社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER RESOURCES

No. 11

THE STUDY ON ELEVEN CENTERS WATER SUPPLY AND SANITATION IN FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

APPENDIXES
BATI

(Volume III-III)

FEBRUARY, 1996

SANYU CONSULTANTS INC.

KYOWA ENGINEERING CONSULTANTS CO., LTD.

GOVERNMENT OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)
FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF WATER RESOURCES

THE STUDY
ON
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PREFACE

This is the Appendixes for Bati presenting the results of the Study on Eleven Centers Water Supply and Sanitation (the Study) carried out in accordance with the Scope of Work agreed upon between the Government of Federal Democratic Republic of Ethiopia (GOE) through the Water Supply and Sewerage Agency (WSSA) of the Ministry of Natural Resources Development and Environmental Protection (MNRDEP), which was recently reorganized Water Supply and Sewerage Service Department (WSSD) under Ministry of Water Resources (MWR), on the one part and the Government of Japan (GOJ) through the Japan International Cooperation Agency (JICA) on the other part dated April 8, 1994.

The major objectives of this Study are 1) to conduct a feasibility study on the water supply system in order to improve living condition of the population in the Study area by enhancing the level of the water supply services in terms of water quantity, water quality and its accessibility, 2) to formulate a plan for sanitary education and the diffusion of sanitary facilities in order to raise peoples' awareness on hygiene and improve environmental sanitation, which will be able to prevent the contamination of water source(s) and to secure safe water supply, and 3) to transfer technologies to the Ethiopian counterpart personnel in order to strengthen the managerial aspects of water supply services.

The Study had been conducted over a two (2) Japanese fiscal year-period from 1994/95 to 1995/96 and divided into two (2) phases. The Phase I study was conducted between December 1994 and March 1995, and Phase II was conducted between May 1995 and February 1996, for a total study period of 15 months during which three (3) times of visit to Ethiopia were made.

The survey items and major activities are meteo-hydrological survey, geo-electric prospecting (GEP) survey, water quality, water use condition, sanitary and health condition and people's awareness, social background, socio-economy, initial environmental examination (IEE), environmental impact assessment (EIA), sanitary education practice, and existing pump investigation.

The Study Team extends heartiest thanks to WSSD especially those assigned counterparts for their close cooperation and hard work in both office and the field, and the officers of related agencies of Japan.

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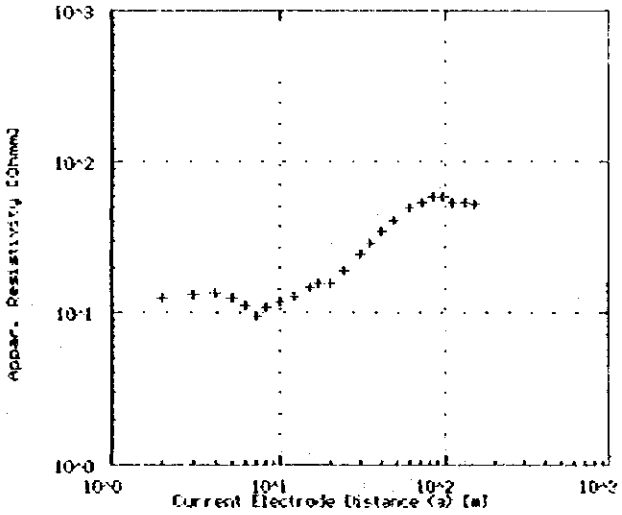
Appendix - 1

Resistivity Interpretation of VEP

Figure 1 Geoelectrical Survey, Wenner Array

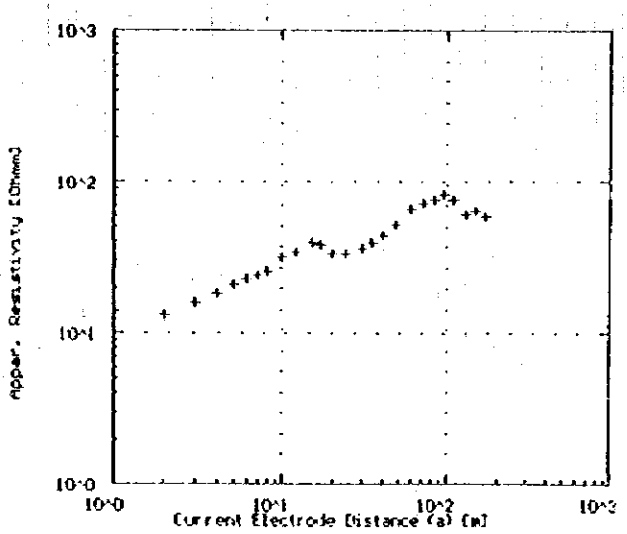
VES St. No.1 -BATI



Point [No]	AB/2 [Mr]	a [m]	Res [ohmm]
1	1.00	119.950	
2	2.00	12.310	
3	3.00	13.190	
4	4.00	13.560	
5	5.00	12.550	
6	6.00	11.300	
7	7.00	9.410	
8	8.00	10.750	
9	10.00	11.930	
10	12.00	12.810	
11	15.00	14.510	
12	17.00	15.320	
13	20.00	15.780	
14	24.00	18.010	
15	30.00	24.300	
16	34.00	28.100	
17	40.00	32.960	
18	45.00	40.030	
19	50.00	43.610	
20	72.00	53.010	
21	85.00	57.500	
22	98.00	57.220	
23	110.00	53.000	
24	130.00	53.070	
25	150.00	51.010	

Specific Resistivity(Ω-m)	224	24.89	8.25	29.4	54	244.5	122.5	37.67

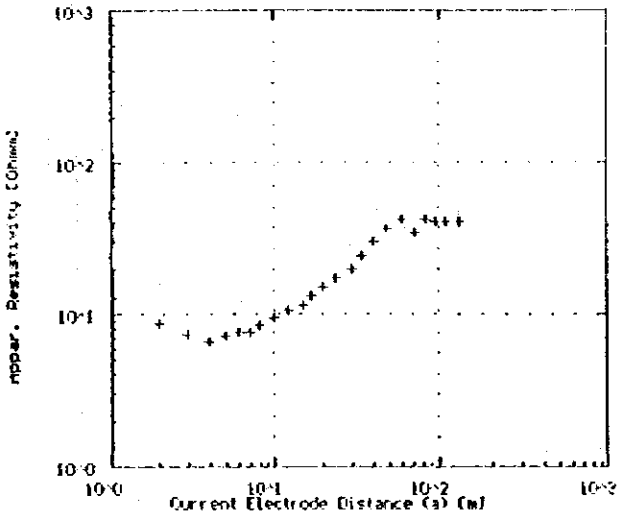
VES St. No.2 -BATI



Point [No]	AB/2 [Mr]	a [m]	Res [ohmm]
1	1.00	11.000	
2	2.00	13.130	
3	3.00	15.030	
4	4.00	18.340	
5	5.00	20.220	
6	6.00	22.510	
7	7.00	24.100	
8	9.00	25.120	
9	10.00	31.400	
10	12.00	34.670	
11	15.00	39.560	
12	17.00	38.630	
13	20.00	33.160	
14	24.00	33.310	
15	30.00	36.140	
16	34.00	39.720	
17	40.00	46.270	
18	48.00	51.250	
19	50.00	60.330	
20	72.00	71.090	
21	84.00	78.490	
22	96.00	81.990	
23	110.00	75.300	
24	130.00	60.610	
25	150.00	61.930	
26	170.00	59.720	

Specific Resistivity(Ω-m)	14.4	9.6	36.3	92	24	120	336	36

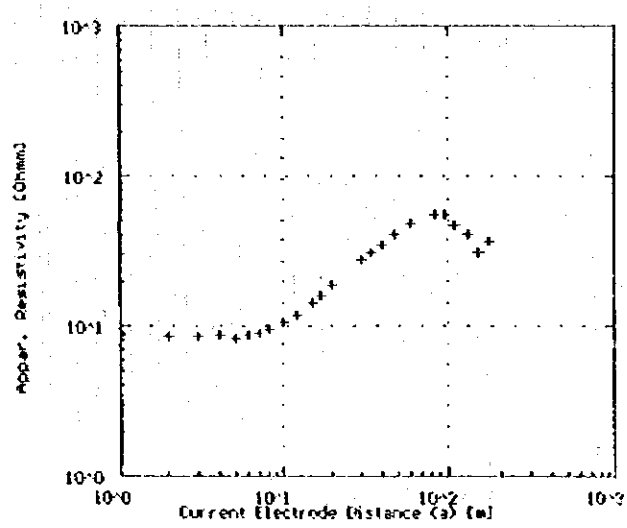
VES St. No.3 -BATI



Point (No)	AB/2 (Ar)	a (m)	Res (ohm-r)
1	1.00	12.000	
2	2.00	5.299	
3	3.00	3.350	
4	4.00	6.650	
5	5.00	7.220	
6	6.00	7.690	
7	7.00	7.490	
8	8.00	8.600	
9	10.00	9.420	
10	12.00	10.660	
11	15.00	11.530	
12	17.00	12.310	
13	20.00	15.220	
14	25.00	17.169	
15	30.00	20.010	
16	35.00	25.120	
17	40.00	29.840	
18	45.00	35.900	
19	50.00	41.150	
20	72.00	36.295	
21	84.00	61.600	
22	96.00	59.360	
23	110.00	60.020	
24	130.00	60.920	

Specific Resistivity(Ω-m)	18.8	6.27	10.5	19.5	102.4	90

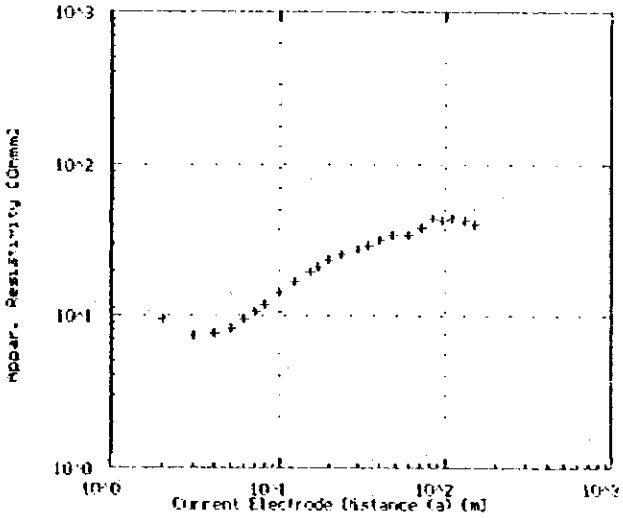
VES St. No.4 -BATI



Point (No)	AB/2 (Ar)	a (m)	Res (ohm)
1	1.00	0.230	
2	2.00	0.020	
3	3.00	0.450	
4	4.00	0.290	
5	5.00	0.320	
6	6.00	0.630	
7	7.00	0.970	
8	8.00	9.350	
9	10.00	10.430	
10	12.00	11.760	
11	15.00	14.320	
12	17.00	16.120	
13	20.00	18.040	
14	30.00	27.510	
15	34.00	30.750	
16	40.00	36.150	
17	42.00	40.330	
18	60.00	47.109	
19	66.00	55.390	
20	90.00	56.260	
21	110.00	60.750	
22	130.00	60.020	
23	150.00	30.500	
24	170.00	30.300	

Specific Resistivity(Ω-m)	12.3	8.2		23	93.6	348		13.75
			12.3				112.5	

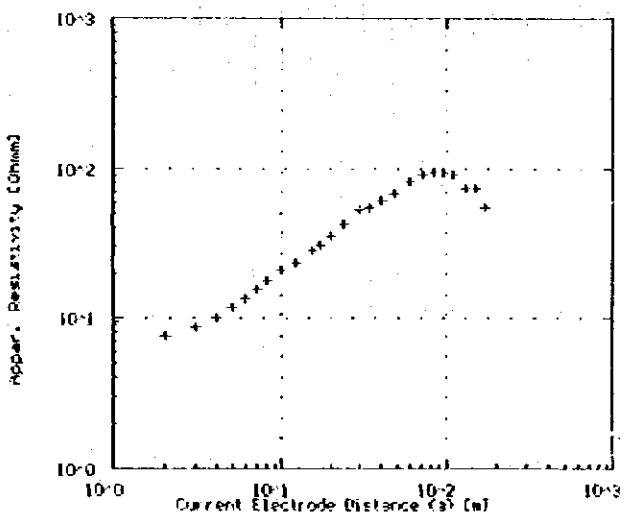
VES St. No.5 -BATI



Point [No]	AB/2 [Mr]	a [m]	Res [ohm]
1	1.00	11.300	
2	2.00	9.620	
3	3.00	7.350	
4	4.00	7.560	
5	5.00	8.220	
6	6.00	9.380	
7	7.00	10.550	
8	8.00	11.860	
9	10.00	14.190	
10	12.00	16.490	
11	15.00	19.610	
12	17.00	20.710	
13	20.00	23.260	
14	24.00	25.670	
15	30.00	27.510	
16	34.00	29.049	
17	40.00	31.800	
18	48.00	34.260	
19	50.00	33.010	
20	72.00	37.030	
21	86.00	40.370	
22	98.00	42.910	
23	110.00	46.210	
24	130.00	47.650	
25	150.00	48.510	

Specific Resistivity(Ω-m)	12	8	3.44	87	58.5	62	24.33

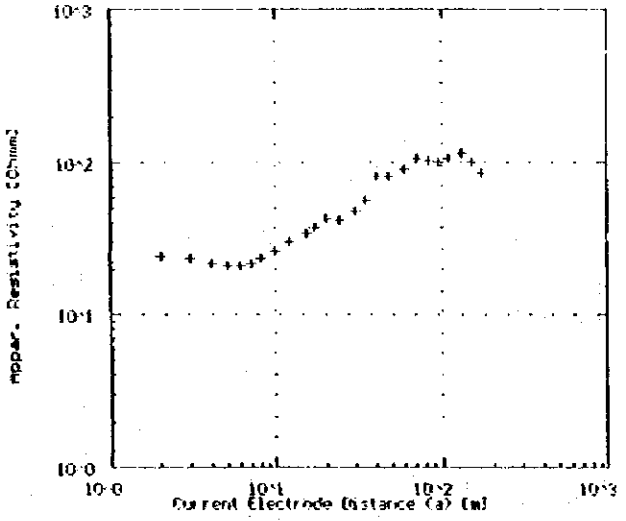
VES St. No.6 -BATI



Point [No]	AB/2 [Mr]	a [m]	Res [ohm]
1	1.00	9.360	
2	2.00	7.540	
3	3.00	8.620	
4	4.00	10.050	
5	5.00	11.930	
6	6.00	13.590	
7	7.00	15.390	
8	8.00	17.580	
9	10.00	20.220	
10	12.00	23.360	
11	15.00	28.260	
12	17.00	30.950	
13	20.00	35.290	
14	24.00	42.030	
15	30.00	52.960	
16	34.00	56.650	
17	40.00	60.760	
18	48.00	69.030	
19	60.00	81.710	
20	72.00	92.690	
21	86.00	91.070	
22	98.00	95.050	
23	110.00	97.260	
24	130.00	73.610	
25	150.00	74.420	
26	170.00	51.650	

Specific Resistivity(Ω-m)	13	6.5	20.4	175.5	222	32.32

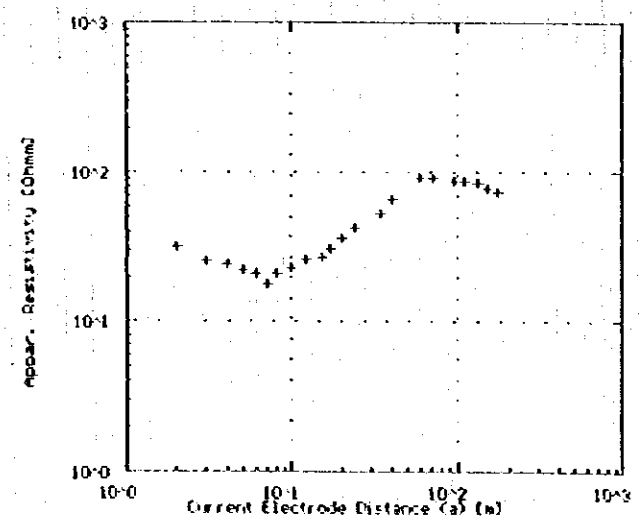
VES St. No.7 -BATI



Point (No)	AB/2 (Nr)	a (m)	Res (ohm)
1	1.00	21.500	
2	2.00	23.050	
3	3.00	23.070	
4	4.00	21.350	
5	5.00	21.045	
6	6.00	20.720	
7	7.00	21.440	
8	8.00	23.040	
9	10.00	25.350	
10	12.00	30.140	
11	15.00	33.910	
12	17.00	37.370	
13	20.00	42.700	
14	24.00	46.300	
15	30.00	48.220	
16	36.00	55.730	
17	40.00	70.520	
18	50.00	80.650	
19	60.00	88.550	
20	72.00	100.260	
21	90.00	102.020	
22	96.00	100.050	
23	110.00	105.090	
24	130.00	110.300	
25	150.00	93.050	
26	170.00	85.610	

Specific Resistivity(Ω·m)	21	31.5	16	90	280	168	55

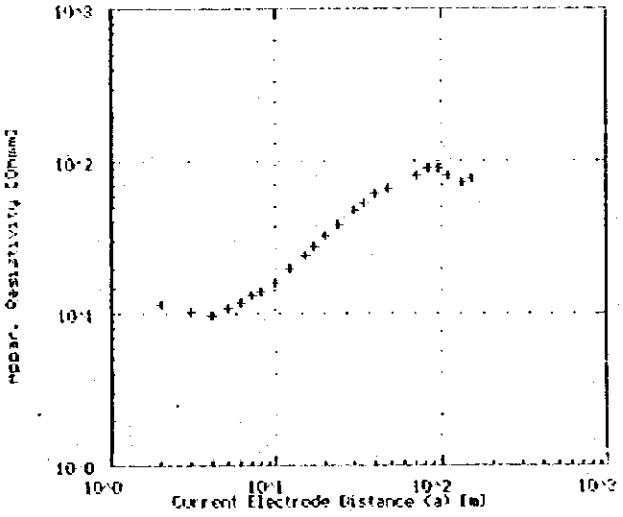
VES St. No.8 -BATI



Point (No)	AB/2 (Nr)	a (m)	Res (ohm)
1	1.00	19.500	
2	2.00	23.400	
3	3.00	25.620	
4	4.00	24.020	
5	5.00	21.900	
6	6.00	21.100	
7	7.00	18.020	
8	8.00	21.100	
9	10.00	22.610	
10	12.00	26.300	
11	15.00	26.750	
12	17.00	30.630	
13	20.00	35.000	
14	24.00	43.110	
15	30.00	53.500	
16	40.00	66.530	
17	50.00	81.560	
18	72.00	92.050	
19	96.00	87.400	
20	110.00	88.350	
21	130.00	85.720	
22	150.00	78.130	
23	170.00	73.650	

Specific Resistivity(Ω·m)	50	20	33	156	132	44

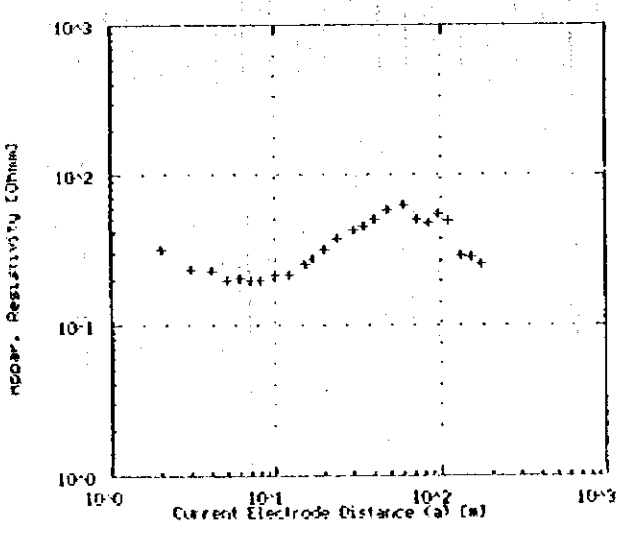
VES St. No.9 -BATI



Point [No]	AB/2 [Nr]	a [m]	Res [ohmm]
1	1.00	18.100	
2	2.00	18.550	
3	3.00	18.360	
4	4.00	9.000	
5	5.00	10.990	
6	6.00	11.680	
7	7.00	13.193	
8	8.00	14.020	
9	10.00	15.060	
10	12.00	19.940	
11	15.00	24.210	
12	17.00	27.440	
13	20.00	32.150	
14	24.00	39.630	
15	30.00	47.290	
16	34.00	53.170	
17	40.00	60.293	
18	48.00	67.070	
19	72.00	81.330	
20	84.00	90.210	
21	96.00	99.050	
22	110.00	80.070	
23	130.00	72.560	
24	150.00	75.080	

Specific Resistivity(Ω-m)	37	9.75	520	216	56

VES St. No.10 -BATI



Point [No]	AB/2 [Nr]	a [m]	Res [ohmm]
1	1.00	42.100	
2	2.00	37.600	
3	3.00	23.550	
4	4.00	22.510	
5	5.00	20.100	
6	6.00	20.350	
7	7.00	19.280	
8	8.00	19.590	
9	10.00	21.350	
10	12.00	23.630	
11	15.00	25.080	
12	17.00	27.450	
13	20.00	31.530	
14	24.00	37.080	
15	30.00	42.500	
16	34.00	45.400	
17	40.00	50.650	
18	48.00	50.699	
19	60.00	57.030	
20	72.00	49.240	
21	84.00	47.490	
22	98.00	54.260	
23	110.00	48.050	
24	130.00	29.390	
25	150.00	28.690	
26	170.00	25.610	

Specific Resistivity(Ω-m)	76	19		112.5	36	7.5
			30.75			

Appendix - 2

Result of Water Quality Test

Result of Physico-Chemical Analysis in Bati

Sample No.1

Origin of Sample : Borehole No.1 (WSS)
Date of Collection: 16/Jan./95
Date of Analysis : 01/Feb./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: Nil
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 250
Turbidity	: 1 FTU
Temperature	: -
Conductivity	: 0.50 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 410
Carbonate Hardness as $CaCO_3$	: 410
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 370
Bicarbonate Alkalinity as $CaCO_3$	: 370
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 8.50
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 30.00
Na^+	: -	NO_2^-	: Nil
K^+	: -	NO_3^-	: 12.30
Ca^{++}	: 120.00	F^-	: 0.43
Mg^{++}	: 2.63	HCO_3^-	: 451.60
Fe(Total)	: 0.02	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 21.00
Cu^{++}	: Nil	PO_4^{---}	: 2.75

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Bati

Sample No.2

Origin of Sample : Borehole No.2 (WSS)
Date of Collection: 16/Jan./95
Date of Analysis : 01/Feb./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: Nil
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 100
Turbidity	: Nil
Temperature	: -
Conductivity	: 0.22 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 480
Carbonate Hardness as $CaCO_3$	: 480
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 560
Bicarbonate Alkalinity as $CaCO_3$	: 560
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 8.50
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 70.00
Na^+	: -	NO_2^-	: Nil
K^+	: -	NO_3^-	: 13.90
Ca^{++}	: 120.40	F^-	: 0.73
Mg^{++}	: 40.76	HCO_3^-	: 463.60
Fe(Total)	: 0.01	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 48.00
Cu^{++}	: 1.00	PO_4^{---}	: 2.75

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Bati

Sample No.3

Origin of Sample : Borehole No.3 (WSS)
Date of Collection: 16/Jan./95
Date of Analysis : 02/Feb./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: Nil
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 400
Turbidity	: Nil
Temperature	: -
Conductivity	: 0.80 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 360
Carbonate Hardness as $CaCO_3$	: 360
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 560
Bicarbonate Alkalinity as $CaCO_3$	: 560
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 8.50
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 20.00
Na^+	: -	NO_2^-	: Nil
K^+	: -	NO_3^-	: 1.60
Ca^{++}	: 120.40	F^-	: Nil
Mg^{++}	: 11.96	HCO_3^-	: 683.20
Fe(Total)	: 0.07	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 19.00
Cu^{++}	: 1.01	PO_4^{---}	: 2.75

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Bati

Sample No.4

Origin of Sample : Borehole No.4 (WSS)
Date of Collection: 24/Feb./95
Date of Analysis : 17/Mar./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: 15 Pt-Co
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 420
Turbidity	: 2 FTU
Temperature	: -
Conductivity	: 0.86 ms/cm at 21.3 °C

General Chemical Characteristics

Total Hardness as $CaCO_3$	: -
Carbonate Hardness as $CaCO_3$	: -
Non Carbonate Hardness as $CaCO_3$	: -
Total Alkalinity as $CaCO_3$	: 400
Bicarbonate Alkalinity as $CaCO_3$	: 400
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: -
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 20.00
Na^+	: -	NO_2^-	: 0.026
K^+	: -	NO_3^-	: 12.76
Ca^{++}	: 96.00	F^-	: 0.33
Mg^{++}	: -	HCO_3^-	: 488.00
Fe(Total)	: 0.29	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 22.00
Cu^{++}	: Nil	PO_4^{---}	: 0.20

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Bati

Sample No.5

Origin of Sample : Spring (at Ghion Hotel)
Date of Collection: 16/Jan./95
Date of Analysis : 02/Feb./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: Nil
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 370
Turbidity	: Nil
Temperature	: -
Conductivity	: 0.80 ms/cm

General Chemical Characteristics

Total Hardness as $CaCO_3$	: 350
Carbonate Hardness as $CaCO_3$	: 350
Non Carbonate Hardness as $CaCO_3$	: Nil
Total Alkalinity as $CaCO_3$	: 560
Bicarbonate Alkalinity as $CaCO_3$	: 560
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: 8.50
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 40.00
Na^+	: -	NO_2^-	: Nil
K^+	: -	NO_3^-	: 6.30
Ca^{++}	: 92.00	F^-	: 1.02
Mg^{++}	: 28.78	HCO_3^-	: 439.20
Fe(Total)	: 0.04	CO_3^{--}	: Nil
Mn^{++}	: Nil	SO_4^{--}	: 26.00
Cu^{++}	: 0.05	PO_4^{---}	: 2.00

Remarks; All the analyzed chemical constituents are within the acceptable range in accordance with WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Physico-Chemical Analysis in Bati

Sample No.6

Origin of Sample : Legashenbeko Spring
Date of Collection: 24/Feb./95
Date of Analysis : 17/Mar./95

Physical Characteristics

Appearance	: Clear
Odor	: Odorless
Taste	: -
Color	: 2 Pt-Co
Settleable Solids	: Absent
Floating Solids	: Absent
Suspended Solids	: Absent
Total Dissolved Solids	: 693
Turbidity	: Nil
Temperature	: -
Conductivity	: 1.38 ms/cm at 20.8°C

General Chemical Characteristics

Total Hardness as $CaCO_3$	: -
Carbonate Hardness as $CaCO_3$	: -
Non Carbonate Hardness as $CaCO_3$	: -
Total Alkalinity as $CaCO_3$	: 380
Bicarbonate Alkalinity as $CaCO_3$	: 380
Carbonate Alkalinity as $CaCO_3$	: Nil
PH	: -
Silica	: -
Sulphide as Hydrogen Sulphide	: -
Carbondioxide	: -
Residual Chlorine	: -
Dissolved Oxygen	: -

Ionic Contents

Cations		Anions	
NH_4^+	: -	Cl^-	: 70.00
Na^+	: -	NO_2^-	: 0.281
K^+	: -	NO_3^-	: 98.56
Ca^{++}	: 124.00	F^-	: 0.66
Mg^{++}	: -	HCO_3^-	: 463.60
Fe(Total)	: 0.02	CO_3^{--}	: Nil
Mn^{++}	: 0.20	SO_4^{--}	: 20.00
Cu^{++}	: 2.13	PO_4^{---}	: 0.10

Remarks; Nitrate concentration is above WHO drinking water quality guidelines.

Note; Unit is mg/litre unless otherwise stated.

Result of Faecal Coliform Test in Bati, Sampled and Analyzed on Jun./23/'95

No.	Kebele	Source	Place of Sampling	No of F.C. per 100ml	Remarks
1	2	BH1&2&3&4	P.Foun.	3	
2	2	BH1&2&3&4	P.Foun.	2	Same as sample No.1 but different tap
3	2	BH1&2&3&4	P.Conn.	2	WT=27°C
4	2	BH1&2&3&4	P.Conn.	1	WT=26°C, WSS tap
5	2	BH1&2&3&4	P.Conn.	4	WT=29°C
6	2	BH1&2&3&4	Barrel	TMTC	WT=26°C, Fetched by sample No.5
7	2	BH1&2&3&4	Clay pot	101	Ph=8.2, Fetched 1 day before, Covered
8	2	BH1&2&3&4	Clay pot	117	WT=21°C, Fetched 1 day before, Covered
9	2	BH1&2&3&4	Clay pot	TMTC	WT=26°C, Fetched on the day
10	2	BH1&2&3&4	Clay pot	TMTC	WT=24°C, Fetched 1 day before, Covered
11	2	BH1&2&3&4	Jerry-can	TMTC	WT=26°C, Fetched on the day
12	2	BH1&2&3&4	Jerry-can	28	WT=24°C, Fetched 1 day before

This test has been carried out in the Community in which the experimental toilet was being constructed. The Community fetch water mainly from the public fountain and private connection of sample No.1 to 5 above.

Note; "F.C. means Faecal Coliform.
"BH" means borehole.
"HDW" means hand-dug-well.
"P.Conn." means private connection.
"Y.Conn." means yard connection.
"P.Foun." means public fountain.
"Barrel" means Barrel-container made of steel.
"TMTC" means too many to count.

Result of Faecal Coliform Test in Bati, Sampled and Analyzed on Feb./23,25/'95

No.	Kebele	Source	Place of Sampling	No of F.C. per 100ml	Remarks
1		BH1	BH1	3	Sampled fr the borehole directly
2		BH4	BH4	NIL	Sampled fr the borehole directly
3		BH3	P.Foun.	NIL	Directly supplied fr BH3, 300m away
4		BH1&2&3&4	Chamber	5	Supplied fr the collecting chamber
5		BH1&2&3&4	P.Foun	40	Located just beside the chamber
6		BH1&2&3&4	Reservoir	NIL	Sampled fr the top
7		BH1&2&3&4	Reservoir	2	Sampled fr the drainage
8		BH1&2&3&4	P.Foun.1	NIL	
9		BH1&2&3&4	P.Foun.2	NIL	Retested and showed same result of NIL
10		BH1&2&3&4	P.Foun.3	1	Retested and showed NIL at the 2nd
11		BH1&2&3&4	P.Foun.4	NIL	Retested and showed same result of NIL
12		BH1&2&3&4	P.Conn.	NIL	
12	1	BH1&2&3&4	P.Conn.	NIL	
13	1	BH1&2&3&4	P.Conn.	NIL	Hotel private connection via small tank
14	2	BH1&2&3&4	Y.Conn.	NIL	
15	1	BH1&2&3&4	Barrel	1	Covered by steel lid, Fetched fr P.Foun.
16	1	BH1&2&3&4	Barrel	8	Covered by steel lid, Fetched fr P.Conn.
17	2	BH1&2&3&4	Barrel	NIL	Covered by steel lid, Fetched fr P.Foun.
18	2	BH1&2&3&4	Barrel	8	Covered by steel lid, Fetched fr P.Conn.
19	3	BH1&2&3&4	Barrel	19	Covered by wooden lid with cloth
20	1	BH1&2&3&4	Clay pot	TMTC	Covered by dirty cloth, Scoop was dirty
21	1	BH1&2&3&4	Clay pot	4	Not covered
22	3	BH1&2&3&4	Clay pot	NIL	Not covered, Fetched on the day morning
23	-	Spring	Legashenbeko	TMTC	Unprotected spring, Goats shown upstream

There are four sources (BH1, BH2, BH3 & BH4) operated WSS, those of which are collected into the collecting chamber and then pumped up to the reservoir.

Note; "F.C. means Faecal Coliform.
"BH" means borehole.
"HDW" means hand-dug-well.
"P.Conn." means private connection.
"Y.Conn." means yard connection.
"P.Foun." means public fountain.
"Barrel" means Barrel-container made of steel.
"TMTC" means too many to count.

Appendix - 3

Social and Gender Data

Bati – Activity Profile by Gender (Public Fountain Users)

Activities	Gender		Remarks/Time/Place
	Male	Female	
Fetches drinking water	n	y	Sometimes children
Does laundry	n	y	Sometimes children at river
Waters livestock	-	-	Not in the town
Takes water from container	y	y	All including children
Disposes of solid waste	n	y	
Constructs latrines	y	n	
Keeps latrine clean	n	y	Do not all have latrines
Keeps compound clean	n	y	
Teaches children about hygiene	y	y	Mostly women
Takes care of sick children	n	y	

Note : We didn't see water containers cleaned but women said they cleaned containers with medicinal leaves one in 3 days.
y = Yes, n = No

Bati – Diagnosis of Each Group by Activities (Private Connection Users)

Activities	Gender		Remarks/Time/Place
	Male	Female	
Fetches drinking water	n	y	Plus children
Does laundry	n	y	
Disposes of solid waste	n	y	
Constructs latrine (Supervision)	y	n	Paid labor
Keeps compound clean	n	y	
Keeps latrine clean	n	y	Do not all have latrines
Teaches children about hygiene	n	y	
Takes care of sick children	n	y	

y = Yes, n = No

Bati – Daily Schedule (Public Fountain Users)

Man	Time	Female
Gets up, fetches donkey	4	Gets up and makes packed lunch for husband
Takes donkey to fetch wood in surrounding	5	Goes back to sleep
countryside	6	〃
〃 (takes food with him)	7	Gets up, fetches water, makes breakfast and
〃	8	eats with children House work (Children go to school)
〃	9	〃
〃	10	〃 including laundry at river
〃	11	〃
〃	12	〃
〃	13	Eats lunch with children
〃	14	Perhaps spinning cotton/sewing or
〃	15	house work
〃	16	Collects wood for domestic use
Short rest then goes to town to sell wood	17	〃
〃	18	Prepares supper
〃	19	〃
Returns home, gives wife cash	20	Eats dinner with family
Eats supper together with family	21	Cleans up dishes
Goes to sleep	22	Goes to sleep

Bati – Daily Schedule (Private Connection Users)

Man	Time	Female
	5	Gets up, bathes and prays
Gets up, washes and prays	6	Prepares breakfast
Eats breakfast before wife	7	Eats breakfast after husband
Goes to shop (shop keeper)	8	Washes dishes
〃	9	Makes beds and cleans house
〃	10	Does laundry etc.
〃	11	〃
Goes to mosque	12	Prepares lunch
Returns home, eats lunch, rests	13	Serves husband lunch
Goes to shop (shop keeper)	14	Eats lunch and has coffee ceremony with
〃	15	mother-in-law
〃	16	〃
〃	17	House work
〃	18	Prepares supper
Goes to mosque	19	Feeds children
Returns home	20	Feeds husband
Eats chat with friends	21	Feeds self, cleans dishes etc.
〃 (3 days a week)	22	Goes to sleep
〃	23	
〃	24	

Note : Man runs a family store selling soap, shoes, clothes and such like

Bati – Access and Control Profile (Public Fountain Users)

Items	Access		Control		Comments
	M	F	M	F	
Resources					
Piped water resources	y	y	n	n	
Money for water, soap etc.	y	y	y	n	Money shared, not willing to discuss mechanism
Labor for latrines	y	y	y	n	
Land for latrines	n	n	n	n	
Benefits					
Time savings	n	y	n	y	Also including girls
Improved health	y	y	y	y	All will benefit

y = Yes, n = No

Bati – Access and Control of Resources/Benefits (Private Connection Users)

Items	Access		Control		Comments
	M	F	M	F	
Resources					
Piped water resources	y	y	y	y	24 hour running water
Money	y	y	y	n	Money shared, not willing to discuss mechanism
Labor for latrines	n	n	n	n	Paid labor
Land for latrines	y	y	y	n	Not all PC users own land
Benefits					
Improved health	-	-	-	-	May indirectly improve

y = Yes, n = No

Bati – Needs Analysis (Public Fountain Users)

Items	Gender		Comments
	Male	Female	
Practical needs			
Water - less queuing	n	y	
- some additional PFs	n	y	
- community shower facility	y	y	Not identified by all groups
Health - bilharzia reduction	y	y	
- malaria reduction	y	y	
- cheaper medicines	y	y	
Sanitation			
-pit emptying system	y	y	Particularly for existing latrines
-public/community latrines	y	y	Some people do not want them near their homes. The latrines must need water and must be segregated by sex
-prefer household not community latrines	y	y	Land not owned or available
-improved drainage	y	y	
Strategic needs			
Water - to be controlled by the government	y	y	
Sanitation - community managed latrines/showers	y	y	Priority need, but only with a valid pit emptying system

y = Yes, n = No

Bati – Needs Analysis (Public Fountain and Spring Users)

Items	Gender		Comments
	Male	Female	
Practical needs			
Water - less queuing	n	y	
- less distance	n	y	
- PFs quality for drinking	y	y	PF water preferred for drinking, better taste
Health - bilharzia reduction	y	y	Major problem in the town
Sanitation			
-privacy between men and women	y	y	
-public/community latrines	y	y	Must have pit emptying system
-segregation for male/female	y	y	+ non water-flush
-community shower facilities	y	y	Lower priority than for improved water supply
Strategic needs			
Water - government must manage the extra PF facilities	y	y	Except for Kersa who could manage the public fountain or hand pump themselves.
Sanitation - community latrines with pit emptying system-self managed	y	y	Need support from Kebele/municipality to enforce

y = Yes, n = No

Bati – Needs Analysis (Private Connection Users)

Items	Gender		Comments
	Male	Female	
Practical needs			
Water			Existing access to water OK
Health			
-require proper medication	y	y	
Sanitation			
-household latrines	y	y	Many use open field. Public latrines would be acceptable
-pit emptying system	y	y	
-segregation for male/female	y	y	
-community showers	y	y	Some have private showers
Strategic needs			
Sanitation			
-Public toilet in public places to be managed by the government	y	y	* Pit latrine preferred. Elder suggested bus stand
-Community latrines could be managed by the community-free of charge.	y	y	
-Public showers could also be community managed.	y	y	

Note : * Unless a vacuum truck can be utilized for Bati there will be resistance to any form of latrines – this will need to be overcome before implementing any sanitation programme in the town.
y = Yes, n = No

Bati – Social and Gender Considerations

Social/Gender Differences	Underlying Factors	Impact on the Project	Possible Measures to be Taken to Improve Situation
Richer people tend to have 24 hour access to safe water while poorer people use public fountains or springs, walking longer distances and waiting in queues	Richer people have private connections and public fountains have limited opening times	Middle income people will benefit most from any improvements in water supply facilities or operating service	Involve community in selection or public fountain locations. Invest in more government water sellers. Initiate income generation component for low/middle income households.
Very wealthy people have and use latrines Other people use open field sites	Only the very wealthy have the control of land to repeatedly build latrines or pay for the service or the suction truck from Desie	Resistance of all but the very wealthy to invest in latrine construction or to use existing latrines effectively	Incorporate a pit emptying system into the latrine programme Sort out existing problem of latrine emptying
Differences between Muslim and Christian and highland groups and Afar were not picked up adequately	Muslim highlanders very dominant in number and in positions of authority	Needs or the Christian and Afar communities may not be represented in this study	Make efforts to contact Christian and Afar leaders and communities to establish that their views and opinions are taken into consideration in project planning and implementation
Some groups willing to manage additional public fountains	Accute water access problem only evident in some areas	Community management not appropriate for whole water system	Support community management initiatives in areas of greatest need
High number of people demonstrating dependency syndrome	Previous relief aid programmes in famine periods encourage dependency among beneficiary groups	Certain unwillingness to take control of their own situation and initiate own solutions. This extends to a reluctance to adopt improved hygiene/sanitation practices promoted by health staff	Use respected community leaders and groups to stimulate interest in self help initiatives, including changing hygiene/sanitation behaviors.

Appendix - 4

Summary of Group Meeting

BATI - Summary of group meetings

Group 1 details	Group characteristics	Group needs
General	Mixture of Amhara and Oromo, Daily labourers	1-Public Fountain
Water	Spring users and public fountain users. Long queues at public fountain. Used to be another public fountain nearer to them but this was closed down.	Re-opening of public fountain. Government should manage it and be responsible for it.
Sanitation	All practice open field defecation. None have latrines.	N/A
Health	N/A	N/A

Group 2 details	Group characteristics	Group needs
General	Mixture of Amhara and Oromo, Daily labourers	1-Re-opening of former public fountain
Water	Private connection vendor users, public fountain and private connection users. Long queues at public fountain. Used to be a public fountain close to them but this was closed down.	Re-opening of public fountain. Government should manage it and be responsible for it.
Sanitation	Most practice open field defecation although some have latrines.	N/A
Health	N/A	N/A

Group 3 details	Group characteristics	Group needs
General	20 women highlanders and 5 Afar men, Kebele 01, Petty traders	1-Increased income /employment, 2-Food, 3- Oil,
Water	Majority use PFs which takes between 15 mins and 2 hours (10c/60l). Others have PCs. PF users (women) go to river to do laundry once a week. Afar use water in Mosque area. Some buy water from vendors (20c/30l).	Some would like PCs but most would like additional PFs with longer service time. Not prepared to undertake community management of additional PFs. Not prepared to pay more for improved water supply service
Sanitation	Most practice open defecation. Children's excreta is disposed of in open field by women. Latrines are problematic in Bati having bad smell and poor maintenance. No room for latrines, even communal ones. Rubbish disposed of in open field sites.	Some people mentioned a problem of poor sanitation conditions near to dwellings and identified a need for Authorities to enforce some measures of control on areas of open waste disposal
Health	Common diseases include coughs, vomiting and diarrhoea for children. Malaria is seasonally a problem. Health education given at clinics mainly on child care. Quality of HEd is good, but medicines are too expensive.	No other health needs identified

BATI - Summary of group meetings (Continued)

Group 4	Group characteristics	Group needs
General	Mixed Oromo and Amhara, Mixed religions, 15 women, 3 men, Kebele 03, Traders and food preparation and selling	1-Improved health/free medicines, 2-Latrine improvement programme, 3-Food distribution
Water	Mostly PF users and some PC and PC Vendor users. PF users do laundry at river (women). Water at PFs only available in mornings (10c/3 pots). When water supply not working, use spring water but this does not happen often	Would like additional public fountains, but not prepared to pay more for water and require Government management of these facilities.
Sanitation	Most practice open defecation, women go to same place but at different times. 3/18 have latrines. All live in rented housing and have no control over land for latrine building.	Vacant sites are available for community latrines, and would be able to manage them and provide labour for construction. Would pay to use public showers if they were available.
Health	Common diseases include TB, Bilharzia	No health improvements identified

Group 5 details	Group characteristics	Group needs
General	Mixed ethnic groups no Afar, Small business people	N/A
Water	Public fountain and private connection users. Laundry done at river.	N/A
Sanitation	N/A	N/A
Health	N/A	N/A

Group 6 details	Group characteristics	Group needs
General	Mixed ethnicity (no Afar), Beggars and Wood collectors/ sellers	N/A
Water	PF Users. Laundry done at river by women. Money for water no problem(!?)	N/A
Sanitation	All practice open defecation	N/A
Health	N/A	N/A

BATI - Summary of group meetings (Continued)

Group 7 details	Group characteristics	Group needs
General (Area known as Kersa)	Mixed ethnicity, Mostly Christians, 9 women, 10 men, some children, Kebele 03, Government workers and teachers	1-Water, 2-Health/medicines
Water	Spring water used for drinking and river used for laundry and bathing. Women fetch water with children. women and single men do laundry. Obtaining spring water very difficult in wet season. Handpump in area not working	Would like piped water supply with PF (community managed) and PCs, or if not possible to have handpump repaired and training in order to manage and maintain it themselves. Would help with labour to construct the PF.
Sanitation	Most practice open defecation, women go under cover of darkness to same sites. Rubbish disposal is also open field.	Would like community latrines and could manage them and assist with labour for construction. Would share latrines by sex. Not interested in public shower.
Health	Common diseases include Bilharzia and Malaria. Fully aware that poor water and sanitation causes diarrhoea and ill-health. Health education only available to the sick at the clinic.	Interested in knowing more about health

Group 8 details	Group characteristics	Group needs
General	Mostly Muslims, Mixed ethnicity (no Afar) Government employees and small business proprietors	1-Latrine
Water	Public fountain and private connection vendor users. A few have private connections (2 in 15). Sometimes laundry is done at the river side.	N/A
Sanitation	N/A	N/A
Health	N/A	N/A

BATI - Summary of group meetings (Continued)

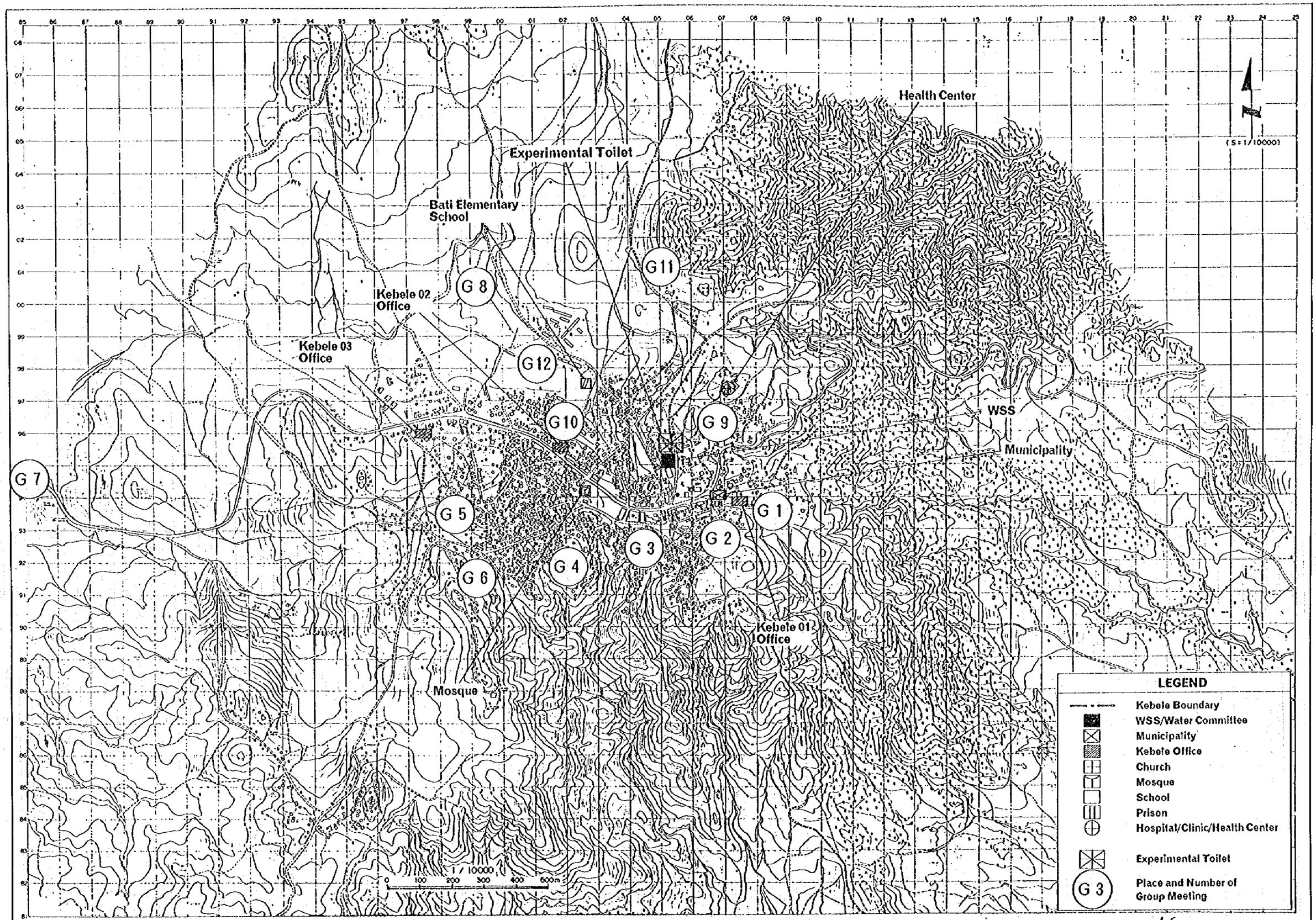
Group 9 details	Group characteristics	Group needs
General (Behind Shell station)	Mixed ethnicity, Mixed religions, 10 women, 3 men, some children, Kebele 02, Petty traders	1-Latrine, 2-Food, 3-Water
Water	Public Fountain users, but PF not open long enough for demand so supply supplemented with spring water and laundry done at river (women). Used to be a PF nearer to them but it was closed down. Sometimes buy water from vendors (25c/30l).	Would like PF opened in their area and can not afford PCs. Could operate PF themselves, but not sure if they could pay for repairs so best for Government to manage.
Sanitation	All practice open field defecation, all must go under cover of darkness. Children's excreta is cleared and thrown in open a little further from the homes. No problem of handling composted excreta but there is a problem with suction truck for emptying.	Would like community latrine with 4-5 cubicles shared by sex. Government land is available for building latrines and could manage themselves. Need water for cleaning purposes but not pour flush latrines. Willing to provide labour for construction.
Health	Common diseases include Bilharzia. Some have awareness of the link between poor water/sanitation and diseases.	No other health needs identified.

Group 10 details	Group characteristics	Group needs
General	Mixed ethnicity but no Afar, Petty traders	1-Latrine
Water	Public fountain and private connection users. Laundry done at river.	N/A
Sanitation	N/A	N/A
Health	N/A	N/A

BATI - Summary of group meetings (Continued)

Group 11 details	Group characteristics	Group needs
General (Ghedi Area)	Mixed ethnicity, Mostly Muslims, 10 women, 10 men, some children, Daily labourers, petty food traders	1-Food, 2-Free medicines,
Water	Public fountain and Private connection users. New PF recently opened in area, but not reliably opened yet. Other PFs are some distance away and supplement with river. PCs only get water at night.	Would like PF to be opened each day for two hour and PCs to function 24 hours each day.
Sanitation	Some have private household latrines, others use open field sites for defecation. Women go to the same sites under cover of darkness. No land available for latrine building as many in rented housing.	Would like some community latrines for those in rented housing. Can help with labour for construction and with management.
Health	Common diseases include TB, Gastritis, Malaria and Pneumonia. Health service and medicines used to be free, but now must be paid for. Health education has not been received	Would like some health education but are not sure that they would be able to afford to make required changes.

Group 12 details	Group characteristics	Group needs
General	Mixed ethnicity but no Afar, Petty traders and daily labourers	1-Latrine
Water	Private connection and public fountain users. Laundry is done at the river.	N/A
Sanitation	N/A	N/A
Health	N/A	N/A


Health Center
Experimental Toilet
Bati Elementary School
Kebele 02 Office
Kebele 03 Office
G 8
G 11
G 12
G 10
G 9
G 7
G 5
G 1
G 2
G 3
G 4
G 6
WSS
Municipality
Kebele 01 Office
Mosque
(S=1/10000)
1/10000
0 100 200 300 400 600m
LEGEND
Kebele Boundary
WSS/Water Committee
Municipality
Kebele Office
Church
Mosque
School
Prison
Hospital/Clinic/Health Center
Experimental Toilet
G 3
Place and Number of Group Meeting

BATI

Appendix - 5

Financial and Socio-Economic Data

Table 1 (1) Summary of Financial Aspects of WSS in Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
1. Population	14,737	3,902	14,354	21,845	11,718	25,575
2. Water production & consumption in 1993/1994 (m3)	n.a. 35,565e	n.a. 29,232e	113,523 90,218	58,318 46,104	11,303e 10,173e	11,930 9,773
*Water consumption/ population/day (l)	6.6e	20.5e	17.2	5.8	2.4e	1.0
*Leakage ratio (%)	n.a.	n.a.	20.5	20.9	10.0e	18.1
3. Income & Expenditure in 1993/1994 (birr)	51,267 60,188	48,818 38,182	131,144 132,245	64,648 53,304	50,863e 22,560e	31,337 78,328
*Bill collection rate (%)	85.7	79.1	94.4	99.9	–	67.8
*Income/consumption (birr/m3)	1.44e	1.67e	1.45	1.40	5.00e	3.21
*Expenditure/production (birr/m3)	n.a.	n.a.	1.16	0.91	2.00e	6.57
*Income/Expenditure (%)	85.2	127.9	99.2	121.3	225.5e	40.0
4. No. of personnel, female, temporary/contract	10 1 10	11 5 11	25 5 8	18 4 0	13 4 8	18 5 0
*Production/worker (m3)	n.a.	n.a.	4,541	3,240	3,478e	663
*Income/worker (birr)	5,126	4,438	5,246	3,592	3,913e	1,741
*Expenditure/ worker (birr)	6,019	3,471	5,290	2,961	1,735e	4,352
5. Average monthly salaries (birr)	129	96	204	217	70	173
6. No. of house/ yard connections, public fountains, hydrants	190(70) 8(2) 1	89 8(5) 1	852 12	396 7(6)	– 5(3)	320 13(2)

Notes: 1. e = estimates or assumptions 2. n.a.= not available
3. parenthesized figure = functional

Table 1 (2) Summary of Financial Aspects of WSS in Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
1. Population	13,726	26,823	14,742	14,629	10,250
2. Water production & consumption in 1993/1994 (m3)	42,216 31,206	74,219 55,045	66,278 55,008	17,810 15,826	46,409 41,201
*Water consumption/ population/day (l)	6.2	5.6	10.2	3.0	11.0
*Leakage ratio (%)	26.1	25.8	17.0	11.1	11.6
3. Income & Expenditure in 1993/1994 (birr)	56,457 79,567	68,590 72,172	66,791 102,309	34,679 71,591	62,089 67,846
*Bill collection rate (%)	91.7	85.8	98.2	96.8	89.0
*Income/consumption (birr/m3)	1.81	1.25	1.21	2.19	1.51
*Expenditure/production (birr/m3)	1.88	0.97	1.54	4.02	1.46
*Income/Expenditure (%)	71.0	95.0	65.3	48.4	91.5
4. No. of personnel, female, temporary/contract	19 5 1	17 6 2	22 7 0	20 6 2	17 3 0
*Production/worker (m3)	2,222	4,366	3,013	891	2,745
*Income/worker (birr)	2,971	4,035	3,035	1,735	3,652
*Expenditure/ worker (birr)	4,188	4,245	4,650	3,580	3,991
5. Average monthly salaries (birr)	153	143	241	170	211
6. No. of house/ yard connections, public fountains, hydrants	383 14(13)	327 12	478 13(12)	238 7	390 7

Notes: 1. e = estimates or assumptions 2. n.a. = not available
3. parenthesized figure = functional

Table 2 (1) Financial Condition of Water Supply Service in Bati

1. Official Water Price: 1 birr/m3 for all clients

2. Production and Consumption of Water, 1993/94

1) Production : 113,523.00 m3

2) Consumption: 90,217.50 m3

* Daily water consumption as divided by total population = 17.2 litre

* Leakage ratio = 20.5%

3. Income and Expenditure

1) Income : 131,144.15 birr

Major sources of income

(1) Measured water sales	74,222.00 birr	(56.6%)
(2) Service charge	25,011.38 birr	(19.1%)
(3) Cash water sales	15,500.50 birr	(11.8%)
(4) Meter rent	9,263.00 birr	(7.1%)

* Bill collection rate = 94.4%

* Income per unit consumption of water = 1.45 birr/m3

2) Expenditure: 132,245.21 birr

Major items of expenditure

(1) Salaries	61,149.56 birr	(46.2%)
(2) Electricity	26,760.00 birr	(20.2%)
(3) Pipes and fittings	6,643.74 birr	(5.0%)
(4) Buildings and improvement	6,221.15 birr	(4.7%)

* Expenditure per unit production of water: 1.16 birr/m3

* Income-expenditure ratio: 99.2%

4. Organization and Personnel

1) No. of personnel: 25 (5) [8]

(1) Head, WSS	1
(2) Customers' service	1

Table 2 (2) Financial Condition of Water Supply Service in Bati

(3) Administration 1 administrator, 1 store keeper, 6 [5] guards, 1 clerk	9 [5]
(4) Finance 1 (1) cashier, 1 (1) bill collector, 1 meter reader, 6 (3) [2] water sellers	9 (5) [2]
(5) Urban water supply & sewerage 1 assistant technician, 3 plumbers, 1 [1] motor operator	5 [1]

Note: Parenthesized and bracketed figures denote the number of female and contract workers respectively.

* Production per worker = 4,541 m3/year

* Income and expenditure per worker = 5,246 birr, 5,290 birr/year

2) Average monthly salaries of employees: 204 birr

5. No. of Distribution Facilities

1) Yard connections : 852

(1) Household	: 751
(2) Governmental & public	: 24
(3) Commercial	: 77

2) Public fountains : 12 (all functional)

3) Hydrant : 1

6. Problems and Bottlenecks

1) Old reservoir with limited capacity.
2) Shortage of pumps. Additional vertical pumps are needed.
3) Limited capacity of the collection chamber.
4) Distribution lines are not only old, but also do not cover all the town.
5) Shortage of trained (technical) manpower.
6) Lack of vehicles.
7) Shortage of water meters.
8) Shortage of pipes and fittings.
9) Lack of tool kits.

Table 3 (1) Summary of Socio-Economic Aspects of Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
I. Administrative Conditions						
1. No. of gov't employees	500e	336	366	322	412	1,674
*No. of gov't employees/1,000 population	34	86	25	15	35	65
2. Average salaries of gov't employees (birr)	311	311	355	308	391	397
II. Population						
1. Population	14,737	3,902	14,354	21,845	11,718	25,575
2. Ethinic composition for top two (%) [Amh.=Amhara, Afa.=Afar, Oro.=Oromo, Tig.=Tigre, Kim.=Kimant, Age.=Agew]	Amh.84 Afa. 6	Amh.69 Oro.14	Amh.49 Oro.28	Amh.97 Tig. 3	Amh.73 Kim.20	Amh.100
3. Religious composition, Christians & Moslems (%)	42 58	43 57	12 88	80 19	81 19	95 5
4. Family size	4.5	4.6	6.2	6.3	5.5	5.7
5. Area (ha)	1,600e	68	260	640	322	1,402
*Population density (persons/ha)	9.2e	57.4	55.2	34.1	36.4	18.2
III. Educational Conditions						
1. No. of pupils/students	3,182	457	2,500	3,817	3,944	7,950
*No. of pupils/students per 100 population	22	12	17	17	34	31
2. Literacy ratio (%)	70	62	48	63	80e	74
3. Primary school enrollment ratio (%)	62	53	53	57	85e	75
IV. Medical Conditions						
1. No. of medical personnel	36	4	22	9	18	81

Table 3 (2) Summary of Socio-Economic Aspects of Eleven Centers

Item	Dupti	Mille	Bati	Werota	Aykel	Debre Tabor
*No. of medical personnel per 1,000 population	2.4	1.0	1.5	0.4	1.5	3.2
2. No. of cases for top ten diseases	14,943	1,611	11,642	18,084	13,683	21,318
*Estimated No. of cases per year as percentage of population (%)	30.4	12.4	24.3	24.8	35.0	25.0
3. Under 5 mortality rate (/1000)[n.a.=not available]	213	154	163	95	n.a.	73
4. Life expectancy (years)	47	53	52	61	55e	64
5. Households using septic tank / pit latrine (%)	86	45	68	61	39	65
V. Economic Conditions						
1. No. of commercial/industrial establishments [parenthesized figures=No. of hotels/restaurants]	1,105 (331)	204 (162)	243 (68)	812 (201)	450 (115)	1,672 (574)
*No. of establishments per 1,000 population	75 (22)	52 (42)	17 (5)	37 (9)	38 (10)	65 (22)
2. Monthly household income (birr)	334	223	306	262	182	248

Note: e=estimates

Table 3 (3) Summary of Socio-Economic Aspects of Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
I. Administrative Conditions					
1. No. of gov't employees	541	727	845	499	378
*No. of gov't employees/1,000 population	39	27	57	57	37
2. Average salaries of gov't employees (birr)	297	368	292	374	407
II. Population					
1. Population	13,726	26,823	14,742	14,629	10,250
2. Ethinic composition for top two (%) [Amh.=Amhara, Afa.=Afar, Oro.=Oromo, Tig.=Tigre, Kim.=Kimant, Age.=Agew]	Amh.100	Amh.74 Age.19	Amh.94 Age. 4	Amh.99 Oro. 1	Amh.99 Tig. 1
3. Religious composition, Christians & Moslems (%)	94 6	44 56	92 7	67 33	65 35
4. Family size	5.9	6.1	6.8	6.2	6.8
5. Area (ha)	648	920	1,280	200	280
*Population density (persons/ha)	21.2	29.2	11.5	73.1	36.6
III. Educational Conditions					
1. No. of pupils/students	3,743	5,339	4,388	3,465	2,661
*No. of pupils/students per 100 population	27	20	30	24	26
2. Literacy ratio (%)	70	74	61	69	61
3. Primary school enrollment ratio (%)	59	77	69	68	64
IV. Medical Conditions					
1. No. of medical personnel	43	25	22	27	5

Table 3 (4) Summary of Socio-Economic Aspects of Eleven Centers

Item	Nefas Mewcha	Chagni	Bure	Bichena	Dejen
*No. of medical personnel per 1,000 population	3.1	0.9	1.5	1.8	0.5
2. No. of cases for top ten diseases	22,002	11,782	15,112	7,441	3,790
*Estimated No. of cases per year as percentage of population (%)	48.1	13.2	30.7	15.3	11.1
3. Under 5 mortality rate (/1000)[n.a.=not available]	196	144	131	173	155
4. Life expectancy (years)	49	54	56	52	53
5. Households using septic tank / pit latrine (%)	58	61	58	45	54
V. Economic Conditions					
1. No. of commercial/industrial establishments	860 (209)	546 (91)	246 (65)	414 (47)	345 (74)
[parenthesized figures=No. of hotels/restaurants]					
*No. of establishments per 1,000 population	63 (15)	20 (3)	17 (4)	28 (3)	34 (7)
2. Monthly household income (birr)	202	203	253	324	312

Note: e=estimates

Table 4 (1) Socio-Economic Condition of Bati

I. Administrative Conditions

1. Administrative Classification: Region 3, Zone = Oromia

2. Government Organizations
1) Agricultural Bureau
2) Natural Resources Development and Environmental Protection (NRDEP)
3) Weroda Administration
4) Ethiopian Electric Light and Power Authority (EELPA)
5) Financial Bureau
6) Educational Bureau
7) Municipality
8) Health Center
9) Customs Office
10) Meteorological Service
11) Relief and Rehabilitation Commission (RRC)
12) Police
13) Post Office
14) Telecommunications
15) Weroda Court
16) Weroda Attorney
17) Water Supply Service (WSS)

Notes: 1. Schools are not included in the above organizations.
2. There is no NGO.

3. No. of Government Employees and Their Average Monthly Salaries: 366, 355 birr

* No. of government employees per 1,000 population: 25

4. No. of Kebele: 3

II. Socio-Economic Conditions

1. Population
1) Total population: 14,354

2) Ethnic composition: Amhara (49.0%), Oromo (27.7%), Afar (12.5%), Tigre (4.5%), Others (6.3%)

3) Religious composition: Christians (12%), Moslems (88%)

4) Average family size: 6.2 persons

Table 4 (2) Socio-Economic Condition of Bati

2. Area: 260 ha * Population density: 55.2 persons/ha

3. Educational Conditions
1) No. of schools, class rooms, teachers and pupils/students

Items	Kinder-garten	Elementary School	Junior and Senior High School
(1) No. of schools	1	1	1
(2) No. of class rooms	15	30	25
(3) No. of teachers	2	44	24
(4) No. of pupils/students	n.a.	1,500	1,000

Notes: 1. n.a. = not available
2. The kindergarten is not yet functional.

* No. of pupils/students per 100 population: 17

2) Literacy ratio: 48% (1984)

3) Primary school enrollment ratio: 53% (1984)

4. Medical Conditions
1) No. of medical institutions/establishments:
1 Health Center, 1 District Health Management, 3 private drug stores

2) No. of medical personnel (Health Center):
2 doctors, 8 nurses, 9 health assistants, 2 laboratory technicians and 1 pharmacy technicians ... 22 in total

3) Incidence of diseases (Health Center, Jul. 1993 - Jun. 1994)
(1) Top ten diseases

i.	Inflammatory diseases of the eyes	1,879 cases
ii.	Infection of the skin and subcutaneous tissue	1,462
iii.	Otitis media and mastoditis	1,372
iv.	Other diseases of digestive system	1,213
v.	Influenza	1,176
vi.	Pneumonia	1,076
vii.	Intestinal parasite	941
viii.	Bronchitis	917
ix.	Malaria	853
x.	Gastritis	754

i. to x. = 11,642

Table 4 (3) Socio-Economic Condition of Bati

(2) Estimated number of cases per year as percentage of population: (11,642 x 1.5) / (14,354 x 5) = 24.3%

Notes: 1.5 = coefficient to estimate the total number of cases,
5 = coefficient to estimate covered population

4) Under 5 mortality rate: 163/1000 (1984)

5) Life expectancy: 52 years (1984)

6) Households more or less using septic tank and pit latrine: 68%

5. No. of Holy Places: 1 church, 4 mosques

6. Economic Conditions

1) No. of commercial and industrial establishments

Classification	Annual Income (birr)			
	< 1,000	1,000 - 3,000	3,000 <	Total
1. Hotels & restaurants				
Hotels	0	3	0	3
Restaurants	11	5	0	16
Bars	8	8	4	20
Snacks	5	1	1	7
Tej houses	14	2	0	16
Beverage groceries	4	2	0	6
Sub-total	42	21	5	68
2. Shops	79	54	30	163
3. Cottage industry (grain mills)	0	0	12	12
Total	121	75	47	243

* No. of commercial and industrial establishments per 1,000 population: 17

2) Major occupations
(1) Retail trade
(2) Government employees

Table 4 (4) Socio-Economic Condition of Bati

(3) Agriculture (farming and animal husbandry)
(4) Day laborers

3) Market
(1) Major marketable items:
grains, animals, clothes and daily household items (vegetables, fruit, candy, butter, salt, etc.)

(2) Prices of some of major marketable items

Grains (unit: birr/100 kg) millet: 200, tef: 260

Livestock (unit: birr/head)

ox	cow	camel	sheep	goat	donkey
700	500	900	60	80	250

(3) Market day - Monday (60,000 people gather.)

4) Average monthly household income: 306 birr

Sources: Water Supply Service, Weroda Administration, Financial Bureau, Educational Bureau and Health Center in Bati; Socio-Economic Sampling Questionnaire Survey by JICA; Central Statistical Authority

Appendix - 6

Result of Initial Environmental Examination

Project Description on Initial Environmental Examination in Bati

Items	Description
Project Title	Eleven Centers Water Supply and Sanitation
Background	1. Insufficient water supply and low per-capita-consumption due mainly to high population growth , aged facilities and poor O&M. 2. Poor sanitation prevailing the Project site which could contaminate the water source(s).
Objectives	To supply domestic water which meets people's demand and to improve sanitary condition.
Location	Bati, Region-3
Executing Agency	Water Supply and Sewerage Service Department Ministry of Water Resource
Beneficiaries	About 14,400 of the population to be benefited.
Dimensions of the Plan	Rehabilitation of existing facilities, and new boreholes, reservoir and distribution network.
Type of Work	Rehabilitation and new construction work
Purpose	1. To provide domestic water and improve sanitation facilities. 2. To initiate people's awareness on water use and sanitation.
Water Resource	Groundwater, There are minor springs but not to be considered in this Project.
Water Quality	Chemical aspects are within WHO guideline values Biological contamination is notified.
Main Facilities	Boreholes with pumping system.
Water Storage Facilities	Reservoir (ground tank type)
Filtration Plant	Not to be considered.
Related facilities	Distribution pipes, public fountains, drainage system and latrines
Remarks	Chlorine or its derivatives such as mainly calcium hypochlorite is used for disinfection in Ethiopia.

Site Description on Initial Environmental Examination in Bati

Items	Description
Project Title	Eleven Centers Water Supply and Sanitation
Social Environment	
Residents (population, tribe, consciousness)	Population about 14,400, majority Amhara with about 30% of Oromo.
Facilities related to life (electricity, etc.)	The electricity is hydro-powered and supplied for 24 hours.
Health and Sanitation (diseases, clinic, etc.)	0 hospital, 1 health center, 1 district health management, 3 drug stores
Natural Environment	
Topography, Geology and Hydrogeology	Located on the Rift escarpment. Ashangi basalt is the major structure of the area. Groundwater exists in weathered basalt or fault.
Meteo-hydrology Groundwater/spring/river	Annual rainfall about 880mm, 2 springs near the town with 0.05 and 0.1 l/s of their yield. Existing borehole yield ranges 2.8 to 3.3 l/s.
Endangered fauna and flora	Nil
Public Nuisance	
Nuisances	Water supply condition is relatively good, supported by 4 boreholes. During rainy season, stagnant water appear and remain behind Kebele 2 office.
Regulations and Compensation	Although the land is officially owned by the state, those who lose their dwelling and commercial area because of the project will be given substitute land. Also, Compensation will be made for properties such as houses and trees, which will be damaged.
Remarks	There is tendency of dependent, which could be major hurdle in terms of motivating the population.

Scoping Format for Initial Environmental Examination in Bati

Environmental Components	Classi-fication	Description
1.Social Environment		
1.1 Resettlement	B	The facilities are small and expected to give no resettlement.
1.2 Economic Activities	D	The economic activities will be enhanced by the water supply and sanitation improvement.
1.3 Facilities	B	The construction work and the facilities have little impact on existing facilities such as schools and hospitals.
1.4 Collapse of Communities	B	Nil. If a water users committee was organized by the community itself to look after the facilities especially public fountains, the community would be enhanced
1.5 Archaeological and Cultural Heritage	B	Nil
1.6 Vested Rights	C	Compensation shall be given for land and properties if these were affected by the Project. Water vendors may lose their income source by the newly supplied water.
1.7 Public Health and Hygienic Condition	D/C	Sanitary improvement will enhance the condition. Drainage system must be accompanied with the improvement of water supply.
1.8 Waste Disposal	B	During construction works, there will be little waste disposal from the view of the small construction scale. After commissionning, no waste disposal is expected.
1.9 Accidental Damages to Facilities	C	Consideration be paid to the alignment of pipelines in order to avoid public nuisance to dwellers.
2. Natural Environment		
2.1 Geographic and Geological Condition	B	No effect is expected to geographic and geological condition.
2.2 Soil Erosion	C	The earth work gives little soil erosion, judging from the construction scale.

Note) A; Advance Impact, B; Negligible Impact C; Unknown Impact D; Enhancement

to be continued.....

2.3 Surface Water Quality and Quantity	B	Nil
2.4 Groundwater Quality and Quantity	C	Effect of overpumping be considered.
2.5 Hydrological Situation	B	No effect is expected to hydrological situation.
2.6 Terrestrial Fauna	B	Nil
2.7 Aquatic Fauna	B	Nil
2.8 Vegetation	B	Little effect is expected to vegetation.
2.9 Climatic Conditions	B	No effect is expected to climatic conditions.
2.10 Aesthetic Condition	B	The facilities would give little change to the condition judging from the size.
3. Public Nuisance		
3.1 Air Pollution	B	Nil
3.2 Water Pollution	B	Nil
3.3 Soil Pollution	B	Nil
3.4 Noise and Vibration	B	The construction works do not give rise to noticeable noise and vibration.
3.5 Land Subsidence	B	The location of new boreholes is designed away from the dwelling area. The land is composed of basalt lava, giving little expectation of land subsidence.
3.6 Odour	B	Nil
3.7 Traffic Nuisance	C	In case of pipeline being laid across road the traffic will be interrupted.

Note) A; Advance Impact, B; Negligible Impact C; Unknown Impact D; Enhancement

Appendix - 7

Project Cost Break-Down (Water Supply)

Summary of Cost Estimation of Water Supply in Bati

No.	Description	F.C.(B)	L.C.(B)	Total(B)
I.	Target year of 2005			
1	Civil Work			
	Mobilization and Demobilization	120,000	200,000	320,000
	Excavation and Earth-work	6,220	20,100	26,320
	Trench excavation	203,940	454,980	658,920
	Pipe-work	198,240	198,240	396,480
	Reservoir	216,000	216,000	432,000
	Pumping station, R.C.pump house	88,032	58,656	146,688
	Access road	178,000	414,000	592,000
	Bore-hole (200mm casing)	196,480	294,720	491,200
	Water purifiction unit	10,000	15,000	25,000
	Booster pump and necessary works	240,000	400,000	640,000
	Electric submersible pump and necessary works	140,000	210,000	350,000
	Power supply	35,850	38,775	74,625
	Concrete work	67,980	120,880	188,860
	Masonsy work	6,000	24,500	30,500
	Structure	108,600	253,420	362,020
	Temporary work(10% of civil work)	181,534	291,927	473,461
	Total of civil work	1,996,876	3,211,198	5,208,074
2	Material & Equipment	7,030,182	492,112	7,522,294
	Sub Total	9,027,058	3,703,310	12,730,368
3	Engineering cost(12% of sub tatal)	1,527,644		1,527,644
4	Contingency(5% of total cost)	527,735	185,166	712,901
	Grand Total-I(birr)	11,082,437	3,888,476	14,970,913
	Grand Total-I(Yen:1birr=15yen)			224,564,000
5	Biuilding		1,225,795	1,225,795
6	WSSD's management cost		323,934	323,934
	Total		1,549,729	1,549,729
7	Prise escalation 6%	664,946	326,292	991,238
	Grand Total	11,747,383	5,764,497	17,511,880
II.	Target year of 2010			
1	Morbilization and demorbilization			1,000,000
2	Rising line			600,000
3	Distribution network			630,000
4	New borehole with pump & materiale			659,000
5				0
6	Booster pump with house			534,000
7	Power supply facilities			170,000
8	Chamber and structures			162,000
9	Buildings			562,200
10	Others			1,838,000
	Sub total			6,155,200
11	Engineering cost (10%)			615,520
12	Contingency (10%)			677,072
	Total-II			7,448,000
13	Prise escalation(42%)			3,128,000
	Grand Total			10,576,000

Cost Estimation of Construction & Materials/Equipment of Bati : Target year of 2005

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
1.	Mobilization and Demobilization	LS				120,000	200,000	
2.	Excavation and Earth-work							
2-1	Clearing and grubbing the site	ha	4	480	2,400	1,920	9,600	to remove bushes, small forest and trees
2-2	Clear off the site	sqm	500	1	4	500	2,000	to remove top soil to an average depth of 20cm
2-3	Bulk excavation							
	a) Earth excavation	cum	100	6	14	600	1,400	
	b) Excavation of weathered rock	cum	100	10	20	1,000	2,000	
	c) Soft rock excavation	cum	50	14	32	700	1,600	
	d) Sound rock excavation	cum	50	30	70	1,500	3,500	
3.	Trench excavation							
3-1	Trench excavation for water pipe							
	1) Single pipe in trench							
	a) 0.6~1.0m depth	m	12,800	4	8	51,200	102,400	
	b) 1.0~1.5m depth	m	4,910	7	17	34,370	83,470	
3-2	Trench, Rock excavation	cum	50	30	70	1,500	3,500	
3-3	Back-fill with the same material	m	10,630	5	11	53,150	116,930	
3-4	Selected soil bedding	m	7,080	2	5	14,160	35,400	150mm thick below barrel
3-5	Back-fill with selected material	m	7,080	7	16	49,560	113,280	compacted in layers not more than 20cm thick
4.	Pipe-work							
4-1	Presure pipe NP 10							with push-in flexible joints
	1) PVC pipe							
	a) DN 50mm	m	6,970	5	5	34,850	34,850	
	b) DN 75mm	m	5,830	8	8	46,640	46,640	
	c) DN 100mm	m	3,160	10	10	31,600	31,600	
	d) DN 150mm	m	2,430	17	17	41,310	41,310	
4-2	Pressure steal pipe							fitting and supports for bridge and road
	DN 200mm	m	320	137	137	43,840	43,840	
5.	Reservoir							
5-1	Ground level reservoir	m3	240	900	900	216,000	216,000	
6.	Pumping station, R.C.pump house	sqm	48	1,834	1,222	88,032	58,656	with accessaries
7.	Access road	m	2,000	89	207	178,000	414,000	3m wide gravel road with draine ditch

Cost Estimation of Construction & Materials/Equipment of Bati : Target year of 2005

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
8.	Bore-hole (200mm casing)							
8-1	New drilling 4wells	m	414	320	480	132,480	198,720	including, casing, packing and pumping test
8-2	Rehabiritation 4wells	set	4	16,000	24,000	64,000	96,000	
9.	Water purifiction unit	No.	1	10,000	15,000	10,000	15,000	
10.	Booster pump	No.	4	60,000	100,000	240,000	400,000	foundation, pump, and motor with accessories
11.	Electric submersible pump	No.	7	20,000	30,000	140,000	210,000	foundation, and pump with accessories
12.	Power supply							
12-1	Generating set	No.	1	5,850	8,775	5,850	8,775	gererater with accessaries
12-2	High tension line	m	2,000	8	7	16,000	14,000	
12-3	Low tension line	m	1,000	6	4	6,000	4,000	
12-4	Trensformer	No.	2	4,000	6,000	8,000	12,000	transformer with accessaries
13.	Concrete work							
13-1	Normal concrete (250kg of cement per cum)	cum	100	250	500	25,000	50,000	including form-work, vibration and curing
13-2	Reinforced concrete (360kg of cement per cum)							including vibration and curing
	Water retaining structure	cum	100	275	642	27,500	64,200	
13-3	Form-work							including all necessary works
	Wall	sqm	40	37	87	1,480	3,480	
13-4	Reinforcement bars; Steel bars	kg	2,000	7	2	14,000	3,200	including cutting, bending and placing
14.	Masonsy work							
14-1	Roughly dressed 40cm thick stone elevation wall	sqm	100	60	245	6,000	24,500	up to 3m height
14-2	Brick work with mortor							
	25cm thick	sqm		23	92	0	0	
15.	Structure							
15-1	Construction of public fountains	No.	2	1,580	3,680	3,160	7,360	
15-2	Construction of hydrant	No.	10	230	540	2,300	5,400	
15-3	Construction of R.C.C. aeration chamber	No.	5	5,730	13,370	28,650	66,850	
15-4	Construction of R.C.C. chamber	No.	13	5,730	13,370	74,490	173,810	
	Sub-Total of Construction work					1,815,342	2,919,271	

No.	Description	Unit	Q'ty	Unit-Rate F.C.(B)	Unit-Rate L.C.(B)	Amount F.C.(B)	Amount L.C.(B)	Remarks
16.	Material & Equipment (Ref.table)							
16-1	CIF Cost at Addis Ababa					7,030,182		
16-2	Inland transportation cost						492,112	CIF cost x 7 %
	Sub-Total of Material & Equipment					7,030,182	492,112	
	Total					8,845,524	3,411,383	
17.	Building							
17-1	Office	sqm	100		1,910		191,000	
17-2	Workshop	sqm	105		1,624		170,520	
17-3	Store	sqm	175		1,337		233,975	
17-4	Residence	sqm	300		2,101		630,300	
	Total						1,225,795	

Imported Cost (Material & Equipment) of Bati :Target year of 2005

No.	Description	Unit	Q'ty	Unit Rate (B)	Amount (8)
1.	Pipe material				
	including joint and accessories				
1.1	PVC pipe NP-10				
	a) DN 50mm	m	7,320	15	109,800
	b) DN 75mm	m	6,120	30	183,600
	c) DN 100mm	m	3,480	40	139,200
	d) DN 150mm	m	2,550	80	204,000
1.2	Suspended pressure steel pipe				
	DN 200mm W/O gilt and screw	m	340	288	97,920
1.3	Fitting cost Total cost × 20%				146,904
2	Pumps (Pump with electric motor/accessories)				
2.1	Centrifugal pumps				
	a) Q= 0.1 m3/min H= 14m HP= 1.5kw	set	2	500,000	1,000,000
	b) Q= 0.72m3/min H= 80m HP= 30 kw	set	2	600,000	1,200,000
2.2	Submersible pumps with accessories				
	a) Q= 0.12m3/min H= 100m HP= 3 kw	set	4	130,000	520,000
	b) Q= 0.3m3/min H= 100m HP= 5.5kw	set	3	171,000	513,000
3	Power Supply(Materials&accessories)				
3.1	Power supply generating set				
	50 KVA	set	2	450,000	900,000
3.2	Tension line				
	a) High tension over head line 15KV	m	2,000	50	100,000
	b) Low tension over head line	m	1,000	28	28,000
3.3	Plate-form mounted transformer				
	Supply of transformer wiht acccessories				
	b) Transformer 70 KVA (H-Type)	set	2	60,000	120,000
4	Valve (Valve with accessories)				
4.1	Sluice valve				
	a) ϕ50	set	4	1,000	4,000
	b) ϕ75	set	2	1,300	2,600
	c) ϕ150	set	1	1,700	1,700
4.2	High speed air valve				
	ϕ50	set	5	7,000	35,000
4.3	Pressure reducing valve				
	b) ϕ75	set	1	7,000	7,000
	c) ϕ100	set	1	9,000	9,000
	d) ϕ150	set	2	10,000	20,000
4.4	Check valve				
	a) 250mm	set		25,000	0
	b) 150mm	set	1	15,000	15,000
5	Flow meter (Meter with accessories ϕ150)	set	1	60,000	60,000
6	Reservoir equipment	set	2	100,000	200,000
7	Well (Materials with accessories)				
7.1	Casing pipe FRP				
	DN 200	m	306	2,093	640,458
7.2	Screen FRP				
	DN 200	m	108	5,700	615,600
7.3	Riser pipe, stainless DN 65	m	430	180	77,400
8	Water purification unit	set	1	80,000	80,000
	Total				7,030,182

Investment Cost of Target Year 2010 in Bati

No.	Description	Unit	Q'ty	Unit Rate (B)	Amount (B)
1	Mobilization and demobilization	LS			1,000,000
2	Rising line	Km	2	300,000	600,000
3	Distribution network	Km	4	150,000	630,000
4	New borehole with pump & materiale	set	1	659,000	659,000
5					
6	Booster pump with house	Set	1	534,000	534,000
7	Power supply facilities	Site	1	170,000	170,000
8	Chamber and structures	Set	6	27,000	162,000
9	Buildings	M2	6	93,700	562,200
	Others	LS			1,838,000
	Sub total				6,155,200
11	Enginering cost (10%)				615,520
12	Contingency (10%)				677,072
	Total				7,447,792

Appendix - 8

Meteorological Data

Table 1 Monthly Precipitation

Station: Bati

Unit:mm

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1960	–	–	–	–	–	2.0	217.2	141.1	118.6	0.0	34.8	0.0	–
1961	–	99.9	126.9	122.3	10.0	68.9	–	–	–	–	–	–	–
1962	1.0	–	–	–	–	–	–	–	–	–	–	–	–
1963	–	–	–	–	–	15.3	229.1	201.0	41.6	–	–	–	–
1964	–	–	99.3	156.7	69.8	100.4	–	–	–	–	–	58.7	–
1965	52.4	0.0	–	0.0	0.0	2.0	290.1	330.3	74.1	–	40.7	0.0	–
1966	0.0	112.3	3.0	77.6	–	77.9	78.3	–	–	–	0.0	0.0	–
1967	0.0	0.0	56.5	132.0	54.6	20.0	210.0	224.0	62.0	42.0	129.0	–	–
1968	–	–	–	198.0	0.0	10.0	352.1	113.1	54.0	0.0	62.0	10.2	–
1969	269.0	0.0	73.4	80.0	70.0	0.0	182.0	–	10.0	–	–	0.0	–
1971	0.0	0.0	62.0	128.0	63.0	0.0	126.1	228.0	43.5	–	–	–	–
1974	–	–	–	–	–	–	–	81.5	147.9	0.0	–	–	–
1978	–	–	48.9	116.7	34.6	–	–	221.7	77.1	62.5	5.9	–	–
1980	–	–	–	–	22.0	–	199.6	–	–	–	–	–	–
1987	–	–	–	–	–	2.5	50.0	228.3	49.6	48.2	0.0	36.3	–
1988	9.3	32.4	5.0	71.5	10.4	19.6	362.2	223.9	129.9	19.5	0.0	13.4	897.1
1989	38.3	126.4	88.8	129.4	27.7	13.6	118.1	153.6	75.7	32.5	0.0	170.1	974.2
1990	57.1	258.4	20.9	68.5	22.9	0.0	160.6	94.1	83.6	3.0	0.0	0.0	769.1
1991	4.6	97.3	200.8	31.8	–	–	–	170.0	63.2	37.8	0.0	91.3	–
1992	90.2	47.0	21.3	29.3	13.6	9.9	145.6	315.4	152.9	37.9	0.4	72.3	935.8
1993	89.9	102.6	0.0	213.0	114.9	5.3	203.5	123.4	85.5	77.0	0.0	0.0	1015.1
1994	0.0	2.3	64.6	28.9	18.1	15.2	333.2	207.5	106.3	0.0	–	–	–

Note: - = not calculated due to missing data

Table 2 Long Term Monthly Mean Potential Evapotranspiration (PET)

Station: Bati

Unit: mm

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1st 10 days	36	36	38	37	38	42	43	47	48	47	48	52	
2nd 10 days	53	57	58	57	58	57	57	57	53	52	49	46	
3rd 10 days	45	42	43	45	45	42	41	38	36	36	35	35	
Total	134	135	139	139	141	141	141	142	137	135	132	133	1649

Table 3 Monthly Average Maximum Air Temperature

Station: Bati

unit: ℃

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1960	–	–	–	–	–	39.7	38.4	39.0	38.7	38.3	39.4	38.5
1961	–	36.1	35.6	36.0	39.6	40.9	–	–	–	–	–	–
1965	–	–	–	25.5	–	–	–	27.3	27.2	–	25.7	25.4
1966	25.3	24.3	27.4	30.4	–	30.3	–	–	–	–	–	–
1967	–	–	26.9	27.5	28.9	31.5	28.5	27.2	28.7	27.1	26.8	–
1968	–	–	–	26.4	29.7	–	29.1	28.6	29.5	27.8	26.0	25.2
1969	25.3	26.2	25.5	29.3	30.0	33.1	31.5	–	29.9	–	–	28.6
1971	25.3	–	28.1	30.3	–	32.1	30.9	28.7	29.0	–	–	–
1974	–	–	–	–	–	–	–	–	27.9	28.8	–	–
1978	–	–	25.4	27.7	–	–	–	27.4	27.7	26.6	25.2	–
1980	–	–	–	–	31.4	–	29.6	–	–	–	–	–
1987	–	–	–	–	–	31.6	32.4	28.9	29.8	28.3	27.1	24.7
1988	24.0	25.3	28.7	28.9	31.6	32.4	29.2	26.8	26.9	26.4	25.2	24.1
1989	22.6	22.9	–	24.6	28.9	32.0	30.8	28.4	28.2	27.9	26.3	23.1
1990	–	21.4	25.0	26.8	31.4	33.4	30.3	30.2	30.2	28.7	27.0	–
1991	25.6	24.9	25.3	28.4	–	–	–	28.5	28.9	27.7	26.1	25.3
1992	22.6	21.7	25.9	29.3	31.0	31.7	29.7	27.0	27.0	26.2	25.6	24.5
1993	24.3	22.7	27.3	26.3	28.5	32.1	31.3	29.9	30.2	29.0	27.5	26.1
1994	25.5	26.7	27.6	30.3	31.3	33.2	29.5	27.8	28.1	27.4	–	–

Note: - = not calculated due to missing data

Table 4 Monthly Average Minimum Air Temperature

Station: Bati

unit: ℃

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1960	–	–	–	–	–	–	24.8	24.0	26.0	25.4	24.1	23.1
1961	–	22.0	23.1	24.6	29.4	30.4	–	–	–	–	–	–
1966	–	–	–	–	–	–	–	–	–	–	13.2	–
1967	14.2	9.0	6.8	7.9	10.1	11.4	6.2	6.6	10.5	12.4	11.1	–
1968	–	–	–	9.6	11.8	10.7	8.9	7.8	11.5	13.0	12.2	12.4
1969	7.2	6.7	8.0	12.9	12.1	13.2	10.8	–	11.3	–	–	14.4
1971	13.4	16.2	15.3	13.7	11.9	15.0	11.1	9.1	11.7	–	–	–
1974	–	–	–	–	–	–	–	–	9.3	11.6	–	–
1978	–	–	4.8	3.6	–	–	–	11.1	13.1	11.9	9.5	–
1980	–	–	–	–	19.8	–	18.8	–	–	–	–	–
1987	–	–	–	–	–	17.0	17.8	16.4	15.2	12.4	9.0	10.3
1988	12.9	15.7	13.8	16.2	16.5	18.0	17.1	16.3	16.0	12.8	8.1	8.7
1989	11.1	12.7	14.2	15.2	14.5	16.2	17.0	16.3	15.3	12.4	8.8	14.1
1990	–	15.6	14.4	14.5	–	–	17.4	16.5	15.6	11.1	10.3	7.9
1991	12.0	14.1	15.6	15.1	–	–	–	16.9	15.0	11.8	9.2	11.8
1992	13.3	14.8	15.3	16.3	16.3	16.9	16.5	15.4	15.4	12.7	11.2	12.4
1993	12.4	12.9	11.6	15.6	15.5	15.1	16.5	15.8	15.0	11.8	9.6	8.2
1994	9.0	10.8	15.1	15.3	15.2	18.8	16.6	16.5	14.0	10.7	–	–

Note: - = not calculated due to missing data

Table 5 Monthly Average Air Temperature

Station: Bati

unit: ℃

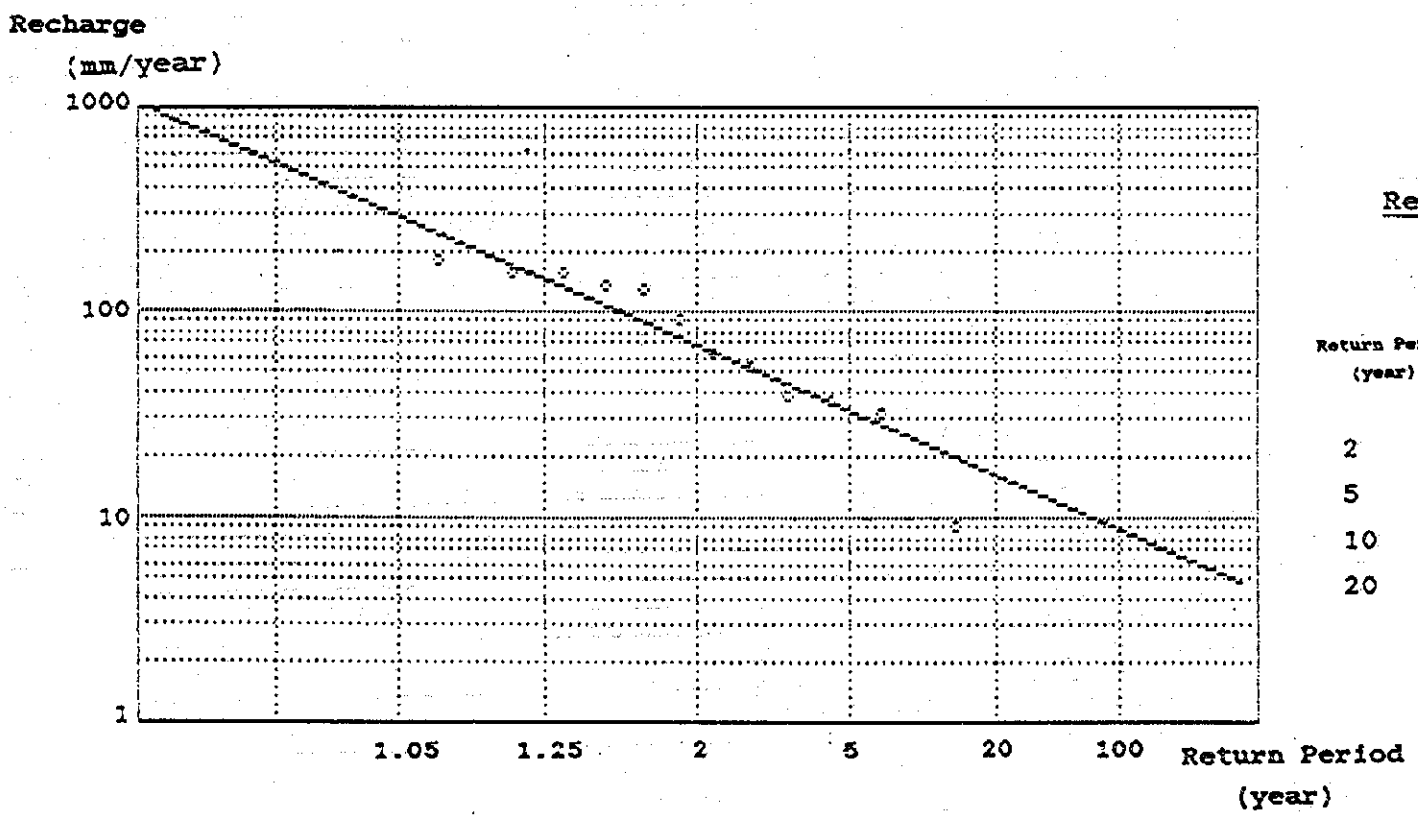
Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1960	–	–	–	–	–	–	31.6	31.5	32.4	31.9	31.8	30.8
1961	–	61.0	29.4	30.3	34.5	35.7	–	–	–	–	–	–
1967	–	–	16.9	17.7	19.5	21.5	17.4	16.9	19.6	19.8	19.0	–
1968	–	–	–	18.0	20.8	–	19.0	18.2	20.5	20.4	19.1	18.8
1969	16.3	16.5	16.8	21.1	21.1	23.2	21.2	–	20.6	–	–	21.5
1971	19.4	–	21.7	22.0	–	23.6	21.0	18.9	20.4	–	–	–
1974	–	–	–	–	–	–	–	–	18.6	20.2	–	–
1978	–	–	15.1	15.7	–	–	–	19.3	20.4	19.3	17.4	–
1980	–	–	–	–	25.6	–	24.2	–	–	–	–	–
1987	–	–	–	–	–	24.3	25.1	22.7	22.5	20.4	18.1	17.8
1988	18.5	20.5	21.3	22.6	24.1	25.2	23.2	21.6	21.5	19.6	16.7	16.4
1989	16.9	17.8	–	19.9	21.7	24.1	23.9	22.4	21.8	20.2	17.6	18.6
1990	–	18.5	19.7	20.7	–	–	23.9	23.4	22.9	19.9	18.7	–
1991	18.8	19.5	20.5	21.8	–	–	–	22.7	22.0	19.8	17.7	18.6
1992	18.0	18.3	20.6	22.8	23.7	24.3	23.1	21.2	21.2	19.5	18.4	18.5
1993	18.4	17.8	19.5	21.0	22.0	23.6	23.9	22.9	22.6	20.4	18.6	17.2
1994	17.3	18.8	21.4	22.8	23.3	26.0	23.1	22.2	21.1	19.1	–	–

Note: - = not calculated due to missing data

Appendix - 9

Hydrological Data

Figure 1 Probability Analysis on Annual Ground Water Recharge



Results of Analysis

Return Period (year)	Probability of Exceedance	Theoretical Values
2	.5	67.025
5	.2	31.910
10	.1	21.652
20	.05	15.723

1960

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	–	–	–	–	–	2.0	217.2	141.1	118.6	0.0	34.8	0.0	–
Q	–	–	–	–	–	0.8	86.9	56.4	47.4	0.0	13.9	0.0	–
P - Q	–	–	–	–	–	1.2	130.3	84.7	71.2	0.0	20.9	0.0	–
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	–	–	–	–	–	1.2	98.7	84.7	71.2	0.0	20.9	0.0	–
ΔS	–	–	–	–	–	0	31.6	0	0	0	0	0	31.6

1965

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	52.4	0.0	–	0.0	0.0	2.0	290.1	330.3	74.1	–	34.8	0.0	–
Q	21.0	0.0	–	0.0	0.0	0.8	116.0	132.1	29.6	–	13.9	0.0	–
P - Q	31.4	0.0	–	0.0	0.0	1.2	174.1	198.2	44.5	–	20.9	0.0	–
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	31.4	0.0	–	0.0	0.0	1.2	98.7	99.4	44.5	–	20.9	0.0	–
ΔS	0	0	–	0	0.0	0	75.4	98.8	0	–	0	0	174.2

1967

Uint:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	0.0	56.5	132.0	54.6	20.0	210.0	224.0	62.0	42.0	129.0	–	–
Q	0.0	0.0	22.6	52.8	21.8	8.0	84.0	89.6	24.8	16.8	51.6	–	–
P - Q	0.0	0.0	33.9	79.2	32.8	12.0	126.0	134.4	37.2	25.2	77.4	–	–
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	0.0	0.0	33.9	79.2	32.8	12.0	98.7	99.4	37.2	25.2	77.4	–	–
ΔS	0	0	0	0	0	0	27.3	35.0	0	0	0	–	62.3

Note: - = not calculated due to missing data or distorted data

1968

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	–	–	–	198.0	0.0	10.0	352.1	113.1	54.0	0.0	62.0	10.2	–
Q	–	–	–	79.2	0.0	4.0	140.8	45.2	21.6	0.0	24.8	4.1	–
P - Q	–	–	–	118.8	0.0	6.0	211.3	67.9	32.4	0.0	37.2	6.1	–
ETo	134	135	139	139	141	14.1	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	–	–	–	97.3	0.0	6.0	98.7	67.9	32.4	0.0	37.2	6.1	–
ΔS	–	–	–	21.5	0	0	112.6	0	0	0	0	0	134.1

1971

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	0.0	62.0	128.0	63.0	0.0	126.1	228.0	43.5	–	–	–	–
Q	0.0	0.0	24.8	51.2	25.2	0.0	50.4	91.2	17.4	–	–	–	–
P - Q	0.0	0.0	37.2	76.8	37.8	0.0	75.7	136.8	26.1	–	–	–	–
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	0.0	0.0	37.2	76.8	37.8	0.0	75.7	99.4	26.1	–	–	–	–
ΔS	0	0	0	0	0	0	0	37.4	0	–	–	–	37.4

1987

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	–	–	–	–	–	2.5	50.0	228.3	49.6	48.2	0.0	36.3	–
Q	–	–	–	–	–	1.0	20.0	91.3	19.8	19.3	0.0	14.5	–
P - Q	–	–	–	–	–	1.5	30	137.0	29.8	28.9	0.0	21.8	–
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	–	–	–	–	–	1.5	30	99.4	29.8	28.9	0.0	21.8	–
ΔS	–	–	–	–	–	0	0	37.6	0	0	0	0	37.6

Note: - = not calculated due to missing data or distorted data

1988

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	9.3	32.4	5.0	71.5	10.4	19.6	362.2	223.9	129.9	19.5	0.0	13.4	897.1
Q	3.7	13.0	2.0	28.6	4.2	7.8	144.9	89.6	52.0	7.8	0.0	5.4	359.0
P - Q	5.6	19.4	3.0	42.9	6.2	11.8	217.3	134.3	77.9	11.7	0.0	8.0	538.1
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	5.6	19.4	3.0	42.9	6.2	11.8	98.7	99.4	77.9	11.7	0.0	8.0	376.6
ΔS	0	0	0	0	0	0	118.6	34.9	0	0	0	0	153.5

1989

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	38.3	126.4	88.8	129.4	27.7	13.6	118.1	153.6	75.7	32.5	0.0	170.1	974.2
Q	15.3	50.6	35.5	51.8	11.1	5.4	47.2	61.4	30.3	13.0	0.0	68.0	389.6
P - Q	23.0	75.8	53.3	77.6	16.6	8.2	70.9	92.2	45.4	19.5	0.0	102.1	584.6
ETo	134	135	139	139	141	14.1	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	23.0	75.8	53.3	77.6	16.6	8.2	70.9	92.2	45.4	19.5	0.0	93.1	575.6
ΔS	0	0	0	0	0	0	0	0	0	0	0	9.0	9.0

1990

Uint:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	57.1	258.4	20.9	68.5	22.9	0.0	160.6	94.1	83.6	3.0	0.0	0.0	769.1
Q	22.8	103.4	8.4	27.4	9.2	0.0	64.2	37.6	33.4	1.2	0.0	0.0	307.6
P - Q	34.3	155.0	12.5	41.1	13.7	0.0	96.4	56.5	50.2	1.8	0.0	0.0	461.5
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	34.3	94.5	12.5	41.1	13.7	0.0	96.4	56.5	50.2	1.8	0.0	0.0	401.0
ΔS	0	150.5	0	0	0	0	0	0	0	0	0	0	150.5

1992

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	90.2	47.0	21.3	29.3	13.6	9.9	145.6	315.4	152.9	37.9	0.4	72.3	935.8
Q	36.1	18.8	8.5	11.7	5.4	4.0	58.2	126.2	61.2	15.2	0.2	28.9	374.4
P - Q	54.1	28.2	12.8	17.6	8.2	5.9	87.4	189.2	91.7	22.7	0.2	43.4	561.4
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	54.1	26.2	12.8	17.6	8.2	5.9	87.4	99.4	91.7	22.7	0.2	43.4	471.6
ΔS	0	0	0	0	0	0	0	89.8	0	0	0	0	89.8

1993

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	89.9	102.0	0.0	213.0	114.9	5.3	203.5	123.4	85.5	77.0	0.0	0.0	1,015.1
Q	36.0	41.0	0.0	85.2	46.0	2.1	81.4	49.4	34.2	30.8	0.0	0.0	406.1
P - Q	53.9	61.6	0.0	127.8	68.9	3.2	122.1	74.0	51.3	46.2	0.0	0.0	609.0
ETo	134	135	139	139	141	141	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	53.9	61.6	0.0	97.3	68.7	3.2	98.7	74.0	51.3	46.2	0.0	0.0	555.1
ΔS	0	0	0	30.5	0	0	23.4	0	0	0	0	0	53.9

1994

Unit:mm

Elements	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
P	0.0	2.3	64.6	28.9	18.1	15.2	333.2	207.5	106.3	0.0	–	–	–
Q	0.0	0.9	25.8	11.6	7.2	6.1	133.3	83.0	42.5	0.0	–	–	–
P - Q	0.0	1.4	38.8	17.3	10.9	9.1	199.9	124.5	63.8	0.0	–	–	–
ETo	134	135	139	139	141	14.1	141	142	137	135	132	133	1,649
ET crop	93.8	94.5	97.3	97.3	98.7	98.7	98.7	99.4	95.9	94.5	92.4	93.1	1,154.3
ETa	0.0	1.4	38.8	17.3	10.9	9.1	98.7	99.4	63.8	0.0	–	–	–
ΔS	0	0	0	0	0	0	101.2	25.1	0	0	–	–	126.3

Note: - = not calculated due to missing data or distorted data

Appendix - 10

Existing Pump Condition

Survey Site: BATTI Date: 29/10/87 E.C.

1. # 1 Well

Well Accessories			Submersible Pump	
Check valve	63.5	mm	Manufacturer:	CALAMA INDUSTRIES PRIVATE LTD. BOMBAY 400062, INDIA
Pressure gauge		kg/cm^2	Head:	150 m
Flow meter	40 m^3/hr.	m^3/sec	Capacity:	120 l/min.
Gate valve	63.5	mm	R.P.M:	2900
Conveyance pipe		mm	Hz:	50
			Stage:	18
			Others:	Dev. stage 531-2

Well Data			Others
Static Water Level	11.18	m	Ampere = 11.5
*Dyanamic Water Level		m	Power = 7.5 HP = 5.6 kw.
Dia. & Length of a riser pipe			Manufacturer date = Year 1986
63.5 mm	42	m	Connection = y/
Total number of riser pipes of 6 mts. long	7	nos.	Well Depth = 54 mts.
Relay cable	Yes	No	Voltage = 380/400
Well Dia.	203.2	mm	Phase = 3

2. # 2 Well

Well Accessories		Submersible Pump	
Check valve	mm	Manufacturer:	
Pressure gauge	kg/cm^2		
Flow meter	m^3/sec	Head:	m
Gate valve	mm	Capacity:	
Conveyance pipe	mm	R.P.M:	
		Hz:	
		Stage:	
		Others:	

Well Data			Others
Static Water Level		m	
Dyanamic Water Level		m	
Dia. & Length of a riser pipe		m	
Total number of riser pipes		nos.	
Relay cable	Yes	No	
Well Dia.		mm	

3. # 3 Well BATTI

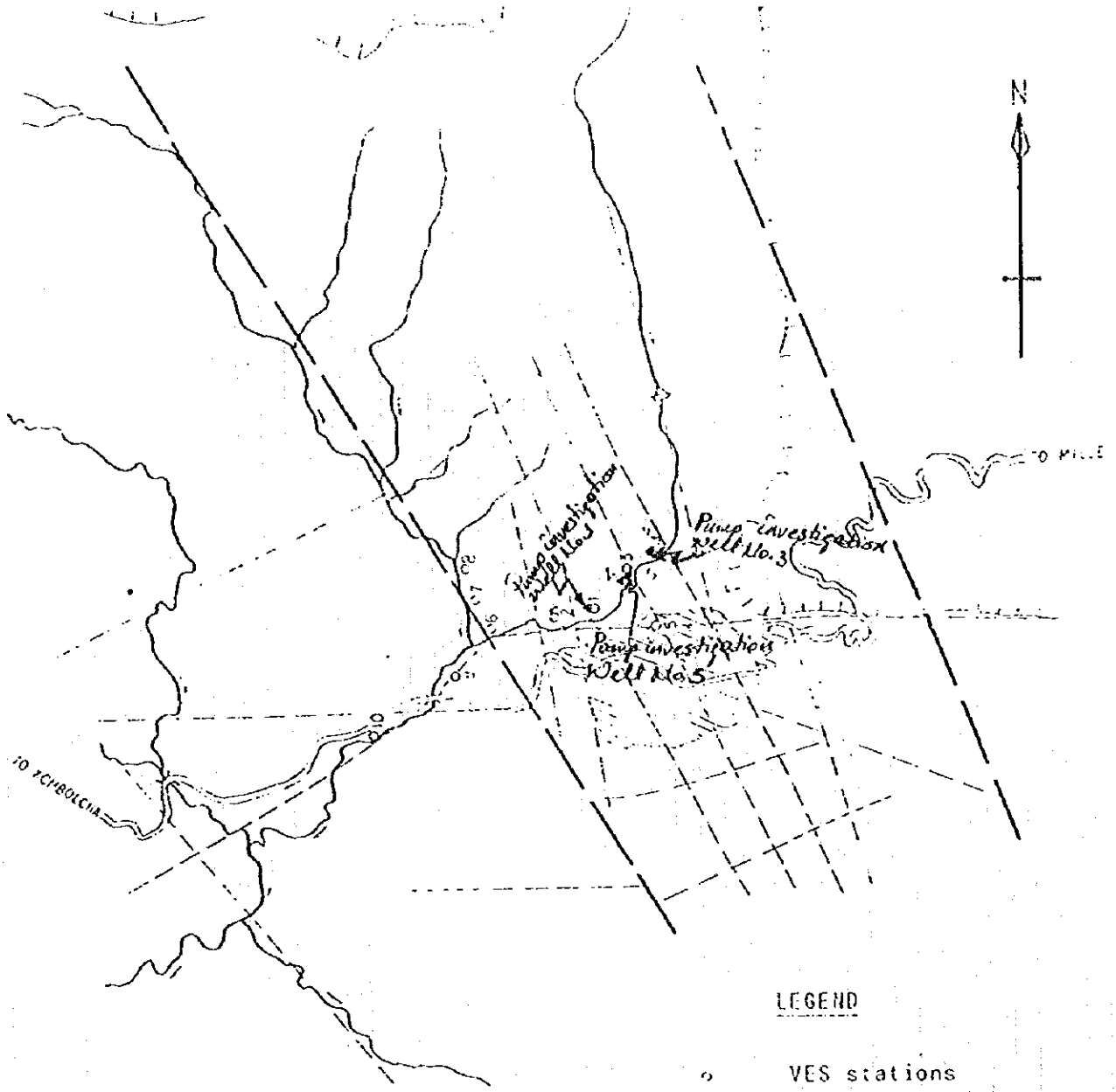
Well Accessories			Submersible Pump	
Check valve	63.5	mm	Manufacturer:	KALAMA INDUSTRIES LIMITED INDIA
Pressure gauge		kg/cm^2	Head:	100 m
Flow meter	30 $m^3/hr.$	m^3/sec	Capacity:	180 l/min
Gate valve		mm	R.P.M:	2900
Conveyance pipe		mm	Hz:	50
			Stage:	12
			Others:	Connection Y/

Well Data			Others
Static Water Level	1.0	m	Power = 7.5 HP = 5.5 kw.
Dyanamic Water Level		m	Volts = 380/400
Dia. & Length of a riser pipe			Year = 1991
63.5 mm	33	m	No. = 1910631698
Total number of riser pipes of 6 mts. long	5.5	nos.	Well depth = 45 mts.
Relay cable	Yes	No	
Well Dia.	203.2	mm	

4. # 4 Well # 5

Well Accessories			Submersible Pump	
Check valve	50.8	mm	Manufacturer:	GROUNDFOS GERMANY
Pressure gauge		kg/cm^2	Head:	192.94 = 90.22 m
Flow meter	30 $m^3/hr.$	m^3/sec	Capacity:	4 - 11 $m^3/hr.$
Gate valve		mm	R.P.M:	
Conveyance pipe		mm	Hz:	50
			Stage:	38
			Others:	Voltage = 380 Vx3

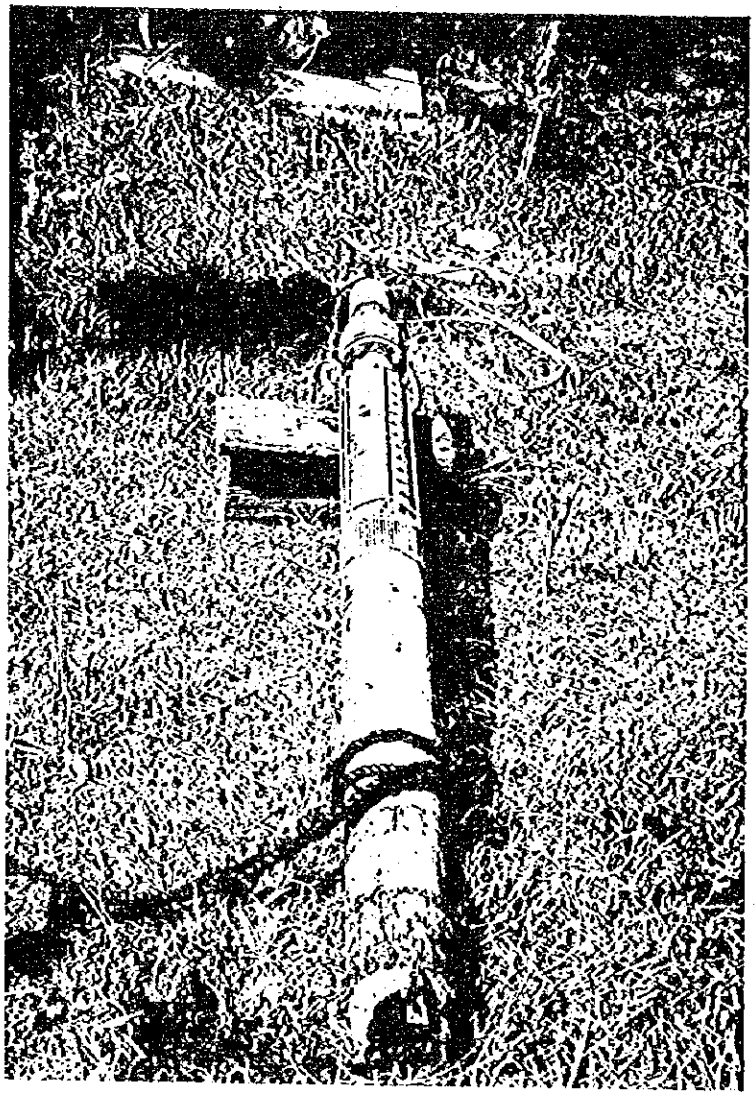
Well Data			Others
Static Water Level	8.95	m	Connection = star
Dyanamic Water Level		m	Type = SP8 - 37
Dia. & Length of a riser pipe			No. = 8850
50.8 mm	15	m	Power = 5.5 kw.
Total number of riser pipes (of 6 mts. long)	2.5	nos.	
Relay cable	Yes	No	
Well Dia.	152.4	mm	



LEGEND

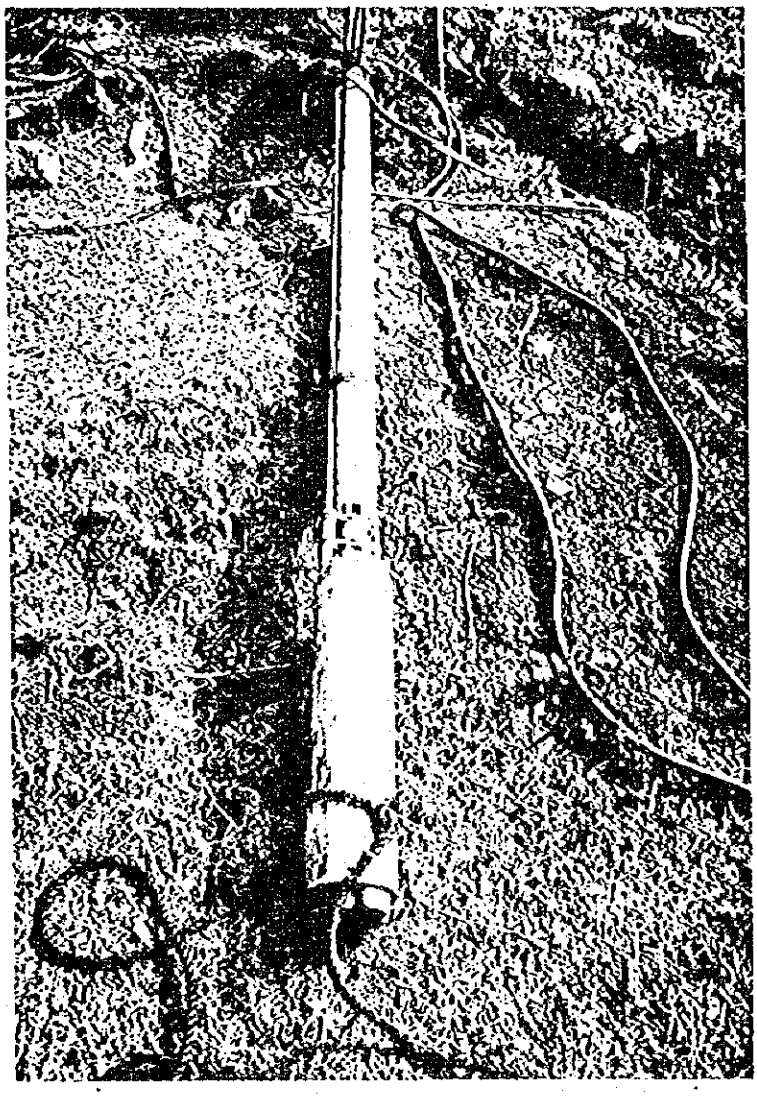
- VES stations
- Proposd drilling site
- Existing borehole
- Abandoned borehole
- Road
- River
- Major lineation
- Minor liniation
- Dam site
- Escarpment
- Town area

WATER WELL DRILLING ENTERPRISE	
LOCATION MAP OF BATI	
SCALE 1:5,000	ADDIS ABABA JULY, 1995



Picture 5 The investigated pump on well No.3

BATI



Picture 8 The investigated pump on well No.5

BATI

Appendix - 11

Result of Pumping Test

1. General

This pumping test was conducted at WSS borehole No.5 which is located adjacent to the borehole No.4. Both of them are located in the compound of Bati Red-Cross. The dimensions of the well is reported as stated hereunder.

- Well Depth : 90m
- Casing Type and Diameter : Steel, 6" (150mm)
- Screen Type and Position : Slot, 15.2-57m
- Yield reported by WSS : 1.5 l/s
- Yield reported by the driller(WWDE) : 4.0 l/s

Little is known about the aquifer probably consisted of weatherd and fractured basalts and the deeper the aquifer is more confined. This borehole was abandoned probably due to its small diameter below 24m below ground level, which is insufficient to install a common submersible pump. For the test, a 6" submersible pump was installed at 23m below ground level. The static water level was 9.36m, so that the maximum allowable drawdown was counted at 13m. The test is composed of the followings.

- Preliminary pumping test with 4 steps of different pumping rates
- Step drawdown test with 5 steps
- Contineous discharge test for 24 hours and recovery observation

The WSS borehole No.4 located 49m away from the well was used as the observation well during the contineous discharge test.

2. Preliminary Pumping Test

The test is aimed to know about the well, measuring the water level variation with different pumping rates and find a suitable pump position. During the test, the well was consecutively pumped

at 0.5, 0.8, 1.15 and 1.83 l/s where each of the former 3 steps lasted 1 hour and the latter lasted 7 hours. The water level reached 20.93m below ground level after 10 hours of pumping. The total drawdown is therefore 11.57m. The variation of water level with time is shown in Figure 1. The drawdown of each step is plotted on the graph of discharge vs. drawdown as shown in Figure 2. The graph implies that aquifer loss was predominant since all the plots are on a line parallel to the linear line having an inclination of 45 degree and the critical yield was not observed.

3. Step Drawdown Test

The test is aimed to determine some characteristics of the well such as critical yield, optimal yield, well loss, aquifer loss, well efficiency, etc.. The test was consisted of 5 steps for a total duration of 15 hours, where each step lasts 3 hours. During the test, the well was pumped in increasing discharges at the first three steps and decreasing discharges at the last two steps, i.e. 0.5, 0.8, 1.15, 0.93 and 0.75 l/s and their respective drawdown were recorded. The recovery was observed after the shut-off of the pump and the water level recovered 100% in 6 hours of time. The variation of water level with time is shown in Figure 3. The graph shows the first, the second and the fourth steps reached the pseudo steady states.
The drawdowns are plotted on the graph of discharge vs. drawdown as shown in Figure 4 including the aforesaid three steps and the third step which is considered to have reached the pseudo steady state at around 1700. The graph confirms that aquifer loss is predominant in the discharge range and the critical yield will be beyond the discharge range. In order to evaluate the well loss and the aquifer loss, the following well loss function is employed.

$$Sw = BQ + CQ^p$$

where	Sw	:	Drawown
	Q	:	Discharge (Yield)
	B,C,p	:	Coefficients
	BQ	:	Aguifer loss
	CQ^p	:	Well loss

The well loss function fits on the plots as shown in Figure 5, obtaining the following equation:

$$Sw = 0.07Q + 8.94 \times 10^{-7} Q^{3.03}$$

The well efficiency is calculated with the following formula:

$$Ew = BQ / Sw$$

The results of step drawdown test are tabulated hereunder.

STEP	YIELD Q (m3/d) (l/s)	DRAWDOWN Sw (m)	SPECIFIC YIELD Q/Sw (m3/d/m)	AQUIFER LOSS BQ (m)	WELL LOSS CQ^p (m)	WELL EFFICIENCY BQ/Sw
1	43.2 0.5	3.23	13.4	3.02	0.08	0.93
2	69 0.8	4.92	14.0	4.83	0.33	0.98
3	99 1.15	7.94	12.5	6.93	1.00	0.87
4	80 0.93	6.44	12.4	5.60	1.65	0.87

This table clarifies aquifer loss is predominant in the yield range because the well efficiencies are very high. Optimal yield of the well is calculated with the well loss equation, assuming that the static water level is 10m below ground level at lowest and the maximum drawdown is 12m considering the pump position. The optimal yield is then obtained at 135m3/day or 1.56 l/s and the well efficiency at the yield is 0.79.

4. Contineous Discharge Test

This test was aimed to evaluate the aquifer characteristics such as transmissivity, storage coefficient, etc.. The well was pumped at a fixed discharge rate i.e. 1.0 l/s for 24 hours and the drawdown was recorded. Recovery was observed after shut-off of the pump. The water level of the observation well was also measured during the test simultaneously together with the pumped well. The

variation of water level with time observed at the pumped well as well as the observation well are shown in Figure 6 and Figure 7 respectively. The water level of the pumped well reached 16.26m below ground level after 24 hours of pumping having a drawdown of 6.90m. On the other hand, the water level of the observation well was lowered by 0.07m. The pumped well was recovered 100% in 14 hours after shut-off of the pump. The drawdown of the pumped well estimated by the well loss equation is 6.71m at 1.0 l/s. The difference from the observed drawdown is 0.19m which is less than 3% of both observed and estimated drawdowns. This implies that the well loss equation is applicable for the cases of longer pumping. The drawdown observed at the observed well is analized using the well known Jacob method. The formula is written:

$$S = \frac{Q}{4\pi KH} \ln \left(\frac{2.25KHt}{r^2 \mu} \right)$$

where

KH	:	Transmissivity
r	:	Distance to the pumped well
μ	:	Storage coefficient
t	:	Time elapsed since pumping started

This method has less error say less than 6% when

$$u = \frac{r^2 \mu}{4KHt} < 0.1$$

The drawdown is plotted on the semi-log graph as shown in Figure 8. A linear line is fit on the drawdown curve between the time of 100 min. and 1000 min. approximately. From the slope of this line, transmissivity is calculated at 380 m2/day. Then, storage coefficient is obtained at 0.0059. Drawdown at the pumped well caused by this Darcyan flow is obtainable by Tiem equation:

$$Sw = \frac{Q}{2\pi KH} \ln \left(\frac{R}{rw} \right)$$

Assuming the radius of cone of depression (R) is 300m, the drawdown is calculated :

$$Sw = 0.30m$$

Since the aquifer loss is estimated :

$$BQ = 0.07 \times 86.4 = 6.05m$$

Almost all the aquifer loss is composed of the drawdown due to vertical flows.

5. Conclusion

It is very difficult to formulate the drawdown caused by vertical flows. It is therefore proposed to apply Tiem equation again, reducing the transmissivity because of the vertical flow problem. One can obtain transmissivity of 18.9m2/day for the aquifer loss of 6.05m for the case of contineous discharge test. For the design purpose, permeability of the aquifer is calculated assuming the thickness of the aquifer is equal to the screen length i.e. 41.8m :

$$K = 18.9/41.8 = 0.45m/day$$

The characteristics of the well are summerized as follows:

Optimal Yield	:	135m3/day(1.56 l/s)
Drawdown	:	12m
Aquifer Loss	:	9.45m
Well Loss	:	2.55m
Well Efficiency	:	0.79

Figure 1 Preliminary Pumping Test
Time Water Level Graph

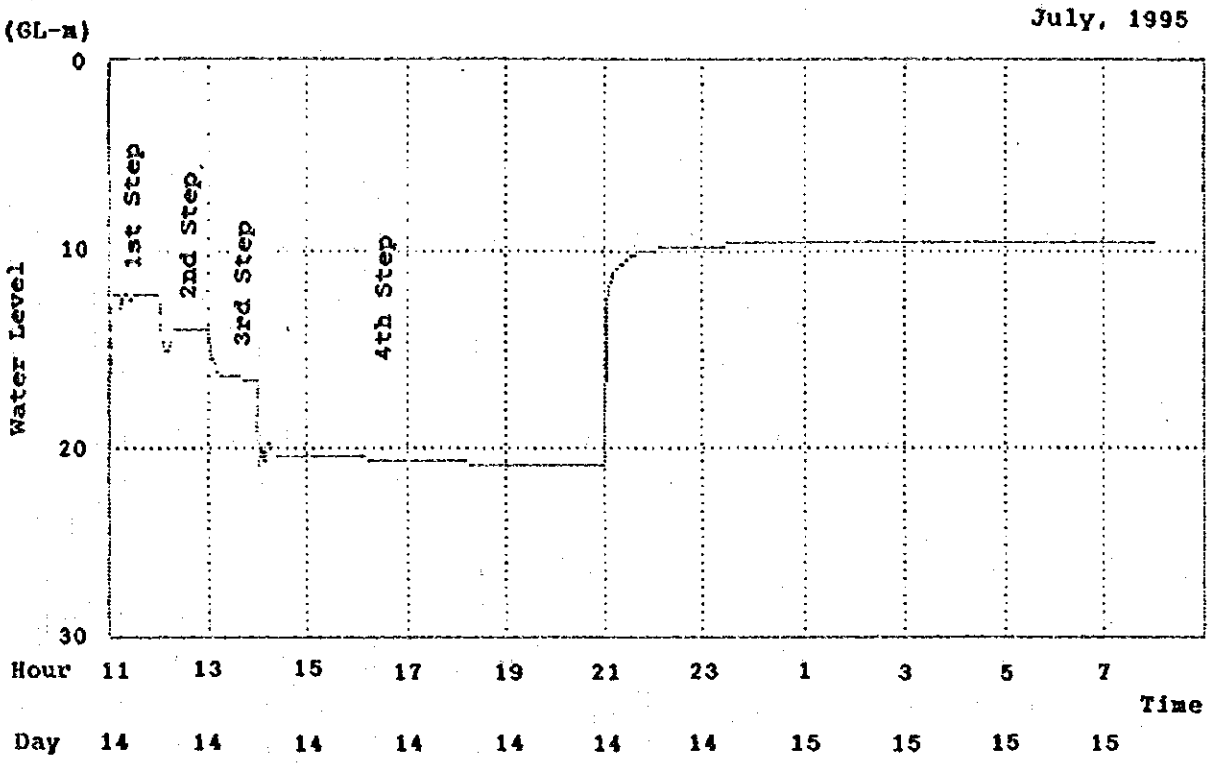


Figure 2 Preliminary Pumping Test
Discharge vs. Drawdown Graph

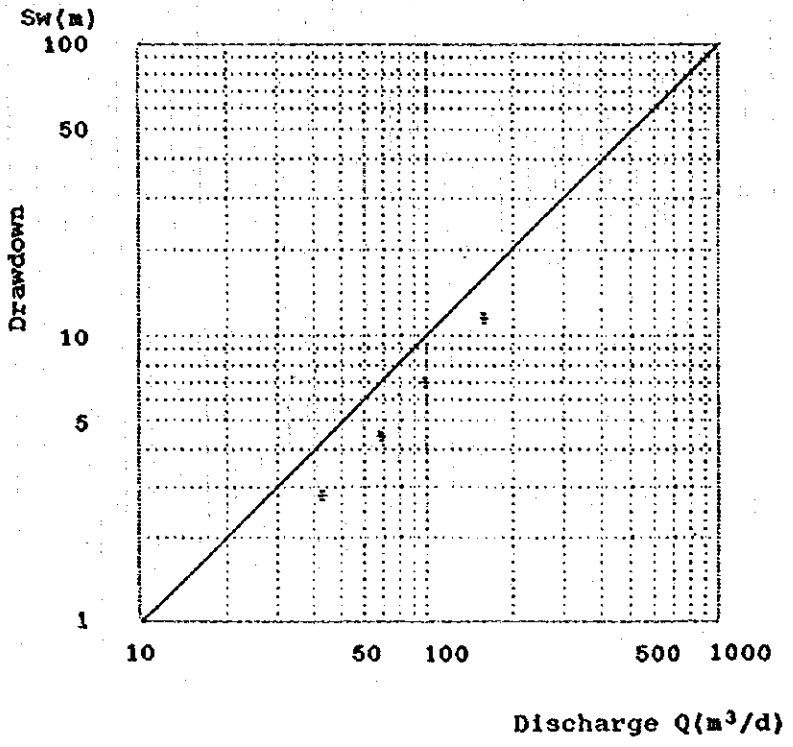


Figure 3 Step Drawdown Test
Time Water Level Graph

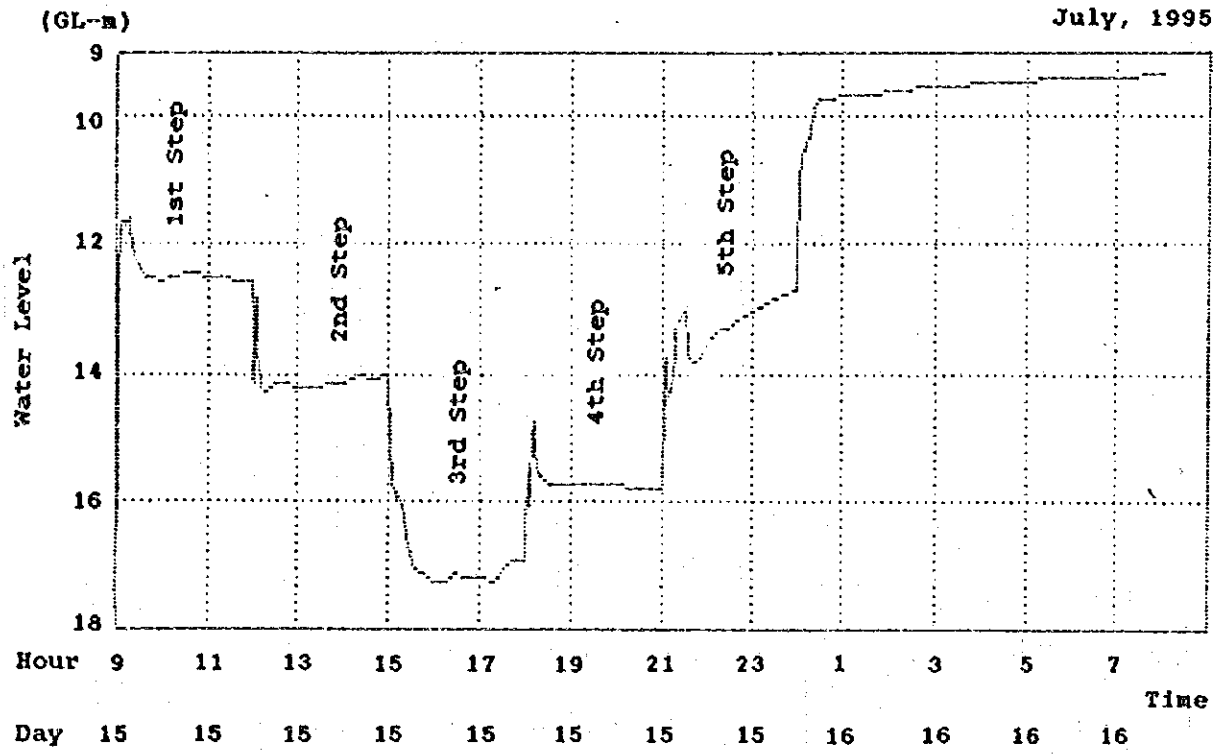


Figure 4 Step Drawdown Test
Discharge vs. Drawdown Graph

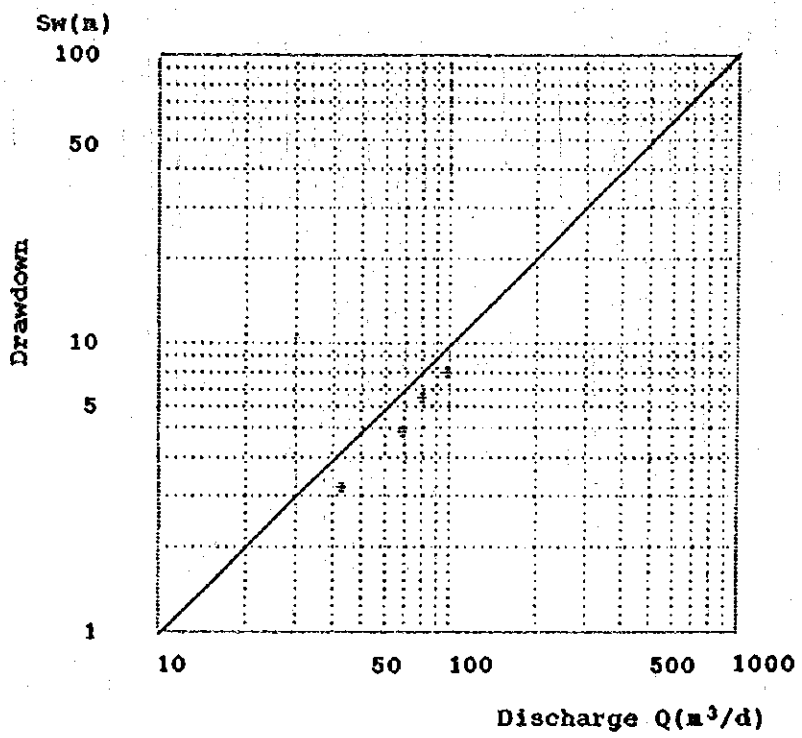


Figure 5 Step Drawdown Test
Well Loss function

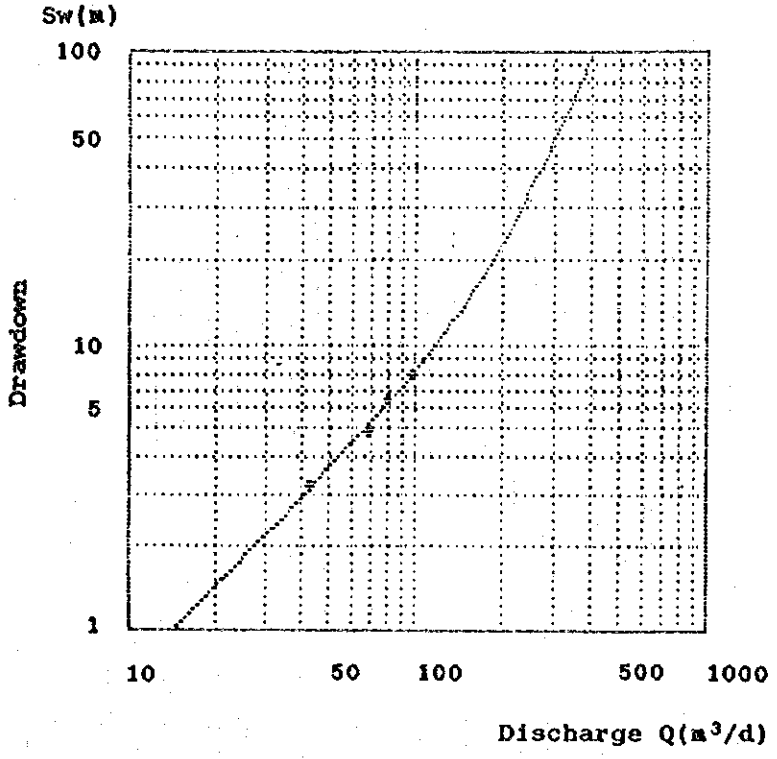


Figure 6 Contineous Discharge Test
Time Water Level Graph of the Pumped Well

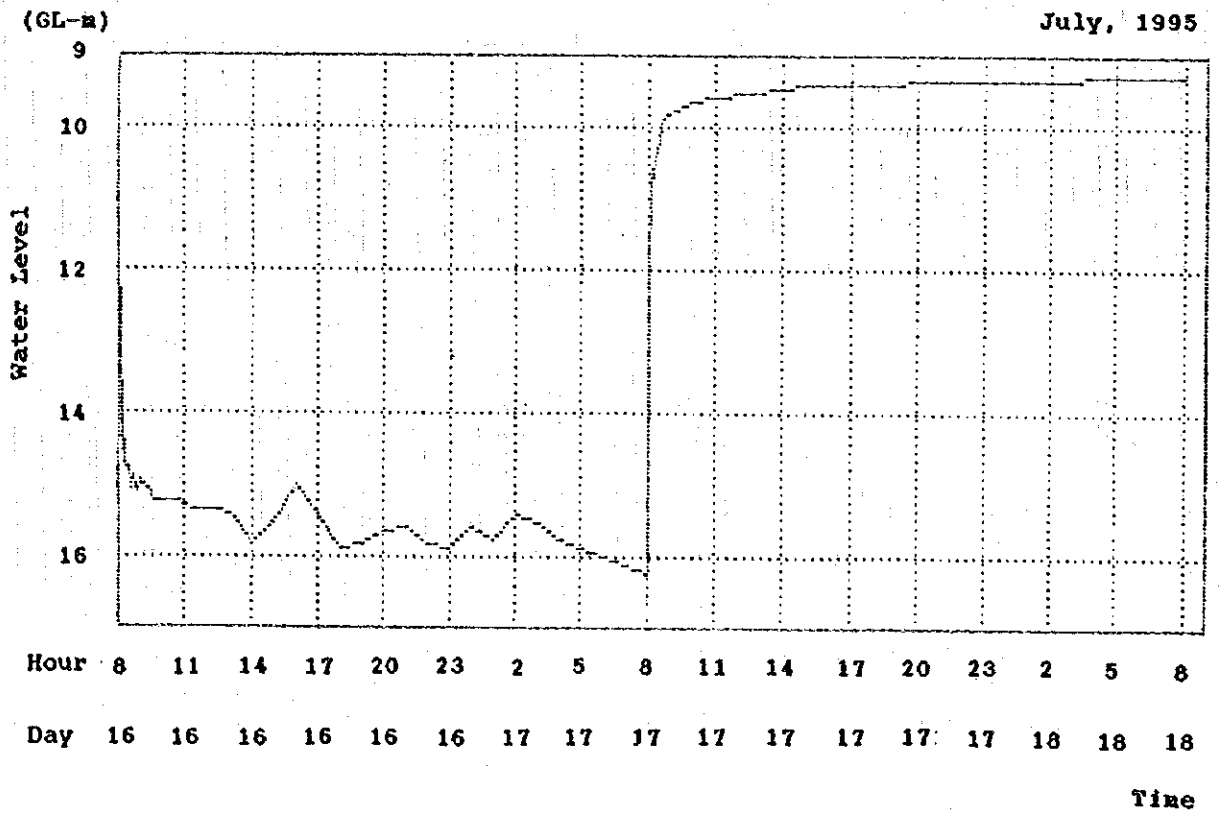


Figure 7 Contineous Discharge Test
Time Water Level Graph of the Observed Well

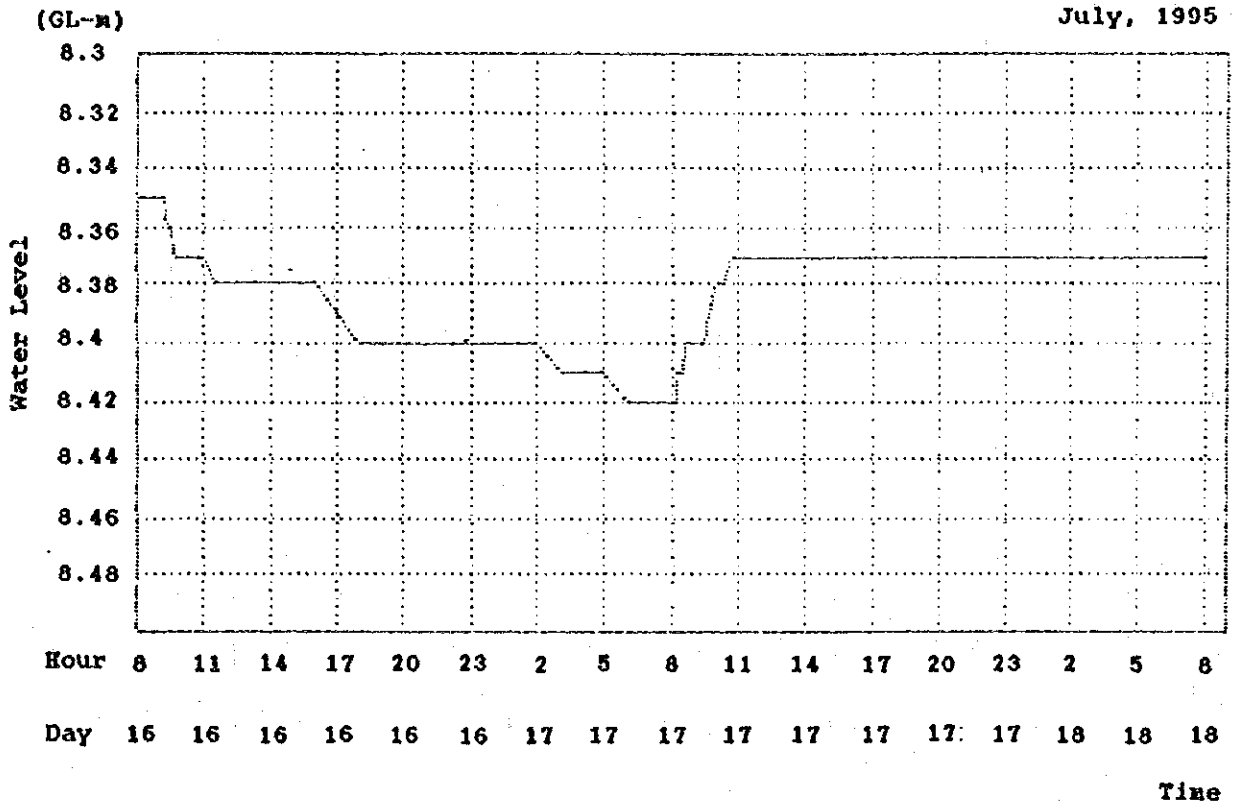
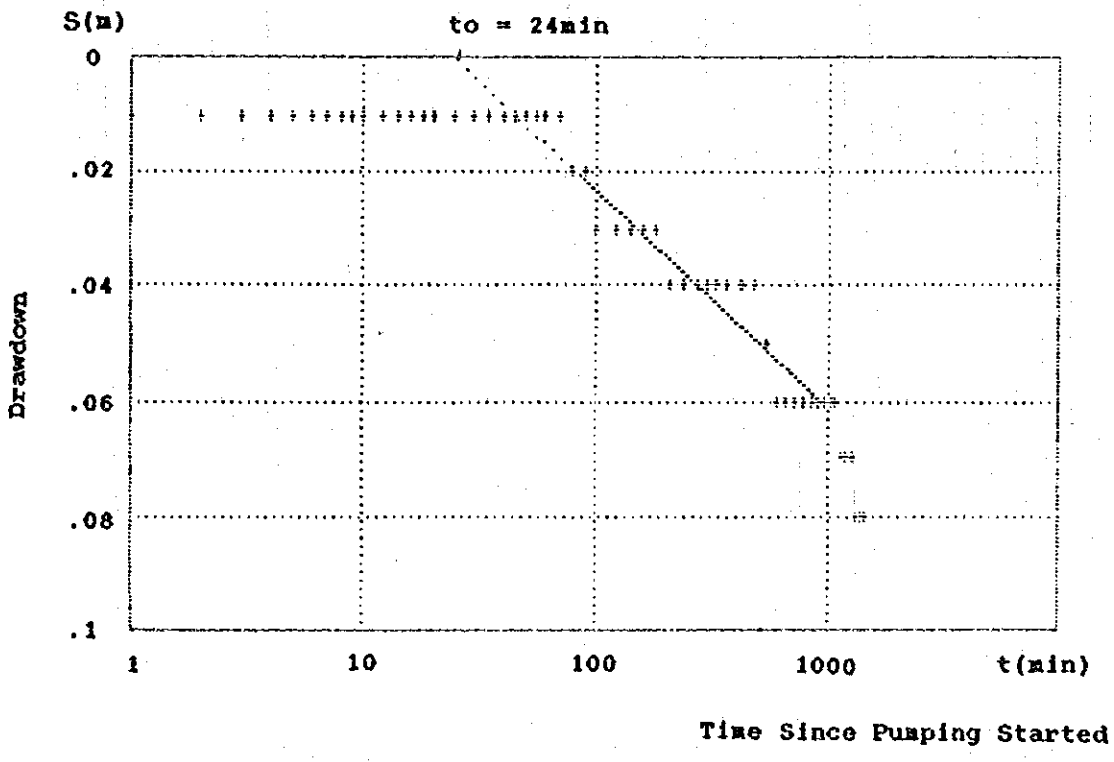


Figure 8 Contineous Discharge Test
Time Drawdown Graph of the Observation Well



PRELIMINARY TEST
PUMPING STAGE

DATE	14/07/95			CONDUCTED BY	WWDB
WELL NO.	5	SWL	9.36 m	STEP	1
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	44 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.5 l/s
WELL DEPTH	90 m	CAP.	10 l/s		43.2 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
11:00	0	9.48	0.12	
	0.5			
11:01	1.0			
	1.5	18.00	8.54	
11:02	2.0	16.20	6.84	
	2.5	14.60	5.14	
11:03	3.0	12.80	3.44	
	3.5	12.80	3.34	
11:04	4.0	12.60	3.24	
	4.5	12.60	3.24	
11:05	5.0	12.23	2.87	
11:06	6.0	12.23	2.87	
11:07	7.0	12.20	2.84	
11:08	8.0	12.21	2.85	
11:09	9.0	12.18	2.82	
11:10	10.0	12.16	2.80	
11:12	12.0	12.10	2.74	
11:14	14.0	12.80	3.44	
11:16	16.0	12.30	2.94	
11:18	18.0	12.10	2.74	
11:20	20.0	12.15	2.79	
11:25	25.0	12.32	2.96	
11:30	30.0	12.07	2.71	
11:35	35.0	12.23	2.87	
11:40	40.0	12.19	2.83	
11:45	45.0	12.20	2.84	
11:50	50.0	12.20	2.84	
11:55	55.0	12.20	2.84	
12:00	60.0	12.20	2.84	

PRELIMINARY TEST
PUMPING STAGE

DATE	14/07/95			CONDUCTED BY	WWDE
WELL NO.	5	SWL	9.36 m	STEP	2
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	50 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.8 l/s
WELL DEPTH	90 m	CAP.	10 l/s		69 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
12:00	0	12.00	2.84	
	0.5	12.80	3.44	
12:01	1.0	13.10	3.74	
	1.5	13.25	3.89	
12:02	2.0	13.55	4.19	
	2.5	13.63	4.27	
12:03	3.0	13.87	4.51	
	3.5	14.10	4.74	
12:04	4.0	14.24	4.88	
	4.5	14.39	5.03	
12:05	5.0	14.48	5.12	
12:06	6.0	14.66	5.30	
12:07	7.0	14.79	5.43	
12:08	8.0	14.89	5.53	
12:09	9.0	14.97	5.61	
12:10	10.0	15.03	5.67	
12:12	12.0	15.10	5.74	
12:14	14.0	14.70	5.34	
12:16	16.0	14.32	4.96	
12:18	18.0	14.12	4.76	
12:20	20.0	14.00	4.64	
12:25	25.0	13.90	4.54	
12:30	30.0	13.88	4.52	
12:35	35.0	13.88	4.52	
12:40	40.0	13.88	4.52	
12:45	45.0	13.88	4.52	
12:50	50.0	13.90	4.54	
12:55	55.0	13.90	4.54	
13:00	60.0	13.90	4.54	

PRELIMINARY TEST
PUMPING STAGE

DATE	14/07/95			CONDUCTED BY	WWDE
WELL NO.	5	SWL	9.36 m	STEP	3
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	57 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	1.15l/s
WELL DEPTH	90 m	CAP.	10 l/s		99 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
13:00	0	13.90	4.54	
	0.5	13.95	4.59	
13:01	1.0	13.96	4.60	
	1.5	14.00	4.64	
13:02	2.0	14.20	4.84	
	2.5	14.78	5.42	
13:03	3.0	15.25	5.89	
	3.5	15.37	6.01	
13:04	4.0	15.38	6.02	
	4.5	15.35	5.99	
13:05	5.0	15.35	5.99	
13:06	6.0	15.35	5.99	
13:07	7.0	15.40	6.04	
13:08	8.0	15.65	6.29	
13:09	9.0	15.83	6.47	
13:10	10.0	16.00	6.64	
13:12	12.0	16.20	6.84	
13:14	14.0	16.27	6.91	
13:16	16.0	16.32	6.96	
13:18	18.0	16.34	6.98	
13:20	20.0	16.35	6.99	
13:25	25.0	16.39	7.03	
13:30	30.0	16.39	7.03	
13:35	35.0	16.40	7.04	
13:40	40.0	16.43	7.07	
13:45	45.0	16.47	7.11	
13:50	50.0	16.47	7.11	
13:55	55.0	16.47	7.11	
14:00	60.0	16.47	7.11	

PRELIMINARY TEST
PUMPING STAGE

DATE	14/07/95			CONDUCTED BY	WWDE
WELL NO.	5	SWL	9.36 m	STEP	4
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	70 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	1.83l/s
WELL DEPTH	90 m	CAP.	10 l/s	158	m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
14:00	0	16.47	7.11	
	0.5	18.20	8.84	
14:01	1.0	19.10	9.74	
	1.5	19.80	10.44	
14:02	2.0	20.20	10.84	
	2.5	20.57	11.21	
14:03	3.0	20.70	11.34	
	3.5	20.83	11.47	
14:04	4.0	20.93	11.57	
	4.5	20.83	11.47	
14:05	5.0	20.20	10.84	
14:06	6.0	20.60	11.24	
14:07	7.0	20.80	11.44	
14:08	8.0	20.40	11.04	
14:09	9.0	20.81	11.45	
14:10	10.0	20.81	11.45	
14:12	12.0	19.70	10.34	
14:14	14.0	19.80	10.44	
14:16	16.0	19.80	10.44	
14:18	18.0	20.30	10.94	
14:20	20.0	20.41	11.05	
14:25	25.0			
14:30	30.0			
14:35	35.0			
14:40	40.0			
14:45	45.0			
14:50	50.0			
14:55	55.0			
15:00	60.0			
15:10	70.0			
15:20	80.0			
15:30	90.0			
15:40	100.0			

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
16:00	120			
16:20	140			
16:40	160			
17:00	180			
17:30	210			
18:00	240	20.83	11.47	
18:30	270	20.85	11.49	
19:00	300	20.87	11.51	
19:30	330	20.88	11.52	
20:00	360	20.90	11.54	
21:00	420	20.93	11.57	

PRELIMINARY TEST
RECOVERY

DATE 14/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	DISCHARGE OF THE FINAL STEP	
LOCATION	BATI	PUMP TYPE	Submersible		
OWNER	WSS	HEAD	200 m	1.83	l/s
WELL DEPTH	90 m	CAP.	10 l/s	158	m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
21:00	0	20.93	11.57	
	0.5	19.00	9.64	
21:01	1.0	17.60	8.24	
	1.5	16.20	6.84	
21:02	2.0	15.48	6.12	
	2.5	14.45	5.09	
21:03	3.0	13.80	4.44	
	3.5	13.12	3.76	
21:04	4.0	12.60	3.24	
	4.5	12.30	2.94	
21:05	5.0	12.00	2.64	
21:06	6.0	11.90	2.54	
21:07	7.0	11.70	2.34	
21:08	8.0	11.53	2.17	
21:09	9.0	11.39	2.03	
21:10	10.0	11.20	1.84	
21:12	12.0	11.00	1.64	
21:14	14.0	10.77	1.41	
21:16	16.0	10.71	1.35	
21:18	18.0	10.68	1.32	
21:20	20.0	10.63	1.27	
21:25	25.0	10.51	1.15	
21:30	30.0	10.39	1.03	
21:35	35.0	10.22	0.86	
21:40	40.0	10.06	0.70	
21:45	45.0	9.96	0.60	
21:50	50.0	9.90	0.54	
21:55	55.0	9.87	0.51	
22:00	60.0	9.83	0.47	
22:10	70.0	9.81	0.45	
22:20	80.0	9.78	0.42	
22:30	90.0	9.73	0.37	
22:40	100.0	9.70	0.34	

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
23:00	120	9.66	0.30	
23:20	140	9.63	0.27	
23:40	160	9.59	0.23	
0:00	180	9.57	0.21	
0:30	210			
1:00	240	9.54	0.18	
1:30	270	9.53	0.17	
2:00	300	9.51	0.15	
2:30	330			
3:00	360			
4:00	420			
5:00	480			
6:00	540			
7:00	600			
8:00	660	9.38	0.02	

STEP DRAWDOWN TEST
PUMPING STAGE

DATE 15/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	STEP	1
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	44 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.5 l/s
WELL DEPTH	90 m	CAP.	10 l/s		43.2 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
9:00	0	9.38	0.02	
	0.5			
9:01	1.0			
	1.5	17.20	7.84	
9:02	2.0	16.50	7.14	
	2.5	14.11	4.75	
9:03	3.0	14.04	4.68	
	3.5	13.00	3.64	
9:04	4.0	12.54	3.18	
	4.5	11.99	2.63	
9:05	5.0	11.71	2.35	
9:06	6.0	11.63	2.27	
9:07	7.0	11.62	2.26	
9:08	8.0	11.64	2.28	
9:09	9.0	11.66	2.30	
9:10	10.0	11.68	2.32	
9:12	12.0	11.71	2.35	
9:14	14.0	11.65	2.29	
9:16	16.0	11.58	2.22	
9:18	18.0	11.81	2.45	
9:20	20.0	12.05	2.69	
9:25	25.0	12.26	2.90	
9:30	30.0	12.39	3.03	
9:35	35.0	12.46	3.10	
9:40	40.0	12.49	3.13	
9:45	45.0	12.52	3.16	
9:50	50.0	12.54	3.18	
9:55	55.0	12.55	3.19	
10:00	60.0	12.56	3.20	
10:10	70.0	12.52	3.16	
10:20	80.0	12.50	3.14	
10:30	90.0	12.47	3.11	
10:40	100.0	12.45	3.09	
11:00	120.0	12.53	3.17	
11:20	140.0	12.53	3.17	
11:40	160.0	12.57	3.21	
12:00	180.0	12.59	3.23	

STEP DRAWDOWN TEST
PUMPING STAGE

DATE 15/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	STEP	2
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	50 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.8 l/s
WELL DEPTH	90 m	CAP.	10 l/s		69 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
12:00	0	12.59	3.23	
	0.5	13.67	4.31	
12:01	1.0	14.07	4.71	
	1.5	14.37	5.01	
12:02	2.0	14.13	4.77	
	2.5	13.77	4.41	
12:03	3.0	13.45	4.09	
	3.5	13.22	3.86	
12:04	4.0	12.97	3.61	
	4.5	12.88	3.52	
12:05	5.0	12.84	3.48	
12:06	6.0	13.43	4.04	
12:07	7.0	13.70	4.34	
12:08	8.0	13.90	4.54	
12:09	9.0	14.06	4.70	
12:10	10.0	14.17	4.81	
12:12	12.0	14.24	4.88	
12:14	14.0	14.27	4.91	
12:16	16.0	14.28	4.92	
12:18	18.0	14.28	4.92	
12:20	20.0	14.28	4.92	
12:25	25.0	14.20	4.84	
12:30	30.0	14.16	4.80	
12:35	35.0	14.16	4.80	
12:40	40.0	14.16	4.80	
12:45	45.0	14.17	4.81	
12:50	50.0	14.19	4.83	
12:55	55.0	14.20	4.84	
13:00	60.0	14.20	4.84	
13:10	70.0	14.21	4.85	
13:20	80.0	14.23	4.87	
13:30	90.0	14.20	4.84	
13:40	100.0	14.18	4.82	
14:00	120.0	14.18	4.82	
14:20	140.0	14.00	4.64	
14:40	160.0	14.08	4.72	
15:00	180.0	14.04	4.68	

STEP DRAWDOWN TEST
PUMPING STAGE

DATE 16/07/95 | CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	STEP	3
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	57 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	1.1 l/s
WELL DEPTH	90 m	CAP.	10 l/s		99 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
15:00	0	14.04	4.68	
	0.5			
15:01	1.0	14.20	4.84	
	1.5	14.40	5.04	
15:02	2.0	14.80	5.44	
	2.5	14.90	5.54	
15:03	3.0	15.10	5.74	
	3.5	15.22	5.86	
15:04	4.0	15.33	5.97	
	4.5	15.43	6.07	
15:05	5.0	15.50	6.14	
15:06	6.0	15.64	6.28	
15:07	7.0	15.73	6.37	
15:08	8.0	15.80	6.44	
15:09	9.0	15.85	6.49	
15:10	10.0	15.89	6.53	
15:12	12.0	15.95	6.59	
15:14	14.0	15.97	6.61	
15:16	16.0	16.00	6.64	
15:18	18.0	16.04	6.68	
15:20	20.0	16.05	6.69	
15:25	25.0	16.60	7.24	
15:30	30.0	16.89	7.53	
15:35	35.0	16.99	7.63	
15:40	40.0	17.08	7.72	
15:45	45.0	17.12	7.76	
15:50	50.0	17.16	7.80	
15:55	55.0	17.20	7.84	
16:00	60.0	17.24	7.88	
16:10	70.0	17.30	7.94	
16:20	80.0	17.26	7.90	
16:30	90.0	17.17	7.81	
16:40	100.0	17.19	7.83	
17:00	120.0	17.20	7.84	
17:20	140.0	17.27	7.91	
17:40	160.0	16.97	7.61	
18:00	180.0	16.97	7.61	

STEP DRAWDOWN TEST
PUMPING STAGE

DATE	16/07/95			CONDUCTED BY	WWDE
WELL NO.	5	SWL	9.36 m	STEP	4
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	53 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.9 l/s
WELL DEPTH	90 m	CAP.	10 l/s		80 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
18:00	0	16.97	7.61	
	0.5			
18:01	1.0	16.57	7.21	
	1.5	16.07	6.71	
18:02	2.0	15.64	6.28	
	2.5	15.70	6.34	
18:03	3.0	15.87	6.51	
	3.5	15.97	6.61	
18:04	4.0	16.02	6.66	
	4.5	16.07	6.71	
18:05	5.0	16.10	6.74	
18:06	6.0	16.02	6.66	
18:07	7.0	15.52	6.16	
18:08	8.0	15.14	5.78	
18:09	9.0	14.87	5.51	
18:10	10.0	14.75	5.39	
18:12	12.0	15.23	5.87	
18:14	14.0	15.47	6.11	
18:16	16.0	15.58	6.22	
18:18	18.0	15.63	6.27	
18:20	20.0	15.64	6.28	
18:25	25.0	15.68	6.32	
18:30	30.0	15.74	6.38	
18:35	35.0	15.77	6.41	
18:40	40.0	15.78	6.42	
18:45	45.0	15.78	6.42	
18:50	50.0	15.78	6.42	
18:55	55.0	15.77	6.41	
19:00	60.0	15.76	6.40	
19:10	70.0	15.76	6.40	
19:20	80.0	15.77	6.41	
19:30	90.0	15.77	6.41	
19:40	100.0	15.78	6.42	
20:00	120.0	15.78	6.42	
20:20	140.0	15.79	6.43	
20:40	160.0	15.80	6.44	
21:00	180.0	15.79	6.43	

STEP DRAWDOWN TEST
PUMPING STAGE

DATE 16/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	STEP	5
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	48 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	0.7 l/s
WELL DEPTH	90 m	CAP.	10 l/s		65 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
21:00	0	15.79	6.43	
	0.5			
21:01	1.0	15.40	6.04	
	1.5	14.92	5.56	
21:02	2.0	14.62	5.26	
	2.5	14.40	5.04	
21:03	3.0	14.19	4.83	
	3.5	14.04	4.68	
21:04	4.0	13.80	4.44	
	4.5	13.82	4.46	
21:05	5.0	13.74	4.38	
21:06	6.0	13.95	4.59	
21:07	7.0	14.25	4.89	
21:08	8.0	14.30	4.94	
21:09	9.0	14.37	5.01	
21:10	10.0	14.31	4.95	
21:12	12.0	14.14	4.78	
21:14	14.0	14.04	4.68	
21:16	16.0	13.60	4.24	
21:18	18.0	13.30	3.94	
21:20	20.0	13.23	3.87	
21:25	25.0	13.13	3.77	
21:30	30.0	13.06	3.70	
21:35	35.0	13.70	4.34	
21:40	40.0	13.83	4.47	
21:45	45.0	13.82	4.46	
21:50	50.0	13.79	4.43	
21:55	55.0	13.65	4.29	
22:00	60.0	13.57	4.21	
22:10	70.0	13.34	3.98	
22:20	80.0	13.31	3.95	
22:30	90.0	13.29	3.93	
22:40	100.0	13.19	3.83	
23:00	120.0	13.06	3.70	
23:20	140.0	12.88	3.52	
23:40	160.0	12.79	3.43	
0:00	180.0	12.70	3.34	

STEP DRAWDOWN TEST
RECOVERY

DATE 15/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	DISCHARGE OF THE FINAL STEP	
LOCATION	BATI	PUMP TYPE	Submersible		
OWNER	WSS	HEAD	200 m	0.7	l/s
WELL DEPTH	90 m	CAP.	10 l/s	65	m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
0:00	0	12.70	3.34	
	0.5	12.06	2.70	
0:01	1.0	11.75	2.39	
	1.5	11.47	2.11	
0:02	2.0	11.37	2.01	
	2.5	11.23	1.87	
0:03	3.0	11.14	1.78	
	3.5	11.02	1.66	
0:04	4.0	10.95	1.59	
	4.5	10.80	1.44	
0:05	5.0	10.70	1.34	
0:06	6.0	10.62	1.26	
0:07	7.0	10.59	1.23	
0:08	8.0	10.54	1.18	
0:09	9.0	10.51	1.15	
0:10	10.0	10.49	1.13	
0:12	12.0	10.40	1.04	
0:14	14.0	10.35	0.99	
0:16	16.0	10.30	0.94	
0:18	18.0	10.18	0.82	
0:20	20.0	10.00	0.64	
0:25	25.0	9.78	0.42	
0:30	30.0	9.74	0.38	
0:35	35.0	9.73	0.37	
0:40	40.0	9.72	0.36	
0:45	45.0	9.71	0.35	
0:50	50.0	9.70	0.34	
0:55	55.0	9.69	0.33	
1:00	60.0	9.68	0.32	
1:10	70.0	9.66	0.30	
1:20	80.0	9.65	0.29	
1:30	90.0	9.64	0.28	
1:40	100.0	9.63	0.27	

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
2:00	120	9.60	0.24	
2:20	140	9.57	0.21	
2:40	160	9.56	0.20	
3:00	180	9.53	0.17	
3:30	210	9.51	0.15	
4:00	240	9.49	0.13	
4:30	270	9.47	0.11	
5:00	300	9.44	0.08	
5:30	330	9.41	0.05	
6:00	360	9.38	0.02	
7:00	420	9.37	0.01	
8:00	480	9.36	0.00	

CONTINEOUS DISCHARGE TEST
Data during Pumping Stage obtained
at the Pumped Well

DATE 16/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36 m	STEP	
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	54 mm
OWNER	WSS	HEAD	200 m	DISCHARGE	1.0 l/s
WELL DEPTH	90 m	CAP.	10 l/s		86.4 m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
8:00	0	9.36	0.00	
	0.5	10.96	1.60	
8:01	1.0	11.60	2.24	
	1.5	11.79	2.43	
8:02	2.0	12.00	2.64	
	2.5	13.24	3.88	
8:03	3.0	13.50	4.14	
	3.5	13.92	4.56	
8:04	4.0	12.40	3.04	
	4.5	12.48	3.12	
8:05	5.0	12.30	2.94	
8:06	6.0	12.62	3.26	
8:07	7.0	13.10	3.74	
8:08	8.0	13.37	4.01	
8:09	9.0	13.74	4.38	
8:10	10.0	14.50	5.14	
8:12	12.0	14.40	5.04	
8:14	14.0	14.32	4.96	
8:16	16.0	14.48	5.12	
8:18	18.0	14.58	5.22	
8:20	20.0	14.69	5.33	
8:25	25.0	14.74	5.38	
8:30	30.0	14.76	5.40	
8:35	35.0	15.05	5.69	
8:40	40.0	14.90	5.54	
8:45	45.0	15.07	5.71	
8:50	50.0	15.10	5.74	
8:55	55.0	14.93	5.57	
9:00	60.0	14.94	5.58	
9:10	70.0	15.02	5.66	
9:20	80.0	15.05	5.69	
9:30	90.0	15.22	5.86	
9:40	100.0	15.23	5.87	

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
10:00	120	15.23	5.87	
10:20	140	15.23	5.87	
10:40	160	15.23	5.87	
11:00	180	15.28	5.92	
11:30	210	15.34	5.98	
12:00	240	15.34	5.98	
12:30	270	15.36	6.00	
13:00	300	15.42	6.06	
13:30	330	15.51	6.15	
14:00	360	15.81	6.45	
15:00	420	15.52	6.16	
16:00	480	15.00	6.64	
17:00	540	15.44	6.08	
18:00	600	15.87	6.51	
19:00	660	15.81	6.45	
20:00	720	15.63	6.27	
21:00	780	15.56	6.20	
22:00	840	15.80	6.44	
23:00	900	15.86	6.50	
0:00	960	15.60	6.24	
1:00	1020	15.79	6.43	
2:00	1080	15.42	6.06	
3:00	1140	15.53	6.17	
4:00	1200	15.79	6.43	
5:00	1260	15.86	6.50	
6:00	1320	16.06	6.66	
7:00	1380	16.11	6.75	
8:00	1440	16.26	6.90	

CONTINEOUS DISCHARGE TEST
Data during Recovery Stage obtained
at the Pumped Well

DATE 16/07/95 CONDUCTED BY WWDE

WELL NO.	5	SWL	9.36	m	
LOCATION	BATI	PUMP TYPE	Submersible		DISCHARGE AT THE PUMPING STAGE
OWNER	WSS	HEAD	200	m	1.0 l/s
WELL DEPTH	90 m	CAP.	10	l/s	86.4 m3/day
WELL DIA.	150mm	POSITION	23	GL-m	

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
8:00	0	16.26	6.90	
	0.5	14.79	5.43	
8:01	1.0	14.00	4.64	
	1.5	13.20	3.84	
8:02	2.0	12.42	3.06	
	2.5	12.05	2.69	
8:03	3.0	11.85	2.49	
	3.5	11.68	2.32	
8:04	4.0	11.55	2.19	
	4.5	11.43	2.07	
8:05	5.0	11.33	1.97	
8:06	6.0	11.13	1.77	
8:07	7.0	11.00	1.64	
8:08	8.0	10.81	1.45	
8:09	9.0	10.72	1.36	
8:10	10.0	10.69	1.33	
8:12	12.0	10.64	1.28	
8:14	14.0	10.58	1.22	
8:16	16.0	10.53	1.17	
8:18	18.0	10.48	1.12	
8:20	20.0	10.43	1.07	
8:25	25.0	10.29	0.93	
8:30	30.0	10.15	0.79	
8:35	35.0	9.96	0.60	
8:40	40.0	9.89	0.53	
8:45	45.0	9.85	0.49	
8:50	50.0	9.84	0.48	
8:55	55.0	9.81	0.45	
9:00	60.0	9.80	0.44	
9:10	70.0	9.77	0.41	
9:20	80.0	9.74	0.38	
9:30	90.0	9.72	0.36	
9:40	100.0	9.69	0.33	

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
10:00	120	9.67	0.31	
10:20	140	9.63	0.27	
10:40	160	9.60	0.24	
11:00	180	9.57	0.21	
11:30	210	9.56	0.20	
12:00	240	9.54	0.18	
12:30	270	9.53	0.17	
13:00	300	9.50	0.14	
13:30	330	9.48	0.12	
14:00	360	9.46	0.10	
15:00	420	9.42	0.06	
16:00	480	9.41	0.05	
17:00	540	9.40	0.04	
18:00	600	9.39	0.03	
19:00	660	9.39	0.03	
20:00	720	9.38	0.02	
21:00	780	9.37	0.01	
22:00	840	9.36	0.00	
23:00	900	9.36	0.00	
0:00	960	9.35	-0.01	
1:00	1020	9.35	-0.01	
2:00	1080	9.34	-0.02	
3:00	1140	9.33	-0.03	
4:00	1200	9.32	-0.04	
5:00	1260	9.31	-0.05	
6:00	1320	9.30	-0.06	
7:00	1380	9.29	-0.07	
8:00	1440	9.28	-0.08	

CONTINEOUS DISCHARGE TEST
Data during Pumping Stage obtained
at the observation Well

DATE 16/07/95 CONDUCTED BY WWDE

WELL NO.	4	SWL	8.34 m	STEP	
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	mm
OWNER	WSS	HEAD	200 m	DISCHARGE	l/s
WELL DEPTH	m	CAP.	10 l/s		m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
8:00	0	8.34	0.00	
	0.5	8.35	0.01	
8:01	1.0	8.35	0.01	
	1.5	8.35	0.01	
8:02	2.0	8.35	0.01	
	2.5	8.35	0.01	
8:03	3.0	8.35	0.01	
	3.5	8.35	0.01	
8:04	4.0	8.35	0.01	
	4.5	8.35	0.01	
8:05	5.0	8.35	0.01	
8:06	6.0	8.35	0.01	
8:07	7.0	8.35	0.01	
8:08	8.0	8.35	0.01	
8:09	9.0	8.35	0.01	
8:10	10.0	8.35	0.01	
8:12	12.0	8.35	0.01	
8:14	14.0	8.35	0.01	
8:16	16.0	8.35	0.01	
8:18	18.0	8.35	0.01	
8:20	20.0	8.35	0.01	
8:25	25.0	8.35	0.01	
8:30	30.0	8.35	0.01	
8:35	35.0	8.35	0.01	
8:40	40.0	8.35	0.01	
8:45	45.0	8.35	0.01	
8:50	50.0	8.35	0.01	
8:55	55.0	8.35	0.01	
9:00	60.0	8.35	0.01	
9:10	70.0	8.35	0.01	
9:20	80.0	8.36	0.02	
9:30	90.0	8.36	0.02	
9:40	100.0	8.37	0.03	

TIME	TIME SINCE PUMPING STARTED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
10:00	120	8.37	0.03	
10:20	140	8.37	0.03	
10:40	160	8.37	0.03	
11:00	180	8.37	0.03	
11:30	210	8.38	0.04	
12:00	240	8.38	0.04	
12:30	270	8.38	0.04	
13:00	300	8.38	0.04	
13:30	330	8.38	0.04	
14:00	360	8.38	0.04	
15:00	420	8.38	0.04	
16:00	480	8.38	0.04	
17:00	540	8.39	0.05	
18:00	600	8.40	0.06	
19:00	660	8.40	0.06	
20:00	720	8.40	0.06	
21:00	780	8.40	0.06	
22:00	840	8.40	0.06	
23:00	900	8.40	0.06	
0:00	960	8.40	0.06	
1:00	1020	8.40	0.06	
2:00	1080	8.40	0.06	
3:00	1140	8.41	0.07	
4:00	1200	8.41	0.07	
5:00	1260	8.41	0.07	
6:00	1320	8.42	0.08	
7:00	1380	8.42	0.08	
8:00	1440	8.42	0.08	

CONTINEOUS DISCHARGE TEST
Data during Recovery Stage obtained
at the observation Well

DATE	16/07/95			CONDUCTED BY	WWDE
WELL NO.	4	SWL	8.34 m	STEP	
LOCATION	BATI	PUMP TYPE	Submersible	NOTCH (H)	mm
OWNER	WSS	HEAD	200 m	DISCHARGE	l/s
WELL DEPTH	m	CAP.	10 l/s		m3/day
WELL DIA.	150mm	POSITION	23 GL-m		

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
8:00	0	8.42	0.08	
	0.5	8.42	0.08	
8:01	1.0	8.42	0.08	
	1.5	8.42	0.08	
8:02	2.0	8.42	0.08	
	2.5	8.42	0.08	
8:03	3.0	8.42	0.08	
	3.5	8.42	0.08	
8:04	4.0	8.42	0.08	
	4.5	8.42	0.08	
8:05	5.0	8.42	0.08	
8:06	6.0	8.42	0.08	
8:07	7.0	8.42	0.08	
8:08	8.0	8.42	0.08	
8:09	9.0	8.42	0.08	
8:10	10.0	8.42	0.08	
8:12	12.0	8.41	0.07	
8:14	14.0	8.41	0.07	
8:16	16.0	8.41	0.07	
8:18	18.0	8.41	0.07	
8:20	20.0	8.41	0.07	
8:25	25.0	8.41	0.07	
8:30	30.0	8.41	0.07	
8:35	35.0	8.40	0.06	
8:40	40.0	8.40	0.06	
8:45	45.0	8.40	0.06	
8:50	50.0	8.40	0.06	
8:55	55.0	8.40	0.06	
9:00	60.0	8.40	0.06	
9:10	70.0	8.40	0.06	
9:20	80.0	8.40	0.06	
9:30	90.0	8.40	0.06	
9:40	100.0	8.39	0.05	

TIME	TIME SINCE PUMPING STOPPED (min.)	WATER LEVEL (GL-m)	DRAWDOWN (m)	REMARKS
10:00	120	8.38	0.04	
10:20	140	8.38	0.04	
10:40	160	8.37	0.03	
11:00	180	8.37	0.03	
11:30	210	8.37	0.03	
12:00	240	8.37	0.03	
12:30	270	8.37	0.03	
13:00	300	8.37	0.03	
13:30	330	8.37	0.03	
14:00	360	8.37	0.03	
15:00	420	8.37	0.03	
16:00	480	8.37	0.03	
17:00	540	8.37	0.03	
18:00	600	8.37	0.03	
19:00	660	8.37	0.03	
20:00	720	8.37	0.03	
21:00	780	8.37	0.03	
22:00	840	8.37	0.03	
23:00	900	8.37	0.03	
0:00	960	8.37	0.03	
1:00	1020	8.37	0.03	
2:00	1080	8.37	0.03	
3:00	1140	8.37	0.03	
4:00	1200	8.37	0.03	
5:00	1260	8.37	0.03	
6:00	1320	8.37	0.03	
7:00	1380	8.37	0.03	
8:00	1440	8.37	0.03	

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Calculation of Water Pipeline

Output data on distribution network for Bati Case: Ordinary, 2005

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	20	19.19	0.61	0.06	3.01	110	
2	2	2	3	75	180	0.24	0.05	0.02	0.11	110	
3	3	2	4	200	240	18.95	0.60	0.71	2.94	110	
4	4	4	5	75	260	0.20	0.05	0.02	0.08	110	
5	5	4	6	200	25	18.46	0.59	0.07	2.81	110	
6	6	6	7	100	420	5.88	0.75	4.15	9.88	110	
7	7	7	8	100	320	5.69	0.72	2.98	9.30	110	
8	8	7	10	75	350	-1.41	-0.32	-1.00	-2.85	110	
9	9	10	9	75	460	-1.94	-0.44	-2.37	-5.16	110	
10	10	9	6	150	150	-12.08	-0.68	-0.78	-5.20	110	
11	11	10	17	75	570	-0.63	-0.14	-0.37	-0.64	110	
12	12	17	13	150	50	-7.20	-0.41	-0.10	-1.99	110	
13	13	13	11	150	80	-8.17	-0.46	-0.20	-2.52	110	
14	14	11	12	75	240	0.44	0.10	0.08	0.33	110	
15	15	11	9	150	550	-9.14	-0.52	-1.71	-3.10	110	
16	16	17	15	75	140	0.81	0.18	0.14	1.02	110	
17	17	15	16	75	340	0.42	0.10	0.10	0.30	110	
18	18	15	14	75	240	0.06	0.01	0.00	0.00	110	
19	19	14	13	75	200	-0.89	-0.20	-0.24	-1.22	110	
20	20	10	20	75	480	0.04	0.00	0.00	0.00	110	
21	21	20	21	75	340	2.90	0.66	3.69	10.85	110	
22	22	20	19	150	125	-3.48	-0.20	-0.06	-0.52	110	
23	23	19	24	75	590	0.50	0.11	0.25	0.42	110	
24	24	19	18	150	40	-4.28	-0.24	-0.03	-0.76	110	
25	25	18	17	150	310	-4.62	-0.26	-0.27	-0.88	110	
26	26	18	22	75	290	0.17	0.04	0.02	0.06	110	
27	27	22	23	75	80	0.17	0.04	0.00	0.06	110	
28	28	22	17	75	540	-0.57	-0.13	-0.29	-0.53	110	

Output data on distribution network for Bati Case: Fire Fighting, 2005

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	20	11.62	0.37	0.02	1.19	110	
2	2	2	3	75	180	0.15	0.03	0.00	0.05	110	
3	3	2	4	200	240	11.47	0.37	0.28	1.16	110	
4	4	4	5	75	260	0.13	0.03	0.00	0.03	110	
5	5	4	6	200	25	11.16	0.36	0.03	1.11	110	
6	6	6	7	100	420	3.62	0.46	1.69	4.02	110	
7	7	7	8	100	320	3.56	0.45	1.25	3.90	110	
8	8	7	10	75	350	-0.94	-0.21	-0.48	-1.36	110	
9	9	10	9	75	460	-1.16	-0.26	-0.91	-1.98	110	
10	10	9	6	150	150	-7.23	-0.41	-0.30	-2.01	110	
11	11	10	17	75	570	-0.38	-0.09	-0.14	-0.25	110	
12	12	17	13	150	50	-4.24	-0.24	-0.04	-0.75	110	
13	13	13	11	150	80	-4.84	-0.27	-0.08	-0.96	110	
14	14	11	12	75	240	0.28	0.06	0.03	0.14	110	
15	15	11	9	150	550	-5.45	-0.31	-0.65	-1.19	110	
16	16	17	15	75	140	0.51	0.12	0.06	0.44	110	
17	17	15	16	75	340	0.26	0.06	0.04	0.13	110	
18	18	15	14	75	240	0.04	0.00	0.00	0.00	110	
19	19	14	13	75	200	-0.55	-0.12	-0.10	-0.50	110	
20	20	10	20	75	480	-0.11	-0.02	-0.01	-0.03	110	
21	21	20	21	75	340	1.81	0.41	1.54	4.54	110	
22	22	20	19	150	125	-1.92	-0.11	-0.02	-0.17	110	
23	23	19	24	75	590	0.31	0.07	0.10	0.17	110	
24	24	19	18	150	40	-2.42	-0.14	-0.01	-0.27	110	
25	25	18	17	150	310	-2.66	-0.15	-0.10	-0.32	110	
26	26	18	22	75	290	0.13	0.03	0.01	0.04	110	
27	27	22	23	75	80	0.11	0.02	0.00	0.03	110	
28	28	22	17	75	540	-0.34	-0.08	-0.11	-0.20	110	

Output data on distribution network for Bati Case: Ordinary, 2010

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia. (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	20	27.77	0.88	0.12	5.97	110	
2	2	2	3	75	180	0.34	0.08	0.04	0.21	110	
3	3	2	4	200	240	27.43	0.87	1.40	5.84	110	
4	4	4	5	75	260	0.29	0.07	0.04	0.15	110	
5	5	4	6	200	25	26.72	0.85	0.14	5.56	110	
6	6	6	7	100	420	8.52	1.08	8.23	19.61	110	
7	7	7	8	100	320	8.24	1.05	5.90	18.45	110	
8	8	7	10	75	350	-2.04	-0.46	-1.99	-5.68	110	
9	9	10	9	75	460	-2.81	-0.64	-4.70	-10.22	110	
10	10	9	6	150	150	-17.48	-0.99	-1.54	-10.30	110	
11	11	10	17	75	570	-0.91	-0.21	-0.73	-1.28	110	
12	12	17	13	150	50	-10.42	-0.59	-0.20	-3.95	110	
13	13	13	11	150	80	-11.82	-0.67	-0.40	-5.00	110	
14	14	11	12	75	240	0.64	0.14	0.16	0.66	110	
15	15	11	9	150	550	-13.22	-0.75	-3.38	-6.14	110	
16	16	17	15	75	140	1.16	0.26	0.28	2.00	110	
17	17	15	16	75	340	0.61	0.14	0.21	0.61	110	
18	18	15	14	75	240	0.08	0.02	0.00	0.02	110	
19	19	14	13	75	200	-1.29	-0.29	-0.48	-2.41	110	
20	20	10	20	75	480	0.06	0.01	0.00	0.00	110	
21	21	20	21	75	340	4.20	0.95	7.32	21.52	110	
22	22	20	19	150	125	-5.04	-0.29	-0.13	-1.03	110	
23	23	19	24	75	590	0.72	0.16	0.49	0.82	110	
24	24	19	18	150	40	-6.20	-0.35	-0.06	-1.51	110	
25	25	18	17	150	310	-6.70	-0.38	-0.54	-1.74	110	
26	26	18	22	75	290	0.24	0.06	0.03	0.11	110	
27	27	22	23	75	80	0.25	0.06	0.00	0.12	110	
28	28	22	17	75	540	-0.83	-0.19	-0.57	-1.06	110	

Output data on distribution network for Bati Case: Fire Fighting, 2010

Serial Number	Pipeline Number	Nord Number Start	Nord Number End	Dia (mm)	Pipeline Length(m)	Flow (liter/sec.)	Velocity (m/sec.)	Hydraulic Gradient (m/1000)	Loss of Head (m)	Velocity Coefficient	Remarks
1	1	1	2	200	20	33.99	1.08	0.17	8.68	110	
2	2	2	3	75	180	0.21	0.05	0.02	0.08	110	
3	3	2	4	200	240	33.78	1.08	2.06	8.58	110	
4	4	4	5	75	260	0.18	0.04	0.02	0.06	110	
5	5	4	6	200	25	33.34	1.06	0.21	8.37	110	
6	6	6	7	100	420	8.53	1.09	8.26	19.66	110	
7	7	7	8	100	320	5.14	0.65	2.47	7.70	110	
8	8	7	10	75	350	1.94	0.44	1.80	5.15	110	
9	9	10	9	75	460	-3.54	-0.80	-7.20	-15.66	110	
10	10	9	6	150	150	-24.36	-1.38	-2.85	-19.02	110	
11	11	10	17	75	570	1.35	0.30	1.49	2.62	110	
12	12	17	13	150	50	-17.69	-1.00	-0.53	-10.53	110	
13	13	13	11	150	80	-19.04	-1.08	-0.96	-12.05	110	
14	14	11	12	75	240	0.40	0.09	0.07	0.28	110	
15	15	11	9	150	550	-19.92	-1.13	-7.21	-13.10	110	
16	16	17	15	75	140	0.27	0.06	0.02	0.13	110	
17	17	15	16	75	340	0.38	0.09	0.09	0.25	110	
18	18	15	14	75	240	-0.41	-0.09	-0.07	-0.30	110	
19	19	14	13	75	200	-1.27	-0.29	-0.47	-2.37	110	
20	20	10	20	75	480	3.12	0.71	5.96	12.41	110	
21	21	20	21	75	340	2.62	0.59	3.06	8.99	110	
22	22	20	19	150	125	-16.73	-0.95	-1.19	-9.49	110	
23	23	19	24	75	590	0.45	0.10	0.20	0.35	110	
24	24	19	18	150	40	-17.45	-0.99	-0.41	-10.26	110	
25	25	18	17	150	310	-16.50	-0.93	-2.87	-9.25	110	
26	26	18	22	75	290	-1.11	-0.25	-0.53	-1.82	110	
27	27	22	23	75	80	0.15	0.03	0.00	0.05	110	
28	28	22	17	75	540	-1.77	-0.40	-2.34	-4.33	110	

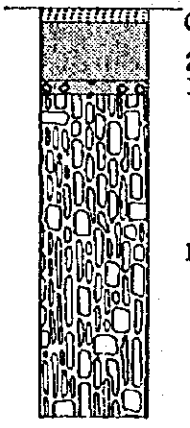
Appendix - 13

Geological Logs of Existing Boreholes

WSS Borehole No.1 in Bati

Depth	Lithology
0 - 12 m	Top Soil
12 - 14 m	Clay
14 - 16 m	Decomposed Rock
16 - 18 m	Cobbles
18 - 20 m	Decomposed Rock
20 - 95 m	Hard Rock

WSS Borehole No.2 in Bati



Depth	Lithology
0 - 2 m	Top Soil
2 - 10 m	Light Brown Clay
10 - 12 m	Clay and Gravel
12 - 57 m	Basalt

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