J4K	0.018	0.135	7.74E-06	-
	J6K	0.145	6.23	1.40E-04	1.00E-05
	J7K	0.763	30	1.20E-03	2.00E-04
	J8K	0.016	0.132	5.10E-06	5.00E-03
Auob	J1A	0.74	25.2	3.90E-04	1.00E-05
	J2A	0.089	3.42	1.60E-04	1.00E-05
	J3A	4.409	194	6.60E-03	1.00E-05
	J4A	0.923	87.6	2.00E-03	1.00E-05
	J6A	0.165	8.44	3.30E-04	3.00E-09
	J8A		0.006	2.30E-07	1.00E-10
	J9A	15.94	1,240	1.90E-02	3.00E-03
Nossob	J2N	0.085	2.94	1.40E-04	5.00E-06
	J3N	0.00082	1.3	1.03E-04	2.00E-05
	J4N	0.21	7.01	1.60E-04	5.00E-05
	J5N	0.016	1.2	5.50E-05	3.00E-05
	J6N	-	1.487	6.10E-05	1.00E-05
	J5N	0.0043	0.01	2.10E-06	1.00E-10
	J7N	-	0.02	8.80E-07	1.80E-06

The Auob Aquifer shows the highest range in specific capacity, transmissibility and permeability. Specific Capacity is generally low, being less than 0.1 m^3/h/m in the Nossob, and less than 1 m^3/h/m in Kalahari, while the Auob Aquifer has a range from 0.1 to 10 m^3/h/m.

Transmissibility shows a similar trend with specific capacity, being generally low. It is approximately less than 10 m^3/day/m in both the Kalahari and Nossob. The Auob Aquifer shows relatively high range of 1 to 100 m^3/day/m.

Permeability of the Nossob and Kalahari Aquifers also low. It is generally less than 1×10^{-4} cm/sec in Nossob, and less than 1×10^{-4} cm/sec for the Kalahari. The Auob Aquifer shows a range from 1×10^{-4} cm/sec to1×10^{-2} cm/sec. As illustrated by the following figure, the permeability calculated in the Nossob and Kalahari can be categorized as a low-permeable silt to clay. A range of 1×10^{-4} cm/sec to1×10^{-2} cm/sec of Auob Aquifer is categorized as a low to high permeable silt to sand.



Interrelationship between permeability and grain size. (After Linsely et al. 1958)

Considering such a permeability range and a relatively high transmissibility and specific capacity, it is suggested that the Auob Aquifer represents the promising aquifer in the area. The Kalahari Aquifer has locally alow potential, and the, Nossob Aquifer is generally a non-productive aquifer from an aquifer constant point of view.

6.2.6 Interaction Between the Aquifers

During the measurement of water levels within the production borehole, if other drilled boreholes or existing boreholes were near the production borehole, water levels in these boreholes were done in a similar way. Such was the case at locations J-2, J-3, J-4, J-6, J-7 and J-8. Only at location of J-3 was a small interaction between the Kalahari and Auob Aquifers observed.

1) Location J-2 (See Fig. 6.2-2)

A total of two boreholes, J2A and J2N, were drilled at this location. No interaction between the aquifers was observed.

2) Location J-3 (See Fig. 6.2-3)

A total of two boreholes, J3A and J3K, were drilled at this location. A small interaction between the Kalahari and Auob Aquifers was observed. A remarkable variation of drawdown was observed prior to the commencement of the recovery test.

3) Location J-4 (See Fig. 6.2-4)

A total of three boreholes, J4K, J4A and J4N, were drilled at this location. No interaction between the aquifers was observed.

4) Location J-6 (See Fig. 6.2-5)

A total of three boreholes, J6K, J6A and J6N, were drilled at this location. No interaction between the aquifers was observed.

5) Location J-7 (See Fig. 6.2-6)

A total of two boreholes, J7K and J7N, were drilled at this location. Two farmer's boreholes named House and Wind pump were was used as observation boreholes. In these boreholes, a variation of drawdown was observed during pumping of J7K borehole. No interaction, however between the Kalahari and Nossob Aquifers was observed.

6) Location J-8 (See Fig. 6.2-7)

A total of three boreholes, J8K, J8A and J8N, were drilled at this location. No interaction between the aquifers was observed.

6.2.7 Pumping Test Analysis of Existing Boreholes

During the series of survey, the pumping test data of the existing boreholes were collected to analysis the aquifer constants. The available data, however, is very limited, only six analyzable data was found. Table 6.2-3 shows the result of analysis. The borehole number of WW24604 at Garton has 3 result. This is not three boreholes, three different pumping test was done in the same borehole.

Table 6.2-1 Summary of Borehole Hydraulics (1/3)

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	60	3.70	61.96	5.43	84.56	Rate at Ew≧80%	
	2	60	6.23	64.70	8.17	76.48	5.00 (m^3/h)	
	3	60	9.00	67.94	11.41	69.24	Pumping Operation	
J1A	4	60	12.90	70.87	14.34	61.09	by 1 hour	None Flow
WW39839	5	60	15.00	73.10	16.57	57.45	1,025 m	Boundary Type
	6	60	12.30	70.60	14.07	62.22	by 12 hours	
	7	60	8.20	67.26	10.73	71.18	3,550 m	
	8	60	6.20	65.69	9.16	76.57	by 24 hours	
	9	60	2.90	61.79	5.26	87.48	5,020 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	90	2.00	33.54	17.78	81.24	Rate at Ew≧80%	
	2	90	3.00	44.13	28.37	74.27	2.00 (m^3/h)	
	3	90	4.00	53.82	38.06	68.40	Pumping Operation	
J2A	4	90	5.00	64.53	48.77	63.39	by 1 hour	None Flow
WW39840	5	90	6.00	75.26	59.50	59.07	434 m	Boundary Type
	6	90	5.00	66.88	51.12	63.39	by 12 hours	
	7	90	4.00	57.65	41.89	68.40	1,502 m	
	8	90	3.00	48.13	32.37	74.27	by 24 hours	
	9	90	2.00	38.31	22.55	81.24	2,125 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	90	1.00	49.27	9.74	97.08	Rate at Ew≧80%	
	2	90	2.00	59.76	20.23	94.32	7.00 (m^3/h)	
	3	90	3.00	71.14	31.61	91.71	Pumping Operation	
J2N	4	90	4.00	82.76	43.23	89.25	by 1 hour	None Flow
WW39841	5	90	5.00	94.49	54.96	86.91	664 m	Boundary Type
	6	90	4.00	85.70	46.17	89.25	by 12 hours	
	7	90	3.00	74.96	35.43	91.71	2,300 m	
	8	90	2.00	63.56	24.03	94.32	by 24 hours	
	9	90	1.00	52.38	12.85	97.08	3,253 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	90	0.99	24.81	5.47	90.07	Rate at Ew≧80%	
	2	90	1.44	28.15	8.81	86.18	2.00 (m^3/h)	
	3	90	1.93	33.56	14.22	82.31	Pumping Operation	
J3K	4	90	2.53	51.20	31.86	78.02	by 1 hour	
WW39842	5						1,746 m	N.A.
	6						by 12 hours	
	7						6,049 m	
	8						by 24 hours	
	9						8,555 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	10.44	18.64	4.02	89.90	Rate at Ew≧80%	
	2	120	15.06	19.72	5.10	86.05	15.00 (m^3/h)	
	3	120	20.05	20.84	6.22	82.25	Pumping Operation	
J3A	4	120	25.09	22.42	7.80	78.74	by 1 hour	Constant Head
WW39843	5	120	30.00	23.17	8.55	75.59	2,379 m	Boundary Type
	6	120	25.00	22.46	7.84	78.80	by 12 hours	
	7	120	20.00	20.91	6.29	82.29	8,240 m	
	8	120	15.00	19.78	5.16	86.10	by 24 hours	
	9	120	10.00	18.71	4.09	90.28	11,653 m	

(2/3)

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
J3N WW39844	1	120	0.06	6.86	31.86	93.80	Rate at Ew≧80%	N.A.
	2	120	0.08	8.22	33.22	91.90	0.10 (m^3/h)	
	3	120	0.15	22.68	47.68	85.82	Pumping Operation	
	4						by 1 hour	
	5						127 m	
	6						by 12 hours	
	7						442 m	
	8						by 24 hours	
	9						624 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
J4A WW39846	1	120	5.15	66.89	13.06	64.27	Rate at Ew≧80%	Constant Head Boundary Type
	2	120	10.21	70.21	16.38	47.57	2.00 (m^3/h)	
	3	120	15.01	75.27	21.44	38.17	Pumping Operation	
	4	120	19.30	79.25	25.42	32.43	by 1 hour	
	5	120	25.10	86.46	32.63	26.96	88 m	
	6	120	19.96	80.79	26.96	31.70	by 12 hours	
	7	120	15.00	74.12	20.29	38.18	303 m	
	8	120	10.00	68.46	14.63	48.09	by 24 hours	
	9	120	5.00	68.28	14.45	64.95	429 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
J4N WW39847	1	90	5.00	25.95	16.36	94.59	Rate at Ew≧80%	None Flow Boundary Type
	2	90	10.00	45.51	35.92	89.74	15.00 (m^3/h)	
	3	90	15.00	66.65	57.06	85.36	Pumping Operation	
	4	90	20.00	86.71	77.12	81.39	by 1 hour	
	5	90	15.00	71.67	62.08	85.36	319 m	
	6	90	10.00	53.08	43.49	89.74	by 12 hours	
	7	90	5.00	31.87	22.28	94.59	1,104 m	
	8						by 24 hours	
	9						1,562 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
J5N WW39848	1	120	0.60	12.17	32.17	13.93	Rate at Ew≧80%	None Flow Boundary Type
	2	120	0.90	24.54	44.54	9.74	0.02 (m^3/h)	
	3	120	1.20	40.04	60.04	7.49	Pumping Operation	
	4	120	1.40	53.03	73.03	6.49	by 1 hour	
	5	120	1.20	51.31	71.31	7.49	73 m	
	6	120	0.90	39.81	59.81	9.74	by 12 hours	
	7	120	0.60	23.35	43.35	13.93	253 m	
	8						by 24 hours	
	9						358 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
J6K WW39849	1	120	1.00	107.83	5.85	92.98	Rate at Ew≧80%	Constant Head Boundary Type
	2	120	2.00	114.82	12.84	86.88	2.00 (m^3/h)	
	3	120	3.00	121.49	19.51	81.53	Pumping Operation	
	4	120	4.00	128.48	26.50	76.80	by 1 hour	
	5	120	5.00	137.72	35.74	72.59	243 m	
	6	120	3.80	126.30	24.32	77.70	by 12 hours	
	7	120	2.90	119.94	17.96	82.03	843 m	
	8	120	1.90	111.72	9.74	87.45	by 24 hours	
	9	120	1.00	108.75	6.77	92.98	1,192 m	

(3/3)

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	2.21	114.52	11.47	96.65	Rate at Ew≧80%	
	2	120	3.01	119.35	16.30	95.50	10.00 (m^3/h)	
	3	120	4.19	125.14	22.09	93.84	Pumping Operation	
J6A	4	120	5.11	130.32	27.27	92.59	by 1 hour	None Flow
WW39850	5	120	6.20	135.30	32.25	91.15	42,488 m	Boundary Type
	6	120	4.82	130.78	27.73	92.98	by 12 hours	
	7	120	3.90	125.95	22.90	94.24	147,182 m	
	8	120	2.89	120.96	17.91	95.67	by 24 hours	
	9	120	1.99	116.05	13.00	96.98	208,147 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	3.10	13.89	4.00	95.45	Rate at Ew≧80%	
	2	120	6.13	17.94	8.05	91.40	10.00 (m^3/h)	
	3	120	9.00	21.55	11.66	87.86	Pumping Operation	
J7K	4	120	12.10	26.85	16.96	84.33	by 1 hour	Constant Head
WW39852	5	120	9.03	21.83	11.94	87.82	269 m	Boundary Type
	6	120	6.30	18.33	8.44	91.18	by 12 hours	
	7	120	3.03	13.87	3.98	95.56	933 m	
	8						by 24 hours	
	9						1,319 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	0.30	44.10	19.60	78.17	Rate at Ew≧80%	
	2	120	0.60	72.19	47.69	64.16	0.25 (m^3/h)	
	3						Pumping Operation	
J7N	4						by 1 hour	
WW39853	5						4 m	N.A.
	6						by 12 hours	
	7						13 m	
	8						by 24 hours	
	9						18 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	0.10	62.84	2.98	50.65	Rate at Ew≧80%	
	2	120	0.20	65.73	5.87	33.91	0.02 (m^3/h)	
	3	120	0.30	71.40	11.54	25.49	Pumping Operation	
J8K	4	120	0.40	79.51	19.65	20.42	by 1 hour	None Flow
WW39854	5	120	0.50	91.65	31.79	17.03	3 m	Boundary Type
	6	120	0.40	91.95	32.09	20.42	by 12 hours	
	7	120	0.30	87.96	28.10	25.49	11 m	
	8	120	0.20	80.87	21.01	33.91	by 24 hours	
	9	120	0.10	75.01	15.15	50.65	16 m	

Borehole No.	Step No.	Time Interval (min)	Discharge Rate Q (m^3/h)	Water Level (m.bgl)	Drawdown Sw (m)	Well Efficiency (%)	Area of Influence of 0.01m Sw	Presumed aquifer boundary
	1	120	15.00	2.83	0.59	67.84	Rate at Ew≧80%	
	2	120	24.00	3.37	1.13	56.87	7.00 (m^3/h)	
	3	120	34.00	4.12	1.88	48.20	Pumping Operation	
J9A	4	120	46.00	5.23	2.99	40.75	by 1 hour	Constant Head
WW39857	5	120	34.00	4.13	1.89	48.20	447 m	Boundary Type
	6	120	25.00	3.41	1.17	55.86	by 12 hours	
	7	120	15.00	2.93	0.69	67.84	1,548 m	
	8	0	0.00	0.00	0.00	0.00	by 24 hours	
	9	0	0.00	0.00	0.00	0.00	2,190 m	

Table 6.2-2 Summary of Aquifer Constants of Test Boreholes

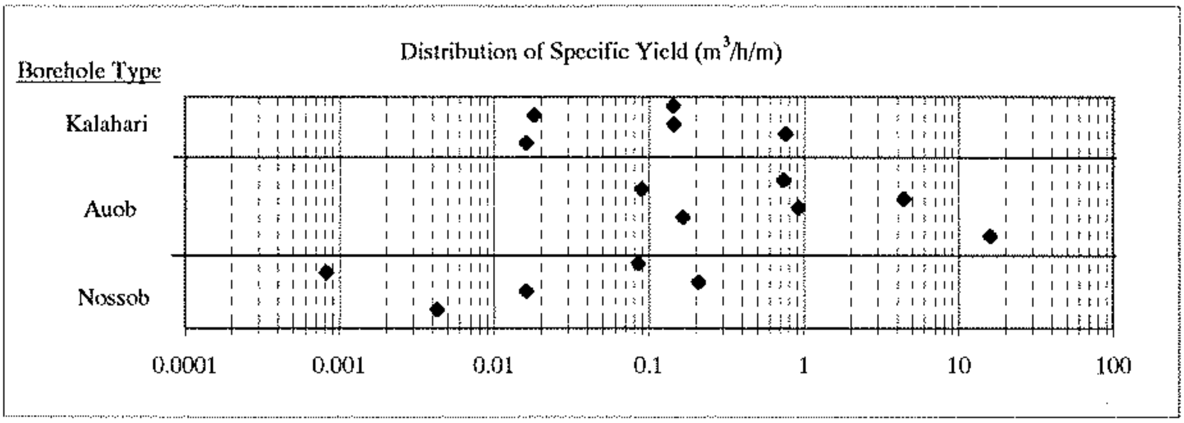
Locality Information				Pumping Test Condition					Aquifer Constants					Remarks
Borehole Number			Ground elevation (masl)	Test applied	Aquifer		S.W.L (mbgl)	P.I.D (mbgl)	Specific yield (m^3/hr/m)	Transmissibility T (m^3/day/m)	Permeability K (cm/sec)	Storage Coefficient S	Accepted method of analysis	
No.	JICA Ref. No.	WW No.			formation	thickness (m)								
J1	J1A	39839	1331.71	PT	Auob	30.55	57.49	82.98	0.74	25.2	3.90E-04	1.00E-05	Hantush draw-down	no interaction with obs. BH 2318BD-35
J2	J2A	39840	1275.26	PT	Auob	20.55	16.94	93.9	0.089	3.42	1.60E-04	1.00E-05	Hantush draw-down	no interaction with obs. BH J2N
	J2N	39841	1275.60	PT	Nossob	23.4	39.72	101.55	0.085	2.94	1.40E-04	5.00E-06	Hantush draw-down	no interaction with obs. BH J2A
J3	J3K	39842	1208.05	PT	Calcrete Rietmond	17.52	19.35	68.85	0.143	6.42	1.50E-04	1.00E-06	Hantush draw-down	small interraction with obs. BH J3A
	J3A	39843	1208.05	PT	Auob	32.15	15.77	101.55	4.409	194	6.60E-03	1.00E-05	Hantush draw-down	small interraction with obs. BH J3K
	J3N	39844	1208.05	PP	Nossob	14.6	-24	N.A.	0.00082	1.3	1.03E-04	2.00E-05	Theis recovery	Artesian
J4	J4K	39845	1258.05	PT	Karoo Dolerite Kalkrand Basalt	20.3	45.1	51	0.018	0.135	7.74E-06	-	Jacob draw-down	very low yield
				ST					-	-	2.10E-06	-	Bouwer - Rice	
	J4A	39846	1256.39	PT	Auob	56.05	59.13	108.5	0.923	87.6	2.00E-03	1.00E-05	Theis draw-down	no interaction wit obs. BH J4K and J4N
	J4N	39847	1256.38	PT	Nossob	23.35	10		0.21	7.01	1.60E-04	5.00E-05	Hantush draw-down	no interaction wit obs. BH J4K and J4A
J5	J5N	39848	1168.33	PT	Nossob	20.46	-20	100	0.016	1.2	5.50E-05	3.00E-05	Theis draw-down	Artesian
				PP					-	1.62	7.50E-05	2.00E-07	Theis draw-down	
J6	J6K	39849	1102.67	PT	Kalahari	17.5	101.98	148	0.145	6.23	1.40E-04	1.00E-05	Hantush draw-down	no interaction with obs. BH J6A and J6N
	J6A	39850	1102.47	PT	Auob A1 only	26.1	104.41	148	0.165	8.44	3.30E-04	3.00E-09	Theis draw-down	no interaction with obs. BH J6K and J6A
	J6N	39851	1103.18	PP	Nossob	23.4	-16	-	-	1.487	6.10E-05	1.00E-05	Cooper / Bouwer	Artesian
J7	J7K	39852	1148.19	PT	Kalahari	23.4	10.04	46	0.763	30	1.20E-03	2.00E-04	Hantush draw-down	obs. BH J7 Huis has been used
	J7N	39853	1148.14	PT	Nossob	14.5	22.45	100	0.0043	0.01	6.80E-07	8.00E-04	Theis recovery	no interaction with obs. BH J7K and Others
				ST				-	-	0.06	2.10E-06	1.00E-10	Cooper / Bouwer	very low yield
J8	J8K	39854	1021.25	PT	Kalahari	23.4	60.31	101	0.016	0.132	5.10E-06	5.00E-03	Theis draw-down	no interaction with obs. BH J8A and J8N
				ST			59.75	-	-	0.27	7.10E-06	1.60E-10	Cooper / Bouwer	very low yield
	J8A	39855	1021.13	ST	Auob A1 only	8.7	172.03	-	-	0.006	2.30E-07	1.00E-10	Cooper / Bouwer	very low yield
	J8N	39856	1021.26	ST	Nossob	17.4	20.76	-	-	0.02	8.80E-07	1.80E-06	Cooper / Bouwer	very low yield
J9	J9A	39857	1210.16	PT	Auob	69.9	2.23	62.82	15.94	1,240	1.90E-02	3.00E-03	Theis draw-down	obs. BH WW31759 has been used

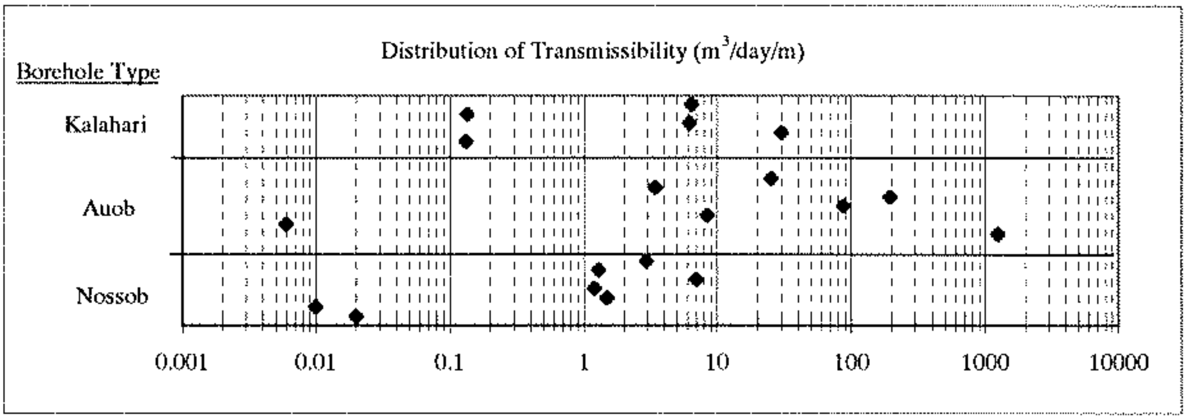
PT : Pumping Test by Submersible Pump
PP : Pumping Test by Pressure Probe
ST : Pumping Test by Slug Body

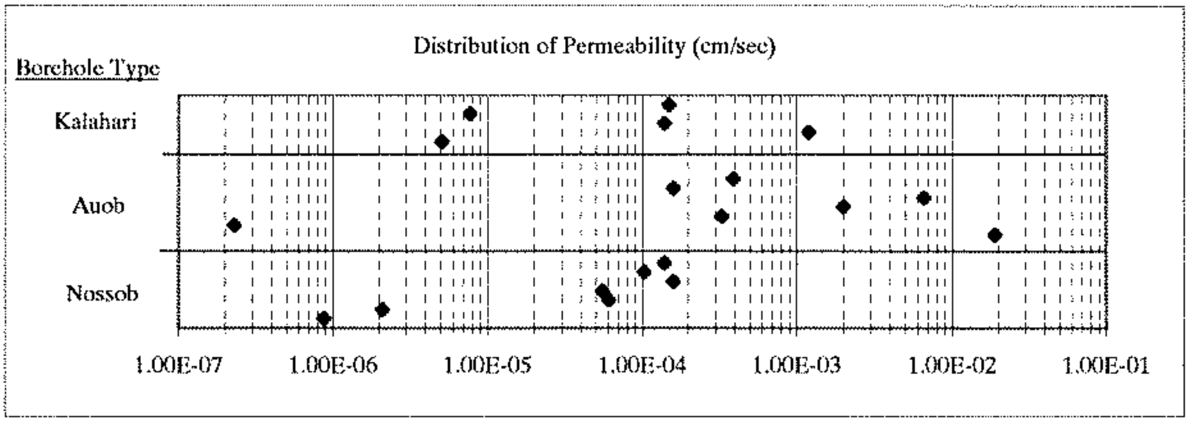
S.W.L: Static water level
P.I.D: Pump inlet depth

Table 6.2-3 Analyzed Aquifer Constants of Existing Boreholes

Locality Information					Pumping Test Condition				Aquifer Constants						Applied
Location		Coordination				Aquifer		S.W.L	Pumping rate	Draw down	Specific yield	Transmissibility T	Permeability K	Storage Coefficient S	Method
Farm Name	WW No.	Latitude (d:m:s)	Longitute (d:m:s)	Elevation (masl)	Borehole Depth (m)	formation	thickness (m)	(mbgl)	(m^3/h)	(m)	(m^3/hr/m	(m^3/day/m)	(cm/sec)		
Olifants-Water	21814	23.68510	18.46970	1,264	55	Rietmond	6	14.3	0.72	28	0.03	13.8	2.66E-03	3.80E-03	Theis drawdown
	21815	23.68540	18.46970	1,264	27	Kalahari	3	14.27	1.00	15.5	0.06	42	1.62E-02	2.00E-03	Theis drawdown
	22545	23.68510	18.47230	1,266	136	Auob	5	19.18	11.33	3.9	2.91	6.6	1.52E-03	2.70E-05	obs. BH
Garton	24604-1	23.28350	18.73350	1,239	63	Rietmond	-	11.57	6.16	41	0.15	84.5	-	1.57E-04	Jacob drawdown (obs. BH)
	24604-2	23.28350	18.73350	1,239	92	Rietmond +Auob (A5) Pre-Karoo	-	0	8.62	35.9	0.24	21.47	-	1.94E-05	Jacob drawdown (obs. BH)
	24604-3	23.28350	18.73350	1,239	134	+ Auob (A5) + Pre-Kaloo	-	0	4.37	33.9	0.13	20.91	-	1.85E-05	Theis drawdown







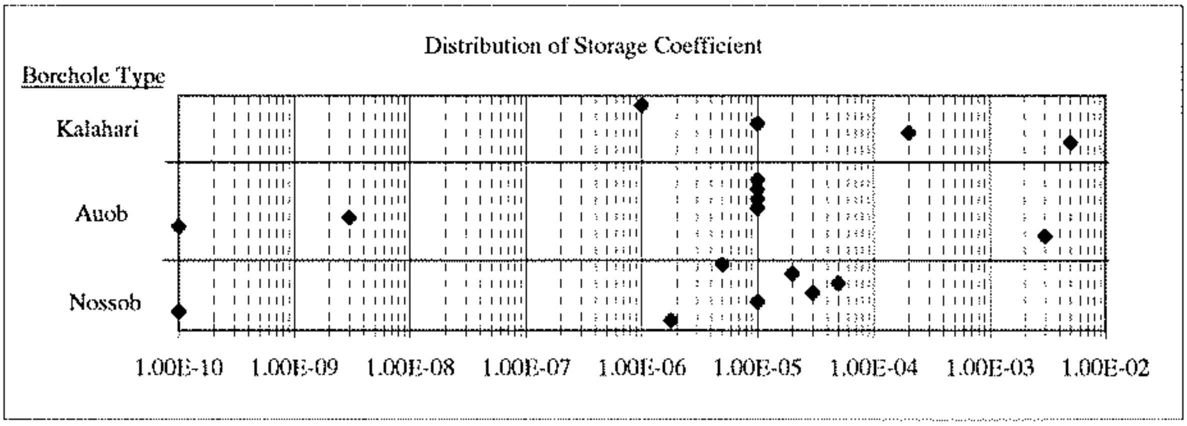


Fig. 6.2-1 Distribution of Aquifer Constants in Each Aquifer

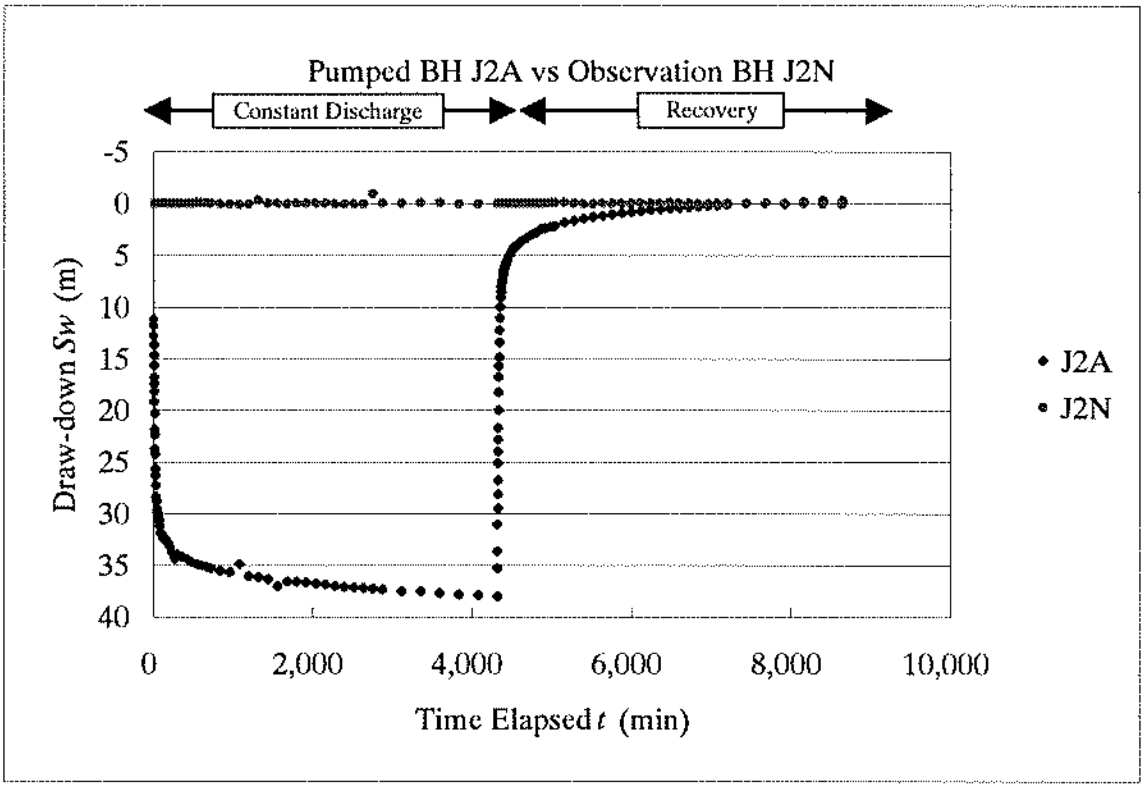


Chart 1a The chart showing the variation of drawdown of pumped BH (J2A) and observation BH (J2N).

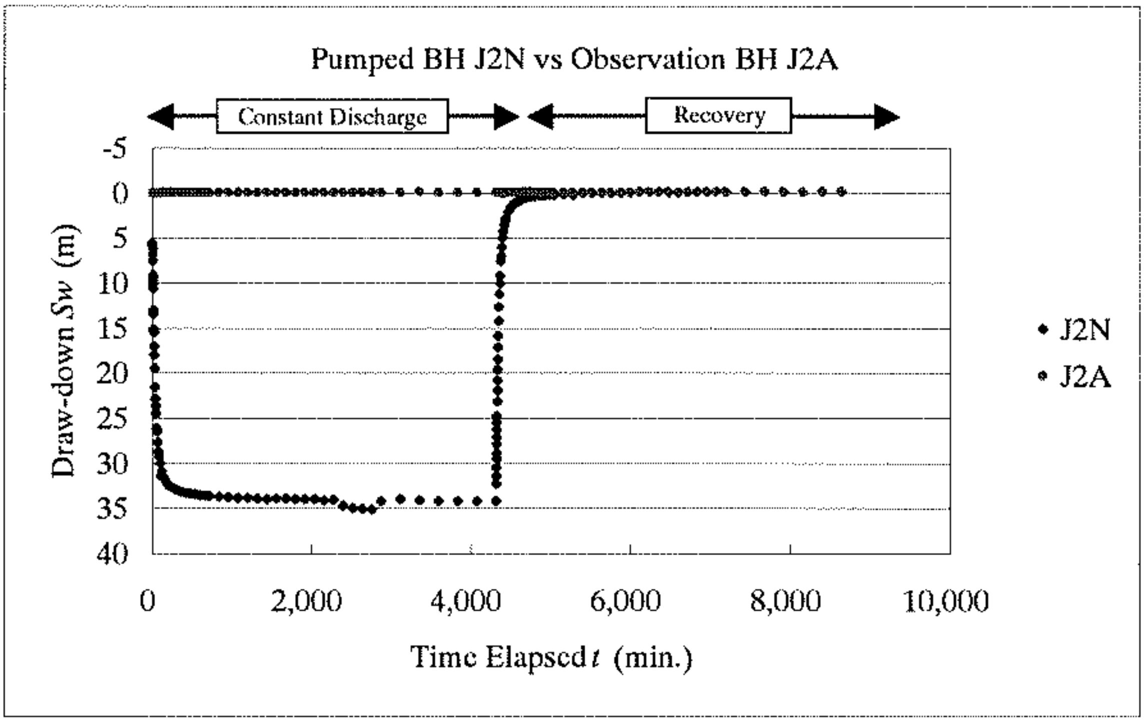


Chart 1a The chart showing the variation of drawdown of pumped BH (J2N) and observation BH (J2A).

Fig. 6.2-2 Interaction Between the Aquifers, in Location J2.

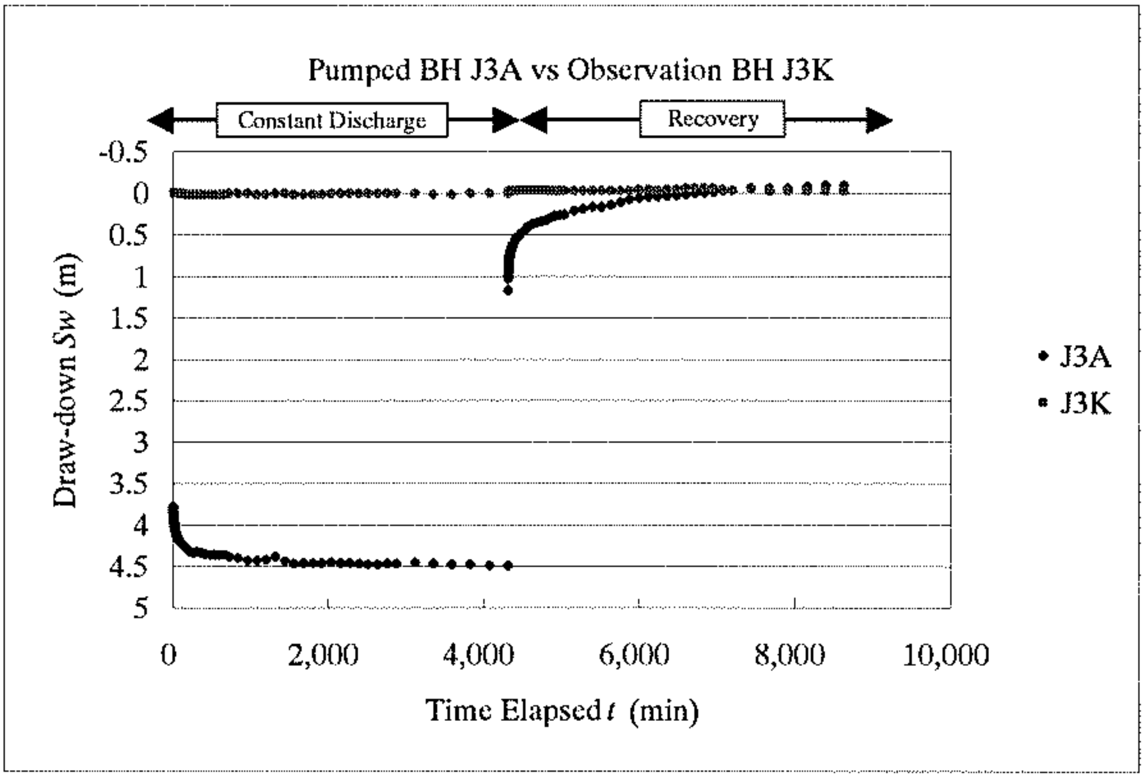


Chart 1a The chart showing the variation of drawdown of pumped BH (J3A) and observation BH (J3K).

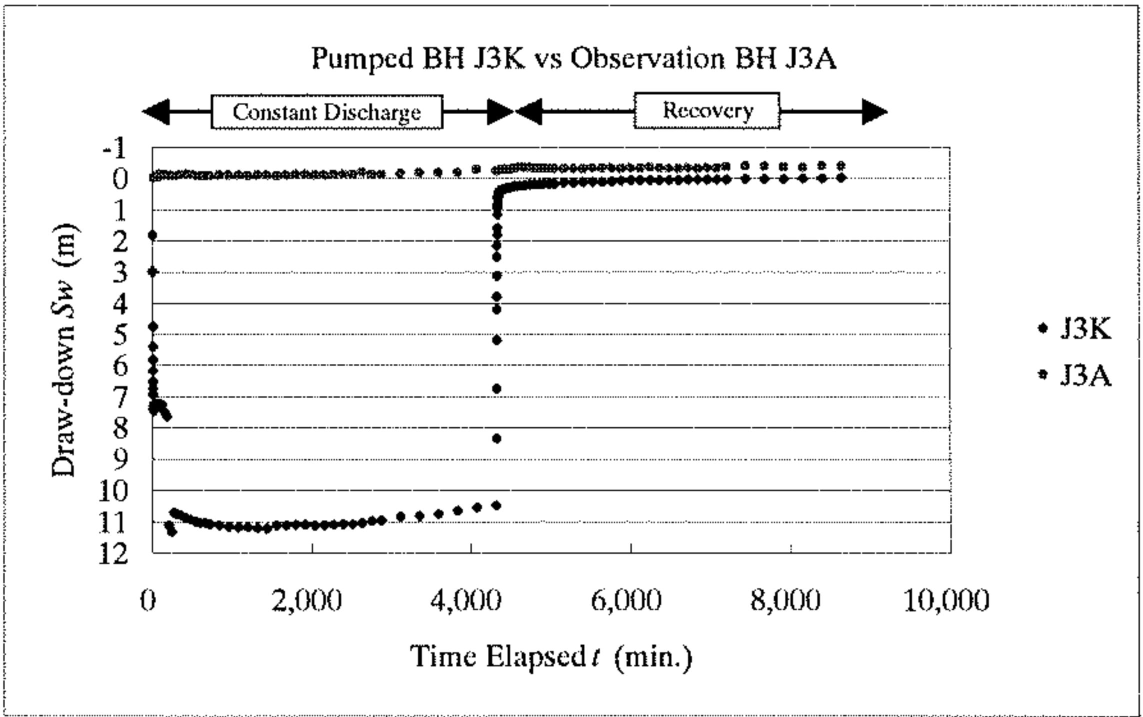


Chart 1a The chart showing the variation of drawdown of pumped BH (J3K) and observation BH (J3A).

Fig. 6.2-3 Interaction Between the Aquifers, in Location J3.

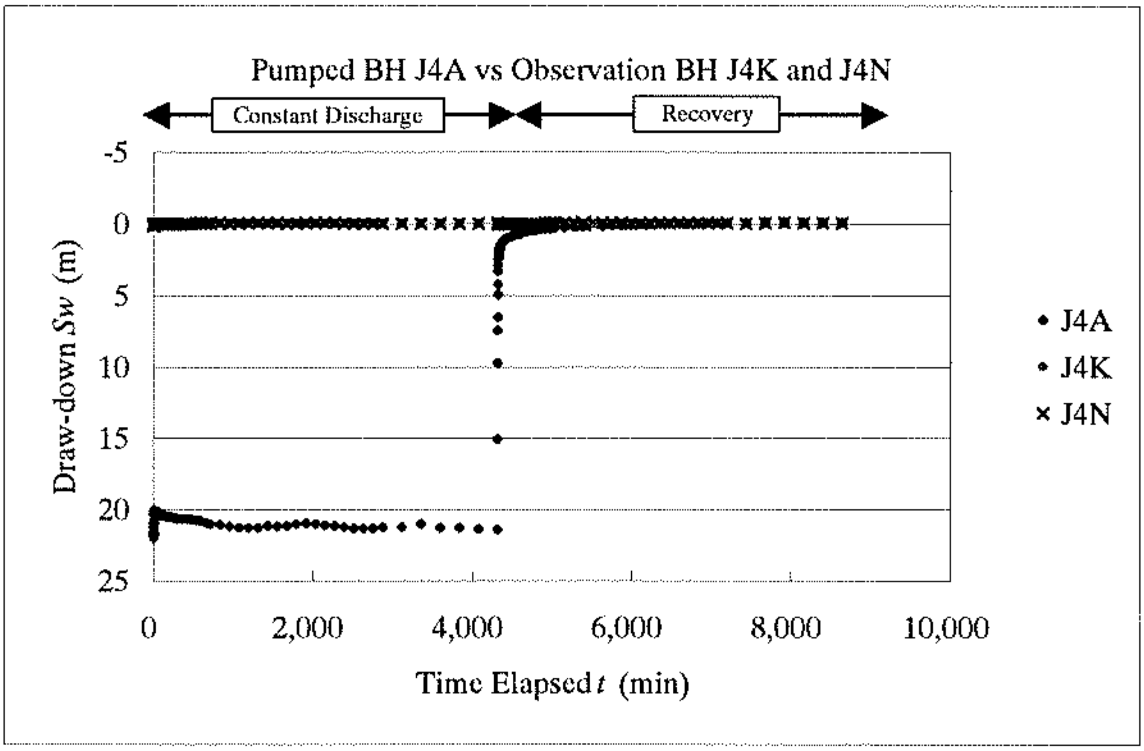


Chart 1a The chart showing the variation of drawdown of pumped BH (J4A) and observation BH (J4K and J4N).

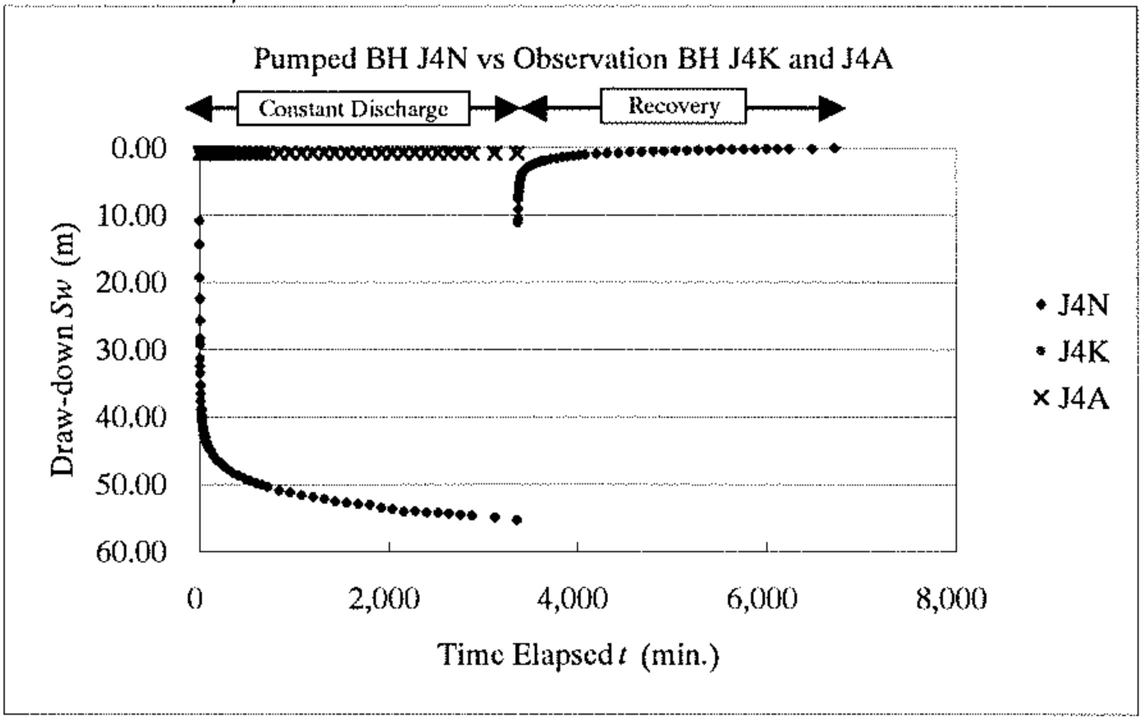


Chart 1a The chart showing the variation of drawdown of pumped BH (J4N) and observation BH (J4K and J4A).

Fig. 6.2-4 Interaction Between the Aquifers, in Location J4.

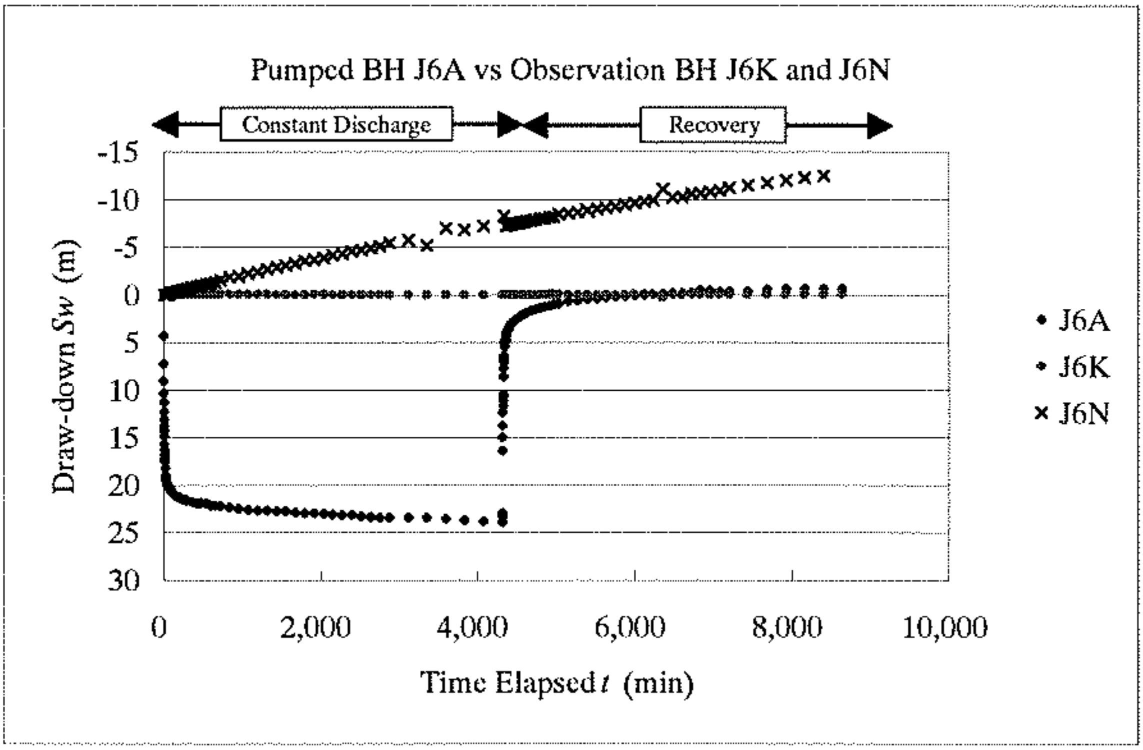


Chart 1a The chart showing the variation of drawdown of pumped BH (J6A) and observation BH (J6K and J6N).

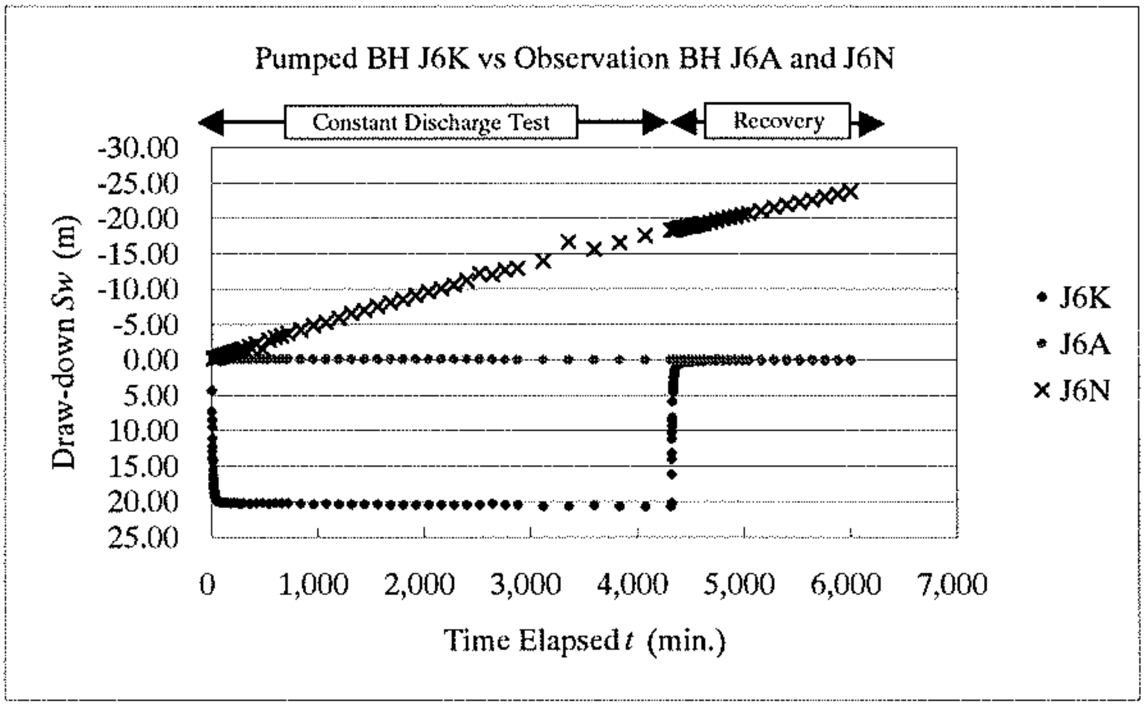


Chart 1a The chart showing the variation of drawdown of pumped BH (J6K) and observation BH (J6A and J6N).

Fig. 6.2-5 Interaction Between the Aquifers, in Location J6.

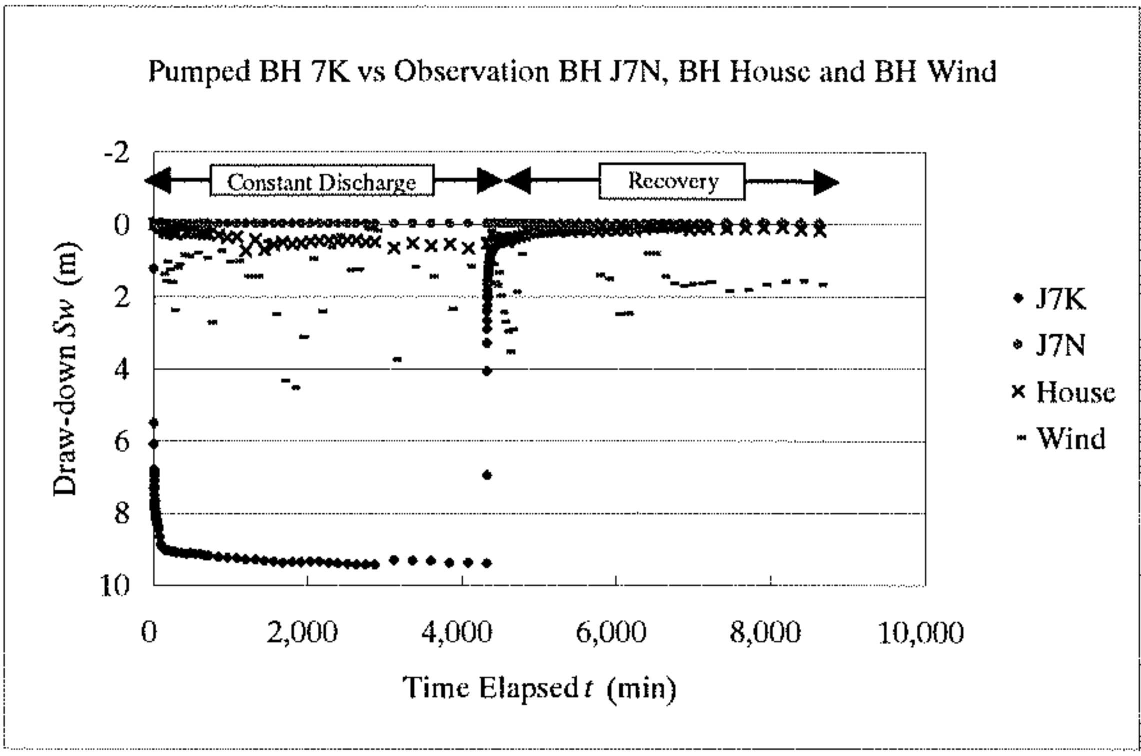


Chart 1a The chart showing the variation of drawdown of pumped BH (J7K) and observation BH (J7N, BH House and BH Wind)

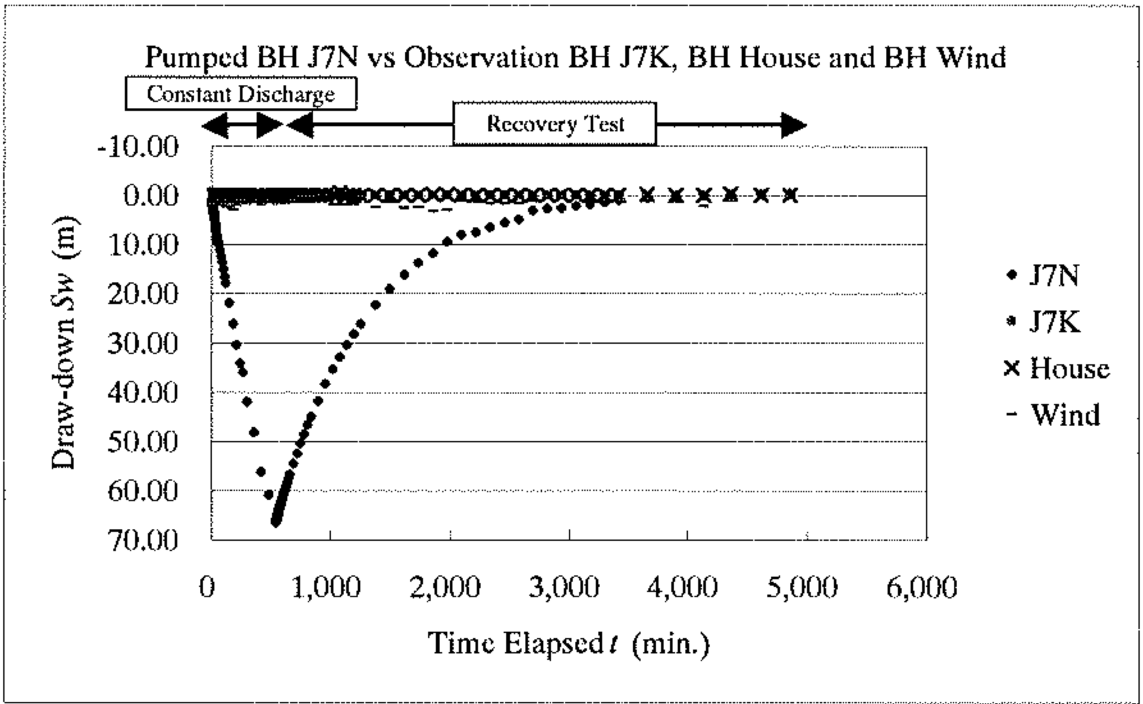


Chart 1a The chart showing the variation of drawdown of pumped BH (J7N) and observation BH (J7K , BH House and BH Wind).

Fig. 6.2-6 Interaction Between the Aquifers, in Location J7.

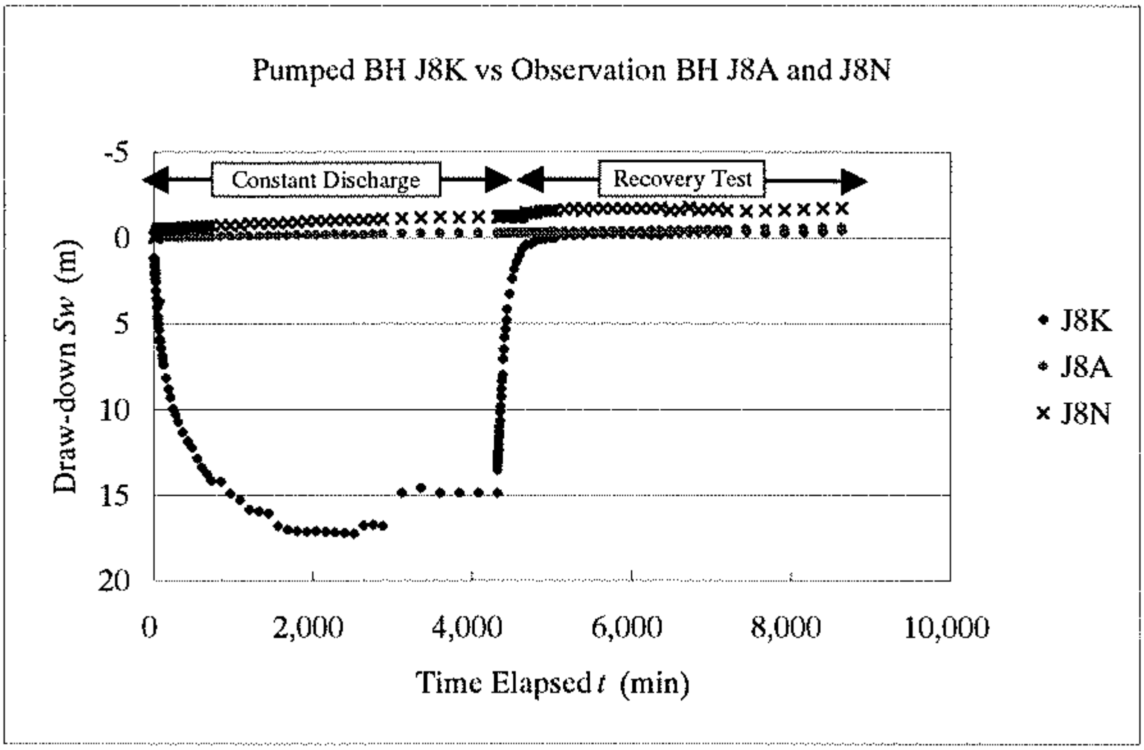


Chart 1a The chart showing the variation of drawdown of pumped BH (J8K) and observation BH (J8A and J8N).

Fig. 6.2-7 Interaction Between the Aquifers, in Location J8.

6.3 Installation of Water Level Recorder

6.3.1 Recorders, Installed

Water level recorders were installed in all of 19 JICA test boreholes as well as on eight existing boreholes. The existing boreholes were selected based on discussions with DWA. The location of these boreholes are shown on Fig.6.3-1. Two types of recorders namely, the floater type and pressure probe type were installed. The pressure probe was fitted to only for four artesian boreholes ie. J3N, J5N, J6N and JO-5N(an existing borehole).

All information in connection with water levels and data-loggers for the JICA boreholes is summarized in Table 6.3-1 and in Table 6.3-2 as for existing boreholes.

In the columns of "Data Logger", information of the data-logger installed is described. "Serial Number" shows the identification of each data logger. "Date Installed" corresponds to the first date on which water level monitoring commenced. "Cut-off A" and "Cut-off B" shows the length of cable from plug to clamp, and from clamp to data probe respectively. Only the float type recorder has such information.

6.3.2 Specification of Water Level Recorder

(1) Float Type (See Fig. 6.3-2 (1) and 6.3-2(2))

The main specification features are summarized as follows:

- memory: 32KByte for at least 32x484 = 15,488 measuring values (without time marks)
- communication: via M-Bus with communication interface at RS232 with 2400Baud
  : increase read data by up to 4800 Baud values
- clock: real time clock ±15ppm
- operating temperature: -20 to +70℃ (exception: glaciation)
- power supply conditions: average tempereature <25℃
  : max. pluses 500/day
  : measuring cycle times ≧15min
  : max. interface operation 5min/month
- operating life: 15 years
- expected runtime: 20 years

The float type recorder consists mainly of a plug, cable, clamp, data logger, ball chain, floater and weight. The data logger connects the plug by clamp and cable.

As described above, the manufacturer guarantees the battery life for 15 years. Therefore, the data logger must be sent to the manufacturer to change the battery.

The memory capacity of the data logger is only 15,488 measuring values. The time interval for data recording was set every 1 hour for monitoring purposes. If data capturing is carried out once a year, the number of data becomes 8,760 measuring values. The data logger can be left for about 1.5 years, with out down-loading the data.

(2) Pressure Probe Type (See Fig. 6.3-3)

The main specification features are summarized as follows;

- memory: 32KByte for at least 32x484 = 15,488 measuring values
- communication: via M-Bus with communication interface at RS232 with 2400baud
  : increase to 4800 baud by read out possible
- clock: real time clock ±15ppm
- operating temperature: -20 to +70℃ (exception: freezing)
- battery life time: average tempereature <25℃
  : measuring cycle times ≧15min
  : with max. 5min interface operation per month
  : >10 years guaranteed

The pressure probe type recorder consists mainly of a plug, cable and data logger with pressure sensor. The data logger connects to the plug by the cable only.

As described above, the manufacturer guarantees 10 years for battery life, whereafter the data logger must be sent to the manufacturer to change the battery.

The memory capacity of the data logger is only 15,488 measuring values. The time interval for data recording was set at every 1 hour for monitoring purposes. If data capturing is carried out once a year, number of measuring values becomes 8,760. The data logger can be left for about 1.5 years, without down-loading the data.

6.3.3 Technical Transfer on Operation and Maintenance of the Recorder

Technical transfer to the DWA officials relating to the operation and maintenance of the recorder was carried out during November 2000. The items transferred and confirmed are summarized as follows:

i) Reading actual value of water level and total memorized number in the data logger
ii) Checking the function of data logger by laptop computer

iii) Data capturing by laptop computer

6.3.4 Recommendation on Operation and Maintenance

As mentioned above, on both types of recorder, the maximum number of the data that can be memorized is only 15,488 measuring values. If this number is exceeded, new data will overwrite the old automatically. In order to avoid such losses, it is recommended that data capturing should be executed at least once a year. The borehole head facility consists of not only of the recorder, but also of other devices is installed to maintain the proper function of the recorder. Inspection of these devicesis also required. From this point of view, it is considered that a visit to the boreholes for data capturing at least once a year is appropriate.

A washer was fixed between the nut and fixing device in the cap in order to prevent the recorder falling down. It must however, be handled with care, water sampling or pumping, and the recorder must be held securely.

When the settings of data-logger are going to be changed, such as interval time, the memory of the data-logger will be initialised automatically. To avoid data losses in the logger, memorized data should first be saved before such settings are changed.

Table 6.3-1 Data Related to Water Level Recorder for Test Borehole

Locality Information							Water Level Information					Data Logger			
Location		Borehole Number		Coordination											
No.	Farm Name	JICA Ref. No.	WW No.	Latitude (d:m:s) / Latitude (decimal)	Longitude (d:m:s) / Longitude (decimal)	Elevation (masl)	Rest Water Level (mbsu)	Stick up (m)	Rest Water Level (mbgl)	Rest Water Level (masl)	Distance logger to RWL (m)	Serial Number	Date installed	*Cut-off A (m)	*Cut-off B (m)
J1	Christiana	J1A	39839	23°15'14.9" 23.25415	18°59'12.0" 18.98668	1331.71	58.90	1.185	57.715	1,273.995	5.91	4560	17-Jun-00	0.99	52.01
J2	Olifantswater West	J2A	39840	23°38'50.9" 23.64747	18°23'19.4" 18.38873	1275.26	16.47	1.460	15.010	1,260.250	2.47	4492	19-Sep-00	0.91	13.11
		J2N	39841	23°38'53.1" 23.64808	18°23'19.4" 18.38871	1275.60	40.79	1.340	39.450	1,236.150	4.79	4556	20-Sep-00	0.91	35.11
J3	Steynsrus	J3K	39842	24°02'45.3" 24.04592	18°47'36.2" 18.7934	1208.05	20.53	1.450	19.080	1,188.970	9.53	4554	6-Sep-00	0.91	10.11
		J3A	39843	24°02'52.5" 24.04792	18°47'35.2" 18.79312	1208.05	14.98	1.365	13.615	1,194.435	4.98	4491	6-Sep-00	0.91	9.11
		J3N	39844	24°02'54.9" 24.04858	18°47'46.1" 18.79614	1208.05	N/a	1.540	-30.910	1,238.960	N/a	F 20223	18-Oct-00	N/a	N/a
J4	Okanyama (Aminuis)	J4K	39845	23°24'03.5" 23.40098	19°37'29.6" 19.62489	1258.05	50.71	1.315	49.395	1,208.655	7.71	4490	18-Sep-00	0.91	42.11
		J4A	39846	23°24'01.8" 23.40049	19°37'32.8" 19.62577	1256.39	60.23	1.085	59.145	1,197.245	5.25	4561	18-Sep-00	0.91	54.11
		J4N	39847	23°24'03.8" 23.40105	19°37'34.4" 19.62621	1256.38	7.48	1.250	6.230	1,250.150	2.48	4493	18-Sep-00	0.91	4.11
J5	Maritzville	J5N	39848	24°19'41.7" 24.32824	18°23'52.6" 18.39794	1168.33	N/a	1.230	-29.57	1,197.900	N/a	F20268	11-Nov-00	N/a	N/a

Locality Information							Water Level Information					Data Logger			
Location		Borehole Number		Coordination											
No.	Farm Name	JICA Ref. No.	WW No.	Latitude (d:m:s) / Latitude (decimal)	Longitude (d:m:s) / Longitude (decimal)	Elevation (masl)	Rest Water Level (mbsu)	Stick up (m)	Rest Water Level (mbgl)	Rest Water Level (masl)	Distance logger to RWL (m)	Serial Number	Date installed	*Cut-off A (m)	*Cut-off B (m)
J6	Cobra	J6K	39849	24°48'00.3" / 24.80009	19°20'05.4" / 19.33483	1102.67	103.5	1.360	102.140	1,000.530	4.5	4540	20-Sep-00	0.91	98.11
		J6A	39850	24°48'02.1" / 24.80059	19°20'06.7" / 19.3352	1102.47	104.25	1.435	102.815	999.655	4.25	4499	20-Sep-00	0.91	99.11
		J6N	39851	24°47'58.7" / 24.79963	19°20'04.5" / 19.33457	1103.18	N/a	1.225	-19.64	1,122.820	N/a	F 20230	6-Oct-00	N/a	N/a
J7	Jackalsdraai	J7K	39852	25°17'29.9" / 25.29163	18°25'00.4" / 18.41678	1148.19	11.1	1.380	9.720	1,138.470	5.1	4542	5-Oct-00	0.91	5.11
		J7N	39853	25°17'28.2" / 25.29117	18°24'59.4" / 18.4165	1148.14	23.01	1.365	21.645	1,126.495	5.01	4552	5-Oct-00	0.91	17.11
J8	Tweerivier	J8K	39854	25°27'40.4" / 25.46122	19°25'57.6" / 19.43266	1021.25	61.06	1.310	59.750	961.500	6.06	4548	4-Oct-00	0.91	54.11
		J8A	39855	25°27'42.3" / 25.46174	19°26'01.4" / 19.43373	1021.13	>185.16	1.345	>183.82	<835.97	N/a	4489	2-Nov-00	0	0
		J8N	39856	25°27'41.3" / 25.46148	19°25'59.7" / 19.43324	1021.26	21.83	1.370	20.460	1,000.800	8.83	4550	4-Oct-00	0.91	12.11
J9	Klein Swart Modder	J9A	39857	24°00'06.5" / 24.00182	18°12'55.0" / 18.21529	1210.16	3.72	1.460	2.260	1,207.900	1.72	4508	20-Sep-00	0.91	1.11

Note: "Cut off A" means length from top plug to connection clamp
"Cut off B" means length from connection clamp to Data Logger

Table 6.3-2 Data Related to Water Level Recorder for Exisiting Borehole

Locality Information							Aquifer	Water Level Information					Data Logger			
Location		Borehole Number		Coordination												
No.	Farm Name	JICA Ref. No.	WW No.	Latitude (d:m:s) / Latitude (decimal)	Longitude (d:m:s) / Longitude (decimal)	Elevation (masl)		Rest Water Level (mbsu)	Stick up (m)	Rest Water Level (mbgl)	Rest Water Level (masl)	Distance logger to RWL (m)	Serial Number	Date installed	*Cut-off A (m)	*Cut-off B (m)
1	Neu Simmern	JO-1N	39872	23°33'37.4" / 23.56039	18°18'59.1" / 18.31642	1288.26	Nossob	20.22	1.400	18.82	1269.44	5.22	4555	16-Nov-00	0.91	14.11
2	Gumuchab Ost	JO-2A	39873	23°31'44.1" / 23.52892	18°17'32.9" / 18.29247	1294.06	Auob	10.56	1.480	9.08	1284.98	4.56	4503	16-Nov-00	0.91	5.11
3	Neu Mark	JO-3A	39874	23°35'56.3" / 23.59897	18°20'44.6" / 18.34572	1276.47	Auob	1.19	2.295	-1.105	1277.58	0.69	4551	16-Nov-00	0.21	0.31
4	Tugela	JO-4N	22837	24°49'14.5" / 24.82069	18°15'13.3" / 18.25369	1205.98	Nossob	33.44	1.280	32.16	1173.82	6.44	4563	6-Oct-00	0.91	26.11
5	Gochas	JO-5N	7995	24°51'31.0" / 24.85861	18°48'21.0" / 18.80583	1096.90	Nossob	N/a	1.465	-12.776	1109.68	N/A	20265	7-Nov-00	N/A	N/A
6	Dagbreek	JO-6N	37194	25°26'45.6" / 25.446	18°15'47.5" / 18.26319	1100.61	Nossob	41.57	1.295	40.28	1060.34	6.57	4562	5-Oct-00	0.91	34.11
7	Clencoe	JO-7A	37225	25°04'21.3" / 25.07258	18°06'30.3" / 18.10842	1170.28	Auob	29.65	1.445	28.21	1142.08	7.65	4547	16-Nov-00	0.91	21.11
8	Cobra	JO-8A	9919	24°45'30.0" / 24.75833	19°19'29.0" / 19.32472	1115.10	Auob	110.79	1.205	109.59	1005.52	5.79	4500	6-Oct-00	0.91	104.11

Note: "Cut off A" means length from top plug to connection clamp
"Cut off B" means length from connection clamp to Data Logger

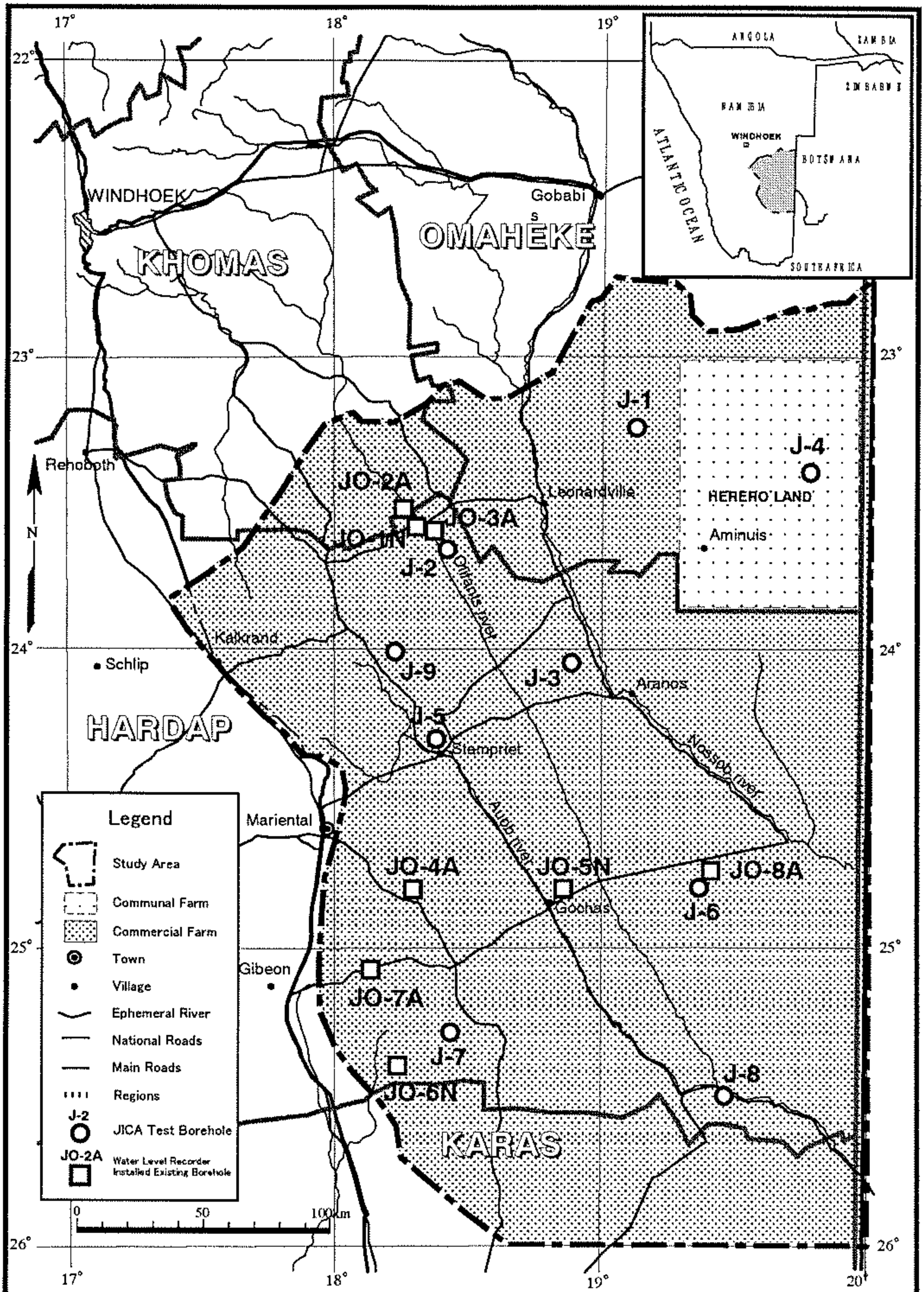


Fig.6.3-1 Location Map of Boreholes with Installed Water Level Recorder

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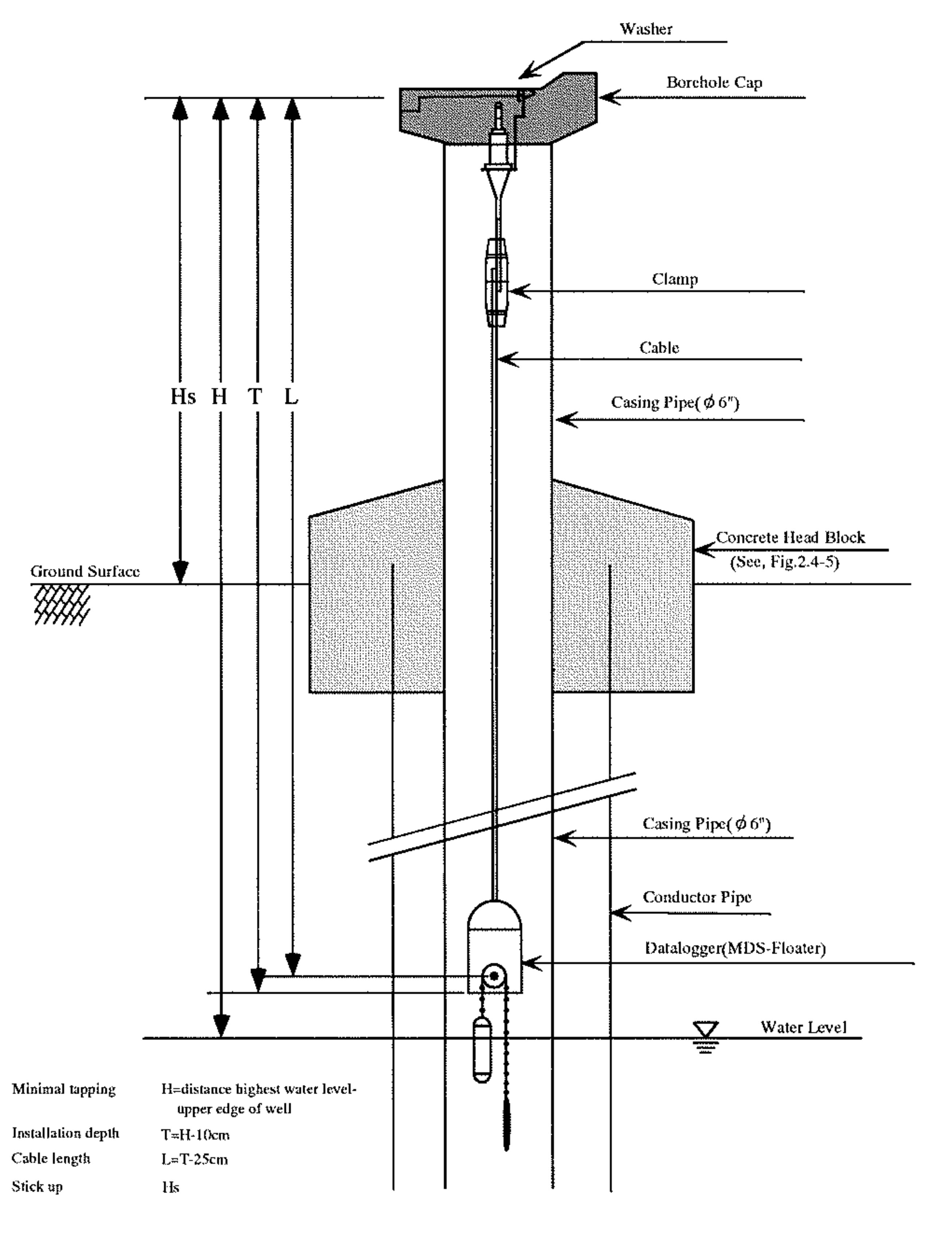

Fig. 6.3-2 (1) Borehole Head Facilities and Water Level Recorder

THE STUDY ON THE GROUNDWATER IN THE STAMPRIET ARTESIAN BASIN	JICA

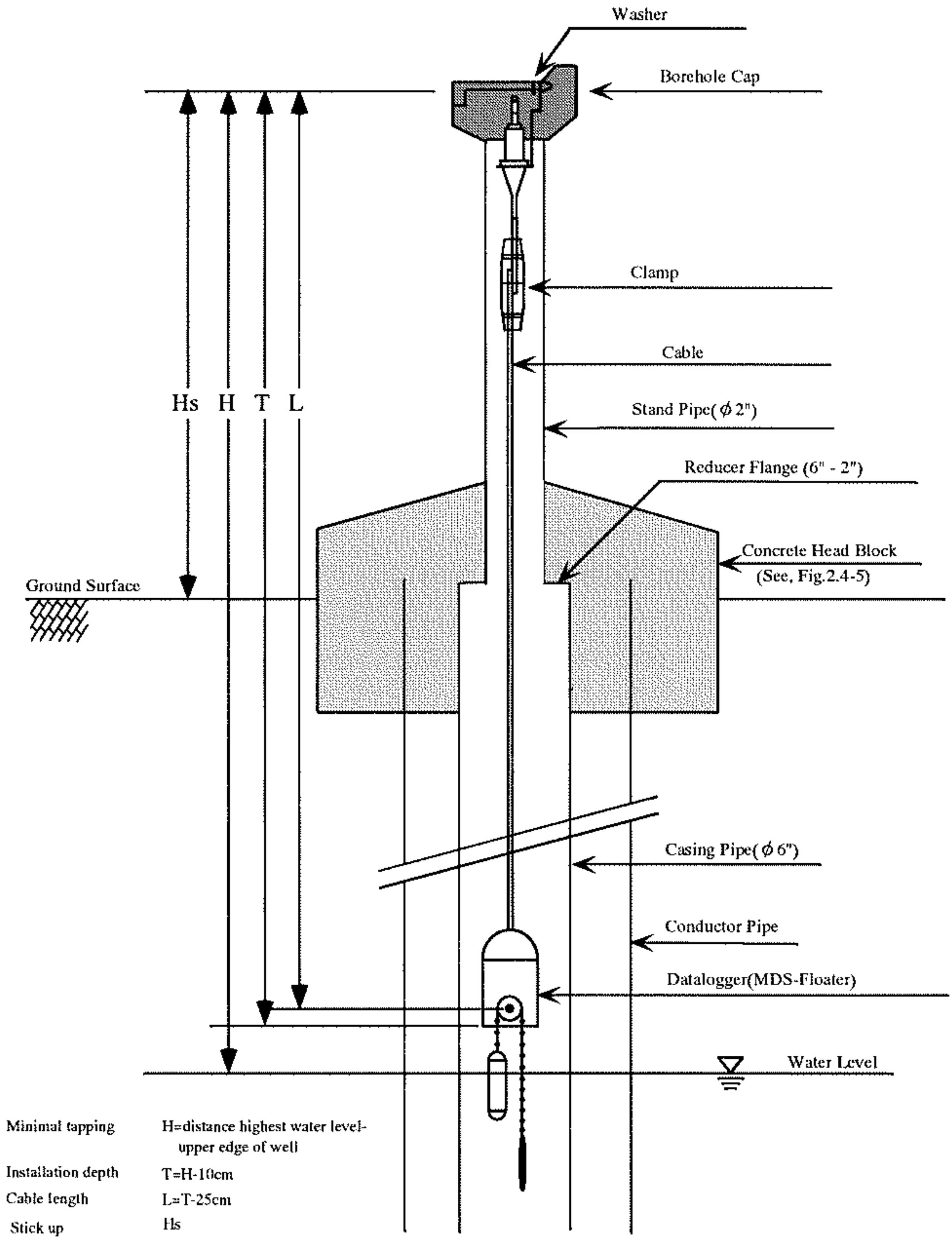

Fig. 6.3-2 (2) Borehole Head Facilities and Water Level Recorder (only for Location J4 and J7)

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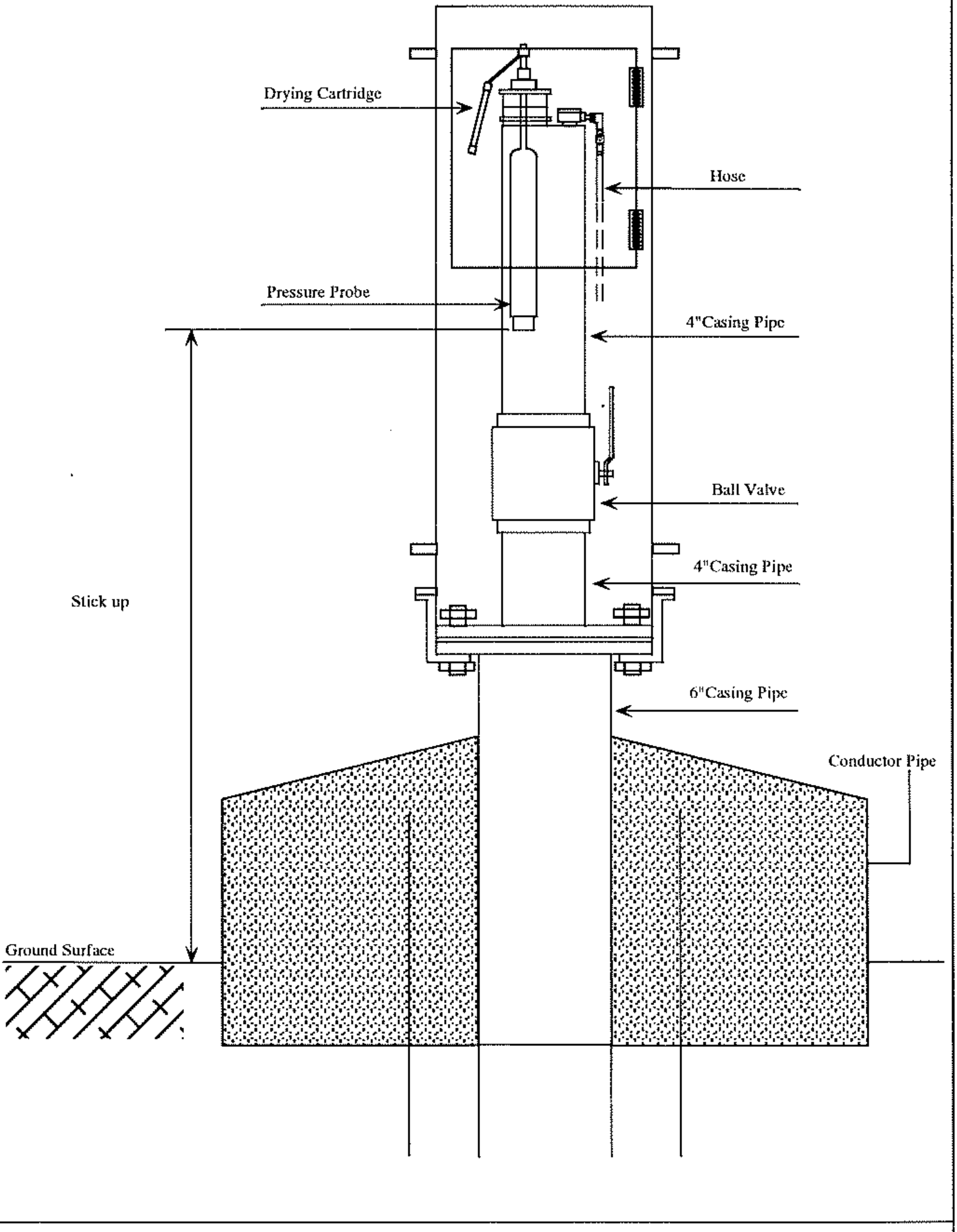

Fig. 6.3-3 Borehole Head Facilities and Water Level Recorder (Pressure Probe Type)