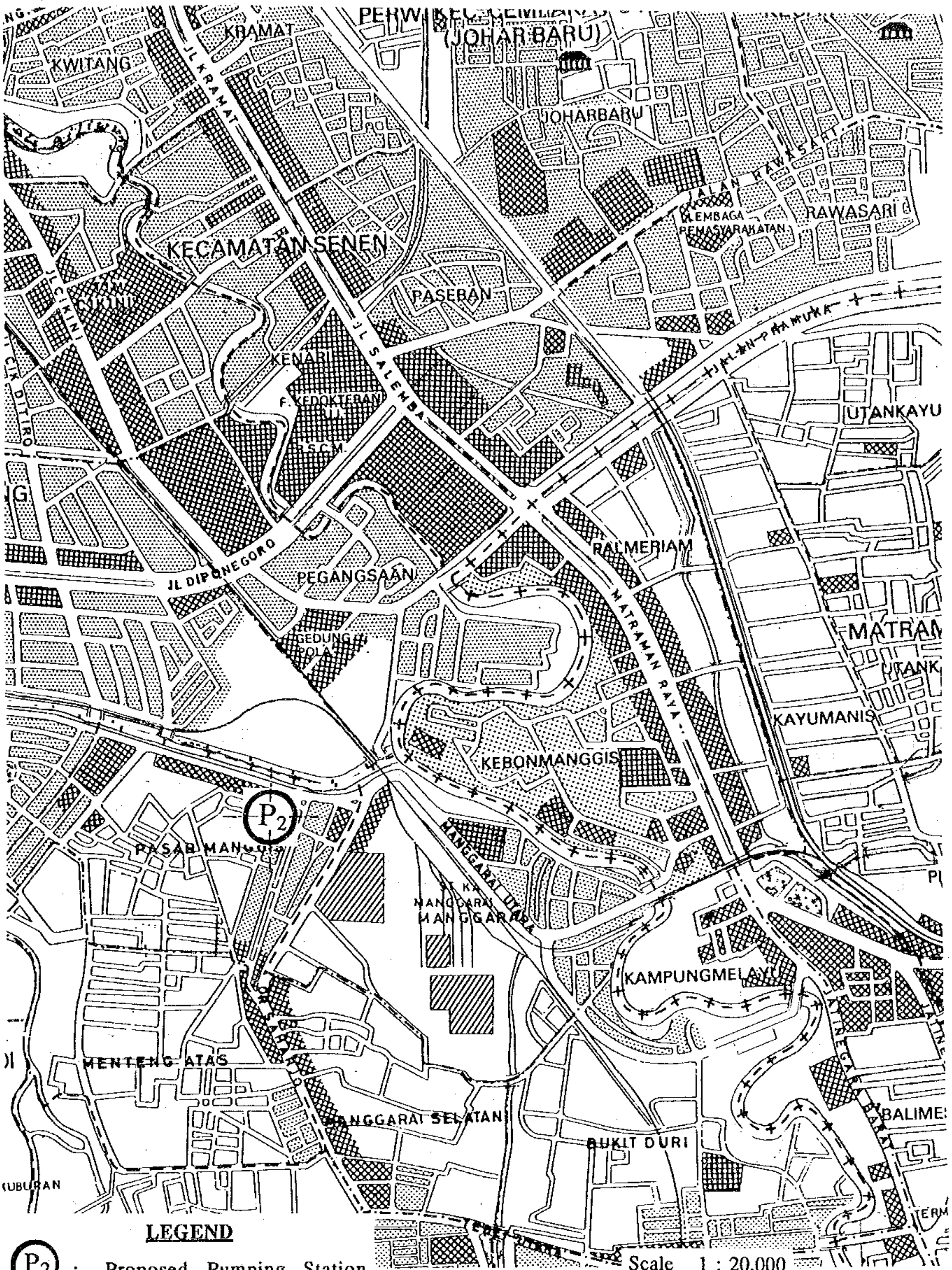


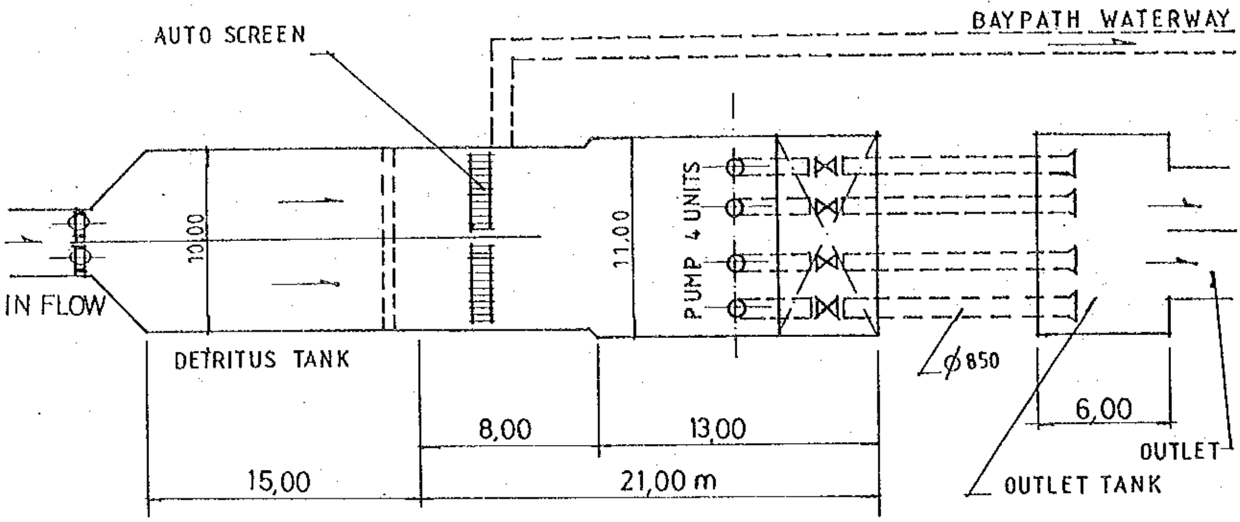
LEGEND

P2 : Proposed Pumping Station

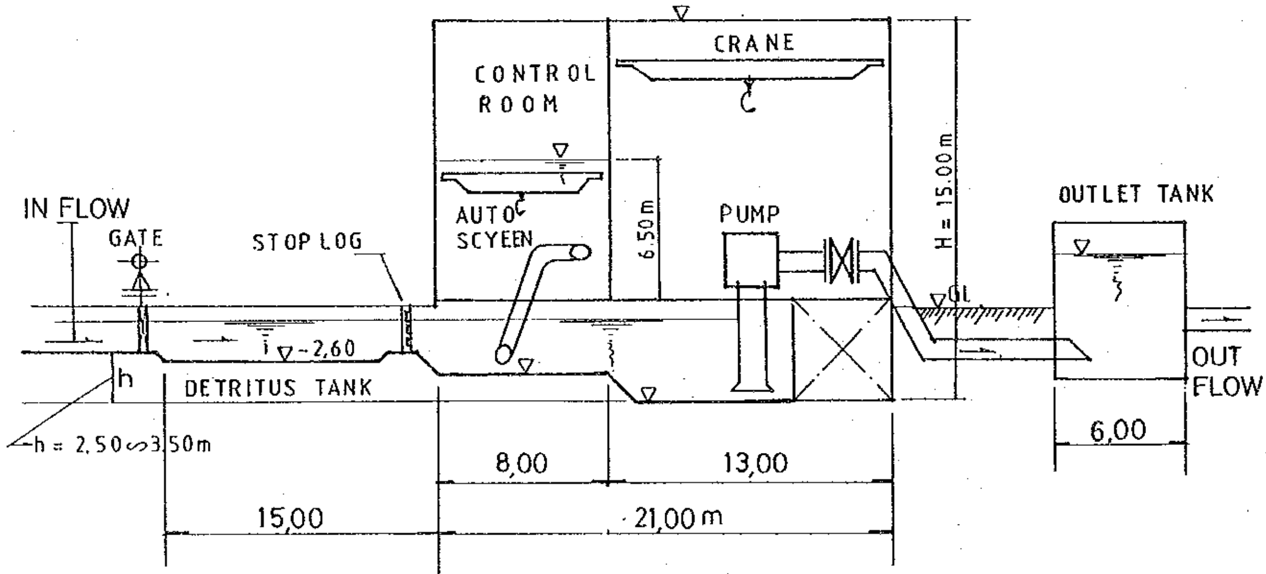
Scale 1 : 20,000

FIG. G.19 (2) LOCATION MAP OF PUMP STATION DEVELOPMENT PLAN

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA



PLAN
NON SCALE



SECTION
NON SCALE

FIG. G.20 PROPOSED PLAN AND SECTION OF PUMP STATION

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

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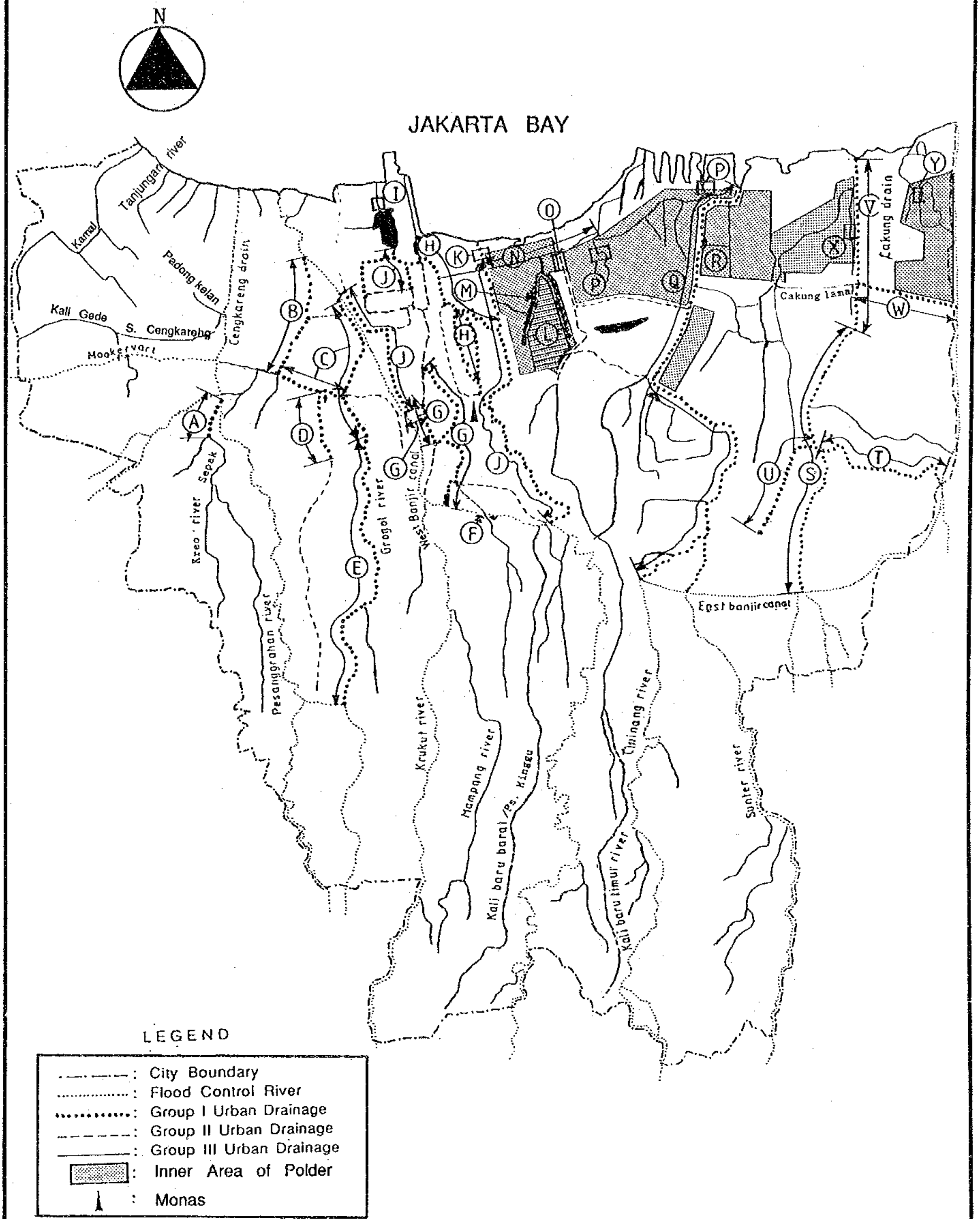


FIG. G.21 LOCATION OF ON-GOING PROJECT

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

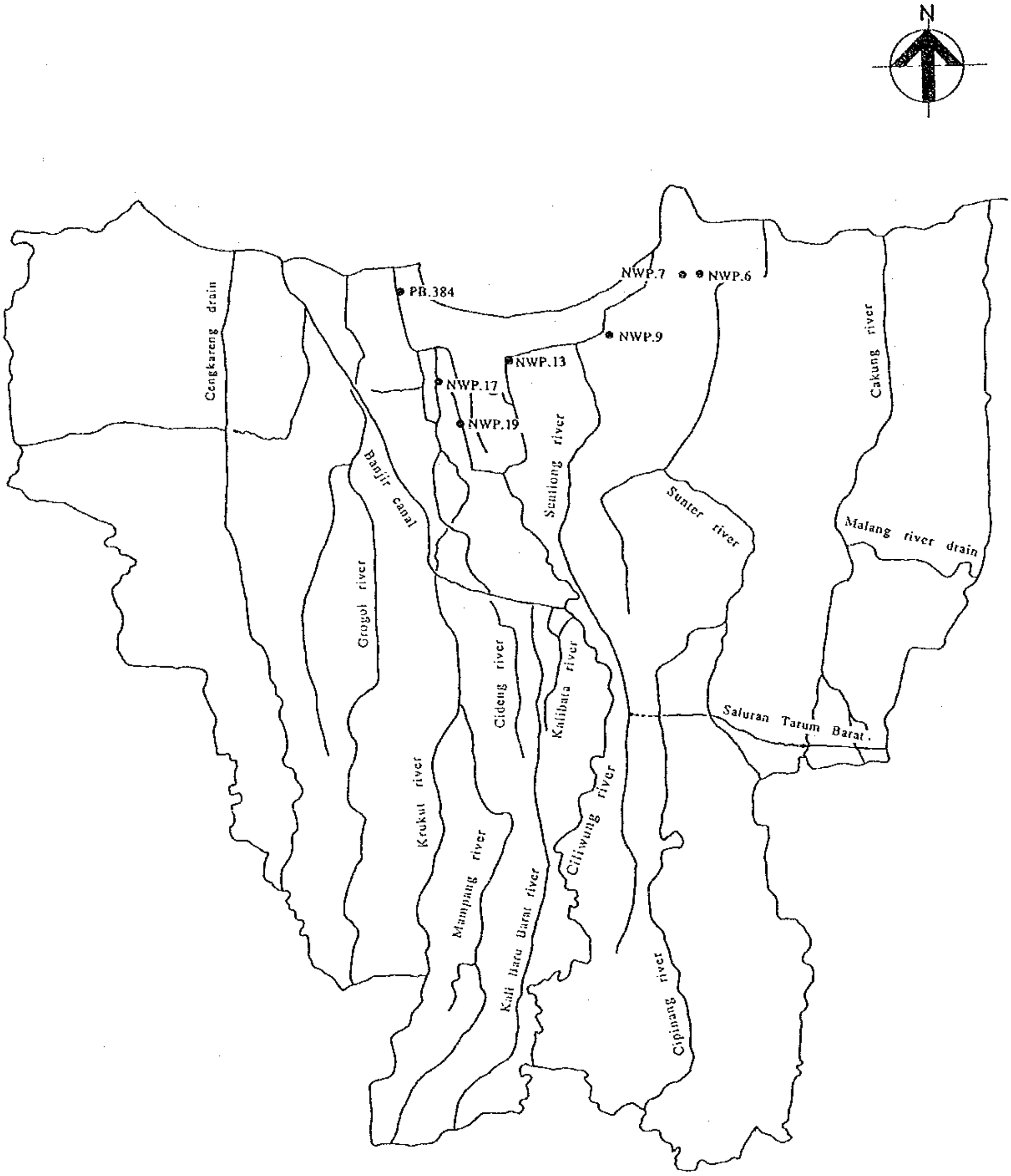


FIG. G.22 LOCATION OF SURVEYD BENCH MARK

THE STUDY ON URBAN DRAINAGE AND WASTE WATER DISPOSAL PROJECT IN THE CITY OF JAKARTA

APPENDIX H

SANITATION AND SEWERAGE DEVELOPMENT PLAN

APPENDIX H SANITATION AND SEWERAGE DEVELOPMENT PLAN

1. Needs for Sanitation and Sewerage Development

1.1 Forecasted Future River Water Pollution

1.1.1 General

In this Section, future river water quality of the Study Area in 2010 is forecasted to confirm the requirements of sanitation and sewerage development, and to identify its priority areas.

The simulation of river water quality are carried out for the rivers and channels located in the central part of the Study Area. The objective rivers and channels include : Ciliwung, Kali Bata, Kali Baru Barat, Mampang, Krukut, Banjir Canal, Lower Angke, Grogol, Sekretaris, Cideng, Lower Ciliwung, Kali Baru Timur, Sentiong, Cipinang, Sunter and others.

The objective area covers the catchment area of 38,385 ha with a total population of 6,484,000.

1.1.2 Simulation of River Water Quality

(1) Division of River Basin

The objective area consists of five (5) river basins : Ciliwung - Banjir Canal, Grogol, Cideng, Sentiong and Sunter. These river basins are further divided into 15 sub-basins as shown in Fig. H.1. Their catchment areas are shown in Table H.1.

The model of the river systems are shown in Fig. H.2. In this figure, the affixed numbers and marks express the following stations and sub-basins.

1 - 15 : Out-put station of water quality (15 stations)
▽1 - ▽15 : Sub-basin of wastewater and pollution load discharge
A - G : Input station of water flow and pollution load (7 stations)
▽A - ▽G : River basin outside the Study Area

(2) Existing River Water Quality

The existing river water quality (BOD) in dry season were established at 92 stations of the Study Area in Appendix C. These stations cover the above-mentioned 15 out-put stations and 7 in-put stations.

Water quality of the above 22 simulation stations in dry season are shown in Table H.2.

(3) Existing River Flow

The existing available data of river low flow are those observed by P4L at 24 stations of the Study Area in dry season of 1988/1989. The observed stations and observed discharge are shown in Fig. H.3 and Table H.3 respectively.

These 24 stations cover only nine (9) stations among the above-mentioned 22 simulation stations. Such stations are seven (7) in-put stations of A - G, and two (2) out-put stations of 4 and 10.

For the other 13 out-put stations, river flow is estimated based on the observation data at their upstream neighbouring stations as described below.

River flow at the objective station is estimated by the following equation.

$$Q = Q_{up} + (q_n \times A + Q_w) \times f$$

Where,

Q : River flow at objective station (m^3/s)

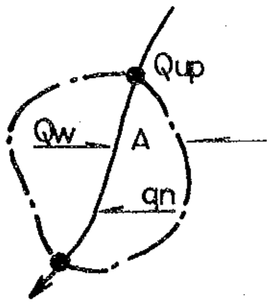
Q_{up} : Observed river flow at a neighbouring upstream station(m^3/s)

q_n : Specific natural discharge due to rainfall and groundwater of the remaining catchment area ($m^3/s/km^2$)

A : Remaining catchment area (km^2)

Q_w : Wastewater discharge of the remaining catchment (m^3/s)

f : Flow run-off coefficient



Discharge of catchment consists of natural discharge due to rainfall and groundwater, and wastewater discharge. While in this Study, it is necessary to separate wastewater discharge from natural discharge for the convenience in the evaluation of sewerage development effects.

Since the river flow in the outside area of the Study Area includes only little wastewater discharge, the river flow observed at the fringes of the Study Area can be considered natural discharge. Table H.4 shows the observed specific discharge in dry season at the stations located in the fringes of the Study Area. They ranges from 0.001 $m^3/s/km^2$ to 0.045 $m^3/s/km^2$ with an average of 0.029 $m^3/s/km^2$. Then, the specific natural discharge of the Study Area is determined to be 0.029 $m^3/s/km^2$.

Flow run-off coefficient of the Study Area is estimated by the following formula.

$$Q_{dw} - Q_{up} = (q_n \times A + Q_w) \times f$$

Where,

Q_{dw} : Observed river flow at downstream station (m^3/s)

Q_{up} : Observed river flow at upstream station (m^3/s)

q_n : Specific natural discharge of the remaining catchment : 0.029 $m^3/s/km^2$

A : Remaining catchment area (km^2)

Q_w : Wastewater discharge (m^3/s)

f : Flow run-off coefficient.

This calculation was applied for the four (4) specified catchment areas of the Krukut, Cideng, Sentiong and Sunter Rivers (See Fig. H.4). The calculation results are shown in Table H.5.

The calculated run-off coefficient ranges from 40.1% to 57.7% with an average of 50.4%. Then, run-off coefficient of 50% is used in this simulation study.

(4) Calibration of Simulation Model

The existing wastewater discharge and pollution load run-off of each sub-basin is obtained by summing up those of the Kelurahans included in its sub-basin (See Table H.6). These existing wastewater discharge and pollution load run-off do not include toilet waste from the residences provided with septic tank/leaching system. Toilet waste of such residences is assumed to completely infiltrate into underground. For wastewater discharge and pollution load generation of Kelurahan, refer to Appendix D.

The observed and simulated river water quality at the respective out-put stations are compared as shown in Table H.2.

In this simulation, BOD run-off coefficient is assumed to be 50%. Self purification coefficient of river is assumed to vary from 0% to 40%, depending on river length and river flow.

As evident from the above table, the simulated river water quality is well in agreement with the observed one.

1.1.3 Forecasted Future River Water Quality

The future wastewater discharge and pollution load run-off in 2010 by sub-basin are estimated in the same manner as the existing ones. The estimated results are shown in Table H.6.

The future river water quality in 2010 without project at 15 stations are also simulated in the same manner as the simulation of the existing water quality. In this simulation, wastewater discharge and pollution load run-off coefficients of the Study Area, the river discharge and quality from the outside areas, and self purification coefficient of river are assumed to be the same as those in the existing conditions.

In 2010, the average river water quality at the 15 stations of the central part of the Study Area will become worse to a level of 91 mg/l as stream BOD. The worst river water pollution to a level of 130 mg/l as stream BOD will occur in the Cideng River basin (St. No. 7 - No. 11), followed by the Sentiong River Basin (St. No. 12 and No. 13) of 115 mg/l as stream BOD and the Grogol River Basin (St. No. 5 and No. 6) of 93 mg/l in stream BOD.

The comparison of simulated river water quality without project in 2010 against that of under existing conditions at the 15 stations are shown in Table H.2 and Fig. H.5.

Based on the above discussions, it is evident that sewerage development is a definite requirement for the central part of Jakarta.

1.2 People's Desire for Sanitation and Sewerage Development

Table H.7 shows the extent of people's desire for sanitation facilities by type and by Kelurahan. It is based on the sampling questionnaire survey simultaneously conducted with the income level survey. Percentage in the table expresses the ratio of population desiring to use a particular type of sanitation facility. The ratios of population that desire to use sewerage facilities were given special stress and importance : they are shown in Fig. H.6. In analyzing Table H.7 it is necessary, as well as useful, to compare it with Table F.1.

One of the most important conclusion that derived from Table H.7 is that 22.2% of the people of the Study Area want to have sanitation facilities connected to sewerage. As for public toilets, 12.4% of people want to use them. In light of the fact that the existing user ratio of public toilet is 6.0%, it is necessary to double the number to satisfy people's needs. The desire for individual on-site sanitation facilities with treatment works out to 55.8%, which is lower by 12.2 % compared with the existing user ratio of the same facilities (68.0%). People desiring for on-site sanitation facilities without treatment comes to 7.1%, which is less by 8.9% than the existing user ratio of the same facilities (16.0%). Population with no desire for sanitation facilities is 0.7%, which is very small in comparison with the existing ratio of population with no sanitation facilities (9.4%). In other words, 90.4% of the people of the Study Area want to use some kinds of modern sanitation facilities. This figure is 16.4% higher than the existing user ratio of such facilities (74.0%).

When the ratio of population in desire of sewerage facilities is examined, in terms of Wilayah, Jakarta Timur is found to have the highest ratio of 27.2%. Jakarta Selatan occupy the second place with 23.9%, immediately followed by Jakarta Barat with 23.3%. The needs for sewerage are 18.5% for Jakarta Pusat and 13.5%, the lowest for Jakarta Utara. Regarding the ratio of population that desire for individual on-site sanitation facilities with treatment, Jakarta Utara is the highest with 64.9%, which is 9.7% higher than the existing user ratio of the same facilities (55.2%). The needs for such facilities are lower than the existing levels in all the other Wilayahs. With regard to the population ratio that desire public toilet, Jakarta Pusat is the highest with 17.3%. The second and the third places are occupied by Jakarta Barat and Jakarta Utara with 13.5% and 12.5%, respectively. Jakarta Timur follows with 11.0% and Jakarta Selatan is the lowest with 9.5%.

Kecamatan wise, Matraman has the highest population ratio that desire for sewerage facilities with 59.5%. Other Kecamatans having the ratios of more than 30% are Cilandak with 59.5%, Taman Sari with 46.2%, Pasar Rebo with 40.2%, Kebayoran Lama with 34.7%, Menteng with 33.5%, Setia Budi with 31.8%, Sawah Besar with 31.2%, Pulo Gadung with 31.1% and Penjaringan with 30.1%. Koja has the lowest ratio with 4.2%. Kecamatans having the ratios of less than 15% are Tanjung Priok with 4.7%, Kebon Jeruk with 9.6%, Gambir with 10.4%, Cempaka Putih with 10.8%, Kebayoran Baru with 11.0%, Kramat Jati with 11.5%, Pasar Minggu with 12.1%, Tebet with 12.7% and Cakung with 13.4%.

It was discovered that the desire for sewerage is the function of both population density and income level. The desire for sewerage is also found to be the function of the existing user ratio of on-site sanitation facilities with treatment. However, the existing user ratio of such facilities is in turn the function of income level, and the correlation of the sewerage needs to income level is higher than to that of existing user ratio of on-site sanitation facilities with treatment. For this reason the above-mentioned relationships have been finally established. The results of statistical analysis of such relationships are presented in Table H.8.

The Kecamatan with the higher needs for public toilet is Sawah Besar with 34.4%. Other Kecamatans having the needs of more than 20% are Cakung with 30.0%, Grogol Petamburan with 28.6%, Tebet with 24.2% and Penjaringan with 20.5%. The Kecamatan with the lowest needs for public toilet is Cilincing with 0%. Kecamatans having the needs of less than 10% are Gambir and Tambora with 1.7%, Matraman with 2.4%, Kebayoran Baru with 2.9%, Jatinegara with 4.5%, Kebon Jeruk with 5.4%, Kebayoran Lama with 5.5%, Mampang Prapatan and Pasar Minggu with 6.5% and Cengkareng with 8.2%.

In terms of Kelurahan, Kebayoran Lama Utara (Jakarta Selatan) has the highest population ratio in desire of sewerage facilities with 100%. Other Kelurahans having the ratios of more than 60% are Cipulir (Selatan) with 89.9%, Utan Kayu Utara (Timur) with 89.4%, Karet (Selatan) with 78.6%, Tangki (Barat) and Glodok (Barat) with 76.3%, Menteng (Pusat) with 72.0%, Semanan (Barat) with 68.2%, Pademangan Timur (Utara) with 66.4%, Rawa Sari (Pusat) with 65.7%, Cilandak Barat (Barat) with 65.5%, Cibubur (Timur) with 63.9%, Kampung Tengah (Timur) with 62.1%, and Pademangan Barat (Utara) and Wijaya Kusuma (Barat) with 61.0%.

The above results are concerned to the needs for sewerage and sanitation facilities from the standpoint of population or households. There are other prospective users such as shops and factories. Sampling questionnaire surveys were carried out to know sewerage needs for commerce/institutions and industry. They were classified into shop, factory, hotel, restaurant, hospital, office, school and religious institutions and the total number of samples reached 1,000. The results are presented in Table H.9. It shows that the ratios of establishments/institutions desiring for sewerage facilities range from 20.9% to 31.1%, the simple average working out at 26.7%. This ratio is a little higher than the ratio for households (22.2%). However, both are of the same order in that they fall between 20% and 30%.

Finally, the third survey was carried out to know how the public officers directly in touch with people think about future sewerage needs of the City of Jakarta. The JICA Study Team selected the chiefs of Kelurahan as the public persons representing the real voices of educated strata of people.

Each of 256 chiefs of Kelurahan was interviewed by surveyors and asked to select one out of the four choices in a questionnaire shown in Table H.10. The result of the survey is also shown in the same table.

Those who feel the urgent needs for all-out sewerage development regardless of budgetary constraints account for 33.6%. Gradual approach to sewerage development due to the enormous financial requirements is recommended by 54.7% of respondents. Negative attitude to sewerage development is taken by 0.4%, siding with people's feelings that they are already burdened with expensive water and electricity bills. Lastly, 11.3% of respondents, convinced that the people and the nation cannot afford to sewerage system, proposed the propagation of on-site sanitation facilities equipped with treatment, such as leaching pit, soak away, septic tank and public toilet.

The first approach is the most desirable, but the problem is that it is too much idealistic to be feasible. The third and fourth view points stick to the status quo, rejecting or avoiding the notion of sewerage development. The second position with gradual, but positive approach to sewerage development is not only reasonable, but also practicable. This position, supported by more than a half of the public opinion leaders, is also recommended by the JICA Study Team.

2. Zoning of On-site Sanitation and Sewerage System Development

2.1 General

Major water pollution sources of the Study Area are domestic, commercial & institutional and industrial wastewater. Domestic and commercial & institutional wastewater cause severe water pollution in many rivers of the Study Area, where river water quality in general exceeds 100 mg/l of BOD. While, water pollution by industrial wastewater is identified in some specific rivers such as Kali Baru Timur, Cipinang and Cakung.

Seventy four percent (74%) of the toilet wastewater of domestic origin in the Study Area is treated by septic tank/leaching system, resulting in infiltration of all wastewater into underground. While, the remaining 26% is directly discharged into ditches/rivers with no treatment. Unit toilet wastewater volume is estimated to be 23 lcd with a BOD load of 10.5 g.

All the domestic gray water (wastewater from kitchen, laundry and bathing) of the Study Area is directly discharged into ditches/rivers with no treatment. Unit domestic gray water is estimated to be 118 lcd with a BOD of 25.1 g.

Based on the above facts, it is considered that domestic gray water aggravate the overall sanitary conditions of the communities and river water quality of the Study Area 9 times, compared to toilet wastewater (25.1 g / 10.5g x 26% = 9).

For treatment of the domestic wastewater, the following three (3) systems are considered to be appropriate.

(1)	Septic tank/leaching system	: treat toilet wastewater only
(2)	On-site treatment system	: treat both toilet wastewater and gray water
(3)	Sewerage system	: treat both toilet wastewater and gray water

Among the above systems, the most suitable one shall be applied, depending on the local conditions of the Study Area.

Commercial and institutional wastewater will be treated by the same systems as domestic wastewater. This is because their sources are widely distributed over the Study Area along with domestic sources and the wastewater quality is similar to that of domestic ones.

However, industrial wastewater will be treated individually by on-site treatment system, in principle, as their sources are concentrated to some specific locations with varying wastewater quality depending on the type of industry.

2.2. Index for Classification of Wastewater Treatment Level

River water pollution will become worse in proportion to the increase in population density of its catchment area.

Relationship between river water quality and population density of respective catchment areas in the Study Area was analysed, based on the water quality data of 27 stations selected from the existing 94 stations. The selection was made according to the following criteria.

(1) Major pollution source for the station is domestic waste
(2) The station is not affected by tide and flushing water
(3) The station is not located in the fringes of the Study Area

Location of the selected stations and their respective catchment areas is shown in Fig. H.7.

There is a high correlation between river water quality in terms of stream BOD (mg/l) and population density of the respective catchment areas as shown in Fig. H.8. The relationship is expressed as follows.

$$Y = 0.237X + 7.285 \quad (r : 0.874)$$

Where,

Y : River water quality in BOD (mg/l)
X : Population density (person/ha)
r : Correlation coefficient

From the above relationship, river water quality (BOD), corresponding to various population density of catchment area is estimated as given below.

Population Density (person/ha)	River Water Quality (BOD mg/l)
100	30
200	55
300	80
400	100
500	130
600	150

While, sanitary conditions of the communities will also become worse as their population densities increase under such present conditions as gray water is discharged into the neighbouring ditches, channels or lands with no treatment.

Therefore in principle, the required wastewater treatment level of each region can be reasonably determined or classified, based on its population density.

2.3 Classification of Wastewater Treatment Level

(1) Target River Water Quality

The target river water quality of the Study Area is determined based on the existing river water quality and environmental river water quality standards.

The existing water pollution of the rivers and channels in the Study Area is classified into four (4) classes in terms of stream BOD as shown below (refer to Appendix C)

Class	BOD (mg/l)	Pollution Condition
I	0 ~ 30	Slight
II	30 ~ 60	Significant
III	60 ~ 90	Heavy
IV	90 ~	Very heavy

Based on the environmental water quality standards, the river courses of the Study Area are classified into four (4) groups, depending on the intended use of river water as shown below (refer to Appendix C).

Group		River Water Use	Water Quality Standard (BOD mg/l) (permissible limit)
A	:	drinking water source	10
B	:	fishery	20
C	:	agriculture	20
D	:	other than A, B and C and suitable to support aquatic biota	30

In view of the above conditions, the target river water quality of the Study Area is set at 30mg/l of BOD, at least to maintain the minimum condition necessary to support aquatic biota in the rivers.

(2) Required Wastewater Treatment Level

1) Low Population Density Area (Area A)

A low population density area is defined as an area where its population density does not exceed 100 person/ha. The river water quality of such an area is 0-30mg/l as stream BOD.

Hence, theoretically no treatment is necessary to attain the target river water quality of 30mg/l. In these areas, toilet wastewater shall only be treated to a sanitarily acceptable level, while, gray water (BOD 180 mg/l) may be discharged with no treatment as it is in principle.

However, in some specified areas with a concentrated pollution load generation such as community center and large scale housing estate, both toilet waste and gray water will be treated to a BOD level of 60 mg/l.

2) Medium Population Density Area (Area B)

Medium population density areas are those areas with a population density in the range of 100-300 person/ha. The river water quality of such an area is 30-80 mg/l as stream BOD.

In these areas, both toilet wastewater and gray water shall be treated to a moderate level of BOD 60 mg/l <1 to attain the target river water quality of 30mg/l as stream BOD.

<1 : $180 \text{ mg/l} \times \dfrac{100 \text{ person/ha}}{300 \text{ person/ha}} = 60 \text{ mg/l}$

3) High Population Density Area (Area C)

High population density areas are those areas with a population density greater than 300 person/ha. The river water quality of such an area is higher than 80 mg/l as stream BOD.

Both toilet wastewater and gray water shall be treated to a high level of at least 30 mg/l as BOD which corresponds to a population density of 600 person/ha to attain the target river water quality of 30 mg/l as steam BOD.

2.4 Wastewater Treatment System

(1) Area A

Septic tank/leaching system will be applied for the treatment of toilet wastewater. No treatment system will be introduced for gray water, in principle.

(2) Area B

1) General

Both on-site treatment system and sewerage system are applicable for this area, from which the economical one will be selected.

Septic tank with upflow filter is considered as the on-site treatment system for this comparative study. The system is capable of reducing the BOD load of a mixture of toilet wastewater and gray water by 70% under anaerobic conditions with a retention time of three (3) days. Layout of the system is shown in Fig. H.9.

While as for sewerage system, conventional sewerage system consisting of individual house connections, collection sewer lines, manholes, lift pump stations and a low level treatment plant is considered. Aerated lagoon with final sedimentation basin, disinfection tank and sludge treatment facilities is considered for the treatment of wastewater. This treatment system is capable of treating a mixture of toilet wastewater and gray water to a BOD level of 60mg/l.

Unit cost of the sewerage system varies according to magnitude of service area and its population density. While, unit cost of the on-site treatment system is relatively constant.

Cost of the on-site treatment system and sewerage system are compared for the following four (4) cases of service areas and population density.

	Service Area (ha)	Population Density (person/ha)
Case 1	500	100
Case 2	500	300
Case 3	2,500	100
Case 4	2,500	300

In this comparative study, it is assumed that :

- Raw wastewater quality : BOD 200 mg/l
- Required treated wastewater quality : BOD 60 mg/l
- All the population of the service area will be served either by on-site treatment system or sewerage system.

2) Estimated Costs of On-site Treatment System

The construction cost covers costs of septic tank with upflow filter and sludge treatment plant. The operation and maintenance cost includes those of desludging and sludge treatment.

The estimated construction and annual O&M costs for the four (4) cases are shown in Table H.11.

3) Estimated Costs of Sewerage System

The construction cost covers costs of sewage collection system and treatment plant of aerated lagoon. The operation and maintenance cost includes those of collection system and wastewater treatment.

4) Conclusion

Construction cost of the on-site treatment system is cheaper than that of the sewerage system. However, annual O&M costs for the on-site treatment system is more expensive than that of sewerage system.

The above construction and O&M costs are converted into present value based on the following assumptions as shown in Table H.13.

- O&M period is 30 year

- Discount rate is 9% per annum

As evident from the above tables, on-site treatment system is more economical than sewerage system.
On-site treatment system will be applied for Area B.

(3) Area C

Similar to that of Area B, both on-site treatment system and sewerage system are applicable and the economical one will be selected.

In this comparative study, household package treatment plant is considered as the on-site treatment system to treat the wastewater to a BOD level of 30mg/l. This system is composed of sedimentation, contact aeration and disinfection systems to treat a mixture of toilet wastewater and gray water under both anaerobic and aerobic conditions. Layout of the system is shown in Fig. H.10.

Conventional sewerage system with a high level treatment plant is considered as sewerage system. Aerated lagoon with a capacity of 48 hour retention time is considered to treat a mixture of toilet wastewater and gray water to a BOD level of 30mg/l.

The sewerage collection system is the same as that of Area B. The area of lagoon and aerator capacity are respectively, 1.7 m^2 per one (1) m^3/d of wastewater discharge and 5 watts per one (1) m^3 of effective lagoon capacity.

Construction and annual O&M costs of the on-site treatment system and sewerage system are estimated for the following four (4) cases of service area.

	Service Area (ha)	Population Density (person/ha)
Case 1	500	300
Case 2	500	500
Case 3	2,500	300
Case 4	2,500	500

The estimated costs are shown in Table H.12.

Both construction and annual O&M costs of the sewerage system are cheaper than that of on-site treatment system for all the cases.

The estimated construction and O&M costs are converted into present value in the same manner as Area B. The results are shown in Table H.14.

As evident from the tables, the sewerage system is more economical than the on-site treatment system.

Sewerage system will be applied for Area C.

2.5 Zoning

2.5.1 Division of Study Area by Population Density.

The following three (3) areas defined in the previous Section 2.3; Area A, Area B and Area C are delineated as shown in Fig. H.11.

Area A : with a population density of less than 100 person/ha
Area B : with a population density of 100-300 person/ha
Area C : with a population density of more than 300 person/ha

Area A covers 21,676 ha of 39 kelurahans located in the fringes of the Study area. The population of this area in the year 2010 is estimated to be 1,526,000.

Area B includes 110 kelurahans with a total area of 31,195 ha. The population in the year 2010 is estimated to be 5,781,000.

Area C comprises 12,277 ha of 107 kelurahans located in the central Jakarta. The population in the year 2010 is projected to be 5,493,000.

Average population density of these three (3) areas in the year 2010 is estimated to be 70 person/ha for Area A, 185 person/ha for Area B and 447 person/ha for Area C.

2.5.2 Sewerage Development Area - Area C

Sewerage development area is delineated based on the following criteria.

(1) Kelurahans with a population density of more than 300 person/ha will be included in the sewerage development area, in principle. However, kelurahans in which the locations are isolated from other high population density areas and kelurahans where large industrial developments are expected, will be excluded. Kelurahans to be excluded are Malaka Sari, Malaka Jaya, Koja Utara and Kali Baru.

(2) Kelurahans surrounded by or located in the vicinity of other high population density areas will be included even when their population density is lower than 300 person/ha. Such kelurahans are:

- Cideng, Petojo Utara, Gambir, Pasar Baru, Gunung Sari Utara, Senen, Rawa Sari, Gondangdia, Cikini, Menteng, Kebon Melati, Sungai Bambu, Tanjung Priok, Koja Selatan, Tugu Utara, Jelambar, Tanjung Duren, Kemanggisan, Pinangsia, Pekojan, Karet, Semanggi, Kuningan Timur, Rawa Barat, Selong, Gunung, Kramat Pela, Melawai, Pulo and Cipinang Besar Selatan.

(3) Main roads and rivers are considered as boundaries of the sewerage development area. Kelurahans located within the boundaries will be included even though their population density is lower than 300 person/ha. Such kelurahans are:

- Sumur Batu, Cempaka Putih Timur, Kayu Putih and Pulo Gadung.

(4) Kemayoran Airport Redevelopment Area will be excluded. A wastewater treatment plan by communal system has already been established for this area.
Based on the above criteria, the sewerage development area is delineated as shown in Fig. H.12.

The total number of kelurahan of sewerage development, and their area and population in the year 2010 are as follows.

Nos. of Kelurahan	:	140
Area	:	16,604 ha or 26% of the Study Area
Population in 2010	:	6,351,000 or 50% of the Study Area

2.5.3 High Level On-site Treatment System Development Area - Area B

Kelurahan with a population density of 100-300 person/ha will be included in principle. However, among then 33 Kelurahans will be reallocated as the sewerage development area. On the contrary, four (4) kelurahans with a population density of more than 300 person/ha will be incorporated (refer to 2.5.2, (1), (2) and (3)).

Kemayoran Airport Redevelopment Area will included in this area.

The delineated on-site treatment system development area is shown in Fig. H.12.

The total number of Kelurahan covered, and their area and population in the year 2010 are as follows.

Nos. of Kelurahan	:	89
Area	:	27,386 ha or 42% of the Study Area
Population in 2010	:	4,967,000 or 39% of the Study Area

2.5.4 Simple On-site Treatment System Development Area - Area A

Kelurahans with a population density of less than 100 person/ha will be included. The covered area is shown in Fig H.12.

The total number of kelurahan covered, and their area and population in 2010 are:

Nos. of kelurahan	: 37
Area	: 21,159 ha or 32% of the Study Area
Population in 2010	: 1,482,000 or 11% of the Study Area.

3. Potential Sites of the Waste Water Treatment Plants

3.1 Concept of Site Selection

Potential sites for wastewater treatment plants are the ones possessing the following characteristics :

(1) Sites where the wastewater from service area could be collected mostly by gravity, in other words, the sites of natural drainage.

(2) Sites that are spacious enough to construct the treatment facilities and other auxiliaries.

(3) Sites where the environmental impact to the surroundings by the operation of the facilities is not very significant.

(4) Green Area (area restricted of urban development) in the future land use plan (Jakarta Structure Plan 2005).

3.2 Significance of Treatment Plant Sites

The initial master plan of sewerage prepared in 1977 was not implemented, other than as a pilot project for Setiabudi and Tebet Manggarai areas due to its too ambitious implementation program.

Accordingly, this master plan will subdivide the sewerage area into realistic size along with the priority of implementation for sewerage development. This has much bearing on the available potential areas for treatment plant sites. As such, every effort will be made to identify as much alternative sites as possible for sitting potential treatment plants.

3.3 Potential Identified Sites

The potential treatment plant sites identified by the Study Team through site reconnaissance are shown in Fig.H.13 and Table H.15.
This identification was made based on the above concept of site selection.

4. Alternative Studies of Sewerage Development System

4.1 General

The objective sewerage development area for the year 2010 covers 16,604 ha located in central Jakarta and Tanjung Priok region as determined in the previous Section 2.5. It includes the on-going sewerage development area of 1,838 ha by JSSP.

The total population and wastewater discharge of the objective area in the year 2010 are estimated at 6.35 million people and 1,348,000 m^3/d respectively.

The following five (5) alternative systems are considered for the evaluation of sewerage development in the objective area.

(1) Multiple Small Scale On-land Treatment System

The objective area will be divided into several nine (9) zones. The wastewater of the objective area will be collected and treated independently for each zone.

(2) Multiple Medium Scale On-land Treatment System

The above multiple small scale systems are integrated into three (3) medium scale systems, Central Zone, West Zone and East Zone. The wastewater from each zone will be collected and treated independently.

(3) Single Large Scale On-land Treatment System

The above multiple medium scale systems are further integrated into one (1) single large scale system. The wastewater from the whole objective area will be collected and treated at one (1) single location.

(4) Ocean Outfall System

The collection system of wastewater is the same as that of the above single large scale on-land treatment system. However, the collected wastewater will be discharged off-shore through ocean outfall with no treatment.

(5) Modified Ocean Outfall System

This is a modified system of the above ocean outfall. The wastewater will be discharged off-shore through ocean outfall with primary treatment.

These alternative systems are compared and evaluated in the following sections. In this comparative study, it is assumed that all the houses and buildings in the objective area will be connected to sewerage system.

4.2 Multiple Small Scale On-land Treatment System

4.2.1 Proposed System

(1) Division of Sewerage Development Area

The objective area of 16,604 ha is divided into nine (9) sewerage zones, considering administrative boundaries, topographical conditions, river networks, road networks and available potential treatment sites. The divided sewerage zones are shown in Fig. H.14.

The area of the divided sewerage zone ranges from 1,032 ha to 3,237 ha, with an average of 1,845 ha. The area, population and population density of the respective sewerage zones are shown in Table H.16.

(2) Design Wastewater Discharge

The design wastewater discharge including groundwater infiltration of the whole objective area is 1,348,000 m^3/d on daily average basis. Its break-down by sewerage zone is shown in Table H.17.

(3) Sewage Collection System

The expected house connections in the year 2010 are about 800,000 in total.

The proposed sewer line networks consisting of tertiary, secondary, main and trunk sewer pipes classified by pipe diameter has a total length of 2,223,000 m. Its break-down by sewer type is shown below.

Sewer Type	Diameter (mm)	Length (m)
Secondary & Tertiary Sewer	150 - 300	1,683,500
Main Sewer	350 - 800	441,700
Trunk Sewer	900 -	97,800
Total		2,223,000

Sewer pipe length in the respective sewerage zones is shown in Table H.18.

(4) Sewerage Treatment Plant

Nine (9) wastewater treatment plants including Setia Budi Pond are proposed to treat independently the wastewater of the nine (9) sewerage zones. Location of the treatment plants is also shown in Fig. H.14.

Aerated lagoon is assumed as the treatment system in this altenative study except for Zones 6,7 and 9. For Zones 6,7 and 9, conventional activated sludge system is applied because of the limited land space for treatment plant. Design capacity of the treatment plants is determined to meet the daily average wastewater discharge.

The capacity of the existing treatment plant (aerated lagoon) of Sewerage Zone 9 (Setia Budi) is limited to 68,000 m^3/d. Its capacity will be expanded to meet the increasing wastewater discharge in future by conventional activated sludge system.

4.2.2 Estimated Costs

(1) Construction Cost

Total construction cost for all the nine (9) sewerage zones is estimated to be Rp 2,201.4 billion at 1990 price, the break-down of which is as shown below.

		(Unit: Rp. billion)
House Connection	:	285.7
Collection Sewer Line	:	1,299.7
Lift Pump Station	:	14.9
Treatment Plant	:	509.7
Land Acquisition	:	91.4
Total		2,201.4

Construction cost of one (1) sewerage zone ranges from Rp.138.5 billion to Rp.387.6 billion. Construction cost by sewerage zone is shown in Table H.19.

(2) Operation and Maintenance Cost

Operation and maintenance cost of the collection sewer lines includes costs for cleaning and repairing. Annual operation and maintenance cost is assumed to be Rp. 200,000 per hectare.

O&M cost of the pump station consists of electricity charge, repairing cost and personnel expenditure. Annual O&M cost is estimated by using the following formula.

$$Mp = 0.00016 \cdot Q \cdot H + A$$

Where
- Mp : Annual O&M cost in million Rp.
- Q : Daily average flow (m^3/d)
- H : Hydraulic Head (m)
- A : Personnel expenditure in million Rp.
  - A=6 when $q \leq 40\ m^3/min$
  - A=8 when $40 < q \leq 50\ m^3/min$
  - A=10 when $50 < q \leq 200\ m^3/min$
  - A=20 when $200 < q$
- q : Maximum flow (m^3/min)

O&M cost of the treatment plant covers costs for electricity charge, chemicals, materials, repairing, personnel expenditure and etc. The annual O&M cost is estimated by using the following formula.

$$M = 110 + 11.705Q - 2.5 \times 10^{-4} Q^2 \ ^{1)}$$

Where,
- M : Annual O&M cost in million Rp.
- Q : Daily design discharge in 1,000 m^3/d
- 1) : This formula is obtained by typical wastewater treatment plant designs of various capacities.

Total annual O&M cost of the nine (9) sewerage zones is estimated to be Rp. 25.9 billion at 1990 price, the break-down of which is as shown below.

(Unit: Rp. billion/year)

Collection Sewer Line	:	3.3
Lift Pump Station	:	0.3
Treatment Plant	:	22.3
Total		25.9

Annual O&M cost of one (1) sewerage zone is in the range of Rp.1.3 billion and Rp.5.0 billion. Annual O&M cost by sewerage zone is shown in Table H.20.

4.3 Multiple Medium Scale On-land Treatment System

4.3.1 Proposed System

(1) Division of Sewerage Development Area

The objective area of 16,604 ha is divided into three (3) sewerage zones, Central Sewerage Zone, West Sewerage Zone and East Sewerage Zone (Ref. Fig. H.15). This system is a modified one of multiple small scale on-land treatment system. Sewerage Zones 1,2 and 9 are integrated into the Central Sewerage Zone, and Sewerage Zones 3 and 4 are combined into the West Sewerage Zone, and Sewerage Zones 5,6,7 and 8 are incorporated into East Sewerage Zone. The three (3) sewerage zones are shown in Fig. H.15. The area of each sewerage zone is 6,107 ha for Central Zone, 4,186 ha for West Zone and 6,311 ha for East Zone. The population and population density of the three (3) Zones are shown in Table H.21.

(2) Design Wastewater Discharge

The design wastewater discharge including groundwater infiltration of the three (3) sewerage zones are 562,000 m^3/d for Central Zone, 263,000 m^3/d for West Zone and 523,000 m^3/d for East Zone.

(3) Sewage Collection System

The proposed sewage collection system is in fact the integrated one of the nine (9) collection systems of the multiple small scale on-land treatment system dealt with in the foregone section of 4.2. However, those trunk sewers of the nine (9) sewerage zone that are located along the route of the proposed conveyance sewer for the three (3) multiple medium scale sewerage system would be eliminated and replaced by conveyance sewer.

Collection and conveyance sewers in the three (3) sewerage zones are as follows:

(Unit : m)

Sewers	Central Zone	West Zone	East Zone	Total
Secondary and Tertiary (ø150 mm~ø300 mm)	619,200	424,400	639,900	1,683,500
Main (ø350 mm~ø800 mm)	162,500	111,300	167,900	441,700
Trunk (ø900 mm~)	28,500	20,100	35,300	83,900
Conveyance	10,200	10,900	20,400	41,500
Total	820,400	566,700	863,500	2,250,600

(4) Wastewater Treatment Plant

The wastewater from the three (3) sewerage zones are proposed to be treated by aerated lagoon system independently. Location of the treatment plants is shown in Fig. H.15. Treatment plant of Central Zone is located in Pluit Pond. The location of treatment plant for West Zone is the same as that of Zone 3 in multiple small scale on-land treatment system. Treatment plant of East Zone is located in the eastern fringe area of DKI Jakarta, because of difficulty in acquiring a sufficient space for the treatment plant within or in the vicinity of the sewerage development zone.

The proposed capacity of each wastewater treatment plant is 562,000 m^3/d for Central Zone, 275,000 m^3/d for West Zone and 523,000 m^3/d for East Zone.

4.3.2 Estimated Costs

(1) Construction Cost

Total construction cost for the three (3) sewerage zones is estimated to be Rp.2,168.7 billion at 1990 price, the break-down of which is shown below.

		(Unit : Rp. billion)
House Connection	:	285.7
Collection Sewer Lines	:	1,216.7
Lift Pump Station	:	14.9
Conveyance Sewer Lines	:	364.3
Booster Pump Station	:	14.8
Treatment Plant	:	263.5
Land Acquisition	:	8.8
Total		2,168.7

(2) Operation and Maintenance Cost

Total annual O&M cost of this system is estimated to be Rp.20.7 billion at 1990 price with the following break-down.

		(Unit : Rp. billion)
Collection Sewer Lines	:	3.3
Lift Pump Stations	:	0.3
Conveyance Sewer Lines	:	0.1
Boester Pump Stations	:	1.0
Treatment Plants	:	16.0
Total		20.7

4.4. Single Large Scale On-land Treatment System

4.4.1. Proposed System

The objective sewerage develoment area of 16,604 ha will be covered by a single large scale sewerage system. All the wastewater of the area will be collected by a single collection system consisting of tertiary, secondary, main and trunk sewer lines, and will be conveyed to the treatment plant located at the west coast of the Jakarta Bay.

The proposed collection system is in fact the integrated one of the nine (9) collection systems of the multiple small scale on-land treatment system dealt with in the foregone section of 4.2.

The conveyance sewer line consisting of three (3) major lines has a total length of 52.5 Km. Its diameter is in the range of ø 1,350 mm and ø 3,500 mm. One (1) booster pump station will be installed along the conveyance sewer line at Kel. Papango. Its pump capacity is 548 m^3/min.

The treatment plant of aerated lagoon system with a capacity of 1,348,000 m^3/d will be constructed at Kel. Kamal Muara.

The main features of this system are summarized as follows.

Service Area		:	16,604 ha
Design Wastewater Discharge	(daily ave.)	:	1,348,000 m^3/d
	(hourly max.)	:	20.5 m^3/s

No. of House Connections	:	800,000 connections
Collection Sewer Lines	:	2,211 Km of total length
Conveyance Sewer Line	:	3 lines with a total length of 52.5 Km
Booster Pump Stations	:	1 P.S. with a total capacity of 548 m^3/min.
Type of Treatment Plant	:	Aerated Lagoon
Treatment Capacity	:	1,348,000 m^3/d

Layout of the system is shown in Fig. H.16.

4.4.2. Estimated Costs

(1) Construction Cost

Total construction cost of this system is estimated at Rp.2,310.8 billion in 1990 price, the break-down of which is as shown below.

(Unit: Rp. billion)

House Connections	:	285.7
Collection Sewer Line	:	1,168.3
Lift Pump Station	:	22.0
Conveyance Sewer Line	:	560.5
Booster Pump Stations	:	17.8
Treatment Plant	:	242.6
Land Acquisition	:	13.9

Total	:	2,310.8

(2) Operation and maintenance Cost

Total annual O&M cost of this system is estimated to be Rp.21.1 billion at 1990 price with the following break-down.

(Unit : Rp. billion)

Collection Sewer Line	:	3.3
Lift Pump Stations	:	0.6
Conveyance Sewer Line	:	0.1
Booster Pump Staitons	:	1.7
Treatment Plant	:	15.4
Total		21.1

4.5 Ocean Outfall System

4.5.1 Proposed System

The objective sewerage development area of 16,604 ha will be covered by a single large scale sewerage system. The wastewater will be collected and conceyed to the west coast of the Jakarta Bay in the same way as the single large scale on-land treatment system described in the previous Section 4.4. The wastewater will be discharged off-shore of the Jakarta Bay through the ocean outfall and diffuser pipes placed on the sea bed, as the means of final disposal.

The ocean outfall will be extended to 20 Km off-shore of the Jakarta Bay to prevent water pollution of the Bay (See Section 4.5.2). The wastewater will be discharged through three (3) pipes with a diameter of ø 2,400 mm each.

One (1) outfall pump station with a capacity of 1,230 m^3/min will be installed at Kel. Kamal Muara to dishcarge the wastewater off-shore. The required pump head is estimated at 35 m.

The main features of this system are summarized as follows.

Service Area	:	16,604 ha
Design Wastewater Discharge (daily ave.)	:	1,348,000 m^3/d
(hourly max.)	:	20.5 m^3/s
No. of House Connections	:	800,000 connections
Collection Sewer Lines	:	2,211 Km of total length
Conveyance Sewer Line	:	3 lines with a total length of 52.5 Km
Booster Pump Stations	:	1 P.S. with a capacity of 548 m^3/min.
Outfall Pump Station	:	1 P.S. with a capacity of 1,230 m^3/min.
Ocean Outfall Pipe	:	20 km

Layout of the system is shown in Fig. H.17.

4.5.2 Assessment of Adverse Effects on the Sea Water Quality of Jakarta Bay

(1) Simulation of Sea Water Quality

Ocean outfall system discharges wastewater with a high COD concentration off-shore. It will aggravate the water quality of the Jakarta Bay.

The initial dilution of the discharged wastewater increases with increasing depth of the point of discharge of outfall resulting in decrease in COD concentration. While, further dilution by subsequent diffusion and dispersion increases with increasing radial distance from the point of wastewater discharge.

The concentration variation of COD in sea water at various radial points from the outfall is estimated by using the Buoyant Jet and Brooks formulas, assuming the depth of discharge point of wastewater.

1) Buoyant Jet Formula

The Buoyant Jet Formula is given below.

$$\frac{du}{ds}=\frac{2gS_n(\rho_a-\rho)\,Sin\theta}{\rho_0 u}-\frac{2u\alpha}{B}$$

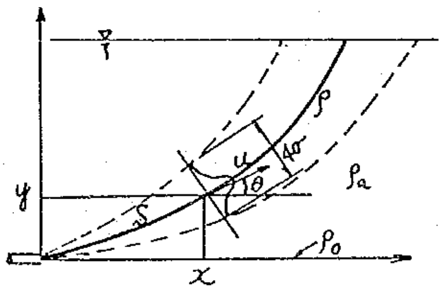
$$\frac{dB}{ds}=2\alpha-\frac{BgS_n(\rho_a-\rho)\,Sin\theta}{u^2\rho_0}$$

$$\frac{d\theta}{ds}=\frac{2gS_n(\rho_a-\rho)\,Cos\theta}{u^2\rho_0}$$

$$\frac{d(\rho_a-\rho)}{dS}=\frac{(1+S_n)\,Sin\theta}{S_n}\cdot\frac{d\rho_a}{dy}-\frac{2\alpha(\rho_a-\rho)}{B}$$

$$\frac{d\chi}{ds}=Cos\theta$$

$$\frac{dy}{ds}=Sin\theta$$



Where,

B : jet width

S : distance along the direction of jet center

g : acceleration of gravity

ρ_a : seawater density

ρ : jet water density (at jet center)

ρ_o : ρ at y=0 (wastewater density)

α : constant

Sn : Schmit No. of turbulent flow = ν/Dt

Dt : turbulent diffusion coefficient

ν : kinematic viscosity coefficient

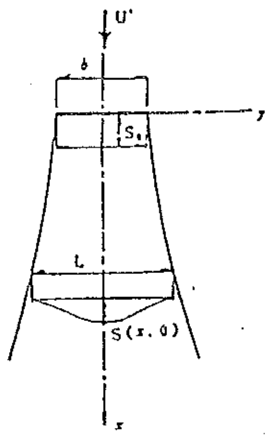
U : Velocity of jet (at jet center)

COD of Jet water on the sea surface is calculated from jet water density at the sea surface determined by the above equations.

2) Brooks Formula

The Brooks Formula on surface water diffusion is given below.

$$\frac{S(\chi,\ 0)}{S_0} = e^{-kt}\,\mathrm{erf}\left[\sqrt{\frac{3/2}{\left(1+\frac{2}{3}\beta\frac{\chi}{b}\right)^{3}-1}}\right]$$



$$\frac{L}{b} = \left(1+\frac{2}{3}\beta\frac{\chi}{b}\right)^{3/2}$$

$$\beta = \frac{12D_0}{Ub},\quad \mathrm{erf}\,[\chi] = \frac{2}{\pi}\int_0^{\chi} e^{-v^2}\,dv$$

Where,

S : water quality at distance X (COD : PPm)
L : wastewater width at distance X (m)
t : movement time for distance X (S)
So : water quality at X=0 (COD : PPm)
b : wastewater width at X=0 (m)
Do : diffusion coefficient at X=0 (m^2/s)
U : average current velocity (m/s)
K : velocity reduction coefficient (1/s)
e^{-kt} : e^{-kt} = 1 in this Study

Water quality (COD) at various radial distances from the point of wastewater discharge can be obtained from the above equations.

(2) Simulated Water Quality

Sea surface water quality (COD concentration) at 0 m, 1,000 m, 2,000 m and 3,000 m radial distances from the point of wastewater discharge was estimated, assuming the following hydraulic conditions.

1)	Wastewater discharge	: 1,500,000 m^3/d (17.36 m^3/s)
2)	Outfall diameter	: ø 2,600 mm
3)	Wastewater discharge velocity	: 3.3 m/s
4)	Tidal current velocity	: 0.2m/s
5)	Seawater density	: 1.023 g/cm^3
6)	Wastewater density	: 0.998 g/cm^3
7)	Water depth at wastewater discharge point	: 5 m, 10 m, 20 m or 30 sm
8)	Wastewater quality	: COD 400 mg/l
9)	Existing Seawater quality	: COD 25 mg/l

The simulated sea surface water quality is shown below.

(Unit : COD mg/l)

Off-Shore Distance(km)	Water Depth(m)	Radial Distance (m)			
		0	1,000	2,000	3,000
1.7	5	116	42	33	29
3.2	10	92	41	32	29
12.2	20	74	38	30	29
22.2	30	64	36	30	29

Sea surface water quality in the case of a reduced wastewater discharge was also estimated for reference. For this simulation, hydraulic conditions were assumed as follows.

1) Wastewater discharge	: 500,000 m^3/d (5.79 m^3/d)
2) Outfall diameter	: ø1,650 mm
3) Wastewater discharge velocity	: 2.71 m/s
4) ~ 9)	: same as the above simulation conditions

The results are shown below.

(Unit : COD mg/l)

Off-Shore Distance(km)	Water Depth(m)	Radial Distance (m)			
		0	1,000	2,000	3,000
1.7	5	102	37	30	29
3.2	10	80	35	30	28
12.2	20	64	34	28	27
22.2	30	56	32	28	27

As evident from the above simulation results, the ocean outfall system will result in considerable aggravation of the seawater quality of the Jakarta Bay.

The boundary of the Jakarta Bay is located approximately 20 Km off-shore.

The ocean outfall should at least be extended to the open sea (outside the Bay) to prevent water pollution of the Jakarta Bay.

4.5.3 Estimated Costs

(1) Construction Cost

Total construction cost of this system is estimated to be Rp. 2,509.4 billion at 1990 price with the following break-down.

(Unit : Rp. billion/year)

House Connections	:	285.7
Collection Sewer Lines	:	1,168.3
Lift Pump Stations	:	22.0
Conveyance Sewer Line	:	560.5
Booster Pump Stations	:	17.8
Outfall Pump Station	:	35
Ocean Outfall	:	420
Land Acquisition	:	0.1
Total		2,509.4

(2) Operation and Maintenance Cost

Total annual O&M cost of this system is estimated at Rp. 10.7 billion at 1990 price, the break-down of which is as shown below.

(Unit : Rp. billion/year)

Collection Sewer Lines	:	3.3
Lift Pump Stations	:	0.6
Conveyance Sewer Line	:	0.1
Booster Pump Stations	:	1.7
Outfall Pump Station	:	5.0
Ocean Outfall	:	---
Total		10.7

4.6 Modified Ocean Outfall System

4.6.1 Proposed System

In principle, this system is basically the same as that of Section 4.5 in which the wastewater is discharged 20 km off-shore with no treatment. However in this case, the wastewater is discharged 5 km off-shore with primary treatment.

The wastewater will be discharged through three (3) pipes with a diameter of ø 2,400 mm each.

One (1) outfall pump station with a capacity of 1,230 m^3/min. will be installed at Kel. Kamal Muara to discharge the wastewater off-shore. The required pump head is estimated at 6 m.

The main features of this system are summarized as follows.

Service Area	:	16,604 ha
Design Wastewater Discharge		
(daily ave.)	:	1,348,000 m^3/d
(hourly max.)	:	20.5 m^3/s

No. of House Connections	:	800,000 connections
Collection Sewer Lines	:	2,211 Km of total length
Conveyance Sewer Line	:	3 lines with a total length of 52.5 Km
Booster Pump Stations	:	1 P.S. with a total capacity of 548 m^3/min.
Outfall Pump Station with preliminary treatment Plant	:	1 P.S. with a capacity of 1,230 m^3/min.
Ocean Outfall Pipe	:	5 Km

4.6.2 Simulated Water Quality

Adverse effects on the sea water quality was also simulated under the same condition as mentioned in the foregone section of 4.5.2 except wastewater quality. Primary treatment is expected to reduce the COD concentration by 30%, hence, the discharged wastewater quality becomes 280 mg/l as COD.

The simulated sea surface water quality in case of 1,500,000 m^3/d of wastewater discharge is shown below.

(Unit : COD mg/l)

Off-Shore Distance(km)	Water Depth(m)	Radial Distance (m)			
		0	1,000	2,000	3,000
1.7	5	87	37	31	28
3.2	10	71	36	30	28
12.2	20	58	34	29	28
22.2	30	52	33	28	28

As evident from the above simulation results, the ocean outfall with primary treatment system will still result in considerable aggravation of the seawater quality of the Jakarta Bay.

4.6.3 Estimated Costs

(1) Construction Cost

Total construction cost of this system is estimated to be Rp. 2,326.9 billion at 1990 price with the following break-down.

(Unit : Rp. billion/year)

House Connections	:	285.7
Collection Sewer Lines	:	1,168.3
Lift Pump Stations	:	22.0
Conveyance Sewer Line	:	560.5
Booster Pump Stations	:	17.8
Outfall Pump Station with primary treatment Plant	:	179.0
Ocean Outfall	:	90.0
Land Acquisition	:	3.6
Total		2,326.9

(2) Operation and Maintenance Cost

Total annual O&M cost of this system is estimated at Rp. 16.6 billion at 1990 price, the break-down of which is as shown below.

(Unit : Rp. billion/year)

Collection Sewer Lines	:	3.3
Lift Pump Stations	:	0.6
Conveyance Sewer Line	:	0.1
Booster Pump Stations	:	1.7
Outfall Pump Station with primary treatment Plant	:	10.9
Ocean Outfall Pipe	:	---
Total		16.6

4.7 Comparative Evaluation

4.7.1 General

The construction and annual O&M cost of the five (5) alternative systems are compared as follows.

	Construction (Rp. billion)	Annual O&M (Rp. billion/year)
Multiple Small Scale	2,201.4	25.9
Multiple Medium Scale	2,168.7	20.7
Single Large Scale	2,310.8	21.1
Ocean Outfall	2,509.4	10.7
Modified Ocean Outfall	2,326.9	16.6

Construction cost is the lowest for multiple medium scale on-land treatment system and the highest for ocean outfall system. Annual O&M cost is the most expensive for multiple small scale on-land treatment system and the cheapest for ocean outfall system.

Project costs of the five (5) alternative systems including construction cost and total O&M cost for the project life time are compared in terms of present values estimated based on the following assumptions to identify the most economical system.

(1) Discount rate is 9% per annum.

(2) O&M period (effective project life time) is up to 30 years after full completion of the systems.

(3) Implementation schedule is as described in the following section 4.7.2.

4.7.2. Implementation Schedule

(1) Multiple Small Scale On-land Treatment System

This system will be constructed by sewerage zone as a package to obtain benefits in proportion to magnitude of investment cost. It will be constructed over the period from 1993 to 2010.

Construction period of each sewerage zone is assumed as four (4) years.

The implementation schedule is shown in Fig.H.18.

(2) Multiple Medium Scale On-land Treatment System

This system will also be constructed by sewerage zone as a package to obtain benefits in proportion to the magnitude of investment cost. It will be constructed over the period from 1993 to 2010. Construction period of the three (3) sewerage zones are assumed as, eight(8) years for both the Central and the East Zones and six (6) years for the West Zone.

A considerable amount of advance investment cost will be expended for construction of the conveyance sewer lines and treatment plant before their full benefit could be realized.

The implementation schedule is shown in Fig.H.19.

(3) Single Large Scale On-land Treatment System

The conveyance sewer lines will be extended from the downstream-most point to upstream according to hydraulic principle. The construction period extends over the period from 1993 to 2010.

The collection system will also be developed from downstream area to upstream area, keeping in pace with the progress of conveyance sewer line construction so as to obtain optimum benefits from the investment .

Construction of the treatment plant will be progressed in stages , along with that of conveyance sewer lines and collection system, so that the completed portion of treatment plant could meet the demand of wastewater discharge from the already completed portions of the collection and conveyance systems. The treatment plant will be constructed in four (4) stages.

A considerable amount of advance investment cost will be expended for construction of the conveyance sewer lines and treatment plant before their full benefits could be realized.

The implementation schedule is shown in Fig.H.20.

(4) Ocean Outfall System

Construction schedules of the collection system and conveyance sewer lines are the same as those of the single large scale on-land treatment system.

Construction of the ocean outfall including outfall pump station and outfall pipe will also be progressed in stages so as to meet the wastewater discharge from the already completed conveyance sewer lines and collection system. The construction of ocean outfall works will be divided into three (3) stages.

A considerable cost of advance investment will also be required for construction of the ocean outfall as well as the conveyance sewer lines even though a stagewise construction is applied.

The implementation schedule is shown in Fig.H.21.

(5) Modified Ocean Outfall System

Construction schedule of this system is assumed to be the same as that of ocean outfall system.

4.7.3. Project Cost in Present Value

The project costs including construction cost and total O&M cost of the five (5) alternative systems are compared as follows.

(Unit: Rp. billion)

	Construction	O&M	Total
Multiple Small Scale	1,157.6	123.7	1,281.3
Multiple Medium Scale	1,145.2	102.5	1,247.7

Single Large Scale	1,323.3	108.2	1,431.5
Ocean Outfall	1,424.5	55.0	1,479.5
Modified Ocean Outfall	1,340.4	84.5	1,424.9

The multiple medium scale on-land treatment system is the most economical one.

4.8 Optimization of Sewerage Development System

As concluded in the previous Section 4.7, the multiple medium scale system is the most economical one in terms of total cost. However, it is not certain that each of the three (3) zones also would represent the most economical system independently. Hence, the most economical zoning for each of the three (3) medium scale zones is studied independently, in order to optimize the whole sewerage development system.

(1) Central Zone

This central Zone covers the zones of 1,2 and 9 of the multiple small scale system. The following three (3) systems are comparatively evaluated.

(i) Independent System
Zone 1, Zone 2 and Zone 9 are all independent , which is the same as the multiple small scale system. Collected wastewater of Zone 1 will be treated at Melati Pond by aerated lagoon, Zone 2 at Pluit Pond by aerated lagoon and Zone 9 at a residential area of Kel. Setia Budi/ Guntur by conventional activated sludge.

(ii) Fully Integrated System
Zone 1, Zone 2 and Zone 9 are fully integrated, which is the same as the multiple medium scale system. The whole wastewater will be treated at Pluit Pond by aerated lagoon.

(iii) Partially Integrated System

Zone 1 and Zone 2 are integrated to treat both zones wastewater at Pluit Pond by aerated lagoon. Zone 9 will be the same as the above independent system.

The construction cost and annual O & M cost of the above three (3) systems are shown below.

	Const.Cost (billion Rp.)	O & M Cost (billion Rp./year)
Independent	855.1	10.0
Zone 1	152.2	1.3
Zone 2	387.6	4.5
Zone 9	315.3	4.2
Fully Integrated	727.4	7.8
Partially Integrated	734.8	9.9
Zone 1 + Zone 2	419.5	5.7
Zone 9	315.3	4.2

As evident from the above table, the fully integrated system is the most economical one. In this system, the whole wastewater is treated at Pluit Pond by aerated lagoon, for which no land acquisition is required.

The fully integrated system is recommended.

(2) West Zone

This West Zone includes Zone 3 and Zone 4 of the multiple small scale system. The following two (2) systems are compared.

(i) Independent System

Zone 3 and Zone 4 are independent, same as the multiple small scale system. Wastewater of Zone 3 will be treated at a green area of Kel. Kembangan by aerated lagoon and Zone 4 at a green area of Kel. Joglo by aerated lagoon.

(ii) Integrated System
Zone 3 and Zone 4 are integrated, same as the multiple medium scale system. Both zone wastewater will be treated at the green area of Kel. Joglo by aerated lagoon.

The construction cost and annual O&M cost of the above two (2) systems are shown below.

	Const.Cost (billion Rp.)	O & M Cost (billion Rp./year)
Independent	499.2	4.5
Zone 3	240.1	2.1
Zone 4	259.1	2.4
Integrated	527.1	4.4

The independent system is more economical than the integrated one. The treatment plant sites of both zones are available in the green area of the future land use plan where urban development is restricted. Land acquisition for both the treatment plant sites is considered not difficult.

The independent system is recommended.

(3) East Zone

This East Zone covers Zone 5, Zone 6, Zone 7 and Zone 8. The following three (3) systems are compared.

(i) Independent System
Zone 5, Zone 6, Zone 7 and Zone 8 are all independent, which is the same as the multiple small scale system. Wastewater of Zone 5 will be treated at a green area of Kel. Cipinang Besar

Selatan by aerated lagoon, Zone 6 at a green area of Kel. Rawamangun by conventional activated sludge, Zone 7 at the green area including Sunter Lake of Kel. Sunter Jaya by conventional activated sludge and Zone 8 at Sunter East II Pond located in Kel. Semper Timur by aerated lagoon.

(ii) Fully Integrated System
Zone 5, Zone 6, Zone 7 and Zone 8 are fully integrated, which is the same as the multiple medium scale system. The whole wastewater will be treated at Sunter East II Pond by aerated lagoon.

(iii) Partially Integrated System
Zone 6 and Zone 7 are integrated and the wastewater be treated at the green area including Sunter Lake of Kel. Sunter Jaya by conventional activated sludge. Zone 5 and Zone 8 are the same as the above independent system.

The constuction cost and annual O&M cost of the above three (3) systems are shown below.

	Const.Cost (billion Rp.)	O & M Cost (billion Rp./year)
Independent	863.2	11.6
Zone 5	138.5	1.7
Zone 6	187.7	2.9
Zone 7	337.4	5.0
Zone 8	199.6	2.0
Fully Integrated	930.5	8.6
Partially Integrated	851.1	10.6
Zone 5	138.5	1.7
Zone 6 + Zone 7	513.0	6.9
Zone 8	199.6	2.0

The partially integrated system is most economical with respect to construction cost, while the fully integrated one with respect to in O&M cost.

The total construction and O&M costs in terms of present value are estimated for the above three (3) systems in the same manner as the previous Section 4.7. The results are shown below.

(Unit : Rp. billion)

	Const. Cost	O&M Cost	Total
Independent	617.2	75.1	692.3
Fully Integrated	686.7	56.1	742.8
Partially Integrated	616.8	68.2	685.0

The partially integrated system is the most economical one. Moreover in this system, all the proposed treatment plants are located in the green area/pond of the future land use plan. Land acquisition for the treatment plant sites is considered not difficult.

The partially integrated system is recommended.

The optimum sewerage development system, which is the combination of above six (6) recommended ones, is shown in Fig. H.22.

5. Proposed Sewerage Development Plan

5.1 Sewerage Development Zone

The proposed sewerage development area covers 16,604 ha in the central part of the Study Area with a total population of 6,351,000 in 2010. The area is divided into six (6) sewerage development zones, as the optimum plan. For each of these zones an independent sewerage development plan will be prepared as mentioned in the foregone Section 4 (See Fig. H.22). The respective zones covers the whole or part of those Kecamatans as shown below, according to zone name.

Zone No.	Kecamatan
Central Zone	Senen, Menteng, Tanah Abang, Gambir, Sawah Besar, Penjaringan, Grogol Petamburan, Taman Sari, Tambora, Tebet, Setia Budi
North West Zone	Tanah Abang, Grogol Petamburan, Kebayoran Lama
South West Zone	Mampang Prapatan, Kebayoran Baru, Kebayoran Lama
North East Zone	Pulo Gadung, Kemayoran, Senen, Cempaka Putih, Matraman
South East Zone	Jatinegara, Kramat Jati
Tanjung Priok Zone	Tanjung Priok, Koja

The area of the respective zones are shown in Table H.22.

The population of each zone is estimated by summing up the population of the Kelurahans covered by its zone. For population data of Kelurahans, refer to Appendix A, Table A.1 - A.2. The zone population in 2010 ranges from 523,000 in South East Zone to 2,466,000 in Central Zone with an average of 1,059,000. Its population density is in the range of 311 person/ha in South West and 441 person/ha in Tanjung Priok with an average of 382 person/ha. The population and population density of the respective zones in 2010 are shown in Table H.22.

The land use of each zone is estimated by summing up the land use of the included Kelurahans. For land use of Kelurahan, refer to Appendix A, Table A.3. - A.4. The land use patterns of the respective zones in 2010 are shown in Table H.22.

5.2 Design Wastewater Generation

(1) Definition of Wastewater Generation

Under the existing condition, toilet waste of 23 lcd is infiltrated into natural soil in the areas provided with septic tank/leaching system. However, complete sewerage system will collect the whole wastewater of those areas including toilet waste. In this Study, wastewater generation is defined as total wastewater volume generated at the origin of pollution source and is separated from actual wastewater volume discharged outside from residence.

(2) Domestic Wastewater

The domestic wastewater generation of each zone is estimated by adding up the wastewater generation of all the Kelurahans included in its zone. For domestic wastewater generation of Kelurahan, refer to Appendix D, Table D.3.2. The total domestic wastewater generation of the sewerage development area in 2010 is estimated at 845,941 m^3/day. Its break-down into the respective zones is shown in Table H.23.

(3) Commercial and Institutional Wastewater

The commercial and institutional wastewater generation of each zone is estimated by adding up those of all Kelurahans covered by its zone. For commercial and institutional wastewater generation of Kelurahan, refer to Appendix D, Table D.3.2. The total commercial and institutional wastewater generation of the sewerage development area in 2010 is estimated to be 280,486 m^3/day. Its break-down into the respective zones is shown in Table H.23.

(4) Industrial Wastewater

The industrial wastewater generation of the respective zones is estimated by summing up those of the covered Kelurahans. For industrial wastewater generation by Kelurahans, refer to Appendix D. Table D.3.2. The total industrial wastewater generation of the sewerage development area in 2010 is estimated at 11,146 m^3/day. Its break-down into the respective zones is shown in Table H.23.

(5) Design Wastewater Generation

The design wastewater generation including domestic, commercial and institutional, and industrial wastewater of the sewerage development area is determined to be 1,137,573 m^3/day. The design wastewater generation by zone ranges from 91,492 m^3/day in South East Zone to 480,916 m^3/day in Central Zone with an average of 189,596 m^3/day as shown in Table H.23.

The average ratios of domestic, commercial and institutional, and industrial wastewater generation to the design wastewater generation is 74.4%, 24.7% and 0.9% respectively.

Commercial and institutional wastewater generation is concentrated in Central Zone with a share of 29.6% to the design wastewater generation. Industrial wastewater generation has a high share of 1.8% in Tanjung Priok Zone.

5.3 Wastewater Collection System

5.3.1 Type of Collection System

(1) General

There are two (2) types of wastewater collection system. One is separate system and another is combined system. Separate system collects only sewage excluding storm water. While, combined system collects storm water along with sewage.
In this Study Area, storm water is drained mainly by open drainage networks consisting of ditches, channels and rivers. There are few drainage pipes installed. Almost all of the on-going drainage projects aim at improvement of the open drainage system. Future development of the storm water drainage will be also attained mainly by strengthening of this open drainage system. There is no major development plan of drainage pipes.

Therefore, separate wastewater collection system is applied for this Study.

As separate sewage collection system, two (2) types of collection system are applicable, depending on the land conditions of the objective area. One is conventional separate sewage collection system which is a complete collection system. Another is interceptor sewage collection system which is a partially developed collection system.

(2) Conventional Separate Sewage Collection System

This system collects both toilet waste and gray water through a complete sewer pipe networks consisting of house connection, main, secondary and tertiary sewer pipes with lift pumps, manholes and other appurtenances.

However, it is difficult to apply this complete system for such densely populated Kampungs as there exist no road networks wide enough to install sewer lines.

This system will be applied for the following areas in principle.

(i) Commercial and institutional areas located along main roads.

(ii) Residential areas where redevelopment has been completed and besides, the existing road width is wider than 2 m which is the minimum width required for laying sewer lines and other appurtenances.

Residential areas where land readjustment has not been completed will be excluded even though the existing road width is wider than 2m to avoid reconstruction of the proposed sewage collection system in future.

(3) Interceptor Sewage Collection System

It is difficult to provide a complete sewer line networks for the densely populated areas as mentioned above. In these areas, the existing road-side ditches will be used for sewage collection and interceptor (main sewer line) will be installed to collect sewage discharged through the road-side ditches.

In the proposed sewerage development area, most of the densely populated areas are those called as Kampung. Such Kampungs have already been provided with small ditches (40 cm wide and 50 cm deep) along both sides of footpath to drain storm water by the Kampung Improvement Programme (KIP). These ditches will be used for sewage collection as well if the width of the road is less than 2 m.

Based on the above considerations, interceptor sewage collection system will be applied for the high population density areas and those areas where land development is yet to be completed, areas which cannot be covered by conventional separate sewage collection system.

This system will collect only gray water, excluding toilet waste. In the areas covered by this system, toilet waste will be treated at on-site in septic tanks.

The proposed interceptor, however, will not receive storm water collected through ditches. Excessive water will be drained to the neighbouring rivers or canals.

5.3.2 Design Criteria

(1) Peak Flow Factor

The following formula is adopted to estimate peak flow factor to daily average wastewater discharge.

$$F=4.02(0.0864Q)^{-0.154}$$

where,

F : Peak flow factor to daily average wastewater discharge excluding groundwater infiltration

Q : Daily average wastewater discharge in l/s

The peak flow factors proposed by the previous relevant four (4) studies are shown below.

Study	Peak Flow Factor
- 1977 Master Plan of Jakarta Sewerage & Sanitation Project	$4.02\ Q^{-0.154}$ Q : daily average discharge in 1000 m^3/d
- Bandung Urban Development Project (BUDP)	1.5 ~ 4 Depending on population density
- Medan Urban Development Project (MUDP)	2 ~ 5 - ditto -
- On going Jakarta Sewerage & Sanitation Project (JSSP)	$4.02(0.0864Q)^{-0.154}$ Q : daily average discharge in l/s

The proposed formula is the same as those of 1977 Master Plan and JSSP.

This formula gives F=5 for a small service area with 1,500 population discharging wastewater of 225 m^3/d. While, it gives F=2 for a large service area discharging 60,000 m^3/d from its population of 400,000.

From the above discussions, the proposed design criteria of peak flow factor is considered similar to the other two (2) proposals.

(2) Groundwater Infiltration

Groundwater infiltration including unexpected surface water intrusion is assumed to be 10% of daily average wastewater discharge.

Groundwater infiltration and unexpected surface water intrusion shall be considered for designing the capacity of sewage collection system.

The design criteria of groundwater infiltration including unexpected surface water intrusion proposed by the previous four (4) relevant studies are as follows.

Study	Groundwater Infiltration
1977 Master Plan	5 m^3/d/ha
BUDP	10 % of daily average discharge
MUDP	10 m^3/d/ha
JSSP	5.2 m^3/d/ha

The proposed criteria of this Study considers a groundwater infiltration of 4.5 m^3/d/ha for a moderate population density area of 300 person/ha and 9.0 m^3/d/ha for a high population density area of 600 person/ha.

The proposed criteria is similar to those of the other four (4) projects.

(3) Flow Velocity

In calculation of flow velocity, the Manning's Formula is applied for gravity flow and Hazen-Williams' Formula for pressure flow. The minimum velocity is 0.6 m/s and maximum velocity is 3.0 m/s.

The Manning's Formula is shown below.

$$V = \frac{1}{n} R^{2/3} I^{1/2}$$

where,

V: Mean velocity

n: Roughness coefficient

R: Hydraulic radius

I: Hydraulic gradient

Roughness coefficient (n) is assumed as follows

Pipe Material	n
RC Pipe	0.013
Vitrified Clay Pipe	0.013
PVC Pipe	0.010
GRP	0.010

The Hazen-Williams' Formula is assumed as follows.

$$V = 0.84935\ C\ R^{0.63}\ I^{0.54}$$

where,

V: Mean velocity (m/s)

C: Coefficient (C=110)

R: Hydraulic radius

I: Hydraulic gradient

The minimum velocity of 0.6 m/s is determined to prevent sediment deposition and to minimize sulfide formulation. The maximum velocity of 3.0 m/s is adopted to prevent erosion of the pipe material.

The above four (4) relevant studies propose 0.6 m/s to 0.8 m/s as the minimum velocity and 3 m/s to 5 m/s as the maximum one.

(4) Allowance of Sewer Pipe Capacity

Allowance of sewer pipe capacity to design peak discharge is determined as follows.

Sewer Diameter (mm)	Allowance (%)
ø 150 -300	100
ø 350 - 800	50
Larger than ø 900	30

(5) Depth of Sewer Pipe Laying

The minimum earth cover depth for laying sewer pipe is 1.0 m and the maximum is approximately 7.0 m.

The minimum earth cover depth for laying sewer pipe is determined as 1.0 m to prevent collapse of pipe due to load on it. While, the maximum depth is determined to be 7.0 m to minimize construction cost.

(6) Manhole Interval

The maximum manhole interval is 100 m for sewer pipe diameter smaller than 800 mm and 200 m for sewer pipe diameter larger than 900 mm.

Sewer pipe with a diameter smaller than 800 mm does not allow a man to enter inside. Cleaning of such small pipes shall be conducted by remote operation. Therefore, its manhole interval shall be limited to 100 m. However, manhole interval of sewer pipe larger than 900 mm can be extended to 200 m.

5.4 Treatment Plant

5.4.1 Selection of Optimum Treatment System

The following treatment systems are capable of treating the wastewater of the Study Area to a level of 30 mg/l as BOD.

- Conventional activated sludge system
- Extended aeration system
- Oxidation ditch
- Rotating biological contactor system
- Aerated lagoon

These five (5) systems are compared from the following points of view to select the most suitable system.

- Adaptability to overload

  In this Study, capacity of treatment plant will be designed to meet a daily average discharge of wastewater to minimize the required land space of treatment plant. The proposed system is required to treat to a practically acceptable level even for a daily peak wastewater inflow.

- Required technology level of operation and facility maintenance

- Required costs of construction and operation and maintenance

- Required sludge disposal

- Required land acquisition

  The comparison of the systems are shown in Table H.24. As evident from the above table, aerated lagoon system is the most appropriate as long as sufficient land space is available. For the areas where available land space is not enough, conventional activated sludge system will be applied.

The processes of the proposed aerated lagoon and conventional activated sludge treatments are shown in Fig. H.23.

5.4.2 Design Criteria

(1) Design Flow

Daily average discharge including groundwater infiltration is used as the design flow of treatment plant.

Daily average discharge including groundwater infiltration is used for the design of treatment plant excluding inlet pumps and grid chamber. Because the detention time of aerated lagoon is generally long enough to regulate the peak discharge of wastewater.

(2) Design Inflow and Effluent Water Quality

	BOD	SS
Inflow water		
Wastewater from Conventional Area	220 mg/l	220 mg/l
Wastewater from Interceptor area	180 mg/l	180 mg/l
Groundwater Infiltration	0	0
Effluent Water	less than 30mg/l	less than 30mg/l

Wastewater flow from the areas covered by conventional sewage collection system includes both toilet waste and gray water. While, wastewater from the interceptor areas contains only gray water. According to the pollution load survey conducted by the JICA Study Team, water quality of a mixture of toilet waste and gray water is estimated approximately at 220 mg/l in both BOD and SS. BOD and SS contents of gray water are also estimated at approximately 180 mg/l both (Refer to Appendix D).

Design effluent water quality is determined to be 30 mg/l in both BOD and SS, considering the existing river water quality and river water quality standards of the Study Area (refer to Appendix C).

(3) Wastewater Temperature

Design wastewater temperature is determined to be 25 ^{o}C.

Monthly average air temperature of the Study Area during the period of 1970 to 1987 was in the range of 26 ^{o}C in January and 27.7 ^{o}C in May and October. Based on the above facts, average wastewater temperature of the Study Area is estimated to be 25 ^{o}C.

(4) Aerated Lagoon

BOD reduction efficiency	85%
Detention time	longer than two (2) days
Depth of lagoon	maximum 5 m

The combined inflow wastewater of 200 mg/l as BOD shall be treated to a level of 30 mg/l as BOD with the reduction rate of 85%.

The design detention time of aerated lagoon is determined to be more than two (2) days, referring to the following standards.

Report	Detention Time	Water Temperature	BOD Reduction Rate
(1) WPCF Design Manual	3 - 20 days	Optimum 20 ^{o}C (0 ~ 40 ^{o}C)	80 - 95%
(2) Water, Wastes and Health in Hot Climate	2 - 6 days	Hot Climate	85 - 90%

Note (1) : Wastewater Treatment Plant Design, WPCF Manual of Practice No. 8

Note (2): Edited by Richard Feachen, Michael Mcgarry and Duncan Mara

The depth of aerated lagoon is generally designed to be 3m to 5m. In this Study, 5m is adopted, considering the limitation of available land space.

(5) Other Facilities

The other appurtenant facilities such as Grit Chamber, Sedimentation Basin, Disinfection Chamber and Anaerobic Sludge Digestion Tank are designed based on the design standards described below.

(i) Grit Chamber

- Flow velocity : 0.3 m/s
- Overflow rate : 1,800 $m^3/m^2/d$

(ii) Sedimentation Basin

- Effective depth of basin : 3 m
- Overflow rate : 20 $m^3/m^2/d$

(iii) Disinfection Chamber

- Contact time : 15 minutes

(iv) Anaerobic Sludge Digestion Tank

- Detention time : 30 days
- Moisture content of sludge : 99% before digestion
  95% after digestion

(v) Drying Bed

- Depth of drying bed : 20 cm
- Drying time : one (1) week

5.5 Sewerage Development of Each Sewerage Zone

Sewerage development plans are established for the six (6) proposed sewerage zones, and a zone-wise description is presented below.

5.5.1 Central Sewerage Zone

(1) General

This zone is located at the central part of DKI Jakarta and consists of 62 Kelurahans given below. (ref. Fig. H.22).

Kel. Kwitang	Kel. Kenari	Kel. Kebon Sirih
Kel. Cikini	Kel. Menteng	Kel. Pegangsaan
Kel. Kampung Bali	Kel. Kebon Kacang	Kel. Kebon Melati
Kel. Kebon Melati	Kel. Cideng	Kel. Gambir
Kel. Gondangdia	Kel. Kartini	Kel. Petojo Selatan
Kel. Kebon Kelapa	Kel. Senen	Kel. Mangga II Selatan
Kel. Karang Anyar	Kel. Grogol	Kel. Pasar Baru
Kel. Gunung Sahari Utara	Kel. Jelambar Baru	Kel. Pademangan Barat
Kel. Pademangan Timur	Kel. Tangki	Kel. Jelambar
Kel. Tomang	Kel. Krukut	Kel. Pinangsia
Kel. Mangga Besar	Kel. Pekojan	Kel. Glodok
Kel. Keagungan	Kel. Jembatan Lima	Kel. Taman Sari
Kel. Maphar	Kel. Krendang	Kel. Roa Malaka
Kel. Tambora	Kel. Kali Baru	Kel. Angke
Kel. Jembatan Besi	Kel. Duri Selatan	Kel. Tanah Sereal
Kel. Duri Utara	Kel. Petojo Utara	Kel. Tebet Timur
Kel. Duri Pulo	Kel. Tebet Barat	Kel. Manggarai Sel.
Kel. Menteng Dalam	Kel. Bukit Duri	Kel. Guntur
Kel. Kebon Baru	Kel. Setia Budi	Kel. Karet Kuningan
Kel. Manggarai	Kel. Karet Semanggi	Kel. Menteng Atas
Kel. Karet	Kel. Pasar Manggis	
Kel. Kuningan Timur		

This Central Zone is divided into two (2) sub zones, North Central Zone and South Central Zone. South Central Zone is covered by ISSP project area. North Central Zone is enclosed by Banjir Canal to the south and west, Let.

Jend. S. Parman Rd. and the boundary of Kel. Widjaja Kusuma to the west, Pangeran Tubagus Angke Rd. to the north and Gunung Sahari Rd. and Kramat Raya Rd. to the east.

The zone covers an area of 6,107 ha with an existing population of 2,139,100. The average population density of all kelurahans in this zone is 350 person/ha, which ranges from 22 person/ha in Kel. Gambir to 1,165 person/ha in Kel. Kali Baru.

The existing land use pattern in Central Zone is summarized as follows.

- Both sides of M.H. Thamrin Rd. are developed as a commercial and institutional center.
- The area enclosed by Banjir Canal, M.H. Thamrin Rd., K.H. Wahid Hasyim Rd. and Cikini Raya Rd. is a residential area of high income communities.
- The area between Banjir Canal and M.H. Thmarin Rd. is highly populated.
- The area especially along H. Rangkayo Rasuna Said Rd. is now redeveloped rapidly as a commercial center.
- The area along Jend. Sudirman Rd. and Jend. Gatot subroto are developed as commercial center.
- Merdeka park which is surrounded by institutional areas is located at the central part of this zone.
- Northern part of this zone is occupied by residential and commercial areas which were developed in old times.

Existing average population density of this residential and commercial areas is 540 person/ha with a range from 124 person/ha in Kel. Roa Malaka to 1,166 person/ha in Kel. Kali Baru. All those residential and commercial areas except that of Gajah Mada Rd. area have already been improved under the Kampung Improvement Program (KIP) of PELITA I and II.

The comparison of existing land use is classified as shown below

Residential area	4,226	ha
Commercial and institutional area	1,393	ha
Industrial area	170	ha

Other area	318	ha
Total	6,107	ha

Based on the future land use plan by DKI Jakarta 2005, commercial and institutional area will expand from 1,393 ha to 1,967 ha with subsequent reduction in residential area by 451 ha, industrial area by 76 ha and other area by 47 ha. The projected future population of this Central Zone is 2,466,000 and the corresponding population density is 404 person/ha.

(2) Collection System

Conventional area covers an area of 3,422 ha or 57% of Central Zone as shown in Fig. H.24. The existing high income residential area, the Kampung areas which have already been improved by KTP and commercial and institutional areas along M.H. Thamrin Rd., Gajahmada Rd., Gunung Sahari Rd. and Rangkayo Rasuna Said Rd., and also the future development area which is enclosed by Jend. Sudirman Rd. Jendral Gatot Subroto Rd. and H. Rangkayo Rasuna Said Rd. is covered by conventional service area. The population served in the year 2010 by this conventional system is 1,149,000 and the population density is 336 person/ha.

The remaining area of 2,595 ha excluding Merdeka Park of 90 ha with a future population of 1,317,000 is covered by interceptor sewer system. The population density of this interceptor area is 508 person/ha. The interceptor area will cover the highly populated and congested areas, namely, Kel. Pasar Manggis, Kel. Kebon Melati, Kel. Pegangsaan and Kec. Tambora.

The Merdeka park covers a large area and its wastewater discharge points are very limited and located far from street sewers. Hence it is more economical to treat wastewater generated in the park by individual on-site treatment system than to discharge it to public sewer system by using long discharge pipe in Merdeka Park. Hence the park area of 90 ha is not incorporated in the sewerage system.

The collection system of Central sewerage Zone is summarized as follows :

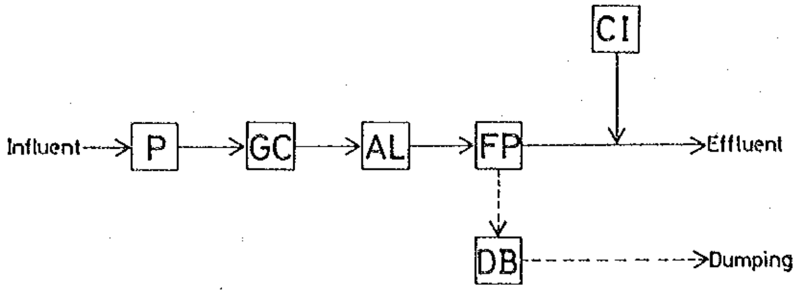
	Conventional System	Interceptor System	Total
Service Area (ha)	3,422	2,595	6,017
Served Population in the year 2010	1,149,000	1,317,000	2,466,000
Population density (Person/ha)	336	508	410
Sewer (m)			
Secondary and Tertiary	347,000	86,400	433,400
Main	91,000	71,700	162,700
Trunk	24,600	4,400	29,000
Conveyance	10,200	-	10,200
Total	472,000	162,500	635,300

(3) Treatment Plant

Pluit pond is proposed as the location of wastewater treatment plant for this central Zone. Pluit pond functions as a detention pond for storm water drainage, with a pond capacity of 2,240,000 m^3 and pump capacity of 29.75 m^3/sec.

Aerated lagoon treatment system of capacity 529,000 m^3/d for this zone requires a pond space of 80 ha, which include the requirement of subsequent facultative pond as well. A portion of treatment plant such as control house, grit chamber, chlorination tank and drying bed are to be constructed in the reserved area near the pond. Hence, no reclamation is required. The plant will also receive 411 m^3/d of sludge, desludged from on-site sanitation/treatment systems located in Service Area-1 (Ref. Fig. H.39 and also Section 6.7).

The flowsheet of treatment process and the capacity, dimension and other relevant details of each treatment facility is shown below.



Where;	P	:	Inflow Pump
	GC	:	Grit Chamber
	AL	:	Aerated Lagoon
	FP	:	Facultative Pond
	DB	:	Drying Bed
	CI	:	Choline Injection

Inflow Pump	:	Capacity of 552.1 m^3/min with 21.0 hydraulic head
Grit Chamber	:	Overflow load 1,770 $m^3/m^2/d$
	:	Retention time 59 sec
	:	Size 5.0 m (W) x 15.0 m (L) x 1.2 m (D) x 6 units
	:	Constructed with R.C.
Aerated Lagoon	:	Pond capacity 1,046,000 m^3
	:	Pond surface area 23.2 ha
	:	Retention time 2.0 days
	:	Size 150.0 m (W) 1,395 m (L) x 5.0 m (D) x 1 unit
	:	Embankment is protected by masonry
	:	Capacity of aerator 2,645 KW.
Facultative Pond	:	Pond capacity 1,278,000 m^3
	:	Pond surface area 56.8 ha
	:	Retention time 2.4 days
	:	Size 500.0 m (W) x 2556.0 m (L) x 2.5 m (D) x 1 unit
Disinfection Basin	:	Size 40.0 m (W) x 250.0 m (L) x 2.5 m (D) x 1 unit
	:	Cholorine injection to effluent ditch
	:	Contact time 68 mins

Drying Bed	:	Drying time 7.8 days
	:	Size 20.0 m (W) x 60.0 m (L) x 0.2 m (D) x 36 units

The treated effluent is discharged to Jakarta Bay.

Layout of treatment plant is shown in Fig. H.25.

5.5.2 North West Sewerage Zone

(1) General

This zone extend over three (3) Region of Central, West and South Jakarta and consist of 11 Kelurahan as follows.

Kel. Petamburan	Kel. Karet Tengsin	Kel. Bendungan Hilir
Kel. Gelora	Kel. Tanjung Duren	Kel. Jati Pulo
Kel. Kota Bambu	Kel. Slipi	Kel. Pal. Merah
Kel. Kemanggisan	Kel. Grogol Utara	

This zone is bounded by Sudirman Rd. and the Boundary of Kel. Grogol Utara to the South, Boundaries of Kel. Pal Merah and Tanjung Duren to the west, Letjen S. Parman Rd. and Taman Raya Rd. to the north and Banjir Canal to the east.

This North West Zone covers an area of 2,016 ha with an existing population of 525,900. Average population density of all Kelurahans in this zone is 261 person/ha which ranges from 42 person/ha in Kel. Gelora to 544 person/ha in Kel. Bambu.

Existing land use pattern of North West Zone is summarized as follows.

- Drainage of this zone is separated into west and east portions by Jend. Gatot Subroto Rd. The west side drain to Grogol river and the east to Krukut river.
- Senayan gymnastic stadium is located in the southern end of this zone.
- The composition of existing land use is classified as follows.

Residential Area	1,399	ha
Commercial and institutional area	473	ha
Industrial area	103	ha
Other area	101	ha
Total	2,016	ha

Based on the future land use plan, commercial and institutional are will increase from 473 ha to 555 ha which is mainly met by increase in industrial area.
The projected population in the year 2010 is 642,000 with a population density of 344 person/ha.

(2) Collection System

An area of 530 ha or 26% of North West Zone comprising Kel. Bendungan Hilir and some parts residential and commercial area of Kel. Jati Pulo, Tanjung Duren and Pal Merah will be covered by conventional system as shown in Fig. H.26.
The remaining area of 1,332 ha is covered by interceptor system, while Senayan gymnastic stadium of 154 ha is not incorporated in sewerage collection system due to the same reason as for the exclusion of Merdeka park.

The projection population served by conventional sewer is 185,000 with a population density off 349 person/ha. While the remaining 457,000 people will be covered in interceptor area where the population density is 343 person/ha. The reason why the population density in conventional area is higher than that of interceptor area is that there are some lowly developed low population density areas with insufficient road networks for laying conventional sewers.

The collection system of North West Zone is summarized as below.

	Conventional System	Interceptor System	Total
Service Area (ha)	530	1,332	1,862

Served Population in the year 2010	185,000	457,000	642,000
Population density (person/ha)	349	343	345
Sewers (m)			
Secondary and Tertiary	53,700	44,400	98,100
Main	14,100	35,400	49,500
Trunk	3,000	1,400	4,400
Force Main	9,700	-	9,700
Total	80,500	81,200	161,700

Lift pump station : Three (3) numbers of lift pump stations with capacity of 22 m^3/min, 31 m^3/min and 172 m^3/min.

(3) Treatment Plant

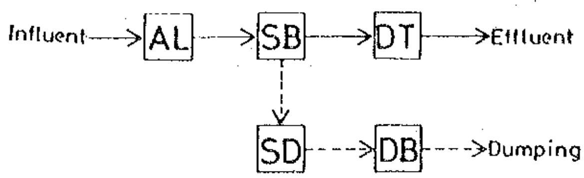
Proposed site of treatment plant is located about 2.7 km away from the eastern boundary of this sewerage zone.

The plant location is at confluence of Angke river and Pesanggrahan river and enclosed by Cengkareng Drain.

Aerated lagoon of 124,000 m^3/d capacity is adopted as the wastewater treatment system for this north west zone and the required land area is 17.7 ha.

This plant will receive 234 m^3/d of sludge from on-site facilities in service Area 2 (ref. Fig. H.39).

Flow of treatment process and capacity and other details of each facility are shown below.



Where :

AL	:	Aerated Lagoon
SB	:	Sedimentation Basin
DT	:	Disinfection Basin
SD	:	Sludge Digestion Tank
SB	:	Drying Bed

Aerated Lagoon
: Pond capacity 246,880 m^3
: Pond surface area 6.3 ha
: Retention time 2.0 days
: Size 49.5 m (W) x 199.5 m (L) x 5.0 m (D) x 5 units
: Embankment is protected by masonry
: Capacity of aerator 1,240 KW

Sedimentation Basin
: Overflow load 19.8 $m^3/m^2/d$
: Retention time 3.6 hrs
: Size 25.0 m x 25.0 m x 3.0 m (D) x 10 units
: Constructed with R.C.

Disinfection Basin
: Contact time 14.9 mins
: Size 4.0 m (W) x 40 m (L) x 2.0 m (H) x 4 units
: Constructed with R.C.

Sludge Digestion Tank
: Digestion time 35.6 days
: Size 25.0 m (ø) x 12.0 m (D) x 8 units
: Constructed with R.C.
(one (1) unit for treating sludge from on-site facilities)

Drying Bed	: Drying time	12.6 days
	: Size 20.0 m (W) x 60.0 m (L) x 0.2 m (D) x 16 units	
	: Constructed with R.C. (five (5) units for treating sludge from on-site facilities).	

Treated effluent discharge to : Cengkareng drain

Layout of treatment plant is shown in Fig.H.27.

5.5.3 South West Zone

(1) General

This South West Zone is located at the northern end of the South Jakarta Region and consists of 14 Kelurahans as follows :

Kel. Pela Mampang	Kel. Senayan	Kel. Rawa Barat
Kel. Selong	Kel.Gunung	Kel. Kramat Pela
Kel. Melawai	Kel.Petogogan	Kel. Pulo
Kel. Gandaria Utara	Kel.Grogol Selatan	Kel. Cipulir
Kel. Kebayoran Lama Utara	Kel.Keb.Lama Selatan	

This zone is bounded by Pesanggrahan river to the west, Krukut and Mampang rivers to the east, boundaries of Kel. Bangka, Cipete Utara, Pondok Pinang, and Gandaria Selatan to the south and boundaries of North West Zone and Kel. Sukabumi Udik to the north.

This sewerage development zone covers an area of 2,170 ha with an existing population and population density of 447,200 and 206 person/ha respectively. Population density ranges from 53 person/ha in Kel. Selong to 414 person/ha in Kel. Gandaria Utara.

Existing land use pattern is summarized as follows :

- The zone is classified into two (2) distinct areas based on existing land use composition.

An area consisting of commerce and institutions surrounded by high income residents. This area encompasses Kel. Selong, Melawai, Kramat Pela and Gunung with an existing population density of 107 person/ha and located between Krukut and Grogol rivers.
The elevation of land ranges from 10 to 25 meters above mean sea level of Jakarta Bay, which is higher than the surrounding area.

- The other lowlying area is occupied by residential use with population density ranging between 106 person/ha in Kel. Pulo and 414 person/ha in Gandaria Utara. In this area, still there remains open spaces between Grogol and Pesanggrahan rivers.

The existing land use is classified as follows :

Residential area	1,628 ha
Commercial and institutional area	391 ha
Industrial area	43 ha
Other area	108 ha
Total	2,170 ha

Based on the future land use plan, commercial and institutional area will expand to 518 ha along with a reduction in residential area of 72 ha, industrial area of 29 ha and other area of 26 ha.

The projected future population is 674,000 and the corresponding population density is 311 person/ha.

(2) Collection System

Conventional system covers the commercial and institutional area and high income residential area of 938 ha as shown in Fig.H.28. It consists of Kel. Selong, Melawai, Kramat Pela and Gunung.
Remaining 1,232 ha or 58% of this South West Zone is covered by interceptor system.

The collection system is summarized as follows :

	Conventional System	Interceptor System	Total
Service Area (ha)	938	1,232	2,170
Population Served in the year 2,010	244,000	430,000	674,000
Population density (person/ha.)	260	349	311
Sewers (m)			
Secondary and Tertiary	95,100	41,000	136,100
Main	25,000	32,700	57,700
Trunk	4,500	1,400	5,900
Force Main	3,700	-	3,700
Conveyance	2,700	-	2,700
Total	131,000	75,100	206,100

Lift pump station : Five (5) numbers of lift pump station with capacity of 8 m^3/min, 11 m^3/min, 12 m^3/min, 74 m^3/min and 148 m^3/min

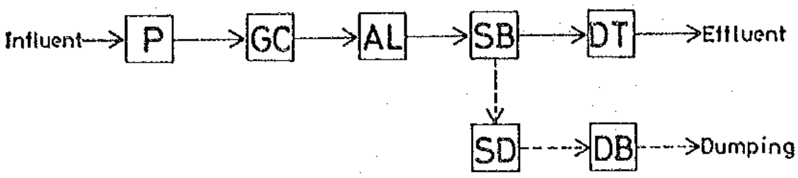
(3) Treatment Plant

Proposed treatment plant site is located in Kel. Joglo about 300 m away from the western boundary of this sewerage zone.

Aerated lagoon of 126,000 m^3/d capacity is adopted as the treatment system for this zone and the land space is 16.0 ha.

This treatment plant encompasses the on-site Service Area-3 (ref. Fig. H.39) and will receive 383 m^3/d of sludge from on-site facilities.

Flow of treatment process and capacity and after details of each facility are shown below.



Where :	P	:	Inflow Pump
	GC	:	Grit Chamber
	AL	:	Aerated Lagoon
	SB	:	Sedimentation Basin
	DT	:	Disinfection Basin
	SD	:	Sludge Digestion Tank
	DB	:	Drying Bed

Inflow Pump	: Capacity of 152.1 m^3/min with 8 m hydraulic head	
Grit Chamber	: Overflow load	1,740 $m^3/m^2/d$
	: Retention time	50 sec
	: Size 3.5 m (W) x 18.0 m (L) x 1.0 m (D) x 2 units	
	: Constructed with R.C.	
Aerated Lagoon	: Pond capacity	246,880 m^3
	: Pond surface area	6.3 ha
	: Retention time	2.1 days
	: Size 49.5m(W) x 199.5m(L) x 5.0 m(D) x 5 units	
	: Embankment is protected by masonry	
	: Capacity of aerator	1,170 KW
Sedimentation Basin	: Overflow load	18.7 $m^3/m^2/d$
	: Retention time	3.8 hrs
	: Size 25.0m x 25.0m x 3.0m(D) x 10 units	
	: Constructed with R.C.	

Disinfection Basin	: Contact time	15.8 mins
	: Size 4.0m(W) x 40.0m(L) x 2.0m(D) x 4 units	
	: Constructed with R.C.	
Sludge Digestion Tank	: Digestion time	34.6 days
	: Size 25.0 m (ø) x 12.0 m (D) x 8 units	
	: Constructed with R.C. (two (2) units for sludge from on-site facilities)	
Drying Bed	: Drying time	10.9 days
	: Size 20.0 m (W) x 60.0 m (L) x 0.2 m (D) x 16 units	
	: Constructed with R.C. (five (5) units for sludge from on-site facilities)	

Treated effluent discharge to : Pesanggrahan river

Layout of treatment plant is shown in Fig.H.29.

5.5.4 North East Sewerage Zone

(1) General

This zone extends over two (2) regions of Central and East Jakarta and consists of the following 32 Kelurahan (ref. Fig. H.22)

Kel. Kayu Putih	Kel. Jati	Kel. Pisangan Timur
Kel. Cipinang	Kel. Pulo Gadung	Kel. Rawamangun
Kel. Gunung Sahari S.	Kel. Kemayoran	Kel. Kebon Kosong
Kel. Serdang	Kel. Harapan Mulya	Kel. Utan Panjang
Kel. Cempaka Baru	Kel. Sumur Batu	Kel. Senen
Kel. Kenari	Kel. Kramat	Kel. Paseban
Kel. Bungur	Kel. Tanah Tinggi	Kel. Johar Baru
Kel. Galur	Kel. Kampung Rawa	Kel. Rawa Sari
Kel. Cempaka Putih B.	Kel. Cempaka Putih T.	Kel. Kebon Manggis

Kel. Pal Meriam	Kel. Kayumanis	Kel. Utan Kayu Utara
Kel. Pisangan Baru	Kel. Utan Kayu Selatan.	

This zone is enclosed by Bekasi Barat Rd. and Bekasi Timur Raya Rd. to the south, Ciliwung River and Matraman Raya Rd. to the west, boundary of Kemayoran airport redevelopment area and Perintis Kemerdekaan Rd. to the north and Bekasi Timur Raya Rd. to the east.

This zone covers and area of 3,556 ha where the total existing population is 1,170,000. The average population density of all those 32 Kelurahans of this zone is 328 person/ha which ranges from 128 person/ha in Kel. Kayu Putih to 881 person/ha in Kel. Guntur.

The existing land use pattern of this North East Zone is summarized below :

- The zone is separated into the north and south portions by Pemuda Rd. and Pramuka Rd.
- These separated north and south portions are again separated into west and east portions by Jend. A. Yani Rd.
- West portion of Jend. A. Yani Rd. is developed mainly for residential use and has a high population density.
- Sunter river flows from south to north along the east boundary and Sentiong river also flows from south to north along the west boundary.

The comparison of existing land use is as follows.

Residential area	2,791 ha
Commercial and institutional area	495 ha
Industrial area	109 ha
Other area	171 ha
Total	3,566 ha

Based on the future land use plan, commercial and institutional area will inclease to 764 ha spread all over the zone. The rest of three (3) areas, residential area, industrial area and other are will decrease to

2,628 ha, 93 ha and 81 ha respectively. While in the eastern portion of this zone, the industrial area will increase from 19 ha to 52 ha.

Projected future population is 1,383,000 with a population density of 388 person/ha.

(2) Collection System

Conventional system covers an area of 1,610 ha or 45% of the North East Sewerage Zone as shown in Fig. H.30. The eastern portion of this sewerage zone covers high and medium income residential area where redevelopment was already completed. In the western portion of this zone, some parts of Kel. Sumur Batu, Cempaka Baru, Cempaka Putih, Tanah Tinggi, Kramat, Bungur and Kemayoran were redevelopment has already been completed are included in this area. The remaining area of 1,886 ha is covered by interceptor system and the horse racing field of 70 ha is eliminated from the sewage collection area as in the case of Merdeka Park.

The population served by conventional sewer is 527,000 where the population density is 327 person/ha. The population covered by interceptor system is 856,000 and the population density is 454 person/ha.

The collection system of this North East Zone is summarized as follows :

	Conventional System	Interceptor System	Total
Service Area (ha)	1,610	1,886	3,496
Population served in the year 2,010	527,000	856,000	1,383,000
Population density (person/ha)	327	454	396
Sewers (m)			
Secondary and Tertiary	163,200	62,800	226,000

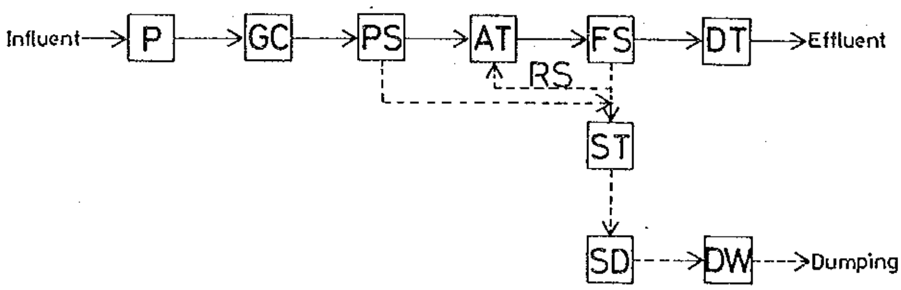
Main	42,800	50,200	93,000
Trunk	12,800	6,400	19,200
Conveyance	7,400	-	7,400
Total	226,200	119,400	345,600

(3) Treatment Plant

Proposed location of treatment plant is at the Sunter East pond which functions as a detention pond for strom water drainage with a capacity of 408,000 m^3. The existing pond surface is approximately 12 ha. The western portion of this pond having an area of 3.5 ha is reserved already for solid waste transfer station. The remaining area of 8.5 ha is not sufficient to provide aerated lagoon for this North East Zone. Hence conventional activated sludge plant with a capacity of 261,000 m^3/d will be constructed by reclaiming 4.5 ha of pond area. Also an additional pump facility with a capacity of 1.94 m^3/sec will be provided to maintained the strom drainage capacity of the pond unaffected.

The plant will receive 283 m^3/d of sludge from on-site facilities in Service Area-4 (ref. Fig. H.39), as the plant also belongs to this service area.

Flow of treatment system and the salient features of each facilities are shown below :



Where :

P	:	Inlet pump
GC	:	Grit Chamber
PS	:	Primary Sedimentation Basin

AS	:	Conventional Activated Sludge
FS	:	Final Sedimentation Basin
DT	:	Disinfection Tank
ST	:	Thickener
SD	:	Digestion Tank
DW	:	Dehydrator
RS	:	Return Sludge

Inflow Pump	: Capacity of 301.8 m^3/min with 20.0 m hydraulic head
Grit Chamber	: Overflow load 1,700 $m^3/m^2/d$
	: Retention Time 51 sec
	: Size 4.0 m(W) x 16.0m(L) x 1.0 m (D) x 4 units
	: Constructed with R.C.
Primary Sedimentation Basin	: Overflow load 40.3 $m^3/m^2/d$
	: Retention Time 1.8 hrs
	: Size 18.0 m x 18.0m x 3.0 m (D) x 20 units
	: Constructed with R.C.
Aeration Tank	: Aeration Time 4.1 hrs
	: BOD-SS load 0.41 kg/SS kg d
	: MLSS 2,000 mg/l
	: Size 8.5m(W) x 26.0m(L) x 5.0 m (D) x 40 units
	: Constructed with R.C.
Sedimentation Basin	: Overflow load 24.0 $m^3/m^2/d$
	: Retention Time 3.0 hrs
	: Size 8.5m(W) x 32.0m(L) x 3.0 m (D) x 40 units
	: Constructed with R.C.
Disinfection Tank	: Contact Time 17.7 mins
	: Size 4.0m(W) x 80.0m(L) x 2.0 m (D) x 5 units

: Constructed with R.C.

Thickener	: Load	62.8 kg/m^2/d
	: Retention Time	13.4 hrs
	: Size 15.0m (ø) x 3.5m (D) x 4 units	
	: Construction with R.C.	
Sludge Digestion Tank	: Digestion Time	30.8 days
	: Size 25.0m(ø) x 12.0m(D) x 8 units (one (1) unit for sludge from on-site facilities)	
Dehydrator	: Filter speed	70 kg/m.hr.
	: Operation time	36 hrs/week
	: Type	Filter press type 3.8m(W) x 36 Units
	(five (5) units sludge from on-site facilities)	

Treated effluent discharge : Sunter River

Layout of treatment plant is shown in Fig. H.31.

5.5.5 South East Sewerage Zone

(1) General

This zone is located at the western end of the East Jakarta Region and Consist of the nine (9) Kelurahans given below, (ref. Fig. H.22).

Kel. Kampung Melayu	Kel. Bali Mester	Kel.Cipinang Cempedak
Kel. Rawa Bunga	Kel. Cipinang Muara	Kel.Cipinang Basar U.
Kel. Cipinang Besar Sel.	Kel. Cawang	Kel.Bidara Cina

This zone is enclosed by Malang river, May.Jend Sutoyo Rd. and Kali Bata Rd. to the south, Ciliwung river to the west, railway beside Bekasi Timur Raya Rd. to the north and Sunter river to the west.

This zone covers an area of 1,243 ha with an existing population of 395,700. The average population density of those Kelurahans in this zone is 318 person/ha which ranges from 177 person/ha in Kel. Cipinang Besar Selatan to 690 person/ha in Kel. Kampung Melayu.

The existing land use in South East Zone is summarized as follows :

- This zone is separated into west and east parts by Jend D.I.Panjaitan Rd.
- West part of Jend. D.I.Panjaitan Rd., except southern end, is occupied by highly developed area with a high population density of 442 person/ha in average.
- While in the east part, open space is still remaining and the average population density is 270 person/ha.

The existing land use is classified as follows :

Residential area	902 ha
Commercial and institutional area	253 ha
Industrial area	3 ha
Other area	85 ha
Total	1,243 ha

Based on the future land use plan, residential area will continue to occupy 905 ha or 73% of the Zone. Commercial and institutional area will expand to 284 ha with subsequent reduction in other area.

The projected future population in this zone is 523,000 with a population density of 421 person/ha.

(2) Collection System

An area of 307 ha or 25% of this South East Zone is covered by conventional system as shown in Fig.H.32.

Some residential area in Kel. Cipinang Muara and Kel. Cipinang Cempedak, Kel. Rawa Bunga and Kel. Bali Mester are included in conventional area.
The projected population in conventional area is 137,000 with a population density of 446 person/ha.

The remaining area of 936 ha with population of 386,000 and a population density of 412 person/ha is covered by interceptor system.

The collection system in of South East Zone is summarized as follows :

	Conventional System	Interceptor System	Total
Service Area (ha)	307	936	1,243
Population served in the year 2,010	137,000	386,000	523,000
Population density (person/ha.)	446	412	421
Sewers (m)			
Secondary and Tertiary	31,100	31,200	62,300
Main	8,200	24,900	33,100
Trunk	2,100	2,100	4,200
Force Main	500	-	500
Total	41,900	58,200	100,100

Lift pump station : One (1) lift pump station with capacity of 48 m^3/min.

(3) Treatment Plant

Proposed site of treatment plant for the South East Zone is located in Kel. Cipinang Besar Selatan adjacent to the Cipinang river. Existing land use condition of this site is cemetery which will be shifted to Kel. Pondok Kopi

Aerated lagoon treatment system with a capacity of 101,000 m^3/d is adopted and the required land area is 13 ha.
The treatment plant will receive 78 m^3/d of sludge from its interceptor area only, which is the smallest on-site service area, Service Area-5 (ref. Fig. H.39), due to its limited plant capacity.

Flow of treatment system is the same as that of South West Zone.

Main features of each facility are given below.

Inflow Pump	: Capacity of 134.2 m^3/min with 8 m hydraulic head
Grit Chamber	: Overflow load 1,530 $m^3/m^2/d$
	: Retention time 56 sec
	: Size 3.5 m (W) x 18.0 m (L) x 1.0 m (D) x 2 units
	: Constructed with R.C.
Aerated Lagoon	: Pond capacity 197,500 m^3
	: Retention time 2.0 days
	: Size 49.5 m (W) x 199.5 m (L) x 5.0 m (D) x 4 units
	: Embankment is protected by masonry
	: Capacity of aerator 1,010 KW
Sedimentation Basin	: Overflow load 20.2 m3/m2/d
	: Retention time 3.6 hrs
	: Size 25.0 m X 25.0 m x 3.0 m (D) x 8 units
	: Constructed with R.C.
Disinfection Tank	: Contact time 18.2 mins
	: Size 4.0 m (W) x 40.0 m (L) x 2.0 m (D) x 4 units
	: Constructed with R.C.
Sludge Digestion Tank	: Digestion time 35.4 days
	: Size 25.0 m (ø) x 12.0 m (D) x 6 units

	: Constructed with R.C.	
Drying Bed	: Drying time	11.8 days
	: Size 20.0 m (W) x 60.0 m (L) x 0.2 m (D) x 10 units	
	: Constructed with R.C. (one (1) unit for sludge from on-site facilities)	

Treated effluent discharge to : Cipinang River

Layout of treatment plant is shown in Fig.H.33.

5.5.6 Tanjung Priok Sewerage Zone

(1) General

This sewerage Zone, is located in the eastern part of the North Jakarta Region near Priok harbour (Ref. Fig.H.22). This zone consist of 10 Kelurahans as follows :

Kel. Papanggo	Kel. Sungai Bambu	Kel. Kebon Bawang
Kel. Tanjung Priok	Kel. Warakas	Kel. Lagoa
Kel. Koja Selatan	Kel. Tugu Utara	Kel. Rawa Badak
Kel. Semper Barat		

This zone is enclosed by Plumpang Semper Rd. and the boundary of industrial estates to the south, Laks.R.E. Martadinata Rd., Pelabuhan Raya Rd. , Jampea Rd. and Cilincing Rd. to the east.

The zone covers an area of 1,502 ha with an existing population of 491,400. The average population density of all those Kelurahans in this zone is 327 person/ha which ranges from 78 person/ha in Kel. Tanjung Priok to 506 person/ha in Kel. Warakas.

The existing land use of Tanjung Priok Zones is summarized as follows :

- The zone is separated into the portions of west and east by Sunter River and Laks.M. Yos Sudarso Rd.. Both the west and east area are Kampung area which were already improved with access road, water supply, sanitation and storm water drainage by K.I.P.

- Industrial estate is located along the north and south boundaries of this zone.

- The existing land use composition of this area is as follows :

Residential area	1,290 ha
Commercial and institutional area	76 ha
Industrial area	50 ha
Other area	86 ha
Total	1,502 ha

Based on the future land use plan, commercial and institutional area, and industrial area would expand to 258 ha and 64 ha respectively. Other area also will increase to 97 ha, while the residential area decreases to 1,083 ha.
Projected population becomes 663,000 with a population density of 441 person/ha in the year 2010.

(2) Collection System

Conventional system covers an area of 700 ha or 47% of Tanjung Priok Zone as shown in Fig. H.34. Some part of Kel. Warakas, Tanjung Priok, Kebon Bawang, Rawa Badak, Koja Selatan, Tugu Utara, Lagoa and Semper Barat are covered by conventional sewer system as the land redevelopment is already completed.

The population served in the year 2010 by conventional system is 337,000 and the population density of the area is 481 person/ha.
The remaining area of 802 ha is covered by interceptor system which would serve a population of 326,000 where the population density is 406 person/ha.

The collection system in of this Tanjung Priok Zone is summarized as follows :

	Conventional System	Interceptor System	Total
Service Area (ha)	700	802	1,502
Population Served in the year 2,010	337,000	326,000	663,000
Population density (person/ha.)	481	406	441
Sewers (m)			
Secondary and Tertiary	71,000	26,700	97,700
Main	18,600	21,400	40,000
Trunk	8,300	-	8,300
Force Main	1,400	-	1,400
Conveyance	1,000	-	1,000
Total	100,300	48,100	148,400

Lift pump station One (1) lift pump station with capacity 81 m^3/min

(3) Treatment Plant

Proposed location of treatment plant is in Kel. Semper Timur towards the east of the Tanjung Priok Zone. The site is occupied by rice field and open area at present. The area is a portion of retention pomd and green area preserved in the land use plan of 2005.

Aerated lagoon system with a capacity of 120,000 m^3/d is adopted for this Tanjung Priok Zone and the required land area is 36 ha. The treatment plant also belongs to the on-site service area, Service Area-6 (ref. Fig. H.39), and will receive 237 m^3/d of sludge from concerned on-site facilities.

Main features of each facility are shown below :

Inflow Pump : Capacity of 150 m^3/min with 12 m hydraulic head

Grit Chamber : Overflow load 1,780 $m^3/m^2/d$
: Retention Time 49 sec
: Size 3.5m(W) x 18.0m(L) x 1.0 m (D) x 2 units
: Constructed with R.C.

Aerated Lagoon : Pond capacity 246,880 m^3
: Retention Time 2.1 days
: Size 49.5.0m(W) x 199.5m(L) x 5.0 m (D) x 5 units
: Embankment is protected by masonry.
: Capacity of aerator 1,200 KW

Facultative Pond : Pond Capacity 534,480 $m^3/m^2/d$
: Pond Surface area 21.0 ha
: Retention Time 4.5 days

Disinfection Basin : Size 4.0m(W) x 40.0m(L) x 2.0 m (D) x 4 units
: Chlorine injected to effluent ditch
: Contact Time 15.4 mins

Sludge Digestion Tank : Digestion Time 32.0 days
: Size 25.0m(ø) x 12.0m(D) x 7 units
: Constructed with R.C.
(one (1) unit for sludge from on-site facilities)

Drying Bed : Drying Time 12.0 days
: Size 120.0m(W) x 60.0m(L) x 0.2m(D) x 15 units
(four (4) units for sludge from on-site facilities)

Treated effluent discharge to : Cakung Drain

Layout of treatment plant is shown in Fig.H.35.

6. Proposed On-site Sanitation Development Plan

The on-site sanitation development plan will principally cover the whole areas of Area A and Area B, the areas that are not designated for sewerage development, as delineated in Section 2.5 of Chapter 2 (ref. Fig.H.12).

In addition, Area C for sewerage as dealt with in the previous chapter, is divided into six (6) zones with each zone being further subdivided into two areas of conventional sewerage and interceptor. The portions of the areas designated for interceptor sewers will also be incorporated for on-site sanitation development, and would be referred to as "Interceptor zone of Area C".

The systems proposed for domestic on-site sanitation development, to treat wastewater of domestic origin, are:

(i) Individual toilets and treatment units
(ii) Public toilets

6.1 Concept of Sanitation Planning

The on-site treatment systems could be broadly classified into two (2) categories, depending on the method of final effluent disposal employed.

- Natural soil based treatment system
- Non natural soil based treatment system

The natural soil based treatment system is generally referred to as on-site system, where partially treated wastewater is infiltrated into natural soil. Suitability of infiltrative disposal depends on soil permeability, level of groundwater table and other local conditions like flooding and land area required.
The method of infiltration may be either by means of direct contact with natural soil, as in the of leaching pit, or distribution through drainfield/soakaway as with septic tank.

On the other hand the natural soil independent systems either treat the wastewater to a level so that the effluent could be disposed to surface drains/ditches (household package treatment units, septic tank with up-flow filter and others) or utilizes artificially instituted soil layer to supplement the effects of unfavorable natural site conditions (septic tank with mound or evapotranspiration bed).

In the Study Area shallow groundwater table level, predominantly in the northern parts, is identified as the critical parameter that would limit the applicability of natural soil based system even when sufficient land area is available, on a macro basis for master plan.

The critical groundwater table level to allow for natural soil based system in determined as 5 m below ground surface during rainy season, based on the following considerations.

- The maximum depth of infiltrative surface below ground surface is 3 m, assuming maximum depth of typical leaching pit as 3 m (Ref. Table H.29).

- A minimum depth of 2 m below the infiltrative surface to the groundwater table level is considered, assuming a safety factor of 2.0 to the recommended minimum depth of 1 m by US. EPA publication on on-site disposal (1977).

Hence the total minimum requirement of groundwater table level under critical conditions in rainy season is 5 m below ground surface elevation.

Based on the groundwater table data of Directorate General of Geology and Mineral (Ref. Section 5.1 of Appendix - C), the 5 m groundwater table level contours was prepared as show in Fig. H.36. The boundary lines were approximated along those of Kelurahan boundaries.

Accordingly, the Kelurahans of Area A and Area B, having groundwater table level shallower than 5 m are assigned non natural soil based on-site sanitation systems, as described in the subsequent sections.

6.2 Design Criteria

The design criteria for the proposed individual toilet and treatment units and public toilet is outlined below.

6.2.1 Criteria of Public Toilet

The basic criteria for the provision of public toilet is as follows which is decided based on field observation by the Study Team whenever necessary.

- Preference will be given to the provision of toilet (Kakus) units in comparison to bath (Mandi) and wash (Cuci) units
- A peak time span of 2 hours, 5.00 - 7.00 AM, is assumed for toilet usage
- Specific usage time of 5 minutes is assumed for toilet unit during peak time span
- One person will be assumed to take bath two (2) times in one day

Accordingly, if 100% usage is to be met during peak time span, then the seating demand of toilet unit is 25 person/seat.

However, it is assumed only a 50% of the total demand will be met during peak time span.

The design seating capacity selected is 50 person/seat

The same design capacity is adopted by JSSP for the recent public toilet development, and also by the Cleansing Department of DKI.

The recommended minimum water requirement for bath (M), wash (C) and toilet (K) by the draft guidelines of the Institute of Human Settlements for public toilet is as follows :

Specific water demand of bath : 20 l/person/day
Specific water demand of wash : 15 l/person/day
specific water demand of toilet : 10 l/person/day

This criteria on specific water demand is in agreement with the field observation conducted by the Study Team. However, the water demand of 20 l is for bathing one (1) time only, however, bathing two times a day is customary. Further more the demand for washing was observed as 20 l/person/day. Accordingly the criteria recommended for specific water demand of public toilet with wash and bath facilities is as follows :

Specific water demand of bath	:	40 l/person/day
Specific water demand of wash	:	20 l/person/day
specific water demand of toilet	:	10 l/person/day

Specific wastewater quantity of public toilet : 70 l/person/day

6.2.2 Criteria of Leaching Pit

The basic consideration is twin leaching pit will be provided to receive only toilet waste, for alternative use, when groundwater table level during rainy season is atleast 5 m deep. However, when detailed information on critical groundwater table level is available, a depth of 2 m below from the base of the proposed leaching pit may be adopted.

The basic design criteria of pit capacity is as follows:

Specific rate of sludge accumulation	:	35 l/person/year
Specific wastewater quantity	:	10 l/person/day
Minimum usage span of one (1) pit	:	3 years

This criteria is in accordance with that proposed by the "Central Java - Small Towns Urban Development Sector Project" Study, April, 1989.

The detailed design considerations are also recommended to conform to the above study report, with due consideration to the infiltration capacity of soil, groundwater table level and others.

6.2.3 Criteria of Septic Tank

As the basic consideration, septic tank shall be of at least twin compartments and will receive the whole domestic wastewater, both the gray water and toilet waste, when natural soil based infiltration is used as the means of final effluent disposal. This is to optimize the benefits of providing a septic tank instead of a leaching pit. In general, provision of septic tank will be limited for zones with critical groundwater table level deeper than 5 m (Ref. Fig.H.36). However, when detailed data on critical groundwater table level is available, a depth of 2 m below the base level of drainfield trench could be considered as adequate for the provision of septic tank with drainfield.

The basic design criteria of septic tank are as follows :

Specific rate of sludge accumulation	:	35 l/person/year
Specific wastewater quantity	:	150 l/person/day
Minimum frequency of desludging	:	2 years, but 3 years is recommended
Detention time at start-up	:	1-3 day
Ratio of length to width	:	2 - 3 to 1
The minimum effective tank width	:	0.75 m
The effective tank depth range	:	1.0 - 2.1 m
Divisional ratio of length between initial and final compartment	:	2 to 1

Further detailed criteria including infiltration/drain field requirement shall be in accordance with those proposed by the above mentioned study report of April 1989.

6.2.4 Criteria of Septic Tank with Mound

Mound is a means for final disposal of septic tank effluent, when unfavorable site conditions like high groundwater table, low soil permeability, or local flooding inhibit the use of natural soil infiltration based systems like leaching pit and septic tank with drainfield, dealt with in the foregone sections.

In the Study Area the necessity of septic tank with mound shall be considered, instead of leaching pit or septic tank with drainfield, for zones of shallow ground water table of less than 5 m, as of rainy season.

Septic Tank :

Basis consideration will be the same as that of previous section. However, only toilet waste will be treated in order to reduce the required area of mound.

Specific wastewater quantity (cistern toilet)	:	30 l/person/day
Specific wastewater quantity (pour flush toilet)	:	10 l/person/day

Mound System :

The media of mound is sand, which will be used in combination with natural soil.
The required area of mound could be determined assuming a media (sand) permeability of 20 $l/m^2/day$.

The detailed design consideration shall be as illustrated in the "Central Java-Small Town Urban Development Sector Project", Study, April 1989.

6.2.5 Criteria of Septic Tank with Upflow Filter

The criteria concerning the septic tank portion which will precede the upflow filter intended to treat anaerobically the septic tank effluent, is the same as that proposed in the previous section. The system will produce an effluent with BOD reduction of 70%, which could be discharged to ditches/drains.

The average frequency of desludging will be once in three (3) years, in consideration to the coarse media recommended as filter media. However, it may be as low as once in about 18 months.

Design criteria of upflow filter is as follows;

Filter media	: Broken stones of 20mm - 25 mm with void ratio 0.45.
Filter height	: The maximum height shall be limited to 0.9 - 1.2 m, to prevent undue head loss in the filter.

Hydraulic loading	: For domestic wastewater the maximum hydraulic loading, based on the gross surface area of the filter, shall be restricted to 3.4 $m^3/m^2 \cdot d$.
Hydraulic detention time	: For domestic wastewater the hydraulic detention time based on void volume of filter shall be 6 - 9 hrs.

6.2.6 Criteria of Household Package Treatment Plant

As an alternative to septic tank with upflow filter, though both economically and in terms of ease of installation and operation and maintenance is not competitive, household package treatment plant with the following criteria is also proposed as an additional technically feasible alternative to realize a BOD reduction of 70%.

The basic design criteria :

The system will comprise three (3) functional sub-units, namely initial sedimentation unit, intermediate aerobic contact unit and final sedimentation unit.

The initial sedimentation unit is similar to twin compartment septic tank.

Other pertinent criteria is as follows ;

Effective water depth : not less than 1.2 m

Total sedimentation tank volume (V_1) in m^3 is given by :
$V_1 = 1.9 + 0.4 (n - 5)$

The intermediate unit is aerobic contact media tank.

The tank volume (V_2) in m^3 is given by : $V_2 = 0.5 + 0.1 (n - 5)$

Aeration air requirement (Q) in m^3 is given by : $Q = 1 + 0.2 (n - 5)$

The pitch of plastic slate contact media is 60 - 80 m.

The gross volume of contact media is 0.6 V_2.

The final unit is final sedimentation tank.

The volume of tank (V_3) in m^3, of slot type, is given by :
$V_3 = 0.2 + 0.06 (n - 5)$

In all the above equations n refers to number of user in the range of 5 - 10 person.
The household package plant is basically the simplified version of the one used for cost comparison in Section 2.4, and shown in Fig. H.10.

6.3 Sanitation Development of Area A

Area A (Ref. Fig. H.12) covers 21,159 ha of 37 Kelurahans located in the fringes of the Study Area. The total population of this area in the year 2010 is estimated to be 1,482,000. The existing population in the year 1988 is 726,400. The average population density of Area A in 2010 will be about 70 person/ha.

In principle, no specific wastewater treatment measures is proposed, other than the sanitary disposal of toilet waste. However, septic tanks are recommended to receive the whole wastewater, except when mound is used for final effluent infiltration/disposal.

The domestic sanitation facility in this area will be restricted to individual septic tank/leaching pit. No public toilet is planned in consideration to the low population density. In fact there exist no public toilet in Area A at present.

However, in case of development schemes of communal nature, such as commercial and institutional enterprises and housing complexes, appropriate communal treatment system treating both the toilet waste and gray water to an effluent BOD level of atleast 60 mg/l shall be provided.

Considerations on communal treatment systems are dealt with in Section 6.6.

Of the 37 Kelurahans in this area, 20 are located within the zone of shallow groundwater table level less than 5 m. The Kelurahans located in the zones of shallow and deep groundwater are shown respectively in Table H.25 and Table H.26 (Ref. also Fig. H.36).

The sanitation systems proposed differ according to the above zone separation as emphasized in Section 6.1. The population in the year 2010 in each Kelurahan of both the zones is divided into three (3) categories according to this planned sanitation facility as given below.

(1) Zone of shallow groundwater table (less than 5 m)

(i) Population to be provided with low grade toilet with pour flush and septic tank cum mound.

(ii) Population to be provided with high grade toilet with cistern flush and septic tank cum mound.

(iii) Population that does not require any major improvement measures to their existing sanitation facilities.

(2) Zone of deep groundwater table

(i) Population to be provided with leaching pit facility.

(ii) Population to be provided with septic tank facility

(iii) Population that does not require any improvement.

This population delineation of (i), (ii) and (iii) of both the shallow and deep groundwater zones is made based on the following considerations ;

- The existing population having no toilets and toilet with no treatment and the population increase of low income group that would occur during the planning period until 2010 would be provided with the least cost option of (i). In this regard, the non suitability of leaching pit for shallow groundwater zone shall be assessed with detailed data on local groundwater table level using existing wells as far as possible.

- The population increase of mid and high income group that would occur until 2010 would opt for (ii), in commensuration with their economic status.

- The existing population having their own toilet facilities with treatment do not require any significant improvement measures. Nevertheless, the systems located in those Kelurahans of shallow groundwater table (Ref. Table H.25) may require mound to upgrade their effluent disposal. Such a requirement is recommended to be evaluated based on local groundwater table level.
  In an overall sense, it is considered that no major improvement is necessary.

The existing sanitation facility survey results of Appendix-F and the income level distribution of Appendix-A were used to compute the above three (3) population groups of both zones.

The results obtained, on a Kelurahan basis, respectively for the shallow and deep groundwater zones is presented in Table H.27 and Table H.28.

Finally the breakdown in total population of Area A according to facility is tabulated as shown below :

Population and Treatment Facility of Area A

Item/Facility		Population in 2010	
		Number	Percentage
Shallow Ground Water Zone	Septic Tank cum mound (pour flush)	469,500	31.7
	Septic tank cum mound(cistern)	281,200	19.0
	No significant improvement	218,600	14.8
Deep Ground Water Zone	Leaching pit	163,200	11.0
	Septic tank	131,000	8.8
	No improvement	218,500	14.7
Total population - Area A		1,482,000	100.0

6.3.1 Considerations of Leaching Pit

The basic criteria of leaching pit is already presented in section 6.2.2. Detailed considerations on leaching pit is illustrated in details in the report, Central Java - Small Towns- Pedoman III - Petunjuk Teknis, April 1989, in Indonesian Language. The same is recommended for the deep groundwater zone of Area A as well (Ref. Fig. H.36).

Table H.29 illustrates the recommended dimensions of twin cylindrical leaching pits according to soil infiltration capacity and population served.

The main aim of providing twin leaching pit is to allow for a resting period of at least 1 year, once one pit is full, for stabilization of sludge in the pit so that the desludged sludge could be used as a soil conditioner or fertilizer. This would eliminate the requirement of further transportation and treatment in sludge treatment plant.

Accordingly, transportation of sludge for further sludge treatment is not considered for the population to be served with leaching pit.

6.3.2 Considerations of Septic Tank Systems

(1) Septic tank with drainfield

For Area A sanitary disposal of toilet waste is adequate, in principle. However, new septic tank with drainfield, to be provided in principle for deep groundwater zone, are recommended to receive the whole domestic wastewater, though no improvement is proposed for the existing ones.
The specific wastewater generation of middle income group is considered as the typical influent to septic tank.

The estimated specific wastewater generation in the year 2010 for middle income group is 150 l/person/day (ref. Section 1.2 of Appendix-D).

Conforming the basic criteria of Section 6.2.3, the required effective volume of twin compartment septic tank for eight (8) person with an initial detention time of two (2) days is 2.4 m^3.

However, assuming a desludging frequency of once in three (3) years, and the tank is desludged when it is 1/3 full with sludge, the effective tank volume would be 2.5 m^3.

Hence, the effective tank volume is assumed to be 2.5 m^3.

The detailed design requirement of septic tank effluent drainfield is illustrated in details in the same report mentioned in the foregone section.

As the basic consideration, length (L) in meters of infiltration field for septic tank effluent is given by ;

$$L = \frac{pQ}{2Di}$$

Where p : No. of person served

Q: Specific wastewater discharge (l/person/day)

D: Depth of infiltration trench (m)

i : Infiltration capacity of soil ($l/m^2/d$)

(2) Septic tank with mound

The provision of this system is limited to the shallow groundwater table zone, which will receive only toilet waste.

The effective tank volume required would be 2.5 m^3, for a desludging frequency of once in three (3) years, as the capacity is governed by sludge accumulation.

The required area of mound for eight (8) person using cistern toilet would be 12 m^2, and for pour flush toilet be 4 m^2.

Finally, for a desludging frequency of once in three (3) years, for all types of septic tanks, either with drainfield or mound, the quantity of desludging is estimated assuming a quantity twice that of sludge accumulation is desludged.

Accordingly, eight (8) person produce 1.68 m^3 of sludge to be desludged once in three (3) years.

Specific quantity of desludging is 0.07 m^3/person/year.

Quantity of desludged sludge for further transport and treatment for Area A in the year 2010 is 92,311 m^3/year. Its breakdown in each Kelurahan is shown in Table H.30. The corresponding quantity of desludging under the existing conditions in the year 1988 is estimated at 32,776 m^3/year.

6.4 Sanitation Development of Area B

Area B (Ref. Fig. H.12) covers 27,386 ha comprising 89 Kelurahans. Nevertheless, unlike the boundary between Area A and Area B, the boundary between Area B and Area C is not always along the boundaries of Kelurahans. In other words, some Kelurahans are divided in between Area B and Area C. Furthermore this area separation is based purely on sewerage area and on-site sanitation area. As emphasized earlier, planning of on-site sanitation facilities are still necessary for the interceptor zone of Area C. Hence for the purpose of on-site sanitation planning, it is not always very necessary to exactly stick to the real boundary between these two (2) areas, instead, boundaries may be redefined along that of Kelurahan boundaries. This is especially so for the planning of public toilets, as both Area B and Area C consist of public toilets.

Those Kelurahans, having their population divided in between Area B and Area C are the following six (6) Kelurahans; Gunung Sahari Utara, Gunung Sahari Selatan and Kebon Kosong of Central Jakarta, and Pademangan Timur, Papanggo and Semper Barat of North Jakarta.

The total population of Area B in the year 2010 is 4,967,000. The existing population in 1988 is 2,890,300. The average population density of this area in the year 2010 will be about 181 person/ha.

The treatment systems planned to treat wastewater of domestic origin in this area are;

- Public toilet for the existing population that has no toilet facilities.

- Individual treatment units to treat both toilet waste and gray water for all remaining population and hence neither leaching pit nor septic tank with mound is proposed.

6.4.1 Public Toilet for Area B

(1) Determination of Public Toilet Requirement

The range of population density of those Kelurahans of Area B is of 100 - 300 person/ha in 2010. Accordingly, it is decided to limit the population to be served by one (1) public toilet to 200 person. This will also conform to the standard type of public toilet, having 4 toilet units, 3 bath units and 1 wash unit (4K - 3M - 1C), widely adopted by the Cleansing Department, to serve a population of 200 person. Typical layout of such public toilet is shown in Fig. H.37.

Existing sanitation facility data of Table F.1 of Appendix-F was used along with existing population data of Table A.1 of Appendix-A to determine the existing population with no toilet facility of all those Kelurahans of Area B.

Out of the six (6) Kelurahans where the area and population is shared by both Area B and Area C, only four (4) have population with no toilet facility, and hence to be considered for the provision of public toilet. They are Kelurahans, Gunung Sahari Utara and Kebon Kosong of Central Jakarta, and Pademangan Timur and Semper Barat of North Jakarta.

The existing population density in all these Kelurahans are greater than 150 person/ha, the average of the range 100 - 300 person/ha, considered principally for the area separation concept of Area B and Area C. Hence, all these four (4) Kelurahans are included entirely under Area C and are not considered under this Area B for the provision of public toilets.

Finally, based on the total existing population of Area B having no sanitation facility and by considering one (1) public toilet unit for 200 person, the total requirement of public toilet of standard type (4K - 3M - 1C) is estimated at 1473 numbers.

These were distributed among each Kelurahans in proportion to the existing population with no sanitation facility.

The number of proposed public toilet for each Kelurahan of Area B along with its existing population with no sanitation facility is shown in Table H.31.

(2) Design and Cost Consideration of Public Toilet

The required septic tank capacity of 4 toilet - 3 bath -1 wash public toilet is estimated under the following conditions.

- Desludging frequency shall be once a year
- Desludging will be done once the tank is one third (1/3) full
- Detention time at start-up is 1-3 day

Hence the sludge accumulation due to 200 persons in one year will be 7 m^3.

The effective septic tank volume is 21 m^3.

The septic tank in Area B is to receive both toilet and gray water to satisfy the criteria of this area as far as possible. However, in case of unfavorable site conditions with shallow groundwater table, exception to receive only toilet waste would be admitted in order to reduce the required area of mound. In fact every effort shall be made to identify favorable site for public toilet, and in this respect a critical rainy season groundwater table level of 2 m below the drainfield trench would be sufficient for providing septic tank with drainfield.

The maximum specific wastewater quantity is 70 l/person/day.

The detention time at start-up is 1.5 day, which is more than the minimum requirement of one (1) day.

The quantity of desludging is estimated assuming the whole tank volume is emptied, in due consideration to the large volume of sludge.

The specific desludging volume is 21 m^3/public toilet/year.

The corresponding quantity for 200 person using one (1) public toilet is 0.105 m^3/person/year.

Based on cost data of Cleansing Department, the average construction cost of the typical public toilet of Fig. H.37 with four (4) toilet seats is Rp.12 million.

Hence the total project cost of 1473 units of public toilet for Area B is Rp.17.68 billion.

6.4.2 Domestic Treatment System of Area B

The domestic individual household treatment system is intended to treat both the toilet waste and gray water to a moderate level to realize an effluent quality of 60 mg/l when the effluent is discharged to ditches/drains. Furthermore, for all those Kelurahans with shallow groundwater, as given in Table H.32, septic tank with upflow filter is proposed to realize a BOD removal of 70%, thereby obtaining an effluent quality of 60 mg/l as BOD for an influent BOD level of 200 mg/l.

Fig. H.38 shows the layout of a typical septic tank with upflow filter for a population of eight (8) person, designed based on the basic design criteria outlined in Section 6.2.5. The design computation is presented in details in the subsequent section.

Using the similar procedure illustrated in Section 6.3.2, assuming an average desludging frequency of once in 3 years, with due consideration to the necessity of emptying the whole treatment unit having a volume of about 4 m^3, the specific quantity of desludging for septic tank with upflow filter is computed as 0.167 m^3/person/year.

Septic tank with necessary infiltration/drain field to receive the whole wastewater is proposed for all those Kelurahans with deep groundwater table (Ref. Table H.33), assuming that sufficient land area would be available for the provision of infiltration/drain field.

It is also considered that all existing domestic sanitation facilities would be upgraded either to septic tank with upflow filter or septic tank with drainfield respectively for shallow and deep groundwater zones to receive both the toilet waste and gray water.

Based on the above criteria the population in the year 2010 in each Kelurahan is divided among the respective three (3) categories, public toilet population, septic tank with upflow filter population and septic tank with drainfield population. The results are shown respectively in Table H.34 and Table H.35 for shallow and deep groundwater zones.

The population of each facility for the whole of Area B is as follows :

Item/Facility	Population in 2010	
	Number	Percentage
Public toilet	472,000	9.5
Septic tank with upflow filter	2,977,300	59.9
Septic tank with drainfield	1,517,700	30.6
Total population - Area B	4,967,000	100.0

Finally, utilizing the respective values of specific quantity of desludging determined in the foregone sections, the total quantity of desludging for treatment in Area B is estimated to be 653,079 m^3/year, and its breakdown for each Kelurahan is given in Table H.36. The corresponding existing quantity in the year 1988 is estimated to be 160,843 m^3/year.

6.4.3 Design of Septic Tank with Upflow Filter

The detailed design procedure of the system shown in Fig. H.38 is illustrated below for the purpose of reference. The procedure incorporates the necessary elements of septic tank design as well.

(1) Basic Considerations

(i) Design wastewater quantity

Septic tank with upflow filter will take in all wastewater generated in the household, both the toilet waste and gray water.

The design specific wastewater quantity is assumed as 150 l/person/day, which is the future water consumption of middle income groups as determined in Appendix-D.

This is in agreement with the design wastewater quantity for septic tanks recommended by the study, "Improvement of sanitation system for 38 small towns-Central Java", April 1989.

The design specific wastewater quantity recommended by the above study is 120-160 l/person/day.

(ii) Design pollution load

The BOD_5 concentration of wastewater will be assumed to be 200 mg/l, which corresponds to a specific load of 30 g BOD_5/person/day.

(iii) Criteria of septic tank portion

The design criteria adopted conforms to the one already proposed by the Department of Public Works, LPMB Foundation, Bandung, basically.

The length to width ratio shall be 2-3:1, as also recommended by Mara (1976).

The minimum width shall be 0.75 m.

The allowable minimum and maximum design liquid depths are respectively 1.0 m and 2.1 m.

The clearance above liquid level shall be 0.2-0.4 m.

Two compartment septic tank portion, with initial portion covering a 2/3 length and final portion a 1/3 length will be adopted (Mara, 1976).

A detention time of 3 day at start-up will be provided, which will be based on the design wastewater influent to the tank.

The sludge accumulation rate in the tank is assumed at 35 l/person/year as already used in all similar cases in Indonesia such as JSSP, Central Java Study and others, though Mara proposes 40 l/person/year.

The desludging frequency which is also the cleansing frequency of upflow filters is considered to be necessary once in 1.5-3 years, when coarse media is only used.

A maximum sludge accumulation of 1/3 the volume of septic tank portion is considered as the allowable maximum between consecutive desludging operations.

(iv) Criteria of upflow filter

Anaerobic upflow filter (AF) was widely tested for sewage treatment in India, and the experience gained is summarized by Askinin (1983) as follows:

- Media adopted are generally broken stones of size 19mm - 25 mm

- Most cases the maximum height adopted is in the range of 0.9 m - 1.2 m

Furthermore based on the accumulated performance evaluation of upflow filters, the detailed design criteria could be based on hydraulic loading and hydraulic detention time in the filter, when the wastewater quality and filter media are established.

The hydraulic loading is defined as the flow rate per unit gross surface area of filter media, whereas the hydraulic detention time is defined as the real time the wastewater is retained in the voids of the filter, and hence is based on the filter void volume.

For a 20-25 mm broken stone filter media treating domestic sewage, the recommended hydraulic loading and hydraulic detention time to obtain a BOD removal of 70 - 80% are as follows (Askinin, 1983; Raman and Khan, 1982) :

Maximum hydraulic loading : 3.4 $m^3/d/m^2$

Hydraulic detention time : 6 - 9 hrs.

Accordingly, the design criteria for anaerobic upflow filters is established as follows :

Filter media : Broken stones, 20 mm - 25 m, for which void ratio is 0.45

Hydraulic loading : 1.7 $m^3/d/m^2$ with a safety factor of 2.0

Hydraulic detention time : 8 hours

Filter height : 0.8-1.2 m, which would also conform the septic tank effective water depth constraint

(2) Design Computations

Based on the design criteria already presented in the foregone section, a Septic Tank-Upflow Filter is designed for a typical family consisting of eight (8) person.

Specific wastewater discharge : 150 l/person/day

Design wastewater inflow $= 150 \times 8 \times 10^{-3}\ m^3/d$
$= 1.2\ m^3/d$

(i) Septic tank capacity

Detention time in septic tank at start-up = 3 d

Effective tank volume $= 1.2 \times 3\ m^3$
$= 3.6\ m^3$

(ii) Check of sludge accumulation

Specific sludge accumulation : 35 l/person/year

Sludge accumulation in 3 years $= 35 \times 8 \times 3 \times 10^{-3}$
$= 0.84\ m^3$

1/3 of tank volume is reserved for sludge accumulation

Hence, volume reserved for sludge accumulation $= 1/3 \times 3.6$
$= 1.2\ m^3$

This is greater than the anticipated sludge accumulation of $0.84\ m^3$ in three (3) years.

The capacity of the septic tank portion is satisfactory

(iii) Septic tank dimensions

Assume an effective water depth of 1.6 m
Then the area of tank $= \frac{3.6}{1.6} = 2.25\ m^2$

For a length to width ratio of 2 : 1
The width of the tank = 1.06 m
The effective width = 1.0 m

The effective length of the tank = 2.3 m

For two (2) compartment tank, divide the tank length as 2:1 between first and second compartment.

Effective length of first compartment = 2/3 x 2.3

= 1.5 m

Effective length of second compartment = 2.3 - 1.5

= 0.8 m

(iv) Anaerobic filter capacity

Filter media : 20mm-25mm broken stones
Void ratio : 0.45

Detention time based on void volume = 8 hrs.
Design flow through the filter = 1.2 m^3/d

Required void volume in filter $= 1.2 \times \frac{8}{24} = 0.4\ m^3$

Required filter volume $= \frac{0.4}{0.45} = 0.9\ m^3$

(v) Filter dimensions

With due consideration to the effective water depth in septic tank portion of 1.6 m, let the effective depth of media be 0.9 m.

Computed filter area $= \frac{0.9}{0.9} = 1.0\ m^2$

Hydraulic loading to the filter $= \frac{1.2}{1.0} = 1.2\ m^3/d/m^2$

Recommended hydraulic loading = 1.7 $m^3/d/m^2$

Hence, this area of 1.0 m^2 is satisfactory as the hydraulic loading is within the design value.

Let the effective width of the filter be the same as that of septic tank portion.

Width of filter = 1.0 m
Length of filter = 1.0 m

The designed filter is of square 1.0 m x 1.0 m with a height of 0.9 m.

The designed treatment system of septic tank with anaerobic filter is shown in Fig. H.38.

References :

Mara, Sewage Treatment in Hot Climates (1976)
Askinin W.B., Design Criteria Development of RBC and Anaerobic Filter System for Sewage Treatment, AIT Master Thesis (1983).
Vigneswaran et. al. Anaerobic Wastewater Treatment-Attached Growth and Sludge Blanket Process, ENSIC, AIT (1986).

6.5 Sanitation Development of Area C

Area C (Ref. Fig. H.12) encompasses the high population density centres of Central Jakarta and Tanjung Priok regions with a total area of 16,604 ha. The total population in the year 1988 is 5,169,300 and the population forecasted in the year 2010 is 6,351,000.

The average population density in the year 2010 is 381 person/ha.

As dealt with in the previous Chapter, this Area C is divided into six (6) sewerage zones, as the optimum sewerage master plan, with each zone further divided into conventional sewerage area and interceptor area.

The on-site sanitation plan will cover basically the interceptor area, the Interceptor Zone of Area C, that could only be partially covered by sewerage. However for the sake of convenience this area will be referred to as Area C.

The population planned for conventional sewerage is 2,579,000. Hence the on-site sanitation development will cover the remaining population of 3,772,000.

The treatment systems planned for this population is similar to that of Area B, and hence detailed explanation is restricted to avoid duplications.

The treatment system planned for the remaining population with no direct sewerage facilities are;

- Public toilet for all remaining existing population with no toilet facilities after delineating the conventional sewerage population.
- Upgrading of existing toilets with no treatment and the provision of new ones as required for the remaining population to ensure that the toilet waste is sanitarily disposed in septic tanks. However drain field or mound is not considered as a must unlike Area A and Area B. This is due to the availability of interceptors, and the possible limitation in available land space for the provision of such facilities in this high population density area.

6.5.1 Public Toilet for Area C

The population of all those Kelurahans covered by Area C will be more than 300 person/ha in the year 2010. Hence it is decided that in principle one (1) public toilet can serve 500 person.

Hence the seat requirement of toilet is 10.

The recommended standard type by Cleansing Department is the system having 10 toilet units, 8 bath units, and 2 wash units (10K-8M-2C).

The total requirement of public toilet and its distribution to each Kelurahan is accomplished using the procedure dealt with in Section 6.4.1 for Area B.

Table H.37 shows the distribution of public toilet for those Kelurahans having population with no sanitation facilities.

The total number of public toilet for Area C is 713.

Assuming a desludging frequency of once in 6 months and only toilet waste as influent to the septic tank, but otherwise the same condition as that of public toilet for Area B, the effective capacity of septic tank is estimated at 27 m^3.

The specific quantity of desludging is 54 m^3/public toilet/year which is equivalent to 0.108 m^3/person/year, similar to that of public toilet for Area B.

The construction cost of one (1) unit of public toilet is Rp.20 million.

Hence the total project cost of public toilet for Area C is Rp.14.26 billion

The total cost of both the Area B and Area C public toilet is Rp.31.94 billion.

6.5.2 Domestic Treatment System of Area C

It is assumed by 2010, all the remaining population other than those served by conventional sewerage and public toilet would have their own toilet with septic tanks. This population group, which also includes the remaining non sewered existing population having toilet with treatment, is categorized as population of on-site under future conditions in 2010.

The provision of infiltration field is considered to be impractical for those septic tanks to be newely constructed due to high population density, particularly prevalent in these interceptor areas. However discharge of septic tank effluent to ditches and drains would be tolerable, if not recommendable, in consideration to the availability of interceptor sewerage.

The population in each Kelurahan belonging to the three (3) categories of public toilet, on-site septic tank, and sewerage is shown in Table H.38.

The population for each of the three (3) facility in the whole of Area C is as follows;

Item/Facility	Population in 2010	
	Number	Percentage
Public Toilet	684,300	10.8
On-site (septic tank)	3,087,700	48.6
Conventional Sewerage	2,579,000	40.6
Total population - Area C	6,351,000	100.0

The quantity of desludging from each Kelurahan of Area C in the year 2010 is given in Table H.39. The total quantity of desludging is 290,674 m^3/year. The existing quantity in the year 1988 is estimated to be 286,550 m^3/year.

6.6 Communal Treatment System

A communal treatment system may either be on-site based or off-site based. The off-site systems are essentially small scale sewerage systems serving a confined high pollution load generation area like commercial/institutional establishments, residential and industrial complexes.

A communal system generally serves a population in the range of 20-5000 population equivalent.

In fact the available alternatives for a communal treatment system are enormous as it encompasses both the traditional "on-site system" and "off-site system".

The selection of the most suitable system is much influenced by the locality. The basic factors that aid in system selection are :

(i) Population served
(ii) Local environmental conditions
(iii) Availability of skilled manpower
(iv) Economics

The typical on-site systems of communal use include :

- Septic tank
- Household package treatment plant
- Extended aeration plant
- SBR (Sequencing Batch Reactor)
- RBC (Rotating Biological Contactor)

The off-site sewerage systems include :

- Extended aeration plant
- RBC
- SBR
- Oxidation pond

The important technical consideration of a typical communal treatment systems is to provide a long solids retention time/sludge storage so that sludge handling appurtenances could be minimized, if not eliminated, other than periodical desludging.

In the Study Area the selection of the most suitable system is recommended to be based on economics and simplicity so that the requirement of skilled operators could be minimized, if not entirely eleminated.

Out of those systems mentioned above, except septic tank and oxidation ponds the remaining ones are elaborate requiring relatively skilled operation and maintenance.

(1) Elaborate system

As dealt with in Section 1.3.2 of Appendix-F in details, some famous establishments in central Jakarta area, falling under the proposed sewerage area of Area C, have elaborate household treatment systems of extended aeration and RBC. However, their treatment efficiency do not measure up to the optimum obtainable with these systems. Darth of skilled operators is understood to be the prime reason, though willful negligence like not disinfecting the effluent is also a contributory factor. Nevertheless such systems are inevitable for areas with high population density, until conventional sewerage connection is made available, where compactness of the system would often be the most important concern in system selection for optimizing the required space of treatment system.

It is expected that with time the necessary skilled personnel to ensure proper operation and maintenance of these systems would become available.

Extended aeration and RBC systems are more suitable to serve relatively high population equivalent of 500 and more.

The widely used extended aeration system is the oxidation ditch (OD), which is basically a modified version of conventional activated sludge process with long solids retention time.

For relatively low population of 20-2000, a household package treatment plant, similar to the one used for cost comparison as shown in Fig. H.10, is more suitable.

(2) Simple system

Simple systems in the Study Area are essentially applicable for the sanitary areas, Area A and Area B, with a not very high population density.

Septic tanks receiving the whole wastewater can serve a population equivalent up to 300 person, if sufficient infiltration/drain field is made available for safe effluent disposal.

In case of oxidation ponds, though they can serve much higher population, as long as sufficient land is made available, aesthetic considerations may limit their widespread application. However, they are extremely useful and should be considered when open land is available at relatively off-site, thereby eliminating the demerits of aesthetic aspects.

6.7 Desludging and Treatment

6.7.1 Quantity of Desludging

The existing and future quantity of desludging in each sanitary area, Area A, Area B and Area C is tabulated below. Details could be referred to in Section 6.3, 6.4 and 6.5.

Sanitary Area	Desludging Quantity (m^3/year)	
	1988	2010
A	32,776	92,311
B	160,843	653,079
C	286,550	290,674
Total	480,169	1,036,064

Furthermore, the estimated quantity of desludging in each Kelurahan of on-site sanitation area of Area A and Area B, and that of whole Study Area is shown respectively in Table H.40 and Table H.41.

Under the existing conditions, as dealt with in Appendix-F, both the existing sludge treatment plant in Pulo Gebang and the one under construction at Duri Kosambi are each of capacity 300 m^3/d. Their combined total capacity is 600 m^3/d. Both employ aerobic digestion followed with anaerobic digestion/sedimentation and drying in drying beds. Both these plants are not sufficient to meet the estimated existing average desludging quantity of 1315 m^3/d (480,169 m^3/year). Hence additional treatment plants are necessary even under the existing conditons. The average quantity of desludging in the year 2010 would further increase to about 2840 m^3/d (1,036,064 m^3/year).

6.7.2 Service Area and Sludge Treatment

The service area of desludging and the requirement of additional sludge treatment plants and their capacity and location in the year 2010 are determined based on the following considerations.

- The six (6) number wastewater treatment plants of sewerage will serve their respective interceptor areas, and the on-site areas (Area A and Area B) in their vicinity in order to optimize the extent of service area and number of required sludge treatment plants.

- In principle, existing as well as any future sludge treatment plants will serve only on-site sanitation areas of Area A and Area B in order to ensure their vitality even under the condition that the whole of Area C to become conventional sewerage area.

- Any additional sludge treatment plants shall optimize the distance of sludge hauling and transport.

Accordingly, the whole study area is divided into ten (10) number service areas, six (6) to be served by the proposed wastewater treatment plants of sewerage, two (2) by the existing plants at Pulo Gebang and Duri Kosambi (under construction), and the remaining two (2) by new sludge treatment plants to be constructed in Kecamatan Pasar Minggu and Pasar Rebo, as shown in Fig. H.39.

The Kelurahans covered by each service area and their respective quantity of desludging for treatment is shown in Table H.6.18. The corresponding total computed quantity for each service area, demarcated between the whole service area and the portion of on-site area (Area A and Area B), is summarized below.

Service Area/ Treatment Plant		Average Quantity of Desludging (m^3/d)	
		Whole Service Area	On-site Area
Wastewater Treatment Plant	1	411	121
	2	234	142
	3	383	298
	4	283	98
	5	78	0
	6	237	170
Sludge Treatment Plant	7(DK)	300	300
	8	304	304
	9	299	299
	10(PG)	310	310
Total		2,839	2,042

Note : DK. : Sludge treatment plant under construction in Duri Kosambi

PG. : Existing sludge treatment plant at Pulo Gebang

All others to be newly constructed

The location, treatment process and other relevant information for the six (6) number wastewater treatment plants are described in details in Section 5.5 of foregone Chapter 5.

Except for Service Area-1 with its treatment plant at Pluit pond (ref. Fig. H.39) all the remaining five (5) wastewater treatment plants will receive the sludge from on-site facilities to their sludge treatment streams of anaerobic digesters. While for Pluit pond the sludge will be discharged to influent of aerated lagoon, as this plant does not have any specific sludge treatment stream other than drying beds.

The locations of the newly proposed two (2) number sludge treatment plants for Service Area No. 8 and Service Area No. 9 are located respectively in Kel. Kebagusan of Kecamatan Pasar Minggu, South Jakarta and Kel. Setu of Kec. Pasar Rebo, East Jakarta. Both the proposed locations of treatment plants are green areas reserved in the land use plan of 2005 (Ref. Fig. H.39). The reserved land area in both these locations could easily meet the required treatment plant area of 4.5 ha.

The capacity of both these plants is 300 m^3/d.

6.7.3 Desludging and Hauling

Existing vacuum trucks of 108 units with capacity ranging from $2m^3$ to 6 m^3 are in operation as shown below.

Capacity	Unit of Truck
2 m^3	77
4 m^3	4
6 m^3	27
Total	108

Required number of vacuum trucks of each service area are determined based on following assumptions.

- Operation time is six (6) days a week and eight (8) to nine (9) hours a day
- Capacity of vacuum truck is 6 m^3
- Standby allowance of 20% is considered for maintenance and repair

The time required to make one (1) cycle is assumed to be dependent on the extent of service area concerned, as given below.

Service Area greater than 7500 ha	:	2 cycle/day
Service Area is in between 5000 ~7500 ha	:	3 cycle/day
Service Area is in between 2500~5000 ha	:	3.5 cycle/day
Service Area is less than 2500 ha	:	4 cycle/day

The total required number of vacuum trucks of capacity 6 m^3 is determined at 266 units. Their breakdown and the extent of service area is shown below.

Service Area	Area (ha)	No. of Vacuum Truck
1	10,523	48
2	3,597	16
3	5,931	30
4	5,106	22
5	1,243	5
6	7,964	28
7	6,950	23
8	8,245	35
9	9,441	35
10	6,149	24
Study Area	65,149	266

Total capacity of existing vacuum truck is 332 m^3, which is equivalent to 55 units of 6 m^3 capacity vacuum trucks.

Then additionally proposed number of vacuum trucks is 211 units.

6.7.4 Sludge Treatment Plant

The existing sludge treatment plant in Pulo Gebang employs aerobic digestion followed with anaerobic digestion cum sedimentation and effluent treatment utilizing stabilization ponds (ref. Fig. F.6 of Appendix F). The effluent water quality is reported to be 30~50 mg/l as BOD, though levels in the range of 110-240 mg/l was observed in the survey conducted by the JICA Study Team in September 1990.

More over, due to inadequate capacity of sludge drying beds, at times desludged sludge is pumped into the adjoining open area.

Aerobic digestion, as used in Pulo Gebang, is unwarranted in consideration to the subsequent stabilization pond based treatment system requiring large land area utilized. Land area requirement is not a serious constraint as plants of this nature can be flexibily located in remote areas. Though aerobic digestion helps in minimizing odour problems, not only it is very energy intensive but also requires skilled and intensive operation and maintenance in order to ensure proper cycle of loading and unloading of sludge to each aeration tanks and cleaning of unloaded tank with a frequency of seven (7) days.

Hence a more simplified, economic and less energy intensive sludge treatment system is proposed for both the new treatment plants. The system is entirely stabilization pond based and consists of anaerobic, facultative and maturation ponds, and sludge lagoon for dewatering and drying the anaerobically digested sludge in the ponds.

The lay-out of the treatment system, for both No. 8 and No. 9 treatment plants of Pasar Minggu and Pasar Rebo, with a capacity of 300 m^3/d, is illustrated in Fig. H.40.

The design criteria and considerations used for the design of the treatment system are as follows :

(1) Influent sludge (septage) characteristics :

Influent flow rate	:	300	m^3/day
BOD_5 of sludge	:	5000	mg/l
Fecal coliform (FC) density	:	10^9	No./100 ml

(2) Effluent quality targeted :

BOD_5 not to exceed 30 mg/l

FC density not to exceed 100 No./100 ml

Hence the effluent could be utilized for unrestricted irrigation.

(3) Environmental conditions

Minimum average mean monthly ambient temperature (T) : 25^0 C

(4) Design loading to ponds

Anaerobic pond	:	200 g BOD_5/m^3-d
Facultative pond	:	(20 T-120) kg BOD_5/ha-d
	:	380 kg BOD_5/ha-d

Pertinent features concerning each treatment units of anaerobic pond, facultative pond, maturation pond and sludge lagoon are summarized below.

(i) Anaerobic pond

Receives the influent raw sludge from vacuum trucks for initial pretreatment. The pH of the pond shall be maintained above 6 to control odour problem due to release of H_2S and to facilitate active anaerobic digestion of settled sludge.

As the natural means of pH control, one to one (1:1) recycle of facultative pond effluent with respect to the influent raw sludge to anaerobic pond is provided (ref. Fig. H.40).

Number of anaerobic ponds	:	1 No.
Detention time (total influent based)	:	12.7 day
Total depth of pond	:	4.5 m
Effective depth	:	4.0 m
Recycle ratio	:	1:1 (facultative pond to anaerobic pond)
Pond areal dimension at mid effective depth	:	20 m (W) x 95 m (L)
BOD removal efficiency of pond	:	70 %

Desludging of pond be carried out once the pond is half full with sludge, which is expected to occur once in 1.5~3 year. Desludged sludge will be dewatered and dried in sludge lagoon.

(ii) Facultative Pond

The pond will receive the effluent of anaerobic pond.

Number of ponds : 2 No. identical ones in parallel.

Detention time (total influent based)	:	30.5 day
Total depth of pond	:	2.0 m
Effective depth	:	1.5 m

Pond areal dimension at mid effective depth : 50 m (W) x 122 m (L)

In principle, the effluent of one (1) facultative pond could be entirely recycled to the anaerobic pond influent to attain the recycle ratio of one to one (1:1).

Design effluent BOD of pond : 60 mg/l

(iii) Maturation pond

Receives the effluent of facultative pond for further polishing and to reduce fecal coliform density. It is recommended to be utilized as fish pond of resource recylcle and to enhance algal reduction.

Number of ponds : 2 No. identical ones in series.

Dentention time	:	5 day
Total depth of pond	:	2.0 m
Effective depth	:	1.5 m

Pond areal dimension at mid effective depth : 20 m (W) x 50 m (L)

Baffles (2 No.) are provided to minimize short circuiting in consideration to the low detention time.

(iv) Sludge lagoon

The sludge lagoon will receive desludged sludge principally from anaerobic pond for dewatering and drying.

Time of dewatering and drying is flexible and be about 6~9 months. Supernatant of dewater be decanted (recycled) to the influent of anaerobic pond.

Number of ponds	: 2 No. indentical and independent for operational and maintenance flexibility.

Total depth of lagoon	: 2.0 m
Effective depth	: 1.5 m

Areal dimension of lagoon at mid effective depth: 42.5 m x 42.5 m sq.

All ponds and sludge lagoon are of slope 1:3 (one vertical to 3 horizontal) typically. All sloping side surfaces of all ponds and lagoons are of masonary construction, while those of bases are of compacted clay.

The total requirement of land area for treatment plant is 4.5 ha.

The major auxiliary facilities of the treatment system includes recycle pump (P_1) and sludge pump (P_2) (ref. Fig. H.40).

The capacity of recycle pump	: 3 No. pump of capacity 5 l/s with 3m head
The capacity of sludge pump	: 2 No. pump of capacity 10 l/s with 9m head.

References :

Mara, Sewage Treatment in Hot Climates, 1976
Metcalf and Eddy, Inc., Wastewater Engineering, 1981

7. Alleviation of Water Pollution

7.1 Reduction of Pollution Load

7.1.1 Existing and Future Pollution Load without Project

(1) Existing Pollution Load

Existing pollution load as BOD in each Sanitary Area A, B and C are estimated as shown in Table H.43. Sanitary Area A of 21,159 ha is defined as simple on-site treatment system development area, principally, for the sanitary disposal/treatment of toilet wastewater, where the existing population is 726,400. Sanitary Area B of 27,386 ha is defined as high level on-site treatment system development area, for the on-site treatment of both the toilet waste and gray water, where the existing population is 2,890,300. Further more, Sanitary Area C of 16,604 ha is defined as sewerage development area where the existing population is 5,169,300.

The total BOD load discharged in Sanitary Area A is 33,204 kg/d, of which toilet waste accounts for a 2,538 kg/d, gray water a 12,107 kg/d, wastewater from commerce and institutions a 2,175 kg/d and industrial wastewater a 16,384 kg/d.

The share of pollution load from industry is 49% and that of gray water is 36%. Specific pollution load as BOD per hectare is 1.6kg/ha/d.

In Area B the total discharged BOD load is 94,243 kg/d.

The share of toilet wastewater is 7,753 kg/d as BOD (8%).
The share of gray water is 51,048 kg/d as BOD (54%).
The share of wastewater from commerce and institutions is 10,110 kg/d (11%).
The share of industrial wastewater is 25,332 kg/d as BOD (27%). Finally, the specific pollution load as BOD for Area B is 3.4 kg/ha/d.

Similarly, in Area C the total discharged BOD load is 138,983 kg/d, of which the share of toilet wastewater is 14,303 kg/d or 10%, the share of gray water is 89,856 kg/d or 65%, the share of wastewater from commerce and institutions is 27,603 kg/d or 20%, and that of industrial wastewater is 7,221 kg/d or 5%.

The specific pollution load of Area C as BOD is 8.4 kg/ha/d.

Consequently the existing total pollution load of the whole Study Area is obtained by summing up those of Area A, Area B and Area C.

Accordingly, the total pollution load in the Study Area is 266,430 kg/d.

The share of toilet wastewater is 24,594 kg/d (9%).
The share of gray water is 153,011 kg/d (58%).
The share of wastewater from commerce and institutions is 39,888 kg/d (15%).
The share of industrial wastewater is 48,937 kg/d (18%).

Finally, the specific pollution load of the Study Area as BOD is 4.1 kg/ha/d.

(2) Future Pollution Load

Future pollution load discharge without project in respective sanitary areas are estimated under the following assumptions.

- The ratio of sanitary disposal of toilet waste by households in septictank/leaching systems remains the same as existing conditions with a 74%
- Gray water, commercial and institutional wastewater and industrial wastewater are discharged to the public water bodies under the same conditions as existing.

Future pollution load as BOD discharged from each pollution sources are estimated and summarized in Table H.44.

In Sanitary Area A, population would be more than doubled that of existing, while the unit pollution load is increased due to enhanced standard of living. Then, pollution load from gray water of 31,321 kg/d as BOD is 2.6

times more than the existing one, and the pollution load of 7,733 kg/d from commercial and institutional enterprise is 3.6 times more than the existing one. Pollution load from the industry will increase to 57,590 kg/d as BOD from the existing one of 16,384 kg/d because new industrial estate development will concentrate mainly in Area A and B. The share of pollution load from industry will be 57% of total pollution load in Area A. Finally, the future specific pollution load will be 4.8 kg/ha/d from the existing one of 1.6 kg/ha/d.

In Sanitary Area B, the share of future pollution load of toilet wastewater, gray water and wastewater from commerce and institutions is respectively, 11,970 kg/d, 114,941 kg/d and 31,172 kg/d. These three (3) accounts for 74% of the total pollution load of 213,940 kg/d. The pollution load from gray water of 114,941 kg/d is more than 2.3 times the existing one of 51,048 kg/d. This is caused both by increase in population and unit pollution load. The pollution load of commerce and institutions will be 3.1 times of existing one. Regarding the pollution load of industry, it will increase to 55,857 kg/d from the existing value of 25,332. The future specific pollution load is 7.8 kg/ha/d in comparison to the existing one of 3.4 kg/d.

In Area C, the future pollution load of toilet wastewater, gray water, and commercial and institutional wastewater is respectively 16,323 kg/d, 143,539 kg/d and 64,796 kg/d which accounts for 98% of the total pollution load. Hence for Area C, sewerage development will be very effective for reducing the pollution load and hence to improve the water quality of public water bodies. The specific pollution load of Area C would become 13.8 kg/ha/d in comparison to the existing one of 8.4 kg/ha/d, with no project.

7.1.2 Reduction of Pollution Load with Project

(1) Reduction of Pollution load by Sewerage Development

Reduction of pollution load by sewerage development in Area C is estimated under the following assumptions.

- All domestic and commercial and institutional wastewater in conventional sewerage areas are collected, treated and discharged to the rivers and canals nearby treatment plant with a BOD of 30 mg/l.

- All gray water discharged by domestic, commercial and institutional sources in interceptor area is collected, treated and discharged with a BOD of 30 mg/l.
- All wastewater from small scale isolated industry is collected, treated and discharged with a BOD of 30 mg/l.
- All toilet wastewater in interceptor area is treated by on-site sanitation facilities.

The pollution load discharged form wastewater treatment plant is 37,560 kg/d as BOD against the total reduction amount of 192,251 kg/d as shown in Table H.45. This implies that the BOD removal efficiency of sewerage development is 84% with respect to the total pollution load of 229,811 kg/d in Area C. With this 84% BOD removal, the specific pollution load becomes 2.26 kg/ha/d.

(2) Reduction of Pollution Load by On-site Treatment

Reduction of pollution load by on-site treatment in Area B is estimated assuming the following :

- All domestic wastewater consisting of toilet wastewater and gray water is treated by on-site treatment plant and discharged to ditches and/or other public water bodies with a BOD of 60 mg/l.

- All commercial and institutional wastewater is treated by individual or communal treatment plants and discharged with 60 mg/l as BOD.

- Industrial wastewater is discharged under the same conditions as existing.

The pollution load discharge form on-site treatment system in Area B is estimated at 44,666 kg/d for domestic source and 8,098 kg/d for commercial and institutional sources.

The total pollution load reduction by project is 105,319 kg/d, which corresponds to a BOD removal efficiency of 67% with respect to the total domestic, commercial and institutional pollution load of 158,083 kg/d as BOD.

The total pollution load discharge is 108,621 kg/d consisting of 44,666 kg/d of domestic, 8,098 kg/d of commercial and institutional and 55,857 kg/d of industrial waste sources.

The corresponding specific pollution load discharge is 3.97 kg/ha/d.

(3) Reduction of Pollution Load by Other Measures

The effluent quality standards of industry is established at 75 mg/l as BOD by Governor's Decree No. 1608. Industries are expected to treat their wastewater either individually or communally to meet the above effluent quality standards.

If this effluent quality of 75 mg/l as BOD is assumed, then the pollution load from industry will decrease to 9,346 kg/d from 57,590 kg/d in Area A and to 9,065 kg/d from 55,857 kg/d in Area B.

(4) Total Reduction of Pollution Load

Reduction of pollution load by sewerage development and on-site treatment system in sanitary Area B and C are 105,319 kg/d and 192,251 kg/d as BOD respectively. While in Area A, though no pollution load reduction is aimed by the project, assuming that toilet waste is sanitarily disposed the specific pollution load will increase to 4.25 kg/ha/d from the existing condition of 1.6 kg/ha/d.

Assuming the industrial effluent quality standards of 75 mg/l as BOD is met, the pollution load of Area A will be reduced to 41,776 kg/ha from 90,020 kg/ha.

The corresponding specific pollution load will be 1.97 kg/ha/d from 4.25 kg/ha/d. Similarly, the pollution load of Area B will be reduced