SECTOR E

WATER QUALITY

1. INTRODUCTION

1.1 General

The water quality of the Musi River Basin worsens at drought time due to the decrease of dilution and self-purification effect of river water. Immediately downstream of Palembang City, the river water is much polluted due to the large quantity of untreated domestic wastewater and the industrial wastewater effluent.

The major point pollution sources of rivers in the Study Area are the untreated domestic and industrial wastewaters from the urban centers shown in **Table E1.1.1**.

Table E1.1.1 Urban Centers in the Study Area

Receiving Water	Urban Centers (Point Pollution Sources)
Musi Main River	Palembang, Sekayu, Surulangun,
Lamatang River	Muaraenim, Lahat, Pagaralam,
Ogan River	Perabumulih, Baturaja
Komering River	Tanjungraja, Kayuagung, Martapura, Muaradua

There have been many specific issues with regard to river water quality in the Study Area. For instance, many people are forced to withstand the deteriorated condition of water quality.

1.2 Scope of the Study

This Sector E covers the following major scopes of the Study:

(1) The analysis of existing river water quality condition based on data and information in order to evaluate the level of river water quality;

(2) The analysis of existing industrial and domestic wastewater qualities based on the data in order to evaluate the point pollution load generation in the basin;

(3) The estimation of existing pollution loads generated in the basin, including point (industrial and domestic wastewater) and non-point (livestock and lands) sources;

(4) The confirmation of the specific issues regarding water quality of rivers, water use, drinking water and sanitary conditions in the whole Musi River Basin; and

(5) The examination of the existing monitoring plan and facility used for water quality analysis, and proposal of the recommendation for the improvement of the existing monitoring system.

2. RELEVANT INFORMATION ON WATER QUALITY

2.1 River System

Musi River originates in the Barisan Mountain Range, collects flow from tributaries and finally pours into the Bangka Strait. River length and drainage area within the Musi River Basin are almost 700 km and approximately 55,900 km^2, respectively.

According to the Report of the Musi River Basin Study (December 1989), the Musi drainage area can be divided into 10 river systems, as shown in **Table E2.1.1**. As for the area of each sub-basin of these river systems, see **Annex E2.1.1**.

Table E2.1.1 Divided River Systems and Sub-basins

No.	Code-No.	River Name	Sub-basins
1	MU	Musi Main	From upper reach to down reach, MU1 to MU8
2	KO	Komering	From upper reach to down reach, KO1 to KO2
3	OG	Ogan	From upper reach to down reach, OG-1 to OG2
4	HA	Harilek	
5	RA	Rawas	From upper reach to down reach, RA1 to RA2
6	LA	Latikan	
7	KE	Kelingi	
8	LE	Lematang	From upper reach to down reach, LE1 to LE2
9	SE	Semangus	
10	PA	Padang	

(1) Musi Main River System (MU)

The Main Musi River System consists of eight sub-basins (MU1 to MU8). The Main Musi River and its tributary named Kelingi drain some of the upper parts of the Study Area. The upper part of the Main Musi River (MU1-MU4) flows through the towns of Muarabeliti, Muaraklingi and Muaralakitan, while the middle part (MU5-MU7) runs through Sekayu City and then Palembang City. The lower part flows down to the sea through the Lowland Area.

(2) Komering River System (KO)

The Komering River System consists of two sub-basins; namely, the Upper Komering River Sub-basin (KO1) and the Lower Komering River Sub-basin (KO2). The Upper Komering River originates in the outflow discharged from the Ranau Lake, and runs through the mountain areas and the towns of Muaradua, Simpang and Marapura. A large quantity of the river water used for irrigation is diverted as intake flow at the Perjaya Headworks located in Marapura Town. Hence, the river flow of the Lower Komering River drastically decreases due to the diversion of river water. This lower section flows down through the towns of Cempaka, Tanjunglubuk and Kayuagung.

(3) Ogan River System (OG)

The Ogan River System consists of two sub-basins, namely the Upper Ogan River Sub-basin (OG1) and the Lower Ogan River Sub-basin (OG2). The Upper Ogan River runs through the mountain areas of the Study Area and Baturaja City. The Lower Ogan River flows through the towns of Muarakuang, Tanjungraja and Indralaya, and finally confluents with the Musi River at Palembang City. In these areas, many channels have been constructed for irrigation; however.

(4) Harilek River System (HA)

The Harilek River runs from the northwest of the Study Area, and is joined downstream by the Main Musi River at Sekayu City. No major city or town is located at the river side.

(5) Rawas River System (RA)

The Rawas River System can be divided into two sub-basins; namely, the Upper Rawas River Sub-basin (RA1) and the Lower Rawas River Sub-basin (RA2). The Upper Rawas River starts from the northwest mountain areas of the Study Area and flows through Muararupit Town. The Lower Rawas River runs through Bingintelok Town and finally meets with the Main Musi River.

(6) Latikan River System (LA)

The Latikan River System has two sub-basins; namely, the Upper Latikan River Sub-basin (LA1) and the Lower Latikan River Sub-basin (LA2). The Latikan River originates in the northwest mountain areas of the Study Area, and runs through the town of Trawas and Muaralakitan. Finally, the river meets with the Main Musi River at Muaralakitan Town.

(7) Kelingi River System (KE)

The Kelingi River starts at the west mountain areas of the Musi River Basin and flows through Muarabeliti Town. Finally, the river joins the Main Musi River at Muarakelingi Town.

(8) Lematang River System (LE)

The Lematang River System has a long river stretch and can be divided into two sub-basins: Upper Lematang (LE1) and Lower Lematang (LE2). The Lematang River starts after the confluence of two tributaries: the Enim River and the Lintang River. The Lematang River finally meets with the Main Musi River in the upstream of Palembang City.

(9) Semangus River System (SE)

The Semangus River runs from the west of the Study Area, and is joined downstream by the Main Musi River near Muarakelingi Town. No major city or town is located at the river side.

(10) Padang River System (PA)

Padang River is located in the Lowland Area and connects downstream with the Main Musi River at Palembang City.

2.2 Classification of River System

It is necessary to classify river systems for the identification of issues regarding river water quality. As mentioned before, the Musi River Basin can be divided into 10 river systems, as shown in **Annex E2.1.1**. Each river system consists of one to eight sub-basins, and has characteristics concerning river water quality; e.g., base river flow rate, domestic and industrial pollution load (point pollution sources), agriculture and land pollution load (non-point pollution sources), and hydrological features (water intake, saline intrusion, tidal action). In order to clarify issues related to river water quality, river systems can be categorized into four, as shown in **Table E2.2.1**.

Table E2.2.1 Classification of River Systems

Category	Name	Corresponded Sub-basins
A	Normal High-Midland Area	All the sub-basins except the ones below
B	Specific Midland Area	KO2
C	Urban Area of Palembang City	OG2, MU7
D	Lowland Area	MU8, PA

Each category is briefly described below.

(1) Category A: Normal High-Midland Area

More than 70% of the whole Study Area corresponds to Category A, which has no serious issue related to river water quality due to the dilution effect of the abundant river flow rate and self-purification. Most of these areas are covered by forests and farmlands; e.g., paddy fields; coffee, rubber and palm plantations and so on. Besides, no large factory exists in these areas and inhabited areas are not congested. Hence, pollution sources are few.

(2) Category B: Specific Midland Area

The hydrological cycle at the Lower Komering River Sub-basin is very complicated due to the diversion of river water for irrigation. In this area, the lack of base river flow in the dry season leads to the reduced dilution effect. Moreover, the slow flow causes sedimentation. Therefore, specific issues in this area need closer identification.

(3) Category C: Urban Area of Palembang City

There are serious issues regarding water quality in the urban area of Palembang City. These issues are caused by the inadequate sanitary conditions and water use. Hence, this area requires examination of the existing conditions of water quality.

(4) Category D: Lowland Area

The Lowland Area is situated on the coast, and the river water quality is very much affected by saline water intrusion, sedimentation and a specific phenomenon caused by reclamation. Hence, specific issues in this area have to be considered.

Based on the above categories and data analysis, the specific issues regarding river water quality are discussed in more detail in Section 4.2.

2.3 Existing Water Use

As discussed in Section B, the total population of the Study Area amounts to approximately 6.3 million people. Of this population, approximately 18% are presently supplied from piped water supply schemes, more than 98% of which exploit surface water. The remaining part of the population relies on the springs, non-piped surface water and shallow handling wells, the latter being by far the most important source of water for domestic use in the Study area.

Most water-consuming industries are located in or around Palembang City and do not use groundwater to any substantial extent. The water intake for domestic use in the Study Area is tabulated in **Annex E2.3.1**.

The main water intake in the Study Area is briefly discussed below

2.3.1 River Water

River water is used for domestic/industrial purposes of the whole Study Area. Moreover, a large quantity of irrigation water is taken from the rivers. According to **Annex E2.3.1**, more than 40 river water intake points are located along the rivers.

About 18% of the populations are served with piped water. In the case of Palembang City, six purification plants as shown in **Table E2.3.1** are currently working, and taking the water of the Musi River for Palembang's water supply.

Table E2.3.1 Purification Plants for Palembang Water Supply

No.	Name of Purification Plant	Intake Quantity (l/sec)
1	Tiga Ilir Installation	800
2	Rambutan Installation	700
3	Ogan Water Treatment	600
4	Karang Anyar Water Treatment	600
5	Borang Water Treantment	90
6	Polygon Water Treatment	50
Total		2,840 (245x10^{3}m^3/day)

According to the interview survey, each purification plant has a sedimentation tank (using aluminum sulfate for coagulation) and disinfecting facility (using gaseous chlorine).

Water quality has been checked for the quality control before treatment (Musi River water) and after treatment (piped water). **Annex E2.3.2** shows the water quality data made by Rambutan Installation during August to September 2002.

2.3.2 Groundwater

Around 4.5 million people use groundwater shallow well. In several cases, it has been observed that shallow wells maintain a high water table as long as nearby paddy fields are irrigated. When irrigation stops, the water level often drops sharply within a few days. Moreover, the insecticides, herbicides, pesticides and fertilizers used in farmlands to improve the yield of crops easily contaminate such shallow wells.

Where people are served by dug wells, it is common for these to become dry during dry seasons, forcing people to seek other water sources such as the rivers and irrigation ditches, and water of low quality is used. In the tidal lowlands and swamp areas there are particular problems since both the surface water and shallow groundwater are brackish and saline. Rainwater is one source of water, however, there is not enough storage to provide adequate water supply during the dry season.

2.4 Health Conditions (Waterborne and Water-Related Diseases)

Many waterborne and water-related diseases have been counted in the Study Area. Based on the statistical data, the summary of health records is given in **Table E2.4.1**.

Table E2.4.1 Waterborne and Water-Related Diseases

Regency	Health Office	No. of Persons Treated				Remarks
		Disease			Total No. of Persons Treated	
		Diarrhoea	Skin disease	Eye Infection		
Musi Banyu Asin (MUBA)	Sekayu	7,464	-	-	Unknown	April to Dec. 1987
Muaraenim	Muaraenim	9,085	9,773	2,111	20,969	1987/1988
Lahat	Lahat	12,66	-	-	Unknown	1987/1988
Musi Rawas (MURA)	Lb. Linggau	2,251	1,952	1,072	5,275	Jan. to Jun. 1988
Rejang Lebong	Curup	8,407	5,885	3,032	17,324	1987
Ogan Komering Ulu (OKU)	Baturaja	2,874	6,209	2,776	11,859	Jan. to April 1988
Palembang	Palembang	22,372	62,049	17,922	102,343	1986

It can be seen that there is a high risk of diarrhea, skin disease and eye infection. These statistics intensify the need to break the various disease transmission cycles and provide adequate quantities of clean water along with appropriate sanitation systems separate from the water sources.

3. EXISTING POLLUTION SOURCES

3.1 Domestic Wastewater

3.1.1 Sanitary System of Urban Area

The sanitary systems used in Palembang City are mainly on-site systems ranging from toilets with septic tanks or pit latrines to toilets on rivers, drainage channels or ponds to no latrine at all and defecation in any place. For the ratio of each type of human waste disposal, refer to **Table E3.1.1**.

Table E3.1.1 Sanitary System of Palembang

No.	Type of Human Waste Disposal	Ratio (%)
1	Toilet with Pit Privy/Septic Tank	51.81
2	Toilet with pipe to Public Tank	5.20
3	Public MCK (Shower, Laundry, Toilet)	3.15
4	Toilet on pond	8.82
5	Toilet on River	27.72
6	No Toilet, Defecate in any Place	3.31

Unclean conditions are especially present in the areas of Palembang that are subject to inundation by flooding. The drainage channels are almost open combined sewers. During floods, the polluted water is spread over areas and into houses, creating a situation of high-risk infectious disease transmission. Water sources for shallow groundwater are contaminated and septic tank effluents also infiltrate the surface water.

Except for Palembang City, more than 10 urban centers; e.g., Sekayu, Lubuklinggau, Baturaya Cities and so on, are located in the Study Area. These urban centers seem to have almost the same features of sanitary system.

3.1.2 Sanitary System of Rural Area

The forms of sanitation in mid-class of towns located in rural areas of the Musi River Basin vary from communal latrines and washing facilities with seal traps and septic tanks to pit latrines and floating latrines on pontoons in streams and rivers. Besides, a majority of village populations defecate in outdoor sites.

3.1.3 Estimation of Domestic Pollution Sources

In the Study Area, or even in Palembang City, no sewerage system has been constructed. Besides, a high percentage of people in the Musi River Basin live in riverine areas. Hence, domestic wastewater is currently discharged into rivers with no treatment or with septic tank through the small ditches or channels.

Usually, human pollution load generation of BOD is estimated, as shown below.

- No treatment 40 g/person/day
- Treatment with septic tank 4 g/person/day

However, the estimation widely varies according to the level of living standards and treatment condition of domestic wastewater. In this Study, domestic wastewater is assumed as the point pollution source, and 20 g/person/day (average value of no treatment and treatment with septic tank) is employed as unit pollution load generation. The population in each sub-basin is tabulated in **Table B3.2.1** of Sector B. Using this data, estimations of domestic pollution load in each sub-basin are as tabulated in **Table E3.1.2**.

Table E3.1.2 Domestic Pollution Load Generation

No.	Sub-basin	Population (1,00)	Domestic Pollution Load Generation (BOD kg/day)
1	Musi	2,740	55,160
2	Komering	1,125	22,500
3	Ogan	918	18,360
4	Harilek	132	2,280
5	Rawas	161	3,220
6	Latikan	226	4,520
7	Keling	152	3,040
8	Lematang	623	12,460
9	Semangs	79	1,580
10	Padang	182	3,640
Total	-	6,338,	126,760

3.2 Industrial Wastewater

3.2.1 Inventory of Factories in the Study Area

There are many factories (large, middle, small) located in the Study Area. Especially in or around Palembang, the number of factories is more than 40. Among them, only three factories have AMDAL documents, while 15 factories have UKL/UPL documents. The rest do not comply with any regulation. As for the existing factories in Palembang City, see **Table E3.2.1**.

Table E3.2.1 Number of Factories in Palembang

No.	Type of Industry	Number	No.	Type of Industry	Number
1	Fertilizer	1	11	Liquid Soda	1
2	Meramin	1	12	Small Food Processing	259
3	Crum Rubber	11	13	Textile	23
4	Glue	1	14	Sawmill and molding	17
5	Pharmacy	1	15	Furniture	8
6	Plastic	10	16	Shipbuilding	13
7	Cool Storage	2	17	Service	103
8	Palm Oil	2	18	Livestock farm	5
9	Asphalt	1	19	Oil Refinery	1
10	Charcoal	1	Total	-	461

Among the above, the fertilizer and meramin factories (Pusri), the oil refinery (Pertamina), and the six crumb rubber factories (Prasidha Aneka Niaga, Aneka Buni Pratama, Muara Kelingi I, Muara Kelingi II, PD Sunan Rubber, and Pancasamudera Simpat) are presumed to be large pollution sources in or around Palembang City.

On the other hand, the Clean River Program designated 33 large factories for the purpose of giving priority for improvement of factory effluent. Except for Palembang City, several large factories are located in the Musi River Basin, as listed in **Table E3.2.2**.

Table E3.2.2 Large Factories Except those in Palembang

No.	Name of Factory	Type of Industry	Location	Recipient River
1	PT TEL	Pulp and Paper	Muaraenim	Lematang
2	Musi Hutan Persada	Pulp	Muaraenim	Lematang
3	PT. Lonsum	Lateks and Palm Oil		
4	PT. Gulf	Oil	Muaraenim	Lematang

3.2.2 Available Analysis Data of Factory Effluent

There may be wastewater analysis data on factory effluent kept by the companies themselves. BAPEDALDA has been observing the wastewater quality of 60 factories once to four times a year for the purpose of cross-check; however, all the analysis data of factory effluent are not available for this Study due to confidentiality. Hence, the data available for this Study is very limited in scope.

On the other hand, analysis data collected in the Clean River Project are available for this Study, as shown in **Table E3.2.3** (periodical data analyzed in 1996-1997) and **Annex E3.2.1** (analyzed in 1995-1996). Based on the analyzed data, the industrial wastewater quality condition is as described below.

(1) BOD has been observed in 46 effluent points. Among them, BOD concentrations vary from 4 to 1,200 mg/l and are high in food, beverage, and cold-storage factories. The total BOD pollution load in the 46 factories are estimated at

13,395 kg/day, and among these factories, 39 large factories are located in Palembang and 13,219 kg/day in 37 of them discharge BOD pollution load into the Musi River.

(2) The pH values show 2.5 to 11.5, an abnormal range in wastewater. TSS values vary between 10 and 760 mg/l, and especially high in food factories.

(3) Data of toxic substances such as heavy metals, cyanide and pesticides are not available; therefore, it is difficult to clarify the probability of pollution caused by toxic substances.

Table E3.2.3 Wastewater Quality of Major Factory Effluent

Name of Factory	Activity	Year	Discharge (l/sec)	pH	BOD (mg/l)	COD (mg/l)	TSS (mg/l)
PT Pusri	Fertilizer	1996	142	8.6	42.4	60.7	53.4
PD Hoklong	Crumb Rubber	1996	43.8	6.6	64.1	151	46.8
PT. Aneka Bumi Pratama	Crumb Rubber	1996-1997	27.8	7.0	70.8	126	51.1
PT. Baja Baru	Crumb Rubber	1994-1997	42.2	6.0	59.0	130	60.0
Gadjah Ruku	Crumb Rubber	1996-1997	64.1	6.5	59.2	98.6	36.4
NV. Muara Kelingi I	Crumb Rubber	1996-1997	38.9	6.7	73.8	143	44.6
Muara Kelingi II	Crumb Rubber	1996-1997	53.2	6.6	78.0	126	40.8
PT. Pacasamudera Simpati	Crumb Rubber	1996-1997	69.8	6.2	54.2	106	63.2
PT. Prasida Aneka Niaga I	Crumb Rubber	1996-1997	31.9	6.3	80.0	187	34.5
PT. Remco	Crumb Rubber	1996-1997	35.0	7.1	86.3	187	60.4
PT. Sunan Rubber	Crumb Rubber	1996-1997	41.3	6.6	77.4	136	62.1
Priosoetanto International Corp.	Plywood	1996	17.3	6.4	16.2	41.2	37.5
PT. Sinar Alam Permai	Palm Oil	1996-1997	38.6	5.9	156	272	249

Note: Average data

3.2.3 Estimation of Industrial Pollution Load Generation

Generally, industrial pollution load generation can be estimated by multiplying the discharge Q by the water quality C. However, data on the existing industrial wastewater discharge and water quality are not available for the whole Musi River Basin. Hence, the estimation of total industrial pollution load generation in this Study utilizes the limited data on factory effluent (analyzed in 1995 1996) because many kinds of factories are included (46 points) in that observation. BOD is considered as the most important water quality parameter for industrial wastewater pollution control of the Basin and selected as a parameter for the estimation in this Study.

BOD load is estimated as follows.

(1) Gross Regional Product

The percentage share of regencies in the total gross regional product is as shown in **Table E3.2.4**.

Table E3.2.4 Percentage of Gross Regional Products

OKU	OKI	Muaraenim	Lahat	Musi Rawas	Musi Banyasin	Palembang	Total
4 %	8 %	27 %	6 %	7 %	24 %	25 %	100 %

Only the BOD pollution load discharged from the Regency of Palembang as calculated in Subsection 3.2.2(1) is available for the estimation of total industrial pollution load generation in the whole Musi River Basin. Hence, BOD pollution load of the other regencies can be assumed using the above percentages.

(2) Estimation of BOD Pollution Load Generation by Regency and River System

BOD pollution load generation by regency is estimated, as shown in **Table E3.2.5**.

Table E3.2.5 BOD Pollution Load Generation by Regency

OKU	OKI	Muaraenim	Lahat	Musi Rawas	Musi Banyasin	Palembang	Total
2,115	4,230	14,277	3,172	3,701	12,690	13,219	53,404

Unit: BOD kg/day

Using the above calculation, BOD pollution load generation by river system is estimated, as tabulated in **Table E3.2.6**.

Table E3.2.6 BOD Pollution Load Generation by River System

MU	KO	OG	HA	RA	LA	KE	LE	SE	PA	Total
31,138	3,649	7,119	3,855	1,784	748	297	8,442	689	2,269	53,404

Unit: BOD kg/day

3.3 Non-point Pollution Source

In this Study, non-point pollution load is assumed as load generated from livestock and land (agricultural land, paddy field, forest). The number of livestock and area of land in each sub-basin are estimated, as shown in **Table E3.3.1**.

Table E3.3.1 Number of Livestock and Area of Land

Source	MU	KO	OG	HA	RA	LA	KE	LE	SE	PA	Total
Livestock (Bovine)*	99	163	75	12	25	11	4	61	9	10	469
Farmland**	8.79	5.32	5.03	1.32	3.06	1.38	1.44	3.74	0.78	0.24	31.1
Paddy Field**	1.12	0.83	0.46	0.40	0.02	0.09	0.03	0.26	0.00	0.38	3.23
Forest**	4.53	3.38	2.54	2.63	2.70	1.03	0.38	3.02	1.18	1.10	22.5
Total Land**	14.44	9.53	8.02	3.98	5.78	2.51	1.85	7.02	1.95	1.73	56.83

Unit: * 10^3head, ** 10^3km^2

Unit pollution load generation of BOD of each non-point source category, as shown in **Table E3.3.2**, is assumed based on previous studies and reports.

Table E3.3.2 Unit Pollution Load of BOD

	BOD	Remarks
Livestock (Bovine)	0.64 kg/head/day	Refer from Japanese Case
Farmland	8.57 $kg/km^2/day$	Ditto
Paddy field	14.3 $kg/km^2/day$	Ditto
Forest	0.75 $kg/km^2/day$	Ditto

3.4 Total Pollution Load Generation in the Study Area

3.4.1 Concept of Pollution Load Generation and Runoff

Total pollution load generation consists of point pollution source and non-point pollution source. Point pollution source can be calculated based on the sum of domestic and industrial pollution load generation. Similarly, non-point pollution source is the sum of livestock and land pollution load generation.

Non-point pollution loads run off on lands or through small channels/ditches to a tributary. On the other hand, point pollution load is discharged directly into a tributary or a main river either with treatment or without treatment.

In case of discharge into a tributary, both point and non-point pollution loads finally flow into the main river. In the first runoff stage, the non-point pollution load is decreased to a large extent by the natural purification effect of lands and small channels. In the second runoff stage, the point and non-point pollution loads are reduced by the self-purification effect of tributaries until they enter the main river, and are further reduced by the self-purification effect of the main river.

Figure E3.4.1 explains the concept of pollution load generation and runoff stage. River water quality should be considered for each condition of river flow, runoff coefficient and self-purification constant.

Usually, as shown in **Figure E3.4.2**, runoff coefficients of non-point pollution loads vary according to the river flow rate. In other words, the value of runoff coefficient is large at an abundant river flow rate, and the value is always less than 0.1. In order to obtain detail values of runoff coefficient and self-purification constant, extensive survey is additionally needed.

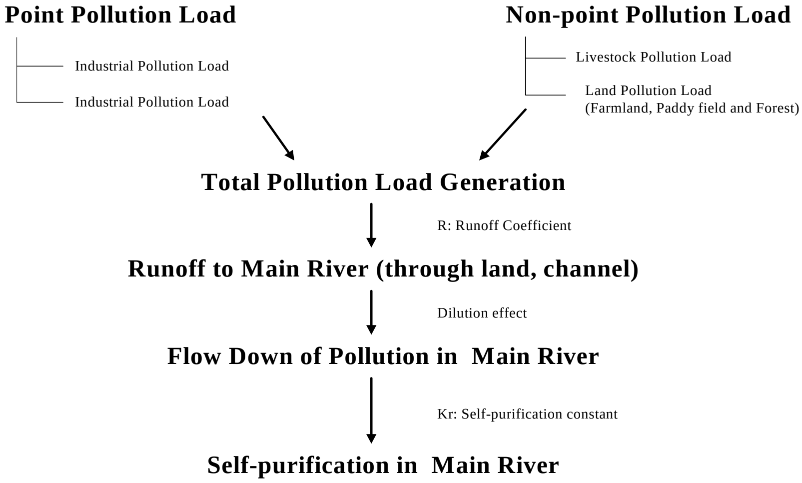

Figure E3.4.1 Concept of Pollution Load Generation and Runoff

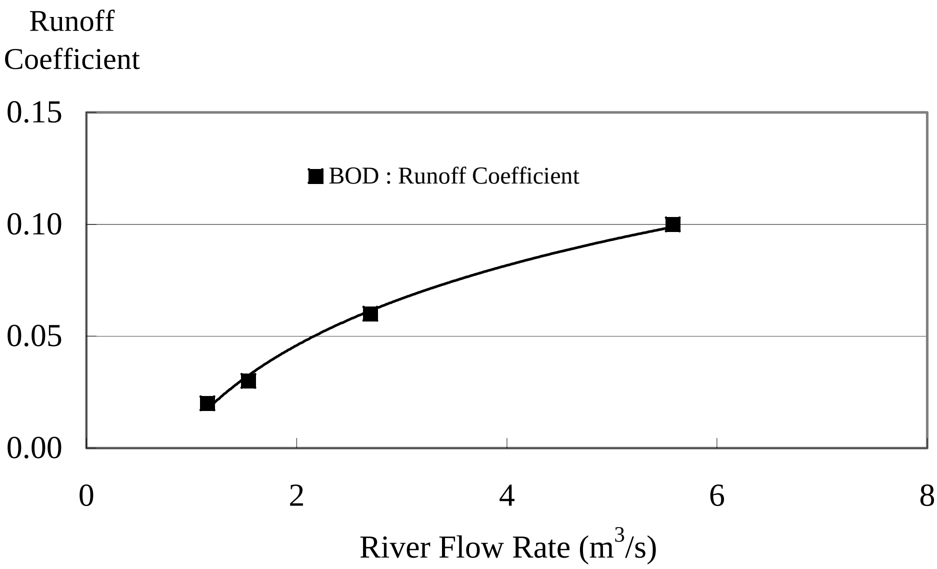

Figure E3.4.2 Sample of River Flow Rate – Runoff Coefficient Curve

3.4.2 Estimation of Total Pollution Load Generation

The total pollution load in the Study Area is assumed as generated from the 10 river systems. The existing pollution load generation of BOD by point and non-point sources are shown in **Table E3.4.1**.

Table E3.4.1 Total BOD Pollution Load Generation

Source	MU	KO	OG	HA	RA	LA	KE	LE	SE	PA	Total	(%)
Point (domestic)	55.2	22.5	18.4	2.3	3.2	4.5	3.0	12.5	1.6	3.6	126.8	12.9
Point (industry)	31.1	3.6	7.1	3.9	1.8	0.7	0.3	8.4	0.7	2.3	60.0	6.1
Sub-total	86.3	26.1	25.5	6.1	5.0	5.2	3.3	20.9	2.3	5.9	186.8	18.9
Non-point (livestock)	98.8	163.3	74.9	12.2	24.9	11.0	4.5	60.6	9.3	9.8	469.5	50.3
Non-point (land)	94.8	60.0	51.6	13.7	28.5	13.9	13.1	38.1	7.5	8.4	329.6	33.4
Sub-total	193.6	223.3	126.5	26.0	53.5	25.0	17.6	98.7	16.9	18.2	799.1	81.1
Total	280.0	249.4	152.0	32.1	58.5	30.2	20.9	119.6	19.1	24.1	985.9	100

(Unit: ton/day)

Non-point loads mostly run off in the rainy season, the runoff is smaller in drought time. Therefore, runoff coefficients of non-point loads vary according to the river flow rate. Using the average value of 0.05 estimated by the recent studies, the existing pollution load runoff of BOD in dry season by point and non-point sources is calculated, as shown in **Table E3.4.2**.

Table E3.4.2 Total BOD Pollution Load Runoff

Source	MU	KO	OG	HA	RA	LA	KE	LE	SE	PA	Total	(%)
Point (domestic)	55.2	22.5	18.4	2.3	3.2	4.5	3.0	12.5	1.6	3.6	126.8	55.8
Point (industry)	31.1	3.6	7.1	3.9	1.8	0.7	0.3	8.4	0.7	2.3	60.0	26.5
Sub-total	86.3	26.1	25.5	6.1	5.0	5.2	3.3	20.9	2.3	5.9	186.8	82.3
Non-point (livestock)	4.9	8.2	3.7	0.6	1.2	0.6	0.2	3.0	0.5	0.5	23.5	10.4
Non-point (land)	4.7	3.0	2.6	0.7	1.4	0.7	0.7	1.9	0.4	0.4	16.5	7.3
Sub-total	9.7	11.2	6.3	1.3	2.7	1.2	0.9	4.9	0.8	0.9	40.0	17.7
Total	96.0	37.3	31.8	7.4	7.7	6.5	4.2	25.8	3.1	6.8	226.7	100

(Unit: ton/day)

As shown in the above table and in **Figure E3.4.3**, point pollution load shares a large ratio of the existing total pollution load runoff of BOD (82%). Hence, the reduction of point pollution load is effective for the improvement of river water quality.

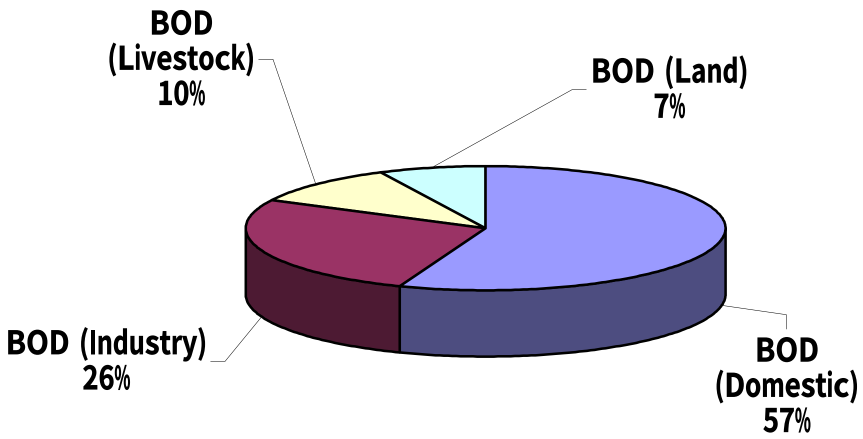

Figure E3.4.3 Ratio of Each Pollution Load Runoff

4. EXISTING RIVER WATER QUALITY CONDITION

4.1 Available Water Quality Data

4.1.1 Sampling Location and Frequency

(1) Available Data of BAPEDALDA

BAPEDALDA has been analysing surface water, industrial wastewater effluent, domestic wastewater effluent, and agricultural effluent of the Study Area since 1985. However, water quality monitoring was focused on industrial wastewater effluent until 2000.

The frequency of water quality sampling planned by BAPEDALDA is once to four times a year. The water quality analysis is also made under the direct management of BAPEDALDA.

The river water quality monitoring survey targeting the whole Musi River Basin was carried out only in 2001. Therefore, the available river water quality data collected from BAPEDALDA are very limited in scope. The sampling locations of this survey are shown in **Annex E4.4.1**.

(2) Available Data of Clean River Project

The Clean River Project was executed with German funds in cooperation with BAPEDALDA during 1993-1998. In this Project, the extensive river water quality survey was made for the whole Musi River Basin. Total sampling points amounted to 90, and the results for fiscal year 1994-1996 are available for this Study.

The sampling locations of this water quality survey are shown in **Annex E4.1.2**.

(3) The Others

Except for the above river quality survey, several water quality observations have been done in the Musi River Basin, as listed in **Table E4.1.1**. The results of these observations are available for this Study; however, target areas are very narrow, and analysed parameters are limited.

Table E4.1.1 Available Data of the Other Water Quality Observations

No	Location	Number of Sampling Points	Year	Type of Samples
1	Lowland	31	1989	River Water
2	Downstream of Musi, Ogan, and Komering rivers	4	1994	River Water
3	Lowland	30	1998	Channels, Pond and Wells
4	Komering River	6	2001	River Water
5	Ogan River	4	2001	River Water

4.1.2 Water Quality Data in the Past

Data on river water quality observed in the past are summarized below. However, it is necessary to consider that river water quality varies in accordance with hydrological (river flow rate) and meteorological (water temperature) conditions.

(1) Available Data of BAPEDALDA

The analysed water quality parameters of the river water survey made by BAPEDALDA are: River Flow Rate, Transparency, Water Temperature, Salinity, TDS, EC, pH, DO (Dissolved O_2), BOD, COD, TSS, and NH_4.

The water quality data at the above 45 sampling locations analysed in 2001 are shown in **Annex E4.1.3**. By using the river water quality data of the above 45 locations, river water condition can be summarized into 10 river systems. The average water quality in major parameters of the 10 river systems in the past is shown in **Table E4.1.2**.

Table E4.1.2 Average River Water Quality (2001)

Parameter	**Musi Main (MU)**	**Komering (KO)**	**Ogan (OG)**	**Harilek (HA)**	**Rawas (RA)**
BOD (mg/l)	4.4	4.5	4.7	-	5.6
COD (mg/l)	9.7	9.8	10.5	-	11.2
TSS (mg/l)	35	33	33	-	43
Parameter	Latikan (LA)	Kelingi (KE)	Lematang (LE)	Semangas (SE)	Padang (PA)
BOD (mg/l)	4.7	5.4	5.2	-	4.6
COD (mg/l)	10.2	10.0	10.7	-	11.0
TSS (mg/l)	45	38	45	-	27

Based on the above Table and **Annex E4.1.3**, the water quality is characterized as follows:

(a) pH is normal and satisfies the river water quality standard.

(b) BOD value varies from 4.4 to 5.6 mg/l, and the difference by sub-basins is little. Compared to the river water quality standard, all the BOD values exceed the criteria (Class I: 2 mg/l).

(c) COD value varies from 9.7 to 11.2 mg/l and some of them exceed the criteria (Class I: 10 mg/l).

(d) All TSS values satisfy the criteria (Class I: 50 mg/l).

As mentioned above, the concentration of organic substances (BOD and COD) is relatively high; however, the average value was estimated in only one observation. In order to obtain more accurate values, periodical observations are needed.

(2) Available Data of Clean River Project

The analysed water quality parameters of this survey are: River Flow Rate, Transparency, Water Temperature, Colour, Smell, Salinity, TS, TDS, EC, pH, DO (Dissolved O_2), BOD, COD, $KMnO_4$ Value, TSS, NH_4,.NO_3, PO_4, Fecal Coliform, and Pesticides (Beta BHC, DDT and others).

The water quality data measured in 1996 (the end of September to November) is shown in **Table E4.1.3**. Among them, averaged data of major water quality data by river system are summarized in **Table E4.1.3**. In addition, the main issues found are indicated in **Annex E4.1.4**.

Table E4.1.3 Average River Water Quality (1996)

Parameter	Musi Main (MU)	Komering (KO)	Ogan (OG)	Harilek (HA)	Rawas (RA)
pH (-)	6.7	7.6	6.7	6.4	7.1
DO (mg/l)	5.4	6.2	6.5	4.9	6.1
BOD (mg/l)	< 2	< 2	-	-	-
COD (mg/l)	29.7	12.8	15.8	20	40
TSS (mg/l)	47	53	57	40	32
Fecal Coliform (N/100ml)	1500	2900	4400	-	-
BHC (mg/m^3)	< 0.066	< 0.066	< 0.066	-	-
DDT (mg/m^3)	0.59	< 0.066	< 0.066	-	-
Parameter	**Latikan (LA)**	**Kelingi (KE)**	**Lematang (LE)**	**Semangas (SE)**	**Padang (PA)**
pH (-)	7.4	7.2	7.1	-	-
DO (mg/l)	6.0	4.9	6.2	-	-
BOD (mg/l)	-	-	< 2	-	-
COD (mg/l)	20	40	19.2	-	-
TSS (mg/l)	30	30	190	-	-
Fecal Coliform (N/100ml)	-		3500	-	-
BHC (mg/m^3)	-	< 0.066	0.13	-	-
DDT (mg/m^3)	-	< 0.066	< 0.066	-	-

Based on the results of this observation, the water quality is characterized as follows:

(a) Organic pollution in the Musi River Basin is low because BOD and COD are found in low concentrations.

(b) Solid content is partly increased. Highest values are found in the Enim River, which flows through a coal mining area where this pollution obviously originated.

(c) DO concentrations in the Musi River are moderate. In the middle river section, DO concentration is below 6.0 mg/l, which is the standard for drinking water resources.

(d) Fecal coliforms were found in concentrations that exceed the allowable limits, and this indicates pollution caused by domestic wastewater.

(e) Very low pH values were measured in the small rivers (Keramasan, Abad and Burnei) that originate in peat swamps. Detected high contents of acid were naturally formed, but they hamper water uses such as drinking, washing and irrigation.

(f) Pesticides were detected (DDT in the Musi River and beta BHC in the Lamatang River). Although the detected concentrations are below the allowable limits, the evidence of pesticides in the rivers used as drinking water resource should be analysed in more detail. The observation of pesticides has been recently executed in OKI Regency; however, the results are not yet available.

(3) Available Data of the Other Sources of Information

Toxic substances such as heavy metals, cyanide and phenol were analysed in Ogan and Komering rivers in 2001. Average values of these toxic substances are tabulated in **Table E4.1.4**.

Table E4.1.4 River Water Quality of Toxic Substances

Parameters	Unit	Average value		Standard Quality
		Ogan River	Komering River	
Hg	(mg/l)	N.D.	N.D.	0.001
As	(mg/l)	N.D.	N.D.	0.005
Ba	(mg/l)	0.02	0.01	1
Cd	(mg/l)	N.D.	N.D.	0.01
F	(mg/l)	0.32	0.38	1.5
Cr^{6+}	(mg/l)	0.001	N.D.	0.05
Se	(mg/l)	N.D.	N.D.	0.01
Zn	(mg/l)	N.D.	N.D.	5
CN	(mg/l)	0.04	0.03	0.1
Cu	(mg/l)	N.D.	N.D.	1
Pb	(mg/l)	N.D.	N.D.	0.1
Phenol	(mg/l)	N.D.	N.D.	0.002

Note, N.D.: not detected

According to the above results, toxic substances were not detected or very small in concentration compared with the standard quality. The available data of other sources are used for the evaluation of river water quality condition in Subsection 4.2.

4.2 Evaluation of River Water Quality

Based on the results of river water quality monitoring made by BAPEDALDA, the Clean River Project, other sources and related reports and with reference to the data of river water quality, the longitudinal change of Musi River Water Quality is as illustrated in **Figure E4.2.1**.

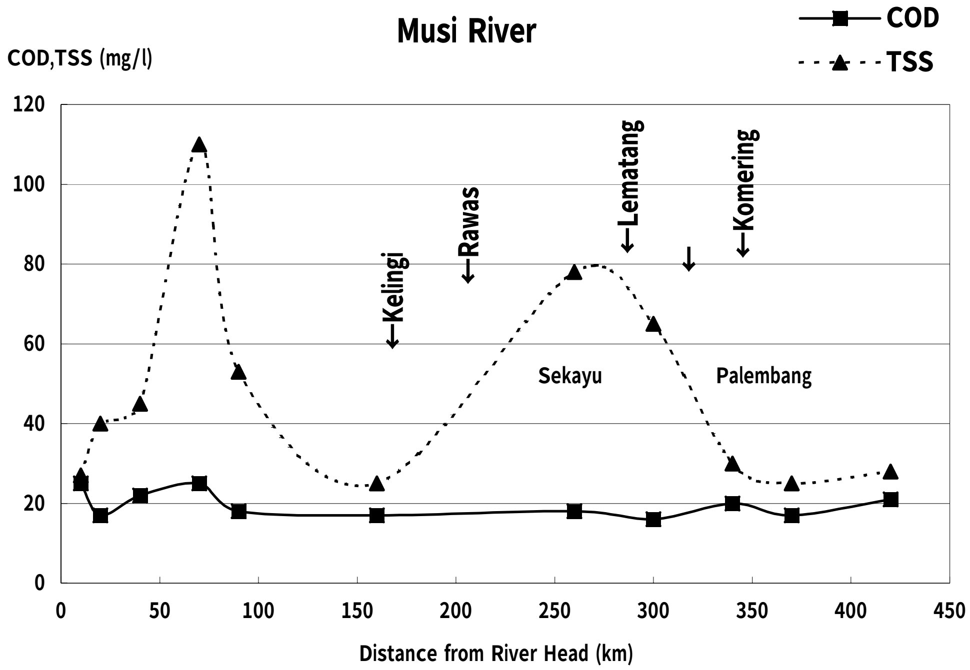

Figure E4.2.1 The Longitudinal Change of Musi River Water Quality

Existing river water quality conditions of the Musi River Basin by category are summarized below.

4.2.1 Category A: Normal High-Midland Area

Forests and farmlands mainly cover the upper and middle reaches of the Musi River Basin. In this Normal High-Midland Area, many settlements and some of the cities are located along roads close to the rivers. Few settlements exist apart from those along the rivers or roads.

The characteristics of water quality in this Area are as follows:

(1) River Water Quality

According to the results of the water quality survey made in the Clean River Project, the river water quality shows low concentrations of BOD and COD in this Normal High-Midland Area. However, the turbidity of rivers is occasionally high due to erosion in devastated land and coal mining area. As for the Musi River, **Figure E4.2.1** shows this phenomenon that COD value is almost constant, however, TSS value widely fluctuates before the confluence with the Kelingi River and the confluence point with the Lematang River.

On the other hand, fecal coliform presents a high concentration in the Highland Area due to domestic wastewater. Pesticides were detected.

(2) Specific Issues

Several factories are located in this Area and discharge industrial wastewater into the water bodies. Some of them cause river water pollution due to their wastewater and they require improvement of the present condition of wastewater effluent.

4.2.2 Category B: Specific Mid-land Area

The following specific issues are discussed in connection with the water quality downstream of the Komering River:

(1) River Water Quality

The river water quality much worsens after diversion from the Perjaya Headworks due to the decrease of base river flow rate and velocity that cause the reduction of dilution effect and acceleration of the growth of aquatic plants. The longitudinal change of the river water quality is shown in **Figure E4.2.2**.

According to the figure below, BOD and COD concentrations become higher at the downstream of the Perjaya Headworks, especially, at the Pulau Negara and Kota Negara villages. However, in order to clarify the influence of the Perijaya Headworks, a detailed study will be needed.

(2) Sedimentation

In this Area, serious sedimentation is pointed out as a specific issue, especially the downstream of Komering River. Recently, serious sedimentation had occurred in the Komering River at the diversion point of the irrigation channel located downstream of Cempaka Town. It is noteworthy that in the downstream of Cempaka Town, no river flow can be found because of the diversion of all the river flow into the irrigation channel. Therefore, dredging works have been executed in this river reach.

According to the Report of the Musi River Basin Study (December 1989), a sediment load survey on this area of Martapura Town was carried out by the Ministry of Public Works during 1986-1987. The result of this survey explains that sediment load may be higher in the Komering River than the results for the Main Musi River.

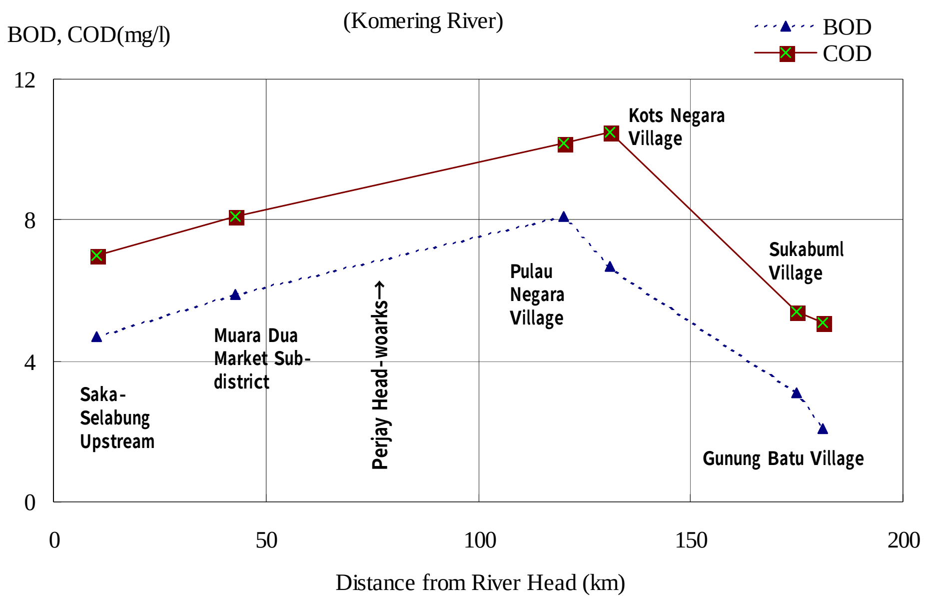

Figure E4.2.2 The Longitudinal Change of Komering River Water Quality

4.2.3 Category C: Urban Area of Palembang City

There are many specific issues regarding water quality in this Area; e.g., huge quality of untreated domestic wastewater effluent, industrial wastewater effluent, inadequate sanitation, low quality of drinking water supply and so on. These issues are discussed below.

(1) Drainage System in Palembang City

The drainage system is used for storm water and domestic wastewater effluent. In Palembang City, primary and secondary drainage channels have been constructed, and the total length of drainage channels amounts to 353 km.

Firstly, large quantities of domestic wastewater are discharged into the small ditches, and continuously flow down into the primary drainage channels. These drainage channels are obviously much polluted by domestic waste and contaminated sludge, which cause the unsanitary condition in the surrounding area.

Accordingly, periodical cleaning and dredging of sludge are necessary for improvement of the unsanitary condition. To date, however, no countermeasure has been sufficiently executed.

(2) Water Supply

Palembang City has been using the Musi River water continuously since 1930. At present, however, many people living in Palembang are forced to purchase bottled water for dinking due to insufficiency of the existing water supply system. Under the circumstances, contaminated shallow wells are frequently used for drinking in areas where poor families live. Besides, many residents utilize wells as alternative to the piped water. Even those with piped water connections use their wells as sources of water for washing and bathing. When there is a lack of water from the piped water connections, the wells become their only source of water.

The unsatisfactory conditions of water supply seem to be the main causes of waterborne and water-related diseases. Hence, a clean water supply system is absolutely necessary.

(3) River Water Quality

According to the river water quality survey, the river water quality of this Area is as shown in **Table E4.2.1**. This table shows the average value of all the analysis data.

BOD, COD, and E. Coli concentrations in the Musi River before its confluence with the Ogan River are lower than those of the two related rivers (Ogan and Komering) and the Musi River after the confluence with Komering River.

On the other hand, as mentioned in Subsection 3.2 of Chapter 3, many factories are located in this Area and discharging large quantities of industrial wastewater into the Musi River. This situation surely affects the river water quality in this Urban Area of Palembang City.

Table E4.2.1 Water Quality of Musi River

Parameter	Standard	Sampling Location			
		Musi River before confluence with Ogan River	The Lowest Point of Ogan River	The Lowest Point of Komering River	Musi River after confluence with Komering River
TSS (mg/l)	1000	16.6	15.5	16.6	17.0
PH	5.0 –9.0	7.2	7.2	7.1	7.0
DO (mg/l)	> 6	7.3	7.4	7.4	6.9
BOD (mg/l)	< 6	1.4	2.2	2.2	1.6
COD (mg/l)	< 10	9.6	11.4	18.1	10.0
NH_4 (mg/l)	0.5	0.05	0.04	0.04	0.04
NO_3 (mg/l)	10	0.87	0.68	0.60	0.71
PO_4 (mg/l)	-	14.8	17.1	10.0	15.25
E . Coli (NPM/100ml)	10000	580	2300	1620	3300

Sampling Date: November 14 to December, 1994

4.2.4 Category D: Lowland Area

The downstream areas of the Musi River Basin, being located in the coastal region of Sumatra Province and in the Lowland that are affected by tides, receive a lower rainfall than the upstream areas. Many entangled river courses with very low slopes run in these areas, and they are much influenced by tides and saline intrusion. Besides, in the Lowland Area, there have been extensive reclamation for paddy fields. The reclamation areas also contain specific issues regarding water quality as discussed below:

(1) Saline Intrusion

The extent of saline intrusion depends on the flow rate in rivers, the tide level, and the width of rivers. During the dry season when the rivers flow at low and high tide, saline water is found up to 40 km inland from the sea. The water quality analysis for saline concentration was executed in the sampling locations, and, with a realistic limit of 400 mg/l for potable water supply, feasible water intake points may be found even further upstream.

On the other hand, the intrusion of saline water has often occurred in paddy fields. Salinity levels can reach unacceptable levels for agriculture after a prolonged dry season (more than 2-1/2 months), although a single application of water with the salinity of 3,000 mg/l is not harmful to paddy. The highest salinity will be less. Intrusion of seawater is highest during spring tides at lesser concentrations. The dry period of the year 1994 was the worst in the past 15 years.

(2) Land Reclamation

Common water-courses in the downstream of the reclamation areas seem to accept leachate from soil flushing. This leachate has a low acidity, but with dissolved hydrogen sulfide or suspended solids. This condition has made the deterioration of water quality in the river water in the vicinity.

Many dead fishes are found in the common watercourses after rainfall and the end of the dry season. Oxidized acids in soil, which contain pyrite (FeS), produce sulfuric acid with a pH of around 3.0. This is harmful to fish, shrimps and crops grown nearby.

(3) Water Supply and Water Quality

In this Lowland Area, water supply for households mostly depends on rainfall, tidal and river action on the water condition inside neighbouring channels, and shallow or deep wells.

Water quality analysis data from different water sources in the Lowland Area provided the present situation of domestic water supply for households. Those analysis data are shown in **Annex E4.2.1** and **Annex E4.2.2**.

According to the above data, the characteristics of drinking water indicate that suspended solids, sulphate concentration, E. coli and organic substances are unsuitable for drinking water.

In this Area, the water supply and sanitation condition of people during the dry season when they have no supply from rainfall is very serious. An improvement programme is absolutely necessary to solve this unsatisfactory condition.

4.3 Water Quality Standards

4.3.1 Relevant Laws and Regulations on Water Quality

The Government of Indonesia had enacted “Regulation Number 82, Year 2001, concerning Water Quality Management and Water Pollution Control.” In compliance with this national regulation, the Governor of South Sumatra prescribed the standards of river water and wastewater effluents to be applied in South Sumatra’s administrative region. Besides, South Sumatra Province categorized the target river water quality into four classes; namely, Classes I, II, III, and IV, in accordance with the water use level of rivers and designated the class of rivers under its jurisdiction.

4.3.2 River Water Quality Standards

According to river quality corresponding to the established conditions of general ecological function and to the condition under which water is used for a particular purpose, the four classes of river water quality correspond to the water uses shown in **Table E4.3.1**.

Table E4.3.1 Water Quality Standards and Water Use

Class	Water Use
I	Water that can be used for drinking or other uses.
II	Water that can be used for water recreation needs and agriculture
III	Water that can be used for agriculture and livestock, as well as industrial and hydropower generation
IV	Water that can be used for agriculture and other uses having the same criteria.

The Decision of the South Sumatra Governor describes the standard water quality of each class and regulates 45 parameters as criteria. The major water quality parameters are shown in **Table E4.3.2**. For details, see **Annex E4.3.1**.

Table E4.3.2 Major Water Quality Parameters Regulated in the Standards

Parameter	Class I	Class II	Class III	Class IV
pH (mg/l)	6 –9	6 – 9	6- 9	5 -9
DO (mg/l)	6	4	3	0
BOD (mg/l)	2	3	6	12
COD (mg/l)	10.0	25.0	50.0	100.0
TSS (mg/l)	50	50	400	400
NH_4 (mg/l)	0.5	-	-	-
NO_2 (mg/l)	0.06	0.06	0.06	-
PO_4 (mg/l)	0.20	0.20	1.00	5.00

In addition, the Decision of the South Sumatra Governor sets the usage of major rivers in the Study Area, as shown in **Table E4.3.3**.

Table E4.3.3 River and Water Use

River	Boundary	Class	Water Use
Musi Main	Kepayang Bengkulu until Selat Jaran	I	Drinking Water
Musi Main	Selat Jaran until Estuary of the River	III	Fishery
Lematang	Upsteram River until Tanjang Jebat Village	I	Drinking Water
Lematang	Tanjung Jebat Village until Musi River Crossing	I	Drinking Water
Enim	Upstream River until Inderamayu Village	I	Drinking Water
Enim	Inderamayu Village until Lematang River	I	Drinking Water
Komering	Upstream River until Musi River	I	Drinking Water
Ogan	Upstream River until Pusar Batraya Village	I	Drinking Water
Ogan	Pusar Village until Musi River Clossing	I	Drinking Water
Selabung	End of Lake until Komering River Clossing	I	Drinking Water
Batang Harilek	Upstream River until Musi River	I	Drinking Water
Tungkai	Upstream River until Muara	I	Drinking Water
Rupit	Upstream River until Rawas River Clossing	I	Drinking Water
Sembiliang	Upstream River until Muara	I	Drinking Water
Sale	Upstream River until Muara	I	Drinking Water
Rawas	Upstream River until Musi River Clossing	I	Drinking Water
Lekitan	Upstream River until Musi River Clossing	I	Drinking Water
Mesuji	Upstream River	I	Drinking Water

4.3.3 Permissible Limits of Industrial Wastewater Effluent

In South Sumatra Province, the permissible limits of industrial wastewater quality and maximum pollution load discharged into rivers are prescribed in the Decision of the South Sumatra Governor. According to this decision, 32 types of industry should comply with the regulation.

With their own small laboratories, factories have to monitor their industrial wastewater by themselves and submit the analysis results to BAPEDALDA. BAPEDALDA has been observing the wastewater quality of 60 factories once to four times a year for the purpose of cross-check.

4.3.4 Quality Standards for Piped Water

PDAM has a quality standard for piped water as shown in **Annex E4.3.2**, which is used in the control of water quality of the piped water. The staff of the purification plant operated by PDAM has to periodically analyze the water quality of ‘before treatment’ and ‘after treatment’ using PDAM’s laboratory.

4.4 Existing Water Quality Monitoring System

4.4.1 Relevant Institution for Water Quality Monitoring

BAPEDALDA was organized in 1985, and has been carrying out the water quality monitoring since 1989. The organization of Provincial BAPEDALDA is shown in **Annex E4.4.1**.

BAPEDALDA executes water quality monitoring under the finance provided by the municipal government. Provincial BAPEDALDA has a central laboratory used for the environmental monitoring. Currently, 12 staffs are assigned in the central laboratory, which has been designated as a reference laboratory in South Sumatra Province. On the other hand, Municipal BAPEDALDA of Palembang also has a newly established laboratory and 20 staffs are assigned for the laboratory work.

4.4.2 Equipment Installed in the Laboratory

Major equipments installed in the central laboratory of Provincial BAPEDALDA consist of the atomic absorption photometer, oil content meter, pH meter, COD reactor, BOD incubator, chemical balance, cold storage and so on. According to the existing equipment line-up, general parameters including heavy metals could be analyzed in the central laboratory; however, the laboratory is not yet equipped with GC or GCMS necessary for the analysis of toxic substances, e.g., insecticides, herbicides, pesticides, etc. Hence, activities for environmental monitoring are very limited.

On the other hand, equipments installed in the laboratory of Municipal BAPEDALDA of Palembang consist only of the spectrophotometer, BOD incubator, COD reactor and handy water quality checker. Hence, parameters possible for the analysis are only pH, BOD, COD, TSS and NH_3-N.

The main activity of monitoring is to check factory effluent. When the analysis of additional parameters such as heavy metals, pesticides and the other toxic organic substances is required, usually, the additional analysis work are entrusted to a government or a private laboratory (Sucofimdo) where high-level equipment is installed and well maintained.

5. SPECIFIC ISSUES TO BE SOLVED

5.1 Specific Issues Regarding Water Quality

Based on the study results, the overall condition of specific issues with regard to the water quality in each category are summarized in **Table E5.1.1**.

Table E5.1.1 Existing Specific Issues

Classification	Category A: High-Midland Area	Category B: Specific Midland Area	Category C: Urban Area of Palembang City	Category D: Lowland Area
River Water	High fecal coliform Toxic substances (pesticides) High turbidity	Sedimentation Low flow (Reduction of dilution effect) Toxic substances (pesticides) High fecal coliform	Low pH Toxic substances (pesticides) High fecal coliform Highly polluted channels in Palembang	Saline intrusion Low pH Brackish water
Water Use (Drinking water)	Direct use of river water Use of highly turbid river water	Lack of water in dry season	Low quality of shallow groundwater Lack of water in dry season	Low quality of shallow groundwater Lack of water in dry season
Pollution Source	Erosion from devastated land Agricultural pollution source Domestic wastewater	Domestic wastewater Agricultural pollution source	Large number of factories Large quantity of domestic wastewater effluent Soil containing pyrite (FeS) in peat swamp	Large number of factories Soil containing pyrite (FeS) in peat swamp

There are many kinds of specific issues in the Study Area. For example, there are many people who suffer from water borne disease due to low quality water use. These issues should be solved by various countermeasures.

5.2 Reduction of Pollution Load

As mentioned before, total pollution load generation consists of point-pollution load and non-point pollution load. However, it is very difficult to reduce the generation of non-point pollution load because the pollution sources are widely scattered. Hence, the reduction of point pollution load should be essentially considered.

5.2.1 Sewerage Treatment System

Sewerage treatment systems can largely reduce the domestic pollution load. The TATA KOTA of Palembang prepared a master plan for the improvement of domestic wastewater in 1990; however, the master plan was not a full-scale project for the whole urban area of Palembang. The plan has a very limited target area and has not progressed due to the lack of budget and affordability of people in Palembang. In Indonesia, sewerage systems have been constructed in other major cities such as Jakarta. For the improvement of water quality in Palembang, a comprehensive plan is urgently necessary.

5.2.2 Improvement of Industrial Wastewater Treatment System

Industrial pollution load generation in the Study Area shares a large ratio of total pollution load generation. Generally, large factories have wastewater treatment plants like the activated sludge system; however, plant maintenance has not been well maintained and the efficiency of treatment is low. Therefore, improvement of the industrial wastewater treatment systems is absolutely necessary giving due consideration to affordability for enough O&M, land acquisition and construction cost of a wastewater treatment plant.

Further, BAPEDALDA needs administrative leadership in environmental improvement and has to reinforce its functions concerning but not limited to the stoppage of operation and the improvement of wastewater treatment plants of factories concerned.

5.3 Reinforcement of Water Quality Monitoring Network

Water quality monitoring is the basic work for the water quality management in the Musi River Basin. The results of monitoring should be widely utilized in relevant institutions and should be open to the general public. Important point is that BAPEDALDA has been the agency responsible for the water quality until now, and in the future, it is proposed that Musi Balai PSDA cover a certain part of this work.

5.3.1 Necessary Improvement in the Present System

Past Water Quality Monitoring

As mentioned in the previous sections, the past water quality monitoring does not sufficiently cover the whole Musi River Basin since the full-scale river water quality monitoring was conducted only in 2001. Necessary data on river water quality has not been stored and utilized for water quality management and control.

BAPEDALDA has a plan for water quality monitoring; however, the plan has not been conducted well due to the shortage of budget and monitoring equipment. Also, parameters in the past monitoring do not cover all the required parameters of 45 specified in the water quality standards as shown in **Table E5.3.1**.

Table E5.3.1 Observed Parameters in the Past

Parameters	Water Quality Observation in the Past		
	BAPEDALDA (2001)	**Clean River Project (1994-1996)**	**Other Observation (2001)**
45 Water Quality Standard : Water Temp. TDS, TSS, Hg, NH_3, As, Ba, Fe, Cd, Cl^-, B, Co, Cr^{6+}, Mn, NO_3, pH, Se, Zn, CN, SO_4, H_2S, BOD, COD, DO, Cl_2, PO_4, Cu, Pb, Aldrin and Didrin, 2,4-D, DDT, BHC, Detergent, Phenol, Heptachlor, Lindane, Methylchlor, Oil and Grease, Toxaphan , Feacal coliform, Total coliform, Gross Alph Active, Gross Beta Active	8 Water Temp., TDS, TSS, NH_3, pH, BOD, COD, DO	13 Water Temp., TDS, TSS, NH_3, NO_3, pH, BOD, COD, DO, PO_4, DDT, BHC, Fecal coliform	27 Water Temp, TSS, Hg, NH_3, As, Ba, Fe, Cad, B, Cr^{6+}, Mn, NO_3, pH, Se, Zn, CN, SO_4, H_2S, BOD, COD, DO, PO4, Cu, Pb, Phenol, Oil and Grease
Additional Parameters	4 EC, Salinity, Flow Rate and Transparency	7 EC, Salinity, Flow Rate, Transparency, Color, Smell, NO2 and $KMnO_4$ Demand	1 NO_2

There is another problem that the institutional issues have been hindering the sufficient usage of monitoring data. Therefore, these obstacles to monitoring should be solved.

Necessary Sampling Locations of River Water

The water quality of the Musi River Basin should be monitored at least at the 45 monitoring points observed in 2001 by BAPEDALDA (see **Table E5.3.2**).

Table E5.3.2 Proposed Water Quality Monitoring Stations

Regency	No.	Location Name	River Name	Regency	No.	Location Name	River Name
Muara Enim	1.1	Tebat Agung	Niru		4.5	Kayu Agung	Komering
	1.2	Muara Niru	Lematang		4.6	Desa Pedamaran	Babatan
	1.3	Teluk Lubuk	Lematang		4.7	Desa Gunung Batu	Komering
	1.4	Banu Ayu	Lematang		4.8	Muara Burnel	Burnel
	1.5	Indramayu	Enim	OKU	5.1	Rantau Nipis	Selabung
	1.6	Jembatan Enim II	Enim		5.2	Desa Selabung	Ogan
	1.7	Tanjung Priok	Lematang		5.3	Desa Mendala	Ogan
Lahat	2.1	Kembatan Kebur	Lematang		5.4	Desa Pusar	Ogan
	2.2	Tanjung Mulak	Lematang		5.5	Martapura	Komering
	2.3	Bunga Mas	Kikim		5.6	Muara Dua	Komering
MUBA	3.1	Sukamerindu	Lematang		5.7	Kota Batu	Warkuk
	3.2	Sungai Dua	Komering		5.8	Danau Ranau	Danau Ranau
	3.3	Desa Upang	Musi		5.9	Tj. Lengkayap	Lengkayap
	3.4	Pulau Burung	Musi	Palembang	6.1	Jembatan Ampera	Musi
	3.5	Hulub Ogan	Ogan		6.2	Hulu Komering	Komering
	3.6	Talang Kelapa	Musi		6.3	Desa Rambutan	Keramasan
	3.7	Kota Sekayu	Musi		6.4	Pulau Kerto	Musi
	3.8	Durian Gadis	Padang	MURA	7.1	Terawas	Hulu Lakitan
	3.9	Desa Teluk	Batangharileko		7.2	Lawang Kidul	Rawas
OKI	4.1	Desa Indralaya	Kelekar		7.3	Muara Rupi	Rupit
	4.2	Desa Pemulutan	Ogan		7.4	Muara Beliti	Beliti
	4.3	Tanjung Raja	Ogan		7.5	Lubuk Linggau	Kelingi
	4.4	Desa SP Padang	Komering				

The monitoring points are widely scattered in the whole Musi River Basin, and the actual river water conditions can be estimated. On the other hand, the monitoring of saline intrusion and low pH in the Lowland Area has not been well executed and hence a continuous monitoring plan for saline intrusion is required. A total of 10 points in Lowland Area should be included.

Sampling Number and Necessary Parameters

The water quality analysis should cover the 45 parameters specified in the water quality standards. **Table E5.3.3** shows the recommended parameters and sampling interval.

Table E5.3.3 Sampling Number and Necessary Parameters on Annual Basis

Parameters	Measurement interval
A. Field Measurement Items Water Temperature, EC, Salinity, Flow Rate, Transparency, Color and Smell	Every month
B. General Items TDS, TSS, NH_3, NO_3, pH, BOD, COD, DO, Cl_2, PO_4 SO_4, Feacal coliform, Total coliform	Every month
C. Heavy Metals and Other Toxic Substances Hg, As, Ba, Fe, Cd, Cl^-, B, Co, Cr^{6+}, Mn, Se, Zn, CN, H_2S, , Cu, Pb, Aldrin and Didrin, 2,4-D, DDT, BHC, Detergent, Phenol, Heptachlor, Lindane, Methylchlor, Oil and Grease, Toxaphan	Once in 6-month

Institutional Reinforcement

Water quality monitoring is a part of basic monitoring for the water management in the Musi River Basin. According to Decree of Musi Balai PSDA (821/003/BPSDA. M/2002, July 18, 2002), the task of water pollution control is given to Musi Balai PSDA with the concrete activities proposed as follow.

(1) To plan the locations of water quality observation point in river, river mouth, delta, reservoir, lake, and *situ*/*embung* (small reservoir).

(2) To plan quality planning of river, river-mouth, delta, reservoir, lake, and *situ/embung* (small reservoir).

(3) To plan the periodical and particular observation point water quality monitoring (usually at the point of discharge measurement station)

(4) To arrange the actions that are needed to be taken

(5) To act or do some actions directly in the field

(6) To provide/give technical recommendation for industrial wastewater disposal to river, river-mouth, delta, lake and *situ/embung* (small reservoir).

On the other hand, Provincial BAPEDALDA is responsible for the following matters: Environmental impact assessment against the specific project, the stipulation of water quality criteria, drawing-up of plans for countermeasures on industrial pollution and so on. In addition, ten municipal BAPEDALDAs have environmental monitoring activities in the Musi River Basin. Another organization related to water quality is PDAM of each municipality. PDAM is responsible for the supply of piped water and has to monitor the water quality according to the criteria, thus the monitoring data of the Musi River have been accumulated.

Demarcation of the tasks relating to water quality monitoring between Musi Balai PSDA, Provincial BAPEDALDA, Municipal BAPEDALDA, and PDAM, and coordination between these organizations is deemed urgent and important for the smooth implementation of water quality monitoring and effective utilization of the monitoring results in the Musi River Basin.

Improvement of Laboratory Facilities

To monitor water quality based on the above recommendations, relevant monitoring equipment must be improved.

5.3.2 Proposed Water Quality Monitoring System Establishment Program

Water Quality Monitoring System Establishment Program (Program 5-2) is proposed as follows: Water quality monitoring is the basic work for the environmental management in the Musi River Basin. The results of the monitoring should be widely utilized in relevant institutions and should be open to the general public.

Coordination between Relevant Agencies (Program 5-2-1)

Dinas PU Pengairan (Musi Balai PSDA), Provincial BAPEDALDA, Municipal BAPEDALDAs, and PDAMs shall coordinate and formulate clear demarcation of the water quality monitoring work. It is preferable that Musi Balai PSDA will be the leading agency. In any case, data and information should be stored and maintained in the Water Resource Data and Information Unit to be established under Musi Balai PSDA, and sharing of the data and information between relevant agencies and dissemination to the general public are deemed important.

Preparation of Monitoring Plan (Program 5-2-2)

Musi Balai PSDA shall finalize water quality monitoring plan based on the proposal above. Presently assumed monitoring plan will be as follows:

(1) Location of Water Quality Monitoring

45 locations shown in **Table E5.3.2** and 10 in tidal swamp

(2) Sampling and Laboratory Test Interval

Sampling and laboratory test interval by parameters are as shown in **Table E5.3.3**.

(3) Monitoring and Laboratory Test Group

To conduct the above monitoring work, three monitoring teams with the following man-power shall be needed, namely, one manager, one secretary, three monitoring group chiefs, three sampling staffs for each group, a total of ten laboratory staffs, two workers and three drivers.

Establishment of Water Quality Laboratory in Musi Balai PSDA (Program 5-2-3)

Musi Balai PSDA shall establish Water Quality Laboratory. The cost of equipment for the water quality laboratory is shown in **Annex E5.3.1** and summarized in **Table E5.3.4**.

Table E5.3.4 Cost of Equipment for Water Quality Laboratory and Monitoring

Item	Quantity	Cost (Rp. Million)	
1. Common Analytical Equipment		1,965.8	
2. General Laboratory Equipment		2,481.4	
3. Water Quality Monitoring Equipment		1,636.5	
Total		Initial Investment	Rp. 6,083.7 million

Monitoring (Program 5-2-4)

Water quality monitoring work shall be conducted following the proposed monitoring program. Necessary cost for man-power of monitoring work is estimated as shown in **Table E5.3.5**. Data storage and processing work shall be conducted under the **Program 5-4**.

Table E5.3.5 Input of Man-Power for Monitoring Work

Item	Quantity	Unit Cost	Cost
1. Man Power for Monitoring Group			
Manager	1	Rp. 25 million/year	Rp. 25 million/year
Secretary	1	Rp. 10 miilion/year	Rp. 10 miilion/year
Monitoring Group Chief	3	Rp. 15 million/year	Rp. 45 million/year
Sampling Staff	9	Rp. 10 million/year	Rp. 90 million/year
Laboratory Staff	10	Rp. 10 million/year	Rp. 100 million/year
Worker (Cleaning, etc.)	2	Rp. 3 million/year	Rp. 6 million/year
Driver	3	Rp. 5 million/year	Rp. 15 million/year
Total		Annual Cost	Rp. 291 million

REFERENCES

1) Musi River Basin Study; Final Report, ANNEX No. 2 - Water Supply and Sanitation, December 1989

2) Decision Number 13 of the Year 2002 of the South Sumatra Governor concerning Water Use and Water Quality Standard of River Water and Liquid Waste for Industries, Hotels, Restaurants and Hospitals in South Sumatra

3) Young Professionals Forum; Seminar Guide Book, International Commission on Irrigation and Drainage, July 1998

4) Robiyanto H. Suanto; Management of Deltaic Areas for Sustainable Development: A Case Study in South-Eastern Sumatra Region

5) Bagian Project; The Report of the River Water Quality Analysis Data of Musi, Ogan and Komering River in Kotamaya, Paleman, Jan. 1995.

6) BAPEDALDA and Sriwijaya University; Final Report of the Study on the Damaged Area Caused by the Sedimentation in Komering River, 2001

7) BAPEDALDA and Sriwijaya University; Final Report of the Study on the Erosion Process in Ogan River, 2001

8) Monitoring and Recovery Unit of BAPEDALDA; Clean River Project 2005, Musi River Basin, South Sumatra Province, 2001

9) Yearly Report of Clean River Project on the Musi River Basin, Period 1995-1996

10) Yearly Report of Clean River Project on the Musi River Basin, Period 1996-1997