d) Distribution Chambers
e) Anaerobic Pond
f) Septage Lagoon
g) Facultative Pond
h) Maturation Pond
i) In-plant Piping
j) In-plant Maintenance Roads
k) Administrative Building (Office, Laboratory, Lounge, Storage)

(2) Trunk Sewers

a) Trunk Sewer (Areas 2, 6, 13, 18A, 18B and 33, and Connection Pipe to the New Treatment Plant)
b) Aqueduct Bridge

(3) Sewer Network

a) Sewer Network (Areas 1 and 2, and Connection Pipe in Area 6)

(4) Maintenance Equipment

a) Water Quality Analysis Instruments
b) Sewer Cleaning Equipment and Vehicles
c) Treatment Plant Maintenance Vehicles, Boat and Engine-driven Pumps

3.3.3 Location and Condition of the Project Site

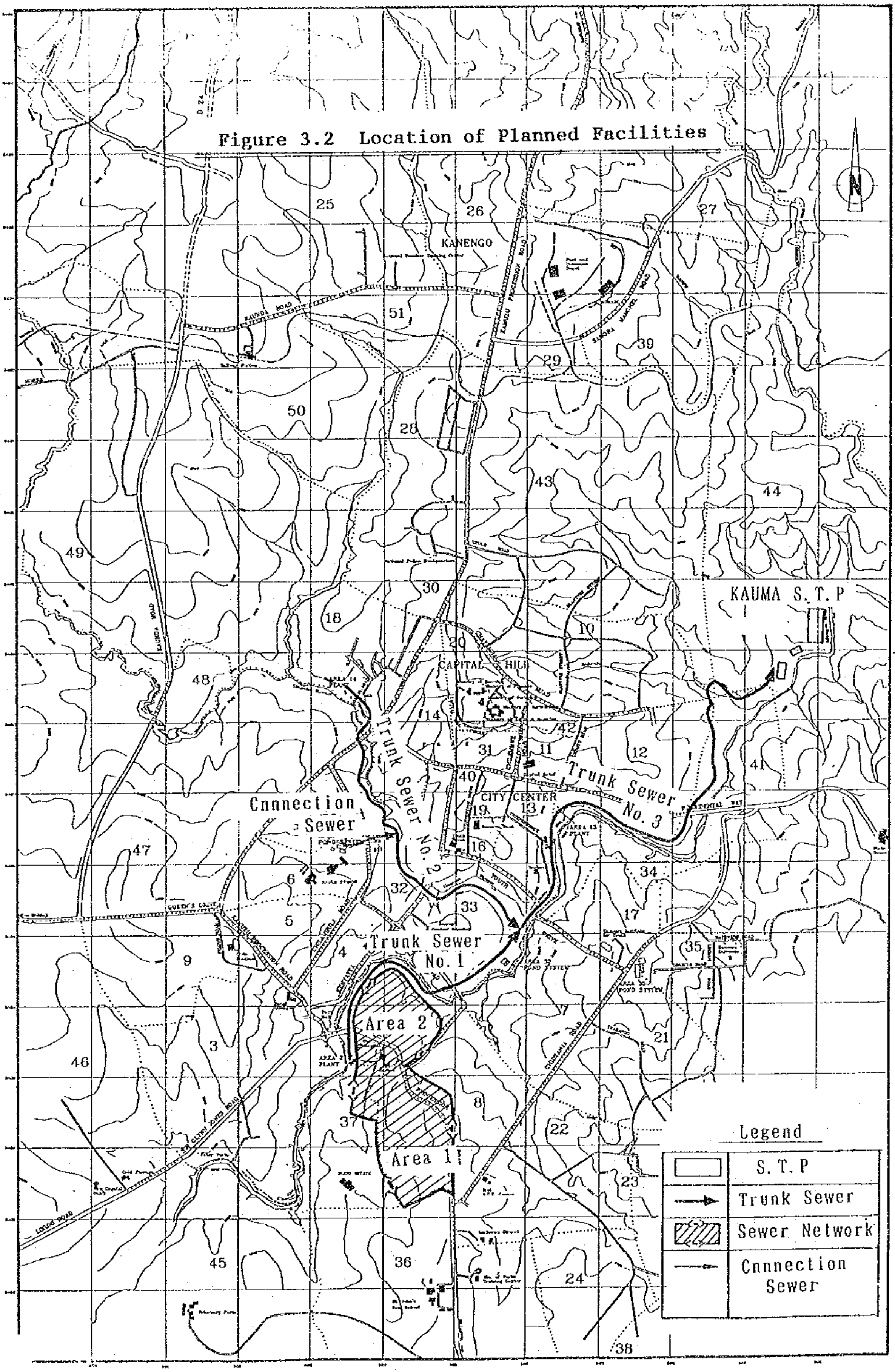
Figure 3.2 presents locations of the sewage treatment plant and the trunk sewers to be constructed, and the sewer network development area.

(1) Surrounding Condition of the Construction Site

1) Sewage Treatment Plant

The new sewage treatment plant is located on the left bank of the Lilongwe River about 7km downstream from the confluence of the Lingadzi River, and about 11km from the M1 road bridge in the Old Town in the core of Lilongwe.

Figure 3.2 Location of Planned Facilities



Scale 1:7300, 1 grid = 1 km

The proposed treatment plant site is owned by the Malawi government with surrounding area. However, there is a squatter hamlet adjoining the site and illegal cultivation by squatters is carried out in the site. An about 3km-long access road will have to be constructed passing by this hamlet to connect the plant site with existing road. An intake weir and an intake pumping station are used to draw river-water for the State House located on the opposite side of the river directly across from the proposed treatment plant site. The opposite shore is also occupied by farm-fields and forested areas.

2) Trunk Sewer

The trunk sewer is divided into three sections.

The upstream end of the No. 1 trunk sewer will be the inflow pipe to the existing Area 2 treatment plant. From there, it will run on the right bank of the Lilongwe River, cross the river with aanaqueduct to Area 33 just in front of the Mzimba road bridge, and continue to run along the left bank of the Lilongwe River to the confluence with the Lingadzi River. The proposed route for pipe installation which is inclined towards the river lying behind the city, is on the site of thick woodlands, and is now inaccessible to vehicles, so the woodlands will have to be cleared prior to the installation work.

The No. 2 trunk sewer will start from the inflow pipe to the existing Area 18 treatment plant, then run on the left bank of the Lingadzi River, cross the river with aanaqueduct just in front of the M1 road bridge, then pass through Areas 32 and 33 along the right bank of the Lingadzi River to the confluence with the Lilongwe River. An approximately 4km-long section from the M1 road to the confluence, which occupies most of the No. 2 trunk sewer will pass through the nature sanctuary. It is densely wooded, and is the home of wild animals. To construct the trunk sewers in this section, the City Council shall consult the authorities concerned and obtain an environmental impact assessment.

The No. 3 trunk sewer will begin at the junction of the Nos. 1 and

2 trunk sewers, cross the Lingadzi River with an aqueduct, then continue to run on the inclined riverside with woods along the left side of the Lilongwe River as far as the Kauma treatment plan.

3) Sewer Network

The sewer network will be constructed in two areas: Areas 1 and 2, and a connecting pipe will be laid from the existing Area 6 treatment plant to the No. 2 trunk sewers.

a) Area 1

This area is a relatively high-density residential district partially occupied by scattered schools and churches. Most sewers will be installed under the roads, but most of roads are unpaved. The sewer network can be broadly divided into the northern and southern systems, and between these systems, there is a district where a sewer network has been already provided so as to connect to a communal septic tank. This tank will be abandoned, and the existing sewers will be connected at the end to the southern system.

The downstream pipe of the southern system will run along the drainage channel in which the water flows north through Area 37 towards the Lilongwe River, almost to the Lingadzi River, and after running for about 300m along the right bank of the Lilongwe River, it will join the No. 1 trunk sewer at the premises of the existing Area 2 treatment plant. Thick shrubbery growing above the route within Area 37 must be cut down. The downstream pipe of the northern system will run along the drainage channel that runs to the east about 100m south of the market in Area 2, then join the downstream pipe of the southern system.

In order to receive the sewage from the school located on the opposite side of the M1 road in Area 8, a sewer must cross the M1 road, but it is a relatively lightly used road. During the construction work one-way traffic will have to be enforced to maintain the safety of the workers, but it will not be necessary to close the road. The other roads are local roads that will not interfere with construction work.

b) Area 2

Area 2 includes a commercial district occupied by a densely packed collection of shops on both sides of the M1 road, and behind this district, a residential neighborhood enclosed by the Lilongwe River. Sewerage services have been already provided in an area on the south side of the M1 road where the hospital, market, and stores are concentrated. The sewage from this neighborhood will enter into the existing Area 2 treatment plant.

A new sewer network will be installed for the shops, school, and houses on the north side of the M1 road. This area will be enclosed by the newly constructed No. 1 trunk sewer, and considering the topography, the sewer network will be connected to the No. 1 trunk sewers at 7 locations. Almost all sewers will be installed under the paved roads.

Because of the heavy traffic in the commercial area along the M1 road, it will be necessary to pay attention to safety measures during the construction work. However, the sewers will be installed under the side streets, so there is no danger of obstructing traffic on the M1 road. There is no need for concern about obstructing traffic on the other streets, because they run through residential districts.

c) Area 6 Connection Pipe

A pipeline will be constructed to connect the inflow pipe to the treatment plant adjoining the Maula Prison in Area 6 to the No. 2 trunk sewer along the Lingadzi River. It will run through relatively flat land alongside a water channel.

(2) State of the Infrastructure

1) Electric Power

The Electricity Supply Commission of Malawi (ESCOM) will supply the electric power to the treatment plant. Aside from planned power shutdowns, elevated power lines are broken by heavy rainfall during the wet season, but only infrequently, and no problem is expected to be encountered regarding the power supply to the site. As there are no power lines installed to the construction site at this time, a line will have to be strung from a nearby 11kV trunk line before the construction work begins. The work will involve the installation of a 11kV power transmission line from the trunk line, installing transformers, circuit breakers, lightning arrestors, etc., the erection of power poles and the wiring of the line for a distance of 1km along the route to the site of the treatment plant. This work will be done by ESCOM, and the City Council will have to pay the expenses.

2) Roads

Paved roads are found in the middle of the city, but there are no roads out to the vicinity of the treatment plant. There is a natural roadway running out to the hamlets near the treatment plant site, but cars can barely pass over it and it would be very difficult to drive a passenger car from that road to the site.

3) Telephones and Communications

Telephone service is relatively good in the City, but to the treatment plant site, it will be necessary to install an approximately 2km-long service line from the nearest trunk line.

3.3.4 Facilities and Machinery & Materials Summary

A summary of the facilities and of the machinery and materials to be provided by this project are presented on Table 3.6 and Table 3.7 respectively.

Table 3.6 Outline of Major facilities

Name	No. of Units	Structure /Specifications	Analytical Parameter
Kauma Sewage Treatment Plant			
Grit Chamber	1	RC 2 channels (1 standby)	O.F.R. 1,800 $m^3/m^2/d$
Screen	2	Manually-operated	
Flow Meter	1	RC, Parshall Flume Type	
Anaerobic Pond	3	1 standby	BOD Load 160g/m^3/d D.T. >2 days
Septage Lagoon	2		BOD Load 200g/m^3/d D.T. >20 days
Facultative Pond	4	2 series (2 units/series)	BOD Load 192g/m^3/d
Maturation Pond	6	2 series (3 units/series)	D.T. >3 days/unit
Outflow Pipe	2	ACP	
Bypass Outflow Pipe	1	ACP	
In-plant Piping	L.S.	ACP	
Administration Bldg.	1	RC	
In-plant Road	L.S.		
Trunk Sewers			
No.1 Trunk Sewer	1	φ500-600 mm x 4.2 kmL	Manning's Formula n=0.013
No.2 Trunk Sewer	1	φ500-600 mm x 5.4 kmL	Vmax=3.0 m/s Vmin=0.5 m/s
No.3 Trunk Sewer	1	φ800 mm x 7.9 kmL	
Sewer Network			
Area 1	144 ha	including service connection	Manning's Formula n=0.013
Area 2	140 ha	including service connection	Vmax=3.0 m/s Vmin=0.5 m/s
Area 6	-	Connection pipe φ250 mm x 1.2 kmL	

An administration building includes the electrical equipment and a garage.

O.F.R.: overflow rate
D. T. : detention time
n : coefficient of roughness
V : flow velocity
RC : reinforced concrete
ACP : asbestos cement pipe
L : length
φ : diameter

Table 3.7 Outline of Major Equipment

Name	No. of Units	Specifications	Analytical Parameter
<u>Analytical Apparatuses</u>			
pH Meter	2	each for portable and laboratory	pH, ORP
DO Meter	2	each for portable and laboratory	DO
Thermometer	1	for water, Pettencohöl type	water temp., sampling
Thermometer	1	for water, glass stick type	water temp.
Thermometer	1	for air	air temp.
Transparency Meter	1		transparency of water
Zone Meter	1		settled sludge height
Colony Counter	1		No. of coliform bacteria group
Electric Balance	1		weight measuring
Microscope	1		microorganisms species
Hot-air Oven	1		SS
High-pressure Autoclave	1		No. of coliform bacteria group
Water Bath	1		COD
Const. Temp. Incubator	1		No. of coliform bacteria group
Forced Air Incubator	1		BOD
Pure Water system	1		
Vacuum Pump	1		SS
Refrigerator	2	each for chemicals and samples	
Glassware	L.S.		
<u>LLaboratoryFFurniture's</u>			
Center Work Table	1		
Balance Table	1		
Side Work Table	2		
Locker	1	for chemicals	
Locker	1	for instruments	
<u>Equipment for Sewer Cleaning</u>			
High-pressure Cleaning Can	1		
SludgüeVacuum Tanker	1		
Small Truck	1		
Sewer Cleaning Tools	L.S.		
<u>Equipment for Plant Maintenance</u>			
Dump Truck	1		
Plastic Boat	1		
Engine-driven pump	3		

3.3.5 Maintenance Plan

The following is a list of expenses that will be incurred during the implementation of the Project that the Malawi side will have to bear, and an estimate of operation and maintenance costs following the completion of the facilities.

(1) Items Necessary Before and During the Implementation of the Project

a) Establishment of the Project implementation organization
b) Obtaining authorization from agencies in charge of rivers and roads for the installation of sewers across rivers and roads
c) Obtaining authorization for the installation of the trunk sewer in the nature sanctuary from the concerned authorities
d) Land acquisition required for the construction of facilities
e) Land acquisition required for the construction of maintenance roads
f) Compensation for private land used in the construction of the branch pipe network
g) Tax exemption measures covering the materials and equipment to be imported
h) Construction of an access road to the treatment plant
i) Fencing around the treatment plant fence
j) Clearing on the trunk sewer route
k) Installation of the water supply pipe to the facility site
m) Wiring of the power supply line to the facility site
n) Wiring of the telephone service line to the facility site

The Malawi side must, as necessary, estimate the cost of the above measures, and provide the funds to pay for them. Table 4.22 represents a list of the direct expenses which shall be shared by the Malawi side during the Project implementation.

(2) Maintenance Expenses after Completion of the Project

1) Personnel Expenses

The maintenance personnel in the existing treatment plant, which will eventually be closed, will have to be reassigned so that he operation and maintenance including water quality control is performed properly. after the completion of the new treatment plant No additional staff will be necessary. However, cost for assignment of a new manager of the Road Section is required to have the manager of the Sewerage Section work in his duty.

2) Operating Expenses

Because the treatment plant will use neither electricity nor chemicals, there will be no day-to-day operating expense.

3) Maintenance Expenses

The Malawi side must appropriate the budget for the following items so that the maintenance can be properly carried out:

- Cost of piled sludge transportation and disposal

Grit Chamber:			
grit	1 time/15 days	$0.9m^3$/time	$22m^3$/yr
screenings	same to above		$22m^3$/yr
Anaerobic pond:	1 time/5 yrs	$660m^3$/time	$132m^3$/yr
Septage Lagoon:	1 time/1 mo	$270m^3$/time	$3,240m^3$/yr
Facultative Pond:	1 time/5 yrs	$495m^3$/time	$99m^3$/yr
Total:			$3,515m^3$/yr

- Water quality analysis expenses: Cost of chemicals, light and heat required to analyze the water quality at each pond once a month.

Table 3.8 presents the budget for mmaintenancewhich the Malawi side ought to prepare. This trial calculation was based on the above assumptions.

Table 3.8 Estimate of Maintenance Cost for New STP

1) Personnel Expense		
Engineer	1 pr. x 21,000 MK/yr	= 21,000
Operator	1 pr. x 7,200	= 7,200
Guard	1 pr. x 7,200	= 7,200
Water Quality Tech.	1 pr. x 21,000	= 21,000
Water Quality assist.	1 pr. x 7,200	= 7,200
Subtotal		MK63,600/yr
Sewerage Section Manager	1 pr. x 31,000	= 31,000
Total		MK94,600/yr

2) Sludge Transportation Expense

a) Fuel for Truck (182PS, 0.040L/PS-h, 3.1MK/L)

Sludge Volume 3,515 m^3/yr ≈ 3,500 m^3/yr

3,500t / 4t/time x 1h x 182PS x 0.040L/PS-h x 3.1MK/L

MK19,747/yr

b) Fuel for Engine-driven Pump (9kW, 3m^3/min, 0.584L/kW-h, 3.1MK/L)

Anaerobic Pond	13,000 m^3/5yr
Septage Pond	2,000 m^3/mo
Facultative Pond	87,500 x 1/2 m^3/yr
Maturation Pond	9,200 x 3 ponds x 1/2 m^3/5yr
Discharge Volume	38,110 m^3/yr

38,110m^3/yr / 180 m^3/h x 9kW x 0.584L/kW-h x 3.1MK/L

MK 3,450/yr

c) Personnel Expense

Engineer	1 pr x 7,200 MK/yr x 9/12 (9 mo.) =	5,400
Laborer	8 pr x 2,400 MK/yr x 9/12 (9 mo.) =	14,400
Driver	1 pr x 2,400 MK/yr x 9/12 (9 mo.) =	2,400
Subtotal Personal Expense		MK21,600/yr

Total a) + b) + C) MK44,800/yr

3) Water quality and Other Expense ≈ MK 5,000/yr

Grand Total 1) + 2) + 3) MK144,400/yr
≈ MK145,000/yr

The O & M cost for the whole sewerage system in 2000 can be estimated to be as follows:

Remuneration (31,000x1+21,000x5+7,200x29=)	MK344,800/year
Fuel for vehicles (MK20,000/year x 5 vehicles=)	MK100,000/year
Fuel for pumps and Others	MK 50,000/year
Repair of facilities (0.5% of planed F/S project cost)	MK236,000/year
Total	MK730,800/year

The sewage amount in 2000 is estimated to be as follows:

Domestic	1,172m^3/day
Commercial and others	4,939m^3/day
Sewage outside oroject area	5,987m^3/day (based on F/S)
Total	12,098m^3/day

Thus, unit O & M cost per m^3 is derived at MK0.17/m^3 as follows:

$$MK730,800/year \div (12,098m^3/day \times 365\ days) = MK0.17/m^3$$

(3) Sewage rate

As stipulated in Section 3.2.2, the flat rate charging system is adopted for the Lilongwe sewerage system. However, the charge level does not reach to the full-cost recovery level as shown in Table 3.2.

The sewage charge system study conducted in the F/S determined following:

1) The O & M cost including repair cost is assumed to be as 1% of accumulated annual project cost.
2) A metered rating system will be introduce instead of the flat rate system.
3) The present sewage rate (MK12.00/month/h.h.) is equivalent to a unit sewage rate per m^3 at MK0.58/m^3 taking into account an average monthly sewage amount per household (99 lpcd x 7 person/h.h. x 30 days = 20.79m^3). This calculated unit rate is almost equal to a water rate.
4) Total amount of the water rate and sewage rate reaches to 12% of the income per household (MK200). Thus, an appropriate level of sewage rate for covering full amount of the capital and the O & M cost (MK1.12/m^3) cannot be adopted.
5) Therefore, following sewage rate was recommended.

Domestic	MK0.58/m^3
Commercial and others	MK1.12/m^3
Connection charge	MK400

6) The balance between the adopted and appropriate sewage rates (MK0.54/m^3) shall be subsidized from the government.
7) In the case that the connection charge is not introduced, following sewage rate is recommended:

Domestic	MK0.58/m^3
Commercial and others	MK1.15/m^3
Balance to be subsidized	MK0.57/m^3 (Domestic)

Above study is conducted assuming that the construction cost of the F/S project is funded by the city's own fund and by financing arrangement (loan). Thus, if the grant aid of the government of Japan is applied for the Project, the sewage rate can be set at lower level because the cost for amortization will not be necessary. However, it is recommendable that the sewage rate be set at the level recommended in the F/S because of following reasons:

1) The contents of the Project iarethe construction of a treatment plant with a capacity of only 40% of whole project and sewer networks for the areas with urgent needs, and is equivalent to about 30% of whole project in terms of construction cost. Thus, even if the grant aid is adopted for the Project, required fund for further investment to complete the whole project is still enormous.
2) Increase of the personnel cost is high in recent years.
3) The calculated unit O & M cost per m^3 (MK0.17/m^3)i s higher than that in the F/S (MK0.14/m^3).

Since the exchange rate applied in the F/S is 1MK=0.3612US$, the sewage rate recommended in the F/S can be calculated in US dollars as follows:

Domestic	US$0.21/$m^3$
Commercial and others	US$0.40/$m^3$
Connection charge	US$144.48

Above sewage rate can be reconverted to Malawi Kwacha applying the recent exchange rate as follows:

Domestic	MK0.90/m^3
Commercial and others	MK1.74/m^3
Connection charge	MK622
Exchange rate	MK 1.00 = US$ 0.2321

Applying this sewage rate to the sewage amount shown in Table 4.7, the total sewage charge in 2000 can be obtained as follows:

Domestic	1,172m^3/day x MK0.90/m^3	= MK1,055
Commercial and others	4,939m^3/day x MK1.74/m^3	= MK5,013
Sewage outside of project area	5,987m^3/day x MK0.90/m^3	= MK5,388
Total	12,098m^3/day	MK11,456/day

This sewage charge amounts to MK418 million annually, and is equivalent to 14 times the present sewage charge of the city.

3.4 Technical Cooperation

Two problems will be faced after the completion of the project; (a) whether or not the treatment facility will be operated and maintained as expected, and (b) whether or not the sewer system will be cleaned as planned.

The treatment process selected is easily maintained, so as explained in section 3.2.6, there is no need for a JICA expert for the on-the-job training of the management of a sewerage treatment plant at this time. Dispatch of the JICA expert should be decided based on the performance of the treatment plant during a long-term (about one year) operation. For that purpose, execution of a staff training on water quality analysis is desirable, and a Japan Overseas Cooperation Volunteer is considered to be appropriate as a trainer as same as a precedent in the Central Laboratory of the Ministry of Works. In addition, it is recommended that several technical staffs be sent to Japan to participate in JICA training course to acquire basic knowledge on sewage works.

CHAPTER 4

BASIC DESIGN

CHAPTER 4 BASIC DESIGN

4.1 Design Policy

The basic design shall be made in accordance with the following policies:

a) The treatment process shall be decided taking into account the water quality of influent, effluent water quality standard, easiness in repair and maintenance of facilities, economy of operation and maintenance costs, feasibility for future expansion, and so on. Especially in consideration of the present condition of the operation and maintenance at the existing treatment plants, a treatment process, that is as much as simple, that does not require the mechanical and electrical equipment resulting in the daily maintenance and high operation cost shall be selected.

b) The location for pipe installations shall not be limited on the public roads so that the pipe can be installed with a shallow earth cover.

c) The areas to install the branch sewers shall be selected focusing on the residential and commercial areas with the highest need. Priority shall be given to provide the sewerage facilities by constructing the sewage treatment plant first, followed by trunk sewers.

d) The design flow to be used for designing the sewers shall be that at the target year of 2005, but regarding the designing of the treatment plant, the design flow at the interim target year, which can be surely estimated to enter therein, shall be applied to avoid the proceeding investment.

e) The construction material to be used shall be procured in the field as much as possible.

f) The construction period shall not be phased, because the system will not be able to function unless the new treatment plant and trunk sewers collect the sanitary sewage which currently enters into the existing treatment plant are constructed, and the effect of each stage is not definite.

4.2 Consideration of Design Conditions

4.2.1 Design Target Year

As the Lilongwe Water Supply and Sanitation Master Plan (M/P) has a target year of 2005, the design target year of the overall plan for sewerage shall be the year of 2005 to meet the above, while the target year of the Project shall be the year of 2000, taking account of some year allowance after the completion of the Project.

In the Feasibility Study for the Lilongwe City Sanitation Plan (F/S), the projected period is divided into two stages, namely the first stage of 1995 and the second stage. The design flows in 2000 and 2005 are applied to each stage, respectively.

4.2.2 Design Service Area

(1) Overall Plan

The outline of F/S is summarized below.

Areas served by the Kauma Sewage Treatment Plant, to be constructed in the Project, shall be the densely inhabited areas of which the sanitary sewage can enter into the trunk sewer by gravity within the areas along the Lilongwe and Lingadzi Rivers, taking into account the topography, range of the river basin and the operational condition of the existing treatment plants.

As Areas 52 and 53 (located far away from the urban area) have their own plants, they shall be preserved. The sanitary sewage from Areas 25, 26, 29 and 51 cannot be gravitated into the Kauma Sewage Treatment Plant. This sewage shall be treated at the plant to be constructed in Area 51 (which is out of scope of the Project). Likewise, the sanitary sewage from Area 35 shall be treated at its own treatment plant. The sewage from Area 46 is composed of mainly industrial wastewater and its location is far upstream from the proposed trunk sewer, therefore it will not be included in the Project.

Based on the above idea to set the service area, the topography and operational condition of the treatment plants in the above Areas were surveyed, whereupon it was shown that the setting of the service area to be reasonable. The sewage treatment plant in Area 33 is expected to keep operating in the future in the F/S but based on the discussions with the City Council, it will be abandoned after the completion of the Project and the sanitary sewage from there will directly enter into the trunk sewer to be constructed. The district with a residential development plan along the M1 Road in Area 47, and the staff houses of the State House on the other side of the sewage treatment plant in Area 44, which were requested by the City Council to be added to the area for the overall plan shall be included in the planned area as requested due to their having the concrete plans. These areas are within the area served by the Kauma Sewage Treatment Plant.

Figure 4.1 shows the overall planned area served by the Kauma Sewage Treatment Plant based on the ideas mentioned above and Table 4.1 shows the area by Area of the overall planned area which is obtained by measuring the general plan of the F/S.

Table 4.1 Design Service Area of Kauma STP

(Unit:ha)

Area No.	Overall Plan	Project Plan	Area No.	Overall Plan	Project Plan
1	144	144	19	28	7
2	140	140	20	37	37
3	32	-	28	113	-
4	129	-	30	271	9
5	29	-	33	93	15
6	67	10	36	25	-
8	23	-	37	95	1
11	39	2	40	12	-
13	43	43	44	(-)*	-
16	12	12	47	613	-
18	208	80	Total	2,153	500

* staff houses of the State House

(2) Project Plan

The area involved in the Project shall be the area served by existing sewerage system in which the sanitary sewage enters into the sewage treatment plant and the area where sewerage system is expected to be provided by 2000. The outline of the area is as mentioned above.
Figure 4.1 also shows the design service area of the Project and Table 4.1 shows the area to be involved in the Project.

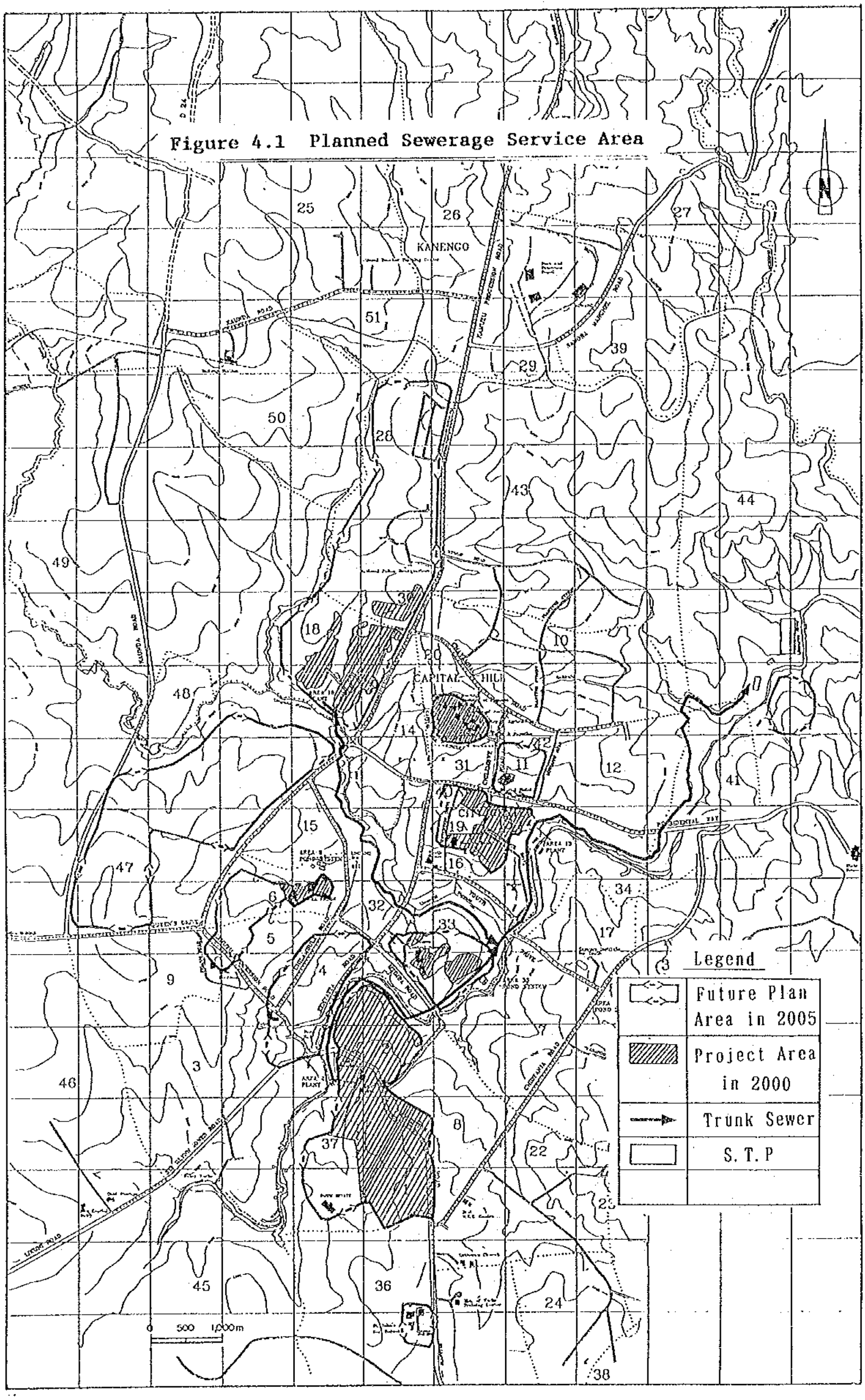


Figure 4.1 Planned Sewerage Service Area
KANENGO
CAPITAL HILL
Legend
Future Plan Area in 2005
Project Area in 2000
Trunk Sewer
S.T.P
0 500 1,000m
25
26
27
51
39
29
50
28
43
44
49
18
30
20
10
48
14
31
11
12
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36
24
38

4.2.3 Design Population

The design population is estimated from the growth of the past population, by forecasting the population of the whole of the city, distributing it to each Area, and summing the population within the design service area.

(1) Forecast of Administrative Population

The values used in the M/P is the data which is used to estimate the future population. Those values were forecasted using the past population data by 1983 an annual average growth rate of 6% (a natural growth rate of 3.6% plus a social growth rate of 2.4%) as shown below.

1983	142,400
1985	160,300
1990	214,200
2000	834,100
2005	444,100

However, because according to the 1987 national census the population was 233,973 with an annual average growth rate of 13%, which largely exceeded the above expectation, the F/S reviewed and forecasted the future population as shown below using the 1987 actual population and an annual average growth rate of 6%.

1989	263,000
1995	373,000
2000	500,000
2005	668,000

The latest predicted values of the population in 1993 were collected from the Statistics Bureau during the Basic Design Study, which still showed high growth, with a population of 271,000 according to the analysis. However, regarding the annual average growth rate of population from 1987, it is below 6%. This value is obtained by applying the constant growth rate of population equally to each Area considering the lack of ground. Since Lilongwe, as the capital of Malawi, is expected to keep a high growth of population in the future. The necessity of continuing to provide infrastructures such as residential areas, roads, and water supply and the sewerage, it is considered reasonable to design the sewerage system based on the projected population in the F/S. As a result, the values in the F/S shall be adopted as the design administrative population in the Project (see Figure 4.2).

(2) Population Projection in the design Service Area by Sewerage

The design population for the Project within the sewerage service area shall be decided by reviewing the design population in the F/S.

The flowchart to calculate the design population in the F/S is shown in Figure 4.3. In the F/S, the population was calculated in accordance with this flowchart and the population within the design service area (the whole area including area 35 and others which are excluded from the subject area of the Project) is projected at 70,000 in 2000 and about 80,000 in 2005 as shown in Table 4.2.

Table 4.2 Population within Design Service Area in the F/S

(Unit: nos.)

Area	2000	2005	Treat.Plant	Area	2000	2005	Treat.Plant
1	8,626	8,635	Kauma	26,7	5,788	7,014	Area 51 STP
2	253	3,309	Kauma	28	460	920	Kauma
3	219	253	Kauma	29	989	1,150	Area 51 STP
4	748	805	Kauma	30	4,389	5,670	Kauma
5	69	92	Kauma	33	1,943	2,011	Kauma
6	115	138	Kauma	35	7,000	7,000	Area 35 STP
8	46	69	Kauma	36	115	138	Kauma
11	939	1,015	Kauma	37	1,633	2,080	Kauma
13	345	460	Kauma	40	138	138	Kauma
16	58	69	Kauma	44	345	345	Kauma
18	15,050	15,190	Kauma	47	10,419	11,927	Kauma
19	150	184	Kauma	51	0	460	Area 51 STP
20	173	207	Kauma	52	1,185	1,230	Area 52 STP
25	930	1,045	Area 51 STP	53	7,184	7,819	Area 53 STP
				Total	69,309 =70,000	79,103 =80,000	

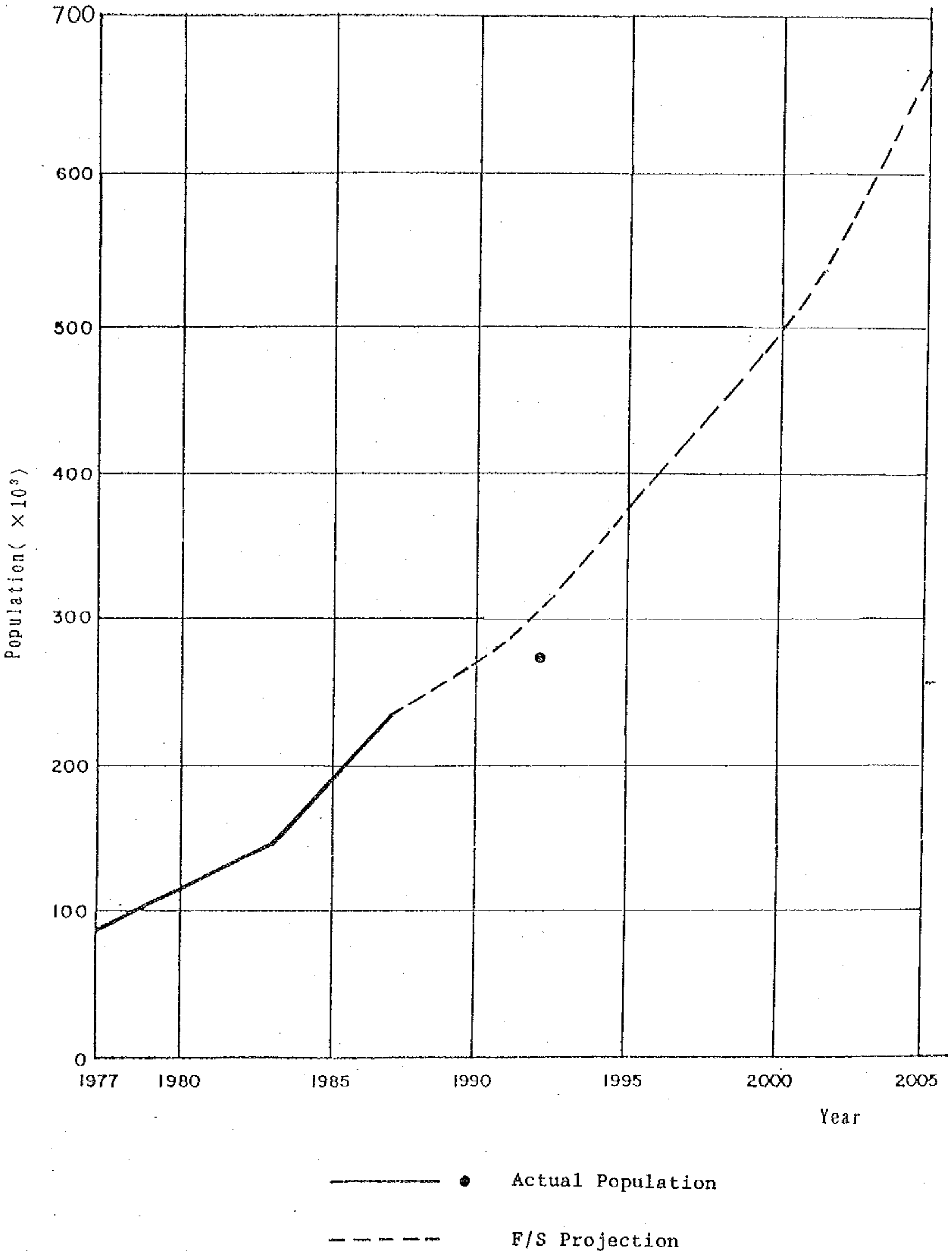


Figure 4.2 Projected Population

Assumption of the present and future land use based on the aerial photographs, land ledger, M/P, city planning, report on the residential area development, data on water consumption, interview with City Council officials, field survey, etc.

↓

Prediction of the no. of households and divisions for the domestic group (high-, middle- and low-dense residential houses and staff houses), and of the area for the non-domestic group (commerce, industry, governmental offices and schools)

↓

Projection of the no. of people per household, division and area predicted above with the 1987 census population and an annual growth rate of 6%

↓

Projection of the no. of people for both the domestic and non-domestic groups

Projection of the no. of households and area for a sewerage system, and the no. of units for the septic tank and pit latrine, after deciding the treatment level corresponding to the land use

↓

Projection of the no. of people per household and area within the sewerage service area, and of the no. of people by treatment level after assuming the no. of people per septic tank and pit latrine

↓

Adjustment with the population in the overall plan

Figure 4.3 Calculation Method of Design Population in the F/S

These values are equivalent to 14% and 12% of the total population in the particular year, respectively, and are roughly considered reasonable (if neglecting whether each area is provided with the sewerage or not). Although, it does seem difficult to attain this service coverage without substantial effort by 2000, especially taking into account that the service coverage was approximately 10% in 1989. The population within the design service area of the Kauma Sewage Treatment Plant in 2005 is calculated by adding the population in Areas 44 and 47, which were newly requested, to the above value. The result of this calculation is shown in Table 4.3.

The design population in the target year of 2000 in the Project shall be the population in the areas where the branch sewers have been already provided and are expected to be provided in the Project for calculation making reference to the F/S as well as that in 2005 (see Table 4.3).

4.2.4 Design Flow

(1) Unit Design Flow for Domestic Group

The design flow for the domestic group is calculated by determining the per capita design flow for the high-, middle- and low-density permanent population areas (H.D.P., M.D.P., L.D.P.), respectively, and multiplying the design populations by those figures. The calculation method of the unit design flow in the M/P and the F/S is summarized below.

1) Method in the M/P

In the M/P, the future unit design flow is decided by calculating the unit design flow in H.D.P., M.D.P. and L.D.P. with the water supply volume and service population for water supply and taking into account the constant growth rate. The unit design sewage flow is calculated using the result of the study on the discharge rate of water into a sewerage system within the sewerage system within the sewerage service area in which the discharge rate was identified at 60%. The yearly unit design sewage flow is as shown in Table 4.4.

Table 4.3 Design Population

(Unit : person)

Year	2000							2005						
Area	COM	INS	STA	HDP	MDP	LDP	Total	COM	INS	STA	HDP	MDP	LDP	Total
1		175	2,061	6,390			8,626		176	2,114	6,345			8,635
2	212	218			2,570		3,000	212	220			2,608		3,039
3								100	153					253
4								805						805
5												92		92
6		520*2	131				651		550*1	138				688
8									69					69
11	23						23	43	23			949		1,015
13	345						345	460						460
16		58					58		69					69
18	88	191	127	*6 7,090			7,496	92	198	126	14,774			15,190
19	81						81	161	23					184
20		173					173		207					207
28								798			122			920
30		429	257				686		442	1,357	3,871			5,670
33		347	444				791		360	1,651				2,011
36									138					138
37		12					12	411	206	229	1,234			2,080
40									138					138
44										2,856*3				2,856
47								66	72		11,789	5,727*4	4,600	22,254
Total	749	2,123	3,020	13,480	2,570		21,942	3,147	3,044	8,471	38,135	9,376	4,600	66,773

*1、*2 Although, institutional waste water from the Prison is expected in Area 6, such Population was not considered in F/S stage, these design population was adopted.

*3 According to the request from Lilongwe City, population in stuff house of the State House,
420 households × 6.8Person/HH = 2,856 person was added.

*4 According to the housing plan of the City, population in Mediumn Density Permanent.
(380+327) × 8.1 persons/HH = 5,727 persons was added.

*5 According to the housing plan of the City, population in Low Density Permanent.
400 × 11.5persons/HH = 4,600 persons was added.

*6 Calculated under the asumption that sewage volume by the year of 2,000 will be 1,000 m^3/day

Table 4.4 Unit Design Sewage Flow Estimated in the M/P

(Unit: lpcd)

Housing Category	Water Supply Volume by Year '83	'84	'85	'86	'87	'88	'89	'90	'91	2000	'05	Sewage Flow (x0.6)
H.D.P.	126	135	142	147	152	157	162	167	192	217	242	150
M.D.P.	128	137	144	149	154	160	166	172	202	232	262	160
L.D.P.	203	217	228	237	245	251	258	264	294	324	354	215

The M/P proposes a water supply plan with a low growth rate of the unit water supply flow which is set at 176lpcd for H.D.P., 185lpcd for M.D.P. and 263lpcd for L.D.P. in 2005.

2) Method in the F/S

The F/S uses the results from the same kind of study conducted by the Lilongwe Water Board in 1989 in addition to the data in 1983 and predicts the future unit water supply flow assuming the growth of both data. The design sewage flow is calculated by determining the discharge rate of water into a sewerage system (water volume excluding those for sprinkling, car washing, etc. which don't enter into sewers) by area based on the water supply volume and multiplying the water supply volume by them. As for H.D.P., as the value of 1989 drops from that of 1983, the unit design water supply flow is set to increase 2lpcd every year since 1989. Table 4.5 shows the values in the F/S.

Table 4.5 Unit Design Sewage Flow Estimated in the F/S

(Unit: lpcd)

Fiscal Year	Water Supply Volume					Sewage Flow	
	1983 Act.	1989 Act.	1983-1989 Ave. Growth Rate	2000 Est.	2005 Est.	Sewage/Water Supply	2005 Est.
H.D.P.	126	110	-2.7 l/yr	130	140	0.90	125
M.D.P.	128	145	2.8 l/yr	175	190	0.80	150
L.D.P.	203	220	2.8 l/yr	250	270	0.75	200

3) Latest Data

According to the latest data on the water supply performance since

1989 collected during the Basic Design Study, the water supply volume and number of connections has been steadily increased, but, when converting the per capita water supply volume, it does not show such a growth as that in the M/P and is considered that the values in the F/S are reasonable (see Table 4.6 and Figure 4.4). The values of 1986 in the M/P is close to those in the F/S.

Table 4.6 Actual Unit Water Supply Volume

	Fiscal Year		1989	1990	1991
	No. of Connections	(nos.)	7,447	8,326	9,203
H.	Per Connection Population	(nos.)	6.1	6.1	6.1
D.	Service Population	(prs.)	45,436	50,789	56,138
P.	Water Supply Volume	(m^3/day)	4,998	5,725	6,310
	Unit Water Supply Volume	(lpcd)	110	113	112
	No. of Connections	(nos.)	1,489	1,526	1,614
M.	Per Connection Population	(nos.)	13.3	13.3	13.3
D.	Service Population	(prs.)	19,871	20,296	21,466
P.	Water Supply Volume	(m^3/day)	2,881	2,883	2,770
	Unit Water Supply Volume	(lpcd)	145	142	129
	No. of connections	(nos.)	1,460	1,513	1,575
L.	Per Connection Population	(nos.)	17.0	17.0	17.0
D.	Service Population	(prs.)	24,891	25,721	26,775
P.	Water Supply Volume	(m^3/day)	5,476	5,105	6,498
	Unit Water Supply Volume	(lpcd)	220	198	243

Note : Predicted the per capita population from 1989 data and assumed that there is no change in its value.

The difference between the water supply volume and the sewage flow is originated from the water for sprinkling, car washing, etc., does not enter into the sewers to add to the water supply volume, which is less than 10% even in Japan. In Malawi this is relatively high, especially since in the low-density permanent residential area with a big housing unit house plot area, the sprinkling is done as routine work, and this has a tendency to increase the water volume not entered into sanitary sewers.

As a result, the non-discharge rates of water which does not enter into sanitary sewers are considered appropriate at around 25% for L.D.P., 10% for H.D.P. because of a small unit house plot area, and 20% for M.D.P. intermediately.

Consequently, the unit design sewage flow shall be the same as

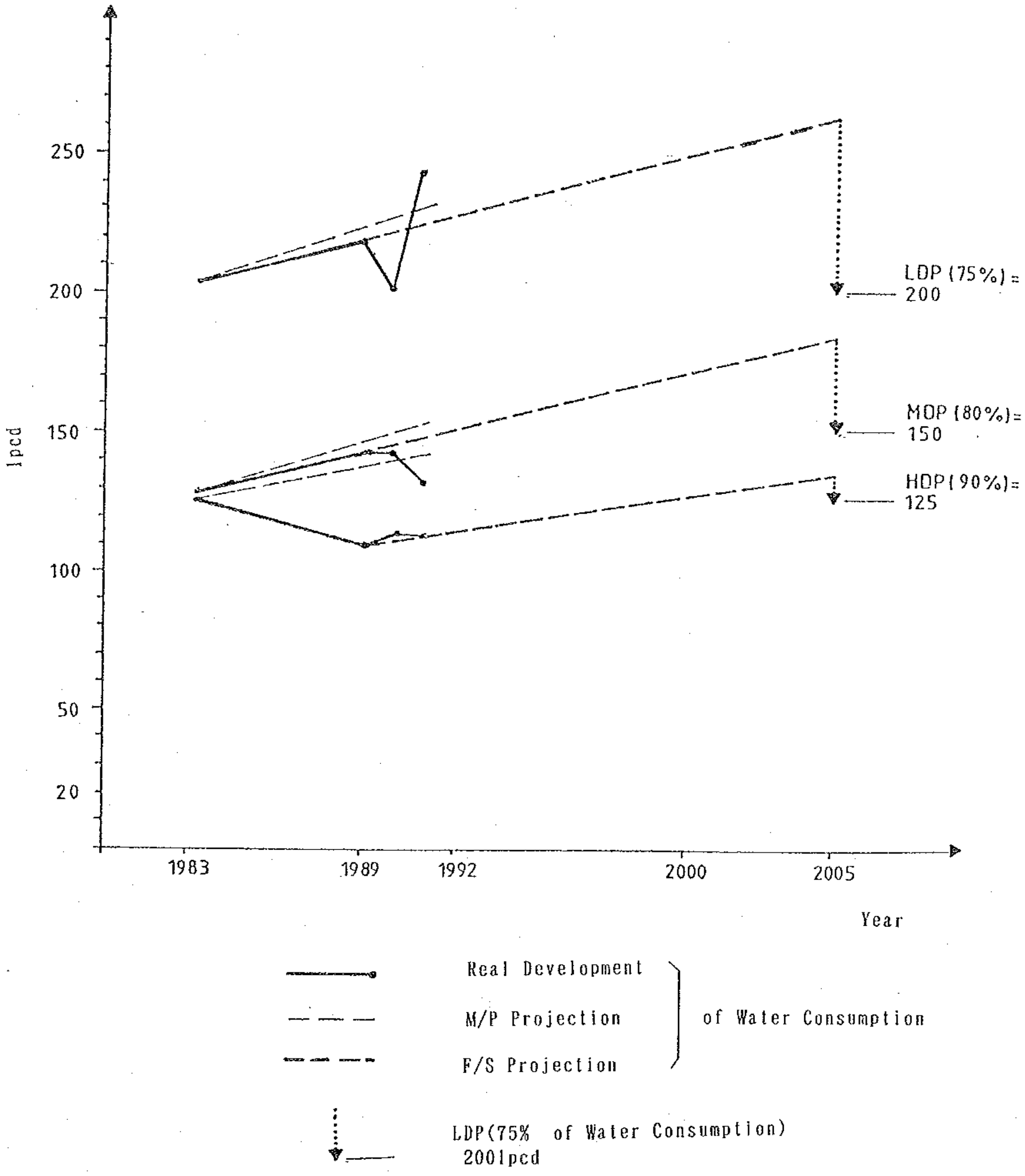


Figure 4.4 Projection of Per Capita Sewage Volume

those in the F/S. As for the staff house, the unit design sewage flow shall be the same as that for H.D.P.

(2) Unit Design Flow for Non-Domestic Group

Regarding the non-domestic sewage flow (the commercial and industrial wastewater is referred to as "COM" and the wastewater from governmental offices, schools and institutions as "INS" hereinafter), both the M/P and the F/S adopt the value of 5 to 20m^3/ha/day based on the actual performance for water supply, which shall be adopted in the Project.

(3) Design Sewage Flow

The design sewage flow is shown in Table 4.7. It should be noted that the unit design sewage flows are the same as those in 2005.

4.2.5 Water Quality of Influent and Effluent

(1) Design Water Quality of Influent

The design water quality shall be determined based on the values in the F/S and the result of the water quality analysis at the existing sewage treatment plants. In the F/S the per capita BOD load of 40g/day is adopted referring the World Bank Technical Report No.7 and the unit design sewage flow for H.D.P. is 125lpcd. Therefore, the water quality of influent is calculated by;

$$40/0.125 = 320g/m^3 = 320mg/l$$

While the results of the water quality analysis with big differences among the treatment plants are as shown in Table 4.8. Because of this big differences and lack of 24-hour continuous analysis, it is difficult to get definite figure regarding the design water quality for the planned treatment plant.

Table 4.7 Design Sewage Volume

(Unit : m³/day)

Year	2000							2005						
Area	COM	INS	STA	HDP	MDP	LDP	Total	COM	INS	STA	HDP	MDP	LDP	Total
1		104	260	800			1,164		110	270	800			1,180
2	350	667			390		1,407	390	720			400		1,510
3								160	60					220
4								1,400						1,400
5									80			20		100
6		100	20				120		120	20				140
8									60					60
11	250						250	280				150		430
13	300						300	400						400
16		100					100		120					120
18	14	84	16	886			1,000	16	92	20	1,850			1,978
19	420						420	520	100					620
20		150					150		180					180
28								800			20			820
30		470	40				510		600	170	490			1,260
33		600	60				660		700	210				910
36									120					120
37		30					30		50	30	160			240
40									170					170
44										360				360
47									150		1,480	860	920	3,410
Total	2.634	2,305	396	1,688	390		6,111	3,966	3,432	1,080	4,800	1,430	920	15,628

Table 4.8 Water Quality of Influent

Plant	BOD (mg/l)	SS (mg/l)
Area 2	145	270
Area 6	80	343
Area 13	102	163
Area 18A	288	480
Area 18B	260	260
Area 33	147	220

The BOD shall be 300mg/l with an allowance for the maximum value in the result of the water quality analysis in the Project. The coliform bacteria is assumed to be 2.0 x 10^7 MPN/100ml as a general value in sewage.

(2) Target Water Quality of Effluent

The water quality of effluent shall be the same as the limit established by the Malawi Water Resource Board as follows:

BOD	20mg/l
SS	30mg/l
Coli.	1 x 10^3 MPN/100ml

As for the coliform bacteria, the value recommended for irrigation use in the water quality standard of the World Bank Technical Report No.7 was adopted.

4.3 Selection of Treatment Method

In selecting the treatment method, the following are taken into account:

a) Quantity and quality of influent and their fluctuation
b) Condition of the receiving water body and type of water use
c) Scale of the sewage treatment plant
d) Available site and its environmental condition
e) Operational institution
f) Operation and maintenance costs

The treatment method has selected through the full study and review on the conditions mentioned above.

4.3.1 Selection of Alternatives

(1) Conditions concerned with the selection of the Treatment Method

1) Design Sewage Flow and Flow Fluctuation

From the review in 4.2, the design sewage flow is as shown in Table 4.9.

Table 4.9 Design Sewage Flow

(unit:m^3/day)

Particular	Overall Plan	Project
Design Daily Average Sewage Flow	15,600	6,100
Design Hourly Maximum Sewage Flow	35,880	14,030

According to the data actually measured at the existing sewage treatment plants, the flow fluctuation is as shown in Table 4.10:

Table 4.10 Flow Fluctuation Rate of Influent at the Plants

Plant Name		Measured Flow	Minimum Flow	Maximum Flow	Fluctuation rate to Daily Ave. Flow
Area	2	230.4 m^3/d	1.41 l/S	3.88 l/S	52.8 ~ 145.4 %
	13	521.5	4.17	10.58	69.0 ~ 174.9
	18A	58.3	0.08	1.73	12.4 ~ 256.9
	18B	736.5	1.11	22.50	13.0 ~ 264.0
	33	471.6	2.90	9.10	53.1 ~ 166.7
	(53)	(132.8)	(0.00)	(2.78)	(0.0 ~ 180.9)
Total (Excl. Area 53)		2,018.3	9.67	47.77	41.4 ~ 204.5

As the treatment plant to be constructed in the Project is to integrate the existing plants in some Areas, the flow fluctuation is expected to be alleviated by 75 to 200%, however, the rate of peak flow to the daily average flow shall be set at 2.3 as well as that of the trunk sewer plan for safety reasons.

2) Water Quality of Influent

From the review in Section 4.2, the water quality of influent is assumed as follows:

BOD5	300mg/l
SS	350mg/l
Coliform Bacteria	2.0×10^7 MPN/100 ml

3) Location and Natural Condition

- The proposed treatment plant is located on national land outside Lilongwe along the Lilongwe River and is currently used for agriculture.
- There is a hamlet west of the proposed site.
- The receiving water body is the Lilongwe River with plenty of flow even during the dry season and has a big fluctuation in water level between the dry and wet seasons.
- The topography has a gentle slope of approximately 6.5 %.
- The wet season is from November to April and almost of the annual rainfall is concentrated in this period. As for the temperature, rainfall, etc. refer to Subsection 2.2.1.

4) Target Water Quality of Effluent

The target water quality of effluent shall be as follows, taking into consideration the effluent standard of the Water Resources Board and the type of water use in the particular river:

BOD5	20mg/l
SS	30mg/l
Coliform Bacteria	1.0×10^3 MPN/100 ml

The limit of the coliform bacteria is taken from the value recommended for irrigation use of the effluent in the water quality standard of the World Bank Technical Paper No.7.

5) Economical Conditions and Construction Material

- The financial conditions of the Lilongwe City council are tight.
- The power supply conditions are good.
- Although cement is made in Malawi, other major secondary products will depend on import.

6) Operational Conditions of Existing Treatment Plants

There are 11 treatment plants in the city (see Subsection 2.4) but these are small with capacities of 200 to 1,900m^3/day. The breakdown of these treatment plants on the treatment plant and capacity is shown in Table 4.11.

Table 4.11 Number of Existing Treatment Plants in the City by Treatment Method and Capacity (1993)

Treatment Plant Capacity (m^3/day)	<500	500-1000	1000-2000	Unknown	Total
Extended Aeration Process	2	-	-	1	3
Oxidation Ditch Process	-	-	2	1	3
Stabilization Pond Process	2	1	1	1	5
Total	4	1	3	3	11

The operation and maintenance of the facilities is undertaken by the City Council or the entity who has installed the facilities. Some of treatment plants have already stopped operating. In consideration of the operational conditions, the operators have been worried about the operation and control of the equipment, and about the allowances for difficulties that are possible in using the extended aeration and oxidation ditch processes, which need some equipment. However, the stabilization pond process with little equipment has been operated in the relatively good conditions.

7) Others

The City Council hopes to adopt an easily operated treatment method which requires little equipment.

(2) Basic Policy for Treatment Process Selection

In selecting the treatment process for the Project, the following have been taken account of in consideration of the conditions in the item (1) above.

- The treatment process shall have as little power consumption and maintenance cost requirements as possible from the economical viewpoint.
- As the construction materials depend on import, such requirements shall be kept to a minimum.
- The treatment process should be easily operated and maintained with little requirement for high technology.
- The target water quality of effluent shall be as for high-quality treatment.
- The treatment process should be easily upgrade if the quality of effluent deteriorates.

(3) Selection of Alternatives

There are many treatment processes developed and used which are categorized as shown in Table 4.12. Out of these treatment process, the following three have been further studied as alternatives in accordance with the basic policy in the item (2) above.

- stabilization pond process
- aerated lagoon process
- oxidation ditch process

Table 4.12 Sewage Treatment Processes and Their Treatment Level

Categorization of Treatment Processes			Treatment Level: Middle	Treatment Level: High
Activated Sludge Process	Conventional Activated Sludge Process			o
	Modified Activated Sludge Process			
		Step Aeration Process		o
		Contact Stabilization Process		o
		Extended Aeration Process		o
		Modified Aeration Process	o	
		High-rate Aeration Process	o	
		Oxidation Ditch Process		o
		Pure-oxygen Process		o
		Complete Mixing Process		o
		Tapered Aeration Process		o
Fixed Membrane Process	Conventional Trickling Filter Process			o
	High-rate Trickling Filter Process		o	
	Rotating Bio-disc Process			o
Oxidation Pond Process	Stabilization Pond Process		o	o
		Anaerobic Pond		
		Facultative Pond		
		Aerobic Pond		
		Maturation Pond		
	Aerated Lagoon Process			
		Aerobic Lagoon	o	o
		Facultative Lagoon	o	o

4.3.2 Study on Alternative Comparison

(1) Study Conditions

In addition to the conditions mentioned above, the following conditions have been also considered in the study on alternative comparison:

a) The treatment plant shall be composed of four trains on the assumption that it will be constructed by phase.

b) The effluent from the septage lagoon shall enter into the reaction tank with a incoming BOD load of 345kg-BOD_5/day.

c) As for chlorination facilities, the chlorine chemicals for disinfection is difficult to be obtained in the Project.

(2) Outline of Alternatives

The flow diagrams and outlines of major facilities of alternatives are indicated in Table 4.13.

1) Stabilization Pond Process (SP)

- The anaerobic pond is installed to reduce the volume requirement for the facultative pond.
- The maturation pond with one train composed of three ponds is installed to upgrade the disinfection effect and the water quality of effluent.
- The sludge piled in the pond shall be naturally dried after draining the sewage once every about five years to be carried out for disposal.
- No requirement for electric-driven equipment.

2) Aerated Lagoon Process (AL)

- The process shall be composed of the aerobic lagoon and facultative lagoon to reduce the power requirement and to upgrade the treatment effect.
- The disinfection shall be done in the maturation pond likewise in the SP.
- The sludge piled in the pond shall be naturally dried after draining the sewage once every several years to be carried out for disposal likewise in the SP.
- The only electric-driven equipment is the aerator but there are several units of aerator.

3) Oxidation Ditch Process (OD)

- Likewise in the SP, the disinfection shall be attained in the maturation pond.
- The sludge handling method shall be the natural drying method following the thickening without dewatering to decrease the number of equipment needed and to reduce the maintenance cost.
- The number of units and power requirement are biggest in thee processes.

Table 4.13 Outline of Facilities for Each Alternative (1/4)

<table>
<tr><th>Alternatives
Items</th><th>Stabilization Pond Method
(SP)</th><th>Aerated Lagoon Method
(AL)</th><th>Oxidation Ditch Method
(OD)</th><th>Remarks</th></tr>
<tr><td>(1) Design Criteria</td><td>・Design Daily Average Qdmean=15,600m³/d
・Design Hourly Maximum Qhrmax=35,880m³/d
・Design Water Quality
<table><tr><th></th><th>Influ-ent</th><th>Efflu-ent</th><th>Removal Rate (%)</th></tr><tr><td>BOD(mg/l)</td><td>300</td><td>20</td><td>93.3</td></tr><tr><td>SS (mg/l)</td><td>350</td><td>30</td><td>91.4</td></tr><tr><td>FC(MPN/100ml)</td><td>2×10⁷</td><td>1×10³</td><td>—</td></tr></table>・Septic Tank Sludge Lagoon BOD Load
= 345kgBOD/d</td><td>Same to left</td><td>Same to left</td><td>・Design Sewage Rate
Qdmean= 6,100m³/d
Qhmax =14,030m³/d

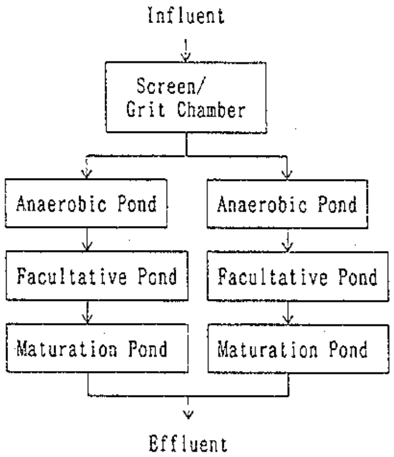
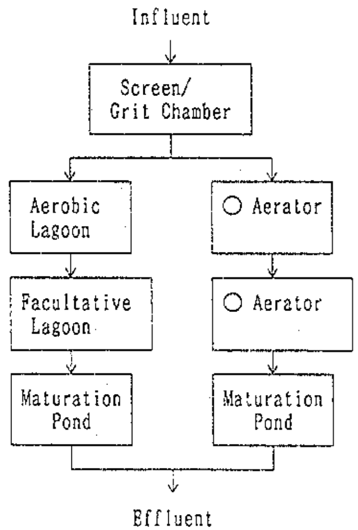
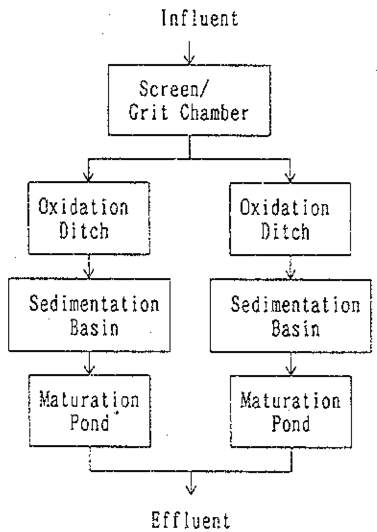
・Effluent water quality shall clear the average of target water quality</td></tr>
<tr><td>(2) Flow Chart</td><td>
</td><td>
</td><td>
</td><td>・Whole plan consists of 4 systems</td></tr>
</table>

Table 4.13 Outline of Facilities for Each Alternative (2/4)

Alternatives Items	Stabilization Pond Method (SP)	Aerated Lagoon Method (AL)	Oxidation Ditch Method (OD)	Remarks
(3) Outline of Major Facilities	①Grit Chamber Type :Parallel flow, Rectangular Tank Dimension:1.3m W×9.0m L×0.6m D×2 units Area Load:1,800㎥/㎡・day	①Grit Chamber Same to left	①Grit Chamber Same to left	
	②Anaerobic Pond Type : Embanked Rectangular Pond Dimension:0.3 ha×4.0m D×4 units Capacity :34,600㎥ Retention Days:2.2 days BOD Volumetric Load:135gBOD₅/ ㎥・day	②Aerobic Aerated Lagoon Type :Embanked Rectangular Pond Dimension:0.28ha×3.0m D×2 units 0.24ha×3.0m D×2 units Capacity :31,200㎥ Retention Days:2.0 days Required Oxygene:5,025×1.5 =7,538 kgO_2/day Required Load : a. Calculated from Required Oxygene P=7,538×1/24×1/2.0=157kW b. Required Agitation Load P=31,200×6W/㎥×1/1000=187kW	②Oxidation Ditch Type :Circulation Channel Dimension:6.0m W×230m L×2.5m D×4 units 6.0m W×189m L×2.5m D×4 units BOD・SS Load:0.05kgBOD/kgSS・日 BOD Volumetric Load:0.2kgBOD/㎥・日 Capacity :25,140 ㎥ Retention Time:39 hours Required Load :5,025×2.0 ×1.3 ×1/24× 1/2.0 =272kW	・Influent BOD Load Whole Plan・ 5,600×300 $\times10^{-3}$+ 345=5,025kgBOD_5/D Basic Design 6,100×300 $\times10^{-3}$+ 240=2,070kgBOD_5/D ・Aerator Load Efficiency =2.0kgO_2/kW
	③Facultative Pond Type :Embanked Rectangular Pond Dimension :1.95ha ×1.5m D×4 units 1.55ha ×1.5m D×4 units Capacity :210,000 ㎥ Retention Days:13.5 日 BOD Area Load :192kgBOD₅/ha ・day	③Facultative Aerated Lagoon Type :Embanked Rectangular Pond Dimension :0.14ha ×3.0m D× 2 units/series×2 series 0.12ha ×3.0m D× 2 units/series×2 series Capacity :31,200 ㎥ Retention Days:1 day/1 unit × 2 units/system Required Load : P=31,200×1W/㎥×1/1000 =31kW	③Grit Chamber Type : Circular Tank with sludge collector Dimension : 13.4m φ×3.0m D×4 units 12.4m φ×3.0m D×4 units Capacity : 3,140㎥ Retention Hours : 4.8 hours Area Load : 15㎥/㎡・day	
	④Maturation Pond Type :Embanked Rectangular Pond Dimension 0.84ha×1.5m D× 3 units/series ×2 series 0.72ha×1.5m D× 3 units/series ×2 series Retention Days:3 days/unit × 3 units/series	④Maturation Pond Same to left	④Maturation Pond Same to left	

Table 4.13 Outline of Facilities for Each Alternative (3/4)

Alternatives / Items	Stabilization Pond Method (SP)	Aerated Lagoon Method (AL)	Oxidation Ditch Method (OD)	Remarks
			⑤Sludge Thickening Tank Solids in excess sludge $15,600 \times (350-30) \times 0.7 \times 10^{-3} = 3,495$ kgDS/D Excess Sludge : wt=99.2% $3,495 \times 100/(100-99.2) \times 10^{-3}$ $= 437\ m^3/day$ Type : Circular Tank with sludge collector Dimension : 7.5mφ×3.5m D×2 units Capacity : 309 m^3 Detension Hours : 17 hours Dry Solid Load : 40kgDS/m^2・day ⑥Sludge Drying Bed Thickened Sludge : $3,495 \times 100/(100-97) \times 10^{-3} = 117\ m^3$ Type : Drying Bed Dimension : 17m W ×34m ×20 units Drying Days : 20 days Depth : 0.2m	
(4)Total Detension Time	Anaerobic Pond 2.2days Facultative Pond 13.5days Maturation Pond 3 ×3 = 9.0days Total 24.7days	Aerobic Aerated Lagoon 2.2days Facultative Aerated Lagoon 1× 2= 2.0days Maturation Pond 3× 3= 9.0days Total 13 days	Oxidation Ditch 39 hours Sedimentation Tank 4.8hours Maturation Pond 3 ×3 = 9.0days Total (9.0+1.8) = 10.8days	

Table 4.13 Outline of Facilities for Each Alternative (4/4)

Alternatives / Items	Stabilization Pond Method (SP)	Aerated Lagoon Method (AL)	Oxidation Ditch Method (OD)	Remarks
(5)Required Site ①Required Water Surface Area	Anaerobic Pond 1.2 ha Facultative Pond 14.0 ha Maturation Pond 9.36ha Total 24.56ha	Aerobic Aerated Lagoon 1.04ha Facultative Aerated Lagoon 1.04ha Maturation Pond 9.36ha Total 11.44ha	Oxidation Ditch 10,056m² Sedimentation Tank 1,047m² Maturation Pond 9.36ha Sludge Thickening Tank 88m² Sludge Drying Bed 11,560m² Total 9.36ha+22,751m²=11.64ha	
②Required Site Area	Approximately 50 ha	Approximately 23 ha	Approximately 24 ha	
(6)Required Load		Aerator(Aerobic) 15kW×16 units=240kW Aerator(Facultative) 2.2kW×16 units=35.2kW Total 275.2kW	Aerator 22kW ×16units = 352kW Sludge collector 1.5kW× 8units = 12kwW (Sedimentation Tank) Return Sludge Pump 3.7kW×16units = 59.2kW Surplus Sludge Pump 2.2kW× 8units = 17.6kW Sludge collector 0.75kW× 2units = 1.5kW (Sludge Thickening Tank) Sludge ThickeningTank 2.2kW ×2units = 4.9kW Total 446.7kW	・Major equipment only

(3) Alternative Comparison

The results of alternative comparison by element, and the maintenance cost and area requirement are shown in Table 4.14 and 4.15, respectively.

1) Treatment Characteristics

Although each process has its own merits and demerits, the OD has the biggest benefit in the aspect of stability and reliability in treatment if the proper maintenance can be expected.

2) Operation and Control

Although all the processes are easy in operation and control, the AL requires more maintenance due to more aerators and the OD requires bio-mass control in addition to equipment control, therefore, the SP is considered best due to no requirement for equipment.

3) Maintenance Cost

The maintenance cost is cheapest in the SP due to no electric-driven equipment and fewer staff required.

4) Area Requirement

Both the AL and OD require relatively large site areas due to the addition of the maturation ponds, but all three processes can be laid out within the site.

(4) Decision of Treatment Process

From the result of the alternative comparison mentioned above, the stabilization pond process (SP) shall be adopted as the treatment process in the Project for the following reasons:

1) As the Project is an emergency improvement project, it is necessary to bring about a fully functional facility during the

Table 4.14 Comparison of Characteristics of Alternatives

Alternatives / Items	Stabilization Pond Method (SP)	Aerated Lagoon Method (AL)	Oxidation Ditch Method (OD)	Remarks
1) Treatment Characteristics ① BOD Removal Rate	· By combination of Anaerobic Pond + Facultative Pond + Maturation Pond, 94 ~95% of removal rate can be expected. *1	· By combination of Aerated Lagoon + Maturation Pond, 93 ~95% of removal rate can be expected. *1	· Target treatment water quality can be easily cleared by this high level method	*1 : Reffered from World Bank Technical Paper No.7, for the case that required pond capacity for influent load and air temperature can be ensured.
② Stability and Flexibility of Treatment	· Stable for load flactuations · Treatment efficiency is affected largely by climate condition, because its surface area is large.	· Stable for load flactuations · Treatment efficiency is affected largely by climate condition, because its surface area is large.	· Stable for load flactuations	
③ Sludge volume and nature	· Sludge volume is small and stable · Sludge treatment facilities are not needed	· Sludge volume is small and stable · Sludge treatment facilities are not needed	· Excess sludge at sedimentation tank must be treated by thickening tank and drying bed	
2) Opearation and Maintenance ① Laborer for O & M	Few	Few but larger than SP system	Largest in 3 methods	
② Technical Level	Low	Low	Level is high comparing with others	
③ Biochemical Management	No need Removal of water plant only	No need	Biochemical management is nacessary	
④ Maintenance Work	Few	Few but Nos of aerator is large	Many number of equipment and much maintenace work	
⑤ Operation of Equipments	None	Operation of aerators only	Every equipment should be operated properly	
3) Environmental Impact ① Odor	Odor at Anaerobic Pond	Few	Odor occurs at sludge drying bed	
② Injurious Insect	Mosquito	Mosquito	———	

Table 4.15 Comparison of Maintenance Cost and Required Land Area of Alternatives

Alternatives / Items	Stabilization Pond Method (SP)	Aerated Lagoon Method (AL)	Oxidation Ditch Method (OD)	Remarks
(1)Maintenance Cost 1)Electric charge a)Consumed Electricity	―――	3,158kWh/day = 1,152,670kWh/year	5,067kWh/day = 1,849,455kWh/year	
b)Electric charge	―――	1,152,670kWh/year × K0.044/kWh = K50,717/year	1,849,455kWh/year × K0.044/kWh = K81,376/year	ESCOM's Tarif(1992 Aug) was adopted for Electric charge K0.044/kWh
2)Labor Cost	Chief 1 × K31,000/year = 31,000 Technitian 1 × K21,000/year = 21,000 Operator 1 × K 7,200/year = 7,200 Total K59,200/year	Chief 1 × K31,000/year = 31,000 Technitian 1 × K21,000/year = 21,000 Operator 2 × K 7,200/year = 14,400 Total K66,400/year	Chief 1 × K31,000/year = 31,000 Technitian 2 × K21,000/year = 42,000 Operator 3 × K 7,200/year = 21,600 Total K94,600/year	
3)Repair Cost. Others	K 4,000/year	K20,000/year	K40,000/year	For minor repair and exchange of spare parts
4)O & M cost total Electric charge Labor cost Repair cost	 — K59,200 K 4,000	 K50,717 K66,400 K20,000	 K81,376 K94,600 K40,000	
Total	K63,200/year	K137,117/year	K215,976/year	
(2)Required Land Area (Approximately)	Approximately 50 ha	Approximately 23 ha	Approximately 24 ha	

initial operation. For this reason, a treatment process with which the operators have been familiar is favorable. In this context, the stabilization pond process has the advantage of the good performance at the existing treatment plant.

2) Under the present management system, priority should be given to as low a maintenance cost as possible.

3) Taking into account the fact that the operators have been worried about the expenses for repairing and replacing the equipment at the existing treatment plants, adopting the extended aeration process or oxidation ditch process, i.e. a treatment process with little or no equipment requirement is better.

4) In case of the stabilization pond process, there may be the unstable treatment efficiency caused by the seasonal fluctuation and the carry-over of the algae, however as described in Item i, the operators are familiar with this treatment process and they will not be experience any difficulties. If they do have a problem, the stabilization pond process can cope with it because of the provision of additional facilities such as aerators, filters, etc.

5) When the incoming flow increases or upgrading of the treatment system is required in the future, the stabilization pond process can cope due to the provision of additional facilities such as aerators, filters, etc.

6) There may be offensive odors emanating from the anaerobic ponds and septage lagoons in the stabilization pond process, it will be coped with by providing a landscaping around the ponds and by regularly removing the piled sludge.

4.4 Basic Design

4.4.1 Sewer Plan

(1) Routes of Trunk Sewers

The trunk sewers are composed of, No.1 from the existing Area 2 plant to the existing Area 33 plant, No. 2 from the existing Area 18 plant to No.1 near the existing Area 33 plant to join, and No.3 from the confluence of Nos. 1 and 2 to the proposed Kauma Sewage Treatment Plant. The routes for installation were selected from the following viewpoint reviewing the routes in the F/S.

a) The trunk sewers shall receive sanitary sewage by gravity from the area where the branch sewers will be provided.
b) Such slopes which do not need pumping midway on the routes of the trunk sewers and at the treatment plant shall be utilized.
c) The sewers shall be installed so as to have a shallow earth cover along the ground slope, and not be necessarily installed on the public roads.

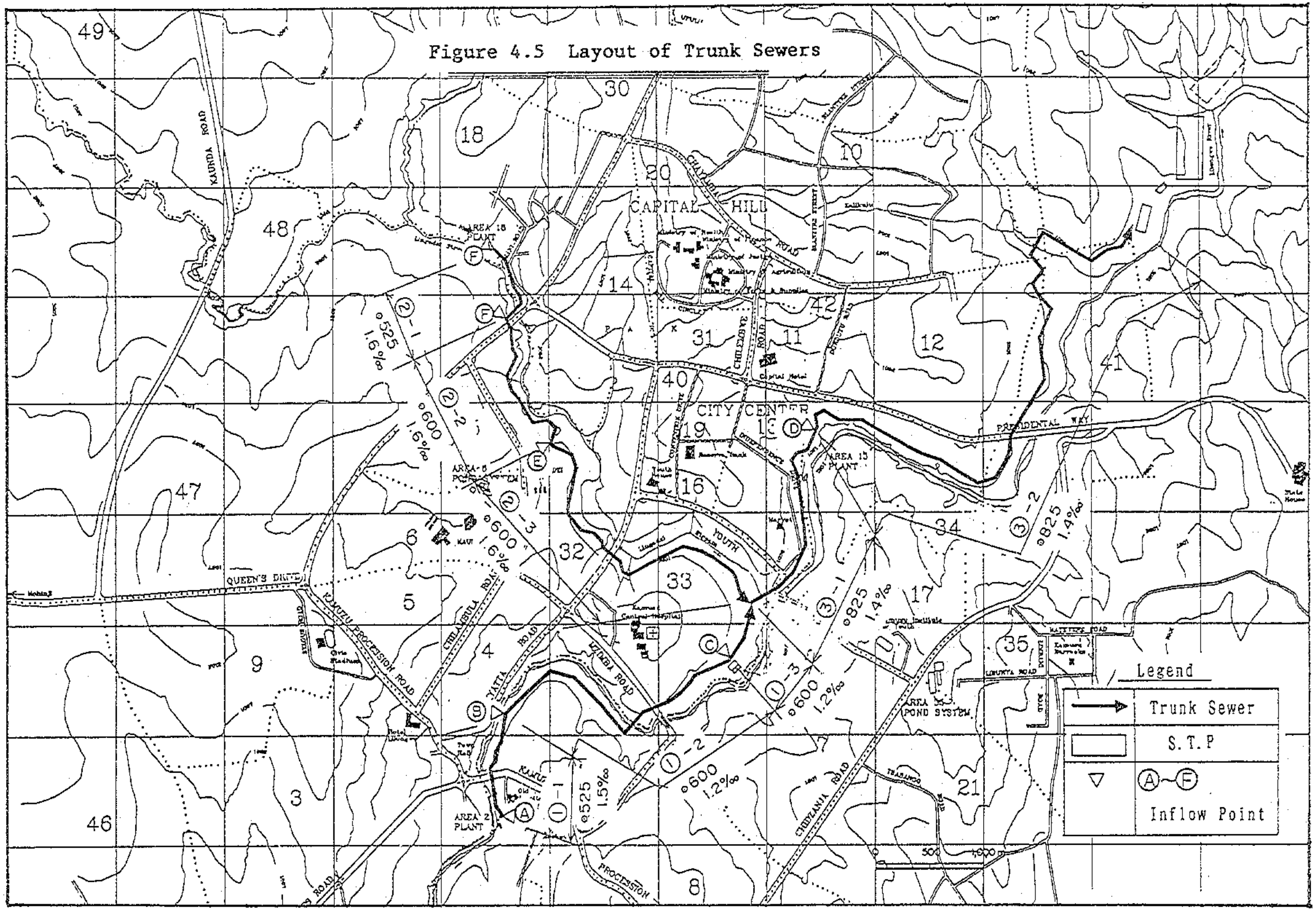
The possible routes were reviewed under the above conditions. The routes shown in the F/S are considered roughly feasible for the following reasons:

a) As both the Lingadzi and Lilongwe Rivers flow with a river bed slope of 0.1 to 0.2%, it is economical to install sewers in accordance with the ground slope along the rivers.
b) Even after taking into consideration the water level of the receiving water body of the effluent from the sewage treatment plant, no pump station is required in the case of the routes in the F/S.

The routes of the trunk sewers are shown in Figure 4.5. As the routes of the trunk sewers run through wasteland with thickly growing shrubs, a passable temporary road is necessary for the heavy construction equipment. For this reason, the shrubs along the route will be cut back to allow the sewers to be installed. It should be considered that this lane will be used as the maintenance road after sewer installation.

As for the exposed portion of the sewers, it will be ductile cast iron pipe fixed on a steel truss for a long crossing over the river and fixed at both ends on a concrete support in the case of a short crossing over a water course.

Figure 4.5 Layout of Trunk Sewers



As the earth cover of the trunk sewers will be shallow, sheet piling will not be necessary and an open cut with a slope will be enough for installation. Heavy equipment shall be used for pipe installation due to the need to handle heavy materials as well as for excavation, however, the construction method in the nature sanctuary shall be determined at the time of detailed design based on the result of the negotiations with the nature sanctuary supervisor.

(2) Location of Branch Sewer

It is decided to install the routes of branch sewers in sewer network as shallow as possible in accordance with the ground slope as shown in Appendix 7. The branch sewer is generally installed under public roads due to the necessity of sewage collection from each house and for maintenance activities such as inspection, repair and so on, but in the Project the installation of sewers outside the public roads is also considered from an economical standpoint.

When installing the sewers on the public roads, they will be installed at both ends in the case of heavy traffic roads or wide roads and in the center for roads other than the above.

As for the aqueduct, the same idea as that for trunk sewers is applied. Most branch sewers can be installed without sheet piling due to their shallow earth cover.

(3) Design Criteria for Sewers

1) Design Sewage Flow

The design sewage flow shall be the hourly maximum flow for sewer designing. The peak factor to the daily average flow shall be in conformity with the rate of the hourly maximum flow to the daily average flow in water supply. The M/P recommends to use a peak factor of 2.5 to 3.0 based on the actual performance, while the F/S describes to use a value of 2.3 for trunk sewers and 2.5 to 3.0 for branch sewers. In the Project, the following values shall be used referring the values in the F/S.

trunk sewer	2.3
branch sewer	3.0

2) Materials of Pipes

The sewer pipe shall be the asbestos cement pipe (ACP) for both trunk and branch sewers, because of its good prior performance as a water supply pipe in Lilongwe. It has stable material quality and is relatively easy to obtain. The Malawi side has strongly requested ACP be used, taking into consideration future maintenance requirements, since the Malawi side is familiar with the handling of ACP.

However, rigid ductile cast iron pipe (DCIP) shall be used for the portion with a high risk of damage, such as the exposed pipe of the aqueduct and the like. Polyvinyl chloride pipe (PVC) shall be used for house sewers from the branch sewers to the boundary of the house lot because of its ease of installation.

According to interviews with local contractors, asbestos cement pipe imported from the neighboring countries is in conformity with the British Standard (BS). Some pipe sizes adopted in the F/S are out of BS. For this reason, the pipe sizes to be used in the Project shall be as follows in accordance with BS.

Pipe Size (mm): 100, 150, 200, 250, 300, 375, 450, 525, 600, 825
(Note: The sizes of 350, 400, 500 and 800mm are out of BS.)

3) Minimum Pipe Size

The minimum pipe size shall be 150mm for trunk and branch sewers and 100mm for house sewers.

4) Average Velocity Formula

In Japan, the Manning's and Kutter's Formulas have been used to calculate the flow capacity of sewers but recently the former is mostly used. Therefore, the following Manning's Formula shall be used in the Project:

$$V = (1/n)\cdot R^{2/3}\cdot I^{1/2}$$

where, V: velocity (m/s)
n: coefficient of roughness
R: hydraulic radius (m) (=A/P)
A: area of water cross section (m^2)
P: length of wetted perimeter (m)
I: gradient (-)

5) Velocity and Minimum Slope

The Japanese design criteria recommends to design the sanitary sewer with a velocity range of 0.6 to 3.0m/s, while the F/S adopts a velocity range of 0.5 to 3.0m/s which shall be applied to the Project. The minimum slope of sewers shall be 0.1% (1m/1km) in consideration of the accuracy in installation.

6) Allowance for Sewers

In the design of sewers, the allowance for the pipe flow capacity is taken into account to cope with the infiltration of groundwater, storm water, etc., which is some 100% for small sewers with a size of not more than φ600mm and 50, 60 and 100% for other a sewers. The F/S proposes to keep the water depth ratio to the pipe size at the time of design flow by 70% for trunk sewers and less than 50% for sewer network. In the Project, the minimum allowance shall be 30% for trunk sewers and 100% for sewer network in water depth ratio in conformity with those in the F/S.

7) Minimum Earth Cover

The earth cover shall be approximately 1.5m or more for sewers installed under the roads with vehicle traffic and more than 1.0m for sewers other than the above. The sewers which cannot utilize the minimum earth cover shall be protected by concrete encasements which also shall be applied to sewers crossing roads with a heavy traffic volume.

8) Pipe Joint

The pipes shall be connected with a method so that two pipes will meet at the pipe crests and a step at the manhole shall be allowed.

9) Maximum Interval between Manholes

The maximum interval between manholes is listed below in accordance with those in the F/S, taking account of the possibility of pipe clogging and the capacity of a pipe cleaning devices.

Pipe Size	Interval
less than 500mm	60m
more than 600mm	80m

(4) Review of Trunk Sewer Size

Based on the sewage flow generated in Section 4.2, the sizes of trunk sewers decided in the F/S were reviewed. The incoming sewage flow from each Area to the trunk sewers and the incoming points are indicated in Table 4.16 and Figure 4.5 meeting those in the F/S. Flow calculation of trunk sewers is presented in Table 4.17.

Table 4.16 Sewage Flow at different Inflow Point on Trunk Sewers

(Unit: m^3/day)

Location	Area/Category	Sewage Flow (Daily Avg.)	Location	Area/Category	Sewage Flow (Daily Avg.)
A	Area 1	1,180	D (cont'd)	19	620
	2 (COM)	390		20	180
	2 (INS)	720		40	170
	8	60		Subtotal	1,920
	36	120	E	Area 5	100
	37	240		6	140
	Subtotal	2,710		47 (part)	680
B	Area 2 (MDP)	400		Subtotal	920
	3	220	F Upstream	Area 18	1,978
	4	1,400		28	820
	Subtotal	2,020		30	1,260
C	Area 33	910		Subtotal	4,058
	Subtotal	910	F Downstrm	Area 47 (part)	2,730
D	Area 11	430		Subtotal	2,730
	13	400	Total		15,268
	16	120			

Table 4.17 Flow Calculation of Trunk Sewers

Sewer No.	Inflow point	Sewage volume in upperstream (m^3/day)	Total Sewage Volume (m^3/day)	Peak Rate	Design Sewage volume m^3/sec	Dimension of Trank Sewer						
						Diameter (mm)	Slope (1/1000)	Length (m)	Velocity (m/sec)	Flow rate (m^3/day)	Flow rate ratio	Depth ratio
①-1	A	2,710	2,710	2.3	0.072	525	1.5	950	0.745	0.146	49 %	49 %
①-2	B	2,020	4,730	2.3	0.126	600	1.2	2,790	0.752	0.213	59	55
①-3	C	910	5,640	2.3	0.150	600	1.2	480	0.752	0.213	70	62
	to③-1											
②-1	F	4,058	4,058	2.3	0.108	525	1.6	800	0.769	0.151	72	63
②-2	F	2,730	6,788	2.3	0.181	600	1.6	1,480	0.869	0.246	74	64
②-3	E	920	7,708	2.3	0.205	600	1.6	3,130	0.869	0.246	83	69
	to③-1											
③-1			13,348	2.3	0.355	825	1.4	2,060	0.984	0.495	72	63
②-2	D	1.920	15,268	2.3	0.406	825	1.4	5.810	0.984	0.495	82	69
	to STP											
STP	Area44	360	15,628	2.3	0.416	Directly inflows in Kauma S.T.P.						

(5) Flow Calculation of Sewer Network

From the result of flow calculation for sewer network, the length of branch sewers at different Area by diameter is shown in Table 4.18.

Table 4.18 Length of Branch Sewer

Area		1	2	6 C.S.*	Total
ACP	150	10,680	8,728		19,408
	200	2,478	570		3,048
	250	165		1,200	1,365
	300	1,100			1,100
	375	250			250
	450	150			150
ACP Total		14,823	9,298	1,200	25,321
DCIP	150		10		10
	300	10			10
DCIP Total		10	10		20
Grand Total		14,833	9,398	1,200	25,341

* connection sewer

(6) Summary of Sewer Plan

Plan of sewers consists of trunk sewers and sewer network is summarized as shown in Table 4.19.

Table 4.19 Outline of Sewers

Name of Facility	No. of	Outlines	Design Criteria
Trunk Sewers			
No.1 Trunk Sewer	1	φ500-600mm x L 4.2km ACP (partly DCIP) w/ 1 aqueduct	Manning's Formula n :0.013 Vmax:3.0m/s Vmin:0.5m/s
No.2 Trunk Sewer	1	φ500-600mm x L 5,4km ACP (partly DCIP) w/ 1 aqueduct	
No.3 Trunk Sewer	1	φ800mm x L 7.9km ACP (partly DCIP) w/ 2 aqueducts	

Sewer Network			
Area 1	144 (ha)	ϕ150-450mm x L 14.8km ACP (partly DCIP) including service connections	Manning's Formula n :0.013 Vmax:3.0m/s Vmin:0.5m/s
Area 2	140 (ha)	ϕ150-200mm x L 9.3km ACP including service connections	
Area 6 (Connection Pipe)	-	ϕ250mm x L 1.2km ACP	

An administrative building includes the electrical equipment and garage.

n : coefficient of roughness
V : velocity

RC : reinforced concrete
ACP : asbestos cement pipe
DCIP : ductile cast iron pipe

4.4.2 Sewage Treatment Plan

(1) Decision of Facility Size

Based on a capacity calculation using the fundamentals for designing the wastewater stabilization process, the size of each facility in the sewage treatment plant is decided (see Appendix 6). The sizes of major facilities to be constructed in the Project are shown in Table 4.20 .

Table 4.20 Outline of Treatment Facilities

Name of Facility	No. of Units	Structure/Specifications	Design Fundamentals
Grit Chamber	1	RC 2 channels (1 channel standby) W 1.2m x L 8.5m x WD 0.6m	O.F.R. 1,800$m^3/m^2/d$
Screen	2	manually-operated, flat steel bar bar W 75mm x T 9mm X S 30mm pitch screen W 1.2m	
Flow Meter	L.S.	RC, Parshall Flume W 1.7m x L 3.7m x WD 0.8m	
Distribution Chamber - 1	1	RC, w/ 3 gates W 6.0m x L 1.5m x H 3.5m	
Anaerobic Pond	3	earth embankment, rectangular 1 standby W 54/30m x L 62/38m x WD 4m (W.L./Bottom)	BOD Load 160$g/m^3/d$ D.T. >2days

Septage Lagoon	2	earth embankment, rectangular W 28.2/10.2m x L 42.2/24.2m x WD 3m	BOD Load $200g/m^3/d$ D.T. >20days
Distribution Chamber - 2	1	RC, w/ 2 gates W 5.95m x L 4.1m x H 3.6m	
Distribution Chamber - 3	2	RC, w/ 2 gates W 2.0m x L 1.5m x H 2.5m	
Facultative Pond	4	earth embankment, rectangular 2 trains (2 units/train) W 105/96m x L 144/135m x WD 1.5m	BOD Load $192g/m^3/d$
Maturation Pond	6	earth embankment, rectangular 2 trains, (3 units/train) W 72/63m x L 95/86m x WD 1.5m	D.T. 3days/unit
Outflow Pipe	2	ACP ϕ400mm	
In-plant Piping	L.S.	ACP ϕ200 - 400 mm	
Administrative Bldg.	L.S.	RC, one-story 9.0m x 12.0m	
Garage	L.S.	RC, one-story 7.0m x 12.0m	
Electrical Equip.	L.S.	primary:11kV, secondary:380V	
In-plant Road	L.S.	gravel-paved, W 5m (brick masonry around ponds)	
Channel Crossing	L.S.	box culvert W 2.5m x H 1.5m x 2 lines	
Bypass Outflow Pipe	1	ACP, ϕ600mm	

An administrative building includes the electrical equipment and garage.

O.F.R.	: overflow rate	W	: inner width
D.T.	: detention time	L	: inner length
RC	: reinforced concrete	T	: thickness
ACP	: asbestos cement pipe	S	: spacing
DCIP	: ductile cast iron pipe	WD	: effective water depth

(2) Layout Plan

The proposed site for the sewage treatment plant is on the left bank of the Lilongwe River about 7km downstream of its confluence with the Lingadzi River. Terrain of the site is sloped toward the Lilongwe River. Although the site boundary is not clearly defined, it is necessary to situate the sewage treatment plant along the river so as not to increase the earth work volume during the construction work and to utilize the land effectively. Also, it is necessary to keep the proper difference in water level between the facilities from the inlet to the outlet by gravity, hence, the facilities are arranged to use the ground slope as much as possible within the site as shown in Appendix 7.

(3) Study on Water Level Plan

1) Study on Water Level of the Receiving Water Body

Due to no data on the water level at the discharging point of the receiving water body, the design high water level (H.W.L.) is set as +1,007m above sea level based on the topographic survey and the hearings in the field.

2) Decision of Water Level for Each Facility

The water level of each sewage treatment facility such as a grit chamber, anaerobic pond, facultative pond and maturation pond shall be set between the water level in the inflow pipe to the plant and H.W.L. of +1,007m of the receiving water body so as to flow by gravity even considering the head loss between facilities.

3) Decision of Design Ground Elevation

The design ground elevation shall be 50cm higher that the water level of each facility.

(4) Environmental Measures

In the wastewater stabilization pond process, odor from the anaerobic pond is inevitable. In addition to this, offensive odor is expected to be generated at the septic tank sludge lagoon in the Project. However, it is not practical to provide equipment for odor control. It is essential to reduce the occurrence of the offensive odor as much as possible through proper removal of the accumulated sludge and proper maintenance of the ponds. As there is a community in a surrounding area, landscaping shall be done around the ponds to help alleviate the odor and to improve the appearance of the sewage treatment plant.

(5) Provision of Fence, Road and Drainage

As the west side of the proposed plant will be a long slope, a fence shall be installed at the top of the slope as a safety measure but not provided on the river side, which has an elevation of less than H.W.L. As for the lane between ponds, brick shall be laid in consideration of appearances and for the prevention of weed growth. The storm water from the hilly side of the plant site shall be collected with gutters installed at the top, middle and bottom of the slope to be drained into the north-to-south marsh.

A box culvert shall be installed at the place where the road going from the anaerobic pond to the facultative pond will cross the valley to drain the storm water flowing in the valley to the Lilongwe River.

(6) Administrative Building

The administrative building shall be of reinforced concrete columns with brick walls. The size of the building will be decided based on the number of operators stationed there and the contents of the water quality analysis laboratory. Adjoining the administrative building, a garage will be constructed for vehicles such as a high-pressure cleaning car, a sludge vacuum car, a dump truck for sludge transportation, a small truck for sewer cleaning and for a boat for pond cleaning to be supplied in the Project.

(7) Construction Plan

1) Soil Condition

From the result of the field survey, test excavation, boring test in the F/S, etc., the soil was found to consists of about 3m thick reddish black silty normal soil from the ground surface, about 1.5m thick weathered rock which is possible to be excavated manually and hard rock at deeper than the above which is difficult to be excavated with the ordinary mechanical excavation. The silty sand near the surface is high self-supporting in nature which can be excavated perpendicular by 3 to 4m according to the results of the test excavation. The coefficient of permeability has an order of 10^{-4} cm/sec. from the result of the soil examination in the F/S and is judged sufficient. According to the F/S, the groundwater has a water level of 7m from the ground surface which goes down toward the river along the ground slope. Although during the wet season, a water table derived from the water level in the river which goes down westward along the ground slope is expected under the proposed plant site, the existence of groundwater has to been confirmed in the test excavation with about a 4m-deep excavation of the upper weathered rock layer due to the fact that the study team made its observation during the dry season.

2) Excavation and Embankment Methods

Open-cut excavation using equipment will be possible at the proposed plant site, but explosives will have to be used for the hard rocks. No protection will be provided for the sloping surface. The slope will be 1:0.5 for hard rocks and 1:2 for silty surface soil. The excavated soil will be used for an embankment with a slope of 1:2 which will be compacted sufficiently.

3) Structural Material

The grit chamber, splitter box, the inflow and outflow portion of each pond shall be of reinforced concrete. Each pond will be excavated manually and then water-proofed with clay. The slope inside of the ponds will be 1:3. The concrete lining will be provided to the portion of each pond above 1.0m below the water level.

(8) Review on Maintenance System

The maintenance of the sewage treatment plant is roughly divided into three activities, namely (1) operation control, (2) water quality control and (3) maintenance.

1) Operation Control

The operator will be responsible for the operating condition of the plant, for supervising the operation and for recording the daily and monthly report.

2) Water Quality Control

The chief of water quality control is responsible for sampling, analysis and recording of data to clarify the relationship between the inflow condition and the water quality of effluent and to provide feedback to be used in the setting of the operating condition.

3) Inspection Control

Taking into account the contents of the facilities and the difficulty in the maintenance of the treatment method adopted, the following organization is proposed:

```
Plant Manager 1 pr.─┬── Operator                             2 prs.
                    ├── Chief of Water Quality Control       1 pr.
                    ├── Assistant of Water Quality Control   1 pr.
                    └── Guard                                1 pr.
```

The major works of the operator are as follows:

Routine Works

- inspection of measuring device
- removal and disposal of screenings and scum
- cleaning of the administrative building
- inspection and repair of gate valves

Regular Works

- inspection and repair of structures, fence, etc.
- maintenance of implant plants
- cleaning inside the plant
- removal and disposal of sand
- cleaning of the outflow weir

In addition to the staff mentioned above, about ten more laborers will be necessary to be mainly engaged in removal and disposal of the accumulated sludge in the ponds, but able to concurrently work at other plants.

4.4.3 Equipment Supply Plan

Besides the civil and architectural facilities and the mechanical and electrical equipment provided to be constructed in the Project, there are some instruments, vehicles, etc. to be supplied. The products are as follows:

- Laboratory instruments
- Instrument for pipe cleaning
- vehicles and boat for plant maintenance

(1) Laboratory Instruments

The purpose of water quality analysis is so that the plant will be properly operated through the feedback of the analytical results to operation control. As the treatment method adopted for the proposed plant is the wastewater stabilization pond system with fewer operating factors, the laboratory instruments shall be supplied for analyzing the minimum parameters. The parameters shall be the air temperature, water temperature, transparency, PH, BOD, COD, SS, DO, ORP, coliform bacteria and the volume of the settled sludge. The laboratory instruments to be supplied in the Project are listed in Table 4.21.

As for the obtainability of chemicals, there will be no problem since a public institution in the city, such as the Central Laboratory of the Ministry of Works, from which the study team requested its analysis during the field survey can replenish the chemicals.

Table 4.21 Outline of Major Equipment

Name	Nos. of Units	Specifications	Analytical Parameter
Analytical Instrument			
PH Meter	1	for portable w/5m lead wire	PH, ORP (site)
PH Meter	1	for laboratory	PH
DO Meter	1	for portable w/5m lead wire	DO (site)
DO Meter	1	for laboratory	BOD, COD
Thermometer	1	for water Pettencohöl Type	Water Temp., Sampling
Thermometer	3	for water stick type, w/alcohol, 0 to 100°C	Water Temp.
Thermometer	1	for air	Air Temp.
Transparency Meter	1	0.5m, plastic	Transparency

Zone Meter	1	for a depth of 5m	Height of Settled Sludge
Colony Counter	1	max. capacity: more than 50g	Coliform Bacteria
Electrical Balance	1	reading limit: 0.001g	Weight Measuring
Microscope	1	optical, binocular head w/illuminator	Species of Microorganisms
Hot-air Oven	1	100°C, 30 Lit.	SS
High-pressure Autoclave	1	232mm x 460mm	Coliform Bacteria
Water Bath	1	electrical, 8 pans	COD
Constant Temperature Incubator	1	desk top type, 36°C, 50 Lit.	Coliform Bacteria
Forced Air Incubator	1	desk top type, 20°C, 50 Lit.	BOD
Pure Water System	1	ion exchange and distillation, more than 1 Lit./hr.	
Vacuum Pump	1		SS
Refrigerator	1	200 Lit. for chemicals	
Refrigerator	1	200 Lit. for samples	
Glassware	1 L.S.		
Laboratory Apparatus			
Center Work Table	1	240cm x 120cm	
Balance Table	1	90cm x 75cm	
Side Work Table	2	240cm x 75cm	
Locker	1	90cm x 40cm, for chemicals	
Locker	1	180cm x 40cm, for lab. equip.	
Equipment for Pipe Cleaning			
High-pressure Cleaning Car	1		
Sludge Vacuum Car	1	tank volume: $3m^3$	
Small Truck	1	max. loading capacity: 1 ton	
Power Drive Machine	1 L.S.	w/accessories	
Air Plug	1 L.S.	w/compressor and small generator one for each size of ϕ150 to ϕ825mm	
Manhole Cover Lifting Device	1 L.S.		
Sewer Inspection Mirror	1 L.S.	one for each ϕ150 and ϕ200mm	
Interlocking Winch	1 L.S.	w/accessories one for each size of 6" to 15"	
Bucket Machine	1 L.S.	w/accessories one for each size of 6" to 15"	
Sludge Lifter	1 L.S.		
Equipment for Plant Maintenance			
Dump Truck	1	max. loading capacity: 4 ton	
Plastic Boat	1	max. loading capacity: 4 prs. w/life jackets	
Engine-driven Pump	3	self-priming, suction head: 5m, total head: 10m Q: $3m^3$/min w/suction and delivery hoses and casters	

(2) Instruments for Pipe Cleaning

The instruments for pipe cleaning will be composed of a high-pressure cleaning car and a sludge vacuum car for periodic mechanical cleaning of sewers, and a power drive, winch, bucket, etc. which will be used for manual cleaning of sewers in the case difficulties in fixing pipe clogging and working by the high-pressure cleaning car. These are indispensable for the maintenance of sewers. Table 4.18 indicates the instruments for pipe cleaning to be supplied in the Project. The spare parts for instruments to be included in the equipment supply shall be enough for two years.

(3) Vehicles and Boat for Plant Maintenance

The maintenance work after the completion of the Project includes the periodic removal and disposal of the settled sludge and the removal of water plants growing in the ponds. The settled sludge in the ponds is dried naturally after draining its liquid portion. At this time, pumps for draining and the truck for transporting the dried sludge are required. The pumps shall be engine-driven with a large capacity. The water plants that will grow in the ponds should be removed since they interfere the penetration of sunlight required for treatment into the ponds. For this reason, a boat shall be supplied in the Project to facilitate water plant removal work.

4.4.4 Basic Design Drawings

The following basic design drawings are shown in Appendix 7:

(Sewage Treatment Plant)

- No. 1 Guide Map and Outline
- No. 2 Layout Plan
- No. 3 Hydraulic Profile
- No. 4 Completion Plan
- No. 5 Cross-sectional Plan
- No. 6 Grit Chamber
- No. 7 Anaerobic Pond and Septage Pond
- No. 8 Facultative Pond and Maturation Pond
- No. 9 Parshall Flume and Distribution Chamber

No.10 Detail (1)

No.11 Detail (2)

No.12 Detail (3)

No.13 Administrative Building

No.14 Fence, Road and Landscape

(Trunk Sewer)

No.15 Trunk Sewer No. 1 (1)

No.16 Trunk Sewer No. 1 (2)

No.17 Trunk Sewer No. 1 (3)

No.18 Trunk Sewer No. 2 (1)

No.19 Trunk Sewer No. 2 (2)

No.20 Trunk Sewer No. 2 (3)

No.21 Trunk Sewer No. 2 (4)

No.22 Trunk Sewer No. 3 (1)

No.23 Trunk Sewer No. 3 (2)

No.24 Trunk Sewer No. 3 (3)

No.25 Trunk Sewer No. 3 (4)

No.26 Trunk Sewer No. 3 (5)

No.27 Trunk Sewer No. 3 (6)

No.28 Trunk Sewer No. 3 (7)

(Branch Sewer)

No.29 Area 1 Branch Sewer

No.30 Area 2 Branch Sewer

No.31 Area 6 Connection Sewer

4.5 Implementation Plan

4.5.1 Policy for Construction

The execution agency of the Project is the Lilongwe City Council under the direction of the Ministry of Local Government.

The implementation system is shown in Figure 4.6. The project team which will be organized in the City Engineer's Department of the City Council, shall be consistently in charge of the Project implementation from the stage of detailed design, which shall be responsible for the following works.

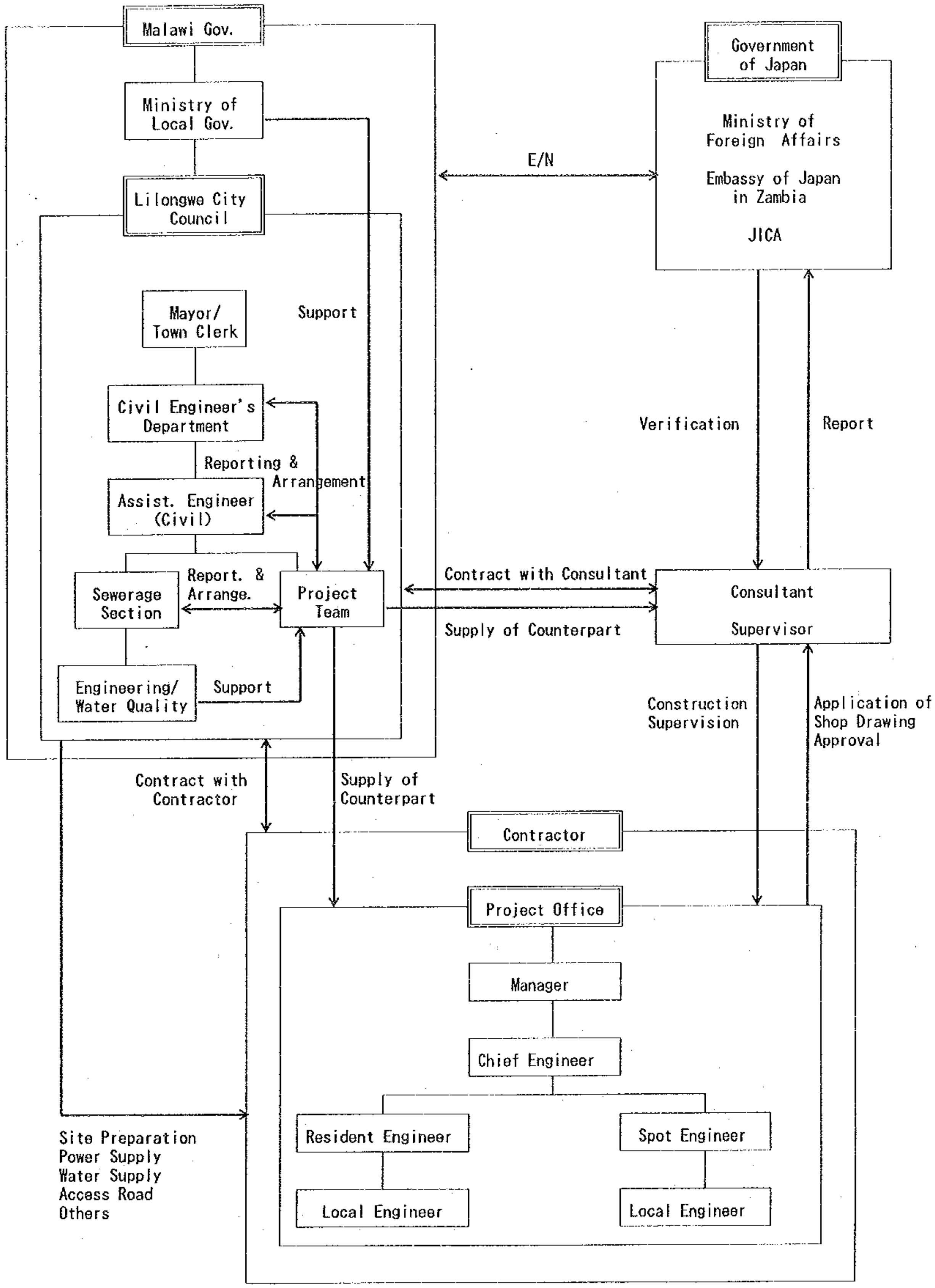


Figure 4.6 Project Implementation Diagram

a) Reception of the City Council for the Project
b) Liaison and adjustment with the divisions concerned in the City Council
c) Liaison and cooperation with the external agencies concerned with the Project
d) Collection of designing and bidding works as the counterparts of the Japanese consultant
e) Assurance of staff required for an additional survey and test, if any

The Japanese consultant will undertake the detailed design, bidding and construction supervision to proceed with the construction work smoothly and complete it within the given construction period. The consultant will send a civil engineer, who will be stationed in the city to supervise the whole of the construction work as an agent of the City Council, and other engineers as required, for example at the time of completion of major facilities and at the end of fiscal year.

The Project is to construct the sewers and the sewage treatment plant. The mechanical equipment to be involved is simple being composed of devices such as a flow meter, etc. and it is considered appropriate that the Japanese civil engineering contractor who has experience in the construction of a sewage treatment plant will undertake the work. In selecting the contractor, the open bid system will be adopted and the qualification and selection criteria for bidders will be defined during the preparatory work for bidding through the negotiation with and confirmation of the City Council.

During the construction work the Japanese contractor will send engineers to direct and instruct the work.

The Project shall not be phased with the following reasons:

a) Even if both the sewer and sewage treatment plant projects are concurrently in progress, each effort will take three years, respectively.
b) When both the sewer and sewage treatment plant projects are completed, they will be fully functional as a sewerage system. Therefore, a concrete effect is not be expected for each phase, even if the projects are phased.

4.5.2 Construction Condition

The local contractors in Lilongwe have experience in pipe installation and it will be no problem to use a local contractor as a subcontractor for pipe installation. In the construction work of the sewage treatment plant, the large earth work is the main effort and the mechanical, electrical and architectural work is minimal. At the proposed site for the plant, there is enough space for a site office, storage and so on.

The items to be considered for the construction work are as follows:

a) The geology of the proposed site for the plant is reddish black silty soil by 4 to 5m below the present ground surface, which shows high self-supporting characteristics during the dry season, but will often be muddy during the wet season. Hence, it will be necessary to pay attention to the drainage from the slope during and after the completion of the Project.

b) Below the silty soil, a rock layer is expected as seen at the river bed of the Lilongwe River, therefore, explosives will be used to excavate it. Due consideration must be given to the handling of the explosives.

c) There is a high possibility that the installation work of some trunk sewers in the nature sanctuary will be restricted from a variety of aspects. The construction methods for this area are should be decided under the direction of the authority concerned.

d) The City Council is confident to find a disposal site for a large volume of surplus soil from the construction works. In this regard, the contractor is required to negotiate with the City Council for an expected location and a manner of disposal.

e) As the river rises rapidly during the wet season, it will be necessary to pay attention to the installation work along the river and to construct an aqueduct during the period of May to October (the dry season).

f) The construction work for the plant involves dangerous work, such as the explosive work, construction of a highly sloped surface, frequent soil transportation and so on, and there is a hamlet near the proposed site; every effort should be maid to assure safety.

g) In Malawi, all major construction materials are imported and it takes a great deal time for inland transportation, therefore, material procurement should be carefully done prior to the commencement of the work.

4.5.3 Construction and Supervisory Plan

(1) Detailed Design

In case that the Government of Japan decides to implement the Project based on the result of the basic design study, then the E/N will be concluded between the Government of Japan and the Government of the Republic of Malawi, the Government of the Republic of Malawi will make a contract with the Japanese consultant, the Government of Japan will verify the contract, and the consultant will start the detailed design work.

Upon commencement of the work, the consultant will conduct a topographical, soil and detailed field surveys in the field, make a detailed design and prepare design drawings and documents.

(2) Bidding

After the approval of all bidding documents by the City Council, the consultant will enter into the bidding stage. As an agent of the City Council, the consultant will undertake a series of works.

The preparation period will be one week for the prequalification documents and about one month for bidding documents from the distribution. The bidding will be done in the presence of witnesses. The lowest bidder will be recommended as the successful bidder of the Project and the consultant will assist in the contract negotiations and contract conclusion between the successful bidder and the City Council.

(3) Construction Supervision

In the construction work, the civil and pipe installation work is primary and the mechanical and electrical work is secondary in job effort. The resident engineer to be sent by the consultant will be a civil engineer and architectural, mechanical and electrical engineers will be sent for a short time, for example, at the completion of the major facilities.

As the construction sites for the plant, trunk sewers and branch sewers are spread in the city, local engineers will be hired to assist the consultant's resident engineer. The consultant's resident engineer will hold close meetings with the City Council, other agencies concerned and with the Japanese contractor in order to implement the Project and to strictly adhere to the submission of regular reports to the JICA Malawi office.

(4) Technical Guidance for Plant Operation

Upon completion of the Project, the contractor will provide technical guidance during the test run for one month. The treatment method adopted in the Project has been used before in Lilongwe and its maintenance is simple and easy. Therefore special technical training will not be necessary on the job, however, it is hopefully considered that the officials concerned with the plant will be trained in the JICA middle-term training course for sewerage in the following subjects:

a) Basic treatment principle
b) Water quality analysis method and plant operation based on the analytical result
c) Discharge, cleaning and disposal of sludge
d) Operational method corresponding to the incoming sewage flow including initial operation
e) Recording and using of data

4.5.4 Procurement Plan

The construction materials necessary for the Project shall be procured in-country as much as possible, however, those which are not obtainable in-country or of which the quality or specifications do not meet the requirements, or which cannot be procured stably with regard to distribution volume or cost shall be procured from Japan or third countries, taking into consideration that the Project should be completed within the given construction period.

The materials obtainable in Malawi are concrete aggregate, brick, small size PVC pipe, fuel, cement, etc. and others are imported from the foreign countries.

Out of the materials to be procured from the third countries, ACP is currently imported from South Africa and Zimbabwe and has already been used in Malawi. Therefore, it shall be likewise in the Project. In addition, reinforcing bar for the building work and asphalt for the road work shall be imported from South Africa and Zimbabwe in accordance with the current practice in Malawi.

Materials other than the above shall be procured from Japan in consideration of quality, specification, delivery time and reliability. As for construction machinery (backhoes, bulldozers, dump trucks, truck cranes and trucks), these have been confirmed to be leased in Malawi, hence, they are to be procured in Malawi. Other construction equipment shall be brought from Japan.

The materials and construction equipment shall be unloaded at the port of Durban in South Africa due to the present security problems and then transported to Malawi.

(1) Materials to Be Procured in Malawi

1) Material

cement, sand, gravel, brick, framing wood, small size PVC pipe, light oil, gasoline, etc.

2) Construction Machineries

truck crane, backhoe, dump truck, bulldozer, truck, etc.

(2) Materials to Be Procured from Japan

1) Material

steel frame for processing, ductile cast iron pipe and joint, manhole cover with a key, step, screen, valve and gate, special framing wood for manhole walls, special paint for chemical-proofing, wire cylinder, framing plywood, etc.

2) Construction Machineries

plate compactor (80-100kg), re-bar cutting and bending tool, submergible pump, power generator, surveying instrument, testing instrument (CBR, etc.), etc.

3) Maintenance Equipment

laboratory instrument, instrument and vehicle for pipe cleaning, vehicle and boat for plant maintenance

(3) Materials to Be Procured from Third Countries

asbestos cement pipe (ACP), reinforcing bar, asphalt, etc.

4.5.5 Implementation Schedule

(1) Implementation Schedule

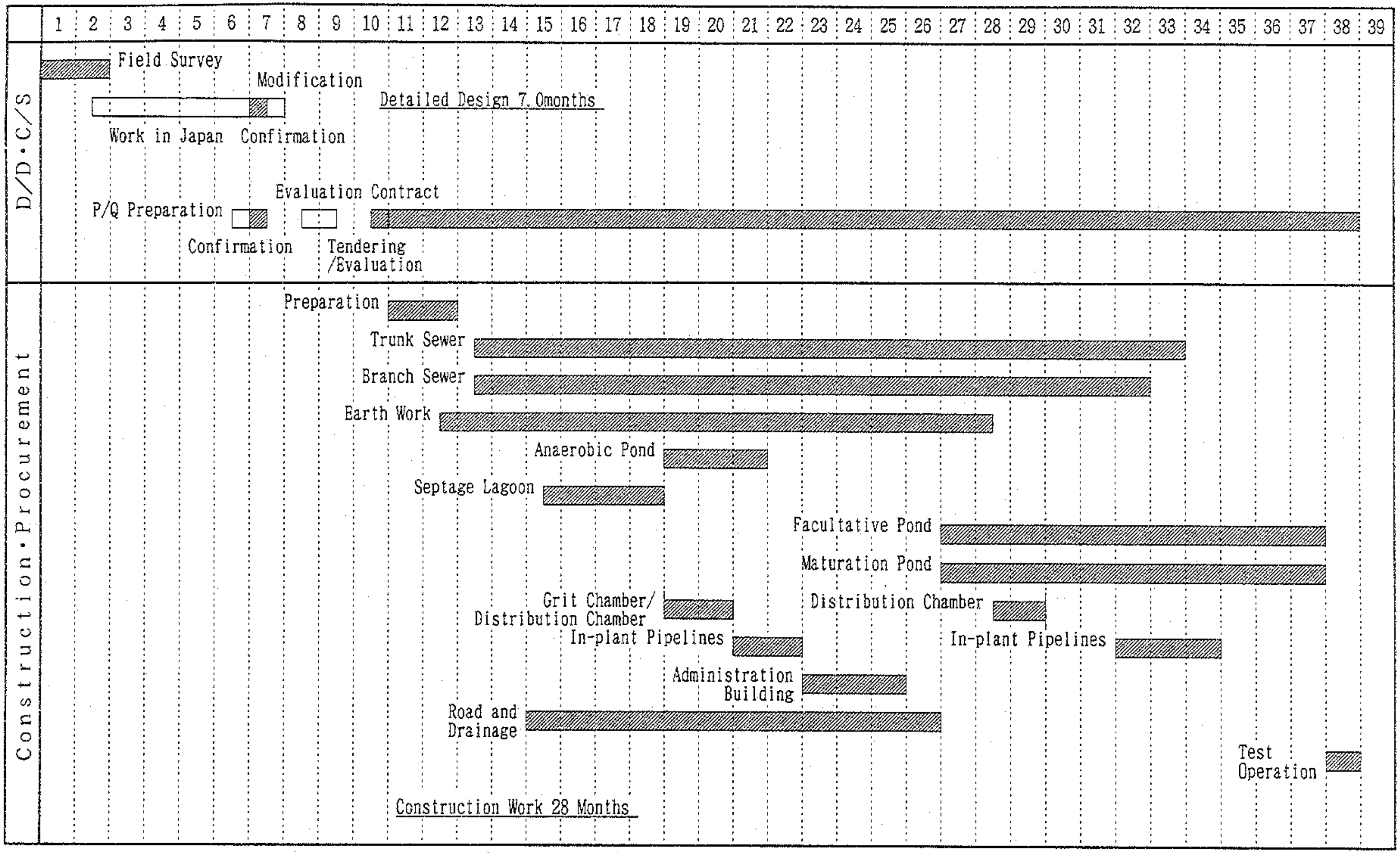
Taking into account the wet season period and the construction time needed to carry out the construction work economically and efficiently, the implementation schedule is defined as shown in Figure 4.7.

(2) Work Assignment

In the Project, the Japanese side shall undertake the detailed design and construction supervision by the consultant on the construction of the sewage treatment plant, trunk sewers and branch sewers and those civil, architectural, mechanical, electrical and pipe installation works by the contractor.

The Malawi side shall undertake the provision of the access road to the proposed site for the sewage treatment plant and infrastructures concerned and shall be responsible of the operation and maintenance of the sewerage system after the completion of the Project.

Figure 4.7 Project Implementation Schedule



LEGEND: (Field Survey) (Work in Japan) D/D - Detailed Design C/S - Construction Supervision

The outline of the work assignment to be undertaken by each side is described below.

1) Scope of Work to be Undertaken by the Japanese Side

a) Sewage Treatment Plant

(Civil, Mechanical, Electrical and Building Equipment Works)

(a) screen, grit chamber

(b) flow meter (Parshall Flume)

(c) distribution chamber

(d) anaerobic pond

(e) septage lagoon

(e) facultative pond

(f) maturation pond

(g) in-plant piping

(h) implant maintenance road

(i) administrative building

b) Trunk Sewers

(a) trunk sewer

(b) aqueduct

c) Sewer Networks

(a) branch sewers

(b) service connections

d) Maintenance Equipment

(a) laboratory instrument

(b) instrument and vehicle for pipe cleaning

(c) vehicle and boat for plant maintenance

2) Scope of Work to be Undertaken by the Malawi Side

a) Sewage Treatment Plant

(a) expropriation of the proposed site

(b) expropriation of the access road to the plant and road construction

(c) fencing around the proposed site

(d) water supply to the proposed site

(e) power supply to the proposed site

(f) telephone line to the proposed site

(g) expenses for assuring the surplus soil disposal site

b) Trunk Sewer

(a) clearing of sewer route

c) Sewer Networks

(a) compensation to the private land when sewer will be installed therein

d) Banking Arrangement

e) Supply of Technical Staff

4.5.6 Project Cost

(1) Expenses to be Borne by the Malawi Side

The expenses to be borne by the Malawi side are approximately MK2.80 million. The breakdown is shown in Table 4.22 and the further details are shown in Appendix 8. As for the expropriation of sites for the sewage treatment plant and sewers, there is no expense due to the sites being on public land. However, as for the compensation for private lands the Malawi side shall estimate the amount for budgeting.

(2) Estimation Condition

1) Time of Estimation : October 1993

2) Exchange Rate : U.S.$ 1 = Japanese Yen 108.80
MK 1 = Japanese Yen 25.25

3) Project Period : The project period will be 38 months composed of 7 months for the detailed design, the bidding period and 28 months for the construction works.

Table 4.22 Expenses to be Borne by the Malawi Side

(Unit: Thousand MK)

Work Name	Amount
1. Fencing at the Plant	1,035
2. Access Road to the Plant	540
3. Water Supply to the Plant	162
4. Power Supply to the Plant	837
5. Telephone Line to the Plant	78
6. Clearing on the Trunk Sewer Routes	150
Total	2,802
7. Remuneration of Technical Staff	*1
8. Commission of B/A	*2

Note: Each work includes a 40% overhead to the direct construction cost. The construction supervision fees are assumed at 8% of the direct construction cost plus the overhead for Items 2 and 3, 5% for Items 1 and 6, and 0% for Items 4 and 5 which is assumed to be directly undertaken by the agencies concerned.

*1: One engineer and one technician are desirable to be assigned for the project team.
Engineer MK21,000/year
Technician MK7,200/year

*2: Advising commission on Authorization to Pay (A/P) (about ¥3,000 for each A/P)
Payment commission (about 0.1% of each payment)

CHAPTER 5

PROJECT EVALUATION AND CONCLUSION

CHAPTER 5 EFFECTS OF THE PROJECT AND CONCLUSION

5.1 Effects

The implementation of the Project will, generally speaking, have the following effects on the city of Lilongwe.

a) Of the total population of about 25,000 persons now living in the sewerage service area, the sewage produced by half of them, or about 13,000 persons, is treated relatively well, while the remaining sewage flows into the rivers with little or no treatment. The implementation of the Project will permit the sewage produced by about 34,000 persons to be properly treated.

b) The stable sewage treatment achieved by increasing the number of the population served by sewerage and by constructing the new treatment plant can be counted on to improve the water quality in the rivers and provide healthier and more sanitary conditions for an estimated 100,000 persons living downstream who use river water as their primary water source.

c) The Project, which will construct the framework for a sewerage system in Lilongwe, is one which anticipates the future growth of service coverage in the trunk sewers, so that in the future, the City Council will be able to extend the sewer system and increase the service coverage without difficulty, by using other funds to extend the sewer network and expand the treatment plant.

d) The Project can indirectly contribute to the improvement of the health and sanitation of the people of the region by permitting the City Council to fund the expansion of the water supply system -- a project which can only be carried out if the sewerage system is also improved.

5.2 Conclusion

Eleven sewage treatment plants are in operation in Lilongwe, but a shortage of funds has prevented the City Council from carrying out the needed repairs and improvements. Many of these plants discharge insufficiently treated sewage into the rivers, contributing to the river's contamination and to the degradation of the sanitary level of the environment of the local population.

Plans to expand the water supply system to meet the needs of a growing population cannot be finalized because of financial problems caused by delays in improvements to the sewerage system.

Under these circumstances, the Project conforms to the Master Plan for the improvement of the sewerage system prepared by the Lilongwe City Council. The Project will not only increase the service coverage and improve the sanitary level of the local living environment, but also lay the foundation for future expansion of the sewerage system. This will provide substantial beneficial effects. Table 5.1 presents a summary of existing problem points and the effects of the Project.

Table 5.1 Effects of the Project

Present Condition and Problems	Measures in the Project	Effects by the Project
-Improper operation and maintenance of existing treatment plants	-Integration of existing treatment plants in the City to one new plant and proper operation and maintenance of the new plant	-Improvement to the river water quality by receiving the well-treated sewage and to the sanitary environment of residents in river basins
-Low service coverage by sewerage	-Provision of branch sewers in the densely inhabited area	-Increase in service population by 34,000 persons
-No Perspective to future sewerage system	-Sizing of trunk sewers to cope with future increase in the incoming flow -Easily expandable layout of treatment facilities	-Easily increase in service coverage by extending the sewer network using other fund after the completion of the frame of trunk sewers and the treatment plant
-No progress in financing for water supply expansion due to suspension of improvements to the sewerage system	-Completion of the frame of sewerage system	-Progress of the water supply expansion work to make it possible to supply the water coping with the increasing population growth

Because, as stated above, the Project will contribute to broad improvements in the people's living standard and to healthier and more sanitary conditions, it would be extremely significant and highly appropriate to implement the Project with grant aid assistance from the Government of Japan.

5.3 Proposals

The City Council and the Government of Malawi have to implement the following measures in order to achieve the goals of the Project and to maximize its effects.

(1) Prior to Project Implementation

a) Obtain funds to pay for the work that the Malawi side has undertaken. The construction of an access road to the treatment plant is a particularly important prerequisite for the construction of the treatment plant, and at least, funds must be obtained to cover this expense.
b) In dealing with the hamlets (squatters on government-owned land) close to the construction site, steps have to be taken to solve problems related to the passage of construction vehicles during the construction work and to the issue of offensive odors after the treatment plant is in operation.
c) Obtain the authorization for construction in the nature sanctuary
d) Make adjustment with other relevant authorizations as necessary

(2) During Project Implementation

a) The technical personnel must be involved in the Project from its design stage, so that they will learn and understand the details of the Project thoroughly, and thereby master the technology.

(3) After Project Implementation

a) Enact appropriate sewage charge collection that will provide funds to operate and maintain the facilities.
b) Conduct systematic training and practice for the key personnel so that the facilities will be properly maintained.
c) Expand the sewer network and increase the influent of the sewage treatment plant to conserve the river water quality.

APPENDICES

Appendix 1 List of Members of the Study Team

Appendix 1 List of Members of the Study Team

1. Project Coordinator/Grant Aid: Yoshikatsu NAKAMURA
   (Study Team Leader)
   Director,
   First Basic Design Study Division,
   Grant Aid Study and Design Department,
   Japan International Cooperation Agency

   (Explanation of the Draft Final Report)
   Hideo MIYAMOTO
   Deputy Director,
   First Basic Design Study Division,
   Grant Aid Study and Design Department,
   Japan International Cooperation Agency

2. Technical Adviser: Naoki HIRAGA
   Planning Department,
   Construction Division,
   Sewage Works Bureau,
   Osaka Municipal Government

3. Chief Consultant / Sewerage Planning: Tetsuo YAMAGIDA
   Nippon Jogesuido Sekkei Co., Ltd.

4. Sewage Treatment Facility: Takafumi KIGUCHI
   Nippon Jogesuido Sekkei Co., Ltd.

5. Mechanical Facility: Hiroki FUJIWARA
   Nippon Jogesuido Sekkei Co., Ltd.

6. Sewer Planning: Satoshi OMOTO
   Nippon Jogesuido Sekkei Co., Ltd.

Appendix 2 Study Schedule

Appendix 2 Study Schedule

1. Field Survey

Aug. 24 (Tue) Tokyo - Amsterdam (Mr. Hiraga, Mr. Yanagida and Mr. Kiguchi)

25 (Wed) Amsterdam - Lilongwe

26 (Thu) Arrival at Lilongwe.
Courtesy call to the JICA Malawi office and the Lilongwe City Council.

27 (Fri) Data collection from the Lilongwe Water Board.
Explanation of the Inception Report.

28 (Sat) Field survey of existing sewerage facilities, sewered area and trunk sewer route.

29 (Sun) Team discussion.
Tokyo - Paris (Mr. Nakamura).

30 (Mon) Preparation for Topo. Survey.
Field survey of existing sewage treatment plant.
Paris - Lilongwe (Mr. Nakamura).

31 (Tue) Team discussion.
Water quality analysis of existing sewage treatment plant.
Arrival at Lilongwe (Mr. Nakamura).

Sep. 1 (Wed) Discussion on the Inception Report with LCC.
Preparation for Topo. Survey.
Tokyo - Amsterdam (Mr. Fujiwara and Mr. Omoto).

2 (Thu) Team discussion.
Discussion on the Inception Report with LCC.
Amsterdam - Lilongwe (Mr. Fujiwara and Mr. Omoto).

3 (Fri) Signing of "Minutes of Discussion".
Field survey of project area and existing sewage treatment plant.

4 (Sat) Team discussion.

5 (Sun) Field survey of downstream of the Lilongwe River.

6 (Mon) Lilongwe - Lusaka (Mr. Nakamura).
Lilongwe - London (Mr. Hiraga).
Field survey of existing sewage treatment plant.

7 (Tue) Data arrangement and analysis.
Arrival at London (Mr.Hiraga).

8 (Wed) Field survey of Lilongwe and Lingadzi River.
Data collection and analysis.
London - Tokyo (Mr. Hiraga)

9 (Thu) Data collection and analysis.
Arrival at Tokyo (Mr. Hiraga).

10 (Fri) Data collection and analysis.

11 (Sat) Data collection and analysis.

12 (Sun) Field survey of project area, site for sewage treatment plant and trunk sewer route.

13 (Mon) Data collection and analysis.

14 (Tue) Field survey of site for sewage treatment plant and existing sewage treatment plant.

15 (Wed) Data Analysis.
Discussion with the admin. officer of the Nature Sanctuary.

16 (Thu) Discussion on the Technical Notes.
Team Discussion.
Lilongwe - Amsterdam (Mr. Fujiwara).

17 (Fri) Discussion on the Technical Notes and signing.
Reporting to the JICA Malawi office.

Mr. Fujiwara left Amsterdam for Tokyo.

Sep. 18 (SAT) Field Survey of Site for Sewage Treatment Plant, Project Area and Trunk Sewer Site.
Arrival at Tokyo (Mr. Fujiwara)

19 (Sun) Field Survey of Project Area.
Lilongwe - Amsterdam (Mr. Yanagida, Mr. Kiguchi and Mr. Omoto).

20 (Mon) Arrival at Paris via Amsterdam

21 (Tue) Mr. Yanagida, Mr. Kiguchi and Mr.Omoto left Paris for Tokyo.

22 (Wed) Arrival at Tokyo (Mr.Yanagida, Mr.Kiguchi and Mr.Omoto).

2. Explanation of the Draft Final Report

Nov. 28 (Sun) Tokyo - Paris (Mr.Miyamoto, Mr.Yanagida and Mr.Kiguchi)

29 (Mon) Paris - Lilongwe

30 (Tue) Arrival at Lilongwe.
Courtesy Call to the JICA Malawi office and the Lilongwe City Council.
Explanation of the Draft Final Report to LCC.

Dec. 1 (Wed) Explanation of the Draft Final Report to the MOLG and LCC.

2 (Thu) Explanation of the Draft Final Report to the MOF and LCC.

3 (Fri) Discussion on the Draft Final Report with LCC.
Signing of "Minutes of Discussion".

4 (Sat) Team meeting.
Lilongwe - London (Mr. Yanagida, Mr. Kiguchi).

5 (Sun) Lilongwe - Lusaka (Mr. Miyamoto).
Arrival at London (Mr. Yanagida, Mr. Kiguchi).

6 (Mon) Reporting to the Embassy of Japan in Zambia (Mr. Miyamoto).
Mr. Yanagida and Mr. Kiguchi left London for Tokyo.

7 (Tue) Arrival at Tokyo (Mr.Yanagida, Mr.Kiguchi).
Lusaka - London (Mr.Miyamoto).

8 (Wed) Arrival at London (Mr. Miyamoto).

9 (Thu) Mr. Miyamoto left London for Tokyo.

10 (Fri) Arrival at Tokyo (Mr. Miyamoto).

Appendix 3 List of Personnel Concerned

Appendix 3 List of Personnel Concerned

1. Lilongwe City Council

Mr. Francis K. Mfune	Town Clerk / Chief Executive
Mr. R. C. Makono	Deputy Town Clerk
Mr. Alaston Kamera	City Engineer
Mr. Walker P. Kaulembe	Assistant Engineer

2. Ministry of Local Government

Mr. B. S. Phangaphanga	Principal Secretary
Mr. James G. Wilson	Chief Technical Advisor
Mr. A. M. Singini	Chief Municipal Engineer
Mr. A. C. Lwanda	Principal Municipal Engineer
Mr. S. M. C. Chirambo	Economist

3. Ministry of Finance

Mr. J. M. Mhango	Senior Assistant Secretary, Treasury
Mr. A. Mzoma	Administrative Officer (Japan Desk), Treasury

4. Lilongwe Water Board

Mr. Eric H. Msolomba	General Manager
Mr. M. J. Mzumara	Engineering Manager
Mr. Titus C. Mtegha	Projects Engineer

5. JICA Malawi Office

Mr. Seiichi KANAI	Resident Representative
Mr. Seiichi KIMURA	Deputy Resident Representative
Mr. Eiji EGASIRA	Asst. Resident Representative
Mr. Jiro INAMURA	ditto

Appendix 4 Minutes of Discussions

MINUTES OF DISCUSSIONS
ON
BASIC DESIGN STUDY
ON
THE LILONGWE SEWERAGE PROJECT
IN
THE REPUBLIC OF MALAWI

Based on the results of the Preliminary Study, the Japan International Cooperation Agency (hereinafter referred to as "JICA") decided to conduct a Basic Design Study on the Lilongwe Sewerage Project (hereinafter referred to as "the Project").

JICA sent to the Republic of Malawi a study team (hereinafter referred to as "the Team"), which is headed by Mr. Yoshikatsu NAKAMURA, Director, First Basic Design Study Division, Grant Aid Study and Design Department, JICA, and is scheduled to stay in the country from August 26 to September 19, 1993.

The Team held discussions with the officials concerned of the Government of Malawi and conducted field surveys at the study area.

In the course of discussions and field surveys, both parties have confirmed the main items described on the attached sheets. The Team will proceed to further works and prepare the Basic Design Study report.

Lilongwe, September 3, 1993

Mr. Yoshikatsu NAKAMURA
Leader
Basic Design Study Team
JICA

Mr. Francis K. Mfune
Town Clerk and Chief Executive
Lilongwe City Council

ATTACHMENT

1. Objective

The objective of the Project is to improve sanitation standard of Lilongwe City and the vicinity area, by means of expanding sewerage facilities in the city.

2. Project Area

The area of the Project is a part of Lilongwe City, as shown in Annex I.

3. Executing Agency

The Lilongwe City Council (hereinafter referred to as "the LCC"), under the Ministry of Local Government, is responsible for the administration and execution of the Project.

4. Project Components

After discussions, the following items were finally agreed in priority order by the both sides as the project components:

1) First Priority

(1) Construction of Trunk Mains

The construction of the trunk mains with a length of approximately 18 km linking the existing sewage treatment plants (Area 2, 6, 13, 18A, 18B and 33) with the proposed treatment plant at Kauma.

(2) Construction of Treatment Plant at Kauma

Note: The capacity of the plant will be decided based on the expected sewage flow after the completion of the Project. An anticipated increase of sewage flow by the expansion of the sewer network in the near future, which is not covered by the Project, may be considered in the Project.

(3) Construction of Pumping Station

Note: The need for the pumping station for the trunk mains will be determined after detailed survey.

2) Second Priority

Construction of Sewer Network

The construction of sewer network for the areas of No. 1, 2, 18, 4 and 47 in priority order

Note: i) Subject areas of the design will be decided by the Team based on the results of further study in Japan.

ii) The house connections will be laid simultaneously with the construction of the sewer network by the Malawi side.

iii) In case the Japanese Grant Aid does not cover the work due to the limit of the budget, the Malawi side will try to seek another financing source for the work.

5. Japan's Grant Aid System

(1) The Government of Malawi has understood the system of Japanese Grant Aid explained by the Team.

(2) The Government of Malawi will take necessary measures, as described in Annex II, for the smooth implementation of the Project, on condition that the Grant Aid Assistance by the Government of Japan is extended to the Project.

6. Schedule of the Study

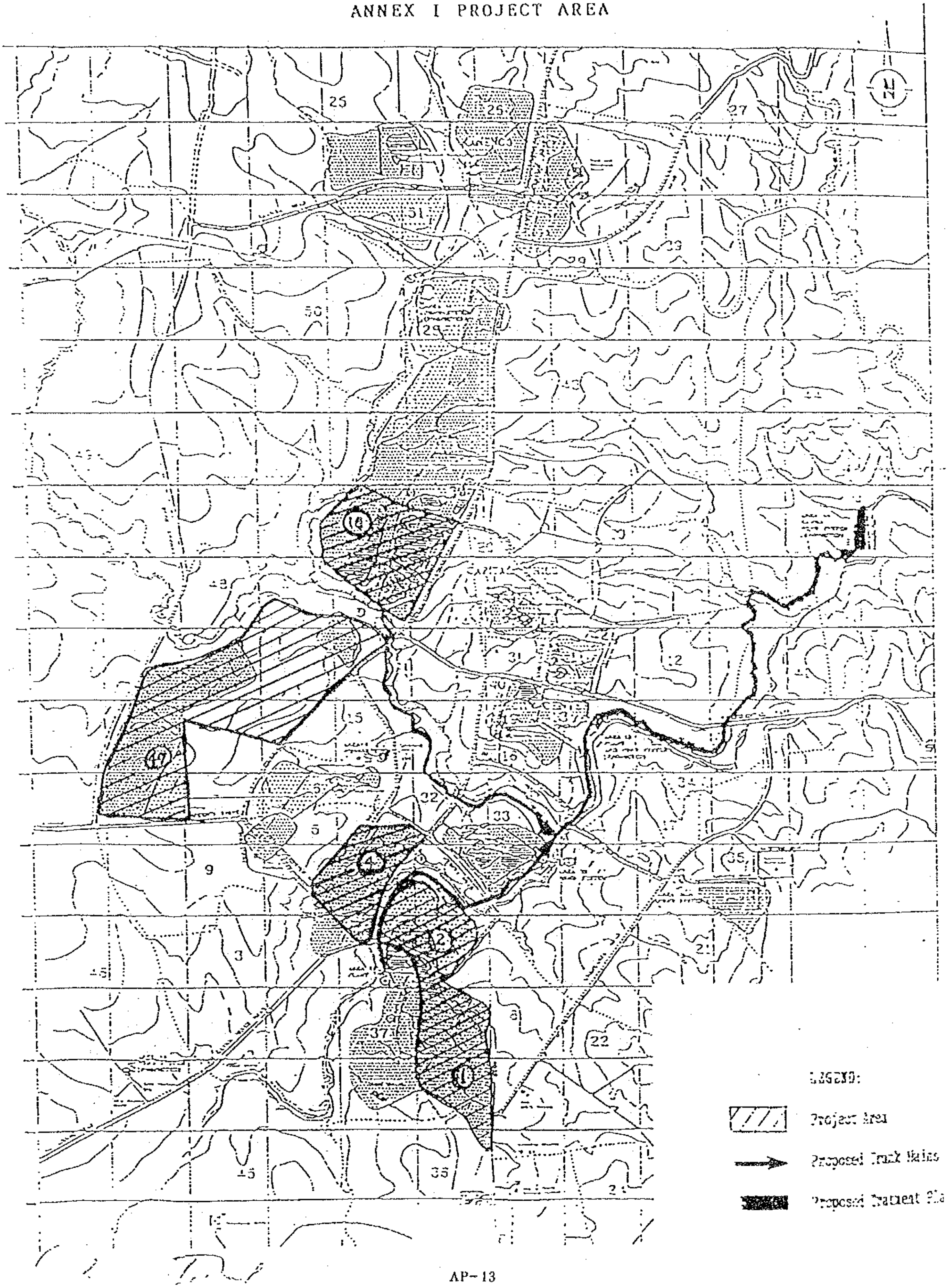
(1) The Team will proceed to further studies in Malawi until Septem-

ber 19, 1993.

(2) JICA will prepare the draft report in English and dispatch a mission in order to explain its contents around December, 1993.

(3) In case that the contents of the report is accepted in principle by the Malawi side, JICA will complete the final report and send it to the Government of Malawi by February, 1994.

ANNEX I PROJECT AREA



ANNEX II NECESSARY MEASURES TO BE TAKEN BY THE GOVERNMENT OF MALAWI

Necessary measures to be taken by the Government of Malawi on condition that Japanese Grant Aid Assistance is extended to the country are:

1. To provide data and information necessary for the Project,

2. To secure the sites for the Project,

3. To clear and level the treatment plant site and to construct the access to the site prior to the commencement of the construction,

4. To undertake incidental outdoor works such as gardening, fencing, gates and exterior lighting within and around the site,

5. To provide facilities to the treatment site, such as;
   1) water supply,
   2) distribution of electricity and telephone line,
   3) general furniture such as tables, chairs, and others for the completed facilities,

6. To bear the commission to the Japanese foreign exchange bank for the banking services based upon the banking arrangement,

7. To exempt taxes and to take necessary measures for custom clearance of the materials and equipment brought for the Project at the port of disembarkation,

8. To exempt Japanese nationals from custom duties, internal taxes and other fiscal levies which may be imposed in Malawi with respect to the supply of the products and services under the verified contracts,

9. To bear all the expenses other than those to borne by the Grant, necessary for the construction of the facilities as well as for the transportation and installation of the equipment.

TECHNICAL NOTES
ON
BASIC DESIGN STUDY
ON
THE LILONGWE SEWERAGE PROJECT
IN
THE REPUBLIC OF MALAWI

The Japan International Cooperation Agency (hereinafter referred to as "JICA") sent to the Republic of Malawi a study team (hereinafter referred to as "the Team"), which is headed by Mr. Yoshikatsu NAKAMURA, Director, First Basic Design Study Division, Grant Aid Study and Design Department, to conduct a Basic Design Study on the Lilongwe Sewerage Project (hereinafter referred to as "the Project").

The Team held discussions with the officials concerned of the Government of Malawi and conducted field surveys at the study area from August 26 to September 19, 1993.

Through discussions and field surveys, both parties have confirmed the technical matters described on the attached sheets for further works. The Team will conduct the basic design and prepare the Basic Design Study report in Japan.

Lilongwe, September 17, 1993

Mr. Tetsuo YANAGIDA
Chief Consultant
Basic Design Study Team
JICA

Mr. Francis K. Mfune
Town Clerk and Chief Executive
Lilongwe City Council

IN WITNESS WITH:

Mr. Eiji EGASHIRA
Assist. Resident Representative
Malawi Office
JICA

Mr. James G. Wilson
Chief Technical Adviser
Ministry of Local Government

ATTACHMENT

In addition to the confirmed items described in the Minutes of Discussions dated September 3, 1993, following matters were confirmed and agreed by both parties for execution of the planning and design of the Project.

1. Service Area

The area to be served by the sewerage system was decided as follows:

Year 2000; Present Served Area, and proposed service areas in Areas 1, 2, 4, and 18.

Year 2005: The service area proposed in the F/S, and Areas 47 and 44.

2. Sewage Flow

The total sewage amount was projected as follows:

Year 2000; 8,400 m^3/day (F/S 8,400 m^3/day)
Year 2005; 15,600 m^3/day (F/S 12,900 m^3/day)
(daily average basis)

3. Principles and Criteria for the Design of Sewer System

(1) Pipe Materials

a. Trunk main and lateral sewer; Asbestos Cement Pipe
b. House connections (Work to be done by Malawi side); PVC Pipe
c. At crossings over streams; Ductile Iron Pipe
d. Sewer bridge; Ductile Iron Pipe on Steel Truss Structure Bridge

(2) Minimum Diameter of Sewer

a. Sewer; 150 mm
b. House connections; 100 mm

(3) Diameter of Trunk Mains

ϕ500mm - ϕ900mm (F/S ϕ600mm - ϕ800mm) (refer to ANNEX I)

Note: Since the planned route of the trunk main along the Lingadzi river runs through the Nature Sanctuary, the Malawi side shall secure the permission of the authorities concerned for the survey for detailed design and implementation of the Project if the Japanese Grant Aid Assistance is extended to the Project.

(4) Slope and Flow Velocity of Sewer

a. Minimum slope; 1m/km (0.1%)
b. Flow velocity; 0.5m/s. ~ 3.0m/s. (same as F/S)

(5) Structure of Manhole

a. Structure; Standard design in Japan will be adopted.
b. Manhole cover; Cast iron with lock
c. Spacing; Sewer with a diameter of ∅500 or less - 60m in max.
Sewer with a diameter of ∅600 or more - 80m in max.
(same as F/S)

(6) Design Peak Flow Factor

a. Trunk main; 2.3 (F/S 2.3)
b. Others; 3.0 (F/S 2.5, 3.0)

(7) Unit Sewage Quantities (same as F/S)

a. High density traditional (HDT); 80 lpcd
b. High density permanent (HDP); 125 lpcd
c. Medium density permanent (MDP); 150 lpcd
d. Low density permanent (LDP); 200 lpcd

(8) Minimum Covering Depth

a. Sewer laid under road; approximately 1.5m
b. Others; approximately 1.0m

Excavated roads should be restored to their former state.

Note: Lateral sewer pipes will be laid under roads except for busy-traffic roads. In addition, the sewer network and the trunk main will cross many roads and rivers. In this connection, the Malawi side shall secure the permission of the authorities concerned for implementation of the Project if the Japanese Grant Aid Assistance is extended to the Project.

(9) Pumping Station

Based on the results of the field survey, the pumping station will not be required, and therefore will not be provided.

4. Principles and Criteria for the Design of Treatment Plant

(1) Basic Parameters

a. Planned Sewage Flow

Phase 1 (JICA);	Daily Avg.	8,400 m^3/day
	Hourly Max.	19,320 m^3/day
Phase 2 ;	Daily Avg.	15,600 m^3/day
	Hourly Max.	35,880 m^3/day

b. Planned Water Quality

Influent;
BOD5 300 mg/L, SS 350 mg/L, Fecal Coli. G. 2.0×10^7 MPN/100mL
Effluent (Target treated water quality);
BOD5 20 mg/L, SS 30 mg/L, Fecal Coli. G. 1.0×10^3 MPN/100mL

c. Treatment Method

Stabilization Pond System will be adopted.

Flow Diagram;

```
Inflow ---> Screen & Grit Chamber ---> Flow Measuring Device --┐
┌ Maturation Ponds <--- Facultative Ponds <-┬- Anaerobic Ponds <-┘
└> Discharge                                └- Septage Lagoon
```

(2) Design Criteria

The design criteria recommended in the "Wastewater Stabilization Ponds" (WHO EMRO Technical Publication No.10) will be applied for the Basic Design as follows:

Item	Applied Formula / Value
1. Grit Chamber	
· Water Surface Loading	1,800 m^3/m^2·day for Qhmax
· Average Velocity	0.3 m/s
2. Anaerobic Ponds (AP)	
· BOD5 Volumetric Loading	v = 160 g-BOD5/m^3·day at air temp. 15.2°C
· Water Depth	4.0 m
· Effective Retention Time	2.0 days or more

· Digested Anaerobic Sludge Production	0.04 m^3/capita·year
· BOD_5 Reduction in AP	50 %
3. Facultative Ponds (FP)	
· Mean Air Temp. during the Coldest Month	Ta = 15.2°C
· BOD_5 Surface Loading	$\lambda s = 60.3 \times 1.0993^{Ta} \times 1/\alpha$ = 192 (kg-BOD_5/ha·day) where, Ta=15.2°C α=Safety Factor (=1.33)
· Water Depth	2.0 m
· Digested Sludge Production	0.03 m^3/capita·year
4. Maturation Ponds (MP)	
· Fecal Coliform Count Permissible in the Final Effluent of the MP	less than 1.0×10^3 MPN/100mL
· Bacterial Reduction Models	$NR/NO=1/\Sigma(K'Ri+1)$ where, NR: bacterial population after R days NO: bacterial population in the effluent K': die-off constant (d^{-1}) R: retention time (days) at 15.2°C $K'=2.0 \times 1.07^{(15.2-20)}$ $=1.446$ (d^{-1})
· Water Depth	1.5 m
· Retention Time per Pond	3 days
5. Septage Lagoon	
· Septage Production	0.001 m^3/capita·day
· BOD_5 Concentration	5,000 mg/L
· Retention Time	20 days or more
· BOD_5 Volumetric Loading	200 g-BOD_5/m^3·day
· Operation	Intermittent
6. Civil Engineering Parameters	
· Embankment Slope	Inside 1:3 Outside 1:1.5
· Freeboard	0.5 m
· Protection	
Inside slope	Concrete Block (t=50mm)
Bottom	Clay (t=100mm)
Walkway	Mainly 3.0 m in width Brick pavement

Note: At the publication if available, design of wastewater stabilization ponds in the south Africa region would be considered in the design.

(3) Outlines of Facilities

Applying the recommended design criteria, outlines of each facility were calculated tentatively as follows:

Item	Phase 1 (JICA)	Phase 2 (Total)
1. Grit Chamber		
· Dimension	W1,200 x L9,000	W1,200 x L9,000
· Number	2 basins (1 basin - stand-by)	2 basins
2. Flow Measuring Device		
· Type	Parshall Flume	Parshall Flume
· Number	1 set	1 set
3. Anaerobic Ponds		
· Dimension	area 0.3ha x depth 4.0m	area 0.3ha x depth 4.0m
· Number	3 basins (1 basin - stand-by)	4 basins
· Retention Time	2.2 days	2.2 days
4. Septage Lagoon		
· Dimension	area 800m^2 x depth 3.0m	area 800m^2 x depth 3.0m
· Number	2 basins	3 basins
· Effective Retention Time	2.2 days	2.2 days
5. Facultative Ponds		
· Dimension	area1.95ha x depth 2.0m	1.95hax2.0m 1.5hax2.0m
· Number	3 basins	4 basins 4 basins
· Retention Time	about 18 days	about 18 days
6. Maturation Ponds		
· Dimension	A 8,400 m^2 x D 1.5 m	8400m^{2}x1.5m 7000m^{2}x1.5m
· Number	3 basins x 2 series	3ba.x 2ser. 3ba.x 2ser.
· Retention Time	3 days/basin	3 days/basin

5. Provision of Equipment and Materials

Through the discussions, the Malawi side requested that the following equipment and materials be included in the Project.

a. Laboratory equipment

Water quality analysis equipment for effective operation and maintenance of treatment plant

b. Sewer cleaning equipment

Cleaning equipment and vehicles such as:
manual cleaning equipment, high pressure water jet truck, vacuum tanker (for cleaning of sewer and septic tank)

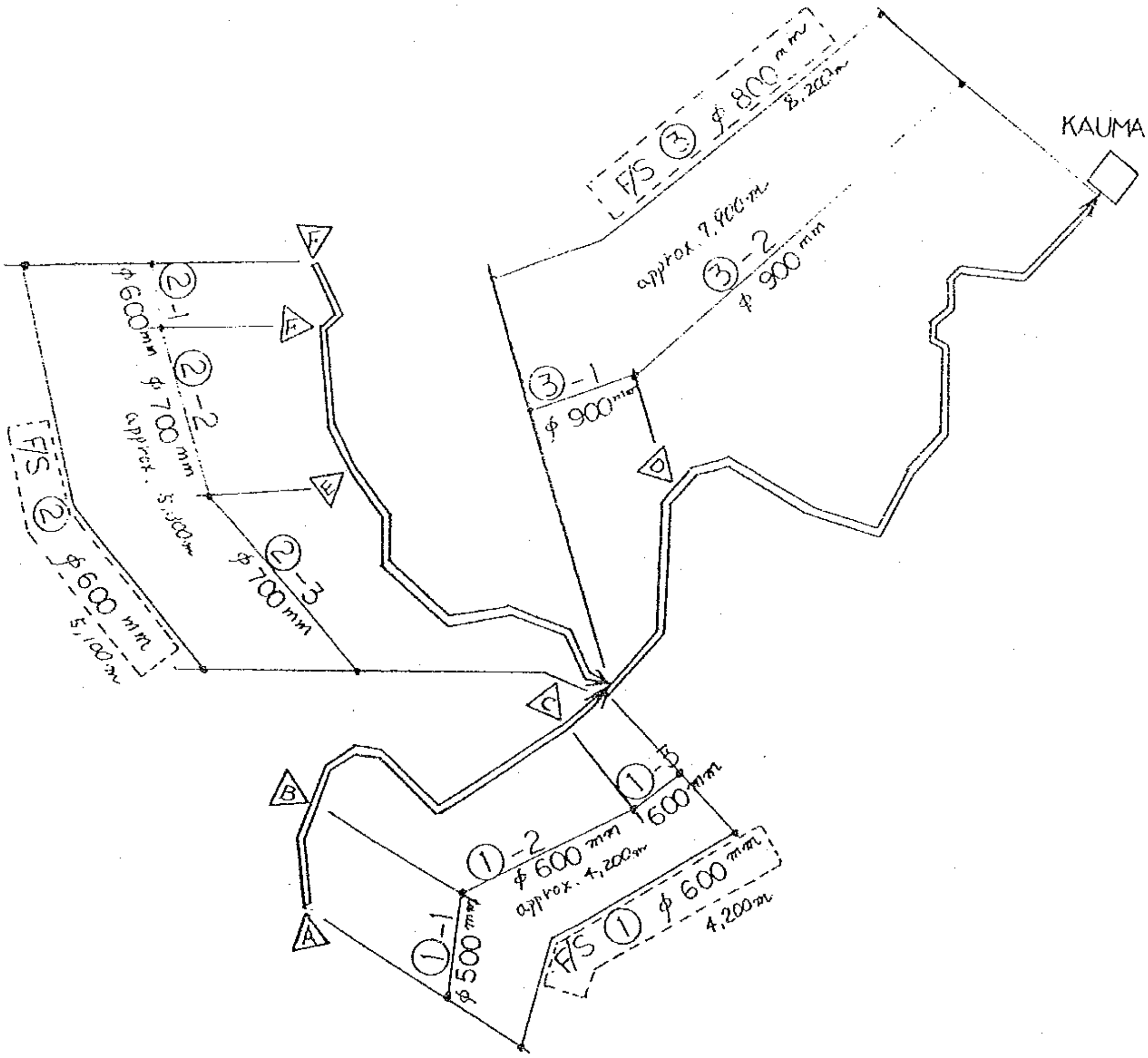
c. Vehicles for maintenance of treatment plant

dump truck, plastic boat

d. House connections and fencing

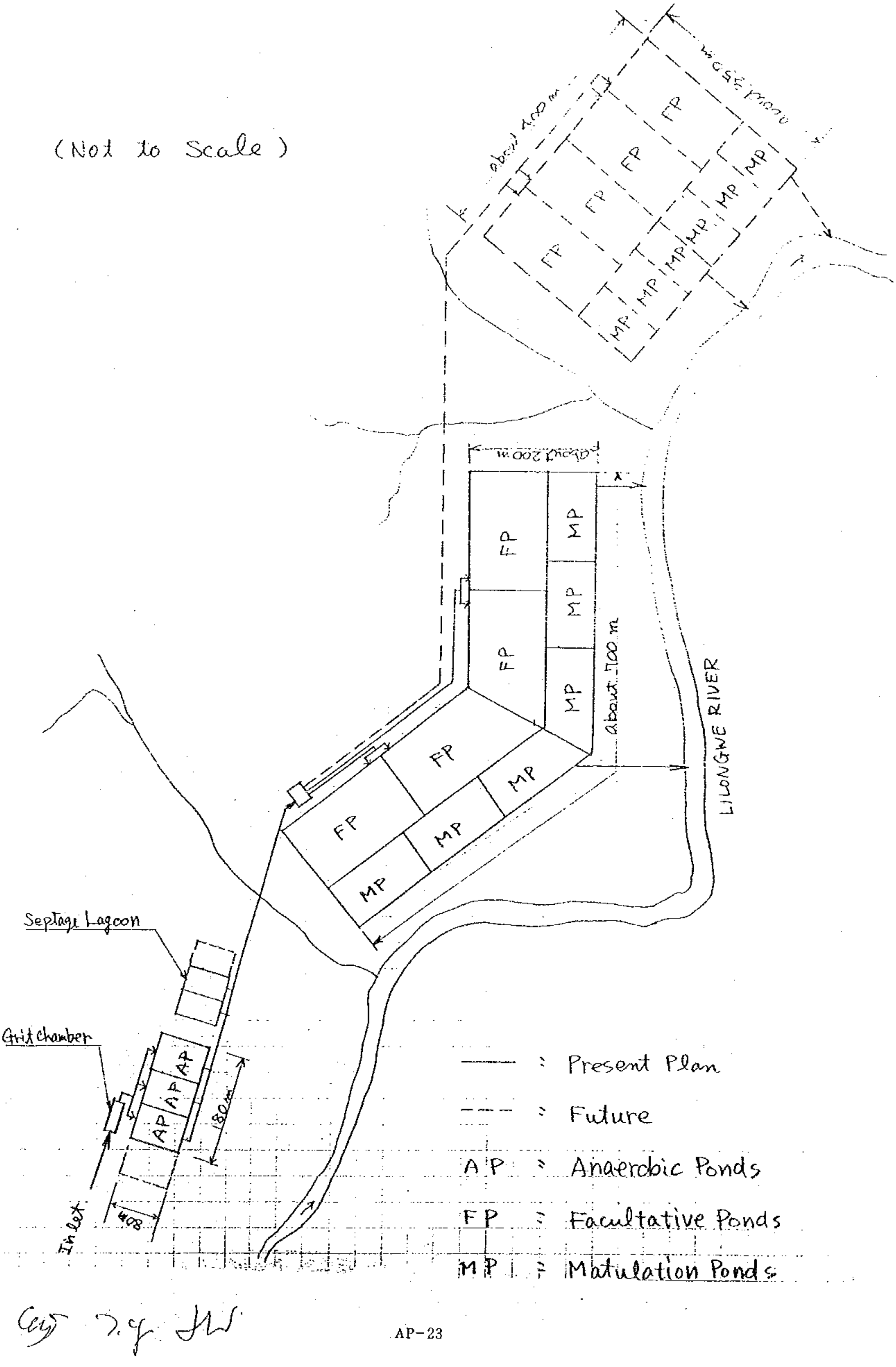
It was agreed that the construction of house connections and fencing of the plant should be undertaken by the Malawi side. However, due to the number of connections (more than 3,000) and the length of the fence (around 2 km), the construction cost for them will be very high. Considering this situation, the Malawi side would like to apply that the construction of these components be included in the Grant Aid.

ANNEX I ALIGNMENT OF TRUNK MAINS

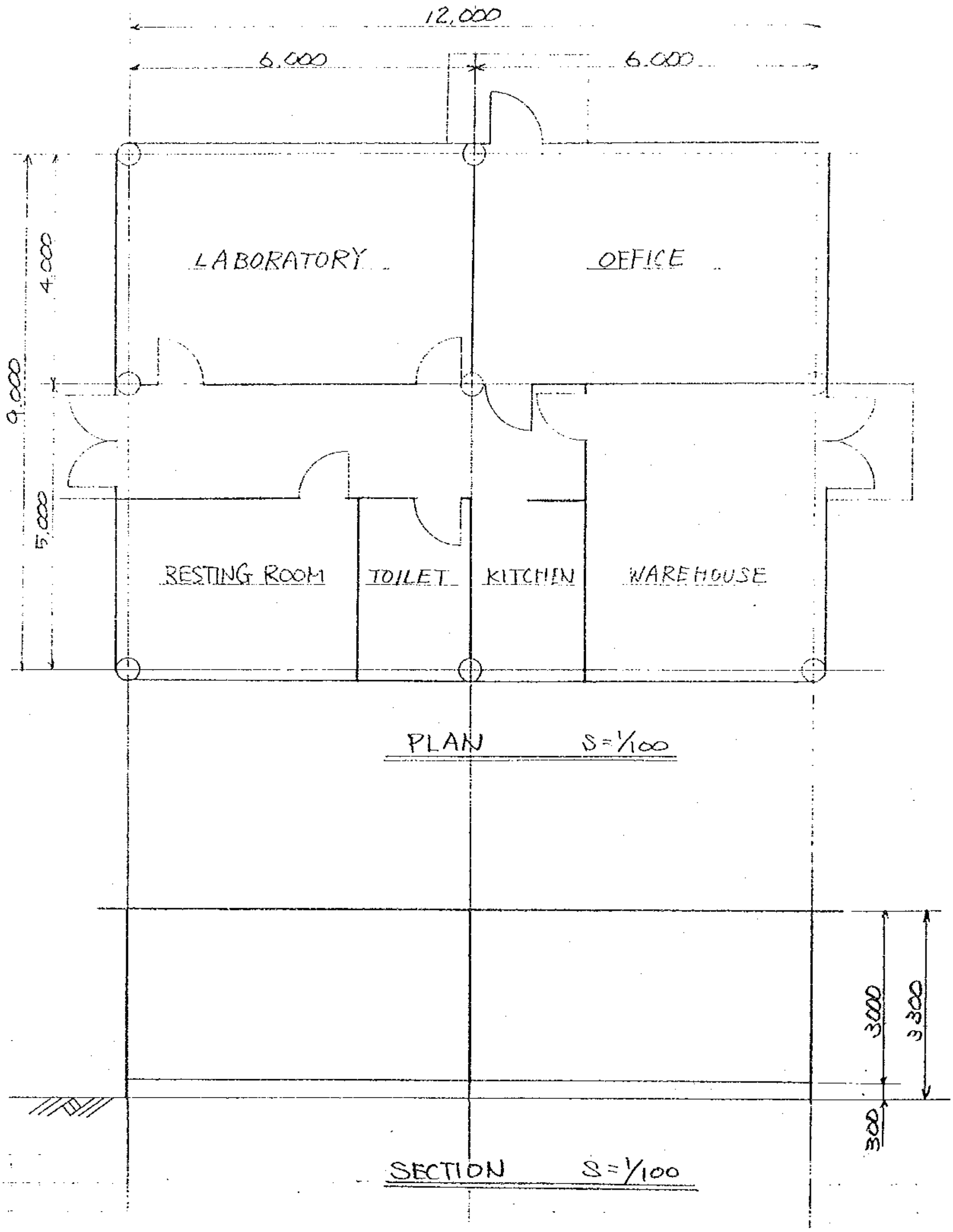


TOTAL LENGTH Approx. 17,400m
(F/S 17,500m)

ANNEX II PLAN OF PROPOSED SEWAGE TREATMENT PLANT



ANNEX III PLAN OF ADMINISTRATION OFFICE AT PROPOSED STP (TENTATIVE)



MINUTES OF DISCUSSIONS
ON
BASIC DESIGN STUDY
ON
THE LILONGWE SEWERAGE PROJECT
IN
THE REPUBLIC OF MALAWI
(CONSULTATION ON DRAFT REPORT)

In August, 1993, the Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a Basic Design Study team on the Lilongwe Sewerage Project (hereinafter referred to as "the Project") to the Republic of Malawi, and through discussions, field survey, and technical examination of the results in Japan, has prepared the draft report of the study.

In order to explain and to consult the Malawi side on the components of the draft report, JICA sent to Malawi a study team (herein after referred to as "the Team"), which is headed by Mr. Hideo MIYAMOTO, Deputy Director, First Basic Design Study Division, Grant Aid Study and Design Department, JICA, and is scheduled to stay in the country from November 30 to December 3, 1993.

As the result of discussions, both parties confirmed the main items described on the attached sheets.

Lilongwe, December 3, 1993

Mr. Hideo MIYAMOTO
Leader
Basic Design Study Team
JICA

Mr. Francis K. Mfune
Town Clerk and Chief Executive
Lilongwe City Council

IN WITNESS WITH:

Mr. B. S. Phangaphanga
Principal Secretary
Ministry of Local Government

Mr. J. M. Mhango
Senior Assistant Secretary
Ministry of Finance

ATTACHMENT

1. Components of Draft Report

The Government of Malawi has agreed and accepted in principle the components of the draft report proposed by the Team.

2. Project Area

The area of the Project is a part of Lilongwe City, as shown in Annex I.

3. Japan's Grant Aid System

(1) The Government of Malawi has understood the system of Japanese Grant Aid explained by the Team.

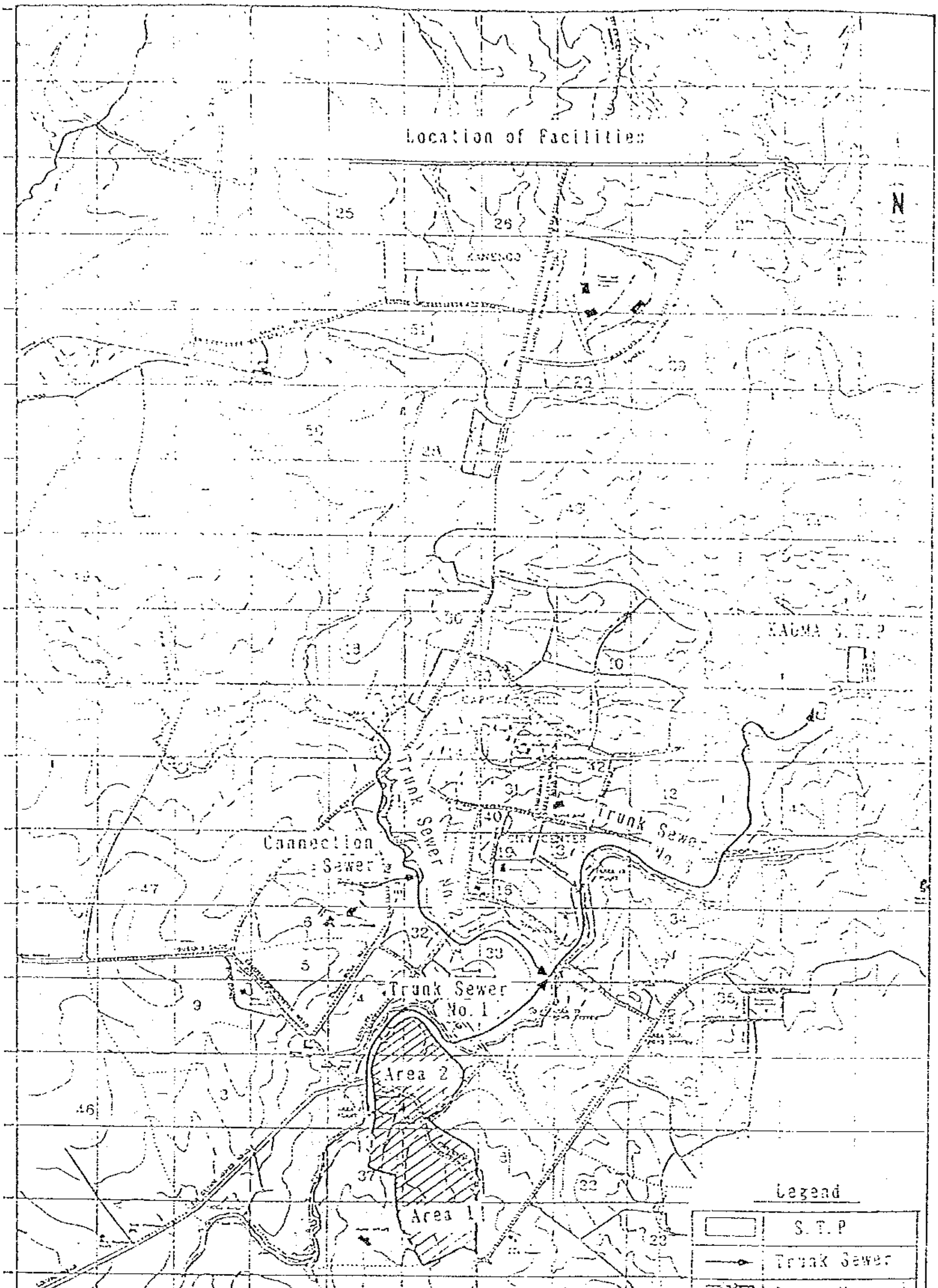
(2) The Government of Malawi will take the necessary measures, described in Annex II, for smooth implementation of the Project, on condition that the Grant Aid Assistance by the Government of Japan is extended to the Project.

4. Further Schedule

The Team will make the final report in accordance with the confirmed items, and send it to the Government of Malawi around February, 1994.

U. M. JMM

ANNEX I PROJECT AREA



ANNEX II

NECESSARY MEASURES TO BE TAKEN BY THE GOVERNMENT OF MALAWI IN CASE JAPANESE GRANT AID ASSISTANCE IS EXECUTED

Necessary measures to be taken by the Government of Malawi in case Japanese Grant Aid Assistance is executed to the country are:

1. To provide data and information necessary for the Project,

2. To secure the sites for the Project,

3. To clear the treatment plant site and trunk sewer routes, and to construct the access to the site prior to the commencement of the construction,

4. To undertake incidental outdoor works such as gardening, fencing, gates and exterior lighting within and around the site,

5. To provide facilities to the treatment site, such as:
   1) water supply,
   2) distribution of electricity and telephone line,
   3) general furniture such as tables, chairs, and others for the completed facilities,

6. To bear the commission to the Japanese foreign exchange bank for the banking services based upon the banking arrangement,

7. To exempt taxes and to take necessary measures for custom clearance of the materials and equipment brought for the Project at the port of disembarkation,

8. To exempt Japanese nationals from custom duties, internal taxes and other fiscal levies which may be imposed in Malawi with respect to the supply of the products and services under the verified contracts, and

9. To bear all the expenses other than those to be borne by the Grant, necessary for the construction of the facilities as well as for the transportation and installation of the equipment.