APPENDIX C

WATER QUALITY ANALYSIS

APPNDIX C
WATER QUALITY ANALYSIS

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APPENDIX C WATER QUALITY ANALYSIS

GENERAL

Periodical water quality analysis has been conducted to examine the current status of the existing water sources. Water sampling has been carried out every month starting from May 2001 to March 2002. Sampling has been carried out by YCDC, and Myanmar Science Technological Research Department (MSTRD) has executed water quality analysis.

Based on the results of analysis, which will be continued almost a year, water treatment method and prospected new water source will be proposed.

1 WATER QUALITY OF EXISTING WATER SUPPLY SYSTEMS

Water quality in the existing water resources, surface water and ground water, and water treatment process were examined to grasp the current water quality in the system.

1.1 METHODOLOGY

1.1.1 Examination Parameters and Possibility Of Laboratory

Water quality examination parameters were selected to contribute for determination of appropriate water treatment process for the proposed plant. The selected parameters are as follows:

Table C.1 Selected Examination Parameters

Bacteriological	BOD, Dissolved Oxygen,
Physical	Temperature, Color, Turbidity,
Chemical	Hardness, Alkalinity, pH, COD, Arsenic, Cadmium,
Cations	Calcium, Magnesium, Potassium, Sodium,
Anions	Chloride, Sulfide, Cyanide, Nitrate, Nitrogen-Ammonia,
Trace Elements	Iron, Manganese, Zinc, Copper, Lead,

YCDC doesn't possess their own water quality analysis laboratory. Water quality analysis equipment only exists in laboratory of the Ministry of Health and Myanmar Scientific and Technological Research Department (MSTRD). However, the former can conduct microbiology test but they cannot perform the most indices of physicochemical examination. While, MSTRD can examine all the indices described above excluding Electric Conductivity.

Based on the abovementioned current situation, water sampling will be conduced by YCDC and water quality analysis will be contracted out to MSTRD. Electric conductivity will be meas-

ured by YCDC counterpart, as one of the technology transfer, using EC meter brought by the Study Team.

1.1.2 Selective Criteria of Water Sampling

Targets of water quality analysis are the existing reservoirs, tube wells and another reservoir and rivers as prospective future water source. Monthly water sampling will be carried out from May 2001 to March 2002 to grasp the seasonal water quality fluctuation in abovementioned water sources. Sampling points in reservoirs shall be intake tower and that of in rivers are selected in connection with saline water intrusion. As to groundwater, tube wells within the areas where having water quality issues were extracted to examine the effective countermeasures. Tube wells with different aquifers were selected. The followings are the details on selected sampling points.

(1) Present Water Supply Systems

The water resources of the existing water supply system are Reservoirs and Tube Wells.

<Reservoirs: Gyobyu, Phugyi and Hlawga>

In Gyobyu and Pugyi Reservoirs, water samples were taken at upstream of intake tower. Sampling depth is 0.5 m to prevent the intrusion of phytoplankton. In Hlawga Reservoir, surface water was taken in front of the intake screen of Hlawga No.1 P/S.

Since Hlawga Reservoir is located in north of Yangon City, near to the residential areas, possibility of future water contamination and eutrophication shall be considered. Incoming water from Phugyi Reservoir was taken once to determine the necessity and method of detailed analysis.

<Tube Wells>

Groundwater in the confined aquifer is not osculated long term with air. Therefore, groundwater characteristics in terms of quality will be soon decomposed comparatively by the time of osculation with air when it is pumped up to the ground.

Consequently, it was evaluated that Exponent of Hydrogen Ion (pH) was examined as nearly R-pH (saturated pH) value or alkaline side and Iron Ion Concentration (Fe) was observed as lower value, respectively. Therefore, sampling of raw groundwater shall be conducted with the utmost care.

Following are selective criteria of tube wells for groundwater sampling.

- Pumping Unit
- Well Structures
- Operation Condition and
- Water Quality Problems

Submersible pump shall be selected to avoid the variation of water quality under the process of aeration. When groundwater is pumped using air compressor, Fe concentration will be lower than raw water while pH vale will be higher.

Deeper and shallower tube well depths shall be selected to compare the quality with different aquifers. Also smaller well diameter may be chose for small osculation rate between water and well materials. Selected wells shall be utilized daily.

Majority of water quality problems in Yangon City are:

(a) Saline/Brackish Groundwater Cl Ion
(b) Ironic Groundwater Fe Ion
(c) Acidic Groundwater pH Value

Following are selected Tube Wells for groundwater sampling.

Table C.2 List of Tube Well Sites for Water Sampling

Location		*Well Structures*		*Discharge*
Township	*Tube Well No.*	*Diameter* (inch)	*Depth* (feet)	(gph)
Ahlone	L 1 (No.1)	12"	380'	10,000
	L 7 (No.7)	12"	165'	15,000
Botataung	No. 2 (No.11)	8"	145'	20,000
	No. 4 (No.13)	8"	120'	8,000
Dagon	Manaw Hari (No.14)	8"	130'	9,000
Insein	No. 1 (No.74)	12"	210'	6,500
Kyeemyindaing	No. 8 (No.108)	10"	143'	15,000
Thaketa	Tha/1 (No.187)	6"	360'	3,000
	Tha/16 (No.197)	8"	85'	3,000
Thingangyun	Thuwana (No.208)	6"	475'	15,000
	Lay Dauntken (No.212)	6"	175'	3,000

Note) (No.1) shows the Tube Well No. indicated in the location map (Figure C-2)

(2) Candidate Water Sources to be developed for Future Demand

YCDC proposed River Water and other reservoirs as prospective future water source.

<River Water>

Based on the newest report issued by YCDC in 1993, water samples will be taken in Hlaing River, which was regarded as the most prospective future water source. Further, Bago River, located in the east of Yangon running to the north, shall also be ex-

amined as alternative source.

At Hlaing River, water samples are taken at Gwedanshe, proposed intake point and at Baw Le Kyun, confluent point with tributary called Bawle River. Samples were taken in the center of river. In said two points, samples were taken in Upper, Middle and Lower Layer to confirm the effluent of saline water. Water depth was measured as well.

While, two sampling points of Bago River were temporary selected since there were no available data on saline water intrusion.

<Reservoirs>

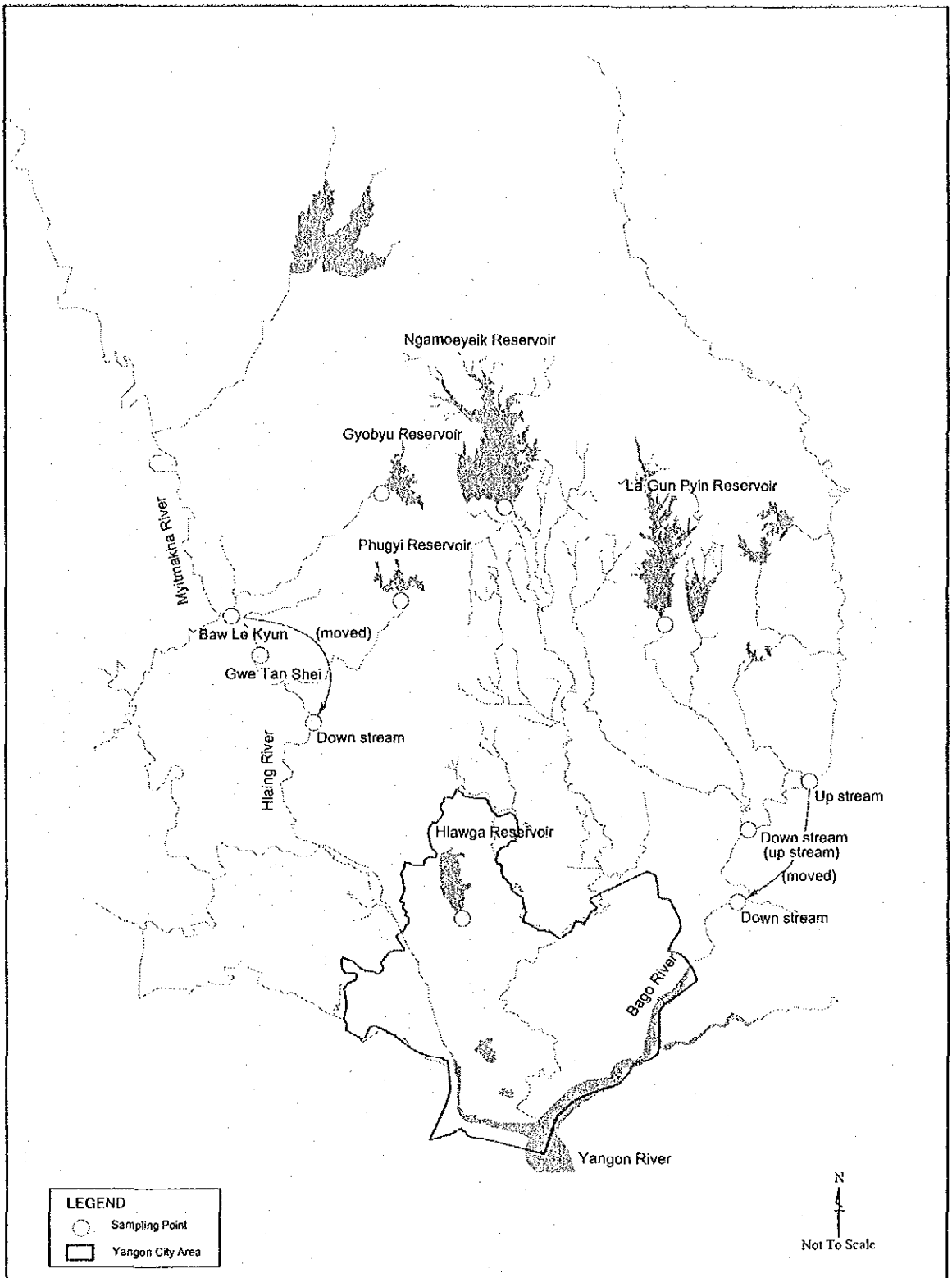
Prospective future water sources are Ngamoyeik reservoir and La Gun Pyin reservoir. In these reservoirs, water samples were taken in front of intake tower and sampling depth was set at 0.5 m to prevent the intrusion of phytoplankton.

Table C.3, Figure C-1 to C-3 are showing these sampling points.

Table C.3 Original Water Sampling Points

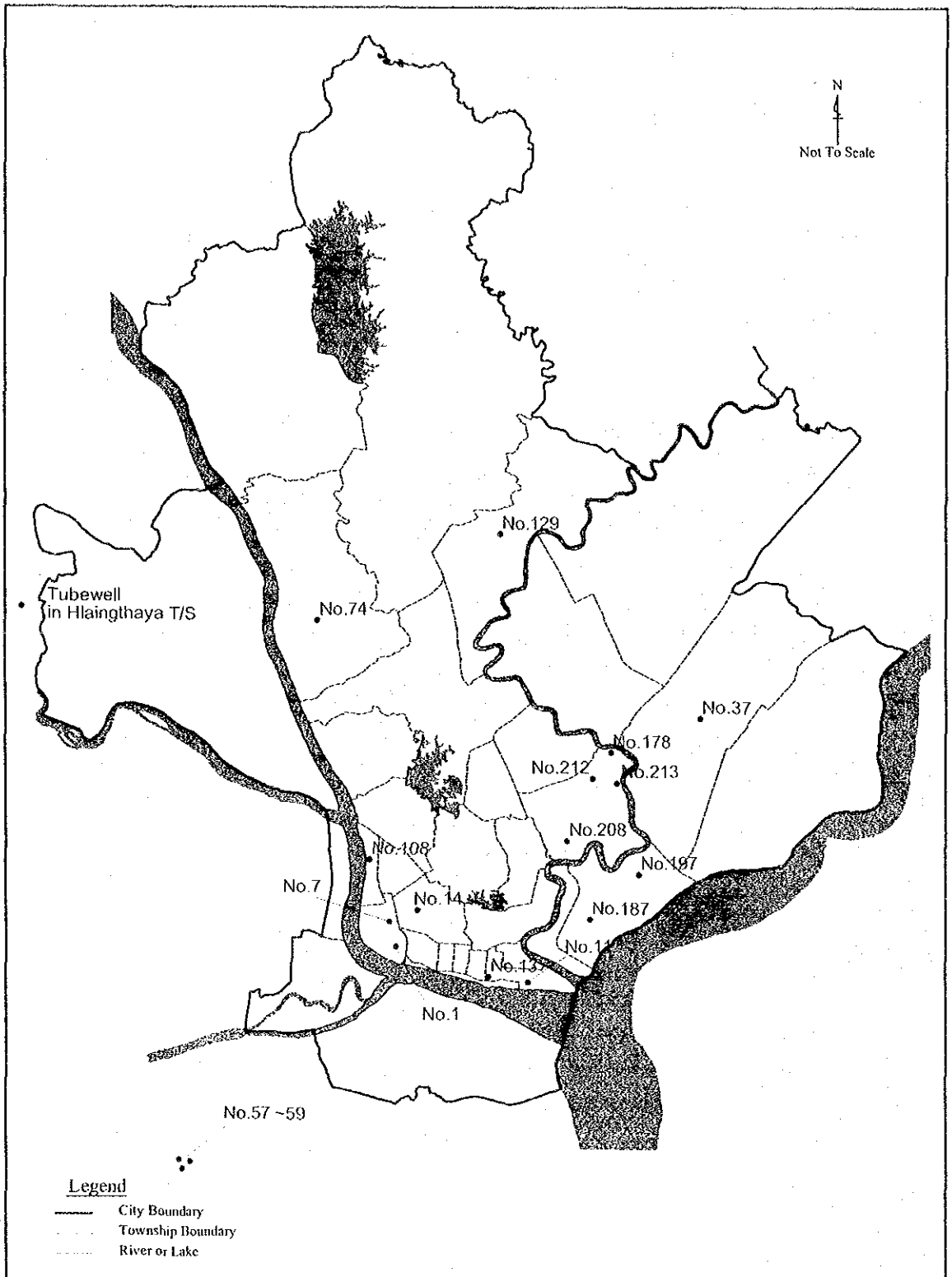
Sampling Points		Sampling Number	Remarks
Existing Reservoirs	Gyobyu Reservoir	1	
	Phugyi Reservoir	1	
	Hlawga Reservoir	1	
Planned Reservoirs	Ngamoeyeik Reservoir	1	
	La Gun Pyin Reservoir	1	
Rivers	Hlaing River	12	High and low tide, 2 points 3 depth (upper, middle, lower)
	Bago River	12	Ditto
Tube Wells		11	
	Total	40	

In the course of survey, the team examined water quality analysis results and in case of river water, there were no remarkable change in water quality by sampling depth. Therefore, the team changed sampling points for further effective water quality analysis to grasp the existing water quality status of Yangon City. Sampling in two rivers will be conducted in middle layer only during high and low tides. To compensate the sample number decrease by this alternation, tube well sample number was increased from 11 to 19. Further, eight samples are taken from water supply system, namely service reservoir and faucets. As aforementioned in the previous Sections, current chlorination in Yangon is quite insufficient and also, there is great possibility of water contamination due to pipe deterioration. For these eight samples taken from water



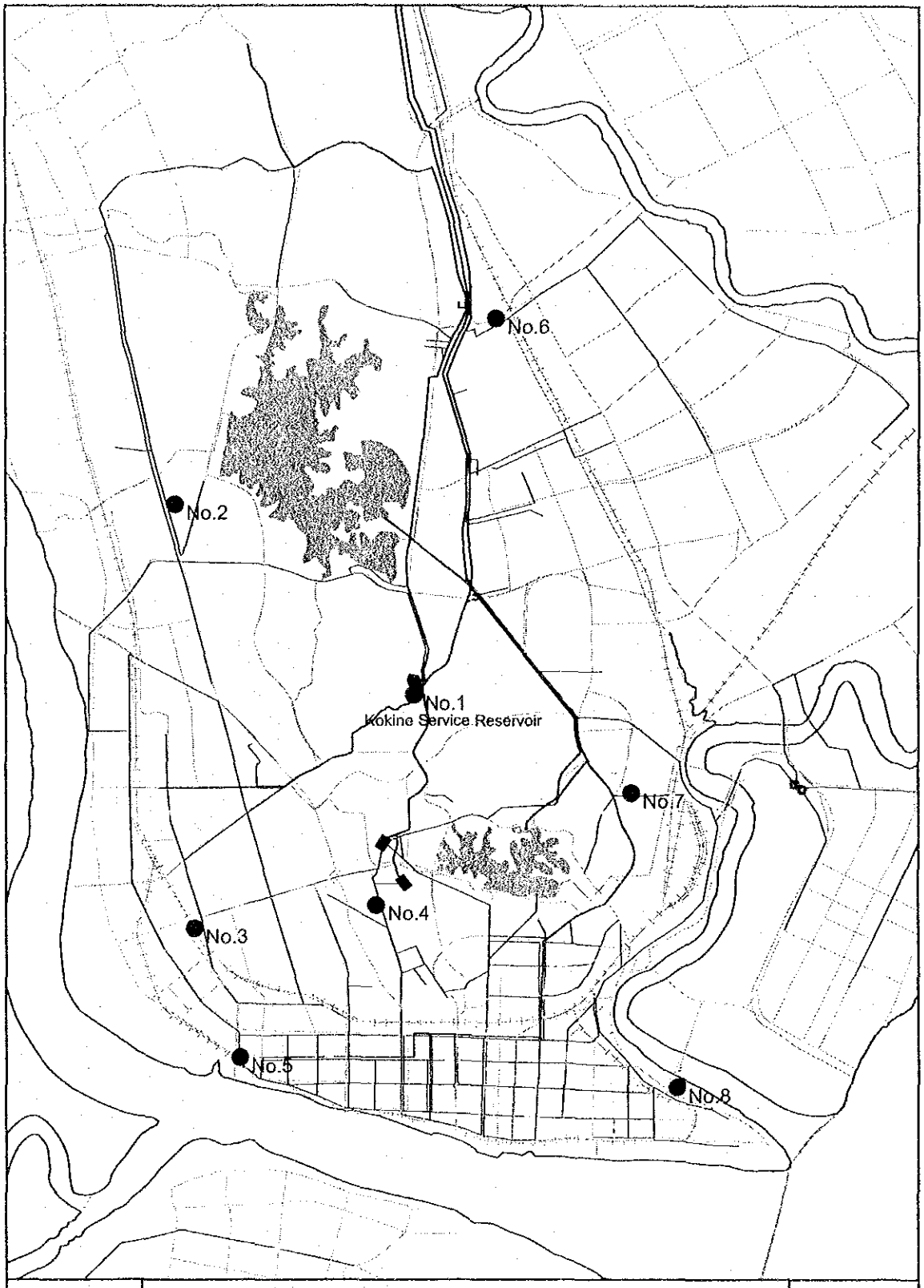
Note) Sampling points of Hlaing and Bago River were moved to down stream in September 2001.

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG C-1
	Location Map of Sampling Points	



Note) 8 wells (No.37, 57 to 59, 129, 178, 213, HT) were added in September 2001.

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG C-2
	Location Map of YCDC Tube Wells for Water Sampling	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR
Location Map of Sampling Points from Water Supply System	FIG C-3

supply system, E-Coliform and Standard Plate Count Bacteria Test was added to confirm the said contamination. Revised sampling number and sampling location is also shown in the figures and table below;

Table C.4 Revised Water Sampling Points

Sampling Points		Sampling Number	Remarks
Existing Reservoirs	Gyobyu Reservoir	1	
	Phugyi Reservoir	1	
	Hlawga Reservoir	1	
Planned Reservoirs	Ngamoeyeik Reservoir	1	
	La Gun Pyin Reservoir	1	
Rivers	Hlaing River	4	High and low tide, 2 points 1 depth (middle)
	Bago River	4	Ditto
Water Supply Facility	Kokine Service Reservoir	1	
	Faucets	7	
Tube Wells		19	
	Total	40	

River water sampling points in upstream were moved to downstream based on the results of saline water intrusion survey, which is described in the following section. The following table shows the specifications of additional tube wells selected;

Table C.5 List of Additional Tube Well Sites for Water Sampling

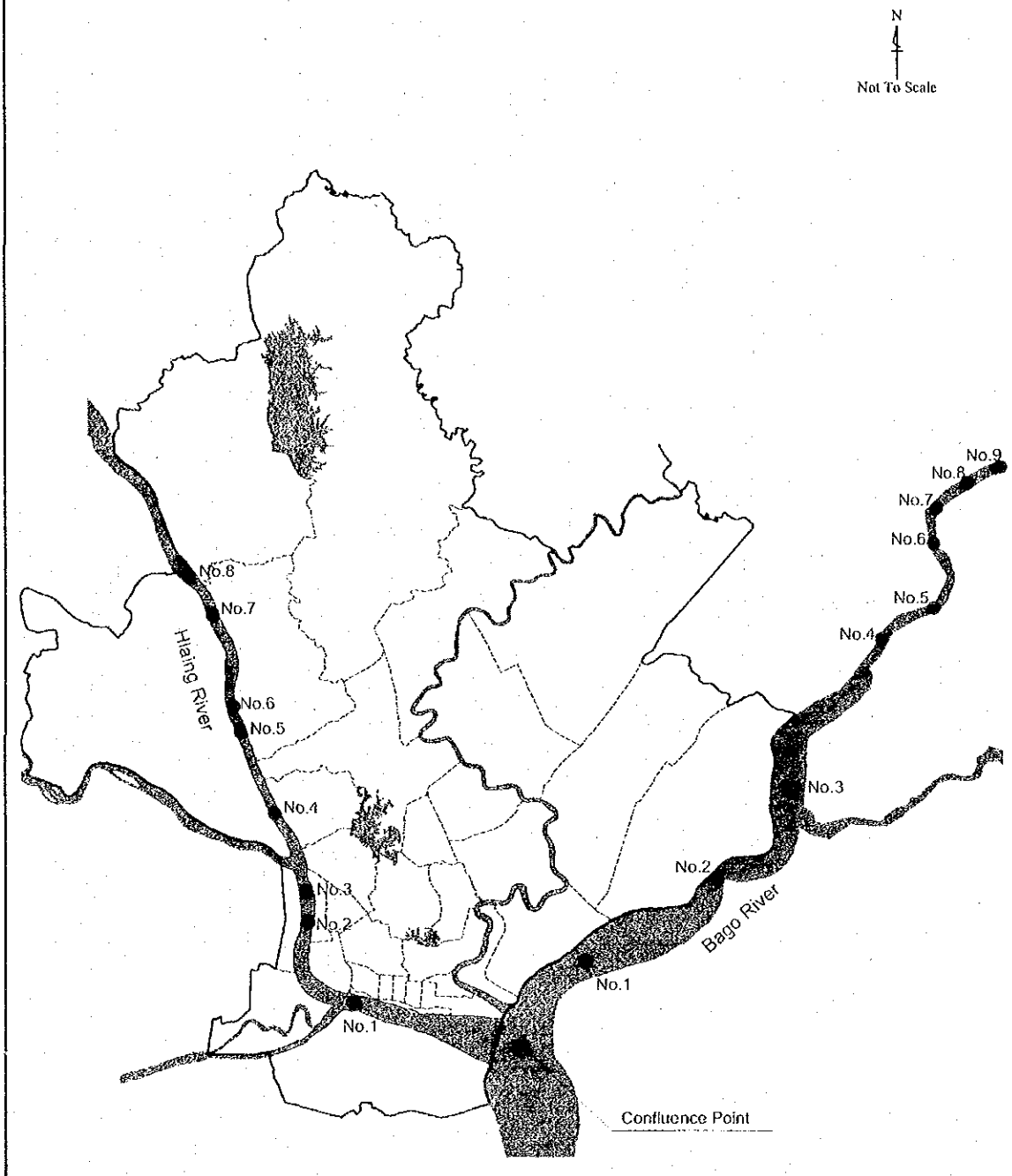
Location		*Well Structures*		*Discharge*
Township	*Tube Well No.*	*Diameter* (inch)	*Depth* (feet)	(gph)
Thingangyun	Thanthnmar (No.213)	8"	180'	3,000
Dagon South	Malar Myaing (No.37)	4"	202'	2,500
North Okkalapa	Wai Bar Gi (No.129)	8"	380'	5,000
South Okkalapa	Yadanar Bon (No.178)	8"	390'	10,000
Dala	Yangon Pauk (No.57)	12"	120'	30,000
	Yangon Pauk (No.58)	12"	120'	30,000
	Yangon Pauk (No.59)	12"	120'	30,000
Hlaingthaya	Thebyu Village	12"	200'	25,000

From September 2001, sampling was conducted based on these revised points.

(3) Saline Water Intrusion Survey

1) Rainy Season

Saline water intrusion survey was conducted at Bago and Hlaing River on 23 and 24 August 2001. Sampling points are shown in Figure C-4 and the results are described



Legend

- City Boundary
- Township Boundary
- River or Lake
- Sampling Points

Note) Conflunce point is about 34.5km upstrean of river mouth flowing into Audaman Sea

JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG C-4
	Location Map of Saline Water Intrusion Survery Sampling Points (Rainy Season)	

Table C.6 Hlaing River Saline Water Intrusion Survey (Rainy Season)

Date : 24 August 2001

No.	Sampling Time	Water Depth (m)	Sampling Depth (m)	E.C.	Cl⁻	pH	ORP	Remarks
				μS/cm	mg/L	-	mV	
1-L	AM 7:25	10	10	12,700	3,316	7.5	315	Turbidity = 180, T = 29.7℃
1-M	7.26	10	5	12,600	3,289	7.5	316	Turbidity = 140, T = 29.8℃
1-U	7:28	10	0.5	12,500	3,262	7.5	316	Turbidity = 140, T = 29.8℃
2-L	7:45	10	10	12,600	3,289	7.5	298	Turbidity = 170, T = 29.8℃
2-M	7:46	10	5	12,600	3,289	7.5	299	Turbidity = 140, T = 29.8℃
2-U	7:47	10	0.5	12,600	3,289	7.5	300	Turbidity = 140, T = 29.8℃
3-L	8:20	10	10	12,900	3,369	7.5	276	T = 29.8℃
3-M	8:21	10	5	12,800	3,342	7.5	279	T = 29.8℃
3-U	8:22	10	0.5	12,800	3,342	7.5	278	T = 29.8℃
4-L	8:35	4.5	4.5	12,900	3,369	7.5	277	T = 29.8℃
4-M	8:36	4.5	2.5	12,800	3,342	7.5	279	T = 29.8℃
4-U	8:37	4.5	0.5	12,800	3,342	7.5	279	T = 29.8℃
5-L	9:20	10	10	13,100	3,422	7.5	258	T = 29.7℃
5-M	9:21	10	5	13,100	3,422	7.6	262	T = 29.8℃
5-U	9:22	10	0.5	13,100	3,422	7.6	263	T = 29.8℃
6-L	10:40	10	10	13,600	3,556	7.6	246	T = 29.7℃
6-M	10:41	10	5	13,500	3,529	7.6	248	T = 29.8℃
6-U	10:42	10	0.5	13,400	3,502	7.5	252	T = 29.8℃
7-L	10:55	10	10	13,500	3,529	7.6	259	T = 29.7℃
7-M	10:56	10	5	13,500	3,529	7.5	265	T = 29.7℃
7-U	10:57	10	0.5	13,500	3,529	7.6	261	T = 29.8℃
8-L	11:10	10	10	13,500	3,529	7.5	267	T = 29.7℃
8-M	11:11	10	5	13,500	3,529	7.5	268	T = 29.7℃
8-U	11:12	10	0.5	13,500	3,529	7.5	266	T = 29.6℃

U = Upper, M = Middle, L = Lower Layer

Table C.7 Bago River Saline Water Intrusion Survey (Rainy Season)

Date : 23 August 2001

No.	Sampling Time	Water Depth (m)	Sampling Depth (m)	E.C.	Cl^-	pH	ORP	Remarks
				μS/cm	mg/L	-	mV	
1	AM 4:43	0.5	0.5	11,800	3,076	7.6	350	
2	5:10	0.5	0.5	10,800	2,809	7.36	290	
3	5:12	3.0	3.0	10,600	2,755	7.26	293	
4-L	6:40	4.6	4.6	7,800	2,009	7.3	289	Turbidity = 140, T = 29℃
4-M	6:42	4.6	2.6	7,900	2,035	7.2	293	Air = 27.5℃
4-U	6:43	4.6	0.5	8,000	2,062	7.1	298	
5	7:20	—	—	8,000	2,062	6.9	295	
6-L	7:55	7.0	7.0	9,200	2,382	7.1	283	Turbidity = 400, T = 29℃
6-M	7:56	7.0	3.5	9,200	2,382	7.1	283	
6-U	7:57	7.0	0.5	9,200	2,382	7.1	285	
7-L	8:20	4.8	4.8	9,800	2,542	7.2	275	Turbidity = 300, T = 29.6℃
7-M	8:21	4.8	2.8	9,800	2,542	7.1	279	
7-U	8:22	4.8	0.5	9,700	2,515	7.1	279	8:45 trace back was stopped at No.7
8-L	8:45	4.9	4.9	10,000	2,595	7.1	285	Turbidity = 300, T = 29℃
8-M	8:46	4.9	2.9	9,900	2,569	7.1	287	
8-U	8:47	4.9	0.5	9,900	2,569	7.1	286	
9-L	9:05	3.7	3.7	10,500	2,729	7.3	286	Turbidity = 400, T = 29℃
9-M	9:06	3.7	1.7	10,400	2,702	7.2	288	
9-U	9:07	3.7	0.5	10,100	2,622	7.2	286	
10-L	9:45	5.9	5.9	11,300	2,942	7.2	264	Turbidity = 500, T = 29.3℃, Flow down
10-M	9:46	5.9	3.9	11,300	2,942	7.2	264	Turbidity = 400, T = 29.3℃
10-U	9:47	5.9	0.5	11,200	2,916	7.2	270	Turbidity = 400, T = 29.3℃
11-L	10:50	6.7	6.7	12,300	3,209	7.2	255	Turbidity = 1000, T = 29.3℃
11-M	10:54	6.7	5.7	12,200	3,182	7.1	264	Turbidity = 700, T = 29.4℃
11-U	10:55	6.7	0.5	12,300	3,209	7.2	262	Turbidity = 400, T = 29.5℃

U = Upper, M = Middle, L = Lower Layer

Figure C-5 Parameters Fluctuation (Hlaing River in Rainy Season)

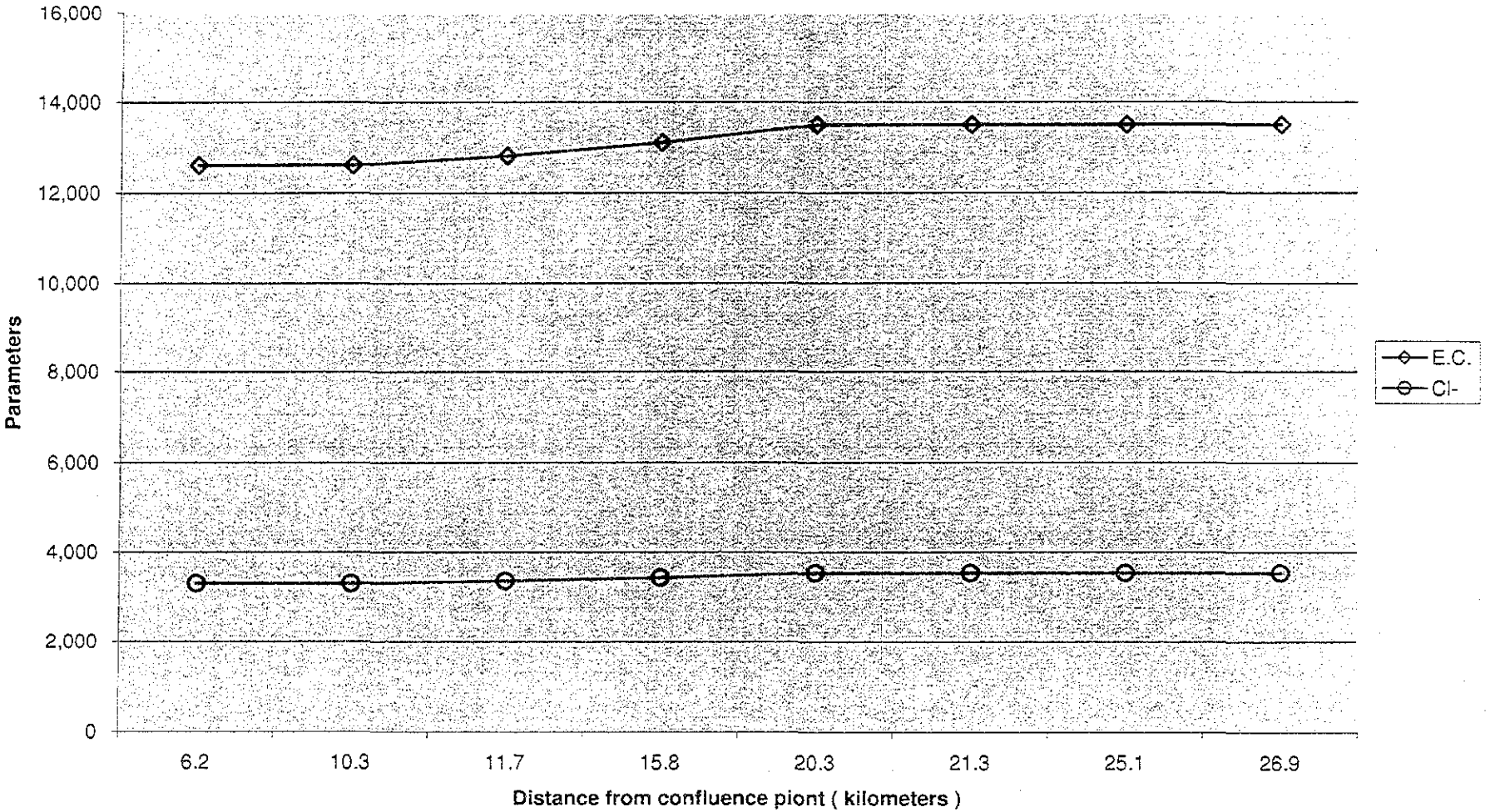
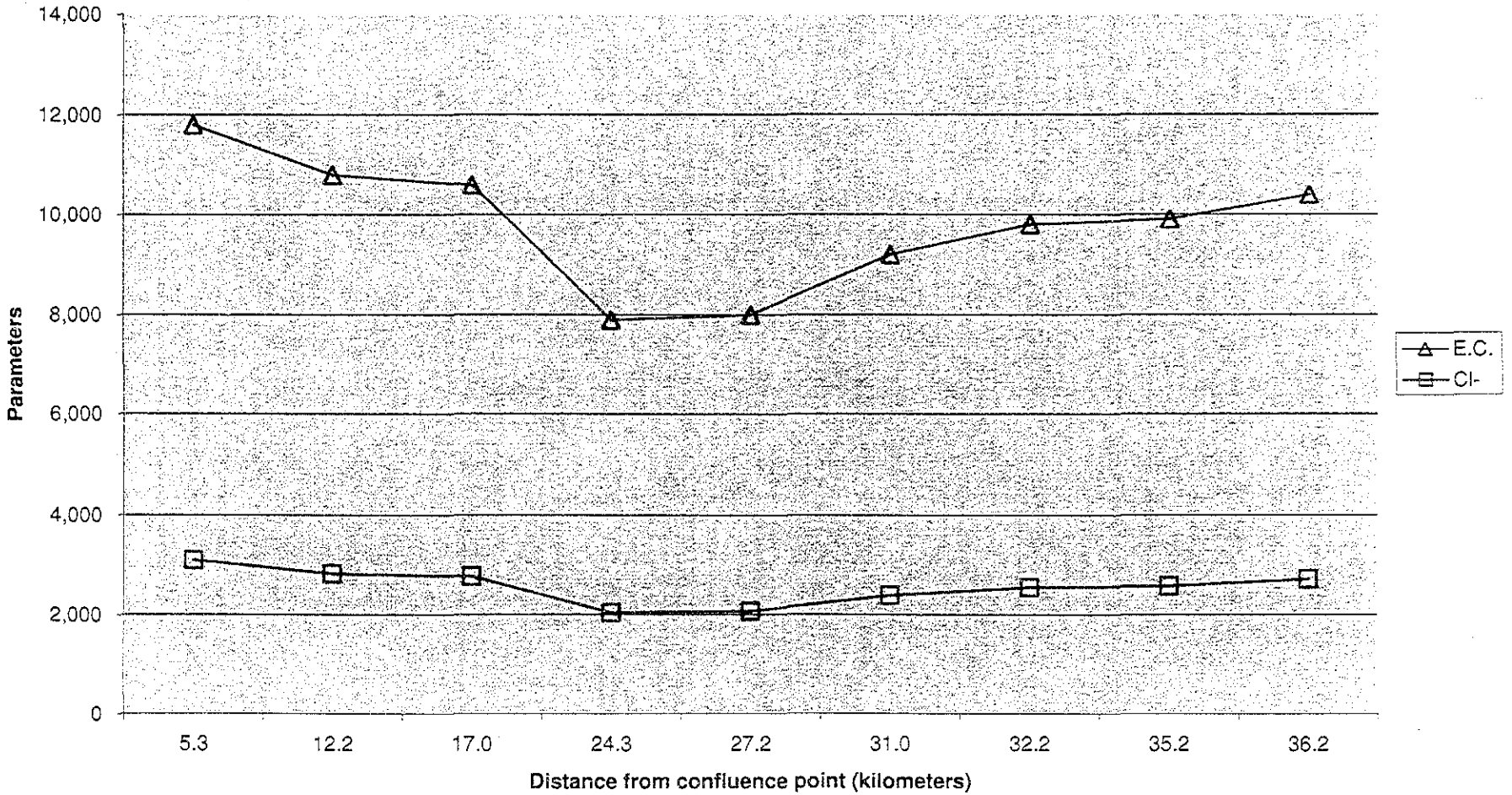


Figure C-6 Parameters Fluctuation (Bago River in Rainy Season)



in Table C.6 to C.7 and Figure C-5 to C-6, showing no trance of saline water.

2) Dry Season

Saline water intrusion survey was conducted again Hlaing River on 23 to 24 January 2002. Sampling points are shown in Figure C-7 starting from Thilawa port to Wataya. Electric conductivity was measured during this survey and results are described in Table C.8. Excluding three points, namely Thilawa, Yangon Port and Wataya, samples were taken in three depths, upper, middle and lower layer.

Table C.8 E.C. value measured in Hlaing River (Dry Season)

No.	Sampling Points	Sampling Time	Distance from Andaman Sea (km)	E.C.(μS/cm)		
				Upper	Middle	Lower
				0.5 m	10 m	20 m
1	Thilawa	23 Jan, 10:30	24.5	11,700		
2	Yangon Port	23 Jan, 9:30	34.5	2,982		
3	Sinmin	24 Jan, 10:50	43.0	1,711	2,010	2,010
4	Bargayar	24 Jan, 10:10	45.0	942	988	1,051
5	Bayint Naung Bridge	24 Jan, 12:00	51.0	973	936	1,001
6	Aungzaya Bridge	24 Jan, 12:30	54.0	856	887	874
7	Shwepitha Bridge	24 Jan, 13:00	59.5	275	284	304
8	Wataya	24 Jan, 13:35	65.0	258		

Based on the results and location of sampling points, distance from Andaman Sea, the following correlation formula was figured out;

$$E.C. = 3 \times 10^{9} \times X^{-3.8421}$$

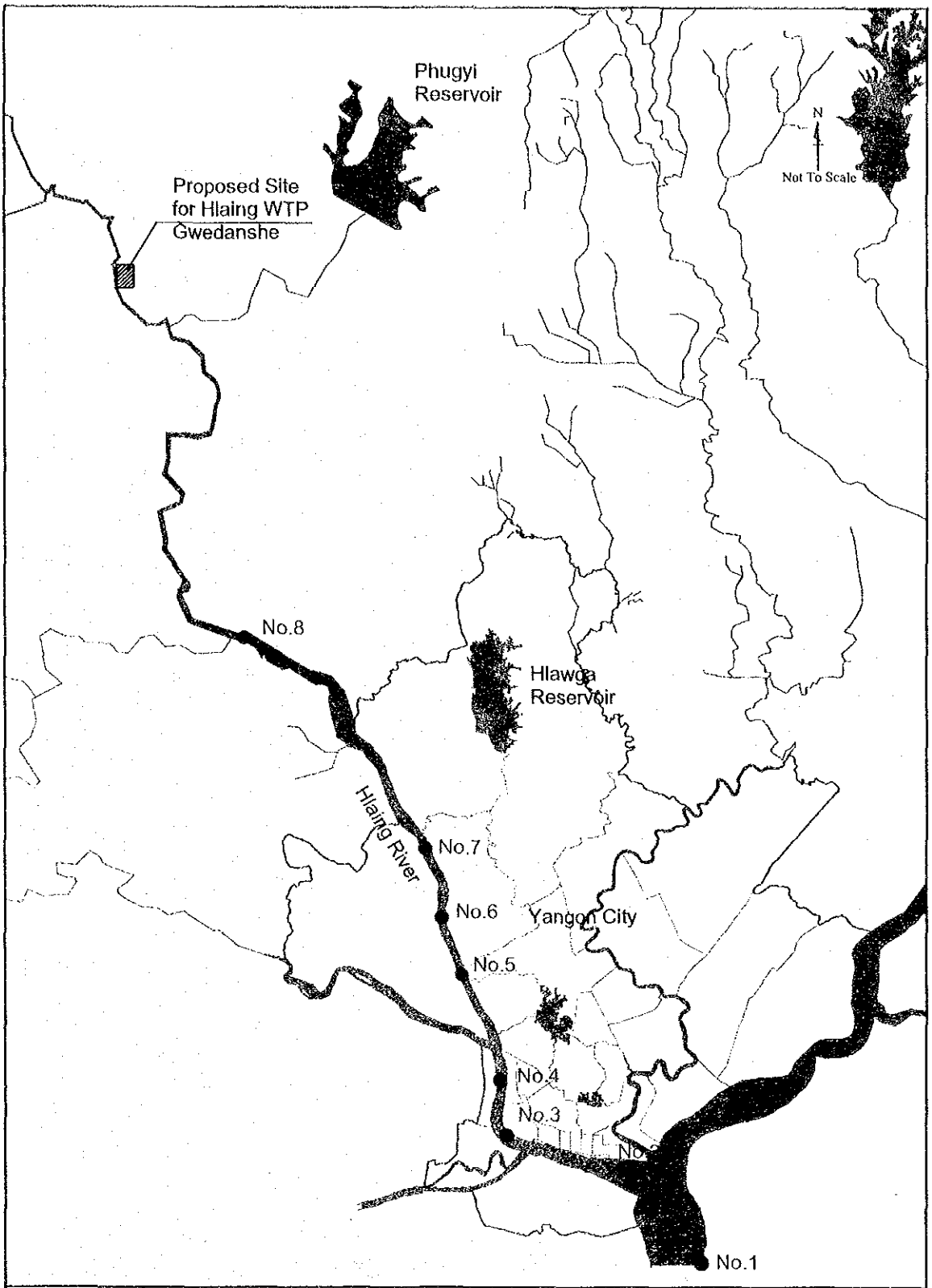
Where, X : Distance from Andaman Sea (km)
Correlation rate was 0.9554

Figure C-8 shows the said correlation between E.C. value and sampling points' distance from Andaman Sea.

The followings are the conclusion of this saline intrusion survey;

No.	E.C. value (μS/cm)	Comments
1	11,700	Brackish water
2	2,982	Brackish water (lower limit)
3 to 6	1,711 to 856	Slightly affected by brackish water
7 to 8	304 to 258	Fresh water

Because the proposed intake site, Gwedanshe, is located 15 km upstream of Wataya (No.8), target river water was determined as free from saline water intrusion.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG C-7
	Location Map of Saline Water Intrusion Survey Sampling Points (Dry Season)	

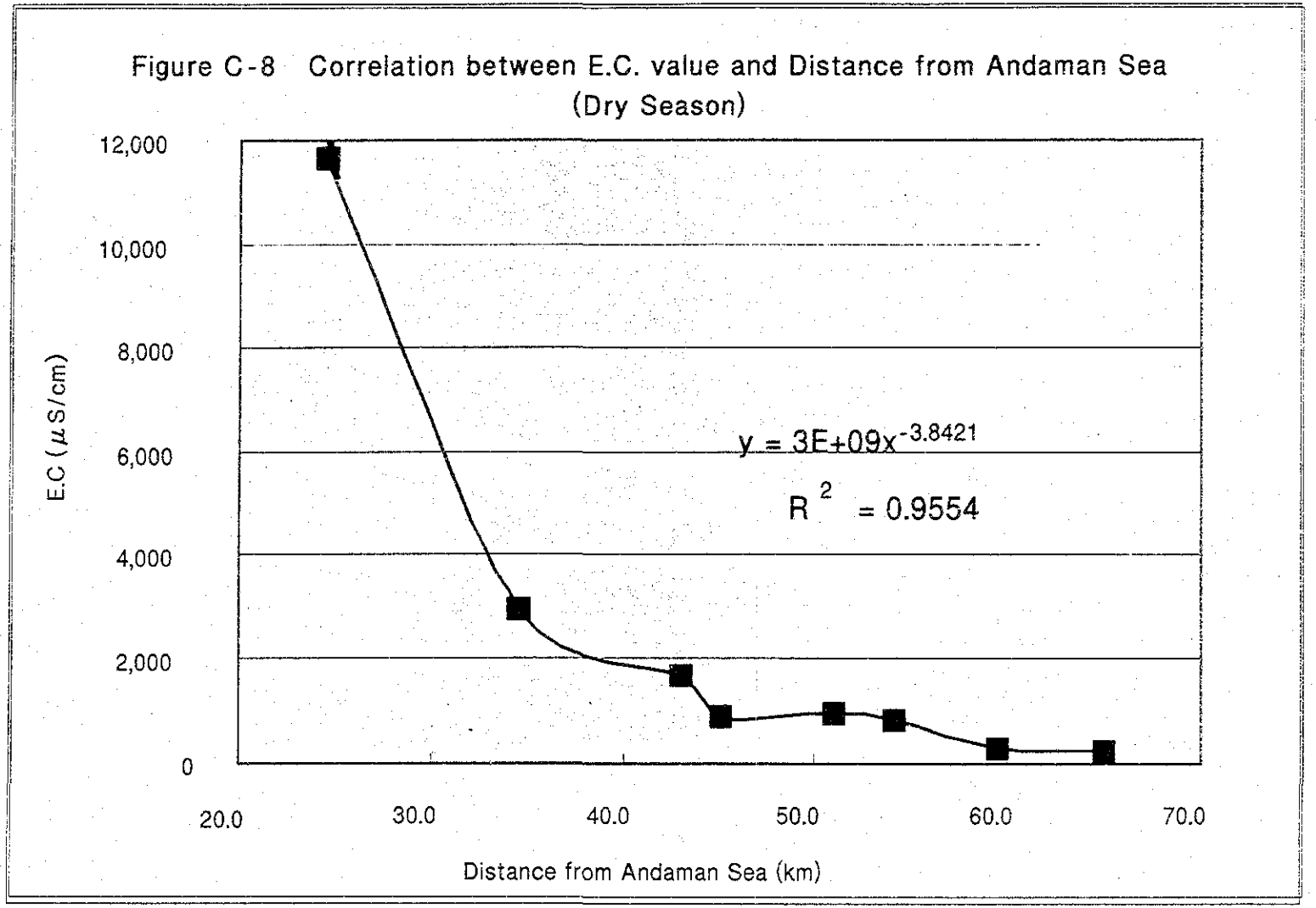


Figure C-8 Correlation between E.C. value and Distance from Andaman Sea (Dry Season)
12,000
10,000
8,000
6,000
4,000
2,000
0
E.C (μS/cm)
y = 3E+09x^-3.8421
R^2 = 0.9554
20.0
30.0
40.0
50.0
60.0
70.0
Distance from Andaman Sea (km)

(4) Drinking Water Standard

Table C.9 is showing the proposed National Drinking Water Standard in Myanmar, which was established in 1990 and drinking water guideline of WHO.

Table C.9 Drinking Water Standard

Parameters	Unit	Myanmar Standard	WHO Standard
Faecal Coliform	No./100 ml	0	0
Coliform Organisms	No./100 ml	0	0
Arsenic	mg/l	0.05	0.01
Cadmium	mg/l	0.005	0.003
Chromium	mg/l	0.05	0.05
Cyanide	mg/l	0.05	0.07
Flouride	mg/l	1.5	1.5
Lead	mg/l	0.05	0.01
Mercury	mg/l	0.001	0.001
Nitrate (as N)	mg/l	10.0	50.0
Nitrite (as N)	mg/l	0.5	3.0
Selenium	mg/l	0.01	0.01
Aluminium	mg/l	0.2	0.2
Chloride	mg/l	200 – 600	250
Colour	TCU	5 – 50	15
Copper	mg/l	1.0	2.0
Hardness (as $CaCo_3$)	mg/l	500	-
Iron	mg/l	0.5 – 1.5	0.3
Manganese	mg/l	0.3	0.5
pH	mg/l	6.5 – 9.2	Preferably < 8.0
Sodium	mg/l	200	200
Sulphates	mg/l	400	250
Taste & Odour	mg/l	inoffensive	No objection
Solids	mg/l	1,000	1,000
Turbidity	NTU	20	5
Zinc	mg/l	5 - 15	3
Calcium	mg/l	75 – 200	-
Manganese	mg/l	30 – 150	-
Electrical Conductivity	μS/cm	1,500	-

1.2 WATER QUALITY

1.2.1 Reservoirs

There are three existing reservoirs currently in operated for water supply and water quality in these reservoirs was similar, low turbidity and low contents of dissolved matters. The following table shows the summary of water quality analysis from May to October 2001, which was conducted in Gyobyu reservoir.

Table C.10 Analysis Results of Reservoir (Gyobyu Reservoir)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	3	2	N.D.	N.D.	N.D.	N.D.
Color	TCU	5 –50	7.5	N.D.	N.D.	N.D.	N.D.	N.D.
pH		6.5 – 9.2	7.65	7.80	7.50	7.65	6.9	7.0
Alkalinity	$CaCO_3$ mg/L	-	58	52	36	42	46	44
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan	Feb	Mar.	
Turbidity	NTU	20	N.D.	N.D.	8	N.D.	N.D.	
Color	TCU	5 –50	N.D.	N.D.	N.D.	N.D.	N.D.	
PH		6.5 – 9.2	6.7	6.8	6.6	6.7	7.6	
Alkalinity	$CaCO_3$ mg/L	-	40	50	56	56	64	

Note) Detailed data is available in Data Book

As shown in the table, water quality in reservoir is good and all detected 26 water parameters were within the standard.

1.2.2 Tube Wells

11 wells were examined from May to August and 8 wells were added and in total, 19 wells were analyzed from September 2001. The following table shows the results of No.197 well in Thaketa T/S, as representative. As shown in the table, values higher than the standard was recorded in parameter of Iron, Manganese, Color and Turbidity.

Along with water quality analysis, EC measurement survey was conducted on 217 YCDC wells to grasp the overall water quality. Survey was executed from the end of August up to the middle of September. Figure C-9 is EC value contour map summarized the measurement results.

Table C.11 Analysis Results of Tube Well (No.197)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	12	2	65	43	35	48
Color	TCU	5 – 50	15	15	80	170	50	50
PH		6.5 – 9.2	8.7	6.97	7.8	7.1	7.0	7.1
Iron	ppm	0.5 – 1.5	0.3	1.05	3.56	3.34	3.06	2.93
Manganese	ppm	0.3	0.7	0.15	N.D.	N.D.	N.D.	N.D.
Electric Conductivity	μ S/cm	1,500	2,200	3,410	3,630	2,310	2,200	2,320
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan.	Feb.	Mar.	
Turbidity	NTU	20	15	28	30	45	55	
Color	TCU	5 – 50	60	90	35	38	90	
PH		6.5 – 9.2	7.1	7.6	7.0	7.0	8.1	
Iron	ppm	0.5 – 1.5	3.34	2.53	1.68		2.53	
Manganese	ppm	0.3	N.D.	N.D.	0.008	N.D.	0.1	
Electric Conductivity	μ S/cm	1,500	1,370	1,410	1,480	2,340	2,390	

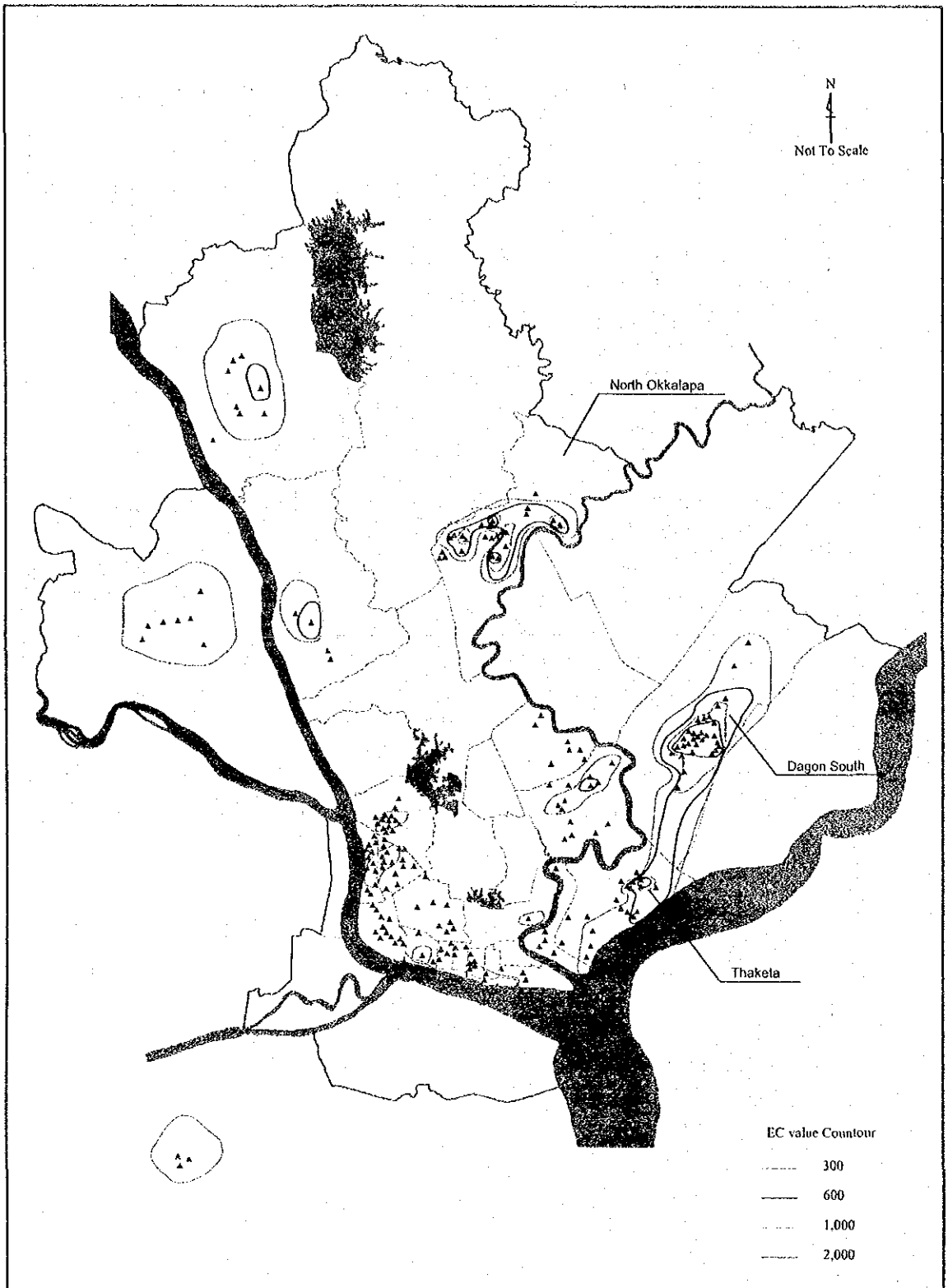
Note) Detailed data is available in Data Book

As shown in the map, wells in eastern, northern areas and T/S in the right bank of Hlaing River have high EC values, showing high contents of dissolved matters.

According to the EC measurement results and water quality analysis results, it was suggested **"groundwater use in the following T/S shall transfer to surface water in the future"**. The said T/S are;

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

This suggestion must be reflected on the subsequent surface water transmission pipe and distribution network development plan.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG C-9
	EC value Countour Map of YCDC Tube well	

1.2.3 Water Supply System

Kokine Service Reservoir and seven private faucets were selected as sampling points of distributed water through the existing water supply system. Locations of seven private faucets were selected from upstream to downstream of the distribution network. Seven faucets are in the following T/S;

- Ahlone T/S
- Botataung T/S
- Dagon T/S
- Kamayut T/S
- Lanmadaw T/S
- Tamwe
- Yankin

The following table shows the results of Botataung T/S, located at the downstream of distribution network.

Table C.12 Analysis Results of Faucet (Botataung T/S)

Parameters	Unit	Myanmar Standard	2001			
			Sept.	Oct.	Nov.	Dec.
Turbidity	NTU	20	N.D.	3.0	2.0	N.D.
Color	TCU	5 – 50	N.D.	N.D.	N.D.	4
pH		6.5 – 9.2	6.2	6.7	7.0	6.7
Iron	ppm	0.5 – 1.5	0.33	3.20	0.39	0.37
E-Coliform	No./100 ml	0	detected	detected	detected	detected
SPCB	No./100 ml	-	detected	detected	detected	detected
Parameters	Unit	Myanmar Standard	2002			
			Jan.	Feb.	Mar.	
Turbidity	NTU	20	N.D.	2.0	N.D.	
Color	TCU	5 – 50	N.D.	9.0	N.D.	
pH		6.5 – 9.2	6.7	7.4	6.9	
Iron	ppm	0.5 – 1.5	0.27	0.43	0.02	
E-Coliform	No./100 ml	0	detected	detected	detected	
SPCB	No./100 ml	-	detected	detected	detected	

Note) SPCB : Standard Plate Count Bacteria

E-Coliform and SPCB was detected in other six samples only excluding Ahlone. This is due to the water contamination in reservoir in upstream. Presence of E-Coliform shows fecal contamination of reservoir water due to the urbanization in surrounding areas.

1.3 EXISTING WATER TREATMENT

1.3.1 Treatment Process and Operation

At present, only water treatment plant is Gyobyu WTP located nearby Gyobyu reservoir.

However, it seldom operated and according to the operation record in 2001, WTP was so far operated only 36 days in January and February in this year. Therefore, water quality of treated water was not yet examined. The followings are the major issues confirmed by field survey:

(1) Mixing of Coagulant

Alum is used as coagulant. Solid alum is dissolved in the tank in second floor of chemical building and dissolved alum is conveyed to the upstream of inlet channel through pipe and then discharged into raw water by flexible hose. Since there is no mixing device such as baffle wall or no overflow weir to generate hydraulic mixing, mixing of coagulant is quite uneven and not sufficient.

(2) Flocculation Basin

Existing baffle wall of flocculation basin is declined and its baffling effect is not enough. It seems that this structural defects and low turbidity of raw water, 3 NTU in average, resulted in inferior flocculation.

(3) Sedimentation Basin

Due to inappropriate flocculation, floc growing is insufficient and sedimentation of floc is also ineffective. Carry over of floc is expected.

(4) Micro-strainer

Micro-strainer used to be employed as countermeasure against bleeding of phytoplankton. However due to its low performance, it seldom introduced nowadays.

1.3.2 Disinfection Systems

The only operational disinfection system is located in Yegu P/S. Bleaching powder is used as chlorination agent. Bleaching powder is imported from India but it is not available throughout a year. One bag is 50 kg weight.

Mixing and dissolving of bleaching powder is done by manual. Chlorination is executed by 3 shifts in a day, at 9, 14 and 22 O'clock. 9 bags of bleaching powder are consumed per shift. Dissolved bleaching powder is conveyed to ejector by gravity and then injected to distribution main directly.

However, due to the budgetary constrains and unavailability of bleaching powder, current disinfection is quite insufficient and there is a great possibility of causing health hazard by this unsafe water distributed to the consumers.

1.3.3 Residual Chlorine Concentration

Residual chlorine was not yet examined since no chlorination was conducted during the study period.

2. WATER QUALITY IMPLROVEMENT PLAN

2.1 CANDIDATE SOURCES FOR FUTURE DEVELOPMENT

2.1.1 Irrigation Reservoirs and Tributaries

So far, Ngamoeyeik reservoir is the most prospective future surface water source because water right of 90 MGD for drinking water use was already agreed between YCDC and the Ministry of Agriculture and Irrigation. The following table shows the summary of water quality analysis;

Table C.13 Analysis Results of Reservoir (Ngamoeyeik Reservoir)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	2	2	2.5	N.D.	N.D.	N.D.
Color	TCU	5 –50	10	N.D.	N.D.	N.D.	N.D.	N.D.
pH		6.5 – 9.2	7.8	7.8	7.3	7.23	6.9	7.3
Alkalinity	$CaCO_3$ mg/L	-	51	45	42	44	44	46
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan.	Feb.	Mar.	
Turbidity	NTU	20	N.D.	N.D.	N.D.	N.D.	N.D.	
Color	TCU	5 –50	6	N.D.	N.D.	N.D.	N.D.	
pH		6.5 – 9.2	6.2	7.1	7.5	6.7	7.48	
Alkalinity	$CaCO_3$ mg/L	-	44	48	50	54	58	

Note) Detailed data is available in Data Book

As shown in the table, water quality in reservoir is good and all detected 26 water parameters were within the standard.

2.1.2 Rivers

There are two rivers flowing into the city boundary, namely Hlaing and Bago River. However, as examined in the previous section, Hlaing River is further prospective future water source compared with Bago River, because river discharge of Bago River during dry season is almost 0 m^3/sec.

The following table shows the summary of water quality analysis conducted at Hlaing River. Theses results were acquire from water samples taken at Gwedanshe, the proposed water intake

point. Sampled in middle layer, during high tide period.

Table C.14 Analysis Results of River (Hlaing River)

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20	800	600	263	232	275	220
Color	TCU	5 –50	17.5	50	575	235	160	320
pH		6.5 – 9.2	8.1	7.6	7.3	7.7	7.2	7.4
Alkalinity	$CaCO_3$ mg/L	-	125	40	44	50	56	60
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan.	Feb.	Mar.	
Turbidity	NTU	20	237	90	45	80	190	
Color	TCU	5 –50	250	63	80	37	18	
pH		6.5 – 9.2	7.5	7.5	7.2	7.3	8.3	
Alkalinity	$CaCO_3$ mg/L	-	74	90	122	138	140	

Note) Detailed data is available in Data Book

Turbidity and color is exceeding the standard. Since river bank erosion during rainy season is regarded as main cause of this high turbidity, turbidity in dry season is expected to be much lower than these results.

The study team also conducted water quality analysis on samples taken at the downstream of agricultural outlet channel discharging into Hlaing River. Said outlet channel is located about 1 km upstream of Gwedanshe. The objective of this survey is to examine the existence of agricultural chemicals, which have been applied in paddy field and might have been discharged into Hlaing River. Two samples were taken in middle layer at 1) Outlet Channel and 2) Gwedanshe. The following chemicals, which are commonly used in Myanmar were analyzed;

Myanmar Name	Common Name
Myanmar-zion	Diazinon
Myanmar-phentho	Phenthoate
Myanmar-endo	Endosulfan
Myanmar-cyper	Cypermethrin

Although there was equipment can analyze such chemicals in Plant Protection Division of Myanmar Agriculture Service, it was malfunctioning. Therefore, samples were sent to Japanese laboratory and analyzed. The followings are the results and no trace of abovementioned chemicals was detected.

Chemical Name	Analysis Results
Diazinon	Less than 0.0001 mg/L
Phenthoate	Less than 0.001 mg/L
Endosulfan	Less than 0.001 mg/L
Cypermethrin	Less than 0.001 mg/L

However, since this survey was conducted during "dry season", same survey shall be carried out again in "rainy season" with larger possibility of chemical discharge into the River.

2.2 WATER TREATMENT PLAN

2.2.1 Improvement of Present Water Quality

(1) Improvement of Gyobyu WTP

Average turbidity of Gyobyu raw water was calculated as 3 NTU and the existing plant is not suitable to treat such low turbidity. Therefore, new treatment plant applied appropriate treatment process shall be constructed in future for the treatment of reservoir raw water with low turbidity. However, the existing plant shall also be optimized until the completion of said WTP.

Following improvement plan was proposed to upgrade its treatment capacity;

1) Construction of coagulant mixing device

Perforated alum injection trough shall be installed over upstream of existing inlet channel and overflow weir to generate hydraulic mixing is built in downstream.

2) Replacement of baffle wall in Flocculation Basin

Declined wall must be removed and baffle wall with right-angle against the flow direction of incoming water shall be built instead to maximize its baffling effect.

3) Installation of supplement settler in Sedimentation Basin

To improve sedimentation effect, installation of tube or plate settler is desirable.

(2) Continuous Chlorination

All piped water must be properly treated as potable water. From the viewpoint of "safe water supply", continuous chlorination must be secured at least. Currently, water is extracted from transmission pipes, namely Gyobyu, Hlawga No.1 and No.2 transmission pipe, chlorination must be conducted in the following stations;

- Gyobyu WTP : Rehabilitation of existing chlorine house
- Hlawga No.1 P/S : Construction of chlorine facility
- Hlawga No.2 P/S : Construction of chlorine facility
- Yegu P/S : Secure continuous chlorination

2.2.2 Treatment for New Water Sources

(1) Reservoirs (Eastern and Western Watersheds)

As aforementioned, turbidity of raw water in the existing reservoirs are low (average turbidity = 3 NTU). Turbidity must be removed nevertheless but coagulated sedimentation is not applicable for such low turbidity. Flocculation is very slow in such low turbidity and sedimentation velocity is also low. It means that sedimentation effect is inferior and longer sedimentation time or installation of auxiliary sedimentation facility such as tube/plate settler is needed.

Plankton mainly causes turbidity in reservoir water and coagulation process for such water needs high operation technology and monitoring system. Considering the present technical level of YCDC, coagulation process should not be employed for reservoir water treatment. Therefore, the following two treatment processes were proposed;

- **Slow Sand Filter**
- **Biological Contact Aeration Process**

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/l
Maximum	5 mg/l

(2) Hlaing River

On the contrary to reservoir water, turbidity of river water is high and coagulation is indispensable. The following is the results of the jar test on Hlaing river water conducted in the YCDC laboratory. Supernatant was extracted for analyze after dosing of Alum and sedimentation.

Table C.15 Analysis Results of Supernatant after coagulation and sedimentation

Alum Dosing Rate (mg/L)	Turbidity	EC	PH	Chloride	Nitrogen-Ammonia	ORP	Iron
0	200	107	7.60	0.4	0.13	277	1.03
10	114	108	7.56	0.3	0.07	286	0.46
20	30	110	7.41	0.3	0.08	295	0.09
30	15	112	7.32	0.3	0.06	303	0.04
40	1.2	115	7.20	0.3	0.06	312	0.01
50	3.8	116	7.02	0.3	0.08	329	0.03
60	7.4	117	6.87	0.3	0.06	336	0.04

40 mg/L was determined as optimum Alum dosing ratio. Remaining concentration of Iron and manganese in supernatant was 0.01 mg/L and 0.001 mg/L, respectively.

Since favorable flocculation and sedimentation effect on Hlaing River water was confirmed by this jar test, the following treatment process was proposed for river water treatment;

- **Coagulated Sedimentation and Rapid Sand Filter**

Optimum chlorine dosing rate was confirmed by "chlorine requirement test" in laboratory. Test was conducted to supernatant of river water after coagulation and sedimentation. Chlorine requirement was below 1 mg/l. Considering the seasonal water quality fluctuation, capacity of chlorination equipment was proposed as follows;

Item	Chlorinator Capacity
Duty	1 mg/l
Maximum	5 mg/l

(3) Tube Wells

1) Hlaing River Left Bank

As aforementioned in the previous section, groundwater use in the following T/S should transfer to surface water due to inferior groundwater quality;

- Dagon South T/S
- North Okkalapa T/S
- Thaketa T/S

2) Hlaing River Right Bank

The following table shows the results of water quality analysis conducted on 3rd September on four completed tube wells in outside of Hlaingthaya T/S. These wells were constructed to serve groundwater to township. However, since submersible pumps were not yet installed, stagnant groundwater was taken in the depth of around 15 m from the water surface;

Parameter	unit	No.1	No.2	No.3	No.4
Chloride	ppm	2.6	2.1	4.1	26.1
Total Hardness	ppm	102	112	98.8	128
Iron	ppm	0.11	1.19	0.75	0.45
Manganese	ppm	0.66	1.07	1.2	0.99
E Conductivity	μ S/cm	277	309	290	403
Nitrogen-Ammonia	ppm	N.D.	N.D.	N.D.	N.D.

High concentration iron and manganese was confirmed. The following day, water analysis was performed again to examine whether high concentration of iron and manganese attributes to "No pump operation". Sample was taken from elevated tank of site office. Water was pumped from well located near by the said four wells. Air-lift Pump was installed.

Parameters	Unit	Results
Iron	ppm	0.07
Manganese	ppm	0.63

Although parameters were affected by air-lifting, manganese concentration was still high.

Table C.16 shows the water quality analysis results in the same well. Submersible pump was installed in the well in a day before the water sampling and pump was operated in 12 hours continuously to introduce fresh groundwater into the well. As shown in the table, high Fe and Mn concentrations are still observed in several months and this means that careful groundwater quality examination shall be conducted upon groundwater development in Hlaingthaya T/S.

100 % water supply by treated surface water must be the ultimate goal of Yangon City water supply, but during transition period, transferring to surface water from current water sources, available sources must be optimized.

Table C.16 Analysis Results of Tube Well in Hlaingthaya T/S

Parameters	Unit	Myanmar Standard	2001					
			May	June	July	Aug.	Sept.	Oct.
Turbidity	NTU	20					N.D.	N.D.
Color	TCU	5 – 50					N.D.	N.D.
PH		6.5 – 9.2					6.7	6.6
Iron	ppm	0.5 – 1.5					0.18	0.59
Manganese	ppm	0.3					0.05	0.1
Electric Conductivity	μS/cm	1,500					340	352
Parameters	Unit	Myanmar Standard	2001		2002			
			Nov.	Dec.	Jan.	Feb.	Mar.	
Turbidity	NTU	20	N.D.	N.D.	N.D.	18	N.D.	
Color	TCU	5 – 50	N.D.	N.D.	N.D.	21	N.D.	
PH		6.5 – 9.2	6.5	7.3	6.7	8.26	7.14	
Iron	ppm	0.5 – 1.5	0.39	0.27	0.29	3.20	0.25	
Manganese	ppm	0.3	1.0	1.0	0.9	0.1	N.D.	
Electric Conductivity	μS/cm	1,500	374	396	443	402	442	