SUPPLEMENT - 1.1

LIST OF HYDROMETRIC STATIONS IN ZAMBIA

(1)List of Hydrometric Stations in Zambia << Zambezi River Basin >> (1/2)

NO	ST.NO.	AREA(km2)	RIVER	LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	1-040	122	Luinga	Ikelenge	N-Western/Solwezi	11/1971		Y	N	Y	00000000*00000**00***
2	1-080	764	Zambezi	Kaleni Hill R/D	N-Western/Solwezi	11/1971		Y	N	Y	0000000000000**00***
3	1-100		Zambezi	Cholose	N-Western/Solwezi	07/1959	04/1972	Y	N	N	*************XXXXXXXXXXXXXXXXXX
4	1-105	75,967	Zambezi	Chavuma Falls	N-Western/Solwezi	10/1955		Y	N	Y	0000000**0*******************0*****
5	1-130	-	Lunkunyi	Lunkunyi school	N-Western/Solwezi	12/1971		Y	N	Y	00000000*00**********
6	1-135	-	Makondu	Chief Nyakulenga	N-Western/Solwezi	12/1971		Y	N	N	********************
7	1-136	749	Makondu	Dipalata Mission	N-Western/Solwezi	12/1971		Y	N	Y	00000000000*00*******
8	1-141	-	Lunyiwu	Kakeki School	N-Western/Solwezi	12/1971		Y	N	N	********************
9	1-143	-	Lunyiwu	Dipalata School	N-Western/Solwezi	12/1971		Y	N	Y	000**00**0**00*****0*
10	1-145	3,354	Makondu	Chivatu Village	N-Western/Solwezi	12/1961		Y	N	Y	00000****000000000000000000*****
11	1-150	82,275	Zambezi	Zambezi Pump House	N-Western/Solwezi	02/1947		Y	N	Y	**00
12	1-205	1,075	Kabompo	Solwezi-Mwinilunga R/B	N-Western/Solwezi	01/1972		Y	N	Y	*000000*0*******0***
13	1-305	469	W/Lumwana	Solwezi-Mwinilunga R/B	N-Western/Solwezi	10/1976		Y	N	Y	000000000***0***
14	1-310	3,041	Mwombezhi	Solwezi-Mwinilunga R/B	N-Western/Solwezi	11/1971		Y	N	Y	0000000000000****0***
15	1-313	-	Chimiwonga	Lumwana	N-Western/Solwezi	10/1976	09/1978	Y	N	Y	000XXXXXXXXXXX
16	1-314	-	E/Lumwana	Lumwana Camp	N-Western/Solwezi	05/1976	12/1978	Y	N	Y	000XXXXXXXXXXXX
17	1-315	640	E/Lumwana	Solwezi-Mwinilunga R/B	N-Western/Solwezi	11/1971	06/1983	Y	N	Y	0000000000000XXXXXXXX
18	1-425	632	Luakela	Sachibondo	N-Western/Solwezi	10/1970		Y	N	Y	*00000000000000000*00**
19	1-430	4,538	W/lunga	Mwinilunga	N-Western/Solwezi	01/1953	11/1986	Y	N	Y	********0*********XXXX000*00*00**XXXX
20	1-610	-	Kabompo	Manyinga R/B	N-Western/Solwezi	11/1971		Y	N	Y	00000000************
21	1-630	-	Manyinga	Manyinga	N-Western/Solwezi	12/1961		Y	N	Y	00********00000000***0********0*
22	1-650	42,740	Kabompo	Kabompo Boma	N-Western/Solwezi	10/1950		Y	N	Y	**************************************00
23	1-660	-	Chikonkwelo	Kashina Village	N-Western/Solwezi	11/1971	10/1977	Y	N	Y	*******XXXXXXXXXXXXX
24	1-670	44,356	Kabompo	Kabompo Old Pontoon	N-Western/Solwezi	10/1952	06/1972	Y	N	Y	*******000000*******XXXXXXXXXXXXXXXX
25	1-690	-	Dongwe	Dongwe	N-Western/Solwezi	10/1958	10/1962	Y	N	Y	*****XXXXXXXXXXXXXXXXXXXXXXXXX
26	1-950	66,449	Kabompo	Watopa Pontoon	N-Western/Solwezi	05/1958		Y	N	Y	00*00000****0000000000000000**00
27	1-970	-	Mumbeji	Kabompo-Mwinilunga R/B	N-Western/Solwezi	12/1971	10/1976	Y	N	Y	0*0*00XXXXXXXXXXXXXX
28	2-020	43,030	Lungwebungu	Siakasumbi	N-Western/Solwezi	03/1958	12/1988	Y	N	N	**************************XXXX
29	2-030	206,531	Zambezi	Lukulu	Western/Mongu	10/1950		Y	N	Y	**************************************00
30	2-120	-	Luena	Longwe	Western/Mongu	02/1977	01/1987	Y	N	Y	*0********XXXX
31	2-123	-	Luena	Kaoma-Kasempa R/B	Western/Mongu	01/1977		Y	N	N	*************XX
32	2-130	7,016	Luampa	Njenga School	Western/Mongu	10/1961	01/1987	Y	N	Y	0000000**000000000*00*****XXX0
33	2-150	15,444	Luena	Kasambamezi (Hydro.site	Western/Mongu	10/1960		Y	N	Y	0000000**000000000**000********
34	2-200	-	Zambezi	Likapai	Western/Mongu	11/1961	02/1972	Y	N	N	*************XXXXXXXXXXXXXXXXXX
35	2-250	34,620	Luanginga	Kalabo	Western/Mongu	11/1957		Y	N	Y	********************************00
36	2-270	5,959	Luambimba	Sishekanu	Western/Mongu	07/1959		Y	N	N	********************************
37	2-310	-	Sikolongo	near zambezi Riv.	Western/Mongu	11/1961		Y	N	N	******************************
38	2-320	831	Namitome	Namitome	Western/Mongu	02/1962		Y	N	Y	0000000**0000*000000*0*0****0
39	2-330	276,710	L/Zambezi	Matonga Platform	Western/Mongu	01/1956		Y	N	N	*X********************************0
40	2-340	140	Sefula	Sefula R/B	Western/Mongu	02/1971		Y	N	Y	00000000*0**0*0****0

<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked
N : Not Available, 0 : Water level and discharge data are available, * : Water level data is available,
X : Data is not available, R.H.Office/Loca. : Regional Hydrological Office and Office location

(2)List of Hydrometric Stations in Zambia

<< Zambezi River Basin >> (2/2)

NO	ST.NO.	AREA(km2)	RIVER	LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1950'–1960'–1970'–1980'–1990')
41	2-350	-	Nalolo Canal	Nalolo	Western/Mongu	11/1961	07/1972	Y	N	N	**************XXXXXXXXXXXXXX**
42	2-360	206,531	Kataba	Siandi R/B	Western/Mongu	02/1971	03/1988	Y	N	Y	00000000*0********XXX
43	2-400	278,298	Zambezi	Senanga	Western/Mongu	11/1947		Y	N	Y	***0*00
44	2-450	15,451	Lueti/s	Lueti Pontoon	Western/Mongu	03/1961		Y	N	Y	*********0**********************
45	2-475	1,854	Lui	Luatembo School	Western/Mongu	11/1960	01/1987	Y	N	Y	000000****0000000000*0******XXXXX
46	2-700	33,605	Zambezi	Sesheke	Southern/Mazabuka	01/1960		Y	N	N	******************************
47	2-990	-	Zambezi	Mambova Harbour	Southern/Mazabuka	10/1971	02/1974	Y	N	N	***XXXXXXXXXXXXXXXXX
48	3-050	223,698	Zambezi	Livingstone Pump House	Southern/Mazabuka	01/1961		Y	N	N	****************XXXXXXXXX*******
49	3-120	-	Kalomo	William's Dam	Southern/Mazabuka	10/1980		Y	N	N	************
50	3-130	1,899	Kalomo	Kalomo Dam site	Southern/Mazabuka	03/1958	10/1984	Y	N	Y	000**********000***0**000**0*****XX
51	3-335	940	Muzuma	Mwezia school	Southern/Mazabuka	07/1970		Y	N	Y	0000****0**0*0*00***0*
52	3-350	215	Kazinze	Sinak-sikile R/B	Southern/Mazabuka	07/1970		Y	N	N	000***000000*0*00***0
53	3-370	228	Nangombe	Tobontes's Village	Southern/Mazabuka	10/1969		Y	N	Y	0000**00000000*0*00***0
54	3-375	-	Lake kariba	Chiyabi	Southern/Mazabuka	05/1984		Y	N	N	********
55	3-380	-	Lake Kariba	Sikolwenzala Hills	Southern/Mazabuka	08/1962	09/1966	Y	N	N	*****XXXXXXXXXXXXXXXXXXXXXX
56	3-950	414,400	Zambezi	Lusitu Pump House	Southern/Mazabuka	08/1961	01/1978	Y	N	N	*****************XXXXXXXXXXXXX
57	3-980	667,715	Zambezi	Chirundu R/S	Southern/Mazabuka	04/1963	06/1977	Y	N	Y	00*************XXXXXXXXXXXXX
58	5-012	-	Chongwe	Chongwe North	Lusaka/Lusaka	10/1973		Y	N	Y	*0000**00**********
59	5-016	303	Ngwerere	Ngwerere Estate Weir	Lusaka/Lusaka	01/1955		Y	(Y)	Y	****************************000000***0
60	5-024	-	Chongwe	Chongwe-Ngwerere Conflu	Lusaka/Lusaka	01/1977		Y	N	Y	0***000000*****
61	5-025	1,813	Chongwe	Chongwe(G.E.R.) Bridge	Lusaka/Lusaka	12/1968		Y	N	Y	*00000000*000**********
62	5-029	118	Chalimbana	Romar Farm	Lusaka/Lusaka	11/1953		Y	(Y)	Y	***0**************00*********00*0*00*0*0
63	5-030	107	Kapiriombwa	Exchange Farm	Lusaka/Lusaka	04/1957		Y	Y	Y	*************000*******0*00**00**000
64	5-099	-	Zambezi	Feira Boma	Lusaka/Lusaka	03/1962		Y	N	N	*****************************

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(3)List of Hydrometric Stations in Zambia

<< Kafue River Basin >> (1/3)

NO	ST.NO.	AREA(km2)	RIVER / LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	4-005	440	Kafue / Kipushi	Lusaka/Lusaka	08/1963		Y	N	Y	*0000000000000000000000*********
2	4-015	285	Muchindamu / Muchindamu	Lusaka/Lusaka	08/1963		Y	N	Y	*0000000000000000000000*********
3	4-040	4,066	Kafue / Ngosa Farm	Copperbelt/Kitwe	10/1962	04/1976	Y	N	Y	*0000000*000***XXXXXXXXXXXXXXX
4	4-050	4,999	Kafue / Raglam Farm	Copperbelt/Kitwe	09/1959		Y	N	Y	***0000000000000000000000*******00
5	4-060	5,207	Kafue / Chililabombwe	Copperbelt/Kitwe	12/1958	10/1974	Y	N	Y	0000*****000****XXXXXXXXXXXXXXXXXX
6	4-090	7,148	Kafue / Kafironda	Copperbelt/Kitwe	12/1958		Y	N	Y	***0****0000000000000000*********00
7	4-095	27	Kafironda / Kafironda	Copperbelt/Kitwe	05/1973	02/1980	Y	N	Y	**000***XXXXXXXXXXX
8	4-100	300	Mutundu / Mutundu	Copperbelt/Kitwe	07/1964		Y	N	Y	**00000000000000000000*******XX
9	4-120	869	Mwambashi / Mwambashi	Copperbelt/Kitwe	10/1959		Y	Y	Y	*0000000000000000000000000*******00
10	4-130	8,599	Kafue / Smith's Bridge	Copperbelt/Kitwe	08/1958		Y	Y	Y	*0000000000000000000000000*******00
11	4-150	1,195	Kafue / Wusakile Bridge	Copperbelt/Kitwe	12/1958		Y	N	Y	*00000000000000000000000000*******0*
12	4-152	192	Kamfinsa / Kamfinsa	Copperbelt/Kitwe	10/1961	10/1987	Y	N	Y	**********00000000000000*****XXXX
13	4-170	339	Baluba / Baluba	Copperbelt/Kitwe	01/1968	04/1985	Y	N	Y	*000000000000000***XXXXXX
14	4-180	18	Chapula / St.Joseph's Mission	Copperbelt/Kitwe	02/1971	11/1986	Y	N	Y	*000000000000****XXXXX
15	4-200	11,655	Kafue / Mpatamato	Copperbelt/Kitwe	12/1950	10/1987	Y	Y	Y	**********00000000000000000000000000*****XX00
16	4-205	2,499	Kafulafuta / Ibenga Mission	Copperbelt/Kitwe	10/1969		Y	N	Y	**0000000000000*******00
17	4-210	306	Kafubu / Itawa-Dambo	Copperbelt/Kitwe	02/1973	09/1984	Y	N	Y	00000000000**XXXXXXX
18	4-239	210	Munkulungwe / Kaposa	Copperbelt/Kitwe	07/1971	04/1987	Y	N	Y	0000000000000*****XXXX
19	4-240	951	Kafubu / Fisenga	Copperbelt/Kitwe	10/1969	01/1989	Y	N	Y	**0000000000000******XXX
20	4-245	1,375	Kafubu / Masaiti R/B	Copperbelt/Kitwe	07/1971		Y	N	Y	0000000000000*******00
21	4-250	4,817	Kafulafuta / Miputu Hills	Copperbelt/Kitwe	11/1962		Y	N	Y	*0000000000000000000000*********
22	4-260	18,726	Kafue / Ndubeni	Copperbelt/Kitwe	12/1962		Y	N	Y	**000000000000000000000*********
23	4-265	829	Lufwanyama / Muteba	Copperbelt/Kitwe	10/1963	02/1972	Y	N	Y	****000000*XXXXXXXXXXXXXXXXXXXX
24	4-266	69	Mpopo / Mpopo School	Copperbelt/Kitwe	05/1971	04/1985	Y	N	Y	*000000000000***XXXXXX
25	4-267	984	Lufwanyama / Mpopo School	Copperbelt/Kitwe	03/1971	04/1985	Y	N	Y	0000000000000***XXXXXX
26	4-268	267	Katembula / Katembula	Copperbelt/Kitwe	06/1971	01/1987	Y	N	Y	*00***************XXXX
27	4-272	2,890	Lufwanyama / Kanakila	Copperbelt/Kitwe	06/1971	08/1987	Y	N	Y	*0*0**************XXXX
28	4-280	22,920	Kafue / Machiya Ferry	Copperbelt/Kitwe	06/1962		Y	N	Y	****0000000000000000000*******00
29	4-281	598	Impumpu / Machiya	Copperbelt/Kitwe	08/1971		Y	N	Y	**0****00000*********
30	4-302	2,666	Luswishi / Lwendo	Copperbelt/Kitwe	06/1971		Y	N	Y	*000000000000*******0
31	4-310	3,600	Luswishi / Kilundu	Copperbelt/Kitwe	10/1964	08/1987	Y	N	Y	***00000000000000000*****XXXX
32	4-340	8,708	Luswishi / Kangondi	Copperbelt/Kitwe	08/1971	10/1086	Y	N	Y	*00000000000****XXXX*
33	4-350	34,162	Kafue / Chilenga	Copperbelt/Kitwe	06/1962		Y	N	Y	000000000000000000000000*******00
34	4-375	80	Lukanda / Chikanda	Lusaka/Lusaka	02/1976		Y	N	Y	**00000*********
35	4-390	-	Lukanga Swamp / Chilwa Island	Lusaka/Lusaka	01/1960	01/1987	Y	N	N	***************************XXXX
36	4-400	-	Lukanga Swamp / Twenty Village	Lusaka/Lusaka	11/1962		Y	N	N	****************************XXX
37	4-435	50,479	Kafue / Mswebi	Lusaka/Lusaka	09/1950		Y	N	Y	*************0000000*000*********************
38	4-450	54,442	Kafue / Lubungu	Lusaka/Lusaka	06/1951		Y	N	Y	*********000000000*00000000000000*******00
39	4-460	11,655	Lunga / Konikombe Hills	N-Western/Solwezi	02/1964	10/1986	Y	N	Y	***00000000000000000*******XX
40	4-500	1,704	Mutanda / Mutanda Mission	N-Western/Solwezi	02/1964	09/1985	Y	N	Y	****0**0000000000000****XXXXX

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(4)List of Hydrometric Stations in Zambia << Kafue River Basin >> (2/3)

NO	ST.NO.	AREA(km2)	RIVER	LOCATION	R.H.Office/loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
41	4-505	427	Solwezi	Solwezi	N-Western/Solwezi	09/1971	09/1985	Y	N	Y	*0*****00000*****XXXX*
42	4-510	7,997	Lunga	Mujimanzovu	N-Western/Solwezi	09/1963	12/1986	Y	N	Y	***00000000000000000***XXXXXX
43	4-515	1,083	Chifubwa	Solwezi Road	N-Western/Solwezi	08/1981	11/1986	Y	N	Y	*0****XXXX*
44	4-550	19,555	Lunga	Kelongwa School	N-Western/Solwezi	12/1963		Y	N	Y	*********0*000000000*******00
45	4-560	21,445	Lunga	Chifumpa Pontoon	N-Western/Solwezi	02/1953		Y	N	Y	******000*******************************00
46	4-595	24,268	Lunga	Kasonso Mine	Lusaka/Lusaka	01/1958	01/1977	Y	N	Y	*00000*************XXXXXXXXXXXXXXX
47	4-620	1,062	Lufupa	Kasempa pump House	N-Western/Solwezi	12/1963		Y	N	Y	*********0*000000000*******0*
48	4-669	95,053	Kafue	Kafue Hook Bridge	Lusaka/Lusaka	01/1968		Y	N	Y	******000000000*******00
49	4-670	95,053	Kafue	Kafue Hook Pontoon	Lusaka/Lusaka	06/1951	07/1973	Y	N	Y	***********0000000*000*XXXXXXXXXXXXXXXX
50	4-675	-	Kafue	Chunga Camp	Lusaka/Lusaka	02/1969	01/1977	Y	N	N	*********XXXXXXXXXXXXXX
51	4-676	-	Kafue	Chunga Rapids	Lusaka/Lusaka	02/1969	04/1973	Y	N	N	*****XXXXXXXXXXXXXXXXXX
52	4-710	105,672	Kafue	Itezhi-Tezhi	Lusaka/Lusaka	01/1952		Y	N	Y	********0000000************00000*********
53	4-750	9,065	Nanzila	Nanzila Mission	Southern/Mazabuka	10/1963		Y	N	N	*****************************
54	4-759	116,032	Kafue	Namwala Boma	Southern/Mazabuka	1914		Y	N	N	**
55	4-760	149,443	Kafue	Namwala Pontoon	Southern/Mazabuka	11/1951		Y	N	Y	**********000*********************************
56	4-780	120,176	Kafue	Busangu Rapids	Copperbelt/Kitwe	11/1962	01/1987	Y	N	N	**************************XXXX
57	4-790	1,526	Nansenga	Tepula	Lusaka/Lusaka	12/1963	01/1980	Y	N	N	*****************XXXXXXXXXXX
58	4-820	1,787	Munyeke	Mapanza R/S	Southern/Mazabuka	1960	05/1966	Y	N	N	******XXXXXXXXXXXXXXXXXXXXXXX
59	4-821	1,787	Munyeke	Mapanza Mission	Southern/Mazabuka	05/1960	01/1987	Y	N	Y	***************************XXXX
60	4-850	1,735	Mutama	Mutama rapids	Southern/Mazabuka	10/1963	01/1987	Y	N	Y	***************************XXXX
61	4-880	777	Nangoma	Myooye Bridge	Lusaka/Lusaka	10/1963		Y	N	Y	****000000********************
62	4-881	-	Nangoma	Muchabi	Lusaka/Lusaka	12/1977	04/1985	Y	N	N	*********XXXXXX
63	4-890	136,234	Kafue	Nyimba	Southern/Mazabuka	10/1962	11/1987	Y	N	N	***************************XXX
64	4-907	1,010	Magoye	Railway Weir	Southern/Mazabuka	03/1952	05/1970	Y	N	N	***000000*00********XXXXXXXXXXXXXXXXXXX
65	4-915	1,865	Magoye	Chimbumbu's	Southern/Mazabuka	08/1970	12/1986	Y	N	N	*****************XXXX
66	4-918	62	Mwembeshi	Great North Road	Lusaka/Lusaka	03/1977		Y	N	N	**************
67	4-930	199	Kabile	Chikoloma Hills	Lusaka/Lusaka	12/1963	05/1971	Y	N	N	**0******XXXXXXXXXXXXXXXXXXXXX
68	4-937	2,163	Mwembeshi	Lusaka- Mumbwa	Lusaka/Lusaka	12/1977	11/1982	Y	N	N	********XX*XXX**
69	4-938	-	Kafue	Luwato	Lusaka/Lusaka	11/1978	08/1985	Y	N	N	*******XXXXXX
70	4-940	3,885	Mwembeshi	Shibuyunji	Lusaka/Lusaka	12/1962		Y	N	Y	*************000***000*******0
71	4-941	45	Kaleya	Kaleya Dam Site	Southern/Mazabuka	12/1952	10/1986	Y	Y	Y	000000000**********0000*******00*****XXX00
72	4-942	63	Kaleya	Water Valley Weir	Southern/Mazabuka	10/1951	1975	Y	(Y)	Y	*********00****************XXXXXXXXXXXXXXX
73	4-943	63	Kaleya	Water Valley R/B	Southern/Mazabuka	10/1958	10.1986	Y	N	N	******************************XXX**
74	4-945	206	Kaleya	Avilion Weir	Southern/Mazabuka	12/1950	06/1988	Y	N	Y	*************************0**0000**0****XXX
75	4-946	206	Kaleya	Avilion R/B	Southern/Mazabuka	11/1958	06/1988	-	N	Y	***0*************0****00*******XXX
76	4-947	376	Kaleya	Mendham Weir	Southern/Mazabuka	11/1951	07/1961	Y	N	N	***********XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
77	4-949	549	Kaleya	Kaleya R/B	Southern/Mazabuka	11/1958	01/1988	Y	N	N	*******************************X00
78	4-950	596	Kaleya	Heal's Estate	Southern/Mazabuka	10/1951	12/1986	Y	(Y)	Y	***************************************XXXX
79	4-952	7	Nakambala	Nakambala Upper Weir	Southern/Mazabuka	03/1958	10/1965	Y	(Y)	N	******XXXXXXXXXXXXXXXXXXXXXXXXXXXXX
80	4-953	9	Nekambala	Nakambala Lower Weir	Southern/Mazabuka	11/1952	03/1987	Y	(Y)	Y	***********************************XXXX

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(5)List of Hydrometric Stations in Zambia << Kafue River Basin >> (3/3)

NO	ST.NO.	AREA(km2)	RIVER / LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
81	4-955	149	Kafue / Cere's	Southern/Mazabuka	05/1951	10/1986	Y	N	Y	********00000***000*****************XXXX
82	4-958	140	Mazabuka / Uruaff Farm	Southern/Mazabuka	10/1952		Y	Y	Y	*****************OO*****************OO
83	4-960	149,350	Kafue / Kafue Polder	Southern/Mazabuka	07/1956	12/1987	Y	N	N	********************************
84	4-965	-	Nega-Nega / Nega- Nega	Southern/Mazabuka	11/1969	12/1987	Y	N	N	******************
85	4-975	148,265	Kafue / Kafue Railway Bridge	Lusaka/Lusaka	1905		Y	N	N	***
86	4-977	150,971	Kafue / Kasaka	Lusaka/Lusaka	08/1943		Y	N	Y	**********00000000000***000*********************
87	4-980	150,997	Kafue / Kafue Road Bridge	Lusaka/Lusaka	01/1948	10/1974	Y	N	N	***************************XXXX******XXXXXXX
88	4-995	148,666	Kafue / Farowe	Lusaka/Lusaka	09/1958	06/1970	Y	N	N	*************XXXXXXXXXXXXXXXXXXXXX
89	4-999	154,882	Kafue / Mafungozi	Lusaka/Lusaka	09/1958	07/1970	Y	N	N	*************XXXXXXXXXXXXXXXXXXXXX

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X : Data is not available, R.H.Office/Loca. : Regional Hydrological Office and Office location

(6)List of Hydrometric Stations in Zambia

<< Luangwa River Basin >> (1/1)

NO	ST.NO.	AREA(km2)	RIVER AND LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	5-300	-	Luangwa / Mulopwe Village	Eastern/Chipata	09/1975	12/1979	Y	N	N	*****XXXXXXXXXXXX
2	5-350	1,101	Lundazi / Lundazi Dam	Eastern/Chipata	02/1957		Y	N	Y	***************00XXXXXXXXXXXXX0*****
3	5-400	-	Lumamba / Lumamba Dam	Eastern/Chipata	08/1976		Y	N	N	*****************
4	5-550	10	Koba / Koba Bridge	Eastern/Chipata	01/1973		Y	N	N	*******************0*
5	5-554	-	Lutembwe / St Marry's Mission	Eastern/Chipata	-	-				XX
6	5-555	-	Lutembwe / Lutembwe weir	Eastern/Chipata						00XXXXXX************
7	5-557	75	M'sipazi / Chadidza RD BG	Eastern/Chipata	02/1973		Y	(Y)	Y	*X00*00**000***0000*0*
8	5-558	-	Kova / Kova Drift D/S	Eastern/Chipata	06/1970		Y	N	Y	**00***********00*0*0*
9	5-560	319	M'sipazi / Madzimoyo Quarry	Eastern/Chipata	07/1970		Y	N	Y	**0*0*****************0
10	5-561	650	Lutembwe / Madzimoyo Bridge	Eastern/Chipata	06/1970		Y	(Y)	Y	0X00X0000000000X**XXXXXX
					09/1970	05/1985	Y	N	Y	
11	5-562	65	Makungwa / Great East RD BG	Eastern/Chipata	08/1970		Y	N	Y	**0*0***********0000*0*
12	5-563	-	Nsadzu / Nsadzu Dam	Eastern/Chipata	07/1973		Y	N	Y	00X****************
13	5-564	60	Katete / Katete Boma	Eastern/Chipata	10/1976		Y	N	Y	********0000*0*
14	5-650	-	Luangwa / M'fuwe	Eastern/Chipata	11/1963		Y	N	Y	****************00000000000**00
15	5-670	995	Lisiwasi / Masase	Eastern/Chipata	11/1965		Y	N	Y	00*00000000*00000*0*******0
16	5-755	181	Chiwefwe / M'kushi Boma	Eastern/Chipata	09/1962		Y	N	Y	*00*****00*0000000000****0***00
17	5-775	106	Mushiwembwa / Johnson's Farm	Eastern/Chipata	09/1962		Y	(Y)	N	********************************
18	5-800	55,488	Luangwa / Ndevu Camp	Eastern/Chipata	09/1960		Y	N	Y	0000000***XX
19	5-815	1,448	Mulungushi / Great North RD BG	Eastern/Chipata	03/1960		Y	N	Y	***********00*000000000*0**0*****
20	5-940	143,781	Luangwa / Luangwa RD BG	Eastern/Chipata	10/1948		Y	N	Y	0000***0000000**00****0**********0000000000**00
21	5-948	2,134	Rufunsa / Janeiro Village	Copperbelt/Kitwe	06/1975		Y	N	Y	000********000****

<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked
N : Not Available, O : Water level and discharge data are available, * : Water level data is available,
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(7)List of Hydrometric Stations in Zambia

<< Chambeshi River Basin >> (1/1)

NO	ST.NO.	AREA(km2)	RIVER	LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	6-105	23	China	Senga Hill	Northern/Kasama	02/1970	11/1973	(Y)	N	Y	OOOOXXXXXXXXXXXXXXXXXX
2	6-130	-	Nakonde	Nakonde Dam Site	Northern/Kasama	09/1975		Y	N	Y	*****OO********OO
3	6-133	32	Kabulukutu	Chamfubu	Northern/Kasama	12/1986		Y	N	Y	OOOOOO
4	6-135	12	Chamfubu	Conflu. with Kabulukutu	Northern/Kasama	12/1986		Y	N	Y	OOOOOO
5	6-138	54	Kabulukutu	Ngoli Coffee Estate	Northern/Kasama	10/1986		Y	N	Y	O*XX**
6	6-140	6,628	Chambeshi	Chandaweyaya	Northern/Kasama	10/1959		Y	N	Y	OOOOOO***O*OOOOOOOO*OOOOO*******
7	6-145	6,045	Chambeshi	Mbesuma Ferry	Northern/Kasama	10/1974		Y	N	Y	OOOOO*OOOO*OO***OO
8	6-160	95	Mansenke	Nansala Falls	Northern/Kasama	10/1961		Y	N	Y	OOOO*O***OOOOOO*O**O**O*O**O*OO
9	6-170	2,901	Kalungwishi	Chunga Ranch	Northern/Kasama	10/1959		Y	N	Y	OOOOOOO****OOOOOOOO*****O********
10	6-200	2,198	Chozi	Chozi	Northern/Kasama	12/1959		Y	N	Y	OOOOO****O*OOOOO*OO*OO*O*********
11	6-224	101	Mungu	Mungwi School	Northern/Kasama	01/1958		Y	N	Y	OOOOOOOO**OOOOOOOOOOOOOOOO*OO*OOOO
12	6-235	2,097	Kalung Bemba	Kalungu	Northern/Kasama	10/1959		Y	N	Y	OOOOOOO***OOOOOOOOOO*OOOOOOO*O*OO
13	6-242	640	Chimanabuwi	Chipoma Falls	Northern/Kasama	05/1956		Y	N	Y	*OOOOOOOOOO***OOOOO*OOO*O***O**O***OO
14	6-250	2,839	Lubu	Mundu Brigde	Northern/Kasama	10/1959		Y	N	Y	OOOOOOO***OOOOOOOOOOOOOO***OO*O*OO
15	6-275	1,038	Mansha	Shiwa Nganda	Northern/Kasama	08/1964		Y	N	Y	OO******OOOOOOOO*O**O*****OO
16	6-289	34,188	Chambeshi	Chambeshi Pontoon	Northern/Kasama	12/1952		Y	N	Y	OO*OOOOOOOOOOO****OO*OO**O*******O*OO***OO
17	6-290	-	Chambeshi	Chambeshi RD BG	Northern/Kasama	02/1963	06/1971	(Y)	N	Y	OO****OOOXXXXXXXXXXXXXXXXXXXXXX
18	6-330	2,548	Luombe	Chismba Falls	Northern/Kasama	09/1954		Y	(Y)	Y	OOOOOO***OOO***OOOOOO*OOOOOO*O*O**O*OO
19	6-335	550	Lukupa	Kateshi Coffee Estate	Northern/Kasama	10/1986		Y	N	Y	OOOOOO
20	6-340	67	Milima	Milima	Northern/Kasama	02/1957		Y	N	Y	OOOOOOOOOOO**OO*OOOOOOOOOOOOOOO*OO**OOO
21	6-350	6,527	Lukulu	Kasama-Luwindu RD BG	Northern/Kasama	06/1970		Y	N	Y	OOOOOOOOOOOOOOOOO***OO
22	6-370	12	Mulilasolo	Kasama	Northern/Kasama	09/1961	06/1967	(Y)	N	Y	OOOOO**XXXXXXXXXXXXXXXXXXXXXXXX
23	6-400	42,921	Chambeshi	Mbati	Northern/Kasama	11/1957		Y	N	N	*********************************OO
24	6-480	179	Luwitikila	Luwtikila Falls	Northern/Kasama	09/1958		Y	N	Y	OOOOOOOO***OOOOOOO*OO**OO*O**O*****
25	6-486	839	Luwitikila	Mpika RD BG	Northern/Kasama	10/1969		Y	N	Y	*OOOOOOOOOOOOO*O*O*O**OO
26	6-500	1,215	Kanchibya	Mpika-Kasama RD BG	Northern/Kasama	12/1969		Y	N	Y	*OOOOOOOOOOOOO*O*O*O**OO
27	6-510	992	Kachibya	Kopa Bridge	Northern/Kasama	10/1970		Y	N	Y	OOOOOOOOOO*O**O****O***
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<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked
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(8)List of Hydrometric Stations in Zambia

<< Luapula River Basin >> (1/1)

NO	ST.NO.	AREA(km2)	RIVER LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	6-020	161	Lufubu/Green Water Falls Luwingu	Luapula/Kawamba	11/1959		Y	N	Y	0000******00000000*000*00xxx****
2	6-040	-	Bangweulu Lake/Nsombo Harbour	Luapula/Kawamba	05/1954		Y	N	N	*************************************
3	6-060	1,178	Luena/Luena Mission	Luapula/Kawamba	02/1970		Y	N	Y	0000000*****0*********
4	6-065	-	Bangweulu/Lake Muchinchi	Luapula/Kawamba	01/1953	02/1971	(Y)	N	N	******************xxxxxxxxxxxxxxxxxxxx
5	6-080	-	Bangweulu/Samfya	Luapula/Kawamba	08/1954		Y	N	N	*************************************
6	6-090	-	Bangweulu Lake/Mpata Point	Luapula/Kawamba	11/1957		Y	N	N	**********************************
7	6-460	-	Bangweulu Swamps/Nsalushi Island	Luapula/Kawamba	11/1957	02/1971	(Y)	N	N	**************xxxxxxxxxxxxxxxxxxxx
8	6-465	-	Bangweulu Swamps/Mutwamina	Luapula/Kawamba	11/1957	02/1971	(Y)	N	N	**************xxxxxxxxxxxxxxxxxxxx
9	6-476	-	Bangweulu Swamps/Matongo	Luapula/Kawamba	01/1954		Y	N	N	***********************************xx
10	6-520	-	Bangweulu Swamps/Kasoma	Luapula/Kawamba	02/1953		Y	N	N	******************************xxxxxxxx
11	6-525	-	Bangweulu Swamps/Kalimankonde	Luapula/Kawamba	11/1957	02/1971	(Y)	N	N	*************** xx
12	6-665	2,800	Lwela/Chipota falls	Luapula/Kawamba	11/1970		Y	N	N	**********************
13	6-670	122,507	Luapula/Chembe Ferry	Luapula/Kawamba	06/1957		Y	N	Y	0**0x0000*0**********00****************
14	6-700	1,510	Mansa/Mansa Pump House	Luapula/Kawamba	10/1955		Y	N	Y	***************00***0000000*********xx
15	6-745	-	Luongo/Mukonshi	Luapula/Kawamba	1977		Y	N	Y	000000*0*0*****
16	6-750	4,170	Loungo/Mwenda-Kashiba RD BG	Luapula/Kawamba	02/1970		Y	N	Y	*000000000000*0******0
17	6-760	121,088	Lufubu/Chibote Mission	Luapula/Kawamba	02/1976		Y	N	N	***************0
18	6-765	1,220	Lufubu/Chipili	Luapula/Kawamba	11/1970		Y	N	Y	*000000000000*0******0
19	6-770	5,957	Loungo/Musonda Falls	Luapula/Kawamba	11/1957	09/1964	(Y)	N	Y	000000*0xxxxxxxxxxxxxxxxxxxxxxxxxx
20	6-775	6,045	Luongo/Chibondo Pontoon	Luapula/Kawamba	09/1956	02/1962	Y	N	Y	000000xxxxxxxxxxxxxxxxxxxxxxxxxxxxx
21	6-785	16,058	Luapula/Kashiba	Luapula/Kawamba	10/1955		Y	N	Y	***0000000*********00**************
22	6-790	303	Ngona/Ntumbachushi Falls	Luapula/Kawamba	10/1957		Y	N	Y	00000000*************************0
23	6-800	-	Mweru Lake/Nchelenge	Luapula/Kawamba	12/1954	05/1969	(Y)	N	N	***************xxxxxxxxxxxxxxxxxxxx**
24	6-855	383	Mutotoshi/Kapuma Falls	Luapula/Kawamba	11/1957		Y	N	Y	00000000xxxxx00000000x00xxx0******
25	6-860	4,895	Luangwa/Mumbuluma Falls	Luapula/Kawamba	09/1970		Y	N	Y	000000000***0*0*******
26	6-865	10,218	Kalungwishi/Chimpempe Pontoon	Luapula/Kawamba	03/1951		Y		N	**
27	6-900	12,018	Kalungwishi/Olandi	Luapula/Kawamba	08/1970		Y	N	Y	00000000xxxx*********0
28	6-910	2,186	Chishela/Bulaya Pontoon	Luapula/Kawamba	06/1958		Y	N	Y	00000******************************
29	6-915	1,166	Mwawe/Muwawe Cause Way	Luapula/Kawamba	09/1958	09/1971	Y	N	Y	00000*******0xxxxxxxxxxxxxxxxxxxxxx
30	6-920	2,424	Choma/Kaputa	Luapula/Kawamba	09/1957	01/1970	(Y)	N	Y	0000000*****xxxxxxxxxxxxxxxxxxxxxx
31	6-925	-	Mweru Wanitipa/Kampinda	Luapula/Kawamba	09/1957		Y	N	Y	**********************************
32	6-935	707	Mwambeshi/Nsama	Luapula/Kawamba	06/1959		Y	N	Y	00000****0000000*0**00****0**xx**
33	6-955	1,015	Mukubwe/Kambasa	Luapula/Kawamba	07/1958	08/1984	Y	N	Y	0000000****000000000******xxxxxxxx
34	6-960	-	Mufuwe Dambo/Mukupa Latanoula	Luapula/Kawamba	10/1956	01/1971	Y	N	N	**************xxxxxxxxxxxxxxxxxxxx
35	6-980	-	Mweru Lake/Kafulwe Mission	Luapula/Kawamba	11/1955		(Y)	N	N	**********************************
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<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked
N : Not Available, 0 : Water level and discharge data are available, * : Water level data is available,
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(9)List of Hydrometric Stations in Zambia << Tanganyika Lake Basin >> (1/1)

NO	ST.NO.	AREA(km2)	RIVER / LOCATION	R.H.Office/Loca.	OPENED	CLOSED	S.G	AUT	DIS	DATA AVAILABILITY (1940'–1990')
1	7-005	363	Lunzua / Kambole Bridge	Northern/Kasama	05/1970		Y	N	Y	1970': 00000000*00*0***00**00
2	7-006	386	Lunzua / Lunzua Weir	Northern/Kasama	01/1957		Y	(Y)	Y	1957': *00000000***00********************
3	7-010	-	Lake Tanganyika / Mpulungu	Northern/Kasama	04/1957		Y	N	Y	1957': *******************************XX*
4	7-020	57	Lake Chila / Mbala	Northern/Kasama	10/1955		Y	N	N	1955': ************************************
5	7-021	57	Lucheche / Below Lake Chila	Northern/Kasama	03/1970		Y	N	Y	1970': *0000000*0X0********00
6	7-750	6,475	Lufubu / Keso Falls	Northern/Kasama	09/1957		Y	N	Y	1957': 000000000*****0000000**0***0******0
7	7-800	-	Lake Tanganyika / Nsumbu Harbour	Northern/Kasama	12/1960		Y	N	N	1960': *******************************

<NOTE> S.G : Staff Gauge, AUT : Automatic Recorder, Dis : Discharge Rating Curve, Y : Available, (Y) : Previously worked
N : Not Available, O : Water level and discharge data are available, * : Water level data is available,
X : Data is not available, R.H.Office/Loca. : Regional Hydrological Office and Office location

CHAPTER - 2

WELL OBSERVATION

<<<<< CHAPTER-2 WELL OBSERVATION >>>>>

C O N T E N T S

<<< LIST OF FIGURES AND TABLES >>>

2.1 Outline of Hydrogeology

2.1.1 General Geology

The geology of Zambia mainly consists of Precambrian and early Palaeozoic. The basement complex, Muva super group, Katanga super group (Lower and Upper Roan and Kundelung group) are distributed in the eastern, northwestern and southern province of Zambia. The main tectonic events, Ubendian (2000 +- 200 million years), Kibaran (1100 +- 200 million years), Pan-Affrican Orogeny (600 +- million years) are almost Precambrian era. These areas are almost stabilized after the end of the African Orogeny and there is no significant tectonic movemets from the early Palaeozoic era to the Recent age.

The stabilized Precambrian shield is not comformably overlain by Lower Palaeozoic. Karoo super group with the Plateau basalts on the top, in age from Caboniferous to Jurassic, covers the down-faulted rift through of the Mid-Zambezi, Luangwa, Luano-Lukusashi and Kafue Valleys and part of the Barotse Basin. The Karoo rocks are overlain by Cretaceous continental beds and Mid-Tertialy-Quaternary Kalahari Group in Western Zambia.

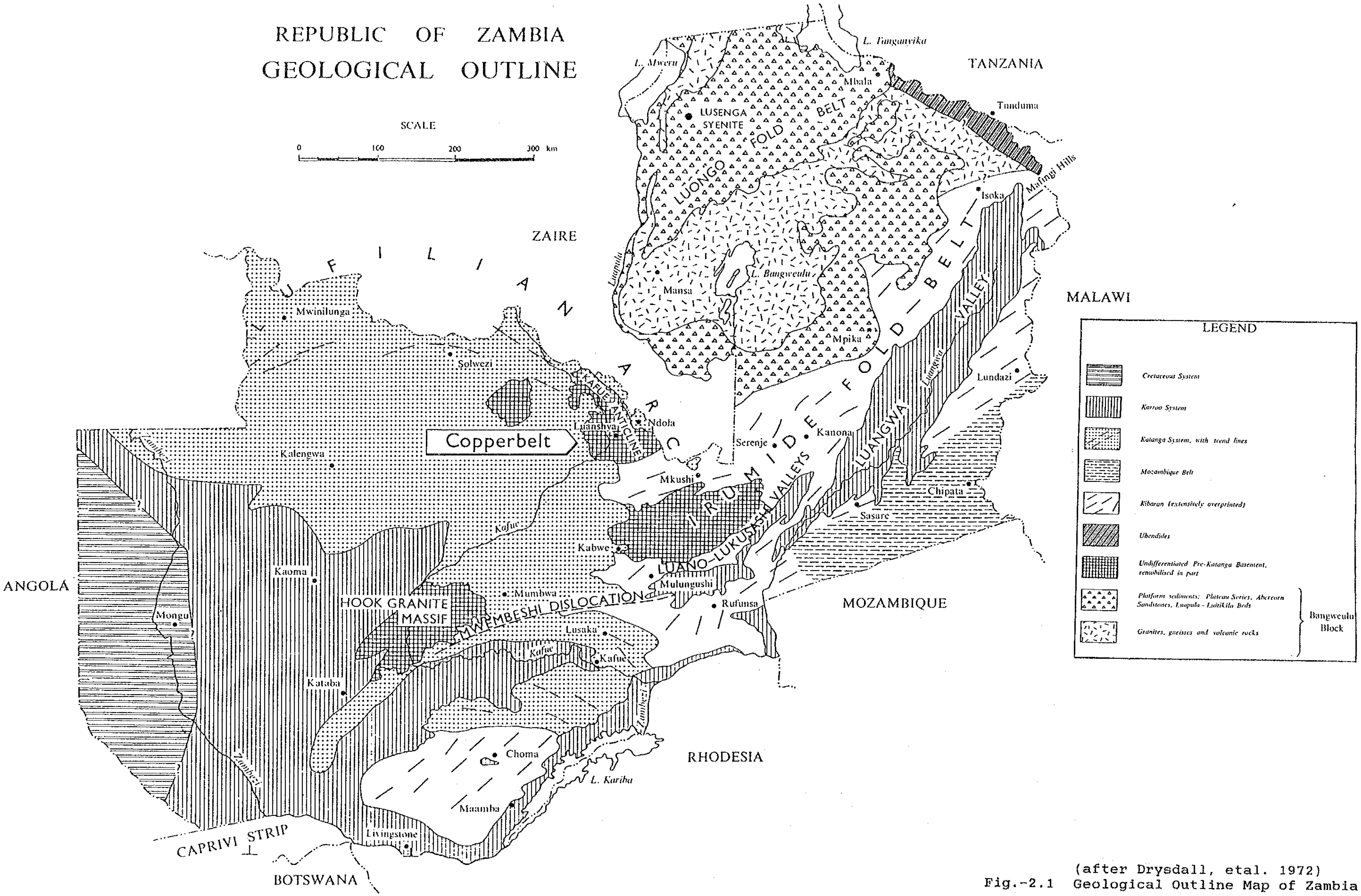
Alluvium are located mainly along the courses of the main rivers and the surrounding areas of the lakes.

The stratigraphical table of Zambia is shown in Table-2.1 and also the geological outline map of Zambia in Fig.-2.1.

The outline of the major sturactural-stratigraphic systems of Zambia is as follows. (according to N.J.Monley 1986, A.R. Drys-dall etal. 1972)

Table-2.1 Stratigraphical Table of Zambia

Geological Age		Super Groups	Groups or Formations	Rocks and Sediments
Cenozoic Era	Quaternary ~ Tertialy	Cenozoic Super Group	Alluvium	Alluvium sands,Gravels Clay near lakes
			Kalahari Group	Fine sands, Sandstones with clays
Mesozoic Era	Cretaceous	Mesozoic Super Group	Lower Cretaceous Formations	Mudstones, Siltstones
	Jurrasic ~ Carboniferous	Karoo Super Group	Upper Karoo Group	Basalt,Interbeded Sand stone,Sandstones,Mud- stones,Siltstones
			Lower Karoo Group	Mudstone with coal mea sures, Siltstones,Sand stones,Conglomerates
Palaeozoic Era	Silurian ~ Ordovician	Lower Palaeozoic Super Group		Quartzites, Shales, Sandstones
Pre-cambrian Era	Early Palaeozoic ~ Precambrian	Katanga Super Group	Kundelung Group	Carbonate rocks with shales,Shales,Silt- stones,Sandstones
			Upper Roan Group	Dolomites, Argillites
			Lower Roan Group	Quartzites,Argillites, Dolomites,Conglomerate Mine series shales
		Basement and Muva Super Group	Muva Group	Shales,Mudstones, Sandstones
			Basement Complex	Basement gneisses, Migmatites, Schists
Various age mainly older Precambrian		Intrusive and Metamorphic Rocks		Basic-igneous rocks, Meta-igneous rocks, Amphibolites, Metasediments, Metavolcanics



(after Drysdall, etal. 1972)

Fig.-2.1 Geological Outline Map of Zambia

2003

1) Bangweulu Block (> 1800 m.y. in part)

This unit is part of an ancient craton. The older rocks were affected by the Ubendian events. The basement complex of the base includes volcanic rocks intruded granitic rocks and is unconformable overlain by the Plateau Series and Luapula beds. The Plateau Series (1800 to 1100 m.y.) include quartzites, grits, arenites, shales. The Luapula beds include arenaceous and argillaceous sediments, conglomerates, limestones.

2) Kibaran (1300 +- 40 m.y. culmination)

In the Kibaran belt, the Basement Complex of the pre-Katanga formations were affected by the Kibaran Orogeny, and includes granites, gneisses, migmatites, metasediments, phyllites, cataclasites, amhibolites and metavolcanics. The pre-Katanga rocks have been subdivided into the pre-Kibaran and the Kibaran elements.

3) Katanga sediments and the Lafilian Arc

The Katanga sediments cover extensive area west of longitude 28.30' E, and divided into the Lower Roan, the Upper Roan, the Mwashya and the Kundelungu series. The Lower Roan consists of conglomerates, aeolian sandstones, clastics and shales deposited in a shallow marine environment, and contains are formations. The Upper Roan consists of carbonaceous shales and argillites. The Kundelungu series consists of tillites, congremerates, shales, quartzites.
The Katanga sequence was affected by three phases of folding and metermorphism during the Lufilian orogeny. The Lufulian Arc is an arcuate orogenic zone containing folding and thrusted Katanga sediments and elongates from North-Western Zambia to Angola and Zaire. A variety of granitic rocks, gabbros, dolerites, syenites are present in the area as remobilized rocks or syntectonic intrusions.

4) The Mozambique Belt

The Belt is part of the Pan-African orogenic belt system, which is extensively distributed throughout East Africa. It is mainly formed by polymetamorphosed and complexly folded high grade gneisses, charnokites and granulites, cut by granitic, syenitic and basic instruction.

5) Lower Paleozoic Sediments

These sediments are locally distributed below Karoo rocks at Western and South-Eastern Zambia. These include unmetamorphosed arkoses and quarzites formed in a marine environment in age from Ordovician to Silurian.

6) Karoo Series

The Karoo series covers the down-faulted rift troughs of the Mid-Zambezi, Luangwa, Luano-Lukusashi , Kafue Valleys and part of the Barose Basin in Western Zambia in age from Caboniferous to Jurassic. The Karoo rocks are divided into the Lower and Upper Karoo. The Lower Karoo rocks consists of basal sandstone and conglomerate of fluvio-glacial and glacial origin, fine grained sediments of fluviatile origin, sandstones, carbonaceous mudstones and coal seams. The Upper Karoo consists of arenaceous continental sediments, the Escarpment grits, fine grained sediments, the Batoka Basalt Formation.

7) The Barotse Basin

In the Basotse Basin, the Cretaceous continental mudstones and siltstones are underlain by the Karoo series. This sequence is overlain by the Kalahali Series containing sand stones and unconsolidated sands in age from Mid-Tertiary to Quaternary. Alluviam unconsolidated sediments are distribut- ed along the main river and lakes.

2.1.2 Hydrogeology of the Well Field

The following is a outline of the hydrogeology of the main well field of study area.

1) Lusaka

The Lusaka region consists of the Chunga formation (quartz shist, mica shist), Cheta formation (carbonate rocks, shist) and Lusaka dolomite, corresponding to the upper Katanga series and lower Roan series. The upper part of the aquifer exists from 0 meters to 50 meters in depth the lower part from 65 to 80 meters.

The specific capacities for shist in 78 wells are, for 0.1 ~ 0.3 m3/hr/m; 41% and for 0.03 ~ 3 m3/hr/m; 91%. The specif- ic capacities for limestone and dolomite in 102 wells were considerable with 88% for 0.3 ~ 100 m3/hr/m. The karstic caves and fissures have a high potential for yield. The groundwater in caves and fissures is under free watertable conditions. The main groundwater flow is directed towards the northwest (Lusaka City Council 1978).

The current Lusaka water supply consists of approximately 120,000 m3/day in groundwater from boreholes and shafts and approximately 80,000 m3/day in intake water from the Kafue river. Of the 42 wells, 35 wells are in operation. The well depths are between 40 and 80m with depths of around 60m being common. (according to interviews with the Lusaka Urban District Council Water works office, 1990 July).

2) Kabwe

In the Kabwe region, the aquifers are mainly in the docloites and limestones of Broken Hill series corresponding to the Upper Roan and Mwasha series of the Katanga super group.
The specific capacity of shist and shale for 27 wells with depths ranging from 34 to 67 m (47m average) is 0.14 ~ 2.4 m3/hr/m (1.2 m3/hr/m average). The specific capacity limestone and dolomite for 32 wells with depths ranging from 22 to 85m (52m average) is 0.01 ~ 148 m3/hr/m (18 m3/hr/m average) (M.J. Jones 1972).

The current Kabwe water supply consists of the Kalulu pump station where there are 9 wells of which 5 are operating and the Mukobeko pump station where there are 6 wells of which 2 are operating providing 24,000 m3/day. In addition the Mulungushi Dam (concrete gravity dam, volume: 23,000 m3, Max. height: 16m, crest length: 585 m) has been completed and water pipelines are under construction (according to interviews with the Kabwe Urban District Council Water Works Office, 1990 July).

3) Ndola

In the Ndola region, the main water beds and treatment plant (capacity: 37,500 m3) are in the dolomites and limestones of Kakontwe formation belonging to the Kundelungu series of the Katanga super group. At the area of the Mufulia syncline, the caves and fissures are well developed (F. Kolman, 1982).

Of the 12 wells on the Musun project, 2 have no water, 9 have a transmissivity of 10 ~ 12,500 m2/day and specific capacities of 0.14 ~ 120 m3/hr/m while 1 well has a large yield with a transmissivity of 6,000 m2/day and a specific capacity of 2,500 m3/hr/m (Brian Colguhoun & Partners, 1975), showing a wide dispersion of capacities.

Currently the 11 wells in the Musun region are pumping 35,000 ~ 45,000 m3/day and apart from that 87,000 m3/day is also being taken from the Itawa river, Ishiku lake and the Katubu dam (according to interviews with the Ndola Provincial Council, 1990 June).

4) Other Northern Cities

Water supply for Kitwe is pumped from river. Chingola has secured 40,000 m3/day, 50% from mine groundwater and 50% from the Kafue river. Chililabombwe is using a part of the groundwater from the Konkola mine. (According to interviews with the respective District Councils, 1990 June).

5) Mongu

In the Mongu region, the sand formations of the Upper Kalahari group are the main water beds. Ten boreholes (6" diameter, 70-80 m in depth with Johnson Type stainless Screens) are being dug for water supply. Transmissivity ranges from 20 to 180 m2/day and specific capacity from 1.4 to 4.1 m3/hr/m (Interconsultant A/S, 1982). The average pumping rate for the 9 currently operating boreholes is 86 m3/day (10l/sec) producing a total of 800 m3/day (according to interviews with the Mongu Pump Station, 1990 June).

Apart from this, in the western province, by the NORAD's WASHE (Water, Sanitation, Health, Education) programme many boreholes with hand pump have been completed at many rural villages. The 8" diameter boreholes are usually drilled for councils water supply and 5" diameter boreholes for small villages. (a total of 352 wells containing digging wells are risted) The depth of these wells ranges from 10 to 100m with depths between 10 and 40m being common. Amongst these there is also a pump station with submersible pump operated by solar power (Shimano village).

Sand formations are dominant in the aquifers and the following is an approximation of the specific capacities.

- Kaoma region 0.2 ~ 7.9 m3/hr/m (ave. 1.6 m3/hr/m)
- Kalabo region 0.07 ~ 13 m3/hr/m (ave. 2.2 m3/hr/m)
- Lukulu region 0.04 ~ 1.8 m3/hr/m (ave. 0.3 m3/hr/m)
- Mongu region 0.4 ~ 23 m3/hr/m (ave. 2.5 m3/hr/m)
- Sesheke region 0.04 ~ 1.6 m3/hr/m (ave. 0.3 m3/hr/m)

(according to the well record of Mongu WASHE office)

6) Mumbwa

Mumbwa takes its water primarily from small dams (2,000 m3/day), there have been 5 boreholes but because of breakages of water pumps, only 1 well (86 m3/day) is currently pumping. Each borehole has the potential to pump 5 ~ 6 liters/sec (according to interviews with the Mumbwa Pump Station, 1990 July)

7) Southern Cities

Almost all cities and towns use river water for their water supplies. In Boma, 2 boreholes supplement this during the period from June to December (according to the DWA Choma Office, 1990). In the southern province, boreholes have been drilled with Japanese Government assistance, with the objective of supplying water to the rural villages. Phase I called for the boring of 100 wells (1987 ~ 88) and Phase II, the boring of 120 wells (1989 ~ 90) and currently there are 32 wells being drilled (in progress). These are 4" and 6" wells and those with yields above 15 lit/min have hand pumps installed (according to interviews with the DWA Monze Office, 1990 July).

These wells are drilled at gneisses, shists, granites, basic rocks, granulites, limestones, basalts, sedimentary rocks and alluviums but the specific yields from granulites, limestones, basalts and sedimentary rocks are relatively height. According to available data, the specific capacities for 35 wells, excluding dry wells, is 0.03 ~ 60 m3/hr/m with an average of 3.5 m3/hr/m. 1.2 m3/hr/m specific capacities are common (Pacific Consultants 1990, Sanyu Consultants 1987).

2.2 Set up of Observation Wells

2.2.1 Objectives of Well Water Level Observation

In the development of water resources, groundwater must be developed along with surface water. With the following objectives, this study, as its first step, has carried out water level observations in shallow wells.

- Understanding the effects of river water to surrounding shallow groundwater
- Linkage between shallow groundwater level and river water levels

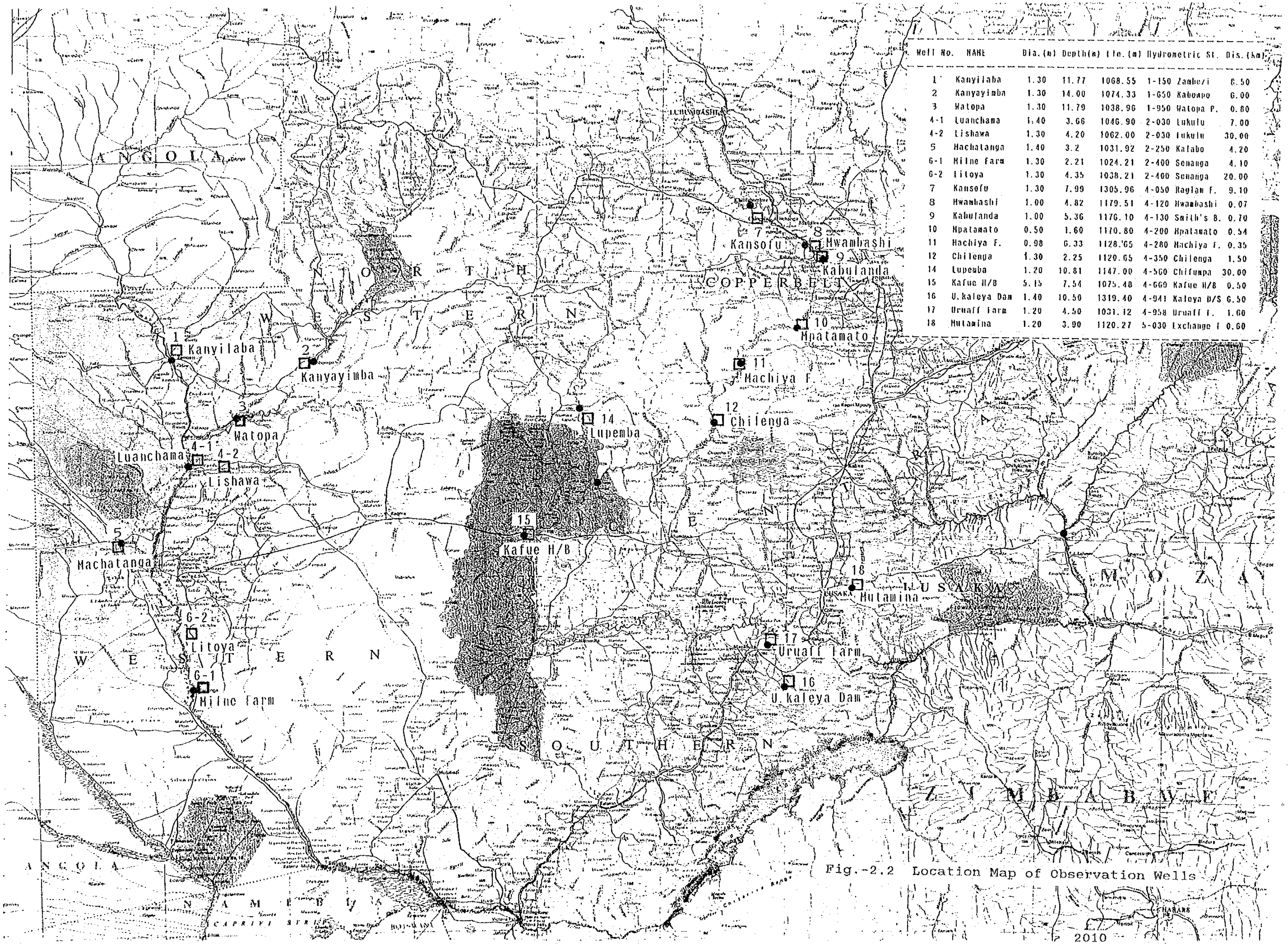
2.2.2 Selection of Observation Wells

Shallow wells close to river water level observation stations were surveyed and in principle, of those wells that could be observed, those closest to the water level observation stations were selected. The details of the 19 observation wells selected are shown in Table-2.2 and their locations are shown in Fig.-2.2. Detailed records for each observation well are given in **Supplement-2.1**.

Where there are multiple observation wells for one river water level observation station, they have been indicated with an auxiliary number. Moreover, at the following points, St. 4-450 Lubangu and St. 5-940 Luanguwa Bridge, there were no wells close to the river water level observation stations and therefore no observation wells were possible, resulting in missing numbers.

Table-2.2 List of Observation Wells

Observation Well	Hydrometric Stations	Diameter(m)	Depth (m)	Distance btw Well & St.
(1) Kanylilaba	1-150 Zambezi	1.30	11.77	8.50 km
(2) Kanyayimbu	1-650 Kabompo B	1.30	14.00	6.00 km
(3) Watopa	1-950 Watopa P	1.30	11.79	0.80 km
(4-1) Luanchama	2-030 Lukulu	1.40	3.66	7.00 km
(4-2) Lishawa	2-030 Lukulu	1.30	4.20	30.00 km
(5) Machatanga	2-250 Kalabo	1.40	3.29	4.20 km
(6-1) Milne Farm	2-400 Senanga	1.30	2.21	4.10 km
(6-2) Litoya	2-400 Senanga	1.30	4.35	20.00 km
(7) Kansofu	4-050 Raglam Farm	1.30	7.99	9.10 km
(8) Mwambashi	4-120 Mwambashi	1.00	4.82	0.07 km
(9) Kabulanda	4-130 Smith's B.	1.00	5.36	0.70 km
(10) Mpatamato	4-200 Mpatamato	0.50	1.60	0.54 km
(11) Machiya	4-280 Machiya F	0.98	6.33	0.35 km
(12) Chilenga	4-350 Chilenga	1.30	2.25	1.50 km
(14) Lupemba	4-560 Chifumpa P	1.20	10.81	30.00 km
(15) Kafue H/B	4-669 Kafue F/B	5.15	7.54	0.50 km
(16) U Kaleya Dam	4-941 Kaleya D/S	1.40	10.50	6.50 km
(17) Uruaff Farm	4-958 Uruaff Farm	1.20	4.50	1.60 km
(18) Mutamina	5-030 Exchange F	1.20	3.90	0.60 km



Well No.	NAME	Dia.(m)	Depth(m)	Ele.(m)	Hydrometric St.	Dis.(km)
1	Kanyilaba	1.30	11.77	1068.55	1-150 Zambezi	0.50
2	Kanyayimba	1.30	14.00	1074.33	1-650 Kabompo	6.00
3	Watopa	1.30	11.79	1038.96	1-950 Watopa P.	0.80
4-1	Luanchama	1.40	3.66	1046.90	2-030 Lukulu	7.00
4-2	Lishawa	1.30	4.20	1062.00	2-030 Lukulu	30.00
5	Machatanga	1.40	3.2	1031.92	2-250 Kalabo	4.20
6-1	Milne Farm	1.30	2.21	1024.21	2-400 Senanga	4.10
6-2	Litoya	1.30	4.35	1038.21	2-400 Senanga	20.00
7	Kansofu	1.30	7.99	1305.96	4-050 Raglan F.	9.10
8	Mwambashi	1.00	4.82	1179.51	4-120 Mwambashi	0.07
9	Kabulanda	1.00	5.36	1176.10	4-130 Smith's B.	0.70
10	Mpatamato	0.50	1.60	1170.80	4-200 Mpatamato	0.54
11	Machiya F.	0.98	6.33	1128.65	4-280 Machiya F.	0.35
12	Chilenga	1.30	2.25	1120.65	4-350 Chilenga	1.50
14	Lupemba	1.20	10.81	1147.00	4-500 Chifumpa	30.00
15	Kafue H/B	5.15	7.54	1075.48	4-669 Kafue H/B	0.50
16	U.kaleya Dam	1.40	10.50	1319.40	4-941 Kaleya D/S	6.50
17	Uruaff Farm	1.20	4.50	1031.12	4-958 Uruaff F.	1.60
18	Mutamina	1.20	3.90	1120.27	5-030 Exchange F	0.60

Fig.-2.2 Location Map of Observation Wells

2.2.3 Geology surrounding the Observation Wells

The geology surrounding the observation wells is as shown in Table-2.3.

Table-2.3 Geology surrounding Observation Wells

Well Number	Geology surrounding Observation Well
1	Alluvium and sands of the Kalahari group
2	Sands of the Kalahari group
3	Alluvium and sands of the Karahari group
4-1, 4-2, 5 6-1, 6-2	Sands of the Kalahari group
7	Alluvium, Base rocks are shales and sandstones of Kundelungu group
8, 9	Alluvium, Base rocks are pre-Katanga shist
10	Alluvium, Base rocks are Muva quartzite
11	Alluvium, Base rocks are sandstones and dolomites of Lower Roan group
12	Shales and sandstones of Kundelungu group
13	Sands and gravels of alluvium in the upper section, siltstones of Upper Karoo group in the lower section
14	Alluvium, Base rocks are pre-Katanga carbonate rock
15	Weathered calc-silicate rocks of pre-Katanga rocks
16	Alluvium, Base rocks are shists of Chunga group

2.3 Observation of Well Water Levels

2.3.1 Observation Method, Organization and Time Period

Locally employed observers were assigned to each observation wells, taking measurements every day, in the morning and evening. Every month the supervisor of the D.W.A (the same for the river water level observation organization) collected measurement records and at the same time carried out checks of the measurements, guidance to the observers and when necessary measuring equipment was repaired or replaced. The well water level measurement system was set up in June and July of 1990 and measurements were carried out until the end of September, 1991.

2.3.2 Observation Records

The observers at each well recorded the water levels and time and date from the observation points. Using personal computers in the office, raw data was input to produce ground water level and groundwater above sea level data tables, groundwater level fluctuation graphs, corresponding river water level graphs and charts showing the relationship with river water levels.

2.4 Analysis of Well Water Levels

2.4.1 Relationship between Well and River Water Levels

River and well water level data collected monthly is shown in Table-2.4 and the pattern taken from the relationship charts between the river and well water levels can be classified as shown in Fig.-2.3.
The mean monthly fluctuation chart and the relationship charts between river water levels and well water levels are shown in Fig.-2.4.
As is seen from the morning and evening water levels in the well water level fluctuation charts, evening water levels generally reflect levels after water used in daily life, etc., has been pumped out of the well. From this, the morning water levels are thought to show the actual groundwater levels while evening water levels are provided as reference data. For the relationship charts with river water levels, the morning water levels are used.

1) Linked Relationship (Type A)

Groundwater level fluctuations occur in unison with river water level fluctuations. In cases where the rivers and wells are close, it is thought that they are connected. Observation wells No.9 and No.12 are examples of this case.

2) Delayed Relationship (Type B)

Groundwater level fluctuations occur with a time lag after fluctuations in river water levels. Groundwater levels show gradual increases after increases in river water levels or gradual decreases after decreases in the river water levels. A time lag of 1 month is common for water level highs and lows. Observation wells No.1, 2, 3, 7, 8, 11 and 18 are examples of this case.

3) Preceding Relationship (Type C)

Groundwater levels decrease, preceding decreases in river water levels. In mountain areas, groundwater levels increase due to the effects of rain, etc., and when decreases in river water levels occur groundwater levels also decrease after a time lag. Observation wells No.5 and No.15 are examples of this case.

4) Combined Relationship (Type D)

Type D1 (A/B combination): Linkage relationship is indicated when the river water levels are high and a delayed link is indicated when the river water levels are low. When river water levels decrease, there is a delay before the groundwater levels decrease. Observation wells No.4-2 and no.14 are examples of this case.

Type D2 (B/C combination): Preceding relationship is indicated when the river water levels are high and a delayed linkage relationship is indicated when the river water levels are low. In mountain areas groundwater levels increase quicker that river water levels due to the effects of rain, etc., and compared to the decrease in river water levels, there is a delay in the decrease of groundwater levels. Observation wells No.4-1 and No.6-1 are examples of this case.

5) Irregular Relationship (Type E)

Type E1 (Stable water levels - temporary water level drop): Groundwater levels are normally stable regardless of river water levels but occasionally show small temporary decreases. Observation well No.6-2 is and example of this case.

Type E2 (Overall decrease trend - temporary increase): Showing a general decrease in water levels for the period from June, 1990 to September, 1991 but show partial recovery during the rainy season. Observation wells No.16 and No.17 are examples of this case.

Type E3 (Flooded): Flooded during the rainy season. Shows a preceding relationship when the river water levels are low. Observation well No.10 is an example of this case.

Table-2.4 Monthly River Water Level and Well Water Level

No.	Stations			JUN'90	JUL	AUG	SEP	OCT	NOV	DEC	JAN'91	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	A/AVG
	1-150 Zambezi P/H	River	Mean	2.05	1.43	1.07	0.72	0.58	0.58	1.18	3.07	7.73	6.39	5.56	3.10	1.76	1.17	0.79	0.62	2.36
(1)	KANYILABA	Well	Morning	35.02	34.62	34.03	33.54	33.10	32.69	32.38	32.87	36.17	36.91	36.94	36.39	35.80	35.14	34.46	33.91	34.62
		Well	Evening	34.79	34.28	33.62	33.09	32.72	32.23	32.05	32.64	36.04	36.78	36.77	36.19	35.47	34.68	34.04	33.33	34.29
	1-650 Kabompo Boma	River	Mean	2.01	1.84	1.75	1.63	1.59	1.54	1.88	2.57	3.21	3.16	2.92	2.20	1.99	1.91	1.84	1.70	2.11
(2)	KANYAIMBU	Well	Morning	15.56	THERE WAS NO SUFFICIENT PERSON FOR							15.36	15.76	15.74	15.51	15.37	15.21	14.98	14.78	13.83
		Well	Evening	15.56	READING TAPE.							15.30	15.57	15.43	15.36	15.13	14.77	14.53	14.10	13.57
	1-950 Watopa Pontoon	River	Mean	2.22	2.05	1.94	1.78	1.73	1.69	2.05	3.37	4.66	3.99	3.69	2.53	2.38	2.27	1.95	1.79	2.51
(3)	WATOPA PONTOON	Well	Morning	2.24	2.09	1.94	1.74	1.57	1.37	1.21	1.19	1.98	2.33	2.33	2.17	1.96	1.78	1.57	1.37	1.80
		Well	Evening	2.11	2.09	1.94	1.74	1.57	1.36	1.22	1.20	1.99	2.33	2.32	2.17	1.95	1.77	1.57	1.37	1.79
	2-030 Lukulu	River	Mean	1.48	1.05	0.83	0.62	0.58	0.57	0.99	2.34	4.96	4.48	3.88	2.65	1.61	0.90	0.71	0.53	1.76
(4-1)	LUANCHUMA	Well	Morning	27.19	27.11	26.98	26.74	26.66	26.55	26.71	27.88	28.28	28.19	27.94	27.64	27.46	27.36	27.25	27.05	27.31
		Well	Evening	27.19	27.10	26.97	26.70	26.53	26.36	26.62	27.65	28.23	28.11	27.85	27.50	27.34	27.23	27.16	26.98	27.24
(4-2)	LISHUNA	Well	Morning	42.08	41.96	41.84	41.63	41.44	41.36	41.48	42.11	42.73	42.56	42.39	42.11	41.99	41.78	41.67	41.42	41.91
		Well	Evening	41.26	41.15	41.00	40.94	40.76	40.68	41.08	41.79	42.36	42.21	42.10	41.71	41.44	41.40	41.13	41.06	41.38
	2-250 Kalabo	River	Mean	1.91	1.40	1.00	0.77	0.58	0.39	0.39	0.55	1.99	3.04	2.76	2.15	1.70	1.28	0.97	0.69	1.35
(5)	MUCHATANGA	Well	Morning	13.28	13.27	13.27	13.24	13.17	13.22	13.25	13.51	14.13	14.05	14.09	13.75	13.73	13.96	13.50	13.27	13.54
		Well	Evening	12.99	13.01	12.95	12.92	12.91	12.87	12.93	13.52	13.93	13.62	13.71	13.22	13.40	12.65	12.95	12.65	13.14
	2-400 Senanga	River	Mean	2.51	1.45	1.02	0.76	0.66	0.62	0.94	1.71	3.02	4.17	4.00	3.58	2.24	1.24	0.95	0.74	1.85
(6-1)	MILNE FARM	Well	Morning	23.02	23.01	22.99	22.92	22.85	22.80	23.01	23.09	23.45	23.37	23.29	23.23	23.22	23.21	23.18	23.08	23.11
		Well	Evening	23.02	23.01	22.98	22.91	22.84	22.79	23.01	23.08	23.44	23.37	23.29	23.23	23.22	23.21	23.18	23.08	23.10
(6-2)	LITOYA	Well	Morning		36.34	36.35	36.31	36.32	36.33	36.32	36.32	36.32	36.31	36.32	36.18	36.21	35.91	36.07	36.31	36.26
		Well	Evening		36.07	36.00	35.90	35.90	35.90	35.92	35.97	35.95	35.97	36.16	35.97	35.91	35.57	35.79	36.13	35.94
	4-050 Raglam Farm	River	Mean	1.33	0.89	0.69	0.51	0.42	0.40	0.55	1.37	3.00	3.24	3.02	2.01	1.27	0.93	0.76	0.56	1.31
(7)	KANSOFU	Well	Morning	41.66	41.55	41.31	41.10	40.84	40.59	40.59	41.40	42.70	42.73	43.50	42.89	42.40	42.16	41.90	41.77	41.82
		Well	Evening	41.67	41.50	41.25	40.99	40.71	40.40	40.44	41.38	42.70	42.74	43.52	42.88	42.38	42.13	41.92	41.73	41.77
	4-120 Mwambashi	River	Mean	1.02	0.91	0.86	0.78	0.69	0.67	0.96	2.23	2.66	2.63	2.13	1.36	1.04	0.97	0.96	0.87	1.30
(8)	MWAMBASHI	Well	Morning	7.15	6.82	6.58	6.38	6.19	6.02	5.97	7.82	8.61	8.45	8.32	7.92	7.61	7.34	7.34	6.76	7.20
		Well	Evening	7.14	6.81	6.57	6.38	6.18	6.03	5.93	7.83	8.60	8.44	8.31	7.94	7.61	7.34	7.34	6.76	7.20
	4-130 Smith's Bridge	River	Mean	2.76	1.51	1.24	1.04	0.91	0.86	1.27	3.45	4.81	5.01	4.44	3.13	2.15	1.72	1.45	1.15	2.31
(9)	KABALANDA	Well	Morning	10.30	10.22	9.90	9.73	9.42	9.39	9.89	11.35	12.79	12.32	12.07	11.12	10.58	10.35	10.11	10.03	10.60
		Well	Evening	10.26	10.16	9.86	9.69	9.39	9.39	9.87	11.37	12.77	12.31	12.05	11.10	10.56	10.34	10.07	10.00	10.57
	4-200 Mpatamato	River	Mean	1.42	1.02	0.75	0.61	0.53	0.49	1.20	3.62	5.09	4.45	3.74	2.42	1.66	1.26	1.03	0.76	1.88
(10)	MPATAMATO	Well	Morning	5.57	5.57	5.57	5.57	5.95	6.62	6.62	6.62	6.62	6.62	6.62	6.60	6.56	6.24	5.55	5.47	6.15
		Well	Evening	5.53	5.53	5.53	5.53	5.95	6.62	6.62	6.62	6.62	6.62	6.62	6.60	6.50	6.01	5.54	5.41	6.11
	4-280 Machiya Ferry	River	Mean	3.08	2.70	2.57	2.42	2.32	2.17	2.53	4.52	6.59	5.89	5.55	3.99	3.20	2.89	2.73	2.55	3.48
(11)	MACHIYA FERRY	Well	Morning	2.70	2.40	1.92	1.54	1.48	1.46	1.43	2.68	4.78	4.89	4.87	4.39	3.84	3.27	2.82	2.44	2.93
		Well	Evening	2.56	2.25	1.74	1.51	1.45	1.46	1.42	2.69	4.77	4.88	4.84	4.36	3.74	3.19	2.74	2.32	2.87
	4-350 Chilenga	River	Mean	2.18	1.63	1.36	1.17	1.03	0.94	1.27	3.37	5.38	5.42	5.19	3.66	2.39	1.86	1.61	1.28	2.48
(12)	CHILENGA	Well	Morning	5.82	5.62	5.22	5.20	4.99	4.74	5.67	6.31	6.55	6.85	6.68	6.33	6.06	5.82	5.61	5.36	5.80
		Well	Evening	5.79	5.59	5.22	5.17	4.95	4.72	5.66	6.31	6.66	6.85	6.66	6.32	6.04	5.79	5.59	5.34	5.79
	4-560 Chifumpa Pon.	River	Mean	0.72	0.62	0.55	0.45	0.40	0.34	0.49	1.30	2.37	1.83	1.43	0.87	0.69	0.60	0.53	0.45	0.85
(14)	LUPEMBA	Well	Morning		32.51	32.24	31.48	30.84	30.57	31.04	34.33	35.24	34.95	34.59	33.83	33.11	32.63	32.28	31.79	32.76
		Well	Evening		32.27	31.79	30.91	30.40	30.39	30.90	34.34	35.22	34.97	34.54	33.78	33.04	32.52	32.02	31.63	32.58
	4-669 Kafue Hook B.	River	Mean	1.99	1.81	1.72	1.63	1.55	1.49	0.49	0.73	3.02	3.01	2.82	2.34	2.02	1.84	1.77	1.67	1.87
(15)	KAFUE HOOK BRIDGE	Well	Morning		5.27	5.00	4.97	5.02	4.93	5.26	5.98	6.16	6.16	5.92	5.60	5.23	5.24	5.00	4.97	5.38
		Well	Evening		4.63	4.39	4.31	4.41	4.34	4.77	5.42	5.68	6.52	6.56	6.24	5.87	5.88	5.64	5.61	5.35
	4-941 Kaleya D/S	River	Mean	0.37	0.36	0.35	0.35	0.34	0.35	0.34	0.34	0.37	0.36	0.31	0.34	0.34	0.34	0.33	0.34	0.35
(16)	UPPER KALEYA DAM	Well	Morning	73.99	73.35	72.58	72.33	71.69	71.65	71.48	72.47	72.75	72.71	72.34	71.43	70.85	70.35	70.02	69.76	71.86
		Well	Evening	73.93	73.26	72.49	72.01	71.34	71.33	71.21	72.12	72.45	72.40	72.10	71.20	70.56	70.10	69.81	69.40	71.61
	4-958 Uruaff Farm	River	Mean	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
(17)	URUAFF FARM	Well	Morning	8.18	7.89	7.39	6.87	6.74	6.67	5.96	6.73	7.03	7.05	6.96	6.93	6.94	7.02	6.36	6.20	6.93
		Well	Evening	8.16	7.88	7.34	6.87	6.80	6.79	6.18	6.74	7.17	7.13	7.18	7.19	7.18	7.19	6.35	6.20	7.02
	5-030 Exchange Farm	River	Mean	0.09	0.07	0.06	0.02	0.07	0.00	0.05	0.45	0.40	0.26	0.18	0.11	0.09	0.09	0.09	0.05	0.13
(18)	MUTAMINA	Well	Morning	1.81	1.80	1.78	1.82	1.71	1.68	1.63	2.01	2.36	1.97	2.01	1.89	1.72	1.83	1.77	1.73	1.85
		Well	Evening	1.73	1.75	1.78	1.80	1.70	1.66	1.62	2.02	2.37	1.96	2.02	1.89	1.72	1.83	1.77	1.73	1.83

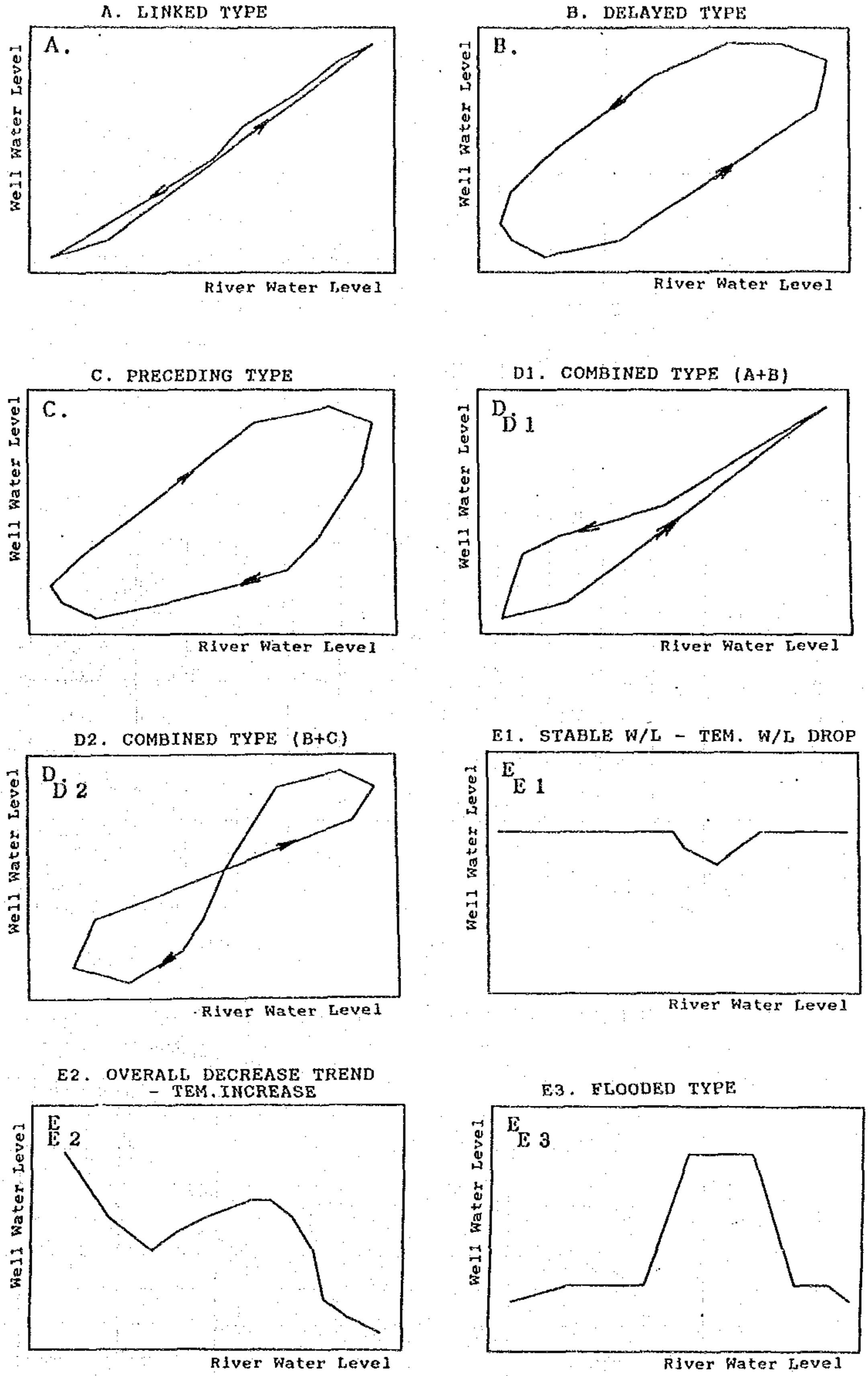
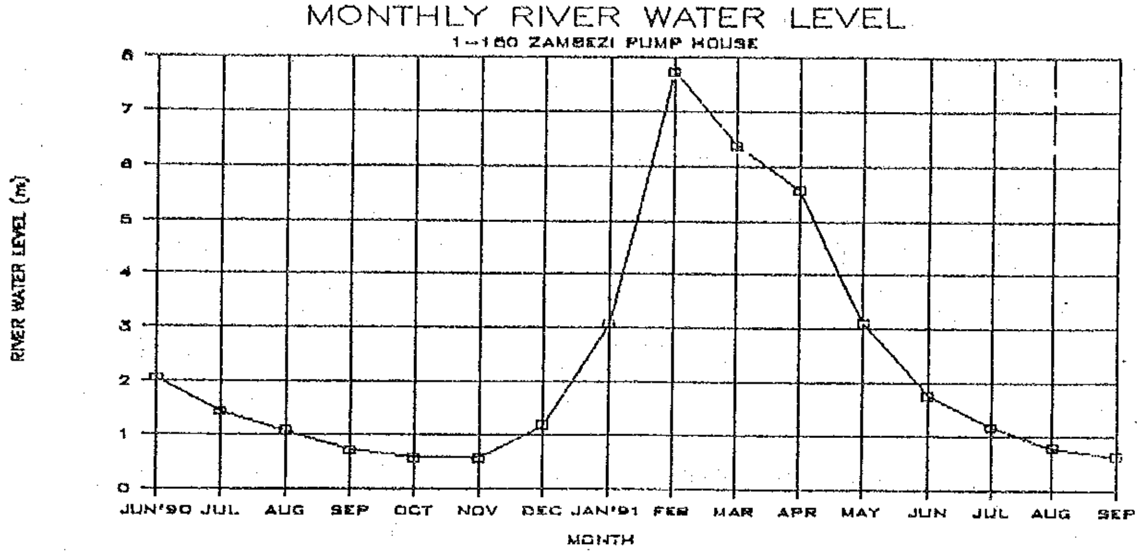
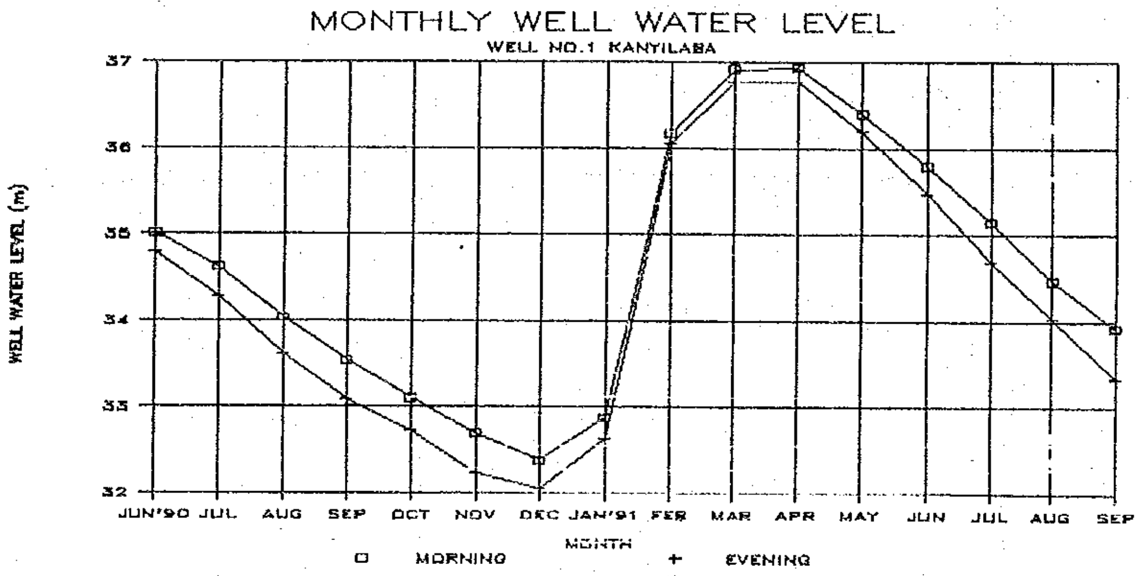


Fig.-2.3 Correlation Pattern between River W/L and Well W/L

Fig.-2.4(1) Monthly Fluctuation (No.1 Kanyilaba)





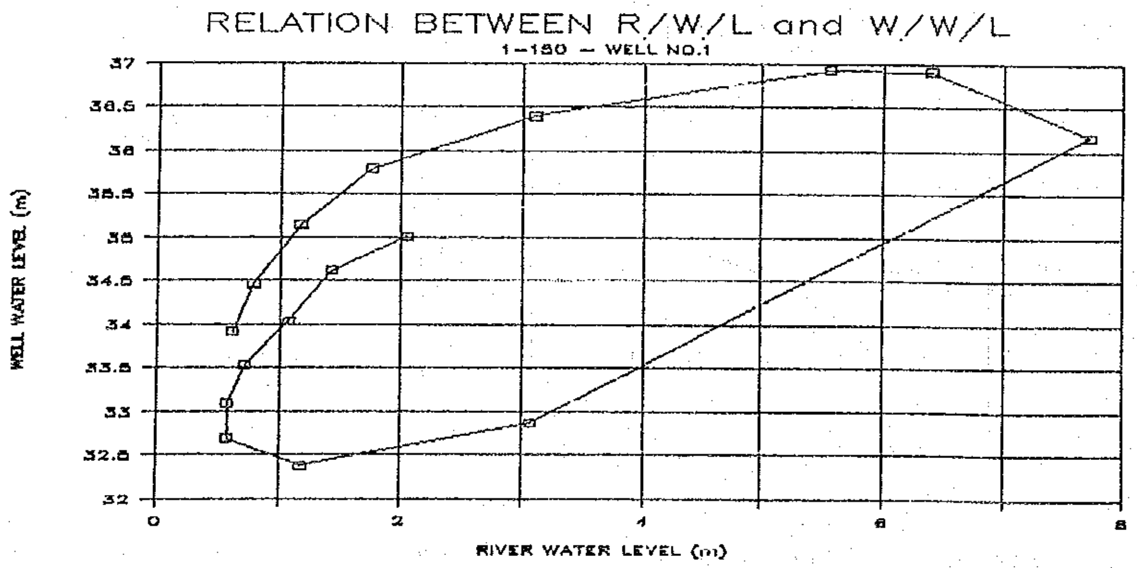
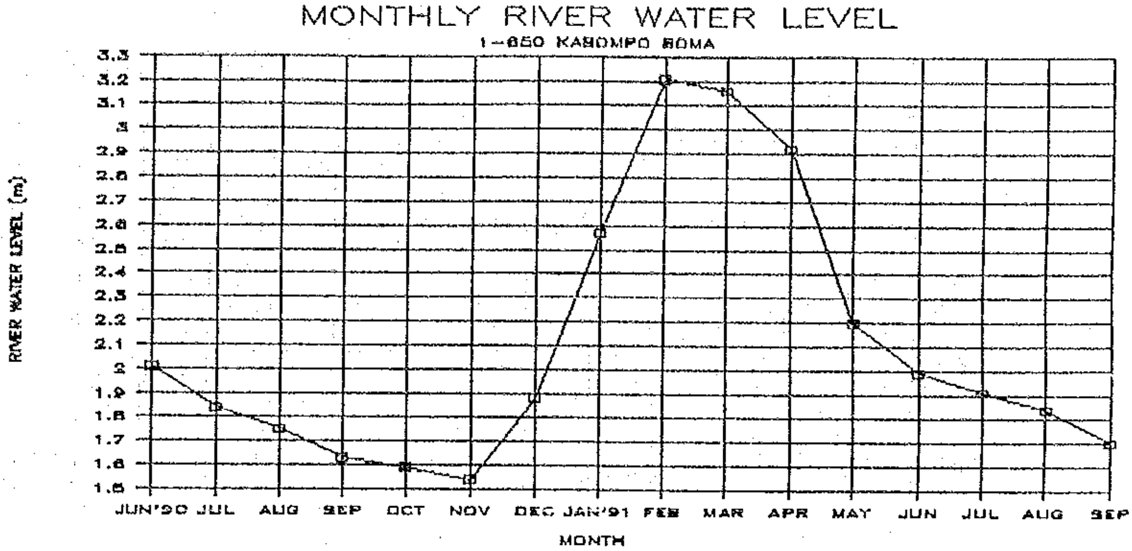
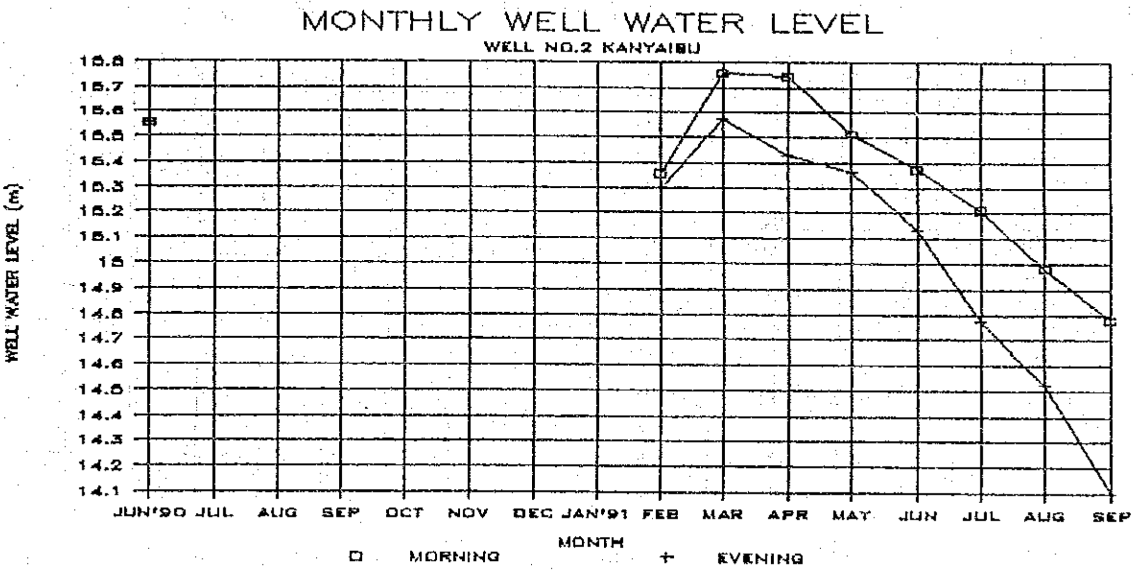


Fig.-2.4(2) Monthly Fluctuation (No.2 Kanyayimba)





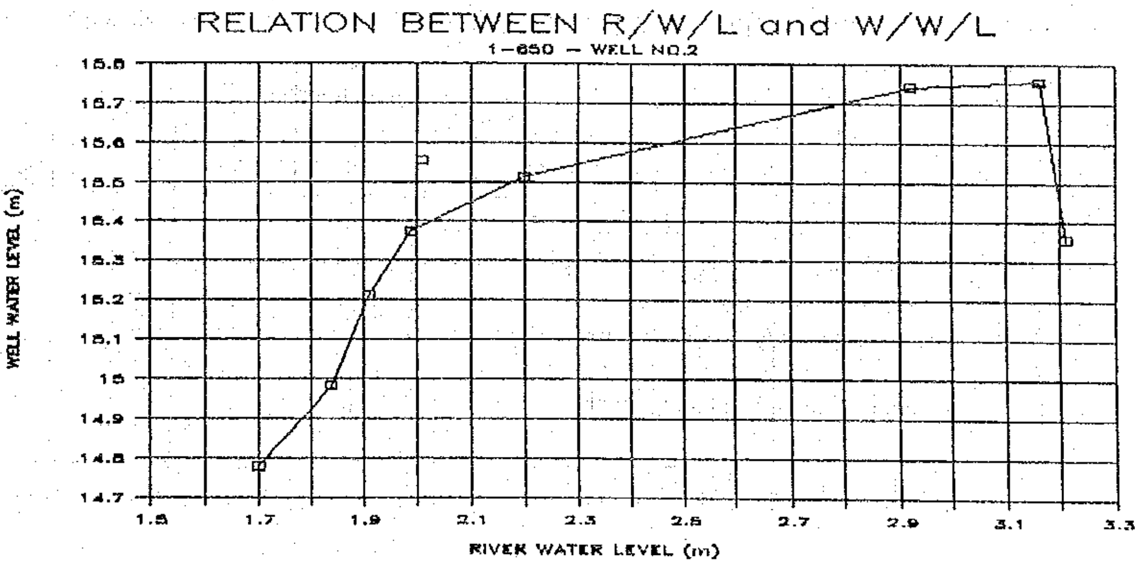
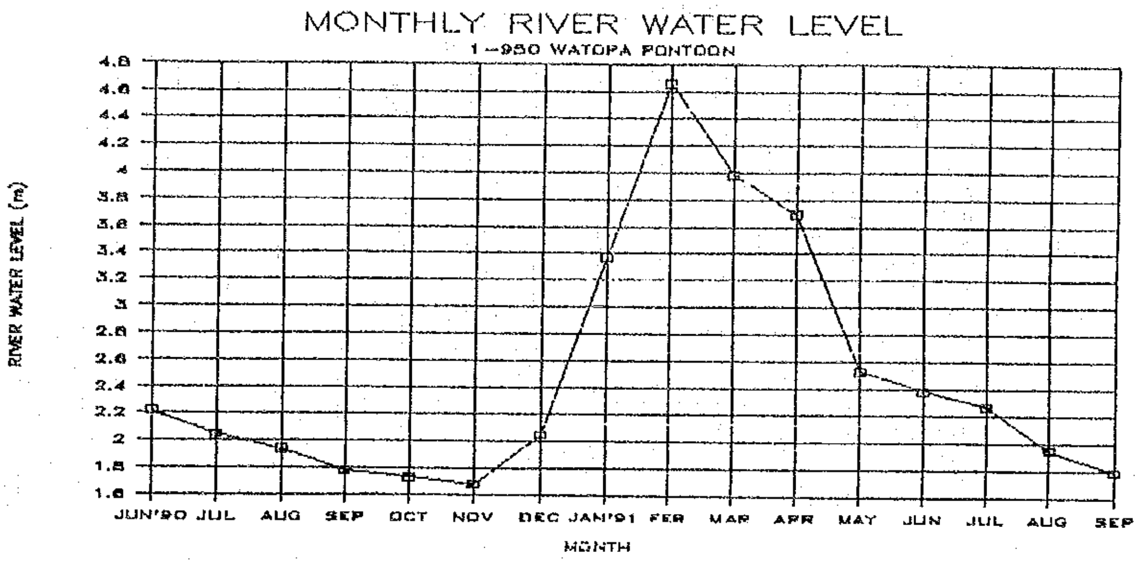
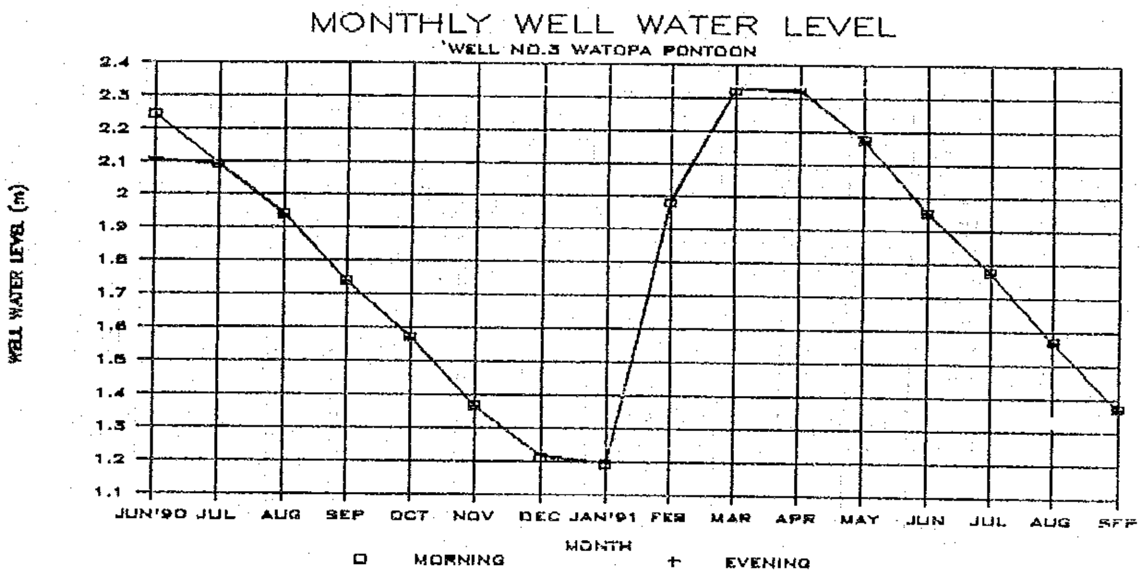


Fig.-2.4(3) Monthly Fluctuation (No.3 Watopa)





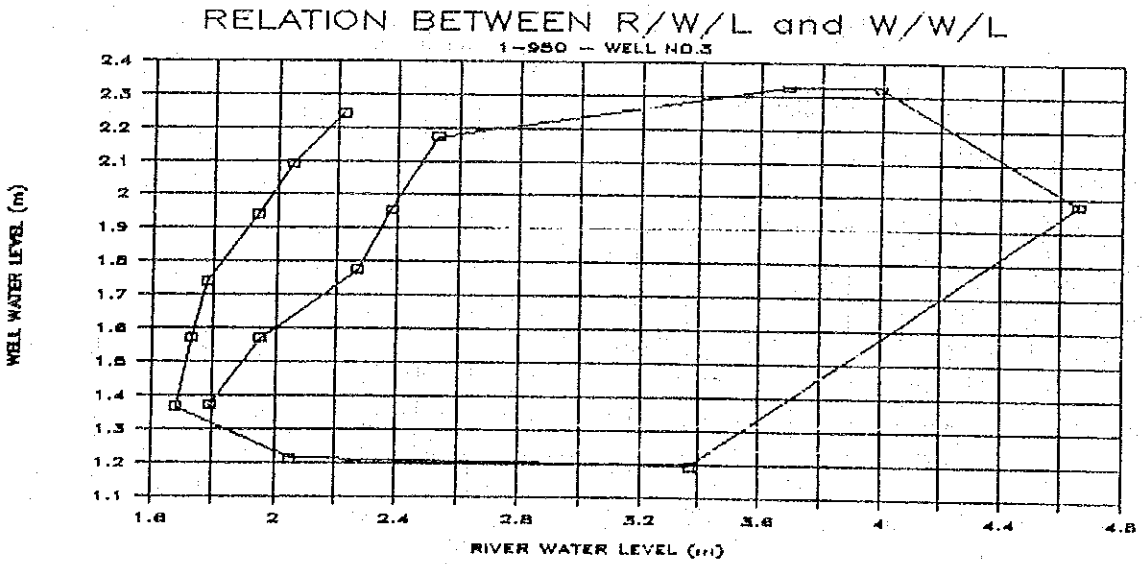
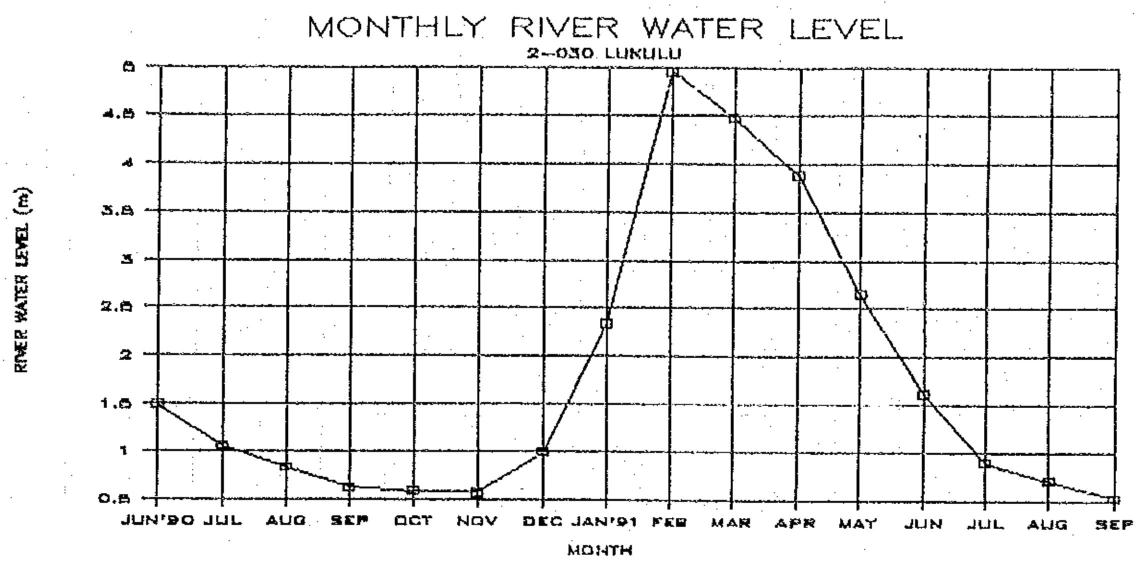
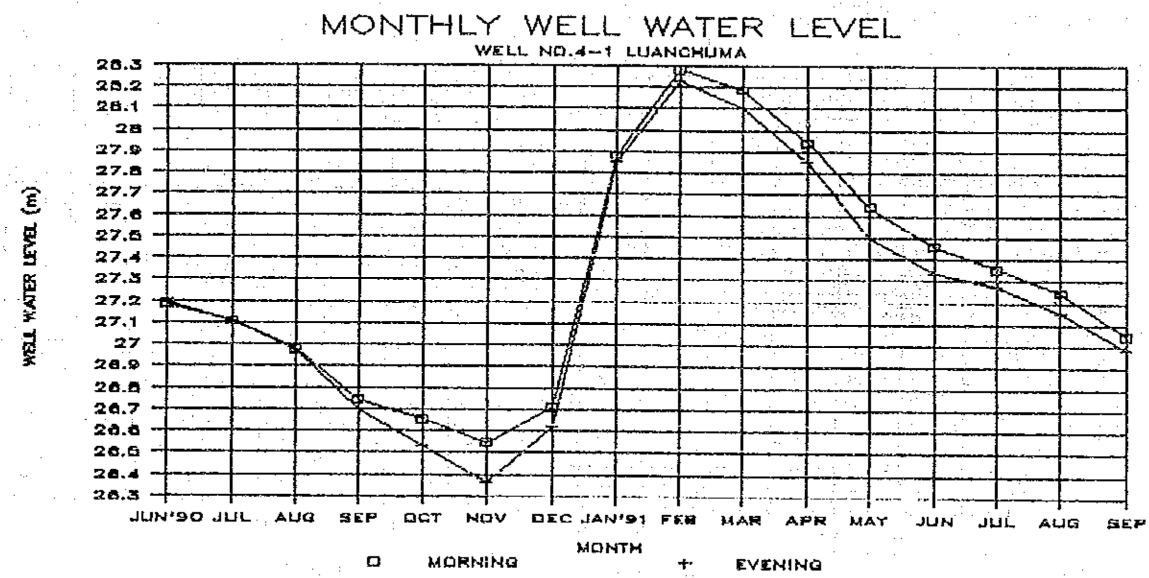


Fig.-2.4(4) Monthly Fluctuation (No.4-1 Luanchama)





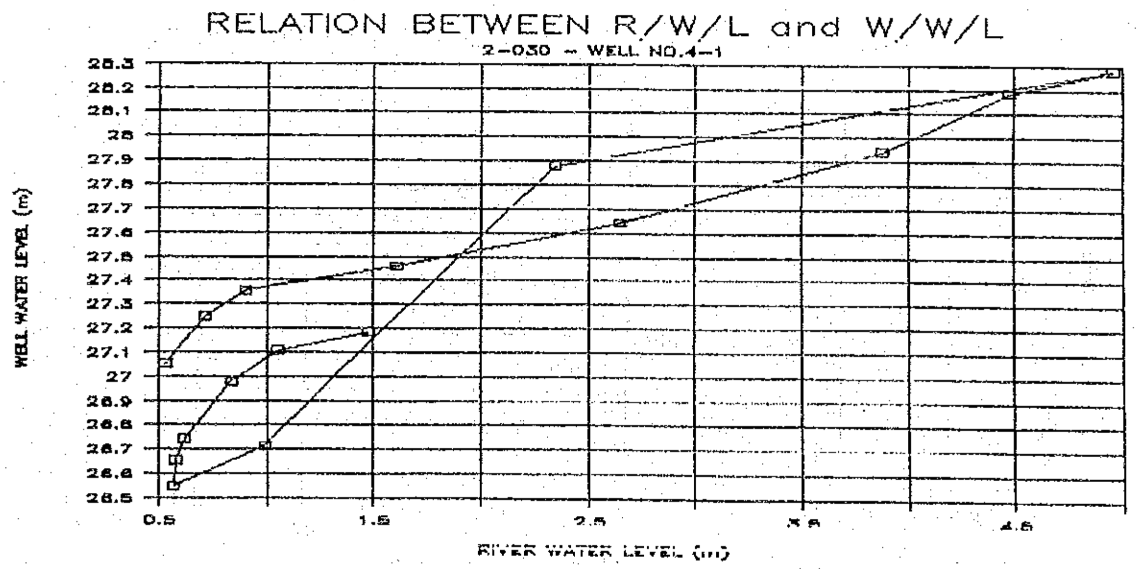
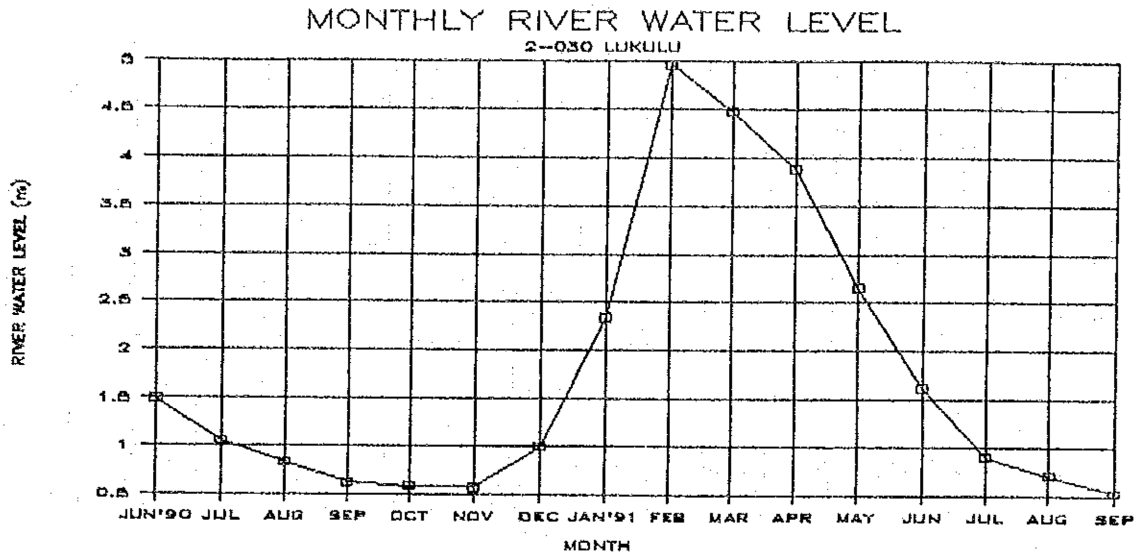
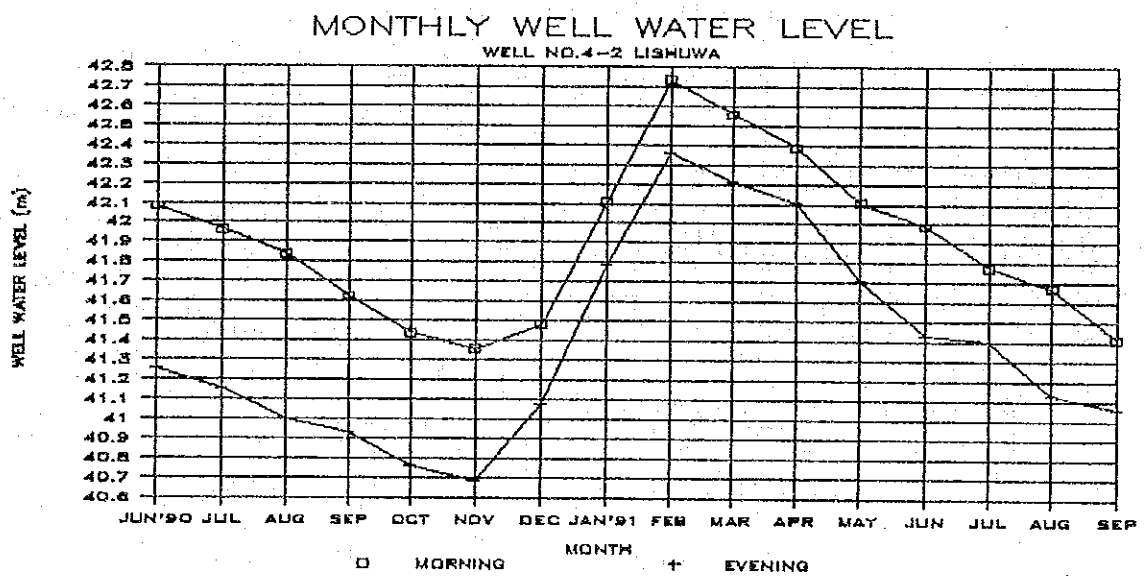


Fig.-2.4(5) Monthly Fluctuation (No.4-2 Lishawa)





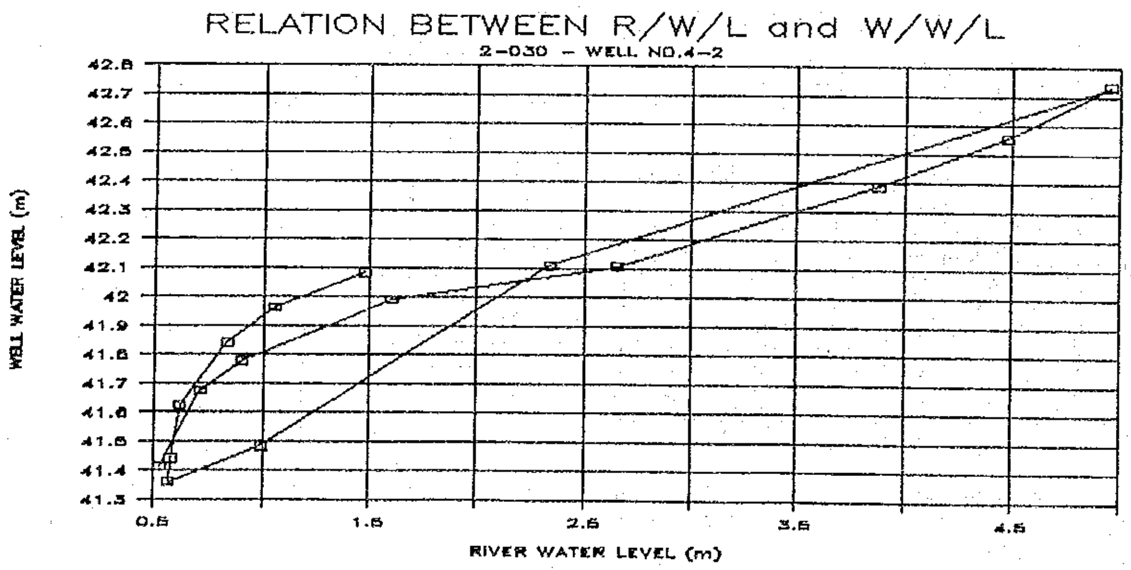
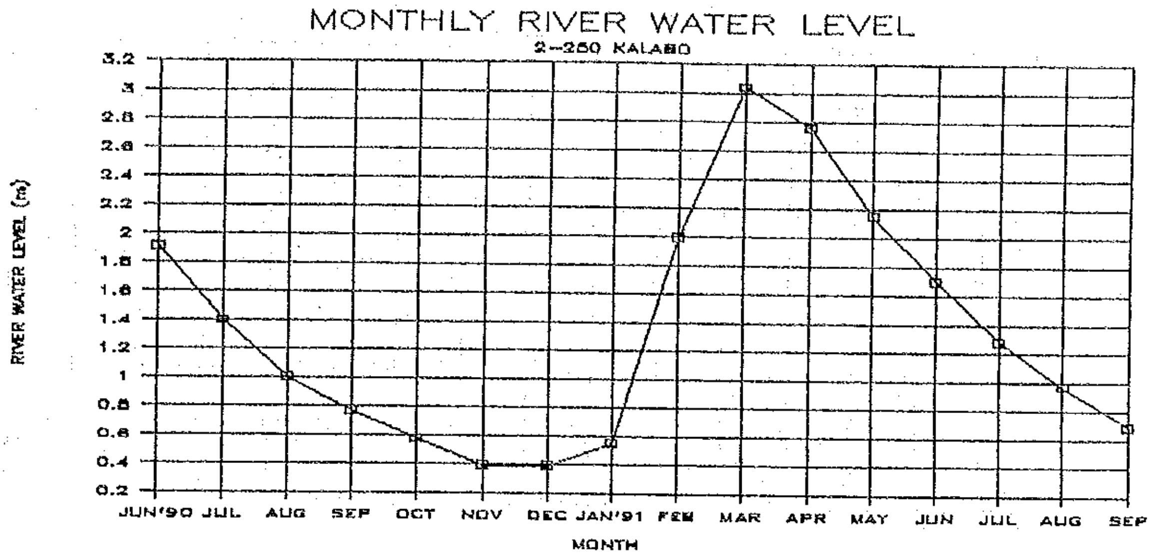
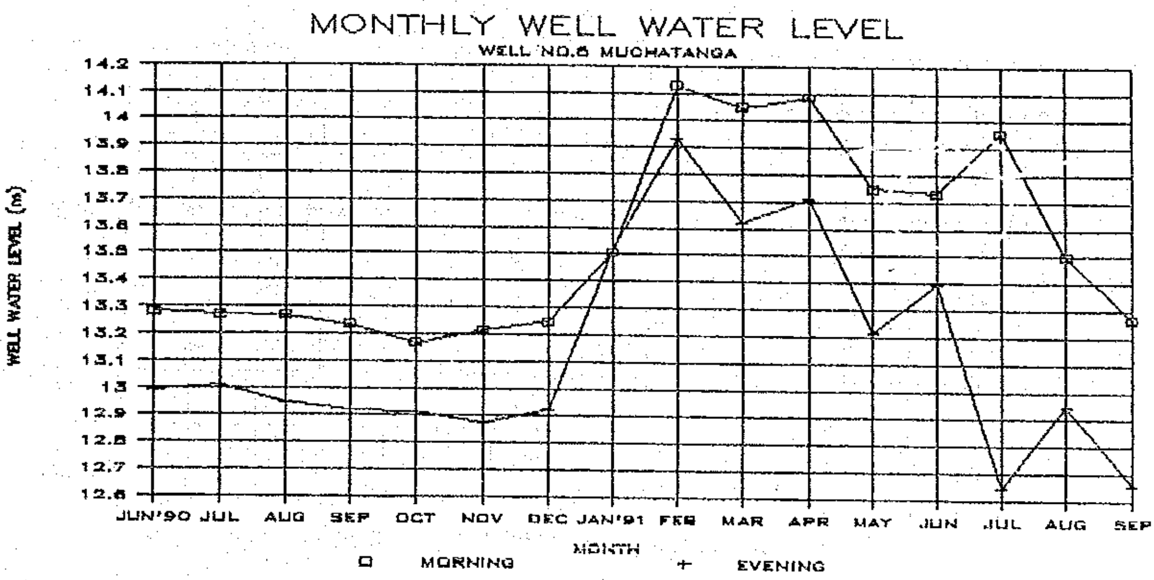


Fig.-2.4(6) Monthly Fluctuation (No.5 Machatanga)





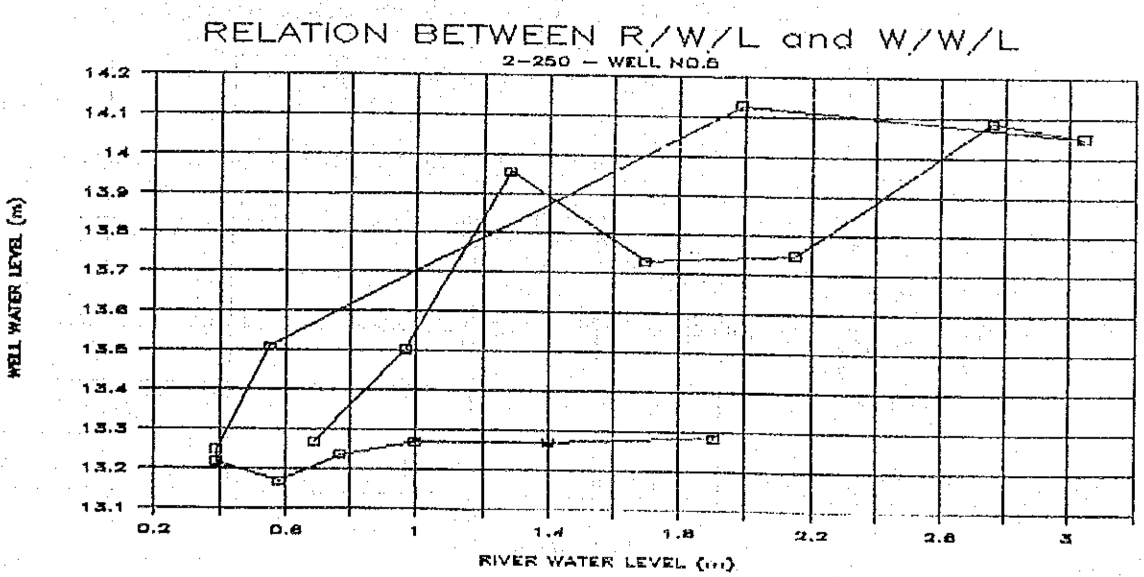
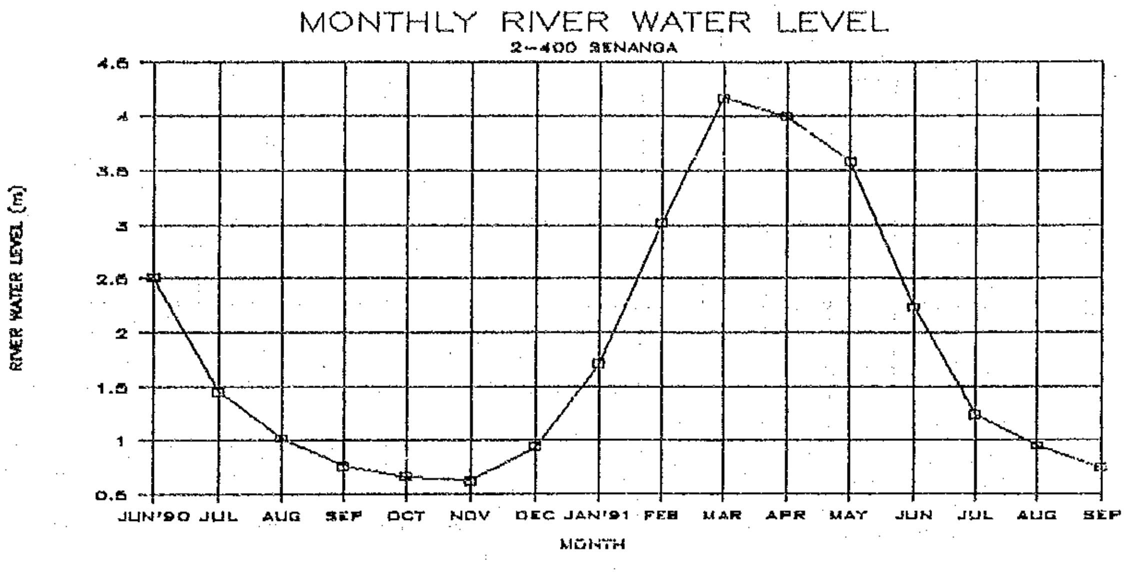
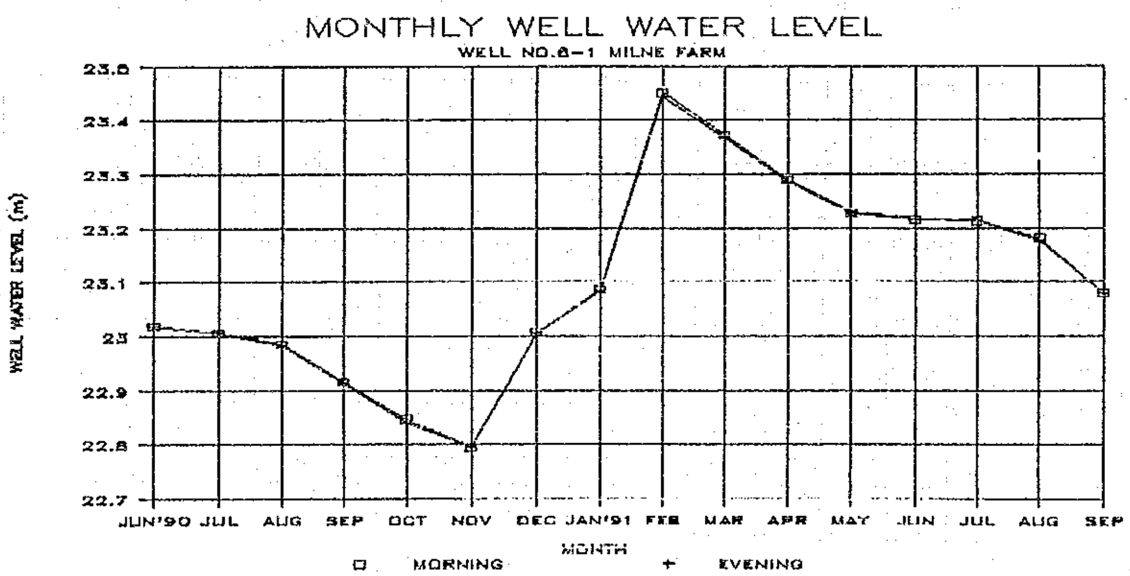


Fig.-2.4(7) Monthly Fluctuation (No.6-1 Milne Farm)





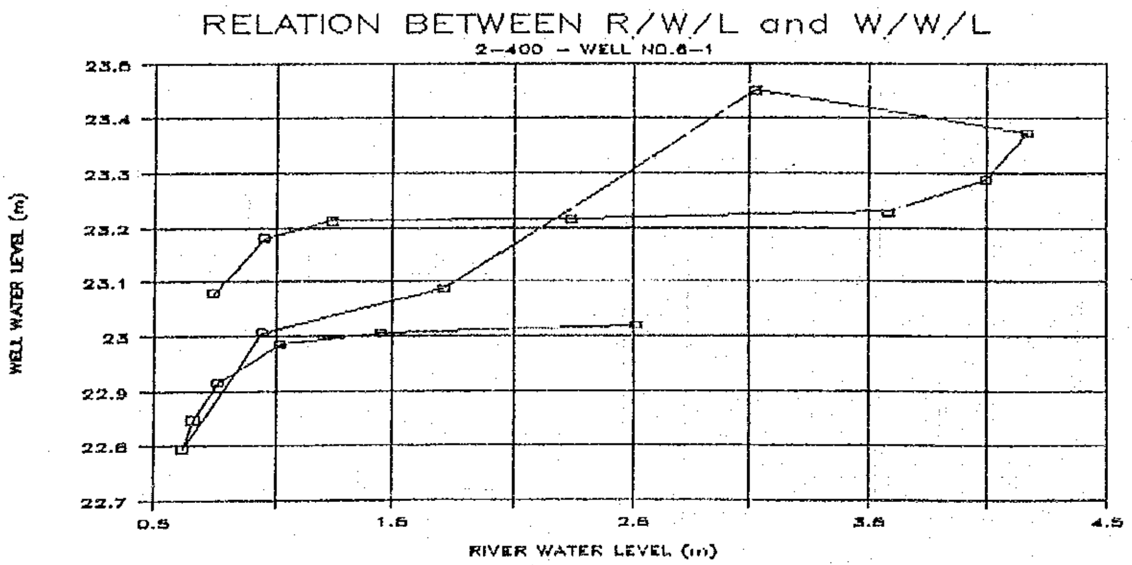
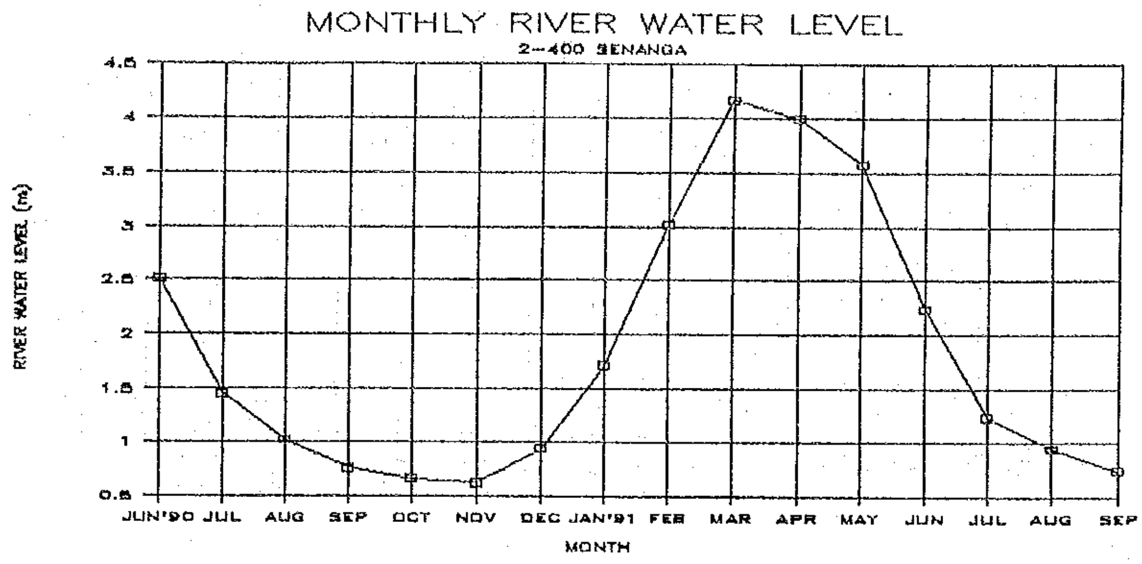
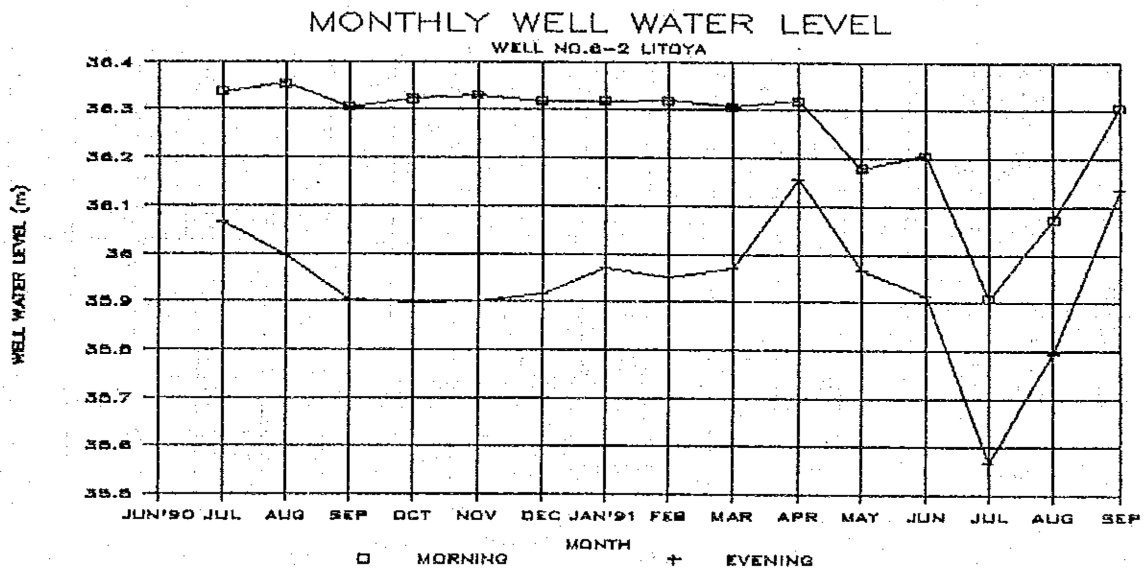


Fig.-2.4(8) Monthly Fluctuation (No.6-2 Litoya)





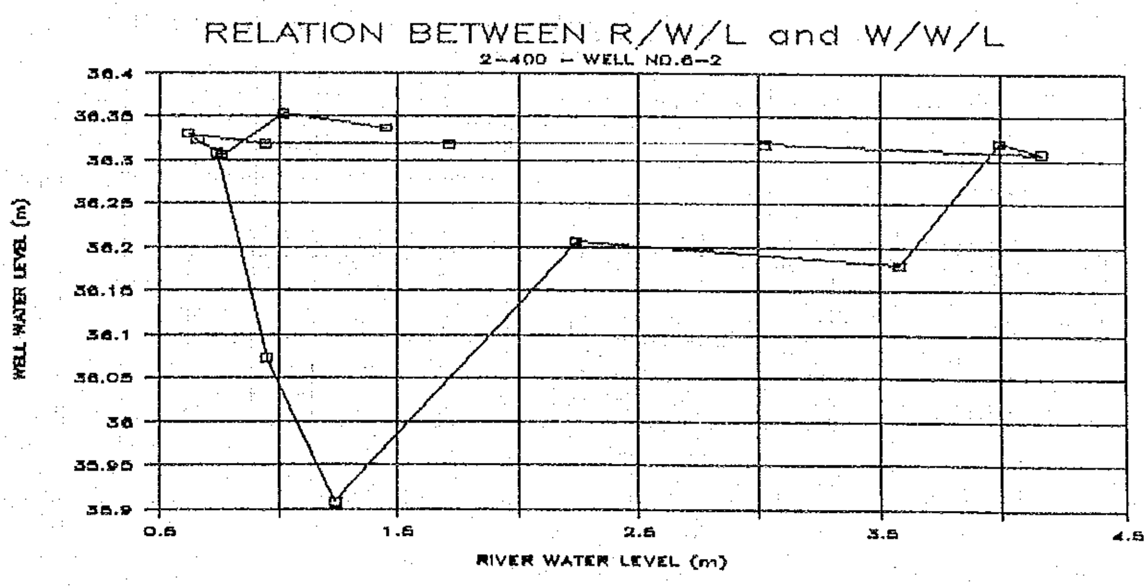
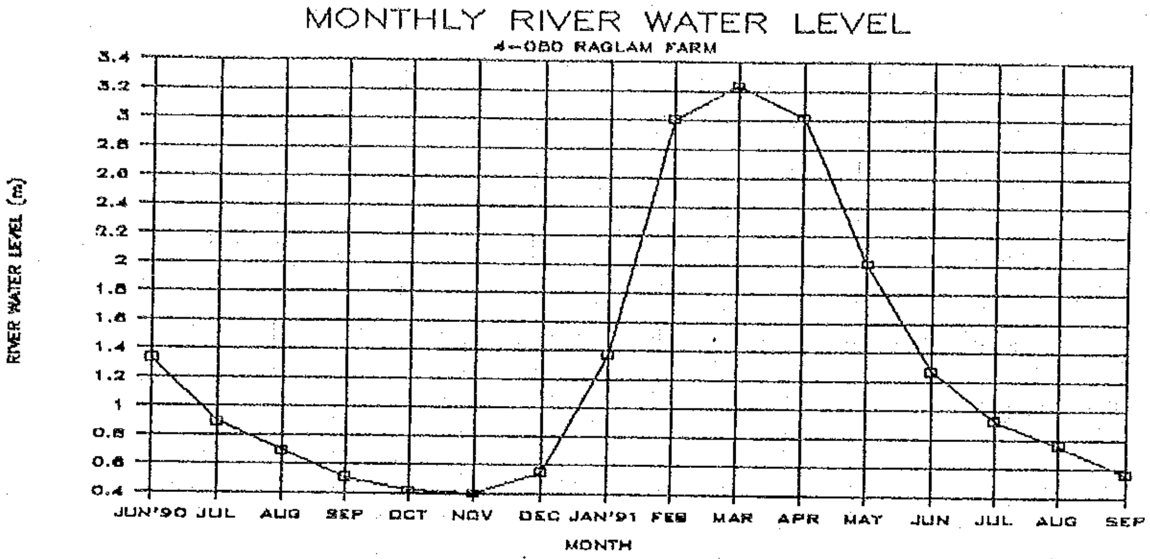
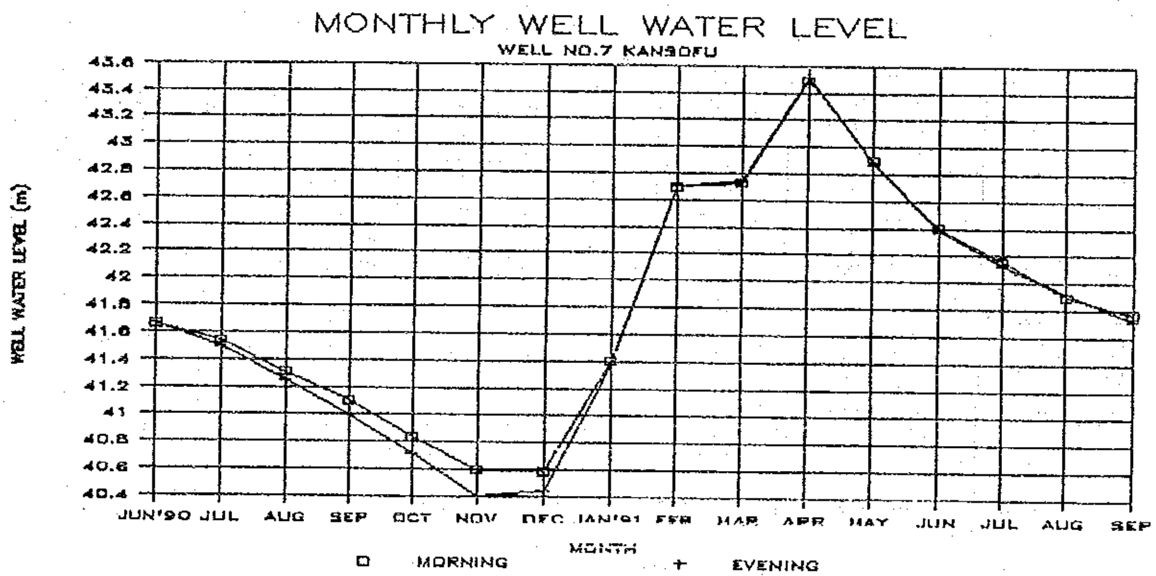


Fig.-2.4(9) Monthly Fluctuation (No.7 Kansofu)





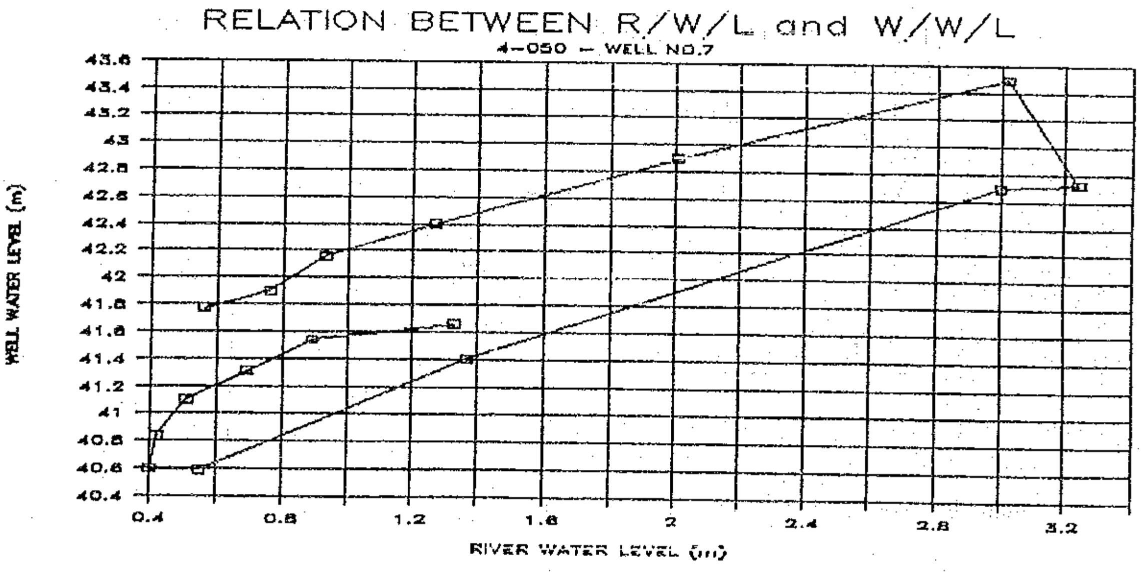
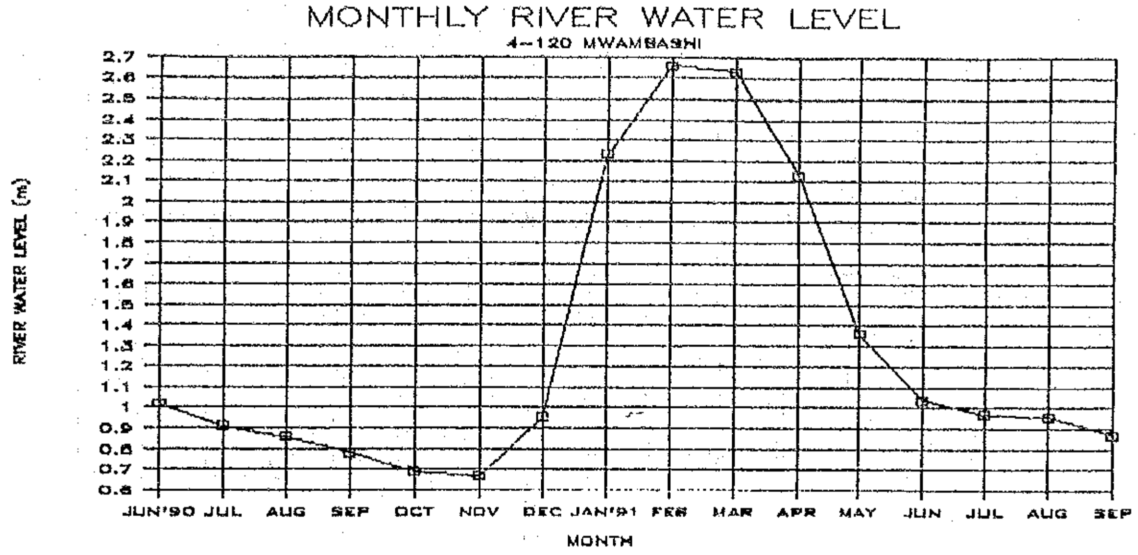
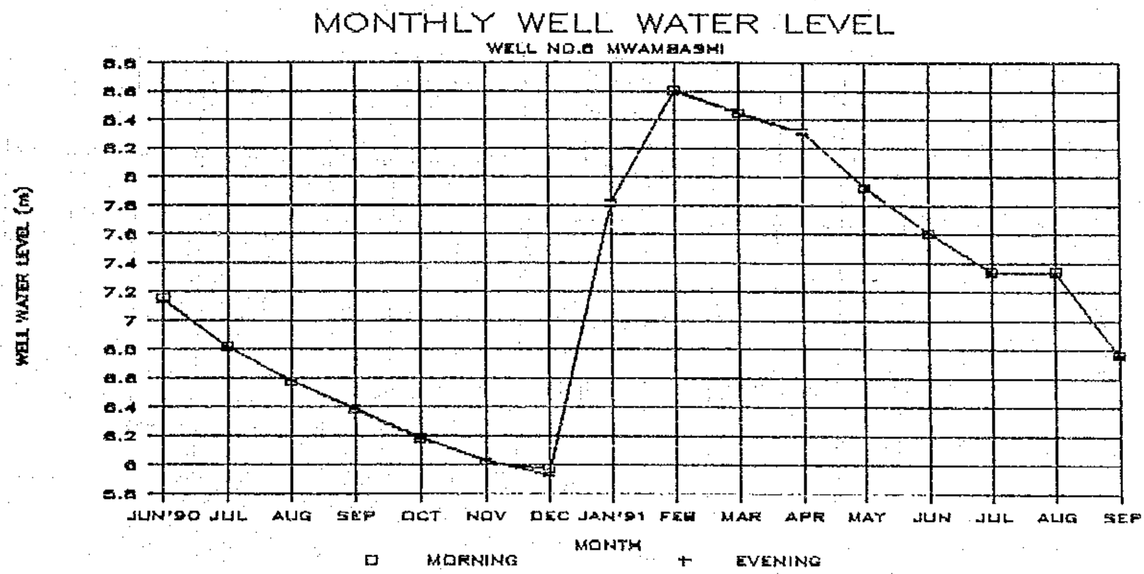


Fig.-2.4(10) Monthly Fluctuation (No.8 Mwambashi)





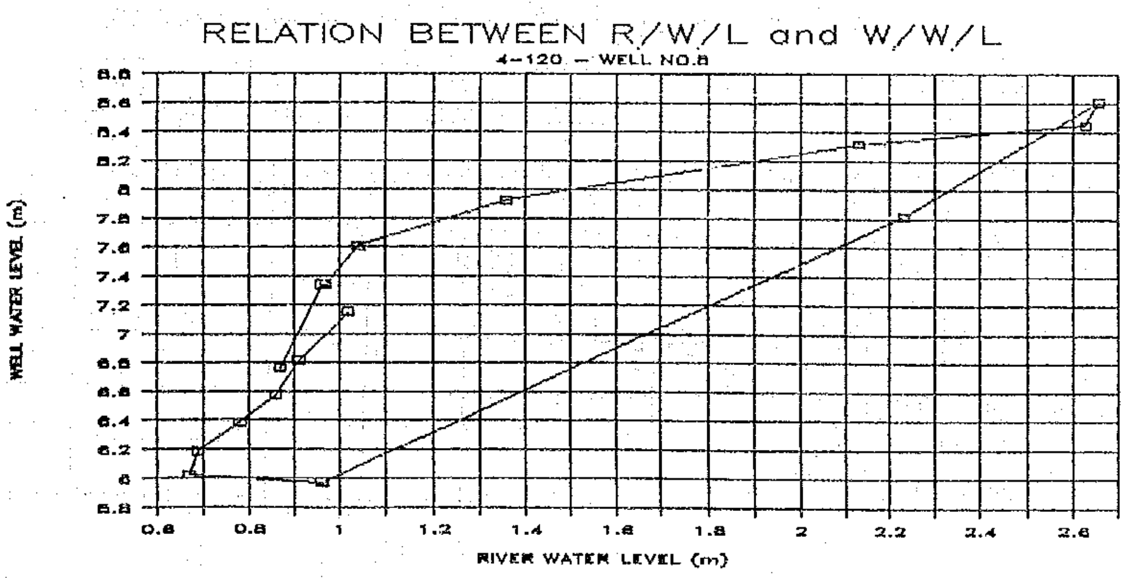
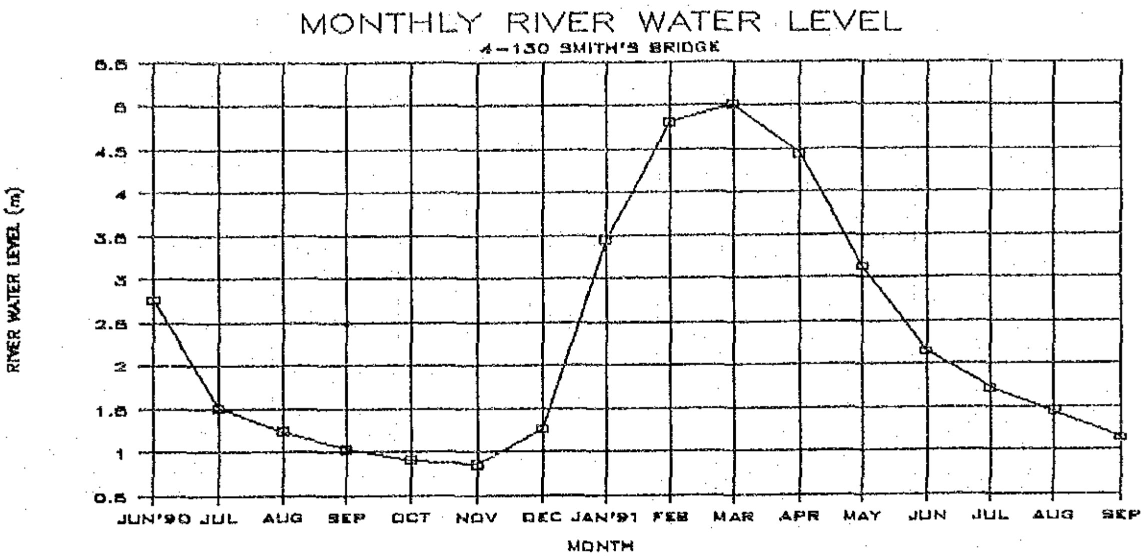
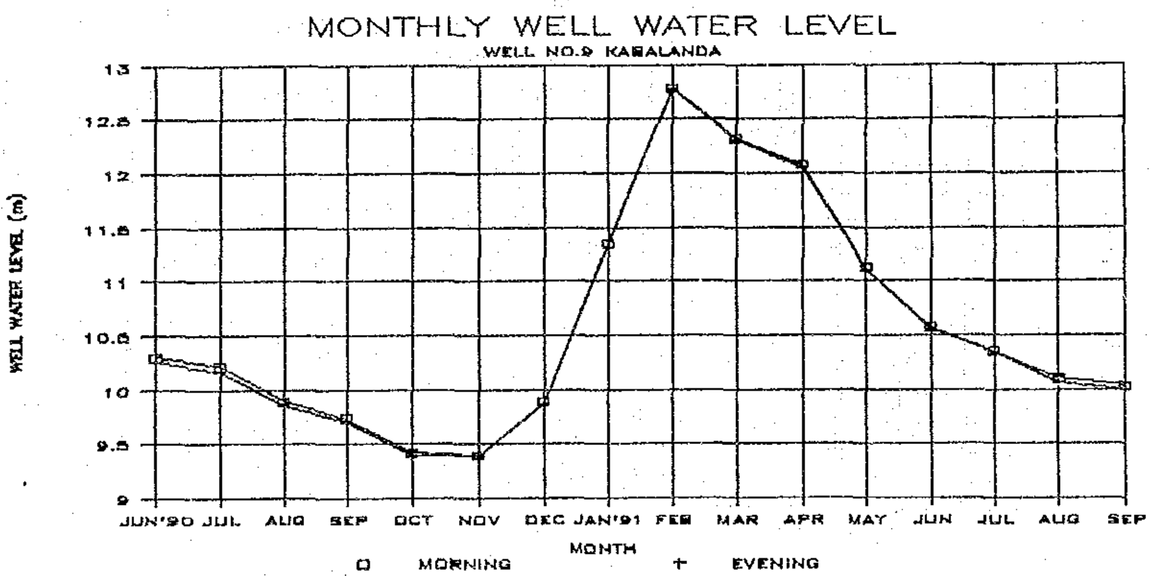


Fig.-2.4(11) Monthly Fluctuation (No.9 Kabulanda)





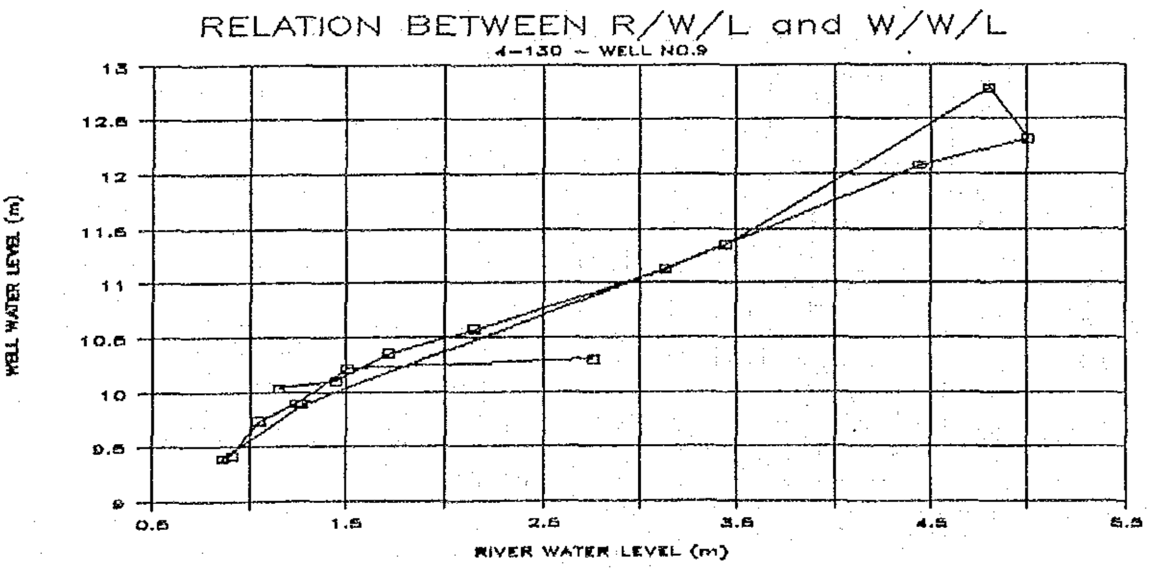
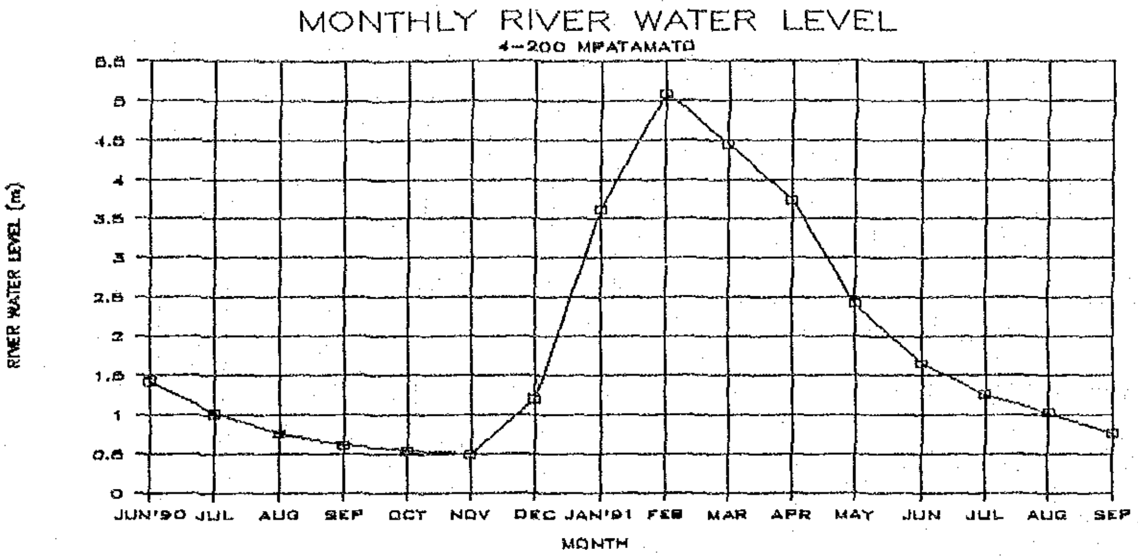
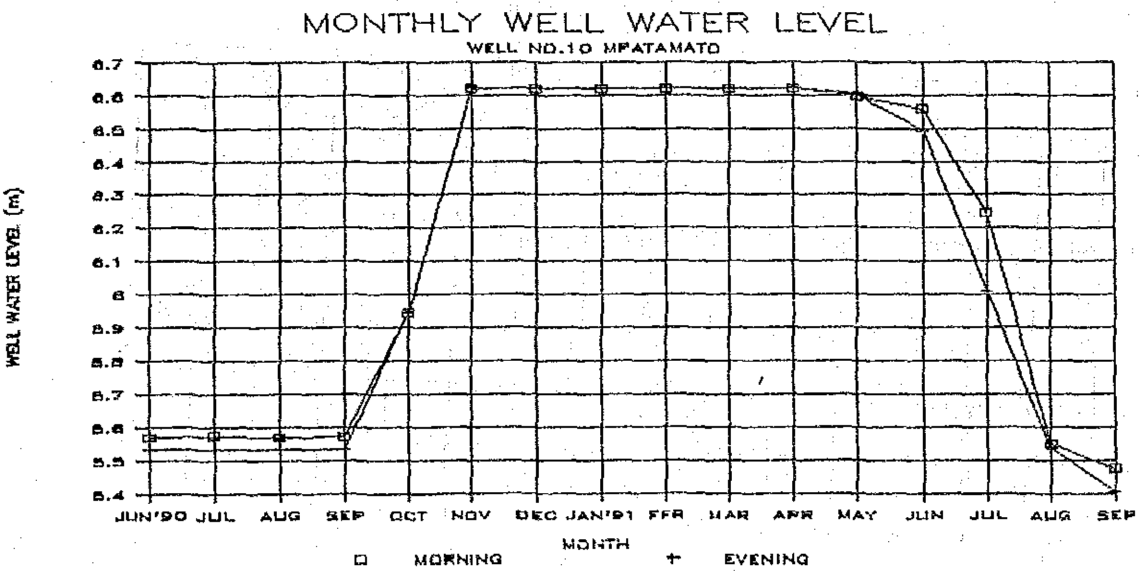


Fig.-2.4(12) Monthly Fluctuation (No.10 Mpatamato)





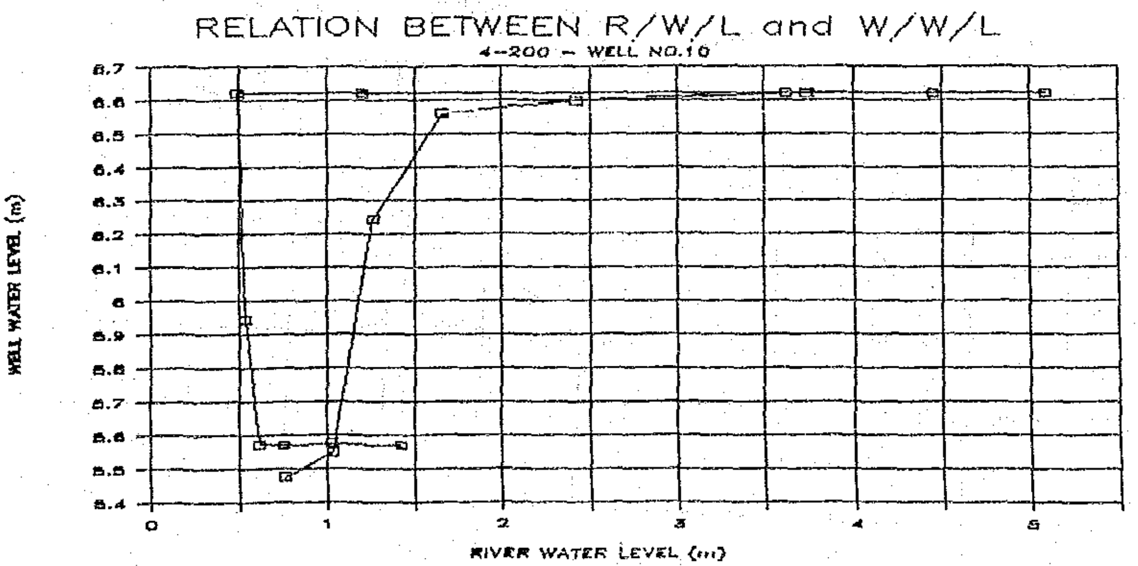
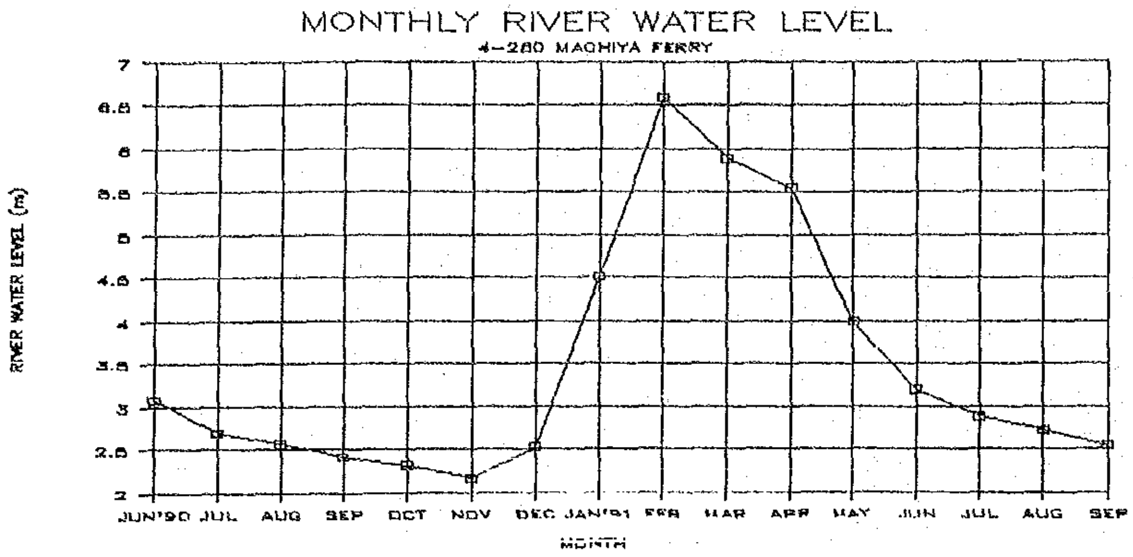
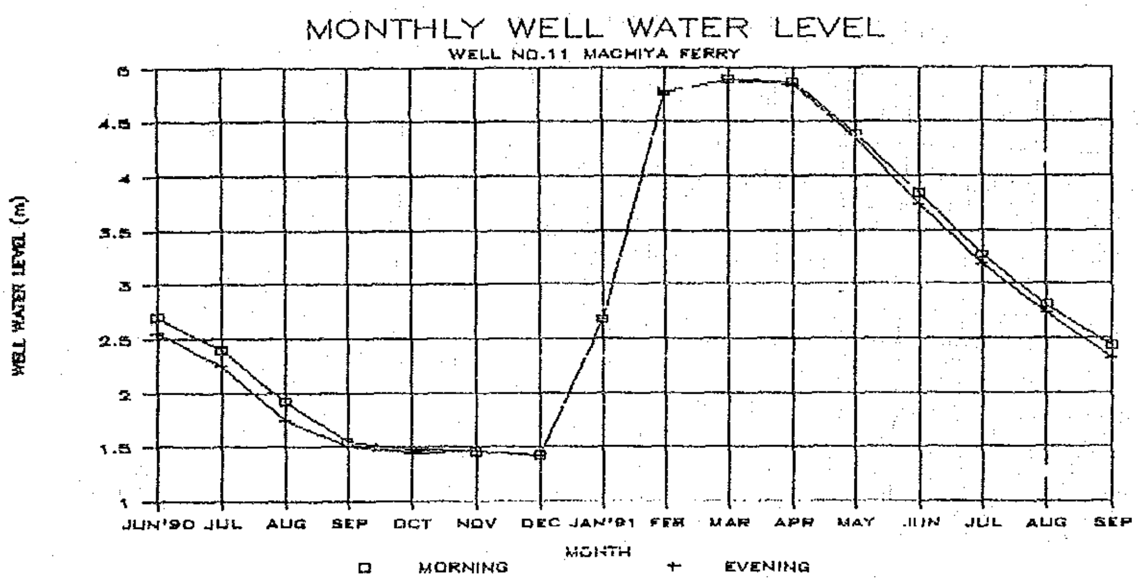


Fig.-2.4(13) Monthly Fluctuation (No.11 Machiya)





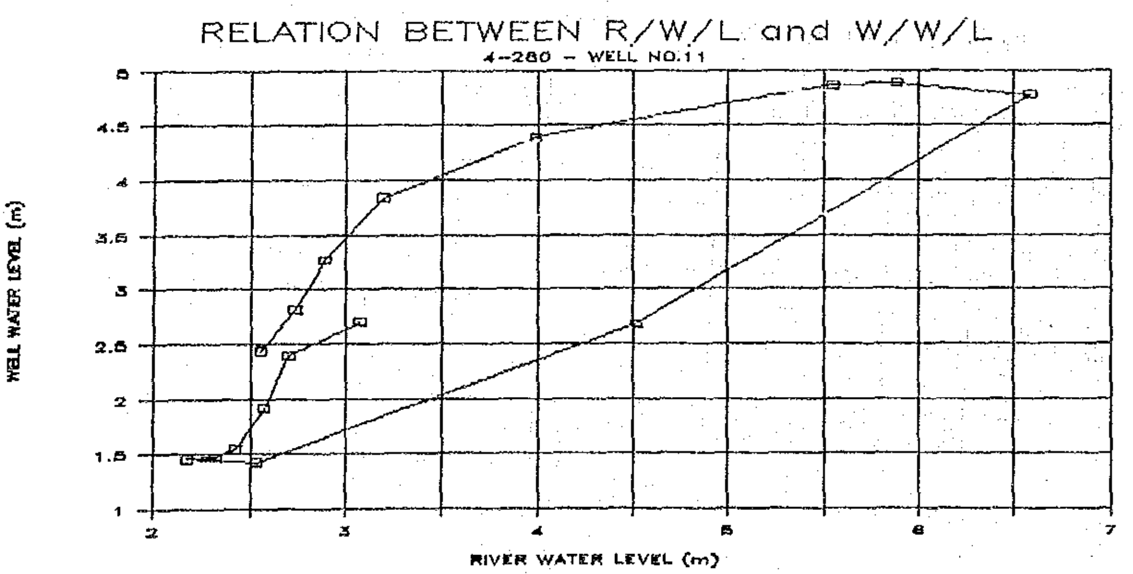
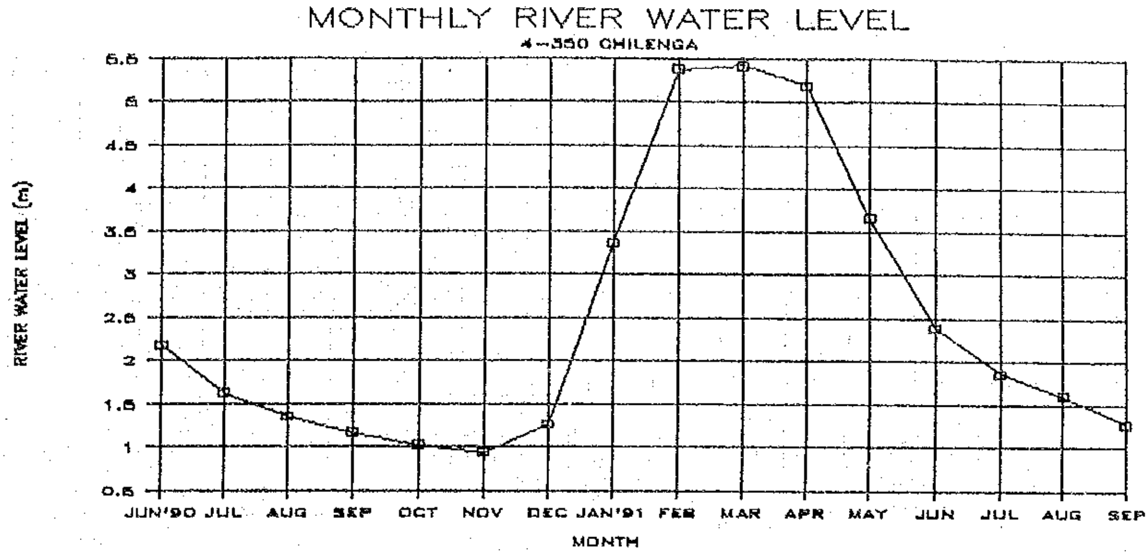
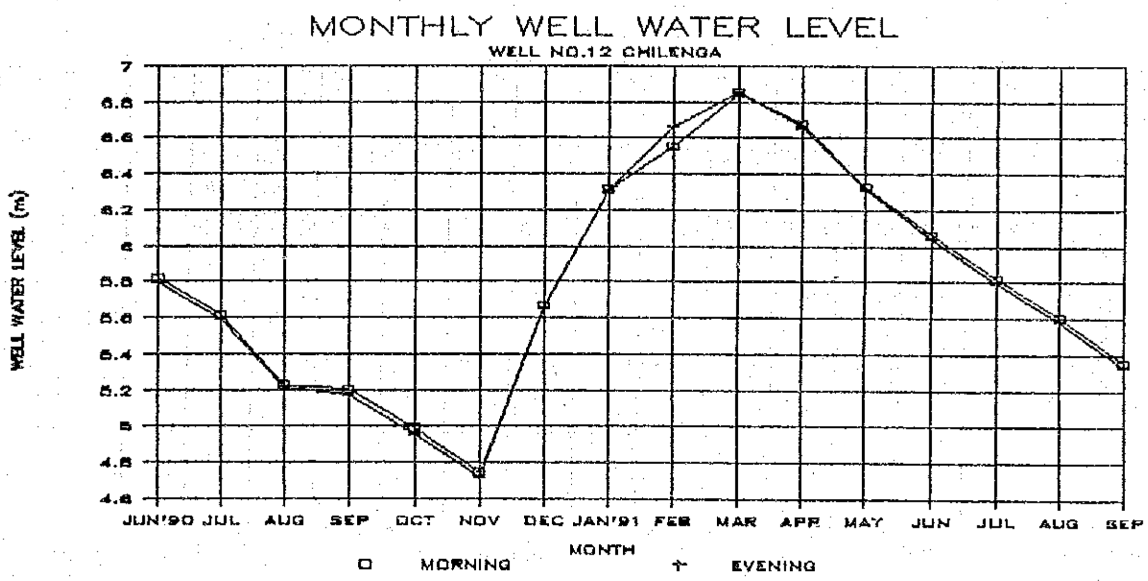


Fig.-2.4(14) Monthly Fluctuation (No.12 Chilenga)





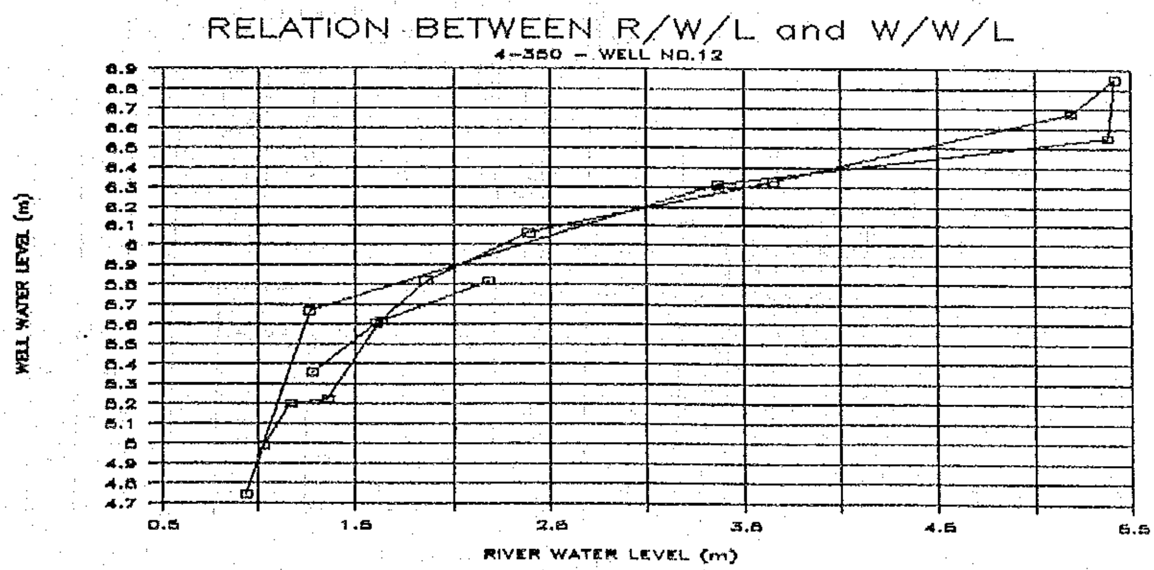
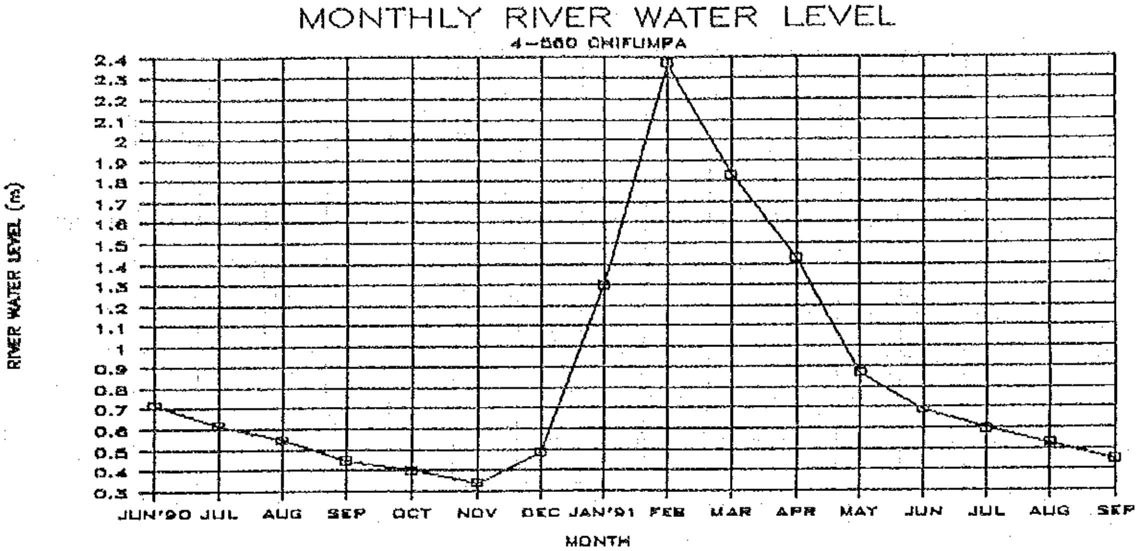
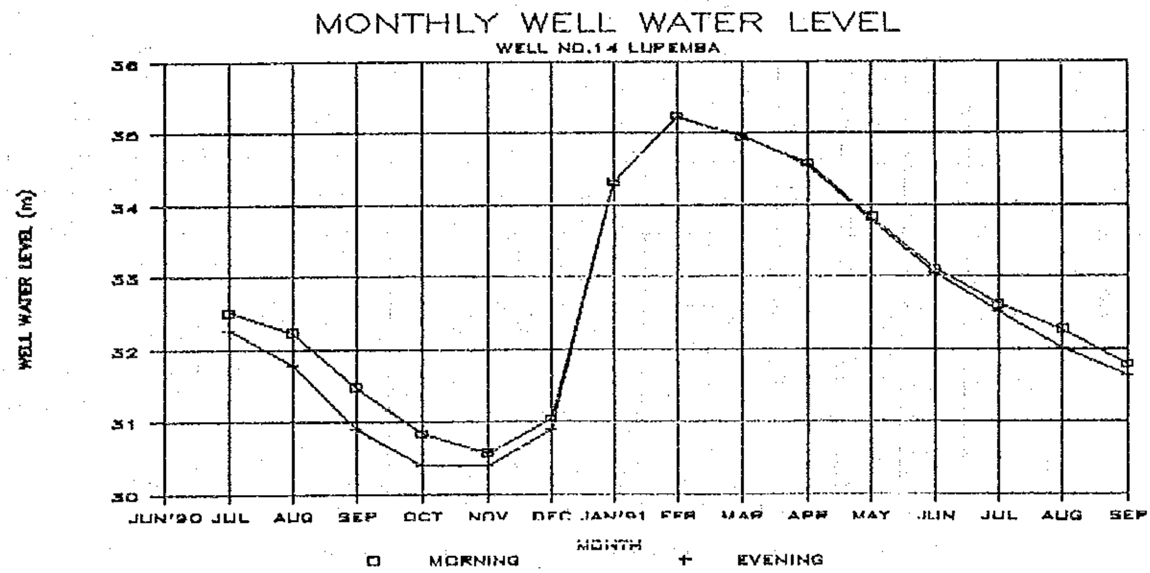


Fig.-2.4(15) Monthly Fluctuation (No.14 Lupemba)





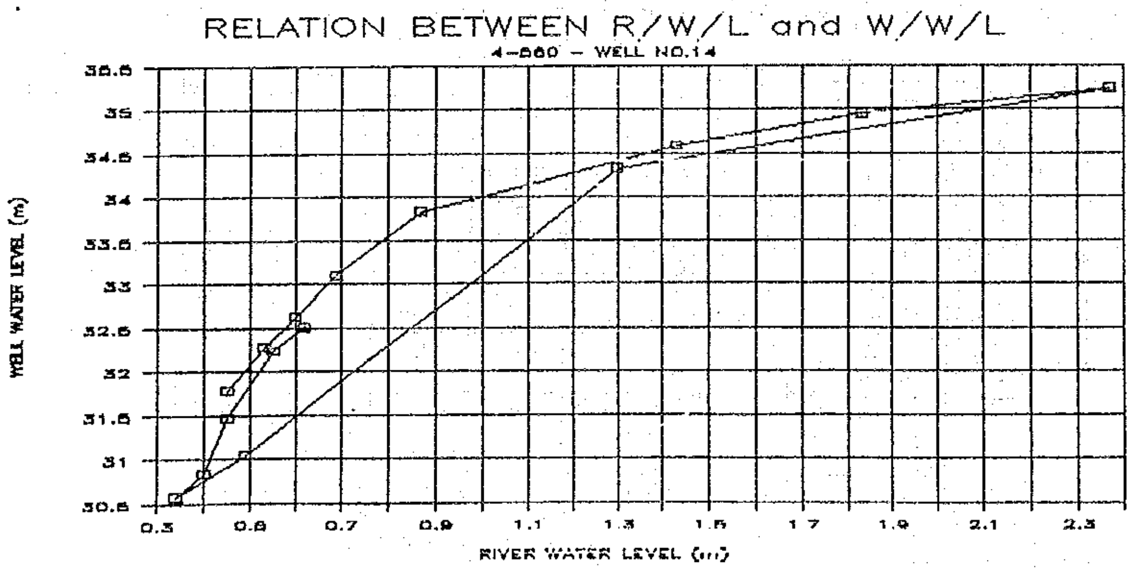
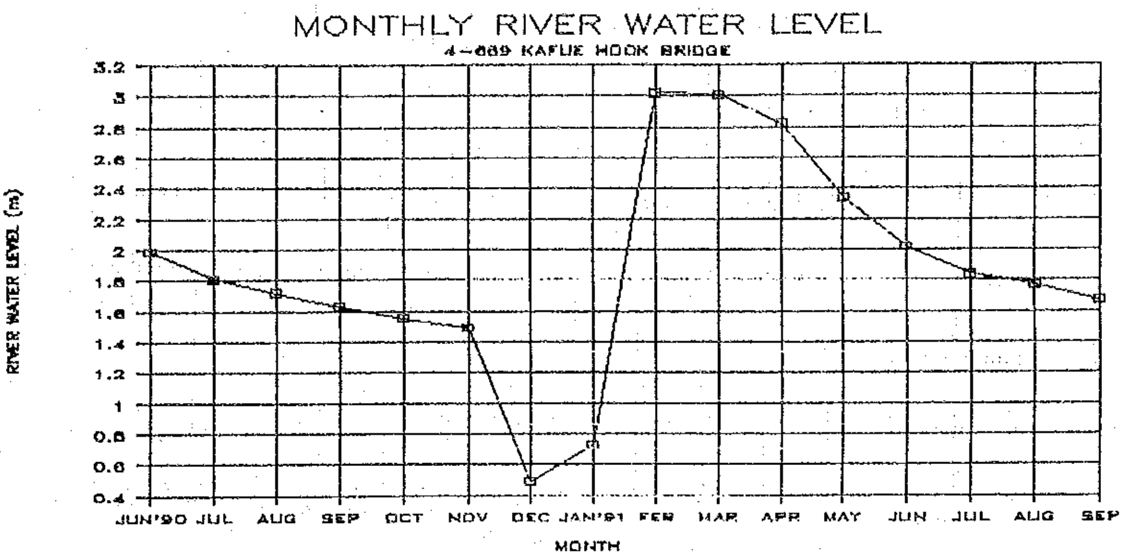
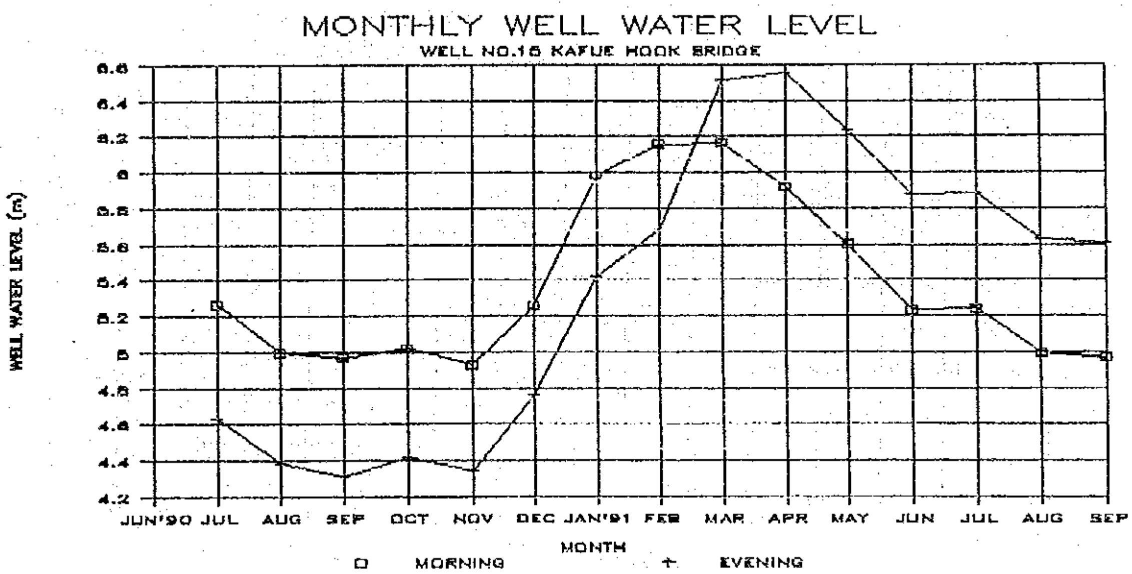


Fig.-2.4(16) Monthly Fluctuation (No.15 Kafue H/B)





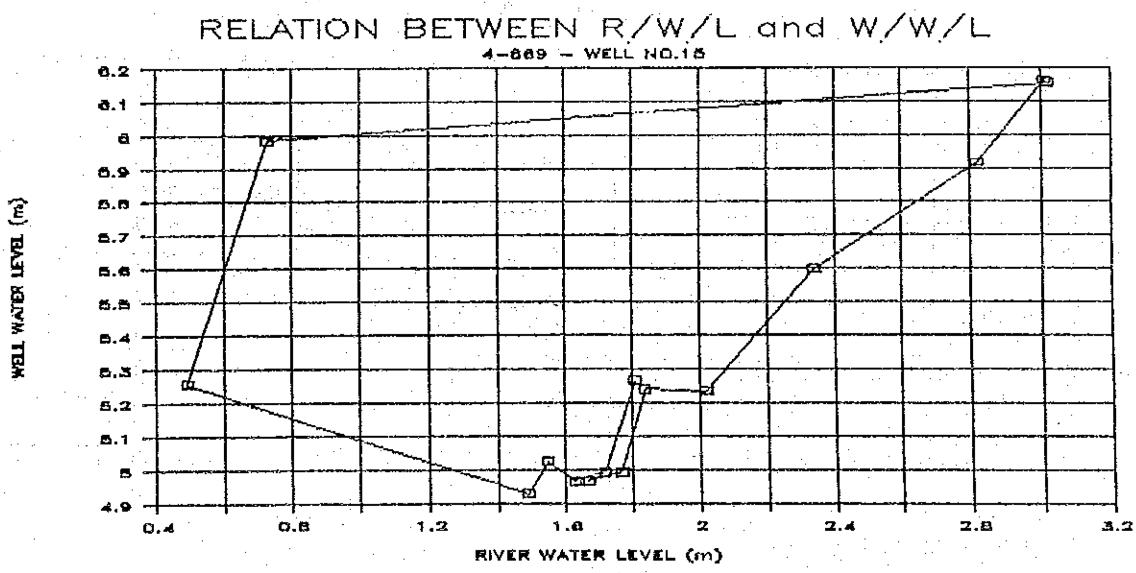
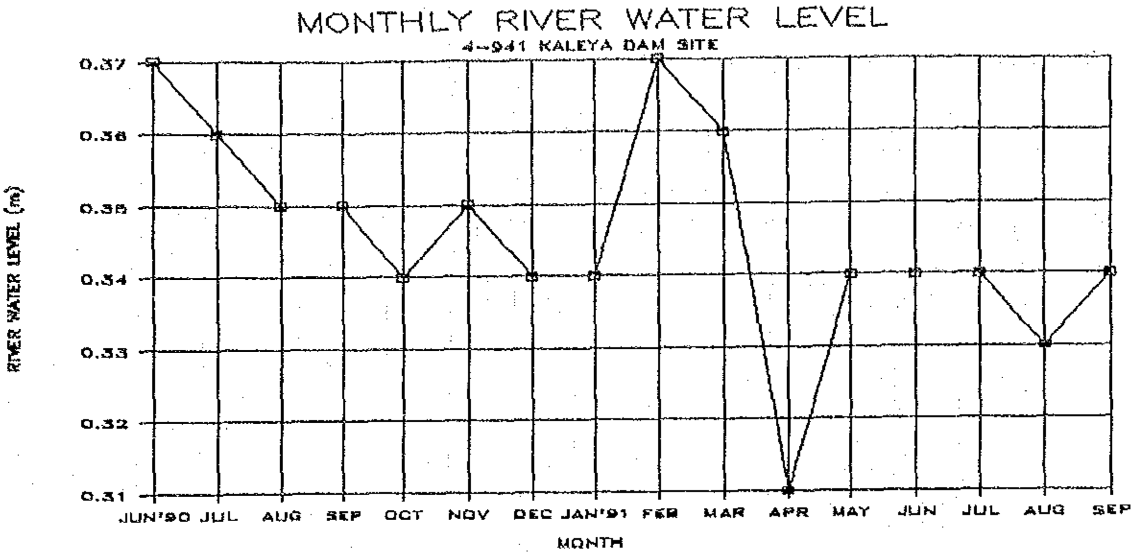
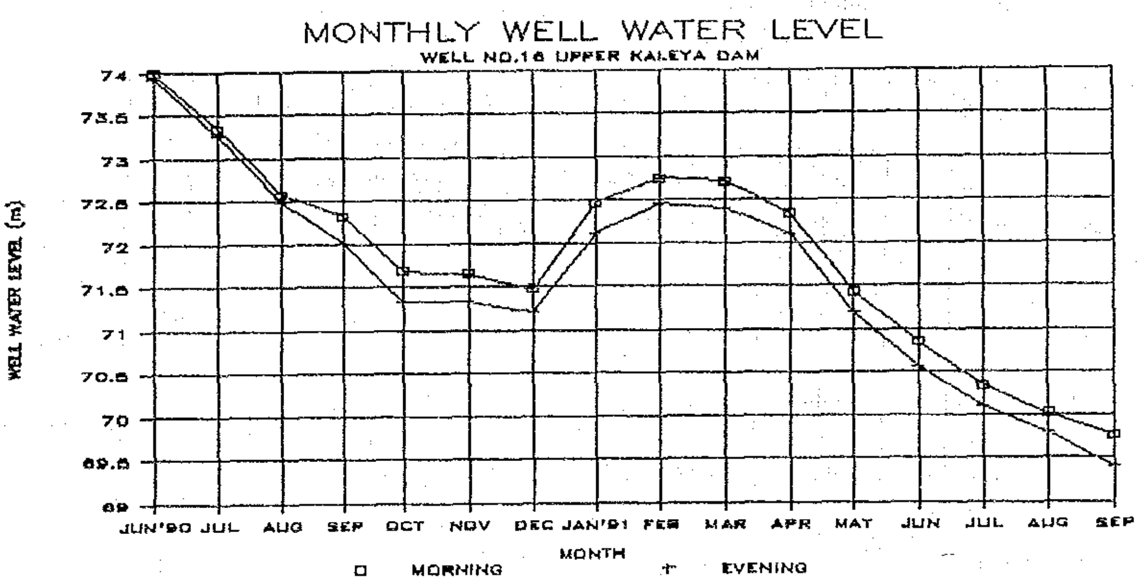


Fig.-2.4(17) Monthly Fluctuation (No.16 Upper Kaleya Dam)





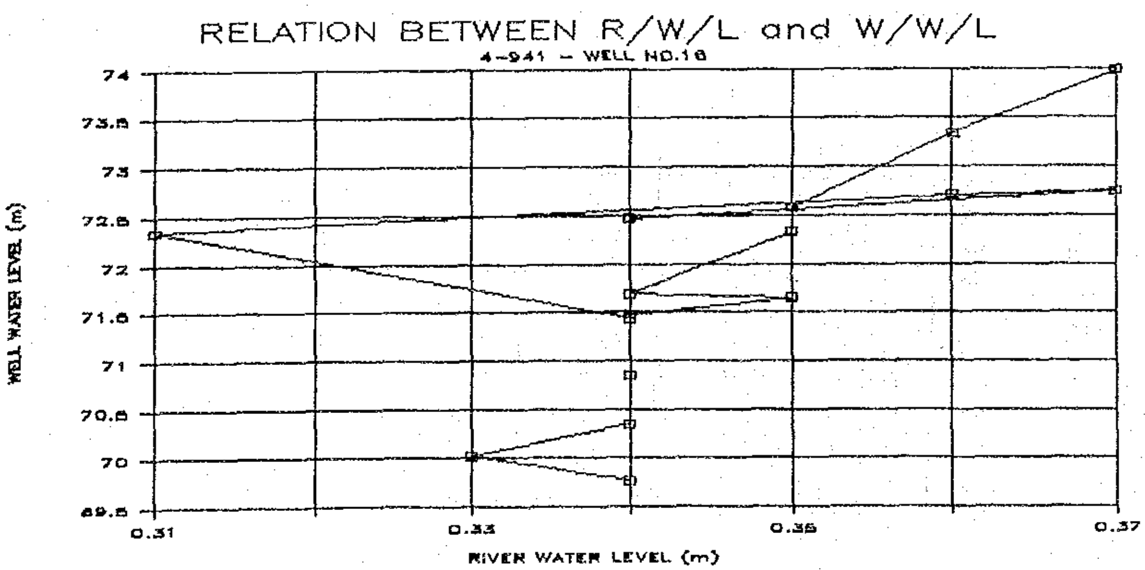
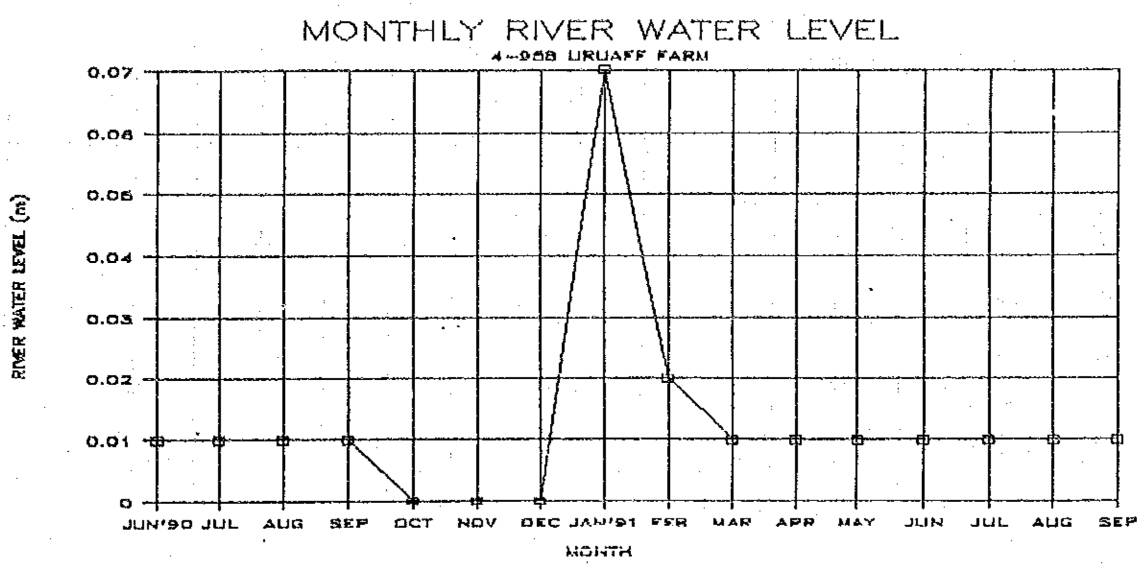
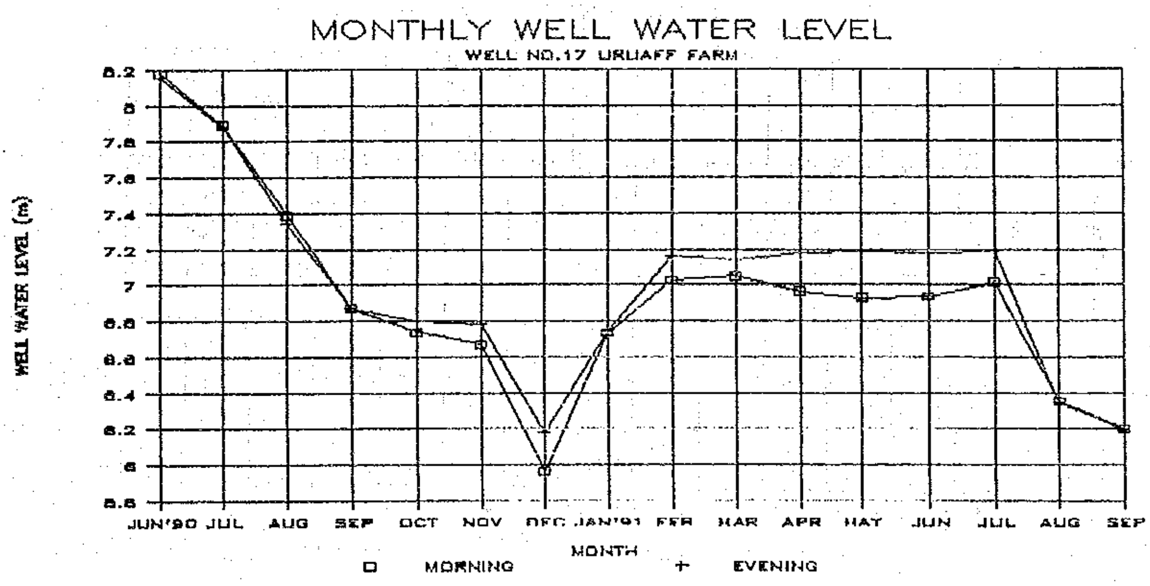


Fig.-2.4(18) Monthly Fluctuation (No.17 Uruaff Farm)





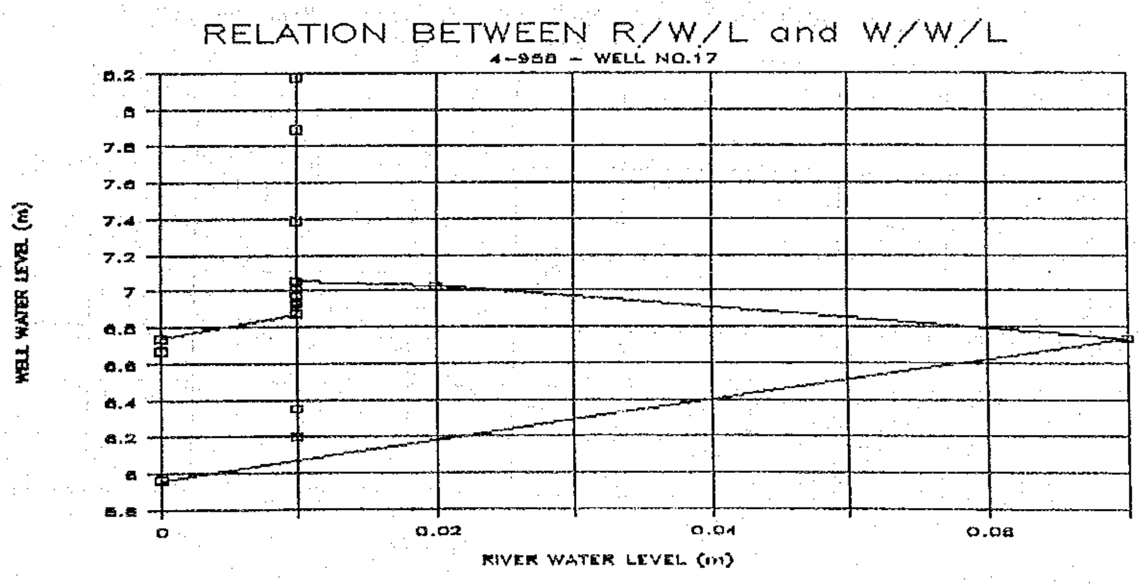
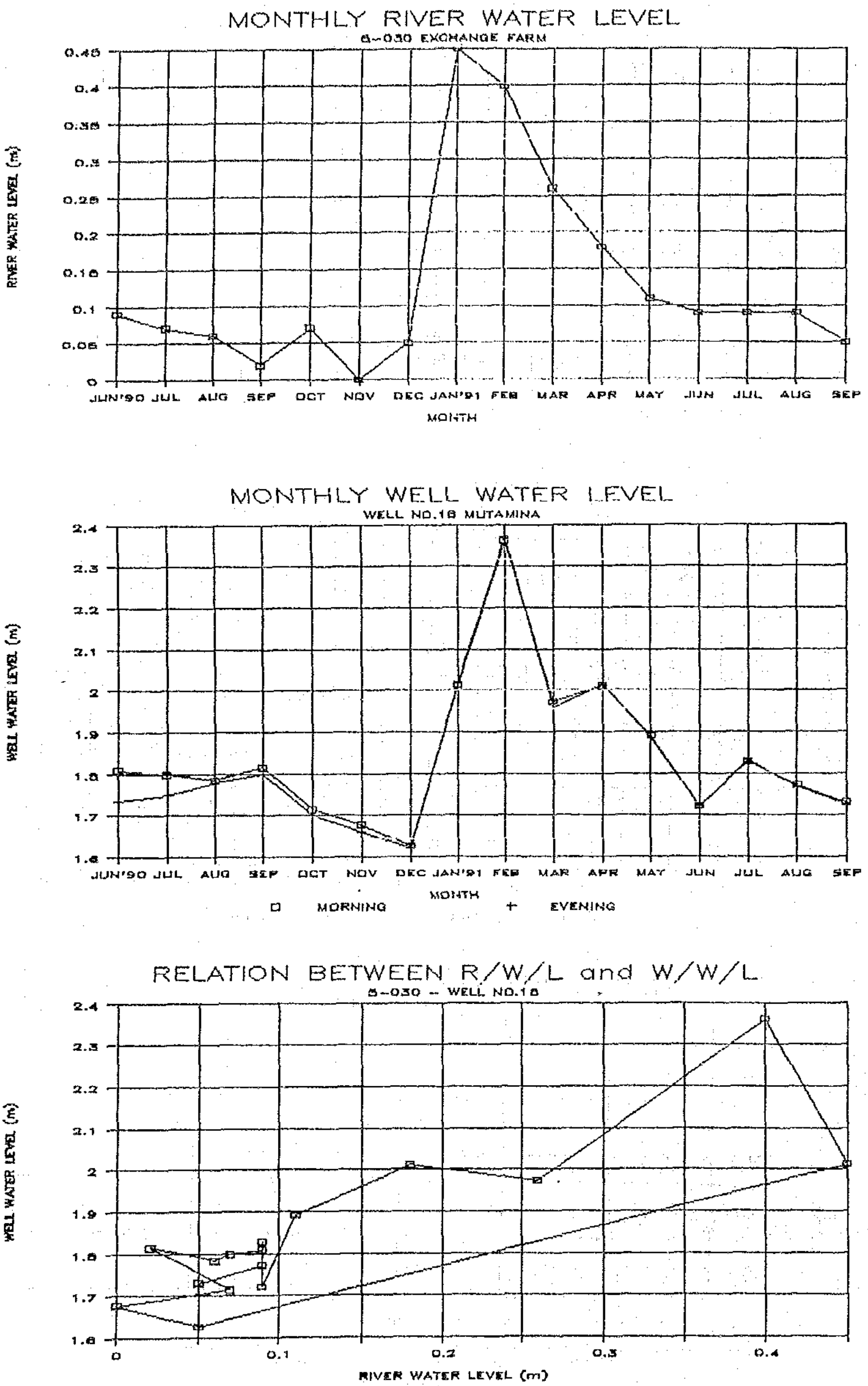


Fig.-2.4(19) Monthly Fluctuation (No.18 Mutamina)



2.4.2 Trends in Well Water Level Fluctuation

The fluctuation of each well water level can be exprssed as follows:

1) Groundwater levels for "B" commonly follow those of river water levels and this is assumed for all areas.

2) Groundwater levels for "C" that have a preceding relationship with river water levels are limited to observation wells No.5 (Kalabo) and No.15 (Kafue Hook Bridge). In the mountain areas, rainfall affects the rises of the groundwater levels preceding rises in river water levels.

3) Groundwater levels in "A" which have a link relationship with river water levels consist of observation well No.9 (Smiths Bridge) and No.12 (Chilenga). These wells are relatively close to the rivers and there is little difference between the well and river heights above sea level and in these areas the water level fluctuations for rivers and wells are considered to be linked.

4) In "D1" (combined relationship), where there is a link relationship in the high water level periods and groundwater shows a delayed relationship in the low water level periods, consists of observation wells No.4-2 (Lukulu) and No.14 (Chifumpa Pontoon). In each case the wells and the observation points were apart and the wells were in considerably high locations. The linkage relationship during the high water level periods is thought to occur because the increases in water levels of ground water levels due to rain, etc., and the periods where the river water levels of the main rivers increase occur in unison. During the low water level periods, the groundwater levels do not drop as suddenly as the river water levels and tend to be retained.

5) In "D2" (combined relationship) following the high water level period and especially when the water levels rise during the low water period, the observation wells that show a preceding relationship are No.4-1 (Lukulu) and No.6-1 (Senanga). During the high water level periods, the increases in the groundwater levels lag behind the increases in the river water level and during the low water level periods, while at the start of the rainy season, groundwater levels are affected very early.

6) In "E" (Irregular), observation well No.6-2 (Senanga)is classified. The Groundwater fluctuation is extremely small, and it is probable that the well is located in the place like a groundwater channel. Observation wells No.16 (Kaleya Dam Site) and No.17 (Vraft Farm) are "E2" classifications with overall groundwater decreasing trends although the shortage of rain in the southern region in 1991 is thought to have affected this. Observation well No.10 (Mpatamato) is an "E3" classification and is flooded during the rainy season.

The characteristics of well water level fluctuation is summarized as below.(Refer to Table-2.5)

Table-2.5 Characteristics of Well Water Level Fluctuation

Well No.	Dis.*1 (km)	Height (m)*2	Geology	Fluctuation Pattern	Hmax. Month	Hmin. Month	dH *3 (m)
1	8.5	28	Sand of Kalahari group	B	Mar	Dec	4.5
2	6.0	21		B	Mar	-	-
3	0.8	2	Alluvium	B	Mar	Jan	1.1
4-1	7.0	17	Sand of Kalahari group	D2	Feb	Nov	1.7
4-2	30	32		D1	Feb	Nov	1.4
5	4.2	11		C	Feb	Nov	0.9
6-1	4.1	14		D2	Feb	Nov	0.65
6-2	20	28		E1	-	Jul	0.4
7	9.1	41	Alluvium	B	Apr	Nov	2.6
8	0.07	4		B	Feb	Dec	2.7
9	0.7	4		A	Feb	Dec	3.4
10	0.54	1.5		E3	-	Aug	1.1
11	0.35	4		B	Mar	Dec	3.5
12	1.5	0		A	Mar	Dec	2.1
14	30	32	*4	D1	Feb	Nov	4.6
15	0.5	2.6	*5	C	Mar	Nov	1.2
16	6.5	183	Alluvium	E2	Feb	Dec	4.0
17	1.6	3.5	*6	E2	Jun	Dec	1.0
18	0.6	1.9	Alluvium	B	Feb	Dec	0.8

[Note]
*1 : Distance between well and Hydro.St.,
*2 : Height from river bench mark up to well observation point
*3 : Max. fluctuation range of well water level
*4 : Weathered shales of Kundelungu group
*5 : Alluvium and Siltstones of the Upper Karoo
*6 : Weathered Calc-Silicate Rocks of the Pre-Katanga

The following considerations are for each observation well;

< Well No. 1 >:

The well water level fluctuates following the patterns of the river water level. The highest and lowest well water levels occur with a one month delay compared to river water levels. December is the time with the lowest water levels and March to April is the time of the highest water levels. The water level fluctuation range is 4.5 m.

< Well No. 2 >:

These recordings were made starting in February 1992. March is the high water level period following the river water level with a delay of one month.

< Well No. 3 >:

The well water level fluctuates following the patterns of the river water level. The highest and lowest well water levels occur with a one month delay compared to river water levels. January is the time with the lowest water levels and March to April is the time of the highest water levels. The water level fluctuation range is 1.1 m.

< Well No. 4-1 >:

Where there are increases in the water level, the well water level increase precedes the increase in the river water level and when there are decreases in the water level, the well water level decrease lags behind the decrease in the river water level. November is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 1.7m.

< Well No. 4-2 >:

When the water level is high a linkage relationship can be seen while when the water level is low the decrease in the well water level is delayed. November is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 1.4m.

< Well No. 5 >:

The well water level precedes the river water level in fluctuations. With both water level highs and lows, well water levels precede river water levels by one month. There is considerable fluctuation each month and this may be because of water usage. October to November is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 0.9m.

< Well No. 6-1 >:

The well water level precedes the river water level in water level increases and lags behind the river water level in water level decreases. November is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 0.65m.

< Well No. 6-2 >:

There is almost no fluctuation in the water level, however, the lowest level was during the period from May to August, 1991. July is the time with the lowest water levels and the water level fluctuation range is 0.4m.

< Well No. 7 >:

The well water level fluctuates following the level of the river water level. There is a one month lag between the well water level and the river water level at the highest and lowest water level periods. November is the time with the lowest water levels and April is the time of the highest water levels. The water level fluctuation range is 2.6m.

< Well No. 8 >:

The well water level fluctuates following the level of the river water level. The highest well water level occurs at the same time as the highest river water level while the lowest well water level occurs with a one month lag after the lowest river water level. December is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 2.7m.

< Well No. 9 >:

Fluctuation in the well water level is linked to the fluctuation in the river level. Close examination shows a slight lag in the increase of water levels during the high water level season. December is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 3.4m.

< Well No. 10 >:

The well is situated in the flood plains near the Kafue river and is flooded from November to April. The increase in the well water level precedes the river water level and lags behind the river water level for decreases. August to September is the time with the lowest water levels and the water level fluctuation range is 1.1m.

< Well No. 11 >:

The well water level fluctuates following the fluctuations in the river water level. There is a lag of one month between the river water level and the well water level during the high water and low water seasons. December is the time with the lowest water levels and March is the time of the highest water levels. The water level fluctuation range is 3.5m.

< Well No. 12 >:

Fluctuations of the well water level are linked to fluctuations of the river water level. Close examination shows a slight lag in the increase of water levels during the high water level season and something close to a preceding relationship in the low water season when the water level increases. November is the time with the lowest water levels and March is the time of the highest water levels. The water level fluctuation range is 2.1m.

< Well No. 14 >:

During the high water periods there is a linked fluctuation and during the low water periods there is a lag in the decrease of the well water level. December is the time with the lowest water levels and February is the time of the highest water levels which are the same as the river water levels. The water level fluctuation range is 4.6m.

< Well No. 15 >:

Well water level fluctuation precedes that of the river water level. For both the high and low water levels the well water level precedes the river water level by one month. November is the time with the lowest water levels and March is the time of the highest water levels. The water level fluctuation range is 1.2m.

< Well No. 16 >:

The water level shows an overall decreasing trend. There was a drop of 4.0m in the period from June 1990 to September 1991although there was a temporary increase of about 1.2m during the rainy season from January to April. This is thought to have been affected by the lack of rain in 1991.

< Well No. 17 >:

Compared to the water level in June 1990, the 1991 level was low. The 1991 water level fluctuation range was about 1.0m with December being the lowest and March being the highest. There are months where the water level is higher during the evening, possibly due to the way the water is used.

< Well No. 18 >:

The well water level fluctuates following the fluctuations of the river water level. During the high and low water periods the is a fluctuation lag of one month. December is the time with the lowest water levels and February is the time of the highest water levels. The water level fluctuation range is 0.75m.

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