12.2.4 Design Criteria and Planning for Sewage Collection System

1. Design Criteria

(1) Collection System

The plan and design of the sewage collection systems differ depending on sewage collection method employed. The two alternative collection systems, the separate and the combined systems, are comparatively studied. The characteristics of the two systems can be summarised as follows :

1) Separate system

A separate system has parallel collection systems for sanitary sewage and stormwater run-off, respectively. This system is advantageous to the surrounding environment and to water pollution control. It is also recommendable in an area where the existing collection facilities are maintained in relatively good condition.

2) Combined system

A combined system refers to a system to that collects sanitatary sewage and stormwater run-off by means of combined sewers. This system may be employed as a low-cost alternative to the separate sewer system under the following conditions:

- Discharge of sewage into public water bodies is acceptable during the rainy season.
- Existing drainage/channels presently collecting rain water and sullage can be used as combined sewers and/or receiving water courses for overflow water from diversion chambers.

According to the following reasons, the separate system was adopted:

- Effective water pollution control in the public water bodies.
- Full use of the existing sanitary sewage and drainage facilities to achieve low cost construction.

(2) Hydraulic Calculation for Sanitary Sewage

1) Equation for flow calculation

The Colebrook-White formula was adopted in the previous studies, while the Manning formula is also applicable for flow velocity calculation. Table 12.2.4.1 shows comparative flows by sewer diameter between the Colebrook-White and the Manning formula.

Table 12.2.4.1 Comparison of Velocity Formula

Diameter		200m	300m	400m	500m	600m	800mm
Gradient		0.006	0.004	0.003	0.0025	0.002	0.0015
Velocity (m/sec)	Colebrook White	0.94	0.99	1.03	1.08	1.08	1.12
	Manning	0.81	0.87	0.91	0.96	0.97	1.02

Note : Roughness coefficient in Manning formula is assumed at 0.013

As a result of comparison, both values are almost the same. The Manning formula was adapted for this study as shown below.

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

$$Q = A \times V$$

Where, V : velocity of flow (m/sec)
n : roughness coefficient
R : hydraulic radius (m)
I : gradient in decimal
A : section area (m^2)

Standard roughness coefficients to be used by material type are shown in Table 12.2.4.2.

Table 12.2.4.2 Roughness Coefficient

Type of Pipe	Roughness Coefficient
Asbestos Cement Pipe	0.013
Vitrified Clay Pipe	0.013
Plastic Pipe	0.010
Concrete Pipe/Conduit	0.013
Coated Steel Pipe	0.012

2) In-pipe velocity

<u>Minimum Velocity</u>

The design of sewers is made ensuring a minimum earth cover along the existing topography as much as possible. Sewers must be designed to convey peak flows. The sewer pipe size and gradient are selected to ensure the flow close to fullbore at the ultimate flow, subject also to achieving self-cleansing velocities at least at peak daily flow. The minimum velocities to be used are employed referring to the practice in Zimbabwe (Sanitation Manual Design Procedures):

Reticulation and collector sewers	: 0.75 m/sec
Trunk sewers	: 0.60 m/sec

Maximum Velocity

Velocity shall not exceed 3.0 m/sec in any type of sewer to protect sewer erosion.

(3) Structural Design of Sewerage Facilities

The structural design criteria of the sewerage facilities are, in principle, referred to the "Sanitation Manual Design Procedures."

1) Earth cover of sewers

The minimum earth cover of the sewers should be determined in consideration of the permissible strength on the weight loading and sewer depth to connect to the house connections as shown in Table 12.2.4.3.

On the other hand, working at depths greater than about 3.5 m is costly and difficult; excavation at a depth in excess of 5.0 m is hazardous, requiring special and costly safety measures and should be avoided wherever possible.

Table 12.2.4.3 Minimum Earth Cover of Sewers

Minimum earth cover of sewer (mm)	Location of Sewer
600	Sewer Servitude
900	Road Reserve

2) Minimum size of sewer

The smallest size of sewer to be used is 150 mm, but it is permissible to use 100 mm sewers where the grade is sufficiently steep. Manholes would, in any case, be spaced at a maximum of 30 m apart.

Such spacing would be affected not only due to alignment of sewers but whether or not the ground is excessively steep. The sewer extention from service connection may be 100 mm diameter, with a change to 150 mm diameter at the connecting manhole.

3) Manhole

The manholes are installed at the end of public sewers, the point where the sewer diameter changes, the junction of sewers and the changing point of the vertical and horizontal alignment. The maximum manhole spacing standards in Zimbabwe and Japanese (by sewer diameter) are shown in Table 12.2.4.4 and 12.2.4.5, respectively.

Table 12.2.4.4 Manhole Spacing Standard in Zimbabwe

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
100	30
150 (high density areas)	75
150 (elsewhere)	90
200 to 250	100

Table 12.2.4.5 Manhole Spacing Standard in Japan

Sewer Diameter (mm)	Maximum Manhole Spacing (m)
Under 300	50
350 to 600	75
700 to 1,000	100
1,100 to 1,500	150
Over 1,500	200

4) Pumped system

A major problem in dealing with domestic sewage in Zimbabwe is the removal of the high quantities of sand and grit which occur due to the widespread use of sand for scouring pots and pans. It is essential to provide some form of grit removal system for the raw sewage collection sump to minimise wear of the pump casing and impellers and to prevent the pump sump from filling up with grit.

The design considerations of a sewage pump station including associated screen, grit chamber and force main are enumerated. The design of a conventional pump station with the capacity of more than 5 m^3/min. is shown in Figure 12.2.4.1, while a manhole type pump station for those with the inflow of less than 5 m^3/min. is shown in Figure 12.2.4.2.

- Design flow for capacity calculation: peak wet weather flow
- Force main

  Minimum diameter of force main: 100 mm
- Screen

Ramoval method of screening: basically manual rake system

- Grit chamber

  Number of channels: more than 2 channels

  Water surface load: 1,800 m^3/m^2/day

  Optimum velocity: 0.25 to 0.30 m/sec

- Pump equipment

  Number of units: more than 2 sets (including 1 standby unit)

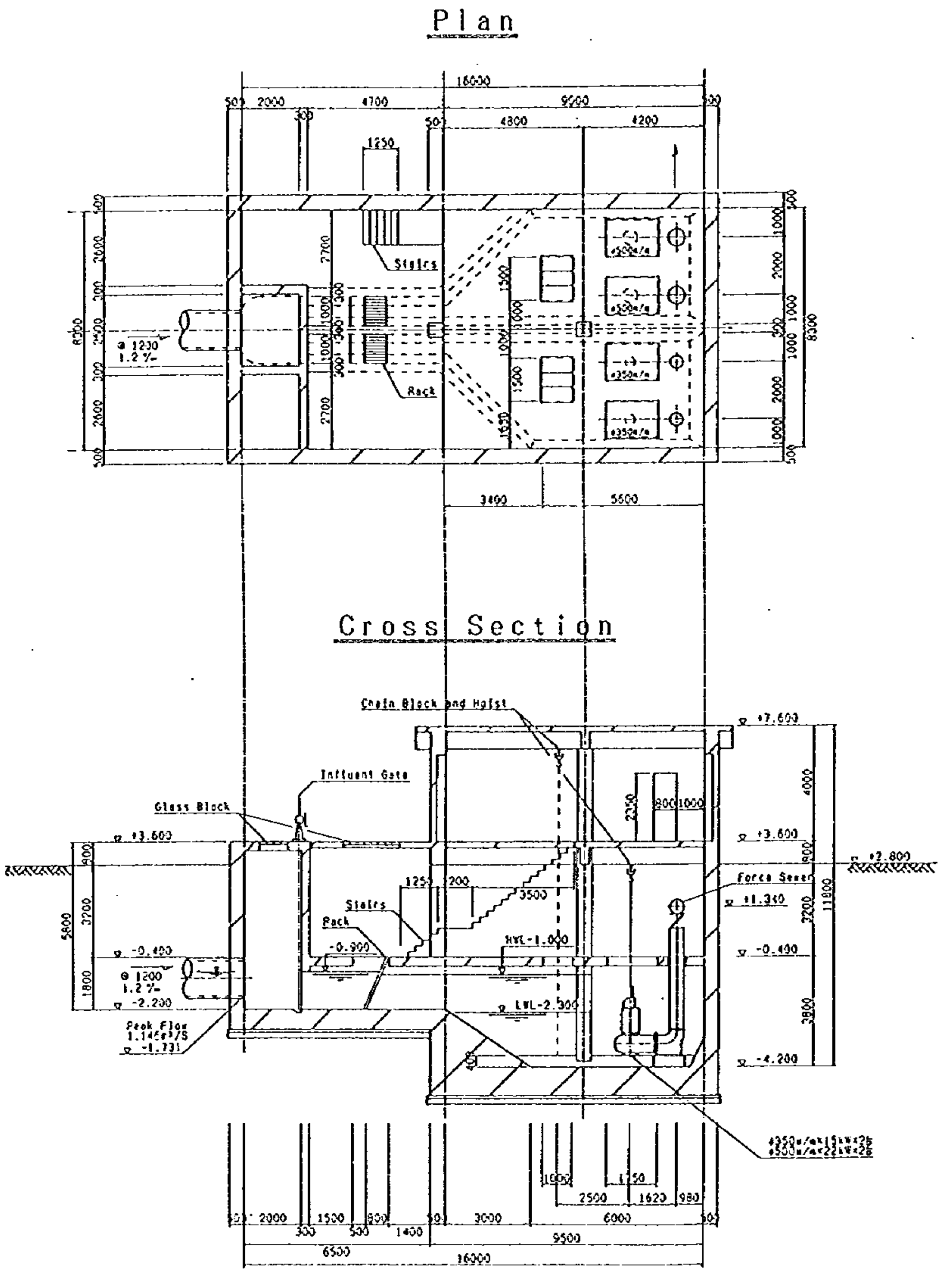

Figure 12.2.4.1 Standard Drawing of Standard Pump Station (S=1/200)
(Capacity: more than 5 m^3/min.)

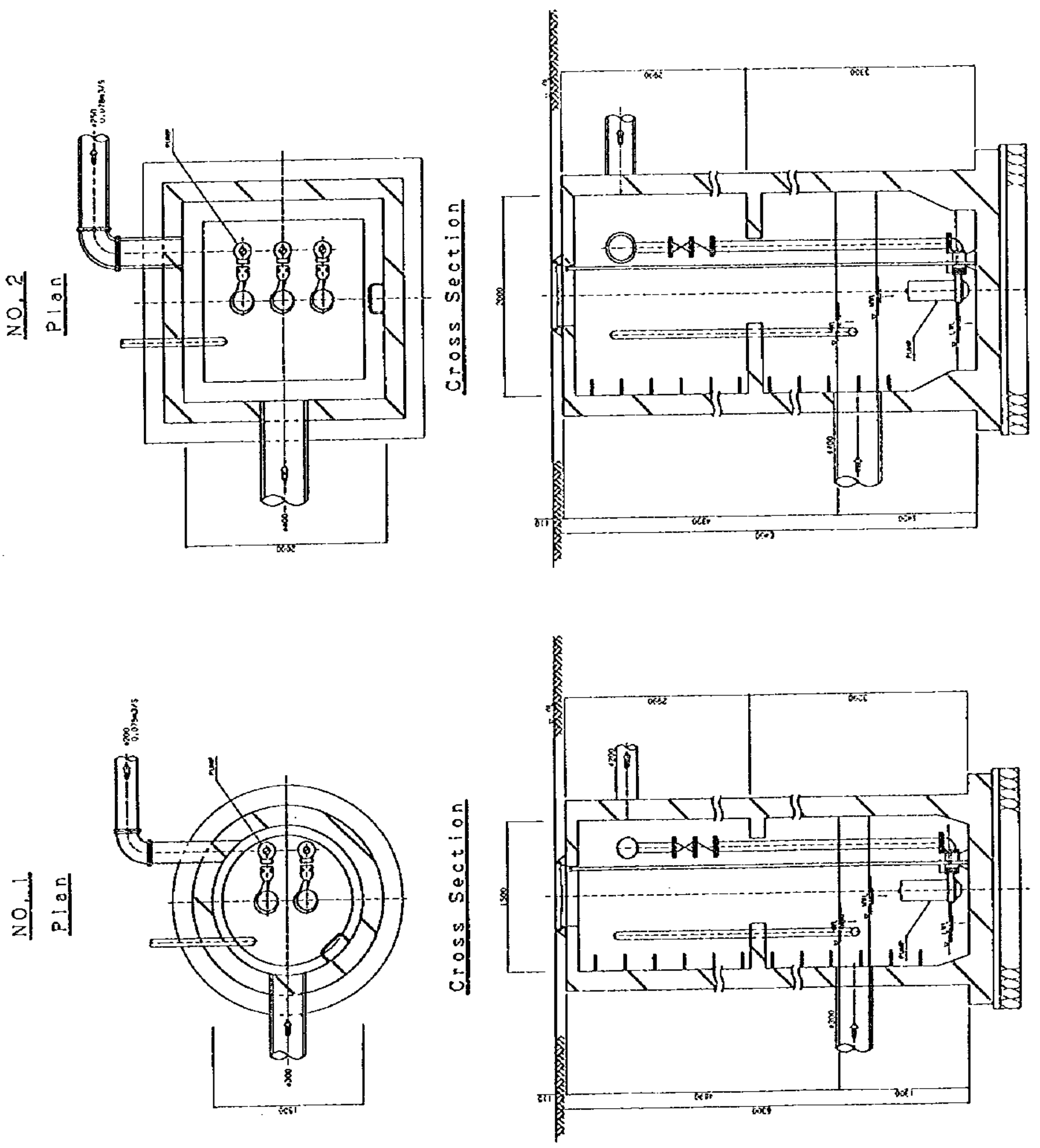

Figure 12.2.4.2 Standard Drawing of Manhole Type Pump Station
(Capacity: less than 5 m^3/min.)

2. Flow Calculation and Design for Trunk Sewers

Table 12.2.4.6 (1) Flow Calculation of Trunk Sewers for Crowborough Treatment Area in Harare

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area[*1] (km^2)	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	4	8.45	8.45	0.423	5,800	800	2.0	1.18	0.591	2005	
2	3	7.50	7.50	0.376	1,200	600	-	1.32	0.373	2005	Pump Main Pipe
3	4	5.46	12.96	0.649	1,700	900	2.0	1.27	0.810	2005	
4	STW	13.71	35.12	1.760	9,500	1,350	1.6	1.49	2.135	2005	
5	7	2.27	2.27	0.113	7,600	500	3.0	1.05	0.207	2005	
6	7	21.45	21.45	1.075	5,100	1,100	2.0	1.45	1.383	2005	
7	STW	0.00	23.72	1.188	4,700	1,200	1.7	1.42	1.607	2005	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (536,800/86,400) / (174-49.87) = 0.0501 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.6 (2) Flow Calculation of Trunk Sewers for Crowborough Treatment Area in Harare

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area[*1] (km^2)	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	4	8.45	8.45	0.293	5,800	700	2.0	1.08	0.414	2005	
2	3	7.50	7.50	0.260	1,200	500	-	1.36	0.267	2005	Pump Main Pipe
3	4	5.46	12.96	0.450	1,700	800	2.0	1.18	0.591	2005	
4	STW	13.71	35.12	1.219	9,500	1,200	1.7	1.42	1.607	2005	
5	7	2.27	2.27	0.079	7,600	400	3.5	0.98	0.123	2005	
6	7	21.45	21.45	0.744	5,100	1,000	1.5	1.18	0.929	2005	
7	STW	0.00	23.72	0.823	4,700	1,100	1.5	1.26	1.197	2005	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (372,500/86,400) / (174-49.87) = 0.0347 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.7 (1) Flow Calculation of Trunk Sewers for Firle Treatment Area in Harare

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area (km^2) *1	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	2	10.10	10.10	0.695	9,200	1,000	1.5	1.18	0.929	2005	
2	3	4.76	14.86	1.022	6,900	1,200	1.3	1.24	1.406	2005	
3	STW	0.00	14.86	1.022	4,800	1,200	1.3	1.24	1.406	2005	
4	6	10.97	10.97	0.755	4,700	1,000	1.5	1.18	0.929	2005	
5	6	6.31	6.31	0.434	3,400	800	2.0	1.18	0.591	2015	
6	7	0.00	17.28	1.189	400	1,200	1.5	1.34	1.510	2005	
7	8	0.00	17.28	1.189	1,700	1,100	-	1.26	1.197	2005	Pump Main Pipe
8	STW	0.00	17.28	1.189	3,600	1,200	1.5	1.34	1.510	2005	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (836,200/86,400) / (194.35-52.20-1.46) = 0.0688 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.7 (2) Flow Calculation of Trunk Sewers for Firle Treatment Area in Harare

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area (km^2) *1	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	2	10.10	10.10	0.623	9,200	1,000	1.5	1.18	0.929	2005	
2	3	4.76	14.86	0.917	6,900	1,200	1.3	1.24	1.406	2005	
3	STW	0.00	14.86	0.917	4,800	1,200	1.3	1.24	1.406	2005	
4	6	10.97	10.97	0.677	4,700	1,000	1.5	1.18	0.929	2005	
5	6	6.31	6.31	0.389	3,400	800	2.0	1.18	0.591	2015	
6	7	0.00	17.28	1.066	400	1,200	1.3	1.24	1.406	2005	
7	8	0.00	17.28	1.066	1,700	1,000	-	1.37	1.072	2005	Pump Main Pipe
8	STW	0.00	17.28	1.066	3,600	1,200	1.3	1.24	1.406	2005	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (750,300/86,400) / (194.35-52.20-1.46) = 0.0617 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.8 (1) Flow Calculation of Trunk Sewers for Harare South Treatment Area in Harare Expansion

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity (m³/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m³/sec)	Construction Time	Remarks
1	3	47.90	47.90	1.748	6,800	1,350	1.5	1.44	2.067	2005	
2	3	11.34	11.34	0.414	3,900	800	1.8	1.12	0.561	2005	
3	5	6.63	65.87	2.404	4,000	1,500	1.3	1.44	2.549	2005	
4	5	8.33	8.33	0.304	3,000	700	2.0	1.08	0.414	2005	
5	STW	13.30	87.50	3.194	2,800	1,800	1.0	1.43	3.635	2005	

Note : Manning formular with roughness coefficient (0.013)
Unit design Quantity = (276,300/86,400) / 87.50 = 0.0365 ($m^3/sec/km^2$)
*1 : Measured values

Table 12.2.4.8 (2) Flow Calculation of Trunk Sewers for Harare South Treatment Area in Harare Expansion

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity (m³/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m³/sec)	Construction Time	Remarks
1	3	47.90	47.90	0.901	6,800	1,100	1.5	1.26	1.197	2005	
2	3	11.34	11.34	0.213	3,900	600	2.5	1.09	0.307	2005	
3	5	6.63	65.87	1.238	4,000	1,200	1.5	1.34	1.510	2005	
4	5	8.33	8.33	0.157	3,000	600	2.0	0.97	0.275	2005	
5	STW	13.30	87.50	1.645	2,800	1,350	1.5	1.44	2.067	2005	

Note : Manning formular with roughness coefficient (0.013)
Unit design Quantity = (142,200/86,400) / 87.50 = 0.0188 ($m^3/sec/km^2$)
*1 : Measured values

Table 12.2.4.9 (1) Flow Calculation of Trunk Sewers for Harare East Treatment Area in Harare Expansion

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area *1 (km^2)	Accumulated Area (km^2)	Design Sewage Quantity (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	3	16.50	16.50	0.833	6,700	1,100	1.5	1.26	1.197	2015	
2	3	9.36	9.36	0.473	4,900	900	1.8	1.21	0.768	2005	
3	STW	0.00	25.86	1.306	400	1,350	1.2	1.29	1.849	2005	

Note : Manning formular with roughness coefficient (0.013)
Unit design Quantity = (112,900/86,400) / 25.86 = 0.0505 ($m^3/sec/km^2$)
*1 : Measured values

Table 12.2.4.9 (2) Flow Calculation of Trunk Sewers for Harare East Treatment Area in Harare Expansion

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area *1 (km^2)	Accumulated Area (km^2)	Design Sewage Quantity (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	3	16.50	16.50	0.833	6,700	1,100	1.5	1.26	1.197	2015	
2	3	9.36	9.36	0.473	4,900	900	1.8	1.21	0.768	2005	
3	STW	0.00	25.86	1.306	400	1,350	1.2	1.29	1.849	2005	

Note : Manning formular with roughness coefficient (0.013)
Unit design Quantity = (112,900/86,400) / 25.86 = 0.0505 ($m^3/sec/km^2$)
*1 : Measured values

Table 12.2.4.10. (1) Flow Calculation of Trunk Sewers for Zengeza Treatment Area in Chitungwiza

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity, PWWF (m³/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m³/sec)	Construction Time	Remarks
1	2	6.81	6.81	0.334	6,700	800	1.5	1.02	0.512	2000	
2	3	0.00	6.81	0.334	3,700	600	-	1.19	0.336	2000	Pump Main Pipe
3	6	0.00	6.81	0.334	3,200	800	1.5	1.02	0.512	2000	
4	5	3.00	3.00	0.147	2,200	450	-	0.93	0.148	2015	Pump Main Pipe
5	6	0.00	3.00	0.147	900	600	1.8	0.92	0.261	2015	
6	STW	0.00	9.81	0.482	500	900	1.5	1.10	0.701	2000	
7	10	3.66	3.66	0.180	6,100	600	1.8	0.92	0.261	2015	
8	10	3.17	3.17	0.156	5,900	600	1.8	0.92	0.261	2015	
9	10	5.67	5.67	0.278	3,900	700	1.8	1.02	0.393	2015	
10	11	0.00	12.50	0.614	300	1,000	1.5	1.18	0.929	2015	
11	STW	0.00	12.50	0.614	1,800	800	-	1.21	0.606	2015	Pump Main Pipe

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (210,500/86,400) / 49.61 = 0.0491 (m³/sec/km²)

*1 : Measured values

Table 12.2.4.10. (2) Flow Calculation of Trunk Sewers for Zengeza Treatment Area in Chitungwiza

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area *1 (km^2)	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m^3/sec)	Construction Time	Remarks
1	2	6.81	6.81	0.513	6,700	900	1.5	1.10	0.701	2000	
2	3	0.00	6.81	0.513	3,700	800	-	1.02	0.512	2000	Pump Main Pipe
3	6	0.00	6.81	0.513	3,200	900	1.5	1.10	0.701	2000	
4	5	3.00	3.00	0.226	2,200	500	-	1.14	0.223	2015	Pump Main Pipe
5	6	0.00	3.00	0.226	900	700	1.8	1.02	0.393	2015	
6	STW	0.00	9.81	0.740	500	1,000	1.5	1.18	0.929	2000	
7	10	3.66	3.66	0.276	6,100	700	1.8	1.02	0.393	2015	
8	10	3.17	3.17	0.239	5,900	700	1.8	1.02	0.393	2015	
9	10	5.67	5.67	0.428	3,900	900	1.5	1.10	0.701	2015	
10	11	0.00	12.50	0.943	300	1,200	1.2	1.19	1.351	2015	
11	STW	0.00	12.50	0.943	1,800	1,000	-	1.22	0.959	2015	Pump Main Pipe

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (323,000/86,400) / 49.61 = 0.0754 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.11. (1) Flow Calculation of Trunk Sewers for Norton Treatment Area in Norton

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area *1 (km^2)	Accumulated Area (km^2)	Design Sewage Quantity, PWWF (m^3/sec)	Sewer Length (m)	Design Sewers: Diameter (mm)	Design Sewers: Gradient (1/1,000)	Design Sewers: Velocity (m/sec)	Design Sewers: Flow (m^3/sec)	Construction Time	Remarks
1	8	18.18	18.18	0.514	6,400	900	1.5	1.10	0.701	2005	
2	3	3.17	3.17	0.090	1,600	350	-	0.96	0.092	2015	Pump Main Pipe
3	5	4.13	7.30	0.207	2,100	700	1.8	1.02	0.393	2015	
4	5	0.96	0.96	0.027	1,900	300	4.0	0.87	0.061	2005	
5	6	0.00	8.26	0.234	1,200	500	-	1.19	0.233	2005	Pump Main Pipe
6	8	0.00	8.26	0.234	1,700	700	1.8	1.02	0.393	2005	
7	8	2.79	2.79	0.079	2,600	450	3.0	0.98	0.156	2005	
8	STW	0.00	29.23	0.827	1,800	1,100	1.5	1.26	1.197	2005	
9	10	4.51	4.51	0.128	2,100	500	3.0	1.05	0.207	2015	
10	STW	7.19	11.70	0.331	4,900	800	1.8	1.12	0.561	2015	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (123,900/86,400) / 50.63 = 0.0283 (m^3/sec/km^2)

*1 : Measured values

Table 12.2.4.11. (2) Flow Calculation of Trunk Sewers for Norton Treatment Area in Norton

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity, PWWF (m³/sec)	Sewer Length (m)	Design Sewers Diameter (mm)	Design Sewers Gradient (1/1,000)	Design Sewers Velocity (m/sec)	Design Sewers Flow (m³/sec)	Construction Time	Remarks
1	8	18.18	18.18	0.331	6,400	800	1.8	1.12	0.561	2005	
2	3	3.17	3.17	0.058	1,600	300	-	0.82	0.058	2015	Pump Main Pipe
3	5	4.13	7.30	0.133	2,100	500	3.0	1.05	0.207	2015	
4	5	0.96	0.96	0.017	1,900	250	5.0	0.86	0.042	2005	
5	6	0.00	8.26	0.150	1,200	450	-	0.95	0.151	2005	Pump Main Pipe
6	8	0.00	8.26	0.150	1,700	600	2.0	0.97	0.275	2005	
7	8	2.79	2.79	0.051	2,600	400	3.0	0.91	0.114	2005	
8	STW	0.00	29.23	0.532	1,800	900	1.5	1.10	0.701	2005	
9	10	4.51	4.51	0.082	2,100	450	3.0	0.98	0.156	2015	
10	STW	7.19	11.70	0.213	4,900	600	2.5	1.09	0.307	2015	

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (79,400/86,400) / 50.63 = 0.0182 (m³/sec/km²)

*1 : Measured values

Table 12.2.4.12. (1) Flow Calculation of Trunk Sewers for Ruwa Treatment Area in Ruwa

(Scenario-1)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity, PWWF (m³/sec)	Sewer Length (m)	Design Sewers: Diameter (mm)	Design Sewers: Gradient (1/1,000)	Design Sewers: Velocity (m/sec)	Design Sewers: Flow (m³/sec)	Construction Time	Remarks
1	2	1.50	1.50	0.046	1,800	250	-	0.94	0.046	2005	Pump Main Pipe
2	4	0.00	1.50	0.046	2,500	350	4.0	0.96	0.092	2005	
3	4	4.32	4.32	0.132	2,400	400	-	1.06	0.133	2005	Pump Main Pipe
4	10	0.00	5.82	0.178	700	600	2.5	1.09	0.307	2005	
5	6	0.99	0.99	0.030	1,600	200	-	0.96	0.030	2005	Pump Main Pipe
6	9	4.49	5.48	0.168	2,700	600	2.5	1.09	0.307	2005	
7	9	3.44	3.44	0.105	3,300	450	4.0	1.13	0.180	2005	
8	9	2.60	2.60	0.080	2,800	450	3.5	1.06	0.169	2005	
9	10	0.00	11.52	0.353	1,500	800	2.0	1.18	0.591	2005	
10	11	1.11	18.45	0.565	1,300	1,000	1.8	1.30	1.016	2005	
11	STW	0.00	18.45	0.565	2,200	800	-	1.12	0.560	2005	Pump Main Pipe

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (68,900/86,400) / 26.10 = 0.0306 ($m^3/sec/km^2$)

*1 : Measured values

Table 12.2.4.12. (2) Flow Calculation of Trunk Sewers for Ruwa Treatment Area in Ruwa

(Scenario-2)

Sewer No.	Downstream Sewer No.	Area (km²) *1	Accumulated Area (km²)	Design Sewage Quantity, PWWF (m³/sec)	Sewer Length (m)	Design Sewers				Construction Time	Remarks
						Diameter (mm)	Gradient (1/1,000)	Velocity (m/sec)	Flow (m³/sec)		
1	2	1.50	1.50	0.017	1,800	150	-	0.94	0.017	2005	Pump Main Pipe
2	4	0.00	1.50	0.017	2,500	200	10.0	1.04	0.033	2005	
3	4	4.32	4.32	0.049	2,400	250	-	1.00	0.049	2005	Pump Main Pipe
4	10	0.00	5.82	0.066	700	350	5.5	1.12	0.108	2005	
5	6	0.99	0.99	0.011	1,600	150	-	0.64	0.011	2005	Pump Main Pipe
6	9	4.49	5.48	0.062	2,700	350	5.5	1.12	0.108	2005	
7	9	3.44	3.44	0.039	3,300	300	6.0	1.06	0.075	2005	
8	9	2.60	2.60	0.029	2,800	300	4.0	0.86	0.061	2005	
9	10	0.00	11.52	0.130	1,500	500	3.0	1.05	0.207	2005	
10	11	1.11	18.45	0.208	1,300	600	2.5	1.09	0.307	2005	
11	STW	0.00	18.45	0.208	2,200	500	-	1.05	0.207	2005	Pump Main Pipe

Note : Manning formular with roughness coefficient (0.013)

Unit design Quantity = (25,500/86,400) / 26.10 = 0.0113 ($m^3/sec/km^2$)

*1 : Measured values

3. Capacity Calculation of Proposed Pump Station

Table 12.2.4.13 (1) Capacity Calculation of Pump Station in Crowborough Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.423
	Q2	m^3/min	Q1 x 60	25.38

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.423
	Q2	m^3/day	Q1 x 86,400	36,547
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	20.30
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	2.82
Therefore	W2	m	-	3.00
Length	L1	m	RSA / W2	6.77
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.50
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	36,547
	Q2	m^3/min	Q1 / 1,440	25.38
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	6.35
Therefore	DU2	m^3/min	-	6.40
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	234
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	34.28
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	6.40
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5

(4) Construction Time : 2005

Table 12.2.4.13 (2) Capacity Calculation of Pump Station in Crowborough Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.293
	Q2	m^3/min	Q1 x 60	17.58

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.293
	Q2	m^3/day	Q1 x 86,400	25,315
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	14.06
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.95
Therefore	W2	m	-	2.00
Length	L1	m	RSA / W2	7.03
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.00
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	25,315
	Q2	m^3/min	Q1 / 1,440	17.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	5.86
Therefore	DU2	m^3/min	-	6.00
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	226
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	32.13
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	6.00
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2005

Table 12.2.4.14 (1) Capacity Calculation of Pump Station in Firle Treatment Area

(Scenario-I)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	1.189
	Q2	m^3/min	Q1 x 60	71.34

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	1.189
	Q2	m^3/day	Q1 x 86,400	102,730
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	57.07
Basin Number	BN	basin	-	6
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	7.93
Therefore	W2	m	-	8.00
Length	L1	m	RSA / W2	7.13
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.33
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	6

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	102,730
	Q2	m^3/min	Q1 / 1,440	71.34
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	14.27
Therefore	DU2	m^3/min	-	14.30
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	349
Therefore	D2	mm	-	350
Required Pump Total Head	TH	m	assumption	30.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	114.88
Therefore	PP2	kw	-	110
(Dimension)				
Diameter	D2	mm	-	350
Pump Discharge per Unit	DU2	m^3/min	-	14.30
Pump Total Head	TH	m	-	30.00
Pump Power	PP2	kw	-	110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2005 ; Pump equipment = 4 units
2015 ; Pump equipment = 2 units

Table 12.2.4.14 (2) Capacity Calculation of Pump Station in Firle Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	1.066
	Q2	m^3/min	Q1 x 60	63.96

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	1.066
	Q2	m^3/day	Q1 x 86,400	92,102
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	51.17
Basin Number	BN	basin	-	6
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	7.11
Therefore	W2	m	-	7.20
Length	L1	m	RSA / W2	7.11
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.20
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	6

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	92,102
	Q2	m^3/min	Q1 / 1,440	63.96
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	12.79
Therefore	DU2	m^3/min	-	12.80
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	330
Therefore	D2	mm	-	350
Required Pump Total Head	TH	m	assumption	30.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	102.83
Therefore	PP2	kw	-	110
(Dimension)				
Diameter	D2	mm	-	350
Pump Discharge per Unit	DU2	m^3/min	-	12.80
Pump Total Head	TH	m	-	30.00
Pump Power	PP2	kw	-	110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2005 ; Pump equipment = 4 units
2015 ; Pump equipment = 2 units

Table 12.2.4.15 (1) Capacity Calculation of Pump Station in Harare South Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.493
	Q2	m^3/min	Q1 x 60	29.58

Q = 13.5 km^2 x 0.0365 m^3/sec/km^2 = 0.493 m^3/sec

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.493
	Q2	m^3/day	Q1 x 86,400	42,595
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	23.66
Basin Number	BN	basin	-	3
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	3.29
Therefore	W2	m	-	3.30
Length	L1	m	RSA / W2	7.17
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.10
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	3

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	42,595
	Q2	m^3/min	Q1 / 1,440	29.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	7.40
Therefore	DU2	m^3/min	-	7.50
Required Pump Diameter	D1	mm	146 x $(DU2 / V)^{1/2}$	253
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	40.17
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	7.50
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5

(4) Construction Time : 2005

Table 12.2.4.15 (2) Capacity Calculation of Pump Station in Harare South Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.254
	Q2	m^3/min	Q1 x 60	15.24

$Q = 13.5\ km^2 \times 0.0188\ m^3/sec/km^2 = 0.254\ m^3/sec$

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.254
	Q2	m^3/day	Q1 x 86,400	21,946
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	12.19
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.69
Therefore	W2	m	-	1.80
Length	L1	m	RSA / W2	6.77
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.90
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	21,946
	Q2	m^3/min	Q1 / 1,440	15.24
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	3.81
Therefore	DU2	m^3/min	-	4.00
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	185
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	21.42
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm	-	200
Pump Discharge per Unit	DU2	m^3/min	-	4.00
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5

(4) Construction Time : 2005

Table 12.2.4.16 (1) Capacity Calculation of P1 Pump Station in Zengeza Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.334
	Q2	m^3/min	Q1 x 60	20.04

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.334
	Q2	m^3/day	Q1 x 86,400	28,858
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	16.03
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	2.23
Therefore	W2	m	-	2.20
Length	L1	m	RSA / W2	7.29
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.10
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	28,858
	Q2	m^3/min	Q1 / 1,440	20.04
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	5.01
Therefore	DU2	m^3/min	-	5.00
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	206
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	53.56
Therefore	PP2	kw	-	55
(Dimension)				
Diameter	D2	mm	-	200
Pump Discharge per Unit	DU2	m^3/min	-	5.00
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	-	55
Pump Unit	PU	unit	(Including 1 Stand By Pump)	5

(4) Construction Time : 2000

Table 12.2.4.16 (2) Capacity Calculation of P1 Pump Station in Zengeza Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.513
	Q2	m^3/min	Q1 x 60	30.78

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.513
	Q2	m^3/day	Q1 x 86,400	44,323
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	24.62
Basin Number	BN	basin	-	3
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	3.42
Therefore	W2	m	-	3.50
Length	L1	m	RSA / W2	7.04
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.17
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	3

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	44,323
	Q2	m^3/min	Q1 / 1,440	30.78
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	6.16
Therefore	DU2	m^3/min	-	6.20
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	230
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	66.41
Therefore	PP2	kw	-	75
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	6.20
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	-	75
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2000

Table 12.2.4.17 (1) Capacity Calculation of P2 Pump Station in Zengeza Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.147
	Q2	m^3/min	Q1 x 60	8.82

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.147
	Q2	m^3/day	Q1 x 86,400	12,701
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	7.06
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.98
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	7.06
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	12,701
	Q2	m^3/min	Q1 / 1,440	8.82
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	2.94
Therefore	DU2	m^3/min	-	3.00
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	160
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	20.08
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm	-	150
Pump Discharge per Unit	DU2	m^3/min	-	3.00
Pump Total Head	TH	m	-	25.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2015

Table 12.2.4.17 (2) Capacity Calculation of P2 Pump Station in Zengeza Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.226
	Q2	m^3/min	Q1 x 60	13.56

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.226
	Q2	m^3/day	Q1 x 86,400	19,526
Water Surface Load	WSL	$m^3/m^2/day$	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	10.85
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.51
Therefore	W2	m	-	1.60
Length	L1	m	RSA / W2	6.78
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.80
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	19,526
	Q2	m^3/min	Q1 / 1,440	13.56
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	4.52
Therefore	DU2	m^3/min	-	4.50
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	196
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	30.13
Therefore	PP2	kw	-	30
(Dimension)				
Diameter	D2	mm	-	200
Pump Discharge per Unit	DU2	m^3/min	-	4.50
Pump Total Head	TH	m	-	25.00
Pump Power	PP2	kw	-	30
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2015

Table 12.2.4.18 (1) Capacity Calculation of P3 Pump Station in Zengeza Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.614
	Q2	m^3/min	Q1 x 60	36.84

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.614
	Q2	m^3/day	Q1 x 86,400	53,050
Water Surface Load	WSL	$m^3/m^2/day$	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	29.47
Basin Number	BN	basin	-	3
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	4.09
Therefore	W2	m	-	4.20
Length	L1	m	RSA / W2	7.02
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.40
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	3

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	53,050
	Q2	m^3/min	Q1 / 1,440	36.84
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	7.37
Therefore	DU2	m^3/min	-	7.40
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	251
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	69.36
Therefore	PP2	kw	-	75
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	7.40
Pump Total Head	TH	m	-	35.00
Pump Power	PP2	kw	-	75
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2015

Table 12.2.4.18 (2) Capacity Calculation of P3 Pump Station in Zengeza Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.943
	Q2	m^3/min	Q1 x 60	56.58

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.943
	Q2	m^3/day	Q1 x 86,400	81,475
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	45.26
Basin Number	BN	basin	-	6
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	6.29
Therefore	W2	m	-	6.30
Length	L1	m	RSA / W2	7.18
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.05
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	6

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	81,475
	Q2	m^3/min	Q1 / 1,440	56.58
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	11.32
Therefore	DU2	m^3/min	-	11.40
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	312
Therefore	D2	mm	-	300
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	106.85
Therefore	PP2	kw	-	110
(Dimension)				
Diameter	D2	mm	-	300
Pump Discharge per Unit	DU2	m^3/min	-	11.40
Pump Total Head	TH	m	-	35.00
Pump Power	PP2	kw	-	110
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2015

Table 12.2.4.19 (1) Capacity Calculation of P1 Pump Station in Norton Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.090
	Q2	m^3/min	Q1 x 60	5.4

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.090
	Q2	m^3/day	Q1 x 86,400	7,776
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	4.32
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.60
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	4.32
Therefore	L2	m	-	4.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	4.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	7,776
	Q2	m^3/min	Q1 / 1,440	5.40
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	2.70
Therefore	DU2	m^3/min	-	2.70
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	152
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	15.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	10.85
Therefore	PP2	kw	-	11
(Dimension)				
Diameter	D2	mm	-	150
Pump Discharge per Unit	DU2	m^3/min	-	2.70
Pump Total Head	TH	m	-	15.00
Pump Power	PP2	kw	-	11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

(4) Construction Time : 2015

Table 12.2.4.19 (2) Capacity Calculation of P1 Pump Station in Norton Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.058
	Q2	m^3/min	Q1 x 60	3.48

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.058
	Q2	m^3/day	Q1 x 86,400	5,011
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	2.78
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.39
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	2.78
Therefore	L2	m	-	3.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	3.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	5,011
	Q2	m^3/min	Q1 / 1,440	3.48
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	1.74
Therefore	DU2	m^3/min	-	1.80
Required Pump Diameter	D1	mm	146 x $(DU2 / V)^{1/2}$	124
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	15.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	7.23
Therefore	PP2	kw	-	8
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m^3/min	-	1.80
Pump Total Head	TH	m	-	15.00
Pump Power	PP2	kw	-	8
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

(4) Construction Time : 2015

Table 12.2.4.20 (1) Capacity Calculation of P2 Pump Station in Norton Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.234
	Q2	m^3/min	Q1 x 60	14.04

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.234
	Q2	m^3/day	Q1 x 86,400	20,218
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	11.23
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.56
Therefore	W2	m	-	1.60
Length	L1	m	RSA / W2	7.02
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.80
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	20,218
	Q2	m^3/min	Q1 / 1,440	14.04
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	4.68
Therefore	DU2	m^3/min	-	4.70
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	200
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	31.46
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm	-	200
Pump Discharge per Unit	DU2	m^3/min	-	4.70
Pump Total Head	TH	m	-	25.00
Pump Power	PP2	kw	-	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2005 ; Pump equipment = 2 units
2015 ; Pump equipment = 2 units

Table 12.2.4.20 (2) Capacity Calculation of P2 Pump Station in Norton Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.150
	Q2	m^3/min	Q1 x 60	9.00

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.150
	Q2	m^3/day	Q1 x 86,400	12,960
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	7.20
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.00
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	7.20
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	12,960
	Q2	m^3/min	Q1 / 1,440	9.00
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	3.00
Therefore	DU2	m^3/min	-	3.00
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	160
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	25.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	20.08
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm	-	150
Pump Discharge per Unit	DU2	m^3/min	-	3.00
Pump Total Head	TH	m	-	25.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2005 ; Pump equipment = 2 units
2015 ; Pump equipment = 2 units

Table 12.2.4.21 (1) Capacity Calculation of P1 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.046
	Q2	m^3/min	Q1 x 60	2.76

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.046
	Q2	m^3/day	Q1 x 86,400	3,974
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	2.21
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.31
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	2.21
Therefore	L2	m	-	2.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	2.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	3,974
	Q2	m^3/min	Q1 / 1,440	2.76
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	1.38
Therefore	DU2	m^3/min	-	1.40
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	109
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	13.12
Therefore	PP2	kw	-	15
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m^3/min	-	1.40
Pump Total Head	TH	m	-	35.00
Pump Power	PP2	kw	-	15
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

(4) Construction Time : 2005

Table 12.2.4.21 (2) Capacity Calculation of P1 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.017
	Q2	m^3/min	Q1 x 60	1.02

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.017
	Q2	m^3/day	Q1 x 86,400	1,469
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	0.82
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.11
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	0.82
Therefore	L2	m	-	1.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	1.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	1,469
	Q2	m^3/min	Q1 / 1,440	1.02
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	1.02
Therefore	DU2	m^3/min	-	1.00
Required Pump Diameter	D1	mm	146 x $(DU2 / V)^{1/2}$	92
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	35.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	9.37
Therefore	PP2	kw	-	11
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m^3/min	-	1.00
Pump Total Head	TH	m	-	35.00
Pump Power	PP2	kw	-	11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

(4) Construction Time : 2005

Table 12.2.4.22 (1) Capacity Calculation of P2 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.132
	Q2	m^3/min	Q1 x 60	7.92

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.132
	Q2	m^3/day	Q1 x 86,400	11,405
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	6.34
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.88
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	6.34
Therefore	L2	m	-	6.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	6.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	11,405
	Q2	m^3/min	Q1 / 1,440	7.92
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	2.64
Therefore	DU2	m^3/min	-	2.70
Required Pump Diameter	D1	mm	$146 \times (DU2 / V)^{1/2}$	152
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	28.92
Therefore	PP2	kw	-	30
(Dimension)				
Diameter	D2	mm	-	150
Pump Discharge per Unit	DU2	m^3/min	-	2.70
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	-	30
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2005

Table 12.2.4.22 (2) Capacity Calculation of P2 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.049
	Q2	m^3/min	Q1 x 60	2.94

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.049
	Q2	m^3/day	Q1 x 86,400	4,234
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	2.35
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.33
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	2.35
Therefore	L2	m	-	2.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	2.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	4,234
	Q2	m^3/min	Q1 / 1,440	2.94
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	1.47
Therefore	DU2	m^3/min	-	1.50
Required Pump Diameter	D1	mm	146 x (DU2 / V) $^{1/2}$	113
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	40.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	16.07
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m^3/min	-	1.50
Pump Total Head	TH	m	-	40.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	3

(4) Construction Time : 2005

Table 12.2.4.23 (1) Capacity Calculation of P3 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.03
	Q2	m^3/min	Q1 x 60	1.8

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.030
	Q2	m^3/day	Q1 x 86,400	2,592
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	1.44
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.20
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	1.44
Therefore	L2	m	-	1.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	1.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	2,592
	Q2	m^3/min	Q1 / 1,440	1.80
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	1.80
Therefore	DU2	m^3/min	-	1.80
Required Pump Diameter	D1	mm	146 x (DU2 / V) $^{1/2}$	124
Therefore	D2	mm	-	150
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	9.64
Therefore	PP2	kw	-	11
(Dimension)				
Diameter	D2	mm	-	150
Pump Discharge per Unit	DU2	m^3/min	-	1.80
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	11
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

(4) Construction Time : 2005

Table 12.2.4.23 (2) Capacity Calculation of P3 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.011
	Q2	m^3/min	Q1 x 60	0.66

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.011
	Q2	m^3/day	Q1 x 86,400	950
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	0.53
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	0.07
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	0.53
Therefore	L2	m	-	1.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.50
Length	L2	m	-	1.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	950
	Q2	m^3/min	Q1 / 1,440	0.66
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	0.66
Therefore	DU2	m^3/min	-	0.70
Required Pump Diameter	D1	mm	146 x $(DU2 / V)^{1/2}$	77
Therefore	D2	mm	-	100
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	3.75
Therefore	PP2	kw	-	3.7
(Dimension)				
Diameter	D2	mm	-	100
Pump Discharge per Unit	DU2	m^3/min	-	0.70
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	3.7
Pump Unit	PU	unit	(Including 1 Stand By Pump)	2

(4) Construction Time : 2005

Table 12.2.4.24 (1) Capacity Calculation of P4 Pump Station in Ruwa Treatment Area

(Scenario-1)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.565
	Q2	m^3/min	Q1 x 60	33.9

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.565
	Q2	m^3/day	Q1 x 86,400	48,816
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	27.12
Basin Number	BN	basin	o -	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	3.77
Therefore	W2	m	-	3.80
Length	L1	m	RSA / W2	7.14
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.90
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	48,816
	Q2	m^3/min	Q1 / 1,440	33.90
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	6.78
Therefore	DU2	m^3/min	-	6.80
Required Pump Diameter	D1	mm	146 x $(DU2 / V)^{1/2}$	241
Therefore	D2	mm	-	250
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.	36.42
Therefore	PP2	kw	-	37
(Dimension)				
Diameter	D2	mm	-	250
Pump Discharge per Unit	DU2	m^3/min	-	6.80
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	37
Pump Unit	PU	unit	(Including 1 Stand By Pump)	6

(4) Construction Time : 2005

Table 12.2.4.24 (2) Capacity Calculation of P4 Pump Station in Ruwa Treatment Area

(Scenario-2)

(1) Design Sewage Quantity

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/sec	-	0.208
	Q2	m^3/min	Q1 x 60	12.48

(2) Grit Chamber and Screen

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/sec	-	0.208
	Q2	m^3/day	Q1 x 86,400	17,971
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q2 / WSL	9.98
Basin Number	BN	basin	-	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q1 / (V x H)	1.39
Therefore	W2	m	-	1.40
Length	L1	m	RSA / W2	7.13
Therefore	L2	m	-	7.50
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	0.70
Length	L2	m	-	7.50
Depth	H	m	-	0.50
Basin Number	BN	-	-	2

(3) Capacity Calculation of Pump Equipment

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q1	m^3/day	Peak Wet Weather Flow	17,971
	Q2	m^3/min	Q1 / 1,440	12.48
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4
Pump Discharge per Unit	DU1	m^3/min	Q2 / (PU - 1)	4.16
Therefore	DU2	m^3/min	-	4.20
Required Pump Diameter	D1	mm	146 x (DU2 / V) $^{1/2}$	189
Therefore	D2	mm	-	200
Required Pump Total Head	TH	m	assumption	20.00
Required Pump Power	PP1	kw	(0.163 x DU2 x TH / 0.7) x 1.1	22.49
Therefore	PP2	kw	-	22
(Dimension)				
Diameter	D2	mm	-	200
Pump Discharge per Unit	DU2	m^3/min	-	4.20
Pump Total Head	TH	m	-	20.00
Pump Power	PP2	kw	-	22
Pump Unit	PU	unit	(Including 1 Stand By Pump)	4

(4) Construction Time : 2005

12.2.5 Design Criteria and Planning for Sewage Treatment Facilitie

12.2.5.1 Design Criteria for Sewage Treatment Facilities

(1) Sewage Treatment Process

The existing sewage treatment works in the study area employ three kind of secondary treatment processes; Wastewater Stabilisation Pond (WSP), Trickling Filter (TF) and Biological Nutrient Removal (BNR). The design criteria of each process are shown below.

WSP process

a) Design flow for capacity calculation: average dry weather flow

b) Anaerobic Pond

Pond depth: At least 3 m

Optimum detention time: 1 - 5 days

Volumetric BOD loading: 400 $g/m^3/day$

c) Facultative Pond

Pond depth: 1.2 to 1.5 m (Zimbabwe standard)

Optimum detention time: 4 - 10 days

Depends on the climatic condition and essential BOD removal ratio

$K_T = K_{20^\circ C} \times \theta^{T-20}$ (Wehner and Wilhelm formula)

Where $K_{20^\circ C}$; 0.25 d^{-1}

θ ; temperature coefficient = 1.06 at 20°C

T; temperature of the coldest month = 14°C

BOD surface loading $L = 20 \times T - 120 = 160$ kg/ha/day

d) Maturation Pond

Pond depth: 1.2 to 1.5 m (Zimbabwe standard)

Optimum detention time: 6 days

TF process

a) Design flow for capacity calculation

Primary and Secondary Sedimentation Tank: average dry weather flow

Trickling Filter: average dry weather flow

b) Primary and Secondary Sedimentation Tank

Surface loading: 1.2 $m^3/m^2/hr$ = 29 $m^3/m^2/day$

c) Trickling Filter

Depth of filter: 3 to 4 m

BOD loading: 0.1 kg/m3/day in the single pass without recirculation

0.2 kg/m3/day in the single pass with recirculation

Hydraulic loading: 0.5 $m^3/m^3/day$ without recirculation (Zimbabwe standard)

BNR process

a) Design flow for capacity calculation

Primary and Secondary Sedimentation Tank: average dry weather flow

Biological Filter: average dry weather flow

b) Primary sedimentation tank

Surface loading: 1.2$m^3/m^2/hr$ = 29 $m^3/m^2/day$

Retention time: 1.5 hr

c) Biological reactor (BNR)

Depth of basin: 4 m

MLSS (mixed liquor suspended solids): 3,000 - 3,600 mg/l

Retention time: total 1.7 days;	anaerobic tank	0.10 day
	anoxic tank	0.20 day
	aerobic tank	1.40 days

Sludge retention time: 12 days

Source: Norton Town Council, Report on the Feasibility Study for New Sewage Treatment Works, May 1996, Appendix D

d) Secondary sedimentation tank

Surface loading: 10 $m^3/m^2/day$

Japanese standard of Anaerobic-Anoxic-Aerobic process, similar to the BNR process is as follows:

Influent quality to basin after primary treatment: BOD = 130 mg/l

Final effluent quality: BOD = 10 mg/l

Recirculation Ratio: 150%

MLSS: 3,000 mg/l

Retention time: total 13.2 hr: anaerobic tank 1.2 hr

anoxic tank 4.8 hr

aerobic tank 7.2 hr

Sludge retention time: 14 days

(2) Sludge treatment process

a) Sludge thickening

Depth of basin: 4 m

Solid matter loading: 60 to 90 kg/m^3/day

Source: Japanese standard

b) Sludge drying bed

Required bed area: 0.08 m^2/person

12.2.5.2 Capacity Calculation of Sewage Treatment Facility

Table 12.2.5.1 (1) Capacity Calculation of BNR in 124,900 m³/day,Crowborough,2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/day	124,900 x 3.00	374,700
	Q2	m^3/sec	Q1 / 86,400	4.337
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q1 / WSL	208.17
Basin Number	BN	basin	-	16
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	28.91
Therefore	W2	m	-	28.80
Length	L1	m	RSA / W2	7.23
Therefore	L2	m	-	7.30
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	1.80
Length	L2	m	-	7.30
Depth	H	m	-	0.50
Basin Number	BN	-	-	16

(2) Primary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	124,900
Retention Time	T	hr	-	1.5
Water Surface Load	WSL	m^3/m^2/day	-	29
Required Surface Area	RSA	m^2	Q / WSL	4306.90
Basin Number	BN	basin	-	24
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	15.12
Therefore	D2	m	-	15.00
Depth	H	m	-	
(Dimension)				
Diameter	D2	m	-	15.00
Depth	H	m	-	0.00
Basin Number	BN	-	-	24

(cont'd)

Table 12.2.5.1 (2) Capacity Calculation of BNR in 124,900 m³/day,Crowborough,2015

(3) Biological Reactor (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	124,900
Retention Time	T1	day	Anaerobic Tank	0.1
	T2	day	Anoxic Tank	0.2
	T3	day	Aerobic Tank	1.4
	T4	day	Total	1.7
Required Volume	RV	m^3	Q x T4	212,330
Depth	H	m	-	4.00
MLSS	MLSS	mg/l	3,000 to 3,600	3,500
Required Surface Area	RSA	m^2	RV / H	53,083
Basin Number	BN	basin	-	8
Width	W	m	-	480.00
Length	L1	m	RSA / W	110.59
Therefore	L2	m	-	110.00
(Dimension)				
Width	W	m	W / BN	60.00
Length	L2	m	-	110.00
Depth	H	m	-	4.00
Basin Number	BN	-	-	8

(4) Secondary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	124,900
Retention Time	T	hr	-	1.5
Water Surface Load	WSL	m^3/m^2/day	-	10
Required Surface Area	RSA	m^2	Q / WSL	12490.00
Basin Number	BN	basin	-	24
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	25.75
Therefore	D2	m	-	26.00
Depth	H	m	-	3.00
(Dimension)				
Diameter	D2	m	-	26.00
Depth	H	m	-	3.00
Basin Number	BN	-	-	24

(cont'd)

Table 12.2.5.1 (3) Capacity Calculation of BNR in 124,900 m^3/day,Crowborough,2015

(5) Sludge Thickening Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	124,900
Inlet BOD Water Quality	WQ	mg/l	500-10	490
Inlet BOD	B	kg/day	Q x WQ / 1000	61,201
Solid Matter Load	SML	kg/m2/day	60 to 90	60
Required Volume	RV	m^3		
Depth	H	m	-	4.00
Required Surface Area	RSA	m^2	B / SML	1020.02
Basin Number	BN	basin		8
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	12.74
Therefore	D2	m	-	13.00
(Dimension)				
Diameter	D2	m	-	13.00
Depth	H	m	-	4.00
Basin Number	BN	-		8

(6) Sludge Drying Bed (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	124,900
Unit Sewage Quantity	USQ	l/capita/day	Assumption	100
Served Population	SP	person	Q x 10^3 / USQ	1,249,000
Unit Required Bed Area	URBA	m^2/person	-	0.08
Required Bed Area	RBA	m^2	SP x URBA	99,920
Width	W	m	-	170.00
Length	L1	m	RBA / W	587.76
Therefore	L2	m	-	600.00
(Dimension)				
Width	W	m	-	170.00
Length	L2	m	-	600.00

(7) Required Land Area

Grit Chamber and Screen	A1	m^2	W2 x L2 x BN	210
Primary Sedimentation Tank	A2	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	4,239
Biological Reactor	A3	m^2	W x L2 x BN	52,800
Secondary Sedimentation Tank	A4	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	12,736
Sludge Thickening Tank	A5	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	1061.32
Sludge Drying Bed	A6	m^2	W x L2	102,000
Sub-Total	A7	m^2	A1 + A2 + A3 + A4 A5 + A6	173,046
Maintenance and Green Belt	A8	m^2	A7 x 1	173,046
Total	A	m^2	A7 + A8	346,093

Table 12.2.5.2 (1) Capacity Calculation of BNR in 237,700 m^3/day,Firle,2015

237,700-72,000=165,700

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/day	165,700 x 2.70	447,390
	Q2	m^3/sec	Q1 / 86,400	5.178
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q1 / WSL	248.55
Basin Number	BN	basin	-	16
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	34.52
Therefore	W2	m	-	35.20
Length	L1	m	RSA / W2	7.06
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	W2 / BN	2.20
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	-	16

(2) Primary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	165,700
Retention Time	T	hr	-	1.5
Water Surface Load	WSL	m^3/m^2/day	-	29
Required Surface Area	RSA	m^2	Q / WSL	5713.79
Basin Number	BN	basin	-	32
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	15.08
Therefore	D2	m	-	15.00
Depth	H	m	-	
(Dimension)				
Diameter	D2	m	-	15.00
Depth	H	m	-	0.00
Basin Number	BN	-	-	32

(cont'd)

Table 12.2.5.2 (2) Capacity Calculation of BNR in 237,700 m^3/day,Firle,2015

(3) Biological Reactor (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	165,700
Retention Time	T1	day	Anaerobic Tank	0.1
	T2	day	Anoxic Tank	0.2
	T3	day	Aerobic Tank	1.4
	T4	day	Total	1.7
Required Volume	RV	m^3	Q x T4	281,690
Depth	H	m	-	4.00
MLSS	MLSS	mg/l	3,000 to 3,600	3,500
Required Surface Area	RSA	m^2	RV / H	70,423
Basin Number	BN	basin	-	8
Width	W	m	-	520.00
Length	L1	m	RSA / W	135.43
Therefore	L2	m	-	135.00
(Dimension)				
Width	W	m	W / BN	65.00
Length	L2	m	-	135.00
Depth	H	m	-	4.00
Basin Number	BN	-	-	8

(4) Secondary Sedimentation Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	165,700
Retention Time	T	hr	-	1.5
Water Surface Load	WSL	m^3/m^2/day	-	10
Required Surface Area	RSA	m^2	Q / WSL	16570.00
Basin Number	BN	basin	-	24
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	29.66
Therefore	D2	m	-	30.00
Depth	H	m	-	3.00
(Dimension)				
Diameter	D2	m	-	30.00
Depth	H	m	-	3.00
Basin Number	BN	-	-	24

(cont'd)

Table 12.2.5.2 (3) Capacity Calculation of BNR in 237,700 m^3/day,Firle,2015

(5) Sludge Thickening Tank (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	165,700
Inlet BOD Water Quality	WQ	mg/l	550-10	540
Inlet BOD	B	kg/day	Q x WQ / 1000	89,478
Solid Matter Load	SML	kg/m2/day	60 to 90	60
Required Volume	RV	m^3		
Depth	H	m	-	4.00
Required Surface Area	RSA	m^2	B / SML	1491.30
Basin Number	BN	basin	(Including 1 Standby)	8
Diameter	D1	m	$(RSA / (BN \times 3.14))^{1/2} \times 2$	15.41
Therefore	D2	m	-	15.40
(Dimension)				
Diameter	D2	m	-	15.40
Depth	H	m	-	4.00
Basin Number	BN	-	(Including 1 Standby)	8

(6) Sludge Drying Bed (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	165,700
Unit Sewage Quantity	USQ	l/capita/day	Assumption	100
Served Population	SP	person	$Q \times 10^3$ / USQ	1,657,000
Unit Required Bed Area	URBA	m^2/person	-	0.08
Required Bed Area	RBA	m^2	SP x URBA	132,560
Width	W	m	-	180.00
Length	L1	m	RBA / W	736.44
Therefore	L2	m	-	740.00
(Dimension)				
Width	W	m	-	180.00
Length	L2	m	-	740.00

(7) Required Land Area

Grit Chamber and Screen	A1	m^2	W2 x L2 x BN	246
Primary Sedimentation Tank	A2	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	5,652
Biological Reactor	A3	m^2	W x L2 x BN	70,200
Secondary Sedimentation Tank	A4	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	16,956
Sludge Thickening Tank	A5	m^2	$(D2 / 2)^2 \times 3.14 \times BN$	1489.3648
Sludge Drying Bed	A6	m^2	W x L2	133,200
Sub-Total	A7	m^2	A1 + A2 + A3 + A4 A5 + A6	227,744
Maintenance and Green Belt	A8	m^2	A7 x 1	227,744
Total	A	m^2	A7 + A8	455,488

Table 12.2.5.3 (1) Capacity Calculation of WSP in 2,800 m^3/day,Marlborough,2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/day	2,800 x 4.50	12,600
	Q2	m^3/sec	Q1 / 86,400	0.146
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q1 / WSL	7.00
Basin Number	BN	basin	(Including 1 By-pass)	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	0.97
Therefore	W2	m	-	1.00
Length	L1	m	RSA / W2	7.00
Therefore	L2	m	-	7.00
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	-	1.00
Length	L2	m	-	7.00
Depth	H	m	-	0.50
Basin Number	BN	-	(Including 1 By-pass)	2

(2) Anaerobic Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	2,800
Retention Time	T	day	BOD Removal = 30 %	1
Required Volume	V	m^3	Q x T	2,800
Depth	H	m	At least 3 m	3.00
Required Surface Area	RSA	m^2	V / H	933
Width	W	m	-	30.00
Length	L1	m	RSA / W	31.11
Therefore	L2	m	-	32.00
Basin Number	BN	basin	-	1
(Dimension)				
Width	W	m	-	30.00
Length	L2	m	L2 / BN	32.00
Depth	H	m	-	3.00
Basin Number	BN	-	-	1

(cont'd)

Table 12.2.5.3 (2) Capacity Calculation of WSP in 2,800 m^3/day, Marlborough, 2015

(3) Facultative Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	2,800
Retention Time	T	day	BOD Removal = 50 %	4
Required Volume	V	m^3	Q x T	11,200
Depth	H	m	1.2 to 1.5 m	1.50
Required Surface Area	RSA	m^2	V / H	7,467
Width	W	m	-	60.00
Length	L1	m	RSA / W	124.44
Therefore	L2	m	-	125.00
Basin Number	BN	basin	-	1
(Dimension)				
Width	W	m	-	60.00
Length	L2	m	L2 / BN	125.00
Depth	H	m	-	1.50
Basin Number	BN	-	-	1

(4) Maturation Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	2,800
Basin Number	BN	basin	-	3
Retention Time	T1	day	6 days at 3 ponds	6
Therefore	T2	day/basin	T1 / BN	2
Required Volume	V	m^3	Q x T2	5,600
Depth	H	m	1.2 to 1.5 m	1.50
Required Surface Area	RSA	m^2	V / H	3,733
Width	W	m	-	45.00
Length	L1	m	RSA / W	82.96
Therefore	L2	m	-	90.00
(Dimension)				
Width	W	m	-	45.00
Length	L2	m	-	90.00
Depth	H	m	-	1.50
Basin Number	BN	-	-	3

(5) Required Land Area

Grit Chamber and Screen	A1	m^2	W2 x L2 x BN	14
Anaerobic Pond	A2	m^2	W x L2 x BN	960
Facultative Pond	A3	m^2	W x L2 x BN	7,500
Maturation Pond	A4	m^2	W x L2 x BN	12,150
Sub-Total	A5	m^2	A1 + A2 + A3 + A4	20,624
Maintenance and Green Belt	A6	m^2	Same as A5	20,624
Total	A	m^2	A5 + A6	46,812

Table 12.2.5.4 (1) Capacity Calculation of WSP in 6,800 m^3/day,Donnybrook,2015

(1) Grit Chamber and Screen (Peak Wet Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Type	-	-	Parallel Flow Type	
Design Sewage Quantity	Q1	m^3/day	6,800 x 3.75	25,500
	Q2	m^3/sec	Q1 / 86,400	0.295
Water Surface Load	WSL	m^3/m^2/day	-	1,800
Required Surface Area	RSA	m^2	Q1 / WSL	14.17
Basin Number	BN	basin	(Including 1 By-pass)	2
Average Velocity	V	m/sec	-	0.30
Depth	H	m	-	0.50
Width	W1	m	Q2 / (V x H)	1.97
Therefore	W2	m	-	2.00
Length	L1	m	RSA / W2	7.08
Therefore	L2	m	-	7.10
Screen Type	-	-	Manual Removal Type Bar Screen	
(Dimension)				
Width	W2	m	-	2.00
Length	L2	m	-	7.10
Depth	H	m	-	0.50
Basin Number	BN	-	(Including 1 By-pass)	2

(2) Anaerobic Pond (Average Dry Weather Flow)

Item	Symbol	Unit	Calculation	Adoption
Design Sewage Quantity	Q	m^3/day	-	6,800
Retention Time	T	day	BOD Removal = 60 %	5
Required Volume	V	m^3	Q x T	34,000
Depth	H	m	At least 3 m	3.00
Required Surface Area	RSA	m^2	V / H	11,333
Width	W	m	-	75.00
Length	L1	m	RSA / W	151.11
Therefore	L2	m	-	150.00
Basin Number	BN	basin	-	2
(Dimension)				
Width	W	m	-	75.00
Length	L2	m	L2 / BN	75.00
Depth	H	m	-	3.00
Basin Number	BN	-	-	2