can naturally be collected to the pumping station by sewer networks which are to be provided by the developer.

Patte d'Oie subzone has been fully developed and sewered. There is no pumping station and all wastewater is collected by gravity sewers and connected to the main collector along the Autoroute.

There are no sewer networks in the three new development subzones, viz. Nord Foire, Stadium and East to Patte d'Oie.

4.2 SEWERAGE PLANNING

4.2.1 Basis for Sewerage Planning

The sewerage system proposed for the Parcelles Assainies and Its Surroundings sewerage zone under the Master Plan was reviewed based on the newly collected data, field reconnaissance and detailed study. Basis of the sewerage planning, such as limits of the sewerage service area, development plans, and criteria for planning and preliminary design, has been established through discussions with Senegalese counterpart staff and various agencies concerned.

It was found that sewer networks can not be planned in the three new development subzones because detailed road network plan is not available. Even the development plan for the Nord Foire subzone can not be used for the planning purpose. However, wastewater flows from the three subzones are taken into account in the preliminary design of the major sewerage facilities, such as secondary collectors and wastewater treatment plant because these should be accommodated by the proposed facilities in the future.

The sewerage facilities proposed in this chapter, therefore, have enough capacities to collect, treat and dispose of all the wastewater flow envisaged in the study area in 2010.

4.2.2 Wastewater Flow

Populations and wastewater flow of the study area at present (1993) and in 2010 projected under the Master Plan are as follows.

Year	1993	2010
Population	159,618	260,696
Sewered Population	51,306	167,237
Connection Ratio (%)	32.1	64.1
Wastewater Flow (m3/day)		
Actual (Collected by sewerage)	3,169	23,946
Total (Generated)	11,360	39,383
Peak Flow (Generated)	22,720	78,762

For the design of sewer pipes and pumping stations, total wastewater flow (peak flow) which is generated in an area is used, while actual wastewater flow which is considered to be actually collected by the sewerage system in 2010 is used for treatment plant design.

Wastewater flow in 2010 presented above include the flow from the small bore sewerage systems in two neighboring areas, viz. Grand Medina and Camberene village. Although small bore sewer system is not planned in the study, wastewater flow can readily be accepted to the nearest sewer networks in the sewerage service area. Wastewater flows are as follows.

Wastewater Flow from Small Bore Sewer System (2010)

(unit: m3/day)

Area	Actual	Total	Peak
Grand Medina	234	1,562	3,125
Camberene Village	229	2,286	4,571
Total	463	3,848	7,696

For the design of sewer pipes and pumping stations, the peak flow is used. The following unit flow per area is calculated to be used for this purpose.

Unit wastewater flow for sewer pipe and pumping station design
78,762 / 820 = 96.1 (m3/day/ha)
(0.00111 m3/sec/ha)

For the design of the wastewater treatment plant, the actual flow of the daily average basis is used. Wastewater flow in the study area will increase from 3,169 m3/day in 1993 to 23,946, i.e. an increment of 20,777 m3/day. Taking the existing design capacity of and wastewater flow to the Camberene WWTP into account, additional two process trains will be required to treat increased wastewater flow.

4.2.3 Wastewater Treatment and Disposal

Wastewater from the sewerage zone is to be treated at the Camberene WWTP. The existing facilities have been put into operation in 1989. The plant is designed as biological secondary treatment by the activated sludge process with sludge treatment by anaerobic digestion and sand drying beds. The treated effluent is disinfected by chlorination and pumped through a force main and finally discharged to the sea at Camberene village.

The same treatment and disposal system should be adopted for the proposed system from public health and environmental protection view point. Although facilities for the reuse of the treated effluent is not planned in the study, this should be considered in the future.

4.3 FACILITIES PLANNING

4.3.1 Basic Concept for Facilities Planning

The following two notions are considered as a basic concept for the sewerage facilities planning.

- Existing facilities should be utilized to the maximum extent possible
- New facilities should be the most economical ones

There are the following existing sewerage facilities in the zone. Although some of them cause occasional problems, they are generally functioning properly. Therefore, the existing facilities should be used as long as they do not conflict with the proposed system for the economy of the project.

Existing Sewerage Facilities

- Sewer networks in many subzones
- Nine pumping stations
- A gravity collector along the Autoroute
- Camberene WWTP including a force main and gravity pipe for effluent discharge

In order to find out the most economical facilities, some alternative plans are developed and evaluated. These are explained in the following sections.

4.3.2 Examination of the Existing Facilities

1) Existing Gravity Collector along the Autoroute to the Camberene WWTP

Downstream sections of the existing gravity collector along the Autoroute from the Camberene WWTP to the neighborhood of Grand Medina, the length 2,463 m, can be used for transfer of wastewater from western part of the sewerage zone consisting of most of Pacelles Assainies, Djily Mbaye, Nord Foire, Stadium and Patte d'Oie subzones. Plans and profiles of the collector were obtained, and the capacity of the collector was examined as shown in Figure B.4.2. The smallest capacity is found to be 1.072 m3/sec in the upper most section. The flow rate of western part of the zone is 0.654 m3/sec. Present peak flow to the Camberene WWTP is approximately 0.1 m3/sec (altogether). If wastewater flow from the other areas increases, e.g. double or triple, the capacity is well over the combined flow rate. The collector is, therefore, considered to have sufficient capacity.

2) Branch Sewers

SONEES has established a sewer network plan to cover all the houses in seven (7) subzones of Parcelles Assainies, viz. Nos. 1 to 7. Diameter of the sewer pipes is 250 mm and they have generally enough gradient, more than 5 in thousand. In general, these branch sewers have enough capacity for the design flow because of the limited contributing service areas.

The capacity of the some sections which have large contributing service areas, however, may not have enough capacity in the future. In this respect, capacity of the sewer pipes has been examined by using the unit flow rate mentioned previously. It is found, as the result of the examination, that some sections may fall short capacity. Improvement of the existing sewer pipes is, therefore, one of the important factors in the preliminary designing of the proposed system. The proposed system resolves the problem, which is described later in Section 4.4.3.

3) Pumping Stations

As mentioned previously, there are nine (9) pumping stations in Parcelles Assainies and a neighborhood area. Pumping stations form a network system as schematically shown in Figure B.4.3. As shown in the figure, the system can be said to be a relay system. Wastewater collected by a pumping station is sent to the nearest pumping station and finally collected to P/S Unite 13. In this system, for instance, wastewater generated in the service area of the P/S Unite 9 is pumped three times before being discharged to the collector, first by P/S Unite 9, second by P/S Unite 15, and third by P/S Unite 13. This system causes overload problem to two pumping stations. In addition, this system is regarded as wasteful system from energy consumption view point.

For the improvement of the system, capacity of each of the existing pumping stations was evaluated based on the future design flow which is generated in its individual service area. The results are shown below.

Pumping Station	A: Existing Capacity (l/s)	B: Design Flow (l/s)	B/A
P/S Unite 15	20	144	7.20
P/S Unite 17	5	6	1.20
P/S Unite 22	21	21	1.00
P/S Unite 13	53	71	1.34
P/S Unite 9	15	21	1.40
P/S Unite 7	24	61	2.54
P/S Unite 2	16	76	4.75
P/S Unite 23	12	28	2.33
P/S Djily Mbaye	35	51	1.46

Capacities of the existing pumping stations do not match the design flow except P/S Unite 22. However, taking into account the fact that connection ratio will not reach 100 % by 2010, i.e. 64 % on the average, three other pumping stations, viz. P/S Unite 17, P/S Unite 13, and P/S Unite 9, most likely, need not increase their capacity before 2000, if their design flows are limited to those of their own service area.

Among the four pumping stations mentioned above, three pumping stations, except P/S Unite 13, are pumping wastewater of their own service area at present. If P/S Unite 7 and P/S Unite 22 can be disconnected from P/S Unite 13 and independently connected to the new collecting system, wastewater to be pumped by P/S Unite 13 is limited to that of its own service area. In this case, pumping station P/S Unite 13 need not increase its capacity. Therefore, disconnection of P/S Unite 7 and P/S Unite 22 should be considered.

Although difference between design flow and pumping capacity is not large for P/S. Djily Mbaye, pumping capacity should be increased before 2010 as housing development proceeds because connection ratio is always 100 % in the subzone. Pumping capacities of the remaining four stations, viz. P/S Unite 15, P/S Unite 7, P/S Unite 2, and P/S Unite 23, should also be increased even before 2000. Particularly, for two pumping stations, viz. P/S Unite 15 and P/S Unite 2, not only the replacement of pump units but also construction of new pumping stations is considered necessary.

Additional two new pumping stations are, therefore, proposed, one for P.A. P/S Unite 15 and another for P.A. P/S Unite 2. In P.A. P/S Unite 15 subzone a new pumping station is proposed in the vicinity of the existing P/S Unite 15. Total capacity of P/S Unite 15 and the new pumping station should include flow from P/S Unite 9 because disconnection of the pumping station from P/S Unite 15 is found to be uneconomical. In P.A. P/S Unite 2 subzone, a new pumping station is proposed not in the vicinity of the existing one but in the center of the subzone so that the existing branch sewers some of which have insufficient capacities for the design flow can be utilized without any modification. The capacity of the new pumping station should be design flow less the existing capacity.

A new pumping station is needed in North to Stadium subzone near the lowest point . Design flow for the station is 63 l/sec.

With considerations mentioned above, a new pumping station network is proposed which is shown schematically in Figure B.4.4.

In addition to the above, at least one new pumping station will be needed in Nord Foire to connect to the new collector because of the topography, although its location can not be determined at present, and therefore its construction is not included construction program.

4) Wastewater Treatment Plant

There is one process train of which capacity is 9,600 m^3/day on daily average basis with raw sewage BOD and SS concentrations of 625 mg/l and 938 mg/l, respectively. Design parameters of the main facilities of the original design compared with the current design are as follows.

Design Parameters (for one process train)

	Original Design	Current Design
Daily Average Flow (m3/day)	9,600	10,000
Peak Flow (m3/day)	16,800	20,000
Raw Sewage BOD (mg/l)	625	380
SS (mg/l)	937	410
Treated Effluent (24 hr. average)		
BOD (mg/l)	20	20
SS (mg/l)	30	30
Main Pump		
Capacity (m3/hr)	700	830
Grit Chamber (aerated)		
Retention Time (min.)	29.7	28.5
Primary Sedimentation Tank		
Retention Time (hr.)	2.38	2.28
Surface Loading (m3/m2/day)	27.7	28.8
Aeration Tank		
Retention Time (hr.)	11.2	10.9
Final Sedimentation Tank		
Retention Time (hr.)	4.6	4.4
Surface Loading (m3/m2/day)	16.7	17.5
Chlorination Tank		
Retention Time (min.)	30	28.8
Sludge Digester		
Retention Time (first stage, day)	12	27.4
Retention Time (second stage, day)	9.5	21.7

As presented above, design parameters of the main facilities are still within the normal range if the wastewater flow increases from 9,600 m3/day to 10,000 m3/day. Detailed investigation of the other design parameters confirmed this too. Therefore, it is considered desirable that the design of the additional two process trains is the same as that of the existing facilities, taking into account advantages such as ease of operation, interchangeable spareparts and so on.

Civil structures of the some facilities, including main pump house, grit chamber, and chlorination tank have been constructed to accommodate the flow from the second stage (additional 9,600 m3/day). The second stage sludge digester also has enough capacity to receive digested sludge from two first stage digesters. These should be utilized with the necessary modification or provision of mechanical and electrical equipment. This will be described later in Section 4.4.3.

5) Force Main and Gravity Pipe for Effluent Discharge

There exists a force main and gravity pipe with diameter 600 mm from the Camberene WWTP to the ocean outfall for effluent discharge. The lengths of force main and gravity pipe are approximately 900 m and 1,800 m, respectively.

The capacity of the force main has been examined. It was revealed that the force main has enough capacity for the peak flow from the two process trains, i.e. approximately 40,000 m3/day. However, the capacity is not enough for the peak flow from the three process trains, i.e. approximately 60,000 m3/day. Higher velocity, approximately 2.5 m/sec, results in excess pumping head. Therefore, an additional force main is needed when the third train is put into operation.

Taking into consideration the continuous operation and further expansion of the treatment plant, construction of a new force main with diameter 900 mm which is capable to cope with the total peak flow from the three trains is proposed. Gravity pipe with the same diameter to follow the force main is also proposed.

4.3.3 Proposed Sewerage System

In order to find out the most appropriate sewerage system, two alternative systems composed of the major sewerage facilities, such as secondary collectors, pumping stations and force mains, are developed.

Alternative A: There are three secondary collectors, viz. western, central and eastern. The western collector receives wastewater flow from Djily Mbaye P/S, P/S Unite 23 and a new pumping station in North to Stadium subzone through a force main connecting these three pumping stations to the collector. Wastewater from the Nord Foire subzone will be received at the same starting point. Wastewater flows through the collector by gravity to the upper end of the existing main collector. The collector also receives wastewater flow from Stadium subzone en route.

The central collector receives wastewater flow from P/S Unite 15, the new P/S Unite 15, P/S Unite 17, P/S Unite 13 and P/S Unite 22 at its starting point. The collector runs along the main road westward and then southwestward between Grand Medina and Patte d'Oie and finally connects to the existing main collector. The level of the road between Grand Medina and Patte d'Oie is lower than that of the Autoroute, and the wastewater flow can not gravitate to the existing main collector. Therefore, one pumping station is needed to lift the wastewater.

The eastern collector receives wastewater flow from P/S Unite 7, P/S Unite 2 and new P/S Unite 2 at its starting point, and runs southward to the Camberene WWTP. Wastewater flow from the three pumping stations are sent to the collector by new force mains.

Alternative B: There are two secondary collectors, viz. western and central/eastern. The western collector is the same as that for Alternative A.

The central/eastern collector runs eastward from its starting point and joins the former eastern collector at near the roundabout, and runs southward to the Camberene WWTP.

Two alternatives are shown in Figures B.4.5 and B.4.6.

Construction costs for the two alternatives are estimated as shown below based on the preliminary design.

Construction Cost of Two Alternatives

(unit: 1,000 FCFA)

Facility	Alternative A	Alternative B
Western Collector	467,710	467,710
Central (/Eastern) Collector	386,340	896,080
Pumping Station	2,191,000	-
Eastern Collector	373,430	-
Total	3,427,480	1,372,790

Construction cost of Alternative B is far less than that of Alternative A because a relatively large pumping station is unnecessary. In addition to the less expensive construction cost, there is obviously an advantage for Alternative B, i.e. less operation and maintenance cost because of elimination of the pumping station. Thus, Alternative B is proposed as the new sewerage system.

4.4 FACILITIES DESIGNING

4.4.1 General

Preliminary design has been carried out for the main sewerage facilities including pumping stations, secondary collectors, wastewater treatment plant, a force main for effluent discharge and an ocean outfall.

Design criteria proposed in the Master Plan were used for the preliminary design of the facilities.

Construction materials and methods which have been readily available in Dakar and adopted for the existing sewerage systems are considered to be applied. There are no facilities which require special construction method except for an ocean outfall. Laying pipes in a ditch on the sea bed for ocean outfall requires some special construction methods. This will be described in the following section.

4.4.2 Pumping Stations

As mentioned in Section 4.3.2, three new pumping stations should be constructed. Design capacities of the pumping stations are as follows.

Name of P.S.	Design Capacity (l/s)
New P/S Unite 15	145
New P/S Unite 2	60
New P/S North to Stadium	63

Dry pit type with centrifugal pumps is proposed for the new P/S Unite 15 because of a relatively large design flow. Three pump units including one standby are to be provided. Plan and section of the pumping station is illustrated in Figures B.4.7 and B.4.8. For the remaining two pumping stations, submersible type pumping station is proposed. Taking into account small design flow, each pumping station is to be provided with two pump units including one standby. Plan and section of these pumping station are illustrated in Figure B.4.9.

Pump units of the existing pumping stations should be replaced to meet the following requirements, while the existing civil structures of these pumping stations should be utilized.

Name of P.S.	Design Capacity (l/s)
P/S Unite 15	20
P/S Unite 17	6
P/S Unite 22	21
P/S Unite 13	71
P/S Unite 9	21
P/S Unite 7	61
P/S Unite 2	16
P/S Unite 23	28
P/S Djily Mbaye	51

One Diesel engine driven generator unit is proposed to be provided to each station for continuous operation when pump unit is replaced.

In order to catch malfunctioning of pumping stations as soon as possible, introduction of a remote monitoring system is desirable. Several systems are available depending on the requirements of monitoring and controlling. These systems usually consist of sensors in pumping stations and displays and recorders in the center connected by telephone lines. Installation cost of the systems varies depending on the number of pumping stations and monitoring items, and kinds of display and recording equipment. Public telephone line or exclusive line can be used for transmitting signals. Operation cost of the exclusive line which is more reliable, is, in general, more expensive.

The simplest system sends signals to the center when malfunctioning of a pumping station occurs. Then, the signals which indicate power failure, stopping of pumps or extraordinary water levels, are displayed in the center. The installation cost of the simplest system in Japan is approximately 2 million FCFA per pumping station and 25 million FCFA per central unit. Thus, if the system is introduced to the proposed sewerage system, the total construction cost is 49 million FCFA as shown below.

Installation Cost of Remote Monitoring System

Pumping station	12 x 2	=	24
Center (Camberene WWTP)	1 x 25	=	25
Total			49 (million FCFA)

4.4.3 Secondary Collectors

Secondary collectors are designed based on the Alternative B described in Section 4.3.3. Results of the leveling survey were used in the hydraulic calculations of pipes. Hydraulic calculations are shown in tables in Data Book . Plans and profiles of the collectors are shown in Figures B.4.10 and B.4.11.

Secondary collectors are defined for the preliminary design purpose as those which have contributing service areas of more than 20 ha. The existing branch sewers which have insufficient capacities for the design flow mentioned in Section 4.3.2 have contributing service areas of more than 20 ha. Therefore, some sections of the secondary collectors proposed include replacement of the existing sewers.

4.4.4 Wastewater Treatment Plant

As proposed in the Master Plan, the Camberene WWTP will have design capacity of 100,000 m3/day in 2010. The facilities are so arranged that staged construction can be carried out to cope with the gradual increase of inflow. There are ten (10) process trains each having 10,000 m3/day capacity. A general plan is shown in Figure B.4.12.

As mentioned in Section 4.3.2, two process trains, each of these has the same sizes as the existing one are to be constructed by two stages. The two trains should be constructed in parallel with the existing one within the boundary of the present site. Civil structures of the main pump house, and grit chamber need not to be constructed for the second train because the existing ones have provisions for two process trains. Also, the chlorination tank have enough capacity to treat effluent from the three process trains. The second stage sludge digester needs not to be constructed for the second train. The main treatment facilities for the second and the third trains to be constructed are as follows.

Main Facilities	Second Train	Third Train
Pump House (civil)	No	Yes
Pump Unit (mech.)	Yes	Yes
Grit Chamber	No	Yes
Primary Sedimentation Tank	Yes	Yes
Aeration Tank	Yes	Yes
Final Sedimentation Tank	Yes	Yes
Chlorination Tank	No	No
Sludge Digester (1st)	Yes	Yes
Sludge Digester (2nd)	No	Yes
Sludge Drying Bed	No	Yes

A boring survey conducted by the Study Team with a depth of 30 m at the point next to the existing facilities revealed that soil conditions are good and no special foundations such as piling are not needed.

Ancillary works such as administration building, workshop, and many other small buildings are not needed for the expansion of the treatment plant.

4.4.5 Force Main, Gravity Sewer and Ocean Outfall for Effluent Discharge

Ductile cast iron pipe (DCIP) is recommended for the force main because of large diameter (900 mm) and water head. Reinforced concrete pipe (RCP) is recommended for the gravity pipe. These pipes should be installed in parallel with the existing ones.

A new junction pit is to be constructed near the existing manhole at the coast of the Camberene village. Provision for connection to the existing manhole and future expansion should be considered.

From the junction pit, a pipe line with diameter 900 mm and length about 200 m is to be laid in a ditch on the sea bed. Steel pipe with external lining against erosion is recommended for pipe material. Plan and section of the pit and outfall pipe are shown in Figure B.4.13.

4.5 Construction Plan and Cost Estimate

4.5.1 General

Construction works for the sewerage facilities includes earth work, concrete work, pipe work, mechanical/electrical work and miscellaneous work.

These works, in general, will be executed by ordinary construction methods using construction equipment readily available in Dakar.

Major works are planned to be carried out with mechanical equipment for smooth and economical performance. However, in order to enhance employment opportunity, man power will be used to the maximum extent wherever possible.

4.5.2 Construction Plan

1) Target Year

The target year of the project is set at the year 2000. However, some of the construction works can not be completed by 2000, e.g. provision of the branch sewers in the already developed but not sewered areas such as Parcelles Assainies. Therefore, the following assumptions are made for cost estimation and implementation schedule.

a. Provision of Branch Sewers

Half of the planned branch sewers in the seven subzones (Nos. 1 to 7) of Pacelles Assainies will be constructed by 2000. The other two subzones of Parcelles Assainies (P.A. P/S Unite 23 and North to Stadium) will be provided with branch sewers so as to raise the connection rate to about

25 %. The three new development subzones (Nord Foire, Stadium and East to Patte d'Oie) will be fully sewered by 2000.

b. Pumping Stations

All three new pumping stations will be constructed by 2000. For the replacement of pump units, five pumping stations (Unite 15, Unite 2, Unite 7, Unite 23, and Djily Mbaye) should be completed.

c. Camberene WWTP

Additional two process trains will be completed by 2000. Although wastewater flow from the study area will not reach design flow, expansion of the Camberene WWTP should be kept pace with the increase of total inflow, because the plant is to receive wastewater from the other areas. However, completion date of the additional trains, the third train in particular, should be reviewed carefully at later stage of the implementation because a sizable amount of investment is necessary for construction.

d. Other Facilities

All other facilities not mentioned above are to be constructed by 2000.

2) Conditions of Construction Sites

Construction sites for the proposed sewerage facilities are located in and around Parcelles Assainies area. There is no difficulty to transport materials and equipment because the area has been urbanized and road networks have been provided adequately. There is neither difficulty in obtaining water and electricity for construction.

Construction sites can be reached within a reasonable short time from offices of Ministry of Hydraulics and SONEES. The location of the Camberene WWTP is most suitable for the supervision of the construction works. Therefore, no special arrangement is necessary.

3) Pipe Laying Work

Various types of pipes are to be laid under roads or roadsides. Construction cost for pipe laying work varies significantly depending on the construction methods which are in turn depending on the conditions of the site, such as soil characteristics, level of groundwater table, traffic conditions and so on. Taking into account these conditions in the study area, all pipe laying works are proposed to be carried out by open-cut methods. Typical methods for pipe laying works are shown in Figure B.4..14.

A special construction method is necessary for laying the ocean outfall pipes. There are a few construction methods available for laying pipes on sea bed. A method which is so-called tug-floating-pipe method is considered most suitable for the site conditions and pipe size. In this method, steel pipes are welded on a pipe yard constructed temporarily at the site, then tugged by a boat to the end point. While the welded pipe is tugged, it floats on the surface of water by pontoons fixed to the pipe. Excavation of ditch can be carried out either before or after laying the pipe.

4.5.3 Cost Estimate

1) Basis for Cost Estimates

The project cost is composed of the same components as described in Section 3.5.1 of the Master Plan. Components and their estimation are as follows.

Project Cost Components and Their Estimation

1. Direct Construction Cost:	Based on the preliminary design of each facility
2. Land Acquisition Cost:	Land area and unit land price
3. Engineering Cost:	10 % of direct construction cost
4. Government Administration Cost:	1.5 % of direct construction cost

5. Physical Contingency: 10 % of direct construction cost

All costs are indicated at March 1994 price level, i.e. prices after devaluation of FCFA.

Direct construction costs are estimated mainly based on the preliminary design of the following sewerage facilities. Although cost for the house connection is to be paid for by the beneficiaries and therefore is not a part of the project cost, it is presented here so as to get an idea of the magnitude of expenses borne by the beneficiaries.

Components of Sewerage Facilities for Cost Estimates

1. House Connection
2. Branch Sewer
3. Pumping Station (Construction of New Pumping Stations and Replacement of Pump Units of the Existing Pumping Satins)
4. Force Main (from Pumping Station)
5. Secondary Collectors
6. Expansion of Camberene WWTP
7. Force Main and Gravity Pipe for Effluent Discharge, and
8. Outfall

2) Direct Construction Cost

Direct construction costs for the above facilities are as follows.

1. House Connection	3,328,710
2. Branch sewer	5,212,454
3. Pumping Station	495,500
4. Force Main	802,550
5. Secondary Collectors	1,548,005
6. Camberene WWTP	4,485,157
7. Force Main for Discharge	1,110,600
8. Outfall	308,440
Total 2 to 8	13,962,706 (1,000 FCFA)

Direct construction costs shown above include the costs for the necessary preparatory works and miscellaneous works. The total direct construction cost for the project is 13,963 million FCFA, of which breakdown is shown in Table B.4..1.

3) Project Cost

The total project cost is 16,958 million FCFA, and its breakdown is shown in Table B.4..2. Of the total project cost, 5,668 million FCFA or 33 % is local currency portion, and the remaining 11,290 million FCFA or 67 % is foreign currency portion.

4) Operation and Maintenance Cost

Increase of the operation and maintenance cost for the sewerage facilities proposed for the study area in 2000 is estimated in the same manner described in Section 3.6.3 of the Master Plan. It is 392 million FCFA annually, and its breakdown is shown in Table B.4..3.

4.6 IMPLEMENTATION PROGRAM

Implementation schedule up to the year 2000 has been developed taking into consideration a period required for the necessary preparatory works, such as survey, design and contract process. The schedule is shown in Figure B.4.15, and cost break down according to the schedule is shown in Table B.4..4.

4.7 ORGANIZATION AND MANAGEMENT

4.7.1 IMPORTANT ORGANIZATIONAL/INSTITUTIONAL ISSUES AND RECOMMENDATIONS

In Chapter 3 the JICA Study Team presented recommendations regarding organizational and managerial aspects of the wastewater master plan project. They are summarized below.

a. The government will take measures so that households which cannot afford to pay sewerage connection fee will be provided a loan at a low interest rate. This is to rectify the existing situation where connection rate to sewerage in the sewered areas is low, making a big investment in the sanitation facilities partially useless.

b. Sewerage charge will be revised in the upward direction step by step so that SONEES can recover capital cost of sewerage projects as well as operation and maintenance cost. The existing situation is that sewerage charge can meet only the cost of operation and a part of maintenance.

c. Institutional revision will be made so that SONEES can plan and execute the sewerage project. By doing so the sewerage sector will be given the same status as the water supply sector. The existing situation is that the government plan and execute the sewerage project and SONEES is assigned only the operation and maintenance of sewerage facilities by the government.

d. The organization related to sanitation in SONEES will be given more importance. It will be structurally revised to accommodate more advanced and diversified functions and roles. At the same time reinforcement in personnel will be done. The existing sanitation organization in SONEES accounts for only 6.8% of the total manpower of the organization.

e. Coordination Committee will be set up to avoid economic losses, people's sufferings and environmental impacts in implementing a sanitation project. It will be composed of the representatives of ministries concerned. Lack of coordination between related organizations was strongly voiced and resultant economic losses were cited by the officials concerned.

f. A law establishing quality standards of industrial effluents that are allowed to be discharged will be introduced. Also, exemption of duties in the acquisition of anti-pollution equipment will be provided in a law. The existing worsening environmental situation demands such legal measures.

g. Reuse of treated wastewater for agriculture and industry will be promoted to reduce the cost of agricultural and industrial products.

The above recommendations can be applied too in connection with the wastewater priority project. In general terms they are applicable item by item to the priority project. In specific terms some items need quantitative explanation and clarification that suit the priority project.

Regarding item b., the upward revision of sewerage charge is proposed to be done in the following way:

Average sewerage charge

Up to 2000	:	6.1% of water supply charge or 21.01 FCFA/m^3
From 2001 to 2010	:	12% of water supply charge or 48.23 FCFA/m^3
From 2011 on	:	14% of water supply charge or 55.12 FCFA/m^3

Note: The per cubic meter charge is based on the actually collected water supply charge.

As the financial resources will be probably provided from the external source in the form of grant, the lending terms from the government to SONEES or an equivalent organization will be softer than those proposed in the master plan study. For this reason the average sewerage charge from 2011 onward will be lower than the one proposed in the master plan study.

Regarding item d., it was recommended in the master plan study that the existing sanitation organization in SONEES which is in charge of operation & maintenance alone be reorganized in future so that it will encompass the planning, construction, pollution control, operation & maintenance, administration and finance functions. It was also recommended that the personnel concerned be increased from the present 100 to 250 in 2010.

So far as the priority project is concerned, the immediate need for additional personnel will be:

Additional personnel need

Camberene Wastewater Treatment Plant	:	24 persons
Pumping stations	:	3 persons
Cleaning of pipes	:	4 persons
Overheads	:	3 persons
TOTAL		34 persons

Note : The number of personnel for the Camberene Wastewater Treatment Plant includes the existing manpower.

4.7.2 Comment on Privatization of SONEES

It has passed several months since devaluation of FCFA was put into force. The general policy of the government nowadays seems to be more independence and self-determination of Senegal in the international economy and trade, and more independence and power of the private sector in the domestic economy. The government seems to consider that by pursuing such a policy the Senegalese economy can be revived and take a dynamic course to property.

Today people talk about the privatization of SONEES. They say that it will materialize in a few years.

They say privatization of SONEES will be done in such a way that SONEES will be separated into two organizations, i.e. one public corporation and one private company. The public corporation will be responsible for the planning and execution of water supply (and sewerage) projects. The private company will be in charge of the operation & maintenance of water supply and sewerage facilities and selling of water supply and sewerage services.

Another proposal is to further divide the public corporation into two: one for water supply and another for sewerage.

The JICA Study Team thinks that such an idea is completely in line with the team's philosophy. The privatization of SONEES is in complete accord with the team's recommendations regarding organizational/institutional matters in that both are motivated by and aim for financial streamlining and success in the water supply and sewerage "business".

Regarding the second proposal, the team considers that in the initial phase it will be hard for the sewerage public corporation to be an independent organization because it lacks experiences and know-how, but in a later phase it will be advisable for the public corporation to be separated into two so that they can compete with each other.

4.8 FINANCIAL ANALYSIS

If the wastewater priority project is decided to be implemented, it is probable that the financial resources for the project will be provided from the external source in the form of grant because of the urgent nature of the undertaking.

In such a case, the government of Senegal will not shoulder any financial burden. It can mean that the terms on which the government will provide the financial resources to the executing agency, i.e. SONEES or a corresponding sewerage organization should not be hard.

The JICA Study Team proposes along this line that the lending terms from the government to the executing organ in the priority project be softer than those proposed in the master plan study. At the same time, it proposes that the sewerage charge be lower from 2011 onward.

4.8.1 Financial Costs and Benefits

The total initial cost to be required for the implementation of the wastewater priority project is estimated at 16,958 million FCFA at the 1994 prices, of which the direct construction cost works out at 13,963 million FCFA. The implementation of the project is scheduled to start in 1995 and end in 2000, taking the duration of 6 years. The cost for the operation and maintenance of the facilities constructed under the project is estimated at 392 million FCFA per annum - to be referred to Table B.4.3.1, which constitutes 2.81% of the direct construction cost. The O & M cost incorporating that of the existing sewerage facilities will reach 809 million FCFA per annum.

The benefits of the project derive from the revenue from sewerage charge. The charge will be collected from the beneficiaries in the project area as well as in the existing sewerage areas. The extent of the revenue depends on the volume of the piped water to be consumed as well as on the sewerage tariff.

The average sewerage charge per m3 of the piped water consumed is proposed to be 41.34 FCFA (or 12% of the average water supply charge) in 2001 and 48.23 FCFA (or 14% of the average water supply charge) in 2011 at the 1994 prices on the actual collection basis. In 1994 it is calculated at 21.01 FCFA (or 6.1% of the average water supply charge).

The piped water to be consumed in the project area as well as in the existing sewerage areas in 1994, 2001 and 2011 is estimated at 31.650, 36.946 and 43.849 in million cubic meters respectively. The revenue in the respective years is, therefore, calculated at 599, 1,375 and 1,903 in million FCFA at the collection rate of 90%. (Refer to Table B.4.5.)

4.8.2 Projection of Financial Statements

1) Preconditions/Assumptions

The financial resources of the initial cost may be externally derived and probably provided in the form of grant. The major part of them will be lent by the government of Senegal to SONEES or a sewerage organization to be newly created.

The lending terms are proposed to be as follows:

a. Sources of initial cost

Government loan	:	60%
Government subsidy	:	40%

b. Terms of government loan

Annual interest rate	:	4%
Repayment period	:	25 years
Grace period	:	5 years

In order that SONEES or a sewerage organization may pay back the government loan it is proposed that the sewerage tariff be revised in the future years as shown below:

c. Average sewerage charge

Up to 2000	:	6.1% of water supply charge or 21.01 FCFA/m3
From 2001 to 2010	:	12% of water supply charge or 41.34 FCFA/m3

From 2011 on : 14% of water supply charge or 48.23 FCFA/m3

Note: The per cubic meter charge is based on the actually collected water supply charge.

In preparing projected financial statements including the income statement and funds statement further preconditions/assumptions were established:

d. Depreciation period

Sewerage facilities	:	50 years
Electro-mechanical equipment	:	15 years

e. Period of projection: 30 years

f. Annual rate of inflation: 2%

g. Rate of tax on corporate income: 30%

h. Source of operation & maintenance cost

Revenue from sewerage charge

i. Sewerage charge collection efficiency: 90%
(taking social tariff into account)

j. Source of replacement cost

Revenue from sewerage charge

2) Projected Financial Statements

Table B.4.6 shows the projected financial statements incorporating both income and funds statements for 30 years from 1995 up to 2024, prepared upon the above listed preconditions and assumptions. They are for the sanitation organization of SONEES or a sewerage organization to be newly created. The areas covered are the priority area as well as the existing sewerage areas. The table reveals that the organization will be sound and stable in terms of both earnings and solvency except initial few years.

4.8.3 Estimation of Financial Internal Rate of Return

Cost benefit streams were prepared for the proposed plan for the period of 40 years as shown in Table B.4.7. Using the streams the financial internal rate of return (FIRR) was calculated at 6.4%. This value is by 2.4% higher than the annual interest rate of the government loan. This margin (2.4%) is a little higher than 2% or the minimum rate of profit on the fixed assets employed as provided in the Second Contract and Plan between the Government and SONEES (Deuxieme Contrat-Plan Etat-SONEES). Therefore, the value of FIRR is judged to be a reasonable one.

4.8.4 Alternative Proposal

1) Alternative I

The government of Senegal has provided SONEES with the financial resources to be used for the construction of water supply facilities always in the form of loans. The idea of subsidizing water supply projects of SONEES has not been evident in the past probably because of the budgetary constraints of the government. This alternative takes such a practice into consideration.

(1) Preconditions/Assumptions

a. Source of initial cost
Government loan: 100%

b. Terms of government loan

Annual interest rate	:	2%
Repayment period	:	25 years
Grace period	:	5 years

c. Average sewerage charge

Up to 2000	:	6.1% of water supply charge or 20.01 FCFA/m3
From 2001 to 2010	:	14% of water supply charge or 48.23 FCFA/m3
From 2011 on	:	16% of water supply charge or 55.12 FCFA/m3

Regarding other preconditions and assumptions, they are the same as in the proposed plan.

As the above conditions show, the government of Senegal will provide SONEES or a new sewerage organization with the financial resources for the initial cost entirely as the loan. The average sewerage charge will be raised a little higher than in the proposed plan. It is to be noted, however, that households and establishments/institutions in the master plan study area are on average willing to pay as sewerage charge 24.7% and 18.7% of water supply charge respectively according to the result of the questionnaire survey. The sewerage charge under this alternative is, therefore, well within what people are willing to pay.

The revenue from the sewerage charge will cover the operation, maintenance, replacement and repayment cost.

(2) Financial Projections

Table B.4.8 shows the projected financial statements under Alternative I. It tells that SONEES or a new sewerage organization will have good earnings as well as be solvent during most of the 30 years excepting initial few years. Table B.4.9 shows the cost benefit streams for 40 years. Using the table FIRR was calculated at 4.8%. This value leaves 2.8% after setting aside 2% for the repayment of the loan. The value of FIRR is, therefore, judged to be a reasonable one for such a public organization as SONEES or its equivalent.

2) Alternative II

Financial resources may be provided from the external source probably in the form of grant. If that is the case, the government of Senegal will not shoulder any budgetary burden. Breaking the past rule and custom, the government can provide SONEES or a new sewerage organization with the financial resources entirely in the form of subsidy. SONEES hopes that such a thing will happen.

Under Alternative II the entire funds for the initial cost will be subsidized by the government. Also, the raising of the sewerage charge will be contained to the minimum.

(1) Preconditions/Assumptions

a. Source of initial cost

Government subsidy: 100%

b. Average sewerage charge

Up to 2000	:	6.1% of water supply charge or 21.01 FCFA/m3
From 2001 to 2010	:	7% of water supply charge or 24.12 FCFA/m3
From 2011 on	:	8% of water supply charge or 27.56 FCFA/m3

c. There will be no depreciation, nor repayment.

Regarding other preconditions and assumptions, they are the same as in the proposed plan.

As the above conditions shows, SONEES or a new sewerage organization will not have any obligations to pay back the financial resources provided by the government. That is to say, there will be no repayment, nor depreciation. However, there will arise the cost for operation, maintenance and

replacement. It will be met by the revenue from sewerage charge. The raising of the sewerage charge can be minimal as shown above.

(2) Financial Projections

At Table B.4.10 shows, SONEES or a new sewerage organization will take a sound and stable course in terms of earnings as well as solvency during most of 30 years excepting initial few years under this alternative.

4.9 PROJECT EVALUATION

4.9.1 Effect of the Priority Project

The priority project consists of:

i) Improvement of the present sewerage facilities, such as pumping station system, sewer networks and collectors in Parcelles Assainies areas (414 ha).

ii) Installation of sewer networks in the unsewered areas (306 ha).

iii) Expansion of the Camberene WWTP.

iv) Reconstruction of ocean outfall of the treated water from Camberene WWTP.

Improvement of the present sewerage system does not have any significant effect upon increase of the sewered population because it does not expand the sewered area. However, some of present sewerage system does not have enough capacity for the future projected population and increase of the connection ratios. Also the arrangement of the present pumping stations are not simple, causing an operational difficulty and higher operation cost. Therefore, the proposed improvement can resolve the present problems and problems expected in future.

Camberene WWTP is presently operated at the much less wastewater flow rate (3,000 to 4,000 m^3/day) than the designed (10,000 m^3/day). This is considered to be wasting the existing capacity of the facilities constructed, which has been pointed out as a big issue in the appraisal report by the African Development Bank. The priority project increases the wastewater flow to Camberene to 30,000 m^3/day, thus the project can immediately resolve the present problem of the low flow rate.

In the Mater Plan Study, higher priority was put to the expansion of the sewerage service when the Ouakam sewerage system was shifted out from the Master Plan. However, this was not because importance of treatment of the wastewater was neglected. The selection was made under the circumstance where either treatment of wastewater or expansion of sewerage collection service must be selected under financial constraint. Therefore, still increase of the wastewater treatment is important issue in the Sewerage Master Plan. In this regards, priority project can increase treated wastewater amount from the present 3,000 or 4,000 m^3/day to 30,000 m^3/day.

4.9.2 Environmental Effect

Most facilities of the priority project are constructed or installed as expansion or replacement of the existing facilities. Pipes are installed under ground. Most pumping stations are replacement of pumps in the existing pumping stations and new pumping stations are to be constructed to the present pumping stations. Expansion of Camberene WWTP is planned within the present treatment site. Therefore, particular negative environmental impacts by the project during operation are not expected compared to the operation of present facilities.

Reconstruction of the ocean outfall at the Camberene beach could apparently improve sanitary conditions around the beach where presently the treated water are spread around over from a broken manhole. In addition, installation of discharge pipe under the sea bed (200 m offshore) may mitigate the pollution of the coastal water by the treated water.

During construction stage, some extent of negative impacts would be unavoidable. Traffic along roads where pipe installation works taken place would be hindered. But the traffic around the area is not so busy and roads in the area have enough width to provide path beside the excavation works. Noise and vibration due to excavation works also would be unavoidable during construction of pumping stations and pipe installation. However, the impact could be minimized by selecting low-noise type construction equipment as far as practicable.

As such, the environmental impacts by the priority project are expected to be negligible or very minor, if there is.

4.9.3 Financial Evaluation

The project cost for the priority project was estimated at 16,958 million FCFA. Financial projections were carried out for several financial source conditions and the project was judged to be feasible by applying increase of the sewerage charge within the range of willingness to pay of the beneficiaries.

The finical source conditions studied varied from the mildest condition; 100 % of the initial investment costs to be provided by a governmental subsidy, to the hardest conditions; 100 % of the initial investment costs to be provided by a governmental loan with 5 % of annual interest. While the proposed sewerage charges for the hardest condition is lower than the willingness to pay, milder conditions are recommended to be applied because the priority project is required to be implemented urgently and sewerage projects necessarily benefit not only those people who discharge their wastewater to sewerage, but more public through reduction of the pollutant loads to the environment.

4.9.4 Operation Maintenance of the Proposed System

The components of the proposed priority project are as same type as those in the existing system. Thus, natures of the required operation and maintenance works for the proposed system would not differ from the present works while quantities of the works would increase according to expansion of the system. Since the existing facilities, such as Camberene WWTP, the pumping stations and sewer collectors, are observed to be well operated, any particular problems are not foreseen in the operation maintenance of the facilities proposed by the priority project, provided that the number of persons concerned to such operation and maintenance works increases.

4.10 RECOMMENDATIONS

(1) General

The priority project is a project to be implemented as the first stage of a series of the Master Plan projects Therefore it is considered that all the recommendations related to the sewerage Master Plan should also be applied to the priority project.

However, considering the high priority of the project, special considerations for earlier implementation of the projects should be arranged. As discussed in the previous section, no particular difficulties are foreseen in the implementation of the project. A few matters concerned are a aspect and an organizational aspect of the implementation.

(2) Financial Aspect

Currently, there is a governmental proposal to privatize the sewerage sector by either re-organization of the sewerage sector of the SONEES or creating a new organization. If this privatization is realized, conditions of the financial sources of the project could change from current government subsidy to government loans. While the financial analysis conducted in the study indicated that the project would be financially feasible even by the financial source provided by 100 % governmental loan, the organization responsible could bear a heavy financial burden. This may hinder the earliest and smooth implementation of the project by any delay or difficulties in raising the sewerage charge. Therefore, it is recommended that the government should provide special considerations on the financial source conditions applied to the priority project. The special considerations would include providing higher percentage of governmental subsidy (at least 40 % and 100 % if an external grant is available) and applying lower interest rate of the government loan (2%). Such considerations can be justified by a nature of sewerage project where beneficiaries in the sewerage project are not only those who pay

sewerage charge but also more public while beneficiaries in water supply projects are limited to those who pay the water supply charge.

(3) Organizational Aspect

The reorganization currently planned by the government will meet the requirement for the organizational strengthening recommended in the Master Plan. The reorganization is expected to proceed along with the progress of the implementation of the priority project. Therefore, it is recommended that reorganization should provide increase of operational persons necessary for the priority project in its earlier stage, as well as keep the present SONEES persons, who have been well experienced in operation of the sewerage system, in the new organization to ensure present operations.

TABLE B.4.1 DIRECT CONSTRUCTION COST

Item	Quantity	Cost (1,000 FCFA)
1 Sewer Network		5,212,454
2. Secondary Collector		
(concrete 350 mm	210 m	31,920
pipe) 400 mm	430 m	104,495
500 mm	60 m	14,280
600 mm	4,440 m	767,780
700 mm	1,520 m	629,530
Sub-Total	6,460 m	1,548,005
3. Force Main		
(ductile 150 mm	430 m	18,490
iron pipe) 200 mm	3,530 m	197,680
250 mm	2,500 m	167,500
350 mm	2,380 m	418,880
Sub-Total	8,840 m	802,550
4. Pumping Station		
Construction		
New P/S Unite 15	1 unit	256,700
New P/S Unite 2	1 unit	53,900
New P/S N.Stadium	1 unit	53,900
Replacement		
P/S Unite 15	1 unit	25,600
P/S Unite 7	1 unit	25,600
P/S Unite 2	1 unit	25,600
P/S Unite 23	1 unit	25,600
P/S Unite Mbaye	1 unit	28,600
Sub-Total		495,500
5. Wastewater Treatment Plant		
second Train	1 unit	1,912,265
Third Train	1 unit	2,572,892
Sub-Total		4,485,157
6. Force Main for Discharge		
Force Main 900 mm	900 m	412,200
Gravity P. 900 mm	1,800 m	698,400
Sub-Total		1,110,600
7. Ocean Outfall		
Junction Pit	1 unit	19,700
Outfall Pipe	380 m	288,740
Sub-Total		308,440
Total Construction Cost		13,962,706

TABLE 6.1 PROJECT COST

(unit: 1,000 FCFA)

Cost Item	L/C	F/C	Total
1. Direct Construction Cost			
1.1 Branch Sewers	1,563,738	3,648,716	5,212,454
1.2 Secondary Collectors	232,200	1,315,805	1,548,005
1.3 Force Mains	120,382	682,168	802,550
1.4 Pumping Stations	123,875	371,625	495,500
1.5 Expansion of Camberene WWTP	1,345,548	3,139,609	4,485,157
1.6 Force Main for Discharge	166,590	944,010	1,110,600
1.7 Outfall	92,532	215,908	308,440
Subtotal	3,644,865	10,317,841	13,962,706
2. Sewer Cleasing Equipment	0	445,000	445,000
3. Land Acquisition	350	0	350
4. Engineering Cost	418,882	977,389	1,396,271
5. Government Administration	209,441	0	209,441
6. Physical Contingency	1,396,271	0	1,396,271
Total Project Cost	5,669,809	11,740,230	17,410,039

TABLE B.4.3 ANNUAL OPERATION AND MAINTENANCE COST

Item	Quantity	Unit Cost (FCFA)	Cost (million FCFA/Year)
1. Sewer Pipes	4 persons	2,160,000/person	9
2. Pumping Stations			
Electricity	8,451,648 m3	4.66/m3	39
Repairing	Construction Cost x 0.5 %		2
Personnel	12 persons	2,160,000 /person	6
Sub-total			47
3. Treatment Plant			
Electricity	10,950,000 m3	22/m3	240
Chemicals	10,950,000 m3	1.5/m3	16
Repairing	Construction Cost x 0.5%		22
Personnel	24 persons	2,160,000/person	52
Sub-total			330
4. Overheads	3 persons	2,160,000/person	6
Total			392

TABLE 6.2 PROJECT COST UP TO 2000

(unit: 1,000 FCFA)

		1995	1996	1997	1998	1999	2000	Total
I. Direct Construction Cost								
1) Branch Sewers	L/C	77,295	77,295	77,295	77,295	627,279	627,279	1,563,738
	F/C	180,354	180,354	180,354	180,354	1,463,650	1,463,650	3,648,716
	Total	257,649	257,649	257,649	257,649	2,090,929	2,090,929	5,212,454
2) Pumping Station	L/C	0	0	80,550	29,850	0	13,475	123,875
	F/C	0	0	241,650	89,550	0	40,425	371,625
	Total	0	0	322,200	119,400	0	53,900	495,500
3) Force Main	L/C	0	0	80,191	60,191	0	0	120,382
	F/C	0	0	341,084	341,084	0	0	682,168
	Total	0	0	401,275	401,275	0	0	802,550
4) Secondary Collectors	L/C	0	0	77,347	77,347	38,753	38,753	232,200
	F/C	0	0	438,301	438,301	219,602	219,601	1,315,805
	Total	0	0	515,648	515,648	258,355	258,354	1,548,005
5) Camberene WWTP	L/C	0	0	286,840	286,840	385,934	385,934	1,345,548
	F/C	0	0	669,292	669,293	900,512	900,512	3,139,609
	Total	0	0	956,132	956,133	1,286,446	1,286,446	4,485,157
6) Force Main for Discharge	L/C	0	0	0	0	0	166,590	166,590
	F/C	0	0	0	0	0	944,010	944,010
	Total	0	0	0	0	0	1,110,600	1,110,600
7) Outfall	L/C	0	0	0	92,532	0	0	92,532
	F/C	0	0	0	215,908	0	0	215,908
	Total	0	0	0	308,440	0	0	308,440
Total Direct Construction Cost	L/C	77,295	77,295	582,223	624,055	1,051,966	1,232,031	3,644,865
	F/C	180,354	180,354	1,870,681	1,934,490	2,583,764	3,568,198	10,317,841
	Total	257,649	257,649	2,452,904	2,558,545	3,635,730	4,800,229	13,962,706
II. Sewer Cleaning Equipment		0	0	0	0	0	445,000	445,000
III. Land Acquisition		0	250	50	0	50	0	350
IV. Engineering Service	L/C	69,814	69,814	69,814	69,814	69,814	69,812	418,882
	F/C	162,898	162,898	162,898	162,898	162,898	162,899	977,389
	Total	232,712	232,712	232,712	232,712	232,712	232,711	1,396,271
V. Government Administration		3,865	3,865	36,794	38,378	54,536	72,003	209,441
VI. Physical Contingency		25,765	25,765	245,290	255,855	363,573	480,023	1,396,271
VII. Total Project Cost	L/C	176,739	176,989	934,171	988,102	1,539,939	1,853,869	5,669,809
	F/C	343,252	343,252	2,033,579	2,097,388	2,746,662	4,176,097	11,740,230
	Total	519,991	520,241	2,967,750	3,085,490	4,286,601	6,029,966	17,410,039

TABLE B.4.5 REVENUE FROM SEWERAGE CHARGE IN CASE OF PROJECT IMPLEMENTATION

(Unit: thousand m3, FCFA million)

Year	Wastewater Generation	Sewerage Revenue
1995	31,650	599
1996	31,650	599
1997	31,650	599
1998	34,885	660
1999	35,532	672
2000	36,180	684
2001	36,946	1,375
2002	37,713	1,403
2003	38,480	1,432
2004	39,247	1,460
2005	40,014	1,489
2006	40,781	1,517
2007	41,548	1,546
2008	42,315	1,574
2009	43,082	1,603
2010	43,849	1,631
2011	43,849	1,903
2012	43,849	1,903
2013	43,849	1,903
2014	43,849	1,903
2015	43,849	1,903

Note: 1. <Wastewater generation> concerns the clients other than farmers and big industrialists.

2. Average sewerage charge is assumed as 41.34 FCFA/m3 from 2001 to 2010 and 48.23 FCFA/m3 from 2011 onward.

3. Charge collection rate is assumed as 90%.

4. The sewerage revenue is at 1994 prices.

TABLE B.4.6 FINANCIAL STATEMENT (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	714	742	771	1,579	1,644	1,711	1,780
Operation and Maintenance	425	502	581	664	749	837	929	948	967	986
Depreciation	3	6	50	94	156	235	235	235	235	235
Payment of Interest	0	0	0	0	0	15	31	122	215	345
Expenditure	428	508	631	758	905	1,088	1,195	1,305	1,417	1,567
Profit before Tax	182	115	4	-44	-163	-318	384	339	294	213
Tax	55	34	1	0	0	0	115	102	88	64
Profit after Tax	127	80	3	-44	-163	-318	269	238	206	149
Funds Statement										
Profit after Tax	127	80	3	-44	-163	-318	269	238	206	149
Loans	318	324	1,889	2,003	2,839	3,773	0	0	0	0
Subsidies	212	216	1,259	1,335	1,893	2,515	0	0	0	0
Depreciation	3	6	50	94	156	235	235	235	235	235
Sources	660	626	3,201	3,389	4,724	6,206	504	473	441	384
Capital Works	529	540	3,148	3,339	4,731	6,288	0	0	0	0
Payment of Principal	0	0	0	0	0	13	27	105	191	315
Working Capital	131	87	53	51	-7	-95	477	368	250	70
Applications	660	626	3,201	3,389	4,724	6,206	504	473	441	384
Loan Liabilities	330	680	2,672	4,862	8,009	12,225	12,657	12,936	13,048	12,910
Cash Balance	872	959	1,011	1,062	1,055	960	1,437	1,805	2,055	2,125

Source: JICA

TABLE B.4.6 FINANCIAL STATEMENT (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
					Income Statement					
Revenue	1,851	1,924	2,000	2,077	2,157	2,240	2,665	2,718	2,773	2,828
Operation and Maintenance	1,006	1,026	1,047	1,067	1,089	1,111	1,133	1,155	1,179	1,202
Depreciation	235	235	235	235	235	235	235	257	277	301
Payment of Interest	516	497	477	456	435	412	389	364	339	313
Expenditure	1,757	1,758	1,759	1,759	1,759	1,758	1,757	1,777	1,794	1,816
Profit before Tax	94	166	241	318	399	482	909	941	978	1,013
Tax	28	50	72	96	120	145	273	282	294	304
Profit after Tax	66	116	169	223	279	337	636	659	685	709
					Funds Statement					
Profit after Tax	66	116	169	223	279	337	636	659	685	709
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	235	235	235	235	235	235	235	257	277	301
Sources	301	351	404	458	514	572	871	916	962	1,010
Capital Works	0	0	0	0	0	0	0	602	526	650
Payment of Principal	481	501	521	541	563	586	609	633	659	685
Working Capital	-181	-149	-117	-83	-49	-13	262	-320	-223	-325
Applications	301	351	404	458	514	572	871	916	962	1,010
Loan Liabilities	12,428	11,928	11,407	10,866	10,302	9,717	9,108	8,474	7,815	7,130
Cash Balance	1,944	1,795	1,678	1,594	1,545	1,532	1,794	1,475	1,252	927

Source: JICA

TABLE B.4.6 FINANCIAL STATEMENT (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	2,885	2,943	3,001	3,061	3,123	3,185	3,249	3,314	3,380	3,448
Operation and Maintenance	1,226	1,251	1,276	1,301	1,327	1,354	1,381	1,408	1,437	1,465
Depreciation	326	326	326	326	326	326	326	326	326	326
Payment of Interest	285	257	227	196	164	131	97	64	35	13
Expenditure	1,838	1,834	1,829	1,824	1,818	1,811	1,804	1,798	1,798	1,805
Profit before Tax	1,047	1,109	1,172	1,238	1,305	1,374	1,444	1,515	1,582	1,643
Tax	314	333	352	371	391	412	433	455	475	493
Profit after Tax	733	776	821	866	913	962	1,011	1,061	1,107	1,150
Funds Statement										
Profit after Tax	733	776	821	866	913	962	1,011	1,061	1,107	1,150
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	326	326	326	326	326	326	326	326	326	326
Sources	1,059	1,102	1,147	1,193	1,240	1,288	1,337	1,387	1,434	1,476
Capital Works	687	0	0	0	0	0	0	0	0	0
Payment of Principal	713	741	771	802	834	839	843	708	557	325
Working Capital	-341	361	376	391	406	450	494	679	877	1,152
Applications	1,059	1,102	1,147	1,193	1,240	1,288	1,337	1,387	1,434	1,476
Loan Liabilities	6,418	5,677	4,906	4,104	3,271	2,432	1,589	881	325	0
Cash Balance	586	947	1,323	1,715	2,121	2,570	3,065	3,744	4,621	5,772

Source: JICA

TABLE B.4.7 COST BENEFIT STREAMS

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:FCFA Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	311	417	728	599	-130
2	1996	311	482	794	599	-195
3	1997	1780	548	2328	599	-1729
4	1998	1851	613	2464	660	-1804
5	1999	2571	678	3250	672	-2578
6	2000	3350	744	4094	684	-3410
7	2001	0	809	809	1375	566
8	2002	0	809	809	1403	594
9	2003	0	809	809	1432	623
10	2004	0	809	809	1460	651
11	2005	0	809	809	1489	680
12	2006	0	809	809	1517	708
13	2007	0	809	809	1546	737
14	2008	0	809	809	1574	765
15	2009	0	809	809	1603	794
16	2010	0	809	809	1631	822
17	2011	0	809	809	1903	1094
18	2012	422	809	1231	1903	673
19	2013	361	809	1170	1903	733
20	2014	437	809	1246	1903	657
21	2015	454	809	1263	1903	641
22	2016	0	809	809	1903	1094
23	2017	0	809	809	1903	1094
24	2018	0	809	809	1903	1094
25	2019	0	809	809	1903	1094
26	2020	0	809	809	1903	1094
27	2021	0	809	809	1903	1094
28	2022	0	809	809	1903	1094
29	2023	0	809	809	1903	1094
30	2024	0	809	809	1903	1094
31	2025	0	809	809	1903	1094
32	2026	0	809	809	1903	1094
33	2027	422	809	1231	1903	673
34	2028	361	809	1170	1903	733
35	2029	437	809	1246	1903	657
36	2030	454	809	1263	1903	641
37	2031	0	809	809	1903	1094
38	2032	0	809	809	1903	1094
39	2033	0	809	809	1903	1094
40	2034	0	809	809	1903	1094

TABLE B.4.8 FINANCIAL STATEMENT (ALTERNATIVE I) (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	714	742	771	1,842	1,918	1,996	2,077
Operation and Maintenance	425	502	581	664	749	837	929	948	967	986
Depreciation	5	11	84	157	260	392	392	392	392	392
Payment of Interest	0	0	0	0	0	12	23	92	162	259
Expenditure	431	512	665	821	1,009	1,241	1,344	1,431	1,520	1,637
Profit before Tax	180	110	-30	-107	-267	-471	498	487	476	440
Tax	54	33	0	0	0	0	149	146	143	132
Profit after Tax	126	77	-30	-107	-267	-471	348	341	333	308
Funds Statement										
Profit after Tax	126	77	-30	-107	-267	-471	348	341	333	308
Loans	529	540	3,148	3,339	4,731	6,288	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	5	11	84	157	260	392	392	392	392	392
Sources	660	628	3,202	3,389	4,724	6,210	740	733	725	700
Capital Works	529	540	3,148	3,339	4,731	6,288	0	0	0	0
Payment of Principal	0	0	0	0	0	24	49	193	349	571
Working Capital	131	88	54	51	-7	-103	691	539	376	129
Applications	660	628	3,202	3,389	4,724	6,210	740	733	725	700
Loan Liabilities	540	1,101	4,335	7,827	12,809	19,444	19,760	19,871	19,758	19,324
Cash Balance	873	960	1,014	1,065	1,058	956	1,647	2,186	2,563	2,692

Source: JICA

TABLE B.4.8 FINANCIAL STATEMENT (ALTERNATIVE I) (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	2,160	2,245	2,333	2,424	2,517	2,613	3,046	3,107	3,169	3,232
Operation and Maintenance	1,006	1,026	1,047	1,067	1,089	1,111	1,133	1,155	1,179	1,202
Depreciation	392	392	392	392	392	392	392	402	411	422
Payment of Interest	386	369	351	333	315	296	277	257	238	217
Expenditure	1,784	1,787	1,790	1,793	1,796	1,799	1,802	1,815	1,827	1,842
Profit before Tax	375	458	543	631	721	814	1,244	1,292	1,342	1,391
Tax	113	137	163	189	216	244	373	387	402	417
Profit after Tax	263	321	380	442	505	570	871	904	939	973
Funds Statement										
Profit after Tax	263	321	380	442	505	570	871	904	939	973
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	392	392	392	392	392	392	392	402	411	422
Sources	655	713	772	834	897	962	1,263	1,306	1,350	1,396
Capital Works	0	0	0	0	0	0	0	602	526	650
Payment of Principal	868	885	903	921	939	958	977	997	1,017	1,037
Working Capital	-213	-173	-131	-87	-43	4	286	-293	-192	-291
Applications	655	713	772	834	897	962	1,263	1,306	1,350	1,396
Loan Liabilities	18,456	17,571	16,668	15,747	14,808	13,849	12,872	11,875	10,859	9,821
Cash Balance	2,479	2,306	2,175	2,088	2,045	2,049	2,335	2,042	1,850	1,558

Source: JICA

TABLE B.4.8 FINANCIAL STATEMENT (ALTERNATIVE I) (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	3,297	3,363	3,430	3,499	3,569	3,640	3,713	3,787	3,863	3,940
Operation and Maintenance	1,226	1,251	1,276	1,301	1,327	1,354	1,381	1,408	1,437	1,465
Depreciation	434	434	434	434	434	434	434	434	434	434
Payment of Interest	196	175	154	132	109	86	64	41	23	8
Expenditure	1,857	1,860	1,864	1,867	1,871	1,874	1,879	1,884	1,894	1,908
Profit before Tax	1,440	1,503	1,567	1,632	1,698	1,766	1,834	1,903	1,969	2,032
Tax	432	451	470	489	509	530	550	571	591	610
Profit after Tax	1,008	1,052	1,097	1,142	1,189	1,236	1,284	1,332	1,379	1,423
Funds Statement										
Profit after Tax	1,008	1,052	1,097	1,142	1,189	1,236	1,284	1,332	1,379	1,423
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	434	434	434	434	434	434	434	434	434	434
Sources	1,442	1,486	1,531	1,576	1,623	1,670	1,718	1,766	1,813	1,857
Capital Works	687	0	0	0	0	0	0	0	0	0
Payment of Principal	1,058	1,079	1,101	1,123	1,145	1,132	1,118	928	721	416
Working Capital	-303	407	430	454	478	538	600	838	1,091	1,441
Applications	1,442	1,486	1,531	1,576	1,623	1,670	1,718	1,766	1,813	1,857
Loan Liabilities	8,764	7,685	6,584	5,461	4,316	3,184	2,066	1,138	416	0
Cash Balance	1,255	1,663	2,093	2,547	3,024	3,562	4,162	5,000	6,092	7,532

Source: JICA

TABLE B.4.9 COST BENEFIT STREAMS - ALTERNATIVE I

CC=Capital Costs; OM=O/M Costs; CS=Costs; BF=Benefits
CF=Cash Flow (=BF - CS)

(Unit:FCFA Million)

NO.	YEAR	CC	OM	CS	BF	CF
1	1995	519	417	936	599	-337
2	1996	519	482	1001	599	-403
3	1997	2967	548	3514	599	-2916
4	1998	3084	613	3697	660	-3038
5	1999	4285	678	4964	672	-4292
6	2000	5584	744	6328	684	-5643
7	2001	0	809	809	1604	795
8	2002	0	809	809	1637	828
9	2003	0	809	809	1670	861
10	2004	0	809	809	1704	895
11	2005	0	809	809	1737	928
12	2006	0	809	809	1770	961
13	2007	0	809	809	1803	994
14	2008	0	809	809	1837	1028
15	2009	0	809	809	1870	1061
16	2010	0	809	809	1903	1094
17	2011	0	809	809	2175	1366
18	2012	422	809	1231	2175	945
19	2013	361	809	1170	2175	1005
20	2014	437	809	1246	2175	929
21	2015	454	809	1263	2175	913
22	2016	0	809	809	2175	1366
23	2017	0	809	809	2175	1366
24	2018	0	809	809	2175	1366
25	2019	0	809	809	2175	1366
26	2020	0	809	809	2175	1366
27	2021	0	809	809	2175	1366
28	2022	0	809	809	2175	1366
29	2023	0	809	809	2175	1366
30	2024	0	809	809	2175	1366
31	2025	0	809	809	2175	1366
32	2026	0	809	809	2175	1366
33	2027	422	809	1231	2175	945
34	2028	361	809	1170	2175	1005
35	2029	437	809	1246	2175	929
36	2030	454	809	1263	2175	913
37	2031	0	809	809	2175	1366
38	2032	0	809	809	2175	1366
39	2033	0	809	809	2175	1366
40	2034	0	809	809	2175	1366

TABLE B.4.10 FINANCIAL STATEMENT (ALTERNATIVE II) (1)

(Unit: FCFA million)

No.	1	2	3	4	5	6	7	8	9	10
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Income Statement										
Revenue	611	623	635	714	742	771	921	959	998	1,038
Operation and Maintenance	425	502	581	664	749	837	929	948	967	986
Depreciation	0	0	0	0	0	0	0	0	0	0
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	425	502	581	664	749	837	929	948	967	986
Profit before Tax	185	121	54	51	-7	-67	-8	11	31	52
Tax	56	36	16	15	0	0	0	3	9	16
Profit after Tax	130	85	38	35	-7	-67	-8	8	22	37
Funds Statement										
Profit after Tax	130	85	38	35	-7	-67	-8	8	22	37
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	529	540	3,148	3,339	4,731	6,288	0	0	0	0
Depreciation	0	0	0	0	0	0	0	0	0	0
Sources	659	624	3,186	3,374	4,724	6,221	-8	8	22	37
Capital Works	529	540	3,148	3,339	4,731	6,288	0	0	0	0
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	130	85	38	35	-7	-67	-8	8	22	37
Applications	659	624	3,186	3,374	4,724	6,221	-8	8	22	37
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	871	956	993	1,029	1,022	955	947	955	977	1,013

Source: JICA

TABLE B.4.10 FINANCIAL STATEMENT (ALTERNATIVE II) (2)

(Unit: FCFA million)

No.	11	12	13	14	15	16	17	18	19	20
Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Income Statement										
Revenue	1,080	1,123	1,166	1,212	1,258	1,306	1,523	1,553	1,584	1,616
Operation and Maintenance	1,006	1,026	1,047	1,067	1,089	1,111	1,133	1,155	1,179	1,202
Depreciation	0	0	0	0	0	0	0	40	75	119
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	1,006	1,026	1,047	1,067	1,089	1,111	1,133	1,196	1,254	1,321
Profit before Tax	74	97	120	144	170	196	390	358	331	295
Tax	22	29	36	43	51	59	117	107	99	89
Profit after Tax	52	68	84	101	119	137	273	250	231	207
Funds Statement										
Profit after Tax	52	68	84	101	119	137	273	250	231	207
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	0	0	0	0	0	0	0	40	75	119
Sources	52	68	84	101	119	137	273	291	307	325
Capital Works	0	0	0	0	0	0	0	602	526	650
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	52	68	84	101	119	137	273	-312	-219	-325
Applications	52	68	84	101	119	137	273	291	307	325
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	1,065	1,132	1,216	1,317	1,436	1,573	1,846	1,535	1,316	991

Source: JICA

TABLE B.4.10 FINANCIAL STATEMENT (ALTERNATIVE II) (3)

(Unit: FCFA million)

No.	21	22	23	24	25	26	27	28	29	30
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Income Statement										
Revenue	1,648	1,681	1,715	1,749	1,784	1,820	1,856	1,894	1,931	1,970
Operation and Maintenance	1,226	1,251	1,276	1,301	1,327	1,354	1,381	1,408	1,437	1,465
Depreciation	164	164	164	164	164	164	164	164	164	164
Payment of Interest	0	0	0	0	0	0	0	0	0	0
Expenditure	1,391	1,415	1,440	1,466	1,492	1,518	1,545	1,573	1,601	1,630
Profit before Tax	258	266	275	284	293	302	311	321	330	340
Tax	77	80	83	85	88	91	93	96	99	102
Profit after Tax	181	186	193	199	205	211	218	225	231	238
Funds Statement										
Profit after Tax	181	186	193	199	205	211	218	225	231	238
Loans	0	0	0	0	0	0	0	0	0	0
Subsidies	0	0	0	0	0	0	0	0	0	0
Depreciation	164	164	164	164	164	164	164	164	164	164
Sources	345	351	357	363	369	376	382	389	396	403
Capital Works	687	0	0	0	0	0	0	0	0	0
Payment of Principal	0	0	0	0	0	0	0	0	0	0
Working Capital	-343	351	357	363	369	376	382	389	396	403
Applications	345	351	357	363	369	376	382	389	396	403
Loan Liabilities	0	0	0	0	0	0	0	0	0	0
Cash Balance	648	999	1,356	1,719	2,088	2,464	2,846	3,235	3,631	4,034

Source: JICA

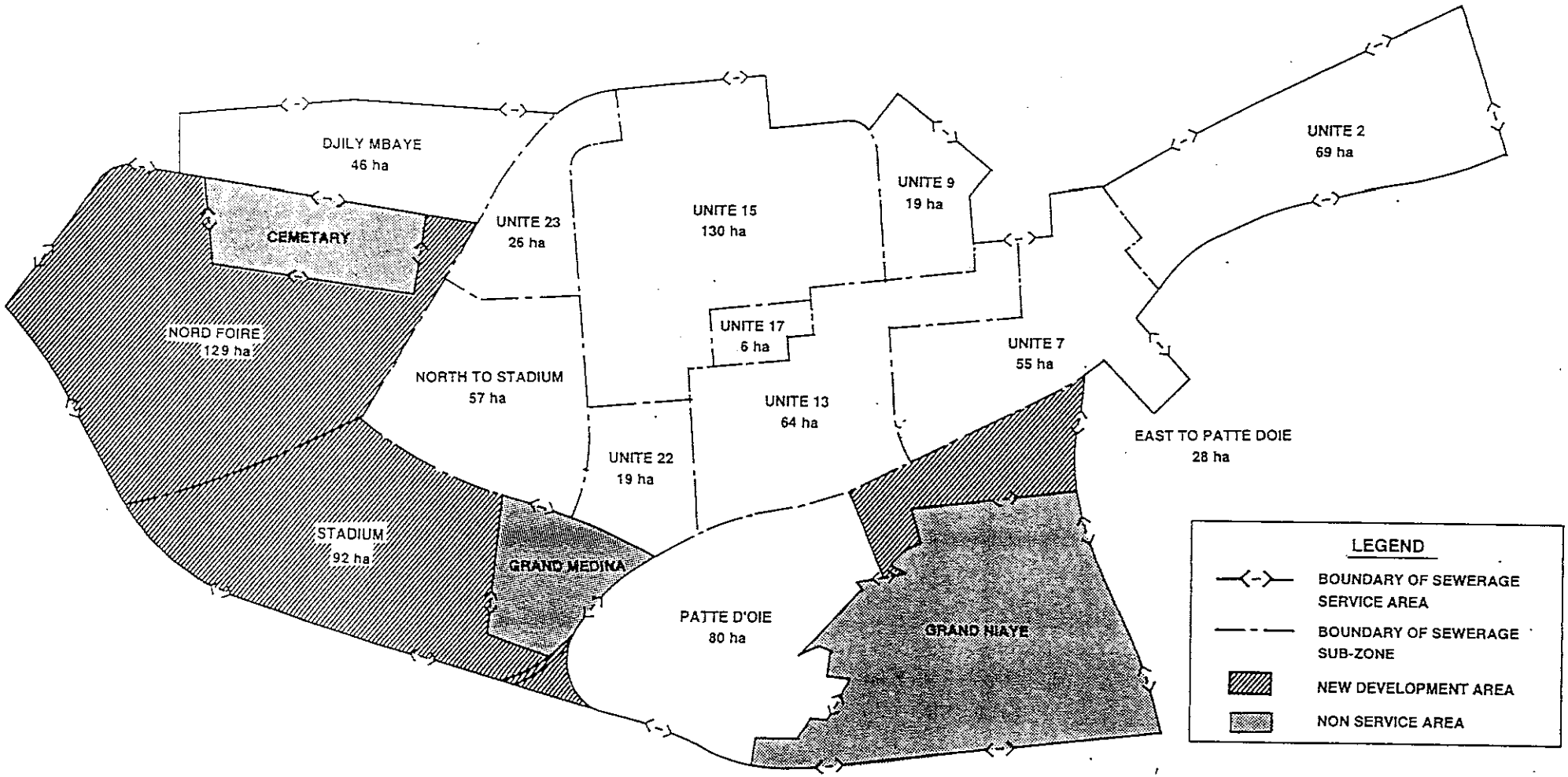

FIGURE B.4.1 SEWERAGE PROJECT AREA AND SUBZONES

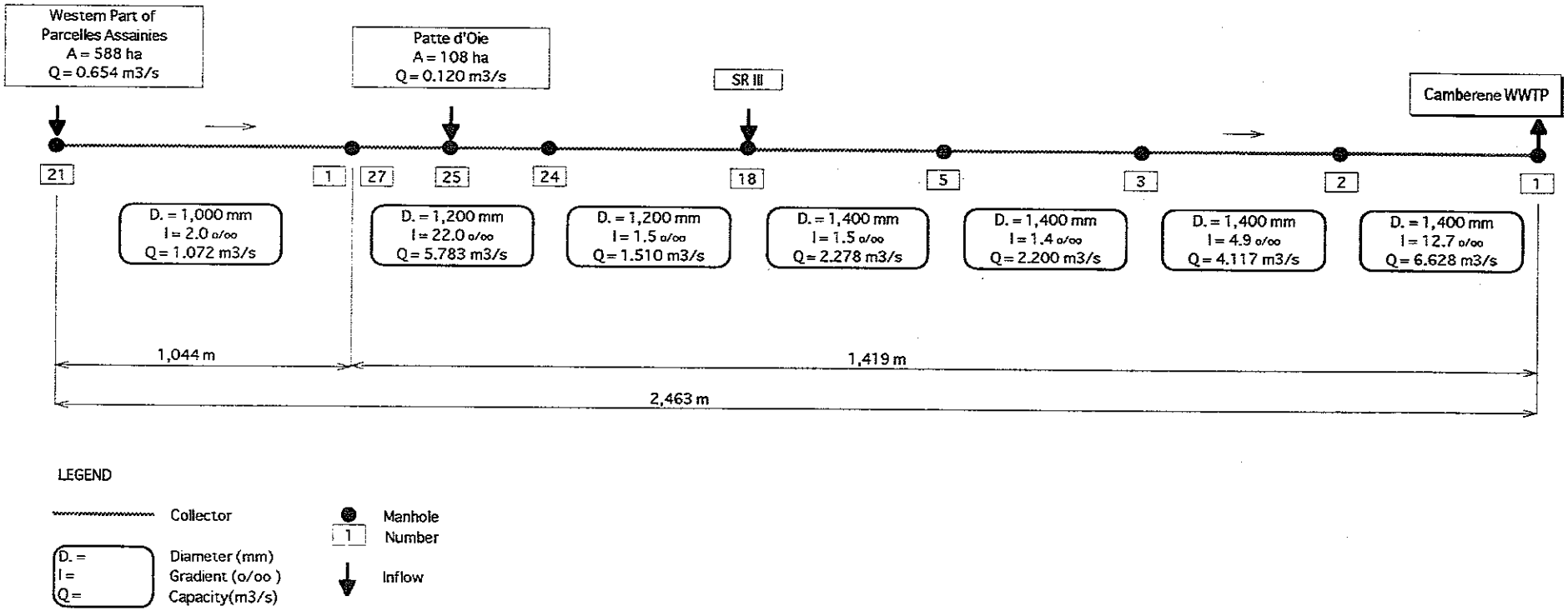

FIGURE B.4.2 CAPACITY OF THE EXISTING GRAVITY COLLECTOR

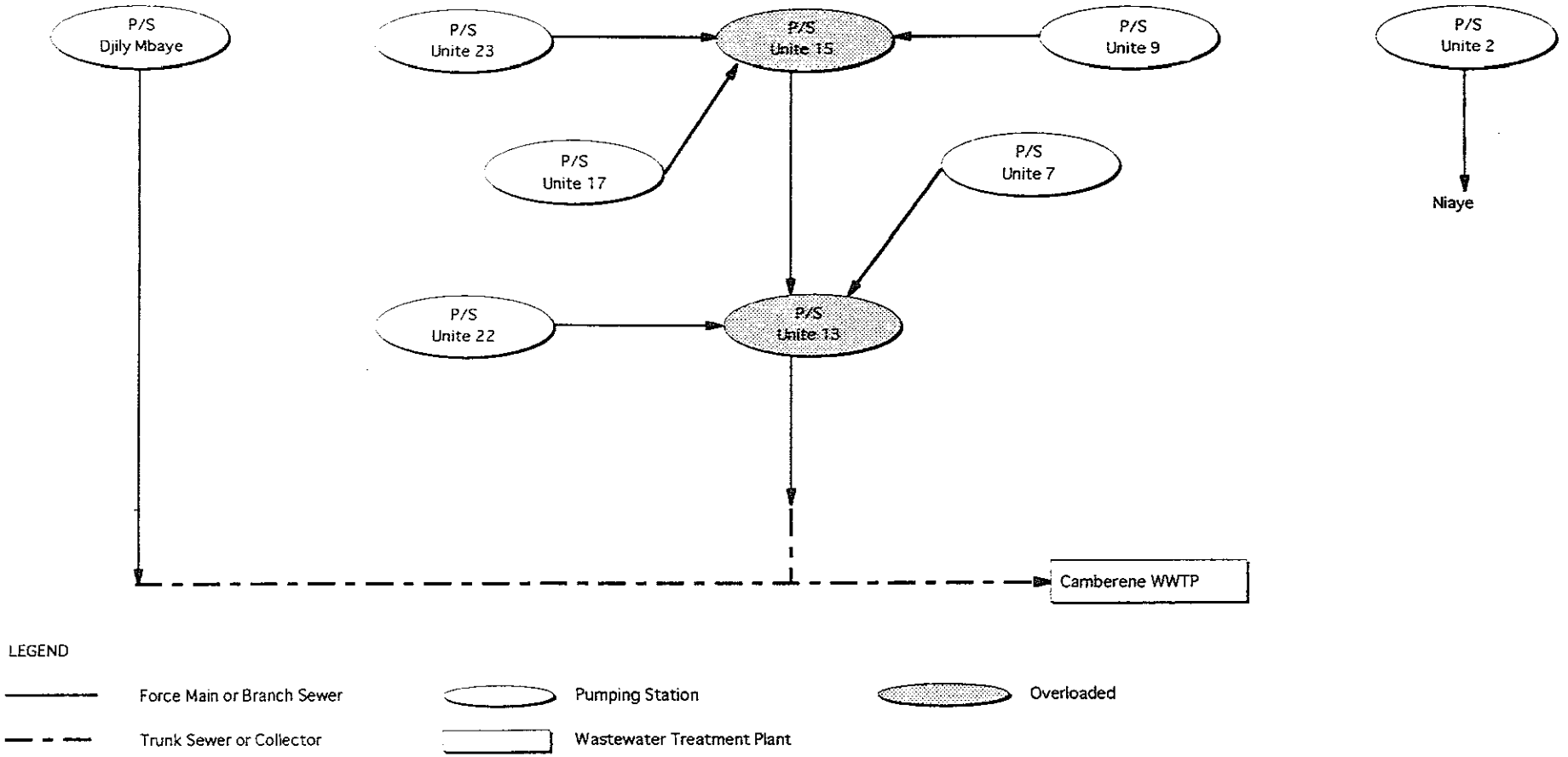

FIGURE B.4.3 EXISTING PUMPING STATION SYSTEM

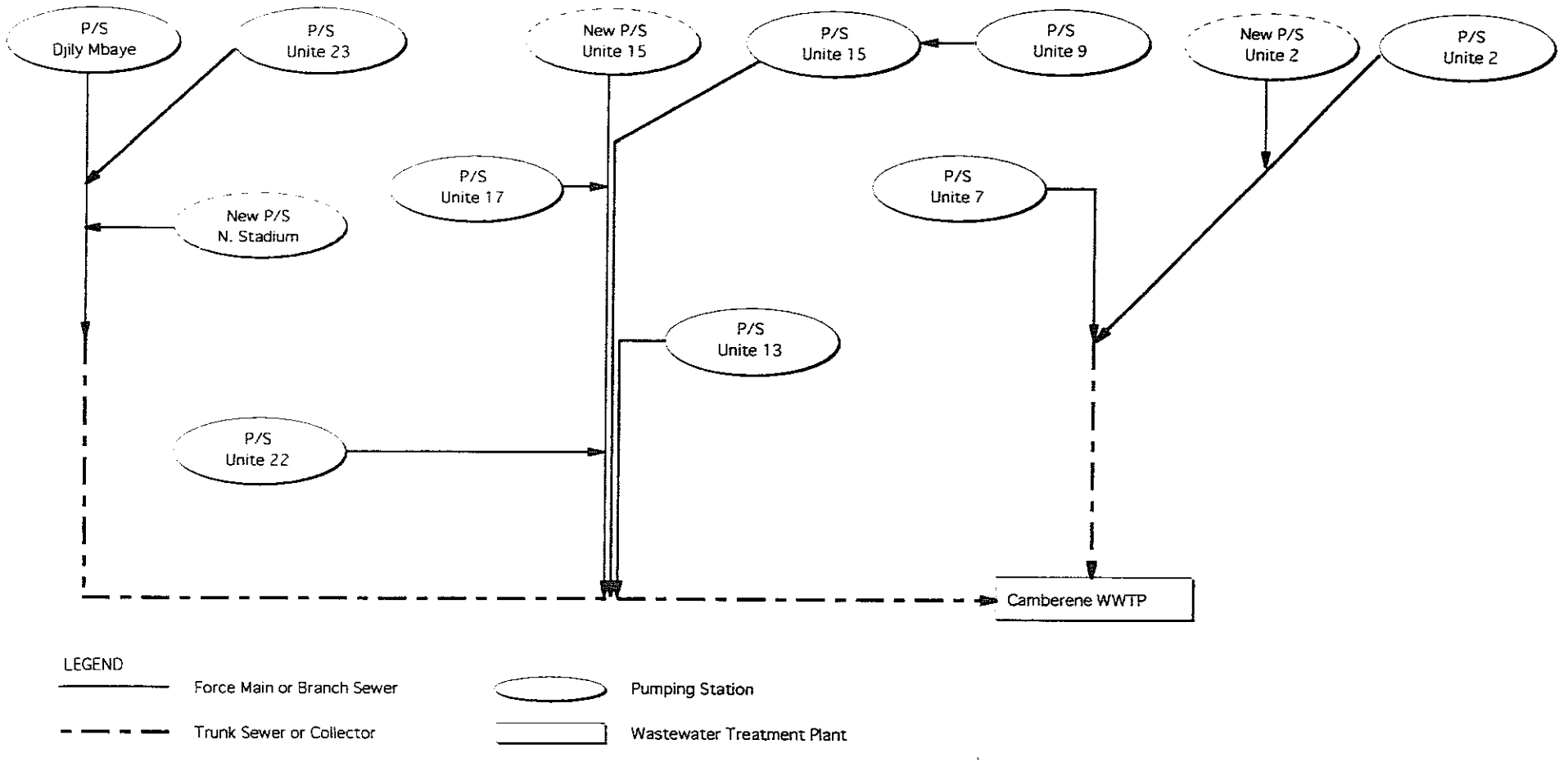

FIGURE B.4.4 PROPOSED PUMPING STATION SYSTEM

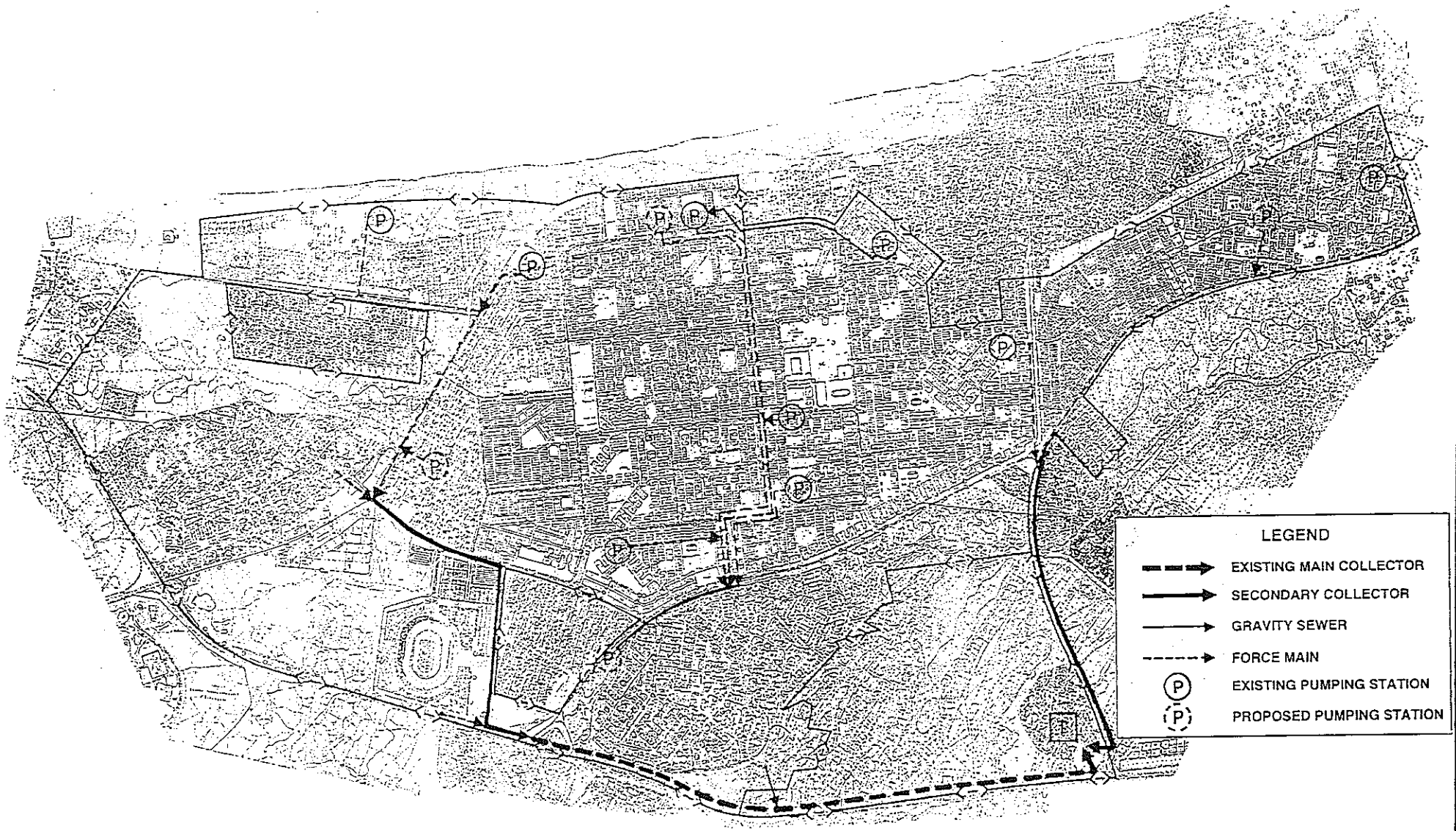

FIGURE B.4.5 ALTERNATIVES FOR SECONDARY COLLECTORS : ALTERNATIVE A

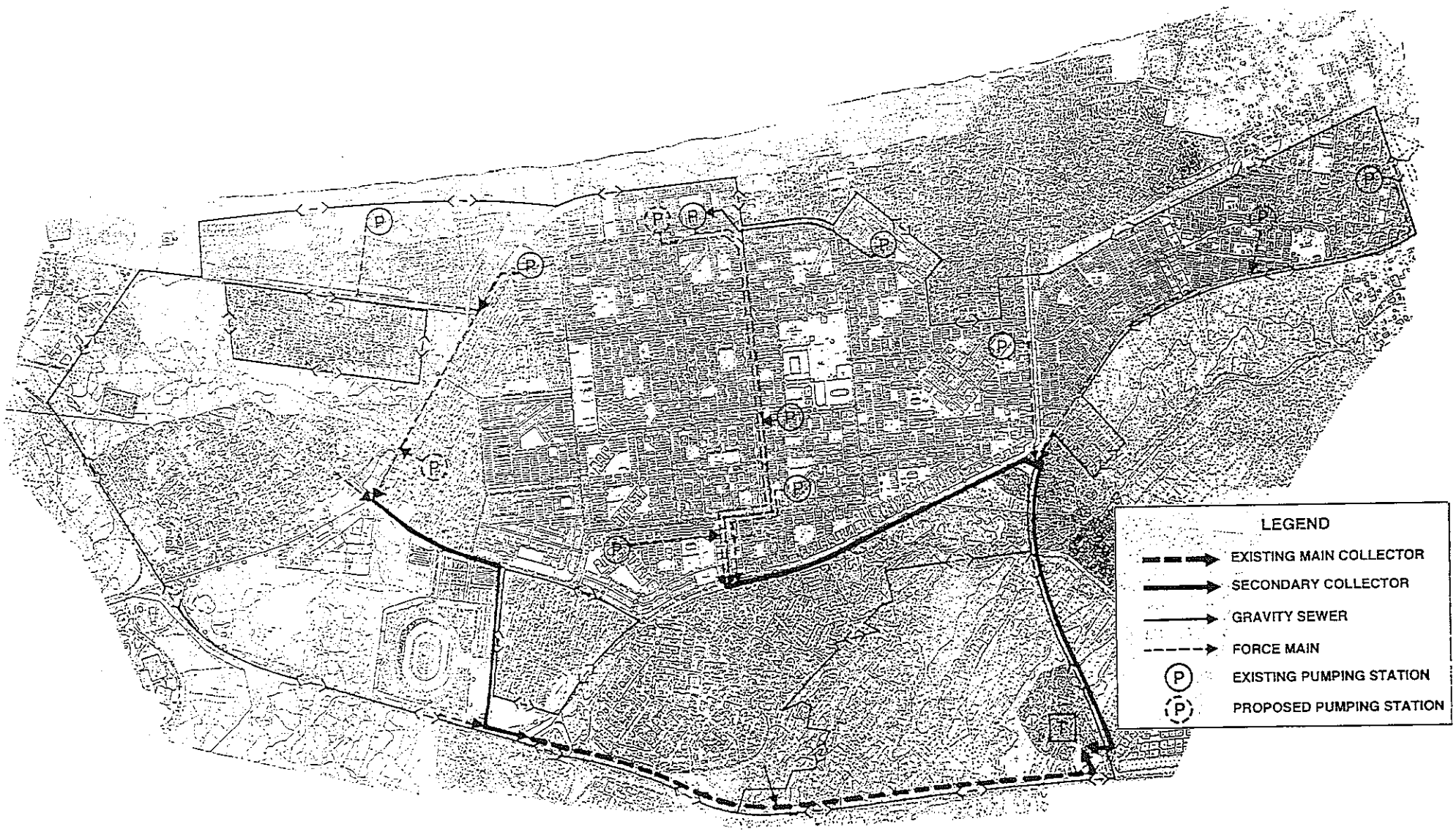

FIGURE B.4.6 ALTERNATIVES FOR SECONDARY COLLECTORS : ALTERNATIVE B

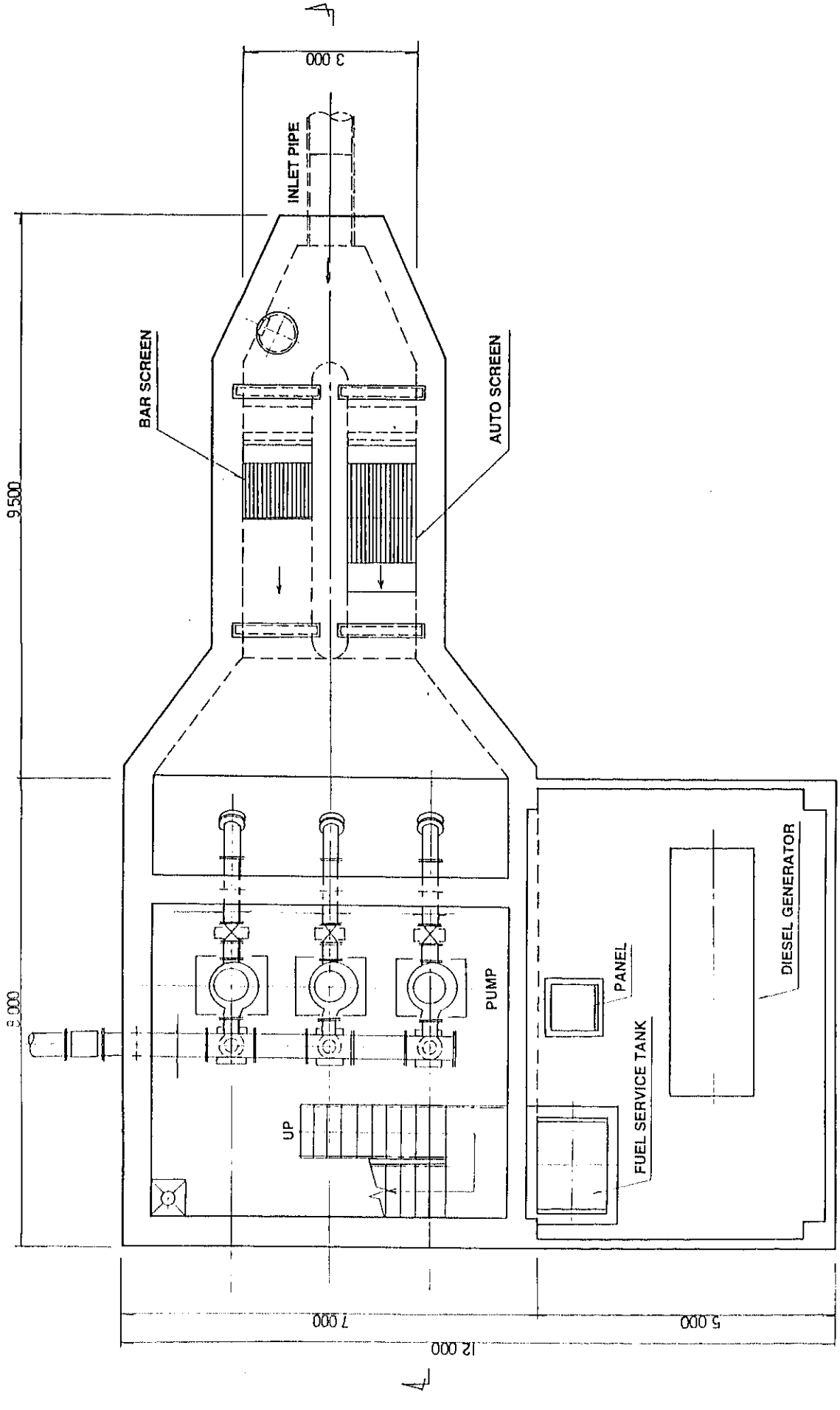

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FIGURE B.4.7 PLAN OF PUMPING STATION (DRY PIT TYPE)

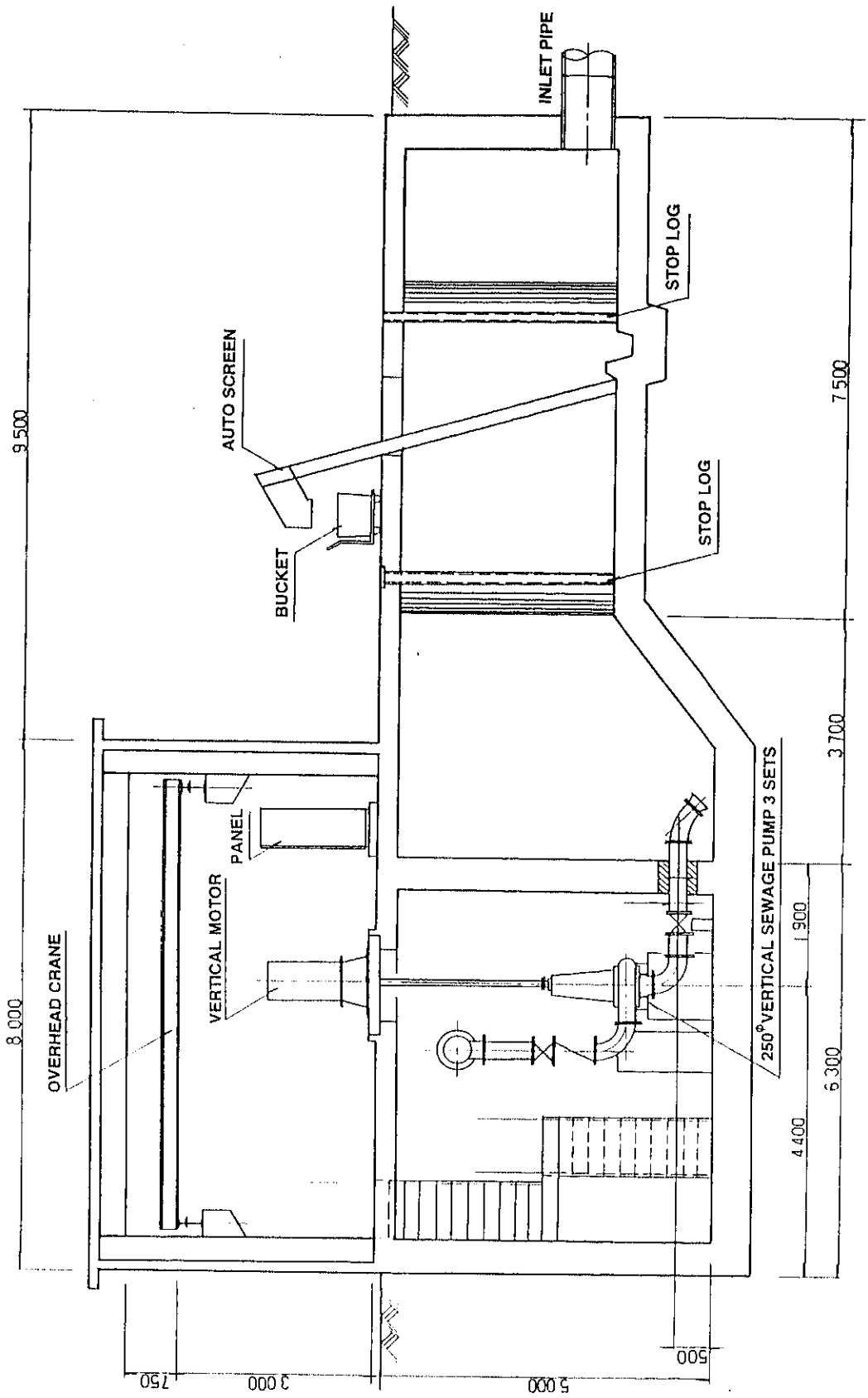
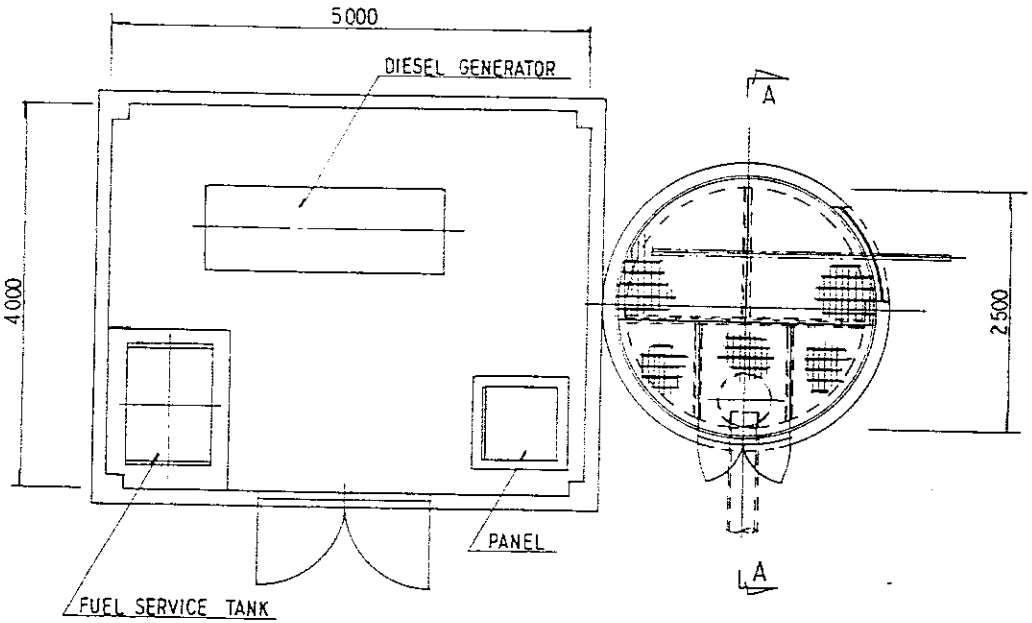
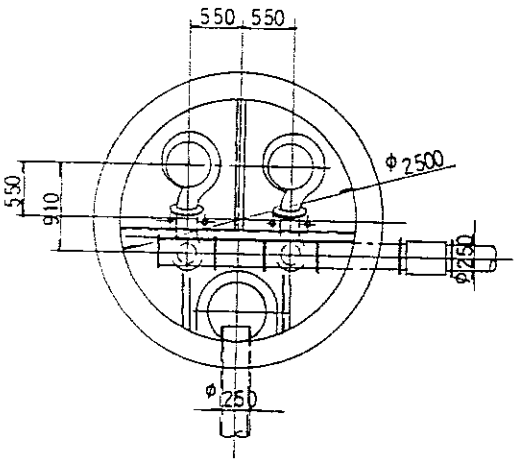


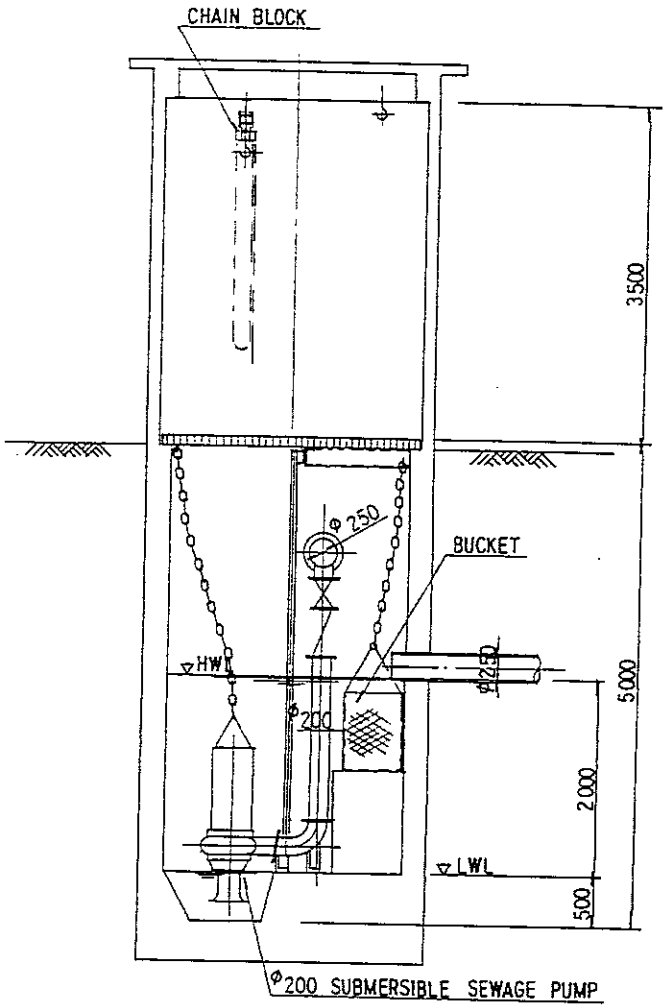
FIGURE B.4.8 SECTION OF PUMPING STATION (DRY PIT TYPE)



GROUND FLOOR PLAN S=1/50



PUMP PIT PLAN S=1/50



SECTION A – A S=1/50

FIGURE B.4.9 PLAN AND SECTION OF PUMPING STATION (SUBMERSIBLE TYPE)

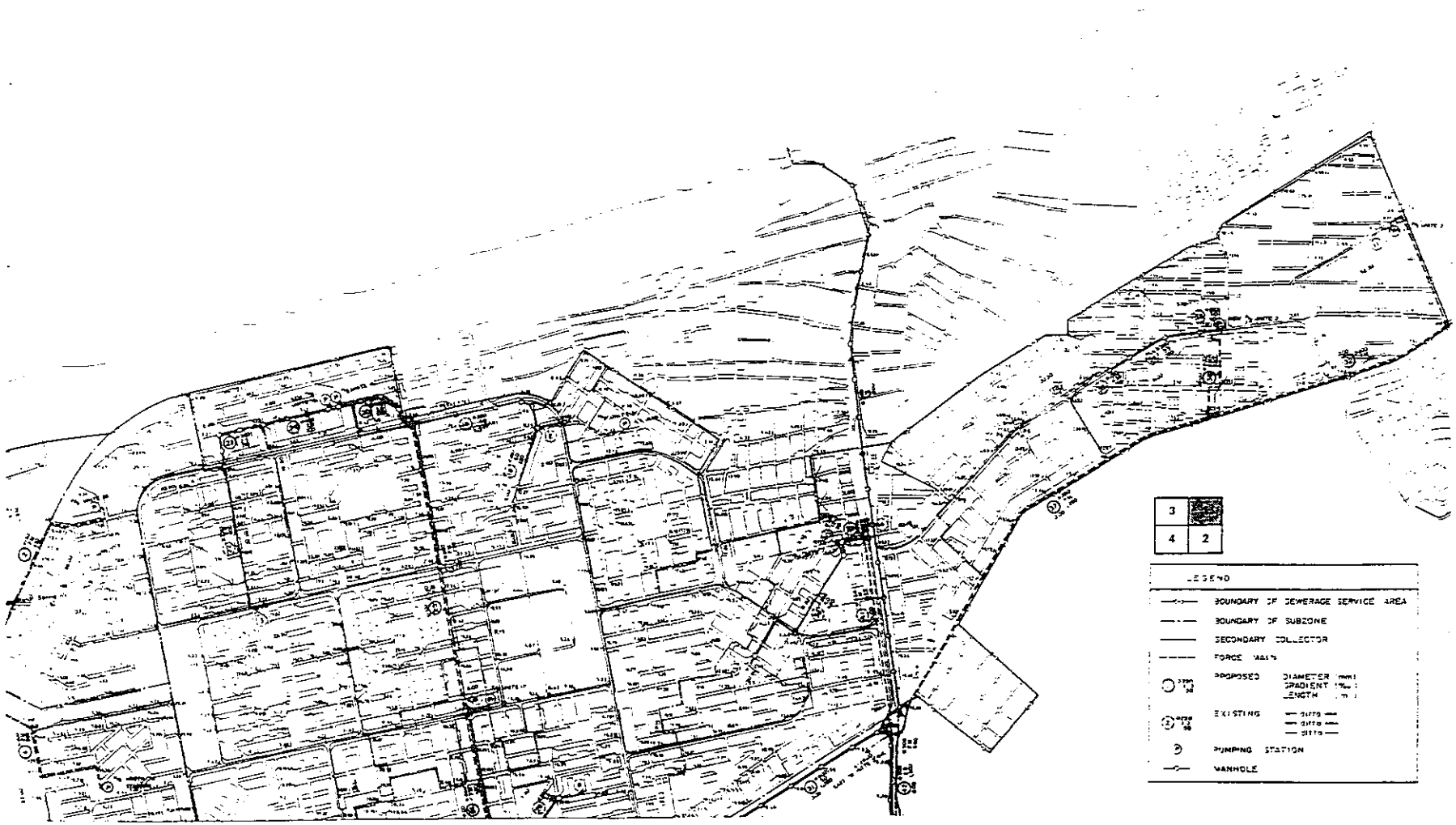


FIGURE B.4.10 GENERAL PLAN OF SEWERAGE SYSTEM FOR PARCELLES ASSAINIES AND ITS SURROUNDINGS (1)

FIGURE B.4.10 GENERAL PLAN OF SEWERAGE SYSTEM FOR PARCELLES ASSAINIES AND ITS SURROUNDINGS (2)

FIGURE B.4.10 GENERAL PLAN OF SEWERAGE SYSTEM FOR PARCELLES ASSAINIES AND ITS SURROUNDINGS (3)

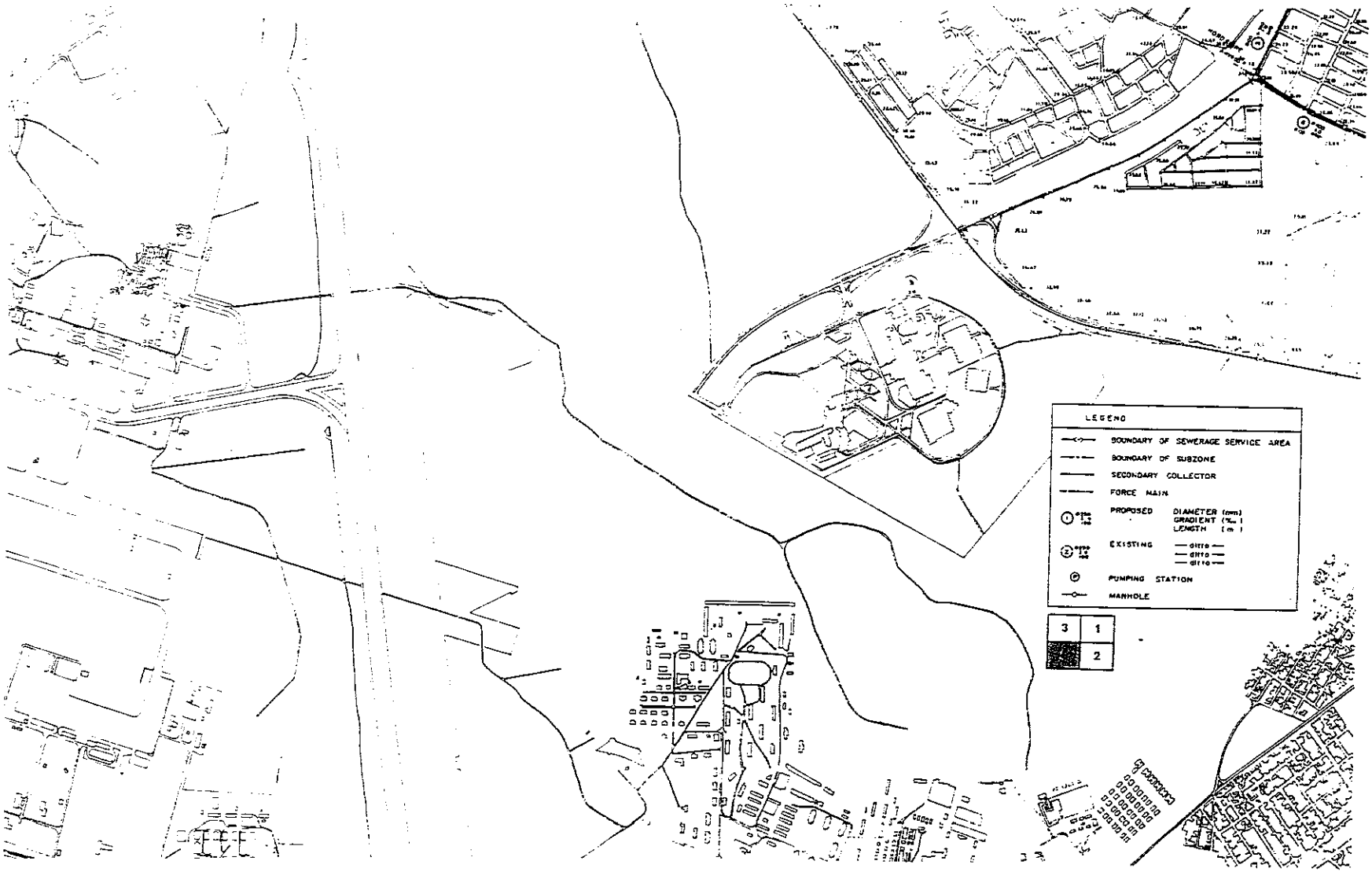


FIGURE B.4.10 GENERAL PLAN OF SEWERAGE SYSTEM FOR PARCELLES ASSAINIES AND ITS SURROUNDINGS (4)

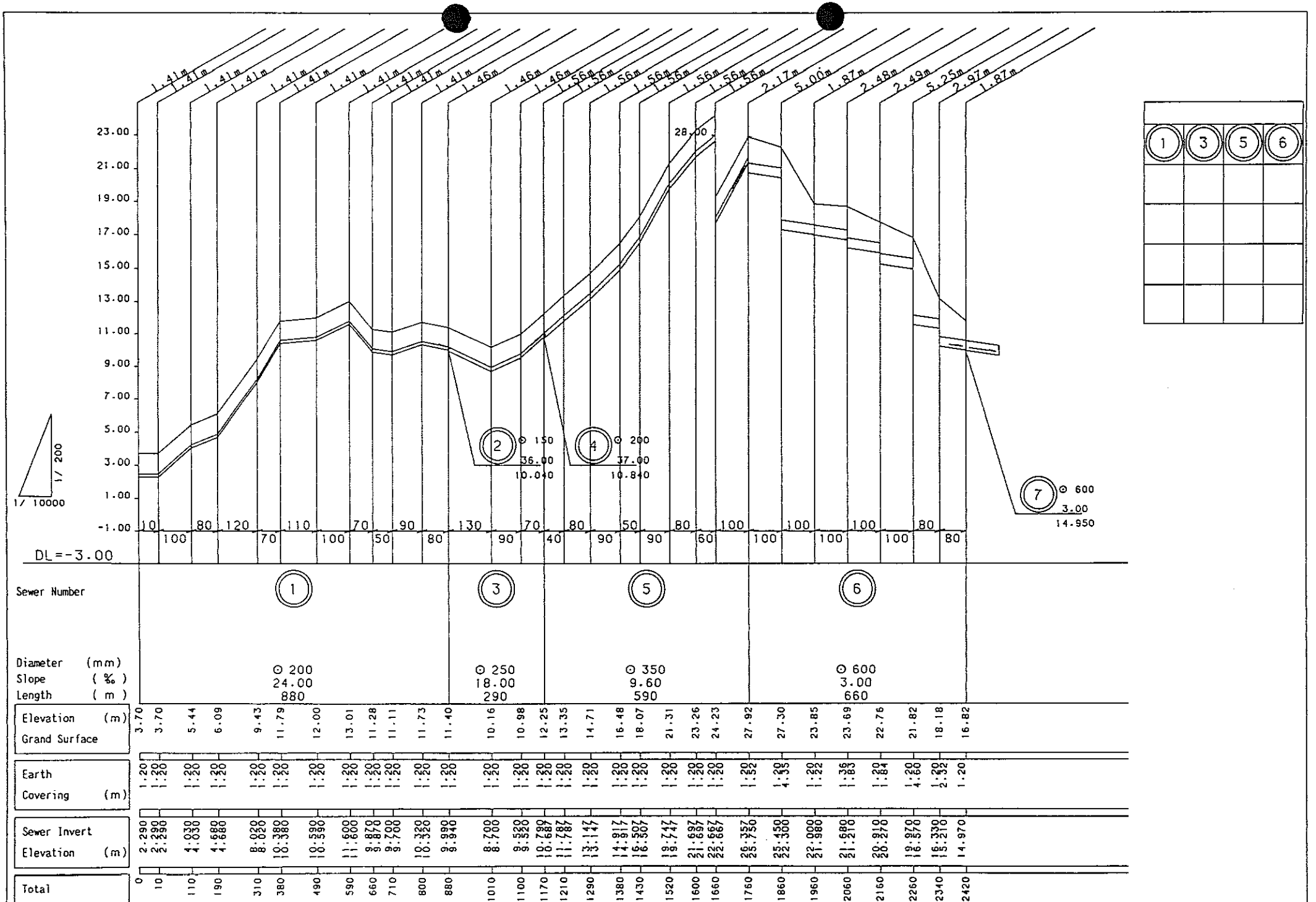


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (1)

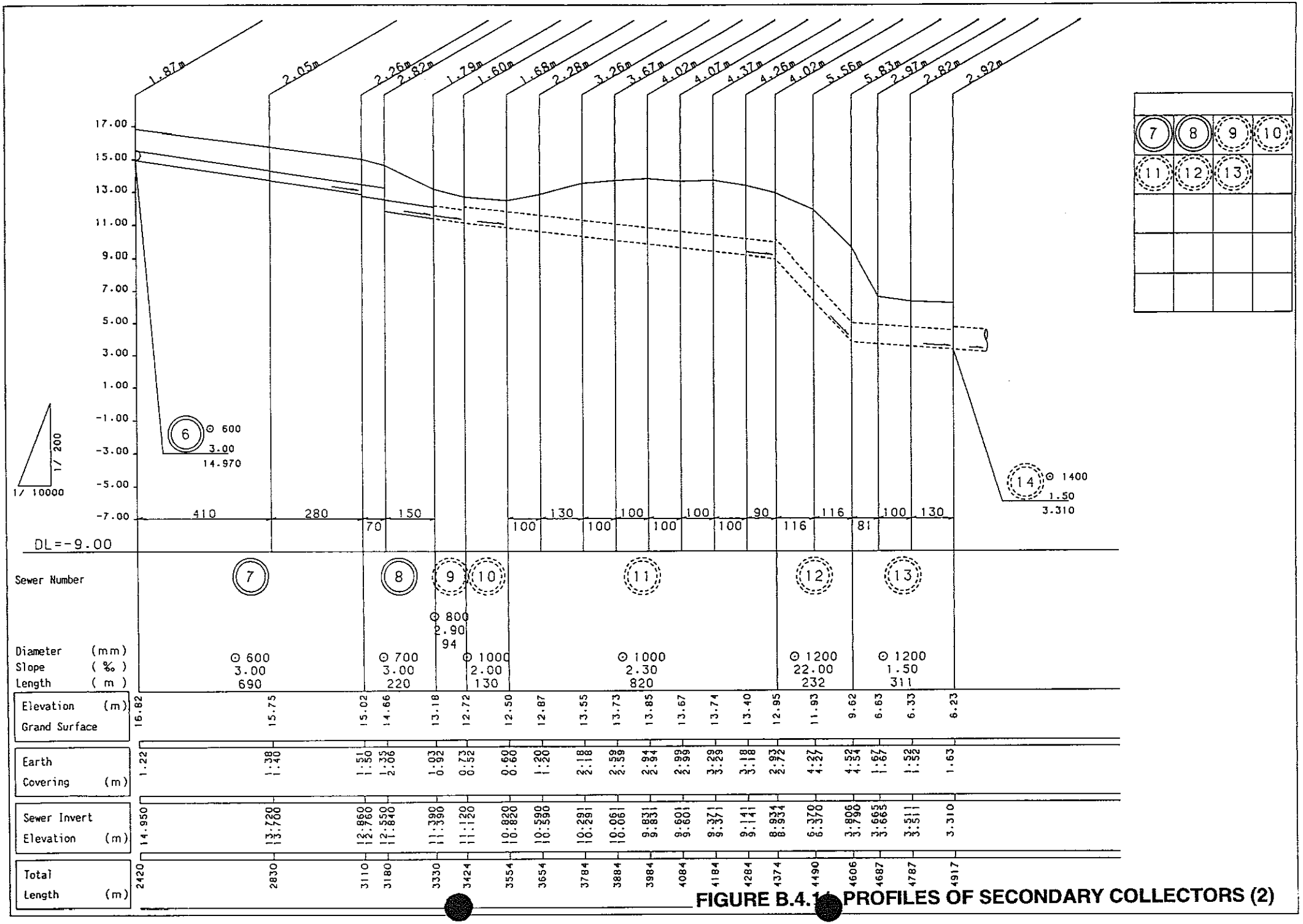


FIGURE B.4.14 PROFILES OF SECONDARY COLLECTORS (2)

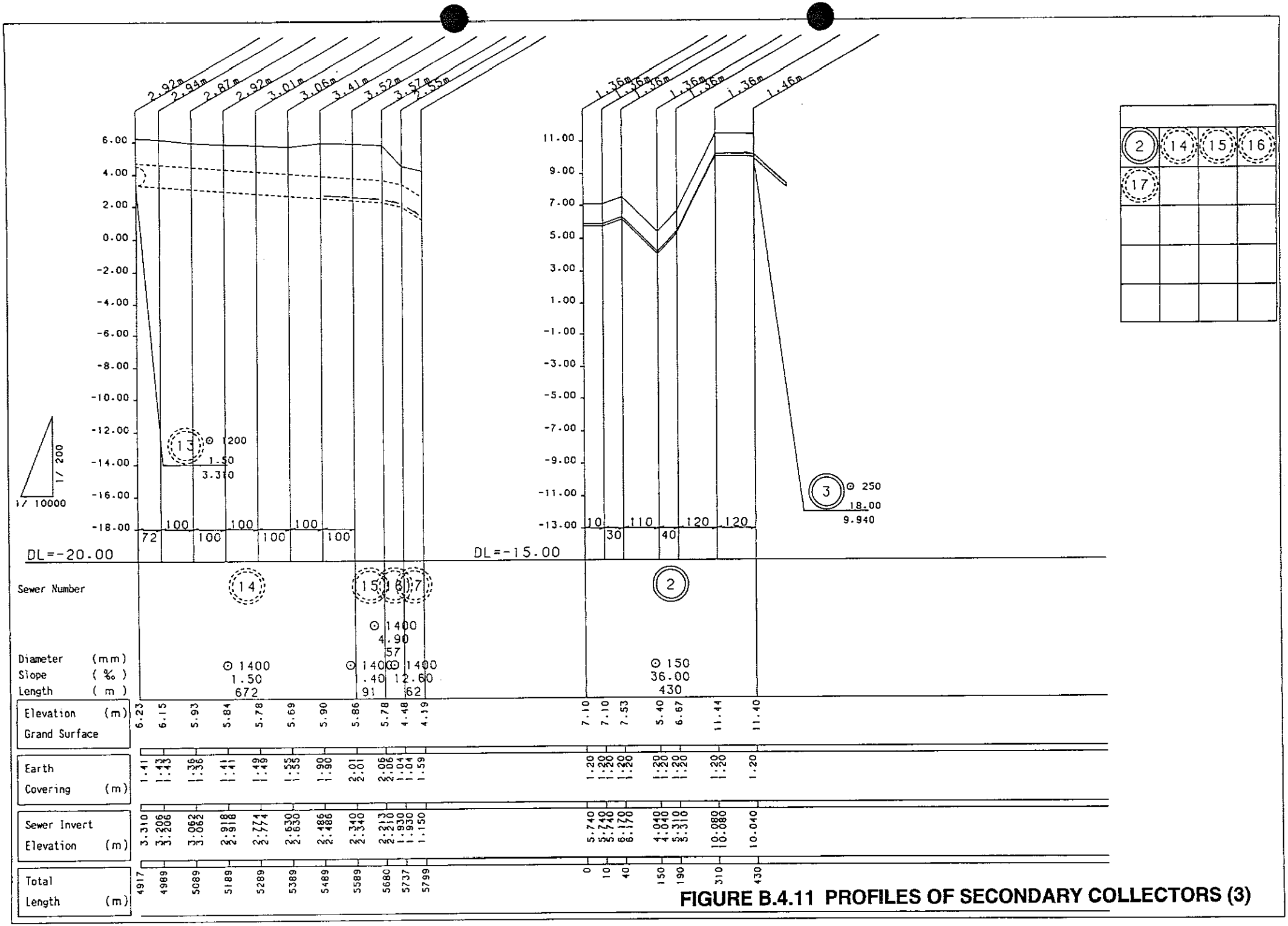


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (3)

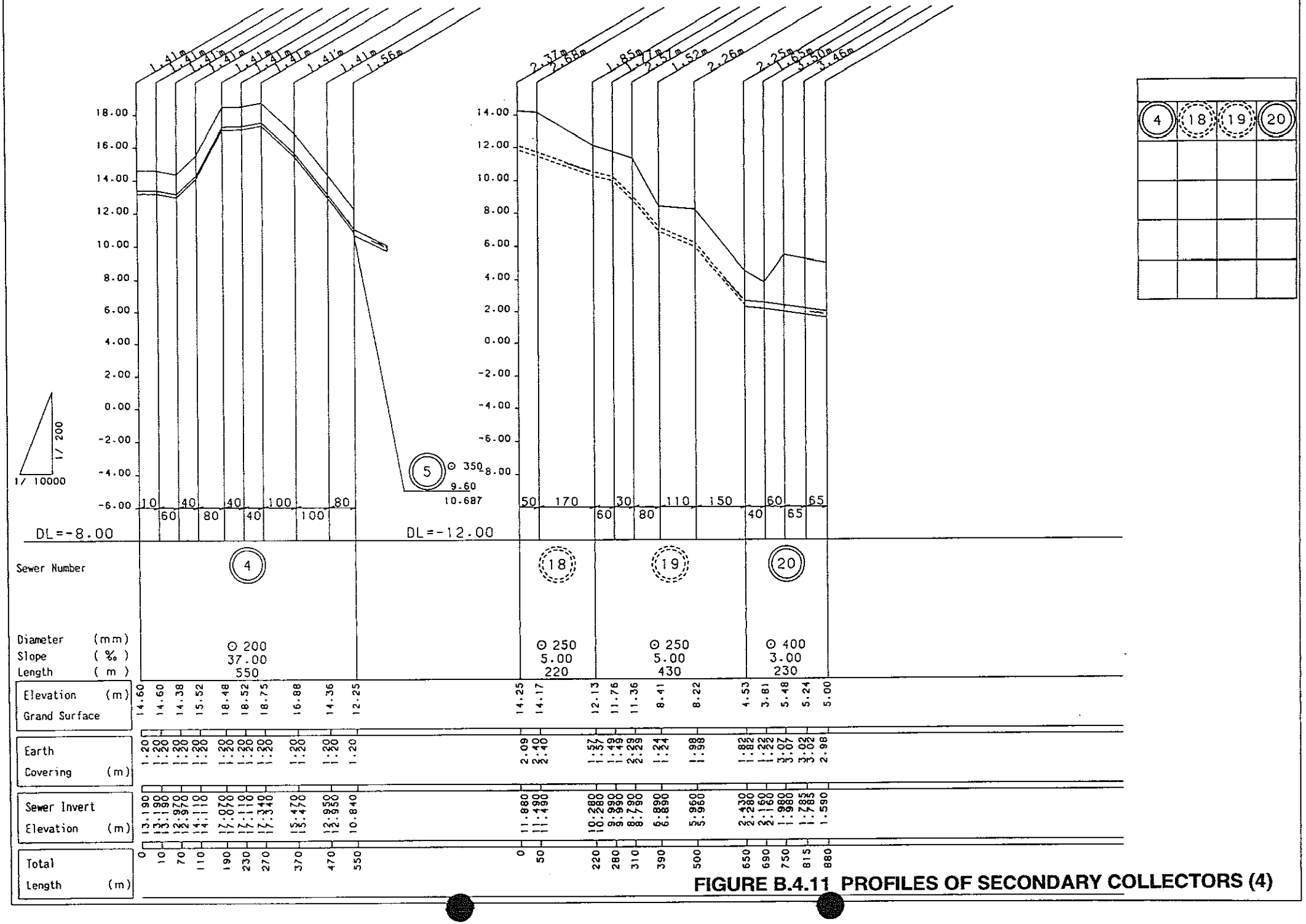


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (4)

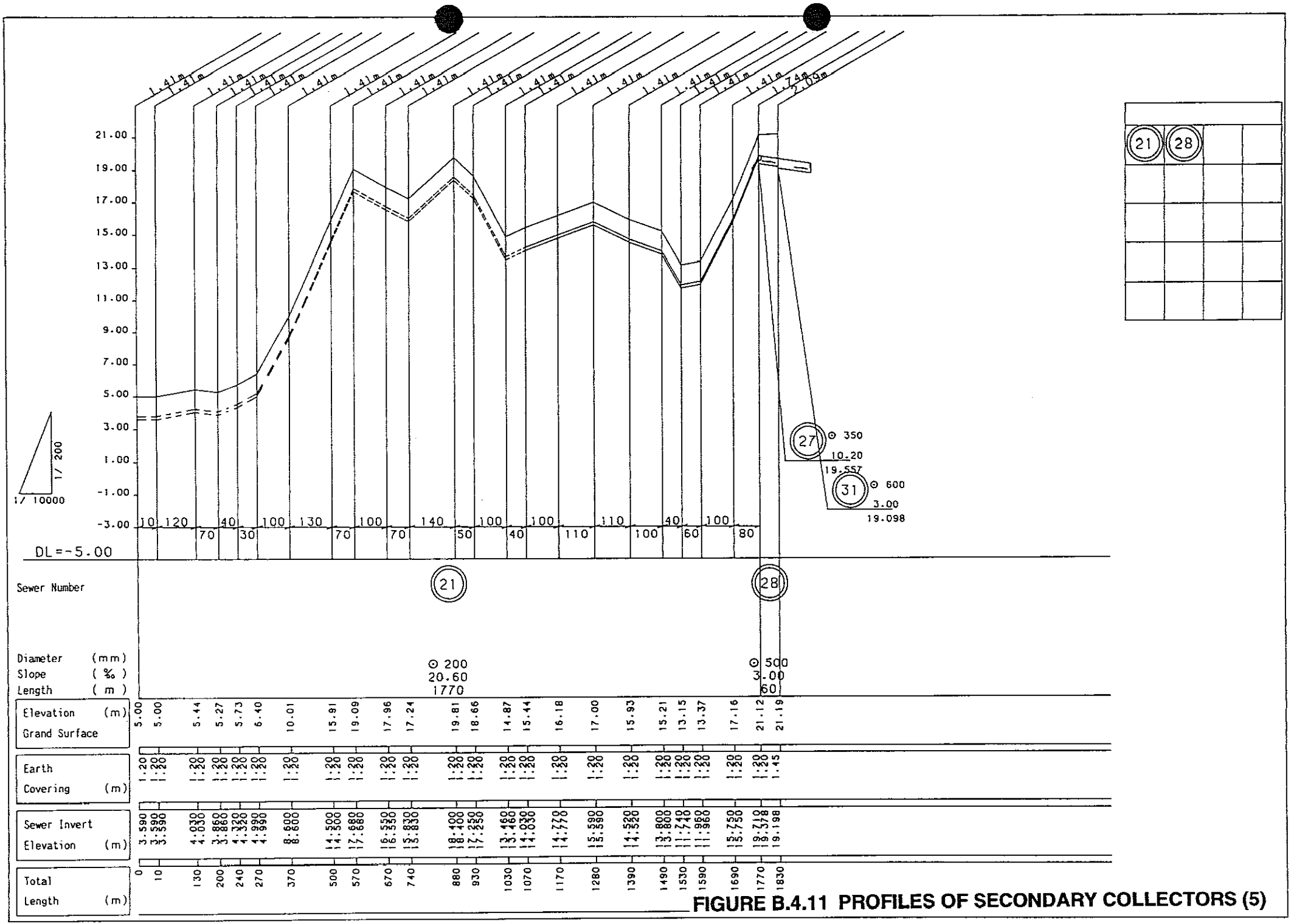


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (5)

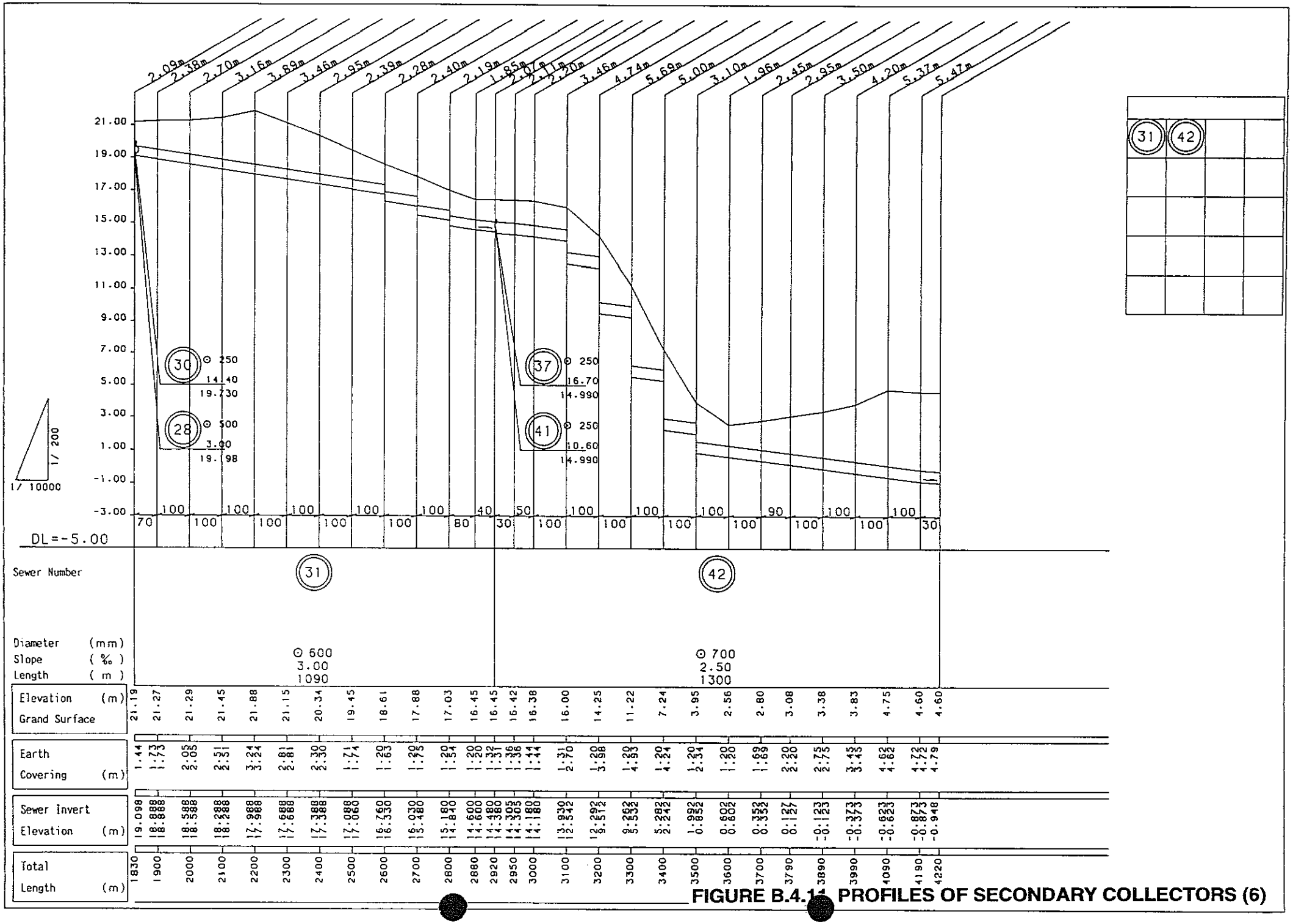


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (6)

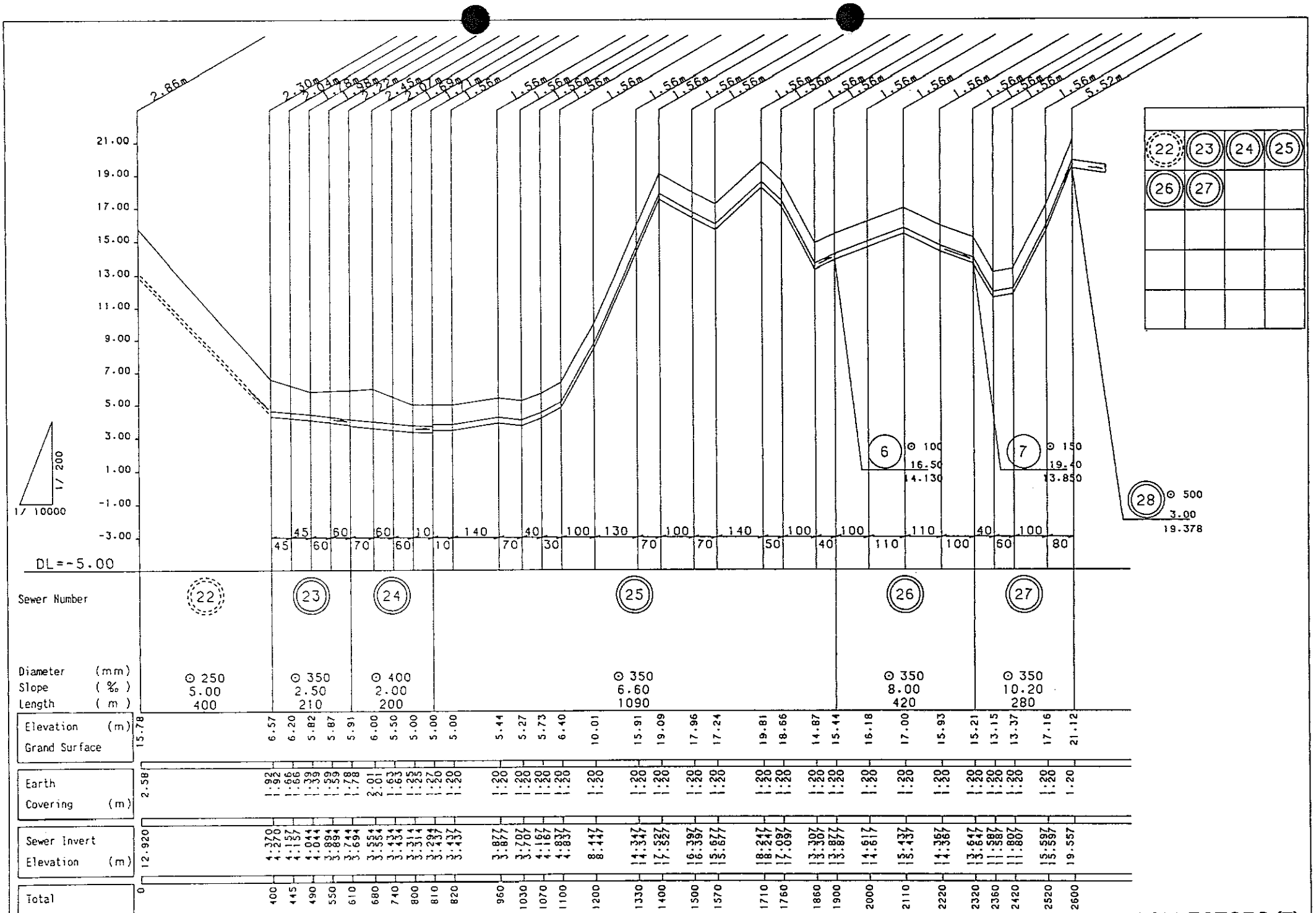


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (7)

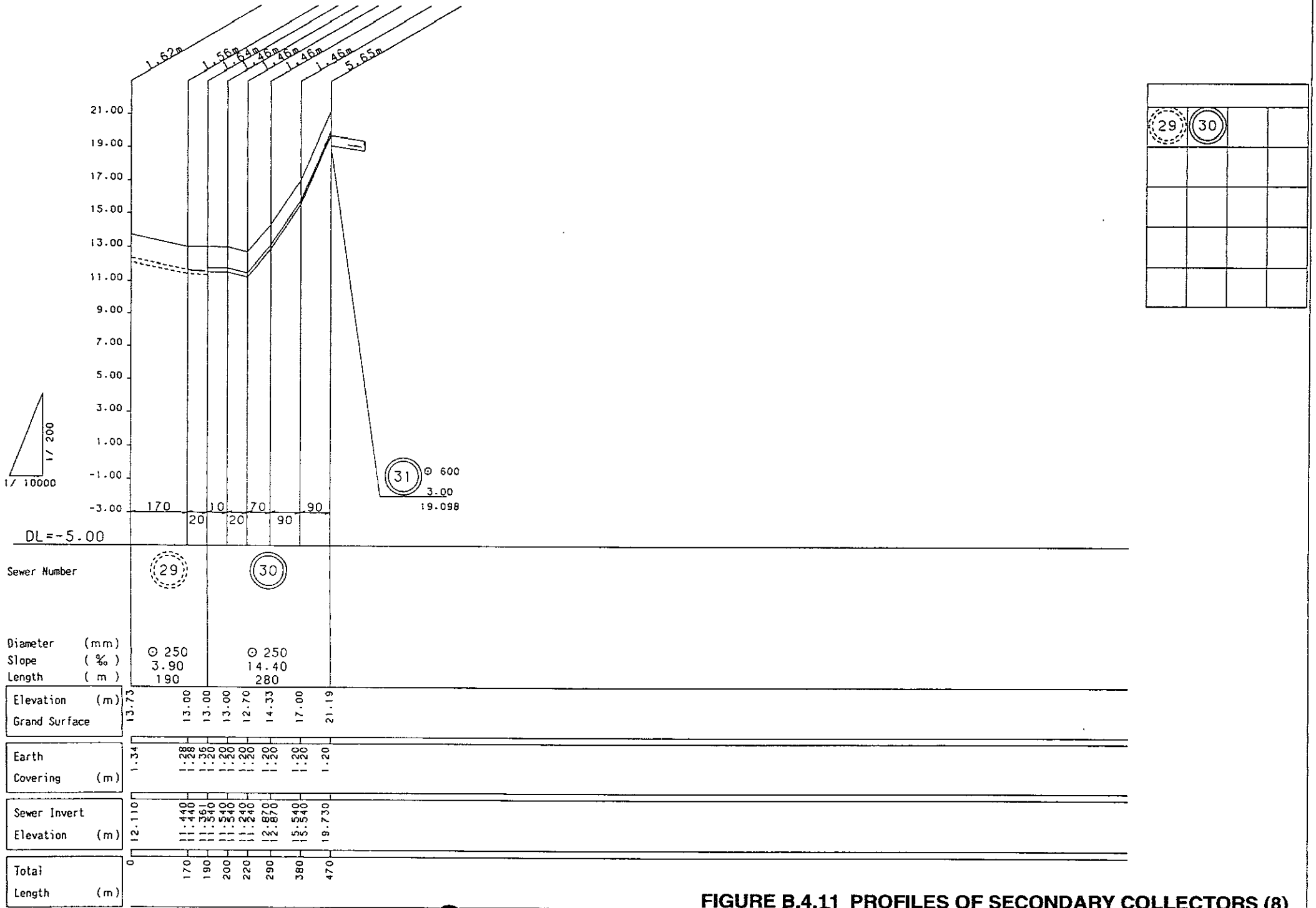


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (8)

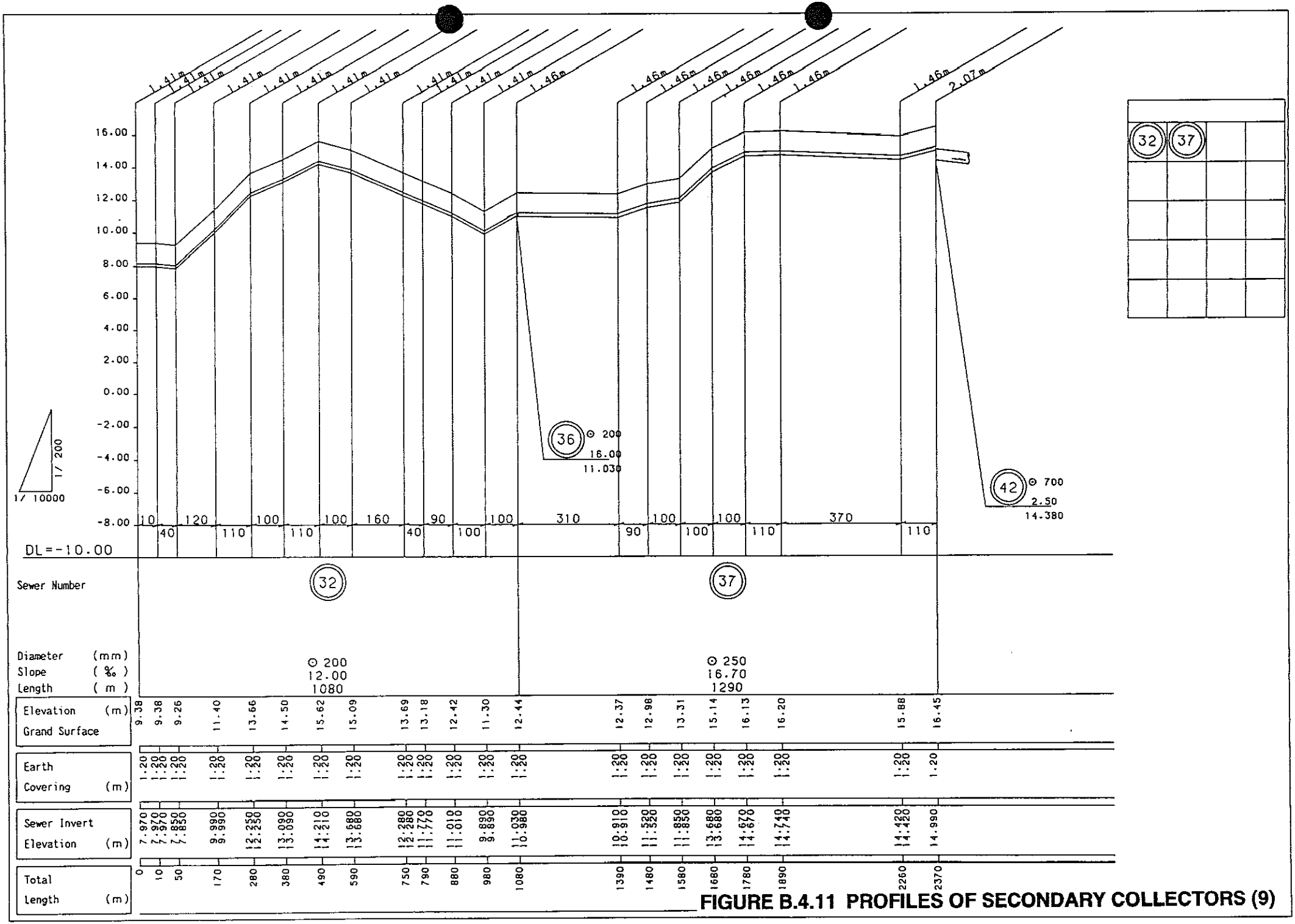


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (9)

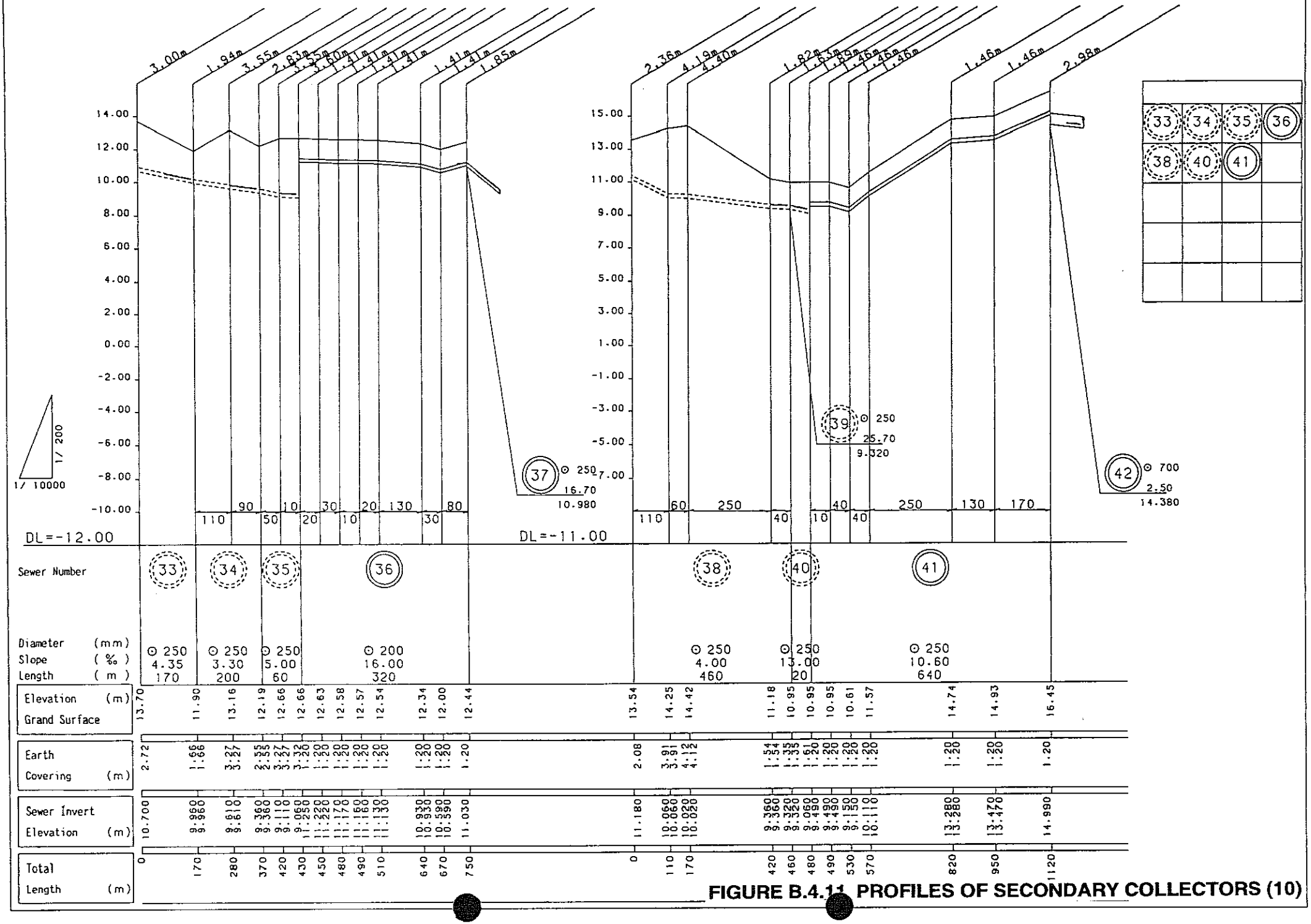


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (10)

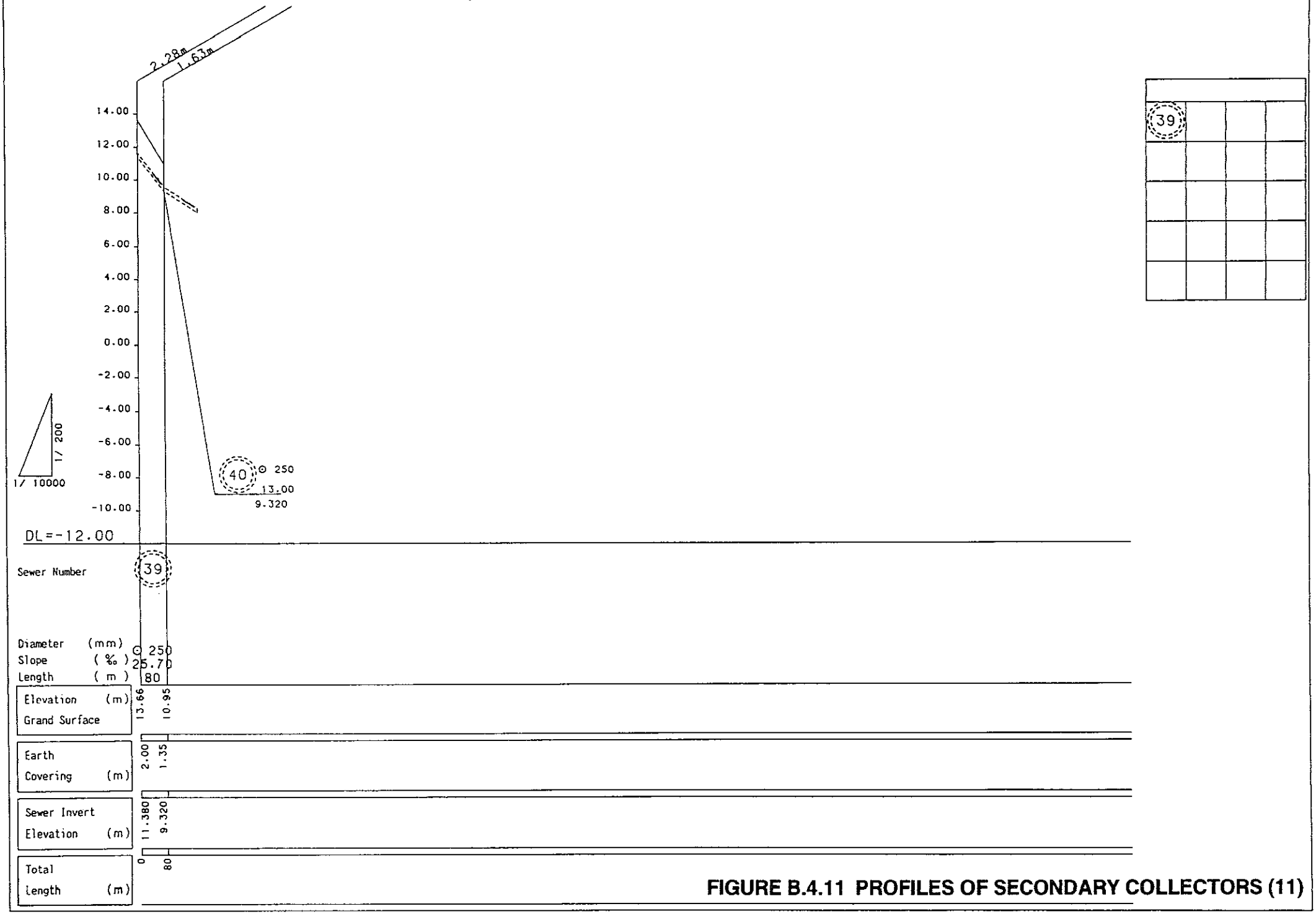


FIGURE B.4.11 PROFILES OF SECONDARY COLLECTORS (11)

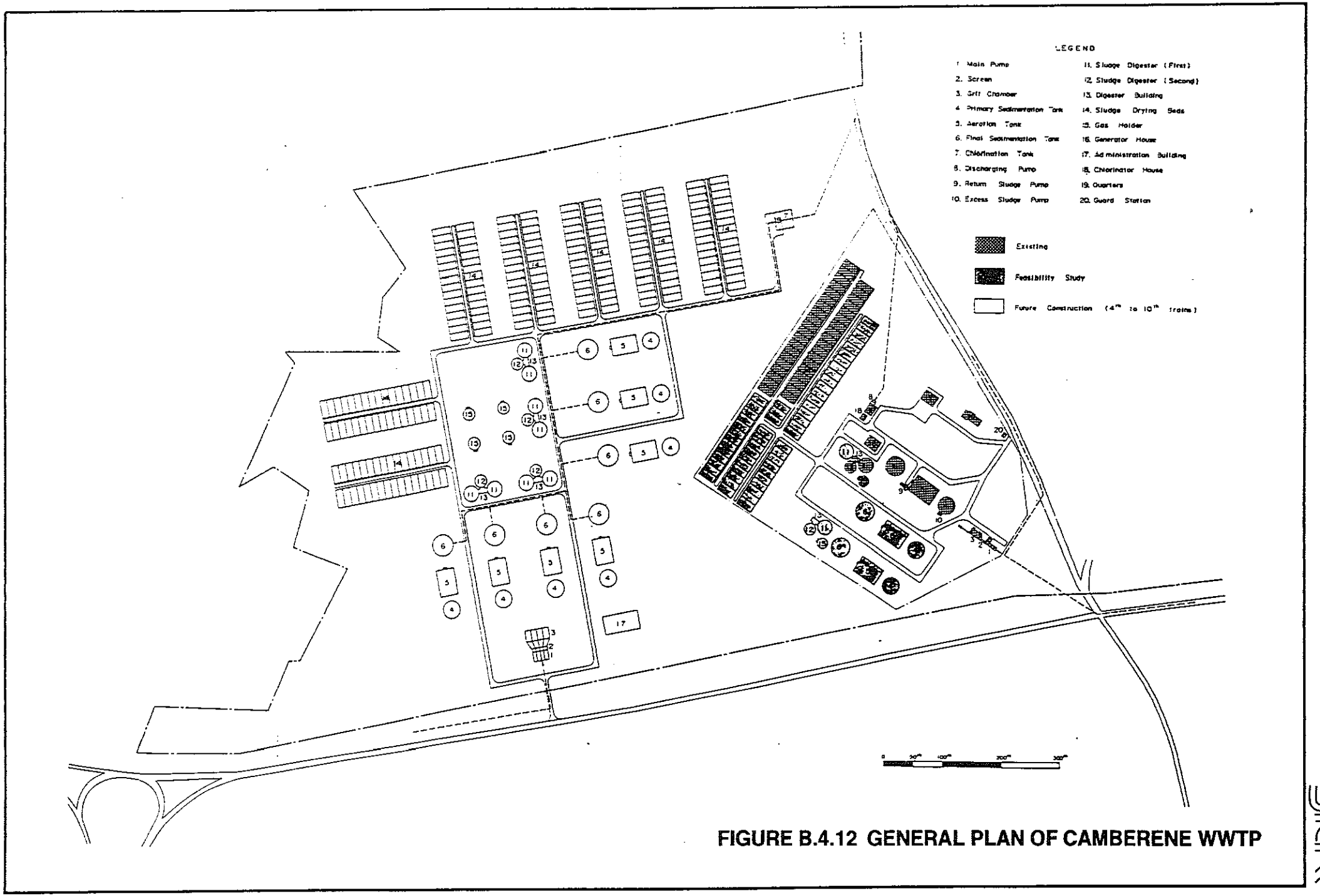
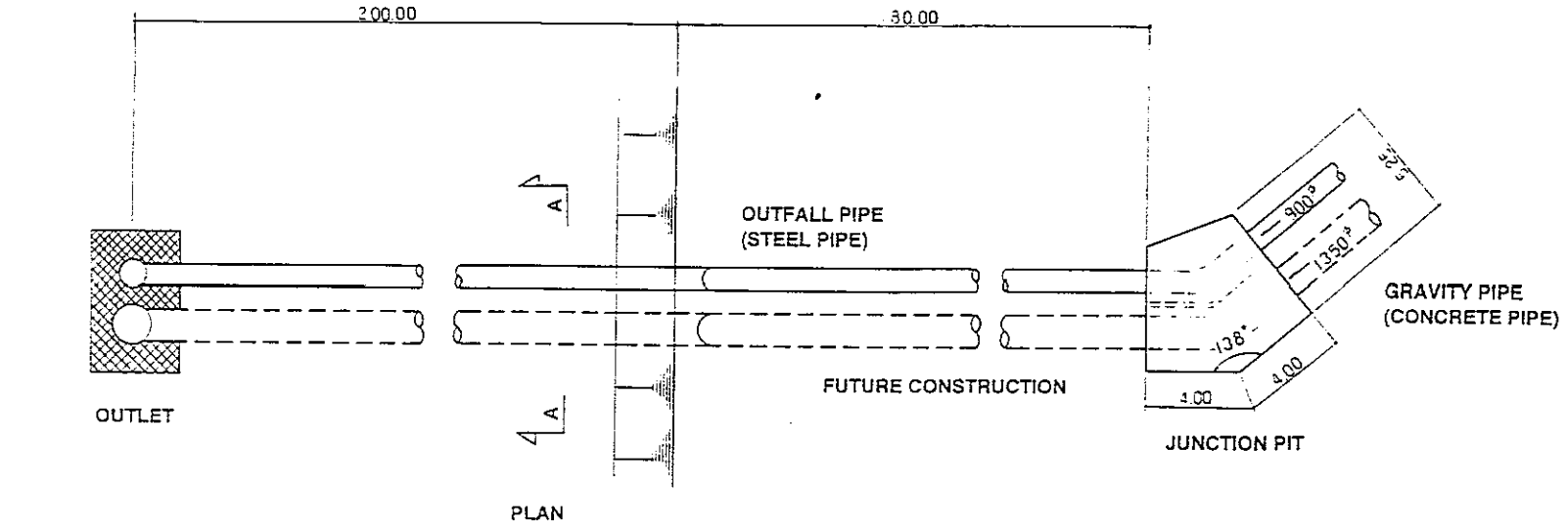
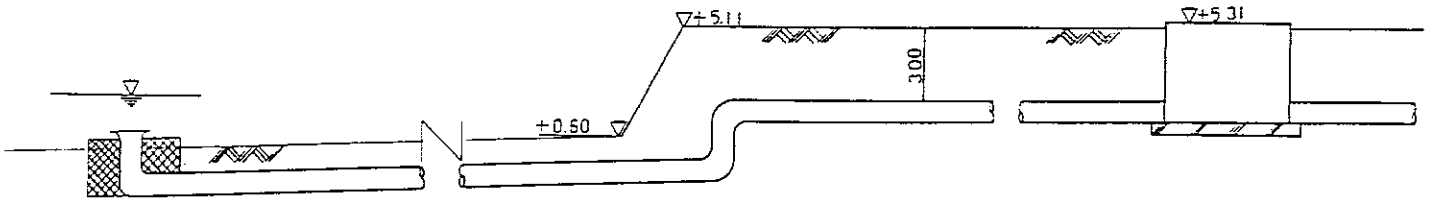


FIGURE B.4.12 GENERAL PLAN OF CAMBERENE WWTP





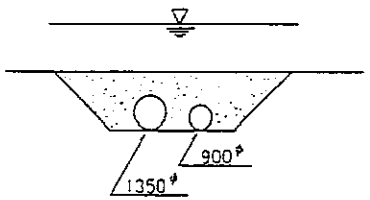


FIGURE B.4.13 PLAN AND SECTION OF OCEAN OUTFALL

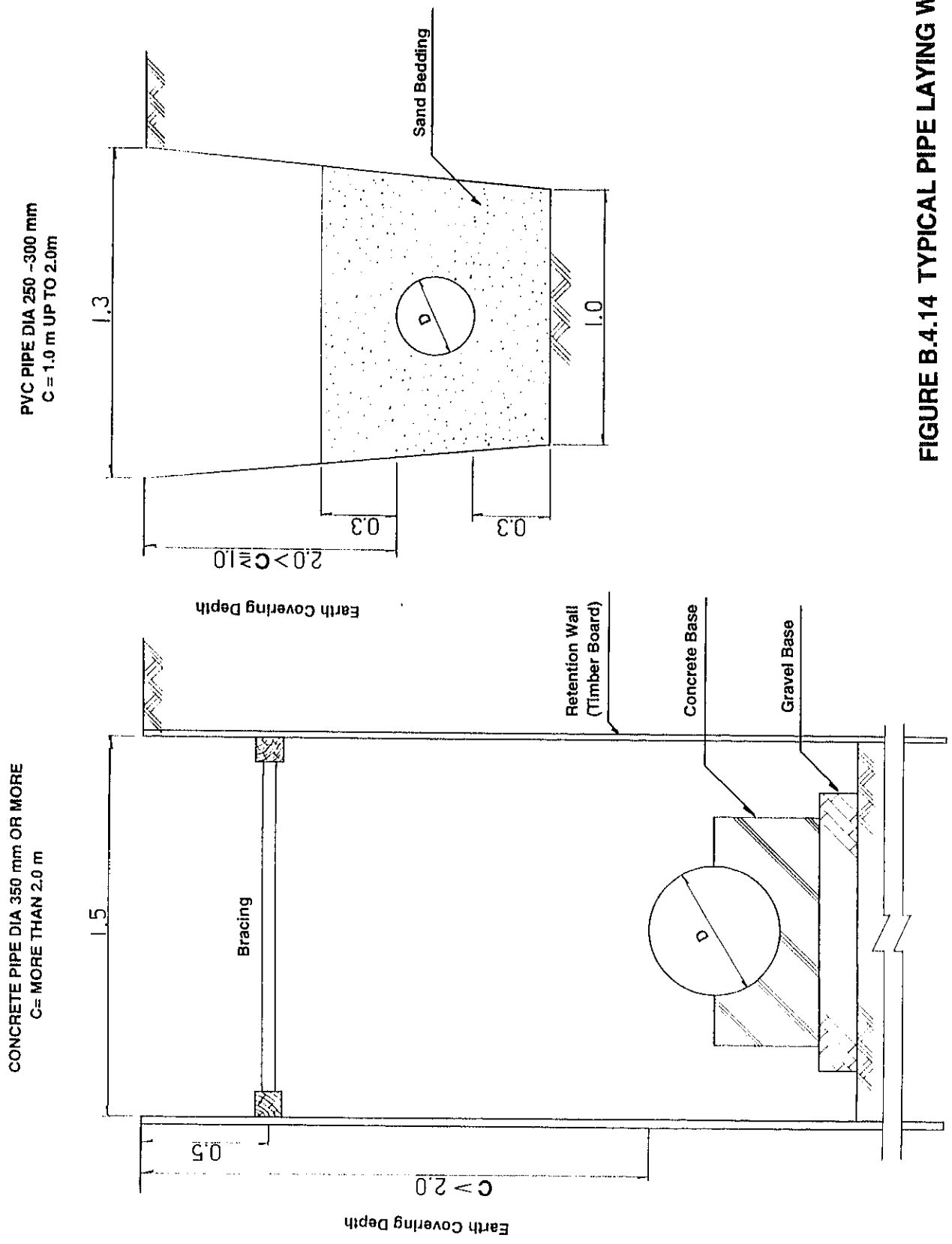


FIGURE B.4.14 TYPICAL PIPE LAYING WORKS

FIGURE B.4.15 IMPLEMENTATION SCHEDULE

	1995	1996	1997	1998	1999	2000
1) Survey, Design, Contract Process						
2) Land Acquisition/Compensation						
3) Branch Sewers						
a. Pacelles Assainies						
b. Nord Foire						
c. Stadium and E. to Patte d'Oie						
4) Pumping Stations and Force Mains						
a. New P/S Unite 15						
b. New P/S Unite 2						
c. P/S North to Stadium						
d. Replacement of Pump Unit P/S 9, 7, 23, D.Mbaye						
5) Force Main						
6) Central/Eastern Collector						
7) Western Collector						
8) Camberene WWTP			2nd Train		3rd Train	
9) Force Main (Effluent Discharge)						
10) Outfall						

SUPPORTING REPORT - C

URBAN DRAINAGE SYSTEM

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CHAPTER 4 FEASIBILITY STUDY ON URBAN DRAINAGE OF PRIORITY PROJECT

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CHAPTER 1 PRESENT DRAINAGE CONDITIONS

1.1 GENERAL

1.1.1 Topography and Geology

Dakar, western half of the study area, is generally high and possible to drain by gravity flow. Some low areas are located in Ngor and the coastal areas of Hann Bay. Laterite is widely distributed and permeability is generally low.

Eastern half of the study area is generally covered by sand. This area is characterized by rows of sand dunes and "Niaye", low strips between the sand dunes developed in parallel. Some areas along the coast of Thiaroye Sur Mer are lower than mean sea level. Topographic characteristics of the Study Area are shown in *Figure C.1.1.*

1.1.2 Rainfall

1) Annual and Monthly Rainfall

Average annual rainfall recorded from 1947 to 1992 at Dakar-Yoff Airport is 458.5 mm and 98% of it occurred in five months from June to October. Usually large storm rainfall occurs in August and September. Monthly rainfall depths are shown in *Table C.1.1* and *Figure C.1.2* shows record of annual rainfall. The table shows tendency described below:

- Large annual and monthly rainfall depths were distributed in 23 years from 1947 to 1969 and small in the rest 23 years from 1970 to 1992. (refer to *Figure C.1.2*).
- The maximum monthly rainfall depths in June, July, August, September and October are 75.9, 272.5, 493.1, 365.3 and 250.0 mm respectively and they were recorded before 1969 except June.
- The maximum and the minimum annual rainfall depths are 901.0 mm in 1951 and 113.2 mm in 1972 respectively.

2) Daily Rainfall

Daily rainfall records, measured from 6:00 a.m. to 6:00 a.m., of Dakar- Yoff Airport were collected. The daily rainfall records are attached in the Databook.

The maximum daily rainfall recorded during past 46 years from 1947 to 1992 are 157.7 mm (August 25, 1964), followed by 153.1 mm (August 26, 1962) and 144 mm (September 17, 1951).

The probability analysis for daily rainfall was conducted. The results are shown in the table below.

Probability Analysis for Daily Rainfall

Return Period	Rainfall (mm)
2 years	66.2
5 years	97.2
10 years	117.7
30 years	148.7
50 years	162.9

Note : Gumbel Method

3) Rainfall Duration and Intensity

To study the relationship between rainfall and its duration, rainfall record charts were collected, however limited data was available. From the available rainfall record chart, the following points can be concluded.

- The storm of this area has relatively short duration. More than 80 % of storms have duration of less than 12 hours and about 50 % of them have duration of less than 6 hours.

- The amount of rainfall observed in one hour, two hours and 24 hours durations equivalent to 56 %, 70 % and 122 % respectively, of the total daily rainfall.

From the above relationships, probable rainfall depths for short duration (30 min., 1 hr., 2 hrs., 24hrs.) are calculated and the results are shown below.

Probable Rainfall Depth for Short Duration

	Rainfall			
Return Period	0.5 hr	1 hr.	2 hrs.	24 hrs.
2 years	28.2	37.1	45.7	81.0
5 years	41.2	54.4	67.2	119.0
10 years	49.9	65.9	81.3	144.1
30 years	63.0	83.3	102.8	182.0
50 years	69.1	91.2	112.6	199.4

1.1.3 Tide

According to the tide table at the Dakar Port from 1989 to 1993, the tide varies from -0.9 m to +0.95 m. High spring tide occurs in August and September during which heavy rainfall occurs, as shown in *Table C.1.2.*

1.1.4 Urbanization

Most of the available land in the study area has been developed except small areas around the Dakar-Yoff Airport, eastern part of the study area, Grand Niaye and some low areas. And some part of these remaining areas are planned to be developed. Comparison of the topographic maps prepared in 1981 and the aerial photographs taken in 1992 indicates the following developments in the last decade:

- Dakar urban area has been extended to the north (Ouakam, Grand Yoff).
- East coast area from Ngor to Guediawaye has been fully urbanized.
- Pikine area has been fully developed except some low areas.
- Grand Niaye, reforestation areas and the lakes have not been developed.
- Area of garbage dumping in Lac Mbeubeusse has been expanded greatly.

1.2 EXISTING DRAINAGE SYSTEM AND PLAN

1.2.1 Group of Drainage Sub-Areas

The study area having a total area of 160.4 sq. km is broadly divided into the following seven (7) group of drainage sub-areas based on natural and drainage conditions.

A-1: Dakar Urban Area (27.9 km^2)
A-2: Grand Yoff and Ouakam Area (6.9 km^2)
A-3: Dakar-Yoff Airport and Its Surrounding Area (17.6 km^2)
A-4: Yoff-Guediawaye Coastal Area (18.5 km^2)
A-5: Grand Niaye Area (15.0 km^2)
A-6: Pikine Area (21.0 km^2)
A-7: Eastern Pikine Area (53.5 km^2)

The group of drainage sub-areas are shown in *Figure C.1.3.*

Boundaries of the above groups have been determined using following data and field reconnaissance:

- Topographic maps (scale=1/5,000) of Dakar, Guédiewaye and Bargny.

- Existing drainage networks, 1/10,000 topographic maps and 1/5,000 topographic maps for southern Dakar.
- Aerial photographs (scale, nearly equal to 1/16,000).
- 1/50,000 topographic maps for northern edge of the study area.

The groups of drainage sub-areas are briefly described below:

A-1 is an urban area of the city of Dakar with high ground elevation in most of the area. The area is covered with the existing stormwater drainage system. Most of the area can be drained by gravity flow.

A-2 consists of two independent catchments; Grand Yoff and Ouakam. Both of them are surrounded by relatively high ground making drainage to the sea difficult by gravity flow. Expansion of urban development of Dakar is now approaching to this area.

A-3 consists of the Dakar-Yoff Airport drainage area and its surrounding coastal areas including Ngor, Ouakam and so on. Most of the area is high except area around Ngor.

A-4 consists of coastal strips that have been urbanized in recent years. Most strips are high enough to drain stormwater to the sea by gravity flow, but there exists some inland strips having no outlet to the sea due to high sand dunes developed along the shoreline.

A-5 is a vast low land surrounded by urban areas of Dakar and Pikine. Grand Niaye, presently consisting of agricultural land , marsh and water surface, is an important source of the groundwater supply. The low land is being developed in the western part.

A-6 covers Pikine and the coast (Thiaroye Sur Mer). The typical topography called "Niaye" lies in this area. Urban area is spread almost all over this area even in such low lands where rainwater concentrates.

A-7 is a suburban area encompassing small towns of Malika, Keur Massar, Mbaw, etc. and is urbanizing towards the neighboring town, Rufisque. There are two reforestation areas. One is the coastal zone of Malika facing to lakes at inland side and another is the Mbaw reforestation area located in the flat inland area. Lac Mbeubeusse has been filled up by dumping of garbage from Dakar and Pikine.

1.2.2 Existing Drainage Facilities And Plans

Drainage network in the study area is provided for Dakar urban area, Dakar-Yoff Airport area and a small part of Pikine. Most of the stormwater in Dakar is drained by gravity to the sea except the areas where drainage system is not established or areas drained to Grand Niaye.

In Pikine, stormwater drainage system has maintained its natural shape although runoff characteristics have been changed by urbanization. Most of the stormwater is drained to Grand Niaye, other Niayes, Lacs and the sandy ground. Only small areas along the coast are drained to the sea.

Existing drainage network including the boundaries of drainage sub-areas and major drainage channels is shown in *Figure C.1.4*.

Existing drainage condition of the sub-drainage areas is described below:

A-1: Dakar Urban Area

The drainage system of Dakar urban area consists of the following drainage basins:

1) Plateau Basin (4.1 km^2)

Stormwater in this area is drained by gravity flow through four pipes to Dakar Port area and four pipes to Madeleines Bay. Stormwater from Cap Manuel with steep topography is drained without any drainage pipe.

2) Gueule Tapee Channel Basin (1.6 km^2)

Stormwater in this area is drained by a two celled box culvert having a drainage capacity of 12.2m^3/s to Soumbedioune Bay. The Gueule Tapee Channel was an open channel before.

3) Channel IV Basin (4.4 km^2)

This area is drained by a concrete lining open channel, Channel IV, to Soumbedioune Bay. Discharge capacity is about 100 m^3/s.

4) Channel IV-3 Basin (3.7 km^2)

This area is drained by an earth open channel to Fann Bay. And its discharge capacity is 10.7 m^3/s.

5) Dakar University Area (1.6 km^2)

The Dakar University Area located between Channel IV and IV-3, is drained by a pipe. Outlet of the pipe is presently clogged with soils and other materials.

6) Channel V & VII Basin (3.5 km^2)

This long area is drained by a large box culvert to the Port area. Discharge capacity of channel V is 5.4 m^3/s.

7) Channel VI & VI-2 Basin (3.8 km^2)

This area is drained to Hann Bay by a concrete lining open channel. Adjacent coastal area is drained by culverts and pipes from factory area. Discharge capacity of channel VI is 25.0 m^3/s.

8) Front de Terre Channel Basin (3.6 km^2)

This area is drained by a wide open channel to a stormwater infiltration area (Centre de Capitage des Eaux), which is covered by sand layer and has a small pond.

Calculation of the discharge capacities of existing drainage channels in Dakar Urban area are shown in *Table C.1.3*.

A-2: Grand Yoff and Ouakam Area

1) Grand Yoff Basin (4.6 km^2)

There exists no drainage facility in this area. Gravity flow drainage to Hann Bay by a floodway was proposed in the Strategy Plan. Now it has been revised by the Community of Dakar because of high cost due to development of the area along the floodway. The following revised drainage improvement plan is presently being proposed:

- Interceptor to collect the stormwater from higher area around International Trade Center.
- Drainage pumping station for the low area of Grand Yoff town to the interceptor.
- Infiltration of the collected stormwater at the sandy area located north of the Interchange, Patte D'oie.

2) Ouakam Basin (2.3 km^2)

This area is a high basin with minimum elevation of 21 m surrounded by hilly areas. The area is located in the east of Ouakam town and has not been developed yet. The stormwater from this area is found to concentrate to the lowest area and finally infiltrates into the ground since there is no drainage facility.

A-3: Dakar-Yoff Airport and Its Surrounding Area

1) Dakar-Yoff Airport Basin (13.7 km^2)

The airport area is drained by three open channels to the sea at Ngor, Yoff and between these two. The largest earth channel (Airport South Channel) flows through the west side of Ngor village and its drainage capacity is 9.5 m^3/s.

A drainage network of Ouakam town is proposed by the Community of Dakar. The town is located in the uppermost of the Airport South Channel catchment and is drained to the Channel at the east of a culvert under runway.

2) Coastal Area (3.9 km^2)

Narrow coastal areas are drained by natural waterways.

A-4: Yoff-Guediawaye Coastal Area

This area has only one drainage channel along the road located in the eastern Yoff village. There is no drainage facility in the recently developed urban areas. This area is basically drained by infiltration into the ground.

A-5: Grand Niaye Area

There is no artificial drainage facility in this area. Almost all of stormwater from this area concentrates to the Grand Niaye and finally infiltrates into the ground. Stormwater discharged from the southern coast is drained into Hann Bay depending on topography.

A-6: Pikine Area

There is one artificial drainage channel in the low area located in the west of Thiaroye Sur Mer. Drainage of this area is basically by infiltration and storage in many low areas. This area is drained to Grand Niaye, Lacs and other low areas. The area draining to the sea is comparatively small.

A-7: Eastern Pikine Area

There is no artificial drainage facilities in this area. There is a natural stream in Mbaw flowing into Hann Bay (Marigot de Mbaw).

1.3 FLOOD CONDITION

The floods in the study area have been occurring in the rainy season of July, August and September. The recorded largest flood occurred in August 1989. The daily rainfall amount of this storm is recorded to be 113.7 mm (see *Figure C.1.5*) and it is estimated to be in a scale of a storm once in 10 years' frequency. The storm coursed flood at many places in Dakar and Pikene. The Strategy Plan identified 45 flood affected areas as shown in *Figure C.1.6*. Flood condition survey for the areas shown in the *Figure C.1.6* was conducted by JICA Study Team to know the condition of 1989 flood and annual floods. Through the survey, three (3) flood affected areas were identified (*Figure C.1.7*) in Pikine area besides the flood affected areas in the Strategy Plan. The results of the survey are summarized in *Table C.1.4*. Possible causes of these floods have been identified as follows:

- Urbanization took place in low land areas, where stormwater gathered in the rainy season.
- Urbanization increased the storm run-off and decreased the stormwater infiltration capacity of the ground.
- In some areas, drainage systems were not completed.

Major flood affected areas are explained below.