CHAPTER 4

SANITATION CONDITIONS AND WATER POLLUTION CONTROL MEASURES AT PRESENT AND IN THE FUTURE

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4.1 Sanitation Conditions

4.1.1 General

Sanitation measures are categorised into on-site treatment (septic tanks) and off-site treatment (public sewerage system). In this section, the sanitation conditions in the Study Area mainly refer to on-site treatment. Off-site treatment is separately discussed in a later section.

In the Study Area, a part of the low density residential areas in the urban areas and entire rural areas use septic tanks, and other types of toilet facilities, while many of the residents in the remaining urban areas are served by the public sewerage system. Table 4.1.1 shows the present septic tank served population in the urban areas in the Study Area.

Table 4.1.1 Septic Tank Served Population in the Study Area

Urban Authority	Population *2
Harare	95,140
Chitungwiza *1	0
Norton	1,290
Ruwa	20
Epworth	68,490

*1: Septic tanks are being used only at 8 schools

*2: Refer to Table 9.3.1 in Water Pollution Master Plan

4.1.2 Harare City

Some stands (lots) in the low density areas have on-site treatment facilities. The rest of the city is served by a public sewerage system. Figure 4.1.1 shows a typical standard design of septic tank in Zimbabwe, and Figure 4.1.2 shows the septic tank service area in Harare.

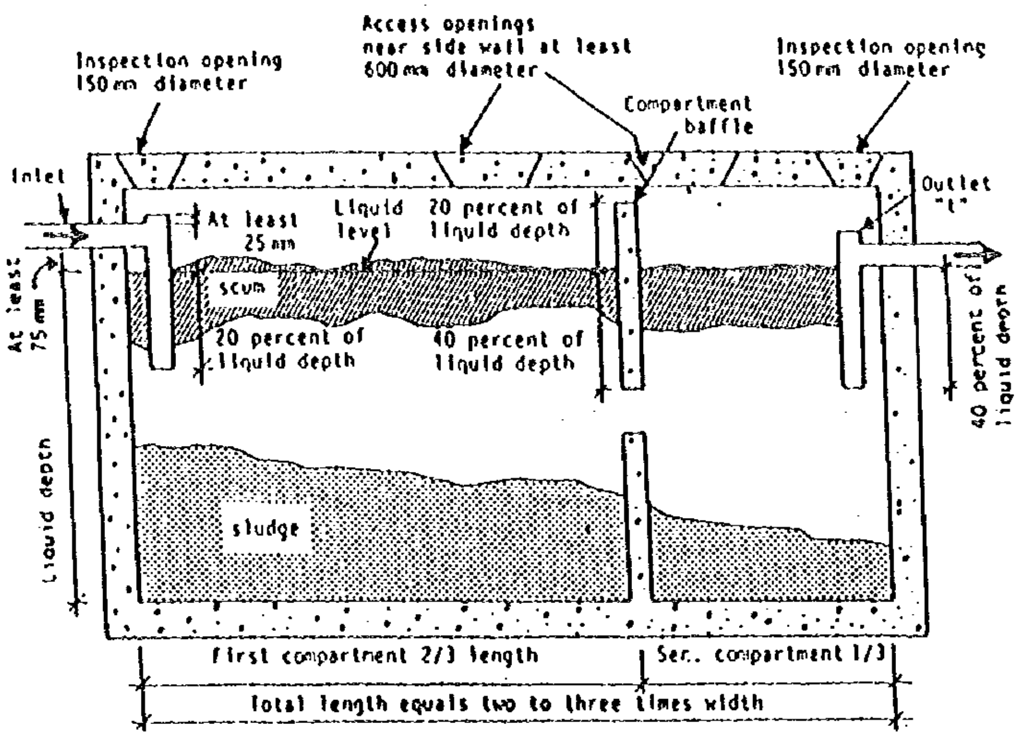


Figure 4.1.1 Typical Standard Design of Septic Tank in Zimbabwe

In the placement of septic tanks, the minimum stand size is principally regulated at more than 4,000 m^2. However, this restriction is loosened to 2,000 m^2 when soil test results are favourable.

4.1.3 Chitungwiza Municipality

At present, only one (1) % of the municipal area is not served by the public sewerage system and depends on septic tanks. Eight (8) schools are also utilising septic tanks. These septic tanks are emptied when they become full. Figure 4.1.3 shows the septic tank service area in Chitungwiza.

The current sanitation problem is the overflow of sewage from manholes into the streets owing to the deposit of sand and sludge in sewers/manholes, as well as increased sewage. The dumping of domestic wastes into sewers/manholes is another cause of this problem.

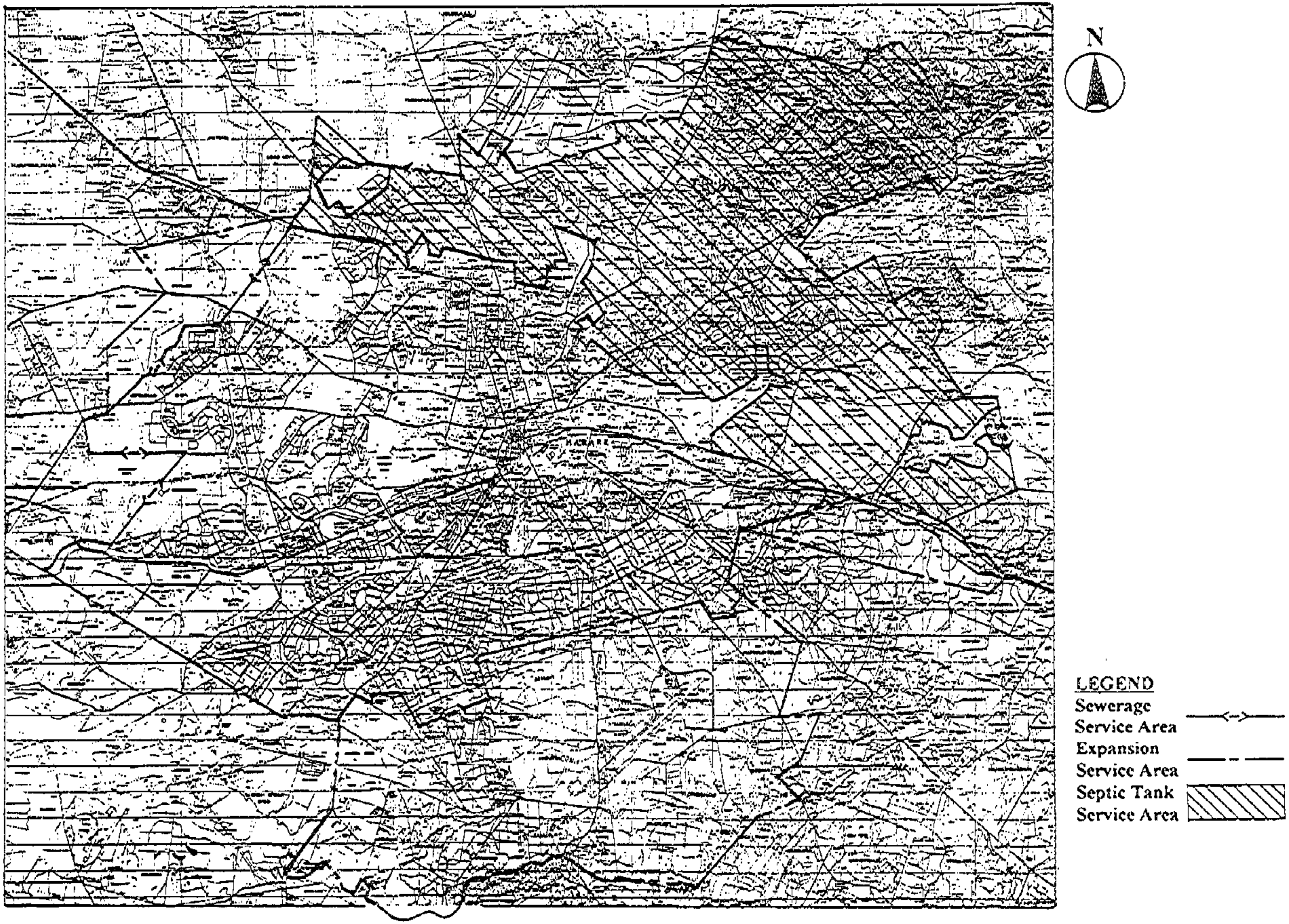


Figure 4.1.2 Septic Tank Service Area in Harare S = 1/200,000

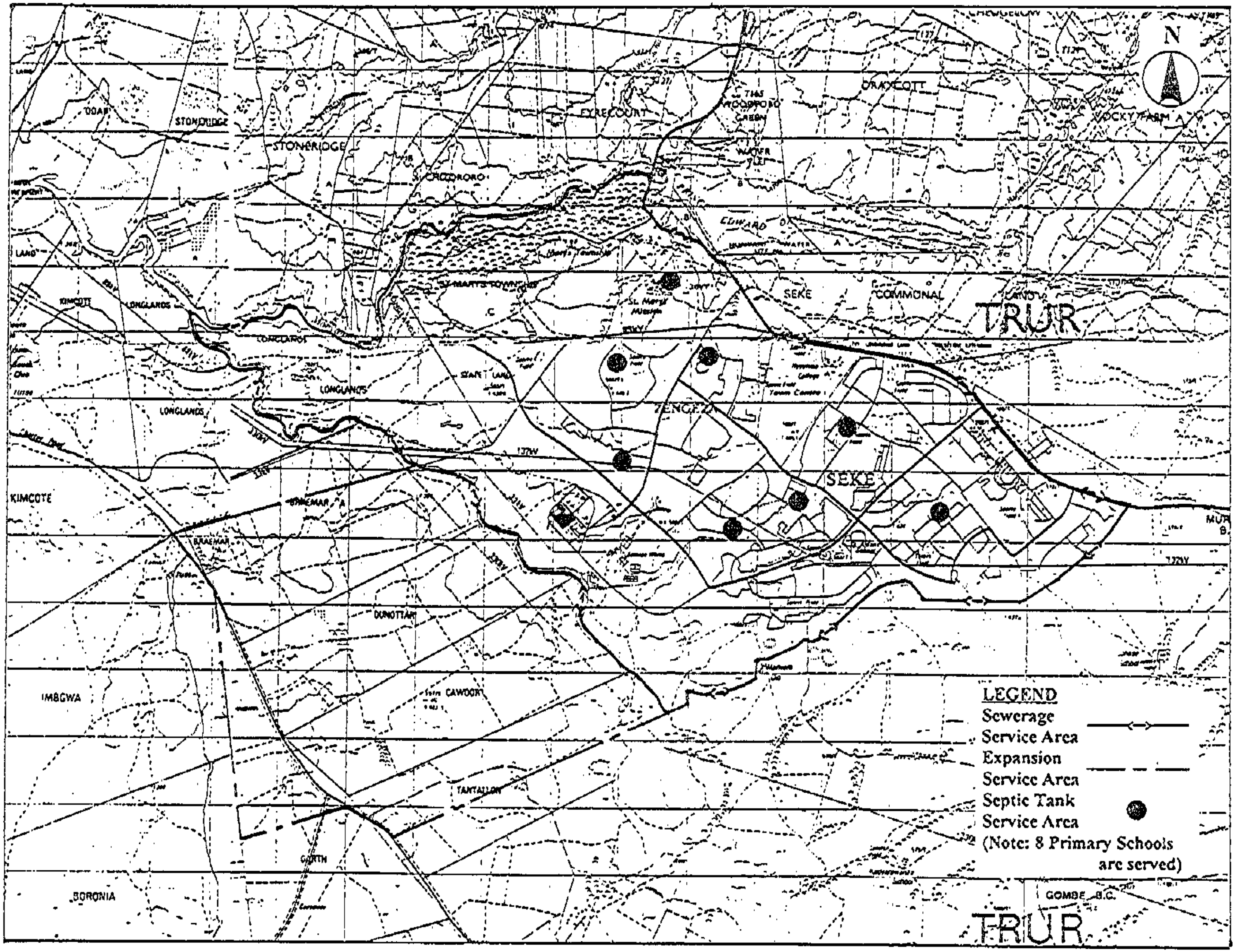


Figure 4.1.3 Septic Tank Service Area in Chitungwiza S = 1/75,000

4.1.4 Norton Town Council

Approximately 95% of the total residential stands (lots) are served by gravity sewer connected to the Town Council's sewers. In addition, sewage from 47 stands located in the low density areas is pumped to the trunk sewer. The rest, 271 houses/stands, rely on septic tanks.

These septic tanks have been constructed in conformity with the Council's policy that the minimum size of each stand shall be larger than 2,400 m^2 in the application of septic tanks. All industrial wastewater is also discharged into the Council's sewerage system. Figure 4.1.4 shows the septic tank service area in Norton.

4.1.5 Ruwa Local Board

The sanitation conditions of Ruwa are being improved and are being provided with sewerage services south of the Harare-Murate Road, excluding 22 stands located in low and high density areas. All industrial wastewater is discharged into the Local Board's sewerage system. Figure 4.1.5 shows the septic tank service area in Ruwa.

4.1.6 Epworth Local Board

At present, there is no public sewerage system in Epworth. The majority of houses/stands are therefore using "ventilated improved pit (VIP)" latrines sponsored by the national government. The presence of unacceptable "drop pit latrines" is quite limited. Generally, appropriate stand spacing is maintained to locate septic tanks in order to avoid environmental hazards.

In the northern part of Epworth a series of temporary sewage ponds has been developed to serve as the overflow area for domestic sewage. However, these ponds are located too close to the existing houses. The Epworth Local Government is considering the closure of these ponds upon the construction of a new and larger treatment works south of the Epworth Local Government area on part of the Lyndhurst Farm. The Epworth Local Government also seeks to reduce the use of pit latrines and to introduce a public sewerage system.

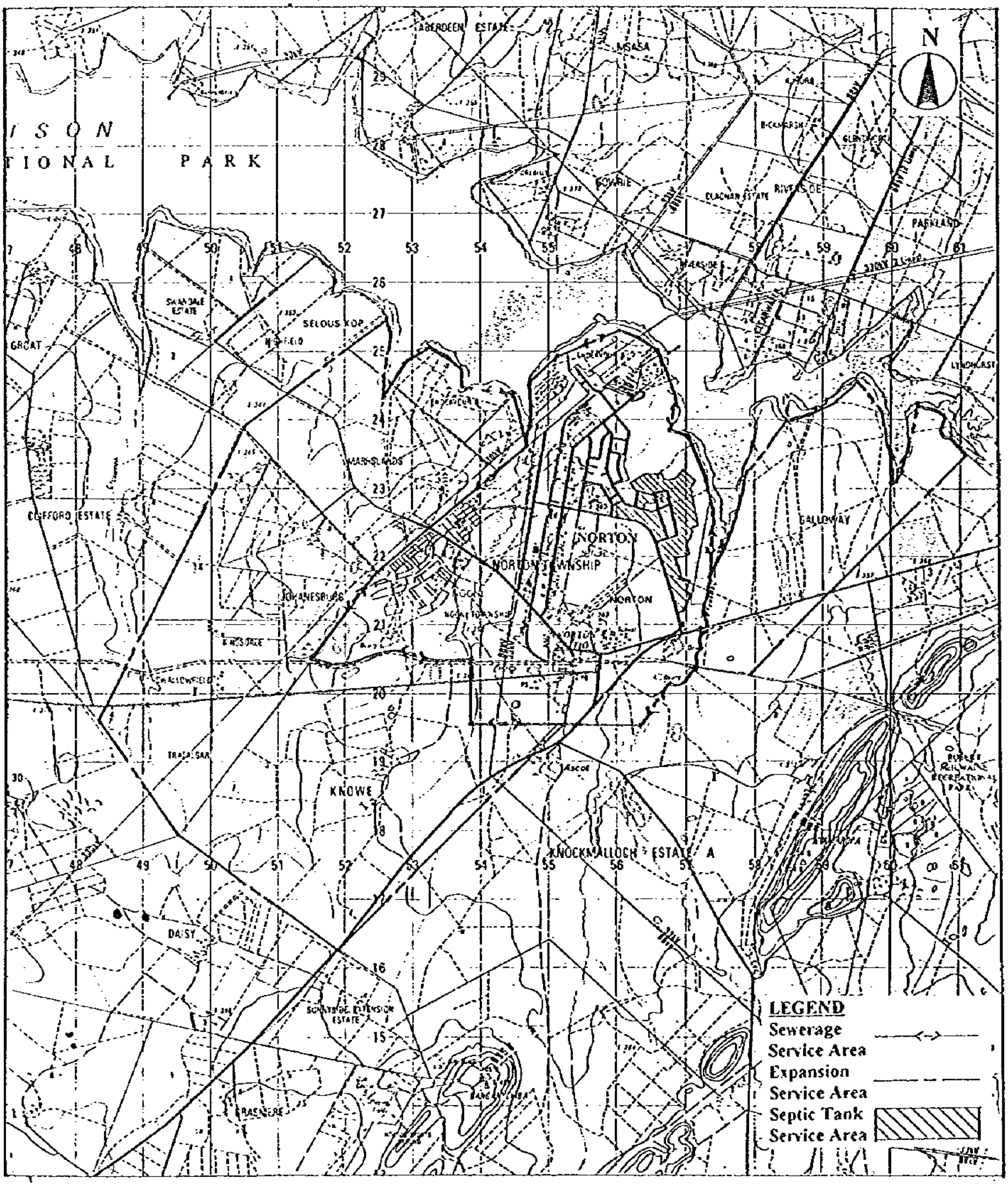


Figure 4.1.4 Septic Tank Service Area in Norton S = 1/75,000

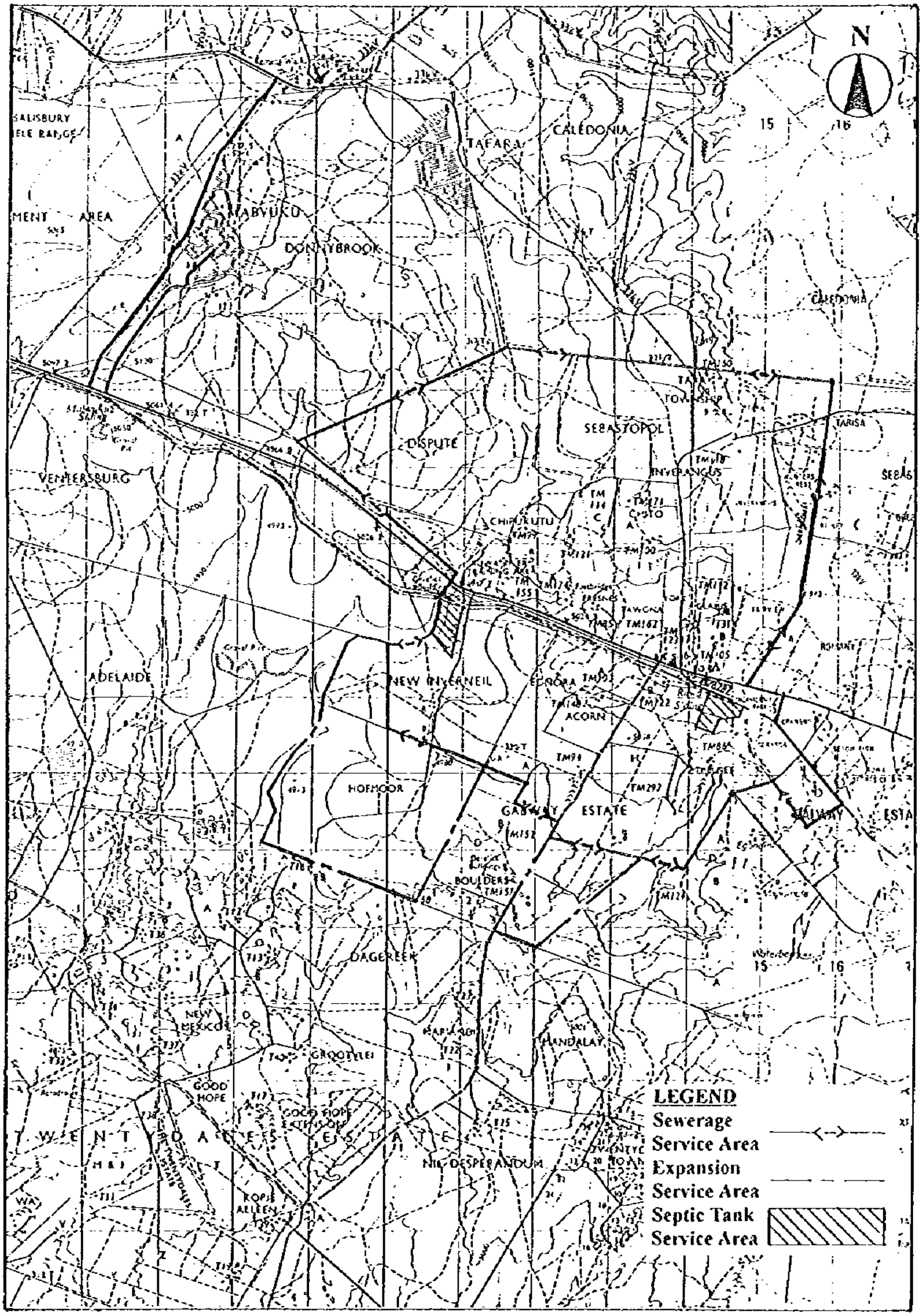


Figure 4.1.5 Septic Tank Service Area in Ruwa S = 1/75,000

4.2 Existing Public Sewage Works, Industrial Wastewater Treatment Works and Urban Drainage

4.2.1 Existing Public Sewage Works

The urban areas in the Study Area, Harare City, Chitungwiza, Norton and Ruwa, have public sewerage systems. In contrast, the rural areas such as the Rural Districts do not have such facilities and use on-site facilities (septic tank and other toilet types).

The conditions of the existing public sewerage systems of the urban areas are summarised as shown in Table 4.2.1 to Table 4.2.4. The following enumerate the present conditions by urban areas, and the study of the existing facilities are shown in Section 4.2, Chapter 2, Supporting Report.

(1) Harare City

Harare City is currently operating four sewage pump stations to convey the raw sewage collected in the service areas to the respective sewage treatment works (STW). These are:

- The Vainona (North Eastern) pump station serving parts of Mt. Pleasant, Vainona and Borrowdule to send sewage into the Firle catchment area. The approximate population served by this pump station is more than 2,400 people (400 stands).
- The Avonlea pump station serving parts of Avonlea, Arundel and Marlborough. Sewage is lifted into the Crowborough catchment area.
- Chisipite, is a small pump station that mainly serves a shopping center and pumps its sewage into the Firle catchment area.
- The pump station to send sewage from Mufakose's high density suburbs to the Crowborough inlet works of STW.

There are two new pump stations which will be operational soon. The first one is under construction by a private developer for an office park in Arundel, and the other one is financed by the City of Harare in Chisipite. The new Chisipite sewage pump station is to replace the existing one and also to facilitate a conventional sewage reticulation for a larger area where septic tanks are currently used.

Table 4.2.1 Sewered Area and Population in 1995

<table>
<tr><th>Item</th><th colspan="2">Harare City</th><th>Chitungwiza Municipality</th><th>Norton Town</th><th>Ruwa Local Board</th><th>Total</th></tr>
<tr><td>Municipal Area (ha)</td><td></td><td>55,745</td><td>4,200</td><td>1,950</td><td>3,140</td><td>65,035</td></tr>
<tr><td>Sewered Area (ha)</td><td>Crowborough
Firle
Marlborough
Donnybrook
Hatcliff
Total</td><td>17,400
19,435
378
1,690

38,903</td><td>4,200</td><td>1,950</td><td>3,140</td><td>48,193</td></tr>
<tr><td>Municipal Population *1</td><td></td><td>1,296,000</td><td>420,000</td><td>22,000</td><td>2,000</td><td>1,740,000</td></tr>
<tr><td>Served Population *2</td><td>Crowborough
Firle
Marlborough
Donnybrook
Hatcliffe
Total</td><td>506,200
600,800
9,800
79,000
N.A.
1,195,800</td><td>420,000</td><td>21,000</td><td>1,600</td><td>1,638,400</td></tr>
<tr><td>Treatment Area No.
Trunk Sewer and Pump Station (PS) by each treatment Area</td><td colspan="2">5
Crowborough
835mm
875mm
PS 3

Firle
1,200mm in 1972
1,350mm in 1972
PS 3</td><td>1
Zengeza
675mm
675mm
300mm
PS 4</td><td>1
Norton

PS 2</td><td>1
Ruwa
375mm

PS 2</td><td></td></tr>
</table>

Note: *1; Projected population (refer to Table 6.2.7 (3) in Water Pollution Master Plan)
*2; Refer to Table 9.3.1 in Water Pollution Master Plan

Table 4.2.2 The List of Existing Sewage treatment Works

Urban Authority	Sewage Treatment Works	Treatment method	Design Capacity m3/d	Present Influent Flow m3/d	Note (Construction Time)
Harare City	Crowborough	TF	36,000	39,325	Unit 1 1957
					Unit 2 1970's
		BNR	18,000	15,986	Unit 3 1980's
		BNR	*1 (25,000)	-	Unit 4 1996 to
			(79,000)		Total in the future
			54,000	55,311	
	Firle	TF	36,000	104,636	Unit 1 1960
					Unit 2 1970's
		BNR	36,000	12,403	Unit 3 1979 to 1981
				15,252	Unit 4 1986 to 1996
		BNR	(72,000)	-	Unit 5(I) 1994 to 1996
					Unit 5(II) 1995 to 1997
			(144,000)		Total in the future
			72,000	132,291	
	Marlborough	WSP	2,000	2,000	
	Donnybrook				
	Block 1	WSP	-	400	
	Block 2	WSP	-	1,350	
	Block 3	WSP	-	1,396	
	Block 4	WSP	-	2,351	
		Total	*2 5,500	5,497	
	Hatcliffe	AL	1,300	2,500	
Chitungwiza Municipality	Zengeza	TF	21,750	36,405	Under repair
Norton Town	Norton	TF	3,400	2,700	Unit 1 1953 Unit 2 1975 Under repair
Ruwa Local Board	Ruwa	WSP	5,300	2,865	1993
Total			(262,250) 165,250	239,569	

Note: Present influent flow is estimated based on the Average Dry Weather Flow (ADWF)

*1; The latest on-going plan for BNR of Crowborough is 60,000 m^3/day

*2; Design capacity (5,500 m^3/day) of Donnybrook (refer to Section 4.2, Chapter 2, Supporting Report)

TF; Trickling Filter
BNR; Biological Nutrient Removal
WSP; Wastewater Stabilitation Pond
AL; Aerated Lagoon

Table 4.2.3 Sewage Treatment Methods/Processes and Effluent Reuse

Sewage Treatment Works	Treatment Process to Discharge Effluent into River	Treatment Process to Use Effluent for Irrigation	Problems Areas Operation of Facilities and Environmental Problems
Crowborough STW	Screen & Grit removal - Primary Sedi. Tank - BNR - Final Sedi. Tank : Marimba River	Screen & Grit removal - Primary Sedi. Tank - Trickling Filter - Final Sedi. Tank - Storage Pond - Pump Station	- routine work is done for operation of STP (effluent quality of secondary treatment needs to be improved) - no special reports on environmental problems
Firle STW	Screen & Grit removal - Primary Sedi. Tank - BNR - Final Sedi. Tank : Mukuvisi River	Screen & Grit removal - Primary Sedi. Tank - Trickling Filter - Final Sedi. Tank - Storage Pond - Pump Station	- routine work is done for operation of STP (effluent quality of secondary treatment needs to be improved) - secondary treatment needs to be improved)
Zengeza STW	None	Screen & Grit removal - Anaerobic Pond - Trickling Filter - Pump Station	- no primary and final sedimentation tank is installed - offensive odour at STP site and its influence to residential area as reported by residents - possible overflow of treated effluent into Naytsime River during rainy season
Norton STW	None	Screen & Grit removal - Primary Sedi. Tank - Pump Facility - Trickling Filter - Final Sedi. Tank - Storage Pond - Pump Station	- no special reports on operation of facilities - unsanitary condition at storage pond (anaerobic condition covered by scum on the pond surface)
Ruwa STW	None	Pump Facility - Anaerobic Pond - Facultative Pond - Matulation Pond	- overflow of effluent into nearby river during rainy season

Table 4.2.4 Present Sewerage Services and Problem Areas

Sewage Treatment Works	Served Population / Coverage (%) *1	Service Area: Sewer Conditions	Service Area: Environmental Problems	Sewage Treatment: Inflow to STW — Flow (m³/d) / Influent Quality (mg/l)	Sewage Treatment: Treatment Capacity (m³/d) / Overloaded Flow (m³/d)	Sewage Treatment: Discharge to River — Flow (m³/d) / Effluent Quality (mg/l)	Sewage Treatment: Irrigation Use — Flow (m³/d) / Effluent Quality (mg/l)	Environmental problems at STW / Environs of STW
Crowborough STW	506,200	- damage of manhole & sewers - build manhole cover - rain water intrusion to manhole	- common offensive odor	55,300	54,000	16,000	39,300	- no special problem
	100			COD 1,108.9 TN 53.0 TP 7.2	1,300	COD 80.6 TN 12.6 TP 0.6	COD 371.0 TN 39.0 TP 5.2	- no special reports on problems with sufficient distance from STW to housing
Firle STW	600,800	- raw sewage spill along 6 routes of lateral sewers (14 km) *2	- health hazard - offensive odor along problem sewers	132,300	72,000	27,700	104,600	- trickling filter is overloaded with offensive odor
	100			COD 943.0 TN 54.0 TP 6.9	60,300	COD 27.9 TN 0.8 TP 0.7-12.0	COD 232.5 TN 39.6 TP 3.4	- no special reports on problems with sufficient distance from STW to housing
Zengeza STW	420,000	- identified 30 problem points along sewer lines	- health hazard - stream pollution by raw sewage	36,400	21,750	None	36,400	- offensive odor pollution of nearby river upon overflow of effluent
	100			BOD 810.0 TN 38.0 TP N.A.	14,700	None	BOD 275.0 TN 57.0 TP N.A.	- pollution of streams in Beatrice down-stream of Imbgwa farm
Norton STW	21,000	- no special reports	- no special reports	2,700	3,400	None	2,700	- unsanitary w/odor problem at storage pond before pump
	95			BOD 660.0 TN 83.3 TP 7.6	(700)	None	BOD 520.0 TN 65.8 TP 7.6	- no special reports on problems
Ruwa STW	1,600	- intrusion of groundwater and storm water	- no special reports	2,900	5,300	None	2,900	- during rainy season overflow of effluent to nearby river
	80			BOD 510.0 TN 31.0 TP 3.6	(2,400)	None	BOD 47.5 TN N.A. TP trace	- no special reports

Note: N.A. Not Available

*1; The term "Coverage" means the percentage of population served by respective STW

*2; Report on Subsidiary Sewers in the Firle Catchment Area, Harare Sewerage Firle V Project, Department of Works, City of Harare

There are five sewage treatment works within Harare, namely the Firle, Crowborough, Hatcliff, Marlborough and Donnybrook STWs (refer to Figure 4.2.1). Firle is the largest STW, serving more than 600,000 people including industrial wastewater (refer to Figure 4.2.1 and 4.2.2, Section 4.2, Chapter 2, Supporting Report). The design capacity of this STW is 72,000 m^3/day and is currently overloaded with about 60,000 m^3/day. A new phase (Firle V) with a capacity of 72,000 m^3/day is being constructed at the same site to augment the capacity of the existing facilities and is expected to be completed by 1997 (refer to Figure 4.2.3, Section 4.2, Chapter 2, Supporting Report).

The Crowborough STW is the second largest sewage treatment works, having a design capacity of 54,000 m^3/day and presently serves more than 500,000 people. The current sewage inflow amount (55,300 m^3/day) is comprised of domestic sewage and industrial wastewater and is almost equal to the design capacity (refer to Figure 4.2.4 and 4.2.5, Section 4.2, Chapter 2, Supporting Report). A new phase for Crowborough is now in the design stage.

The Hatcliffe STW (aerated lagoon) serves the suburb of Hatcliffe only and its present estimated flow is approximately 2,500 m^3/day. A new modern sewage treatment plant with a capacity of 2,810 m^3/day is about to be constructed to replace the existing one.

The Marlborough STW (stabilisation ponds) is serving Marlborough, but is operating in full capacity. A proposal for a new sewage treatment plant within the Gwebi catchment has been made, and the feasibility study is currently on-going.

In Mabvuku and Tafara, there are four sets of stabilisation pond systems which serve a total population of 79,000, of which 55,000 are served by Donnybrook 1 and Donnybrook 2 (refer to Figure 4.2.6, Section 4.2, Chapter 2, Supporting Report) and 24,000 by Donnybrook 3 and 4 (refer to Figure 4.2.7, Section 4.2, Chapter 2, Supporting Report). The City of Harare currently undertakes the feasibility study for the BNR on the Donnybrook STW.

Except for Hatcliffe, which is outside the drainage basin, the sewage treatment systems employed in the existing treatment works in Harare City can be classified generally as follows:

-WSP (AP+FP+MP)

-TF (PST+TF+SST)

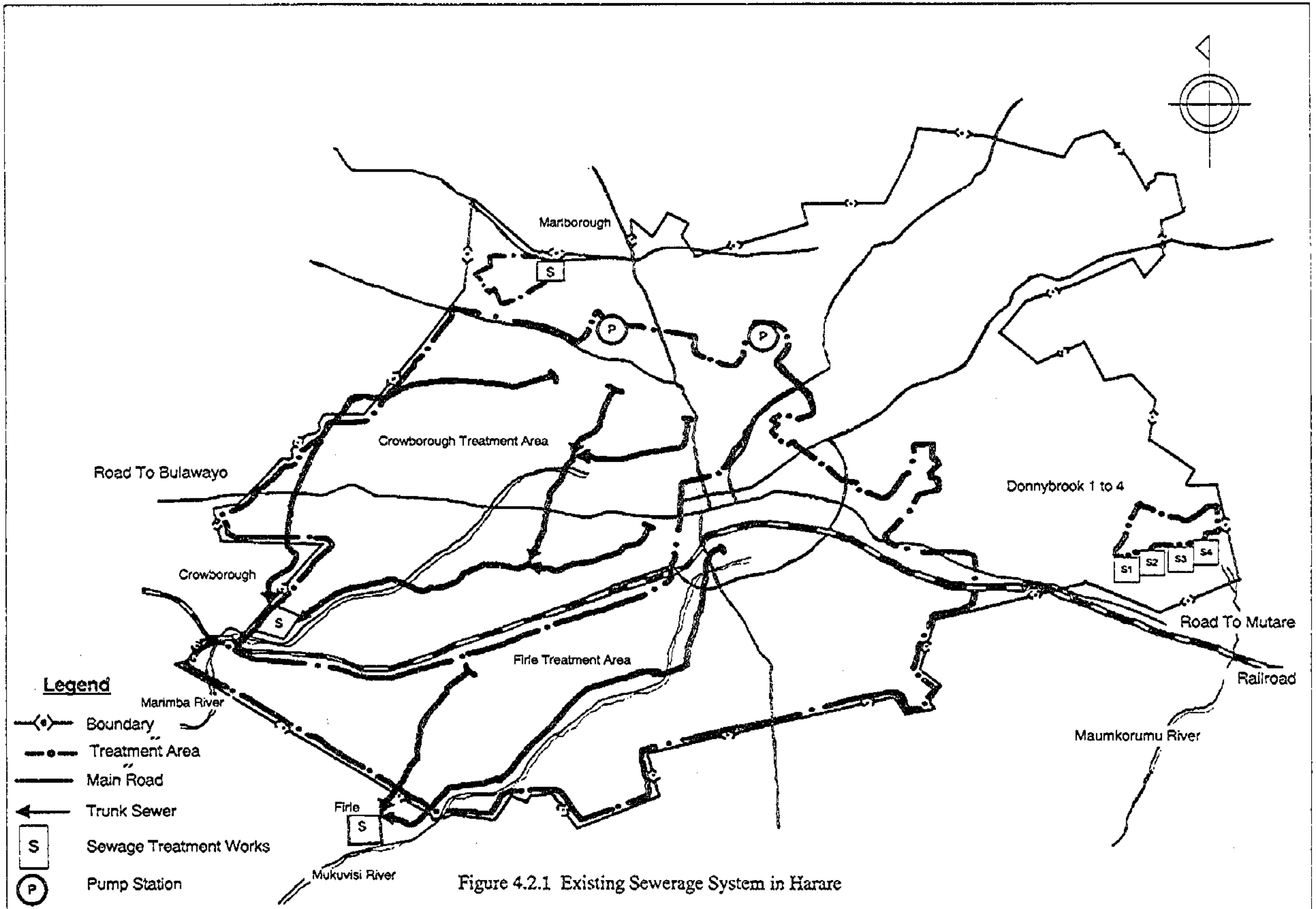


Figure 4.2.1 Existing Sewerage System in Harare

-BNR (PST+BNR+SST)

where, WSP: Wastewater Stabilisation Pond

TF: Trickling Filter

BNR: Biological Nutrient Removal

AP: Anaerobic Pond

FP: Facultative Pond

MP: Maturation Pond

PST: Primary Sedimentation Tank

TF: Trickling Filter

SST: Secondary Sedimentation Tank

Of these, WSP is employed at small treatment facilities -- those treating less than 5,300 m^3/day. Where WSP is not used, TF is generally employed. The modified activated sludge treatment process, BNR, is an advanced treatment process that is used in conjunction with TF. In other words, treatment processes at existing treatment facilities are of the following two types:

WSP	:	Marlborough and Donnybrook
TF + BNR	:	Crowborough and Firle

With the WSP type, the quality of the treated water does not meet the effluent standards and therefore cannot be discharged into rivers. The treated water from these treatment facilities is accordingly sent to irrigation land. The treatment facilities of the TF + BNR type are very large-scale, and these facilities are required to bring a portion of their treated water up to effluent standards and to discharge it to rivers.

The Crowborough and Firle STWs are required to conduct advanced treatment for 20% of their influent and discharge it to the river. At the Crowborough STW, the BNR treatment capacity is 18,000 m^3/day, and the influent flow is 16,000 m^3/day. For the Firle STW, the BNR treatment capacity is 36,000 m^3/day and the influent flow is 28,000 m^3/day. The amount of treated water discharged to the rivers yearly is about 5,840,000 m^3/year for Crowborough and about 10,220,000 m^3/year for Firle.

The following sludge treatment methods are employed:

- for WSP facilities : AP
- for TF, BNR facilities : ADT (anaerobic digestion tank)

In the small-scale facilities that employ WSP facilities, an AP is situated beyond the screen and grit chamber. Settleable organic matter is allowed to settle in the AP for one to several years, and stabilisation is achieved through anaerobic degradation. The stabilized sludge is then dried in an SDB (sludge drying bed) or AP.

In the facilities employing both TF and BNR, sludge is sent to the anaerobic digestion tanks. With the TF train, sludge from the SST is returned to the PST and is sent to the digestion tanks along with the sludge from the PST. With the BNR train, sludge from the SST and the PST are sent separately to the digestion tank. The sludge digestion time is approximately three weeks. At Crowborough, 708 m^3/day of raw sludge (sludge from the PST) and 500 m^3/day of sludge from the SST are sent together for digestion. Gas is released at a rate of 210,000 m^3/month, of which 71,588 m^3/month is burned for heating the digestion tanks (May 1996).

Methods employed for sludge disposal are as follows:

- Agricultural reuse (dried sludge)
- Irrigational reuse (mixing sludge with treated water)

For small-scale WSPs, sludge that has accumulated in the AP is dried and applied to farm land every few years. Larger scale STWs employ the second method: after removing the putrefactivity of the sludge and stabilising in a sludge digestion tank, the sludge is injected into the pipe for conveying treated water for irrigation, and is distributed to the irrigation land along with the treated water.

The funding for most of these STWs is through the World Bank, the European Investment Bank, the Zimbabwe Government and the City of Harare.

(2) Chitungwiza Municipality

The existing sewerage system in Chitungwiza is shown in Figure 4.2.2. In the service area, is the Tilcor Industrial Area has a pre-treatment facility to reduce wastewater BOD from 6,000

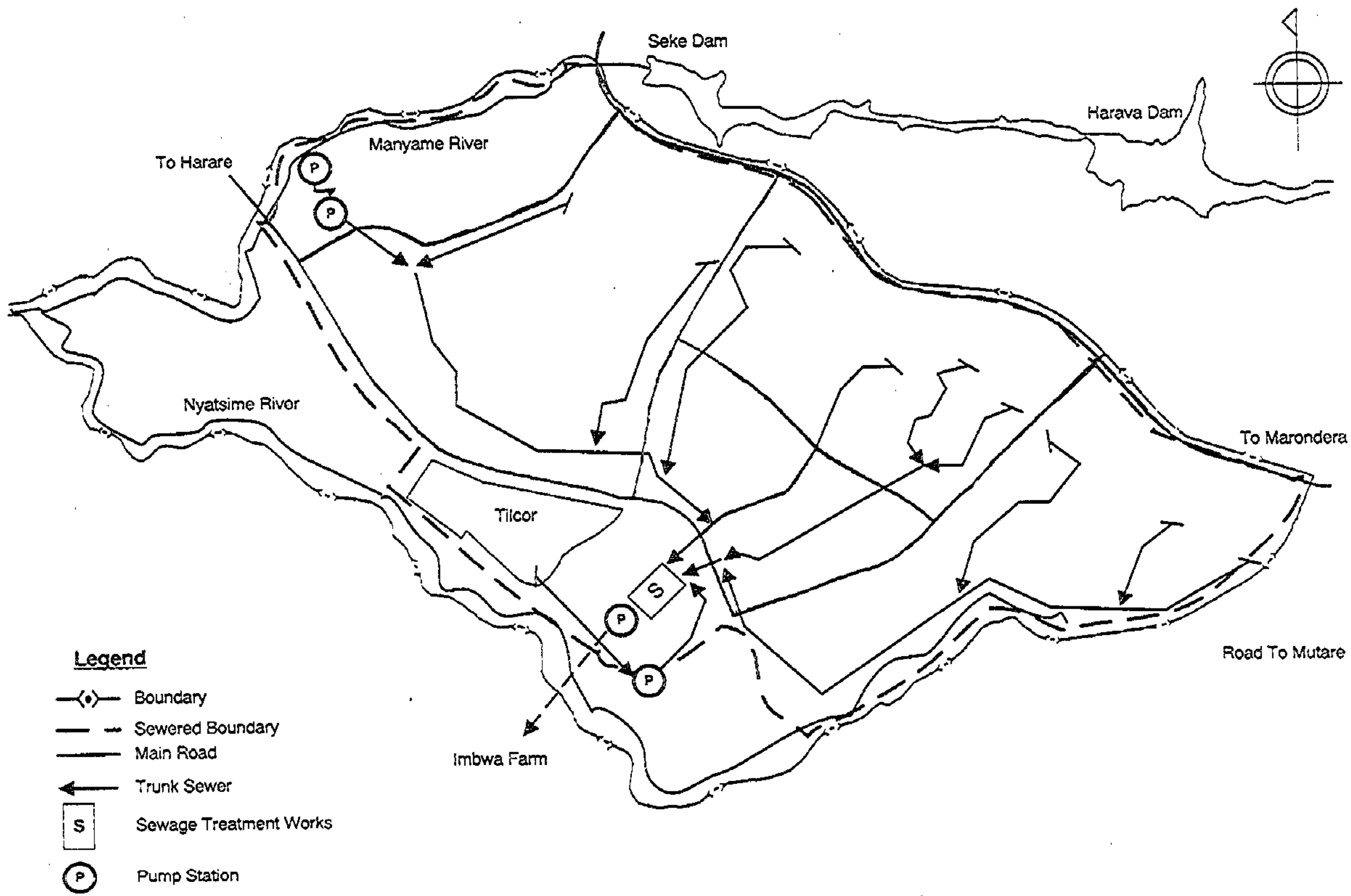


Figure 4.2.2 Existing Sewerage System in Chitungwiza

mg/l to 1,000 mg//l by anaerobic ponds. The treated effluent is then sent to the inlet works of the Zengeza STW from the pump station via a force main (see Figure 4.2.9, Section 4.2, Chapter 2, Supporting Report). The Zengeza STW, with a design capacity of 21,750,"m3/day, is shown in Figure 4.2.8, Section 4.2, Chapter 2, Supporting Report.

The treatment process at this STW is a combination of AP and TF. The reasons for using AP ahead of TF are that the sewage handled is of high strength, there is available space at the facility, and this method simplifies sludge treatment. Because sewage treated in this manner does not meet the effluent standards, the treated water is conversed to irrigation land. In the autumn of last year, a new pump station was completed, which sends all the treated water to irrigation land.

The sludge that accumulates in the AP is dried in the SDB and is released once every few years for reuse on farm land. The sludge from the TF is not removed within the treatment facility but is sent, along with treated water, to irrigation land.

(3) Norton Town Council

The existing sewerage system in Norton is shown in Figure 4.2.3 and the existing Norton STW is shown in Figure 4.2.10, Section 4.2, Chapter 2, Supporting Report. The treatment process employed at this STW is the TF method. Sewage treated by this method does not meet the effluent standards for discharge into Lake Manyame, so the whole treated sewage is kept in a storage pond until it is pumped to irrigation land along with the treated water from a nearby pulp factory. Because it is comparatively small-scale, the sludge from the PST and SST is sent directly to the SDB for drying. The dried sludge is piled up on the land next to the existing facility, and is applied to nearby farmland as needed.

(4) Ruwa Local Board

The existing Ruwa sewerage system is shown in Figure 4.2.4 and the Ruwa STW is shown in Figure 4.2.11, Section 4.2, Chapter 2, Supporting Report. The treatment process employed at this facility is WSP. Because sewage treated in this manner does not meet the effluent standards for discharge into rivers, the treated water is sent to irrigation land. There is a pump at the end of the trunk sewer, which sends the sewage to the STW constructed next to the irrigation land. Because the STW just began operation in 1993, no sludge has yet been

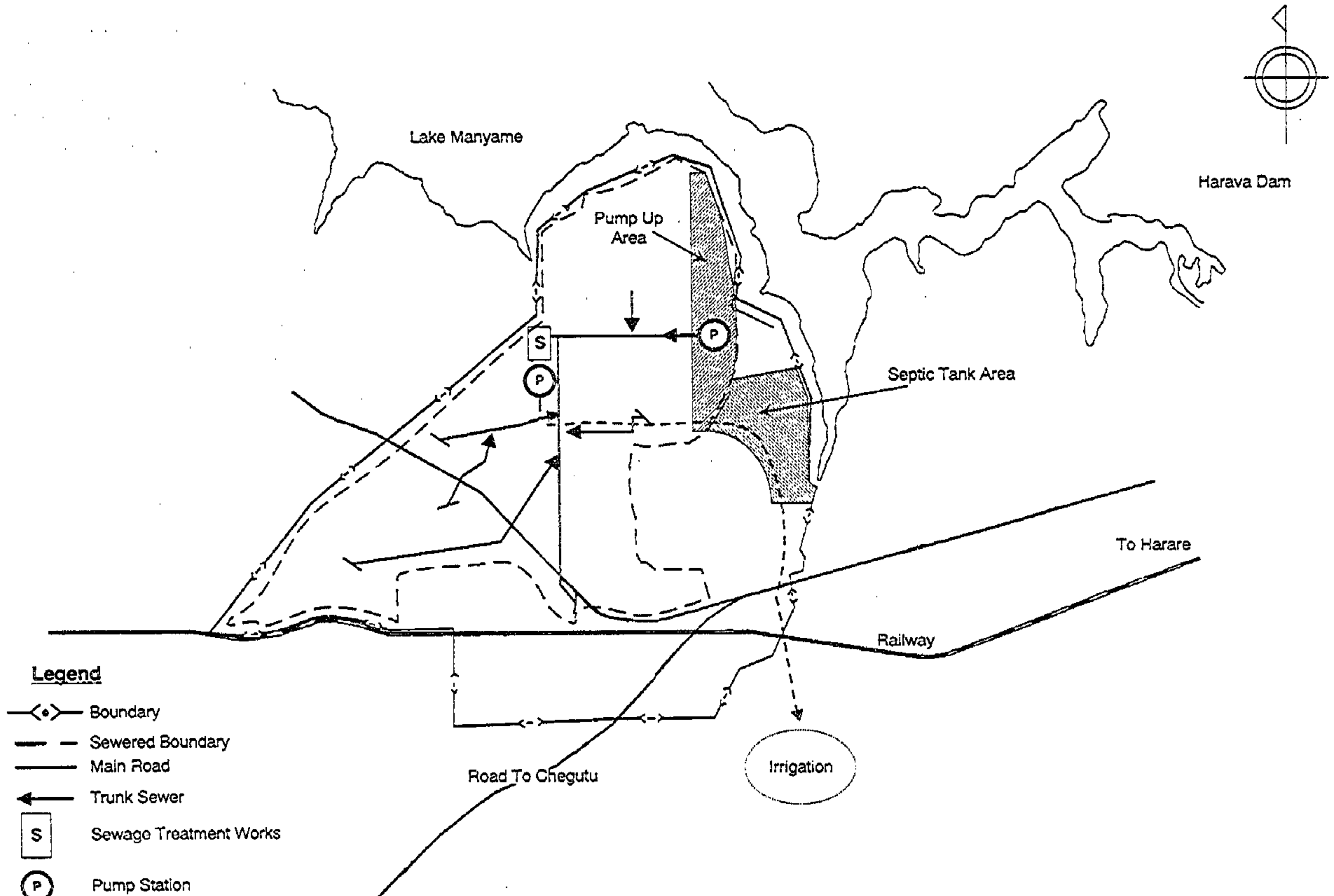


Figure 4.2.3 Existing Sewerage System in Norton

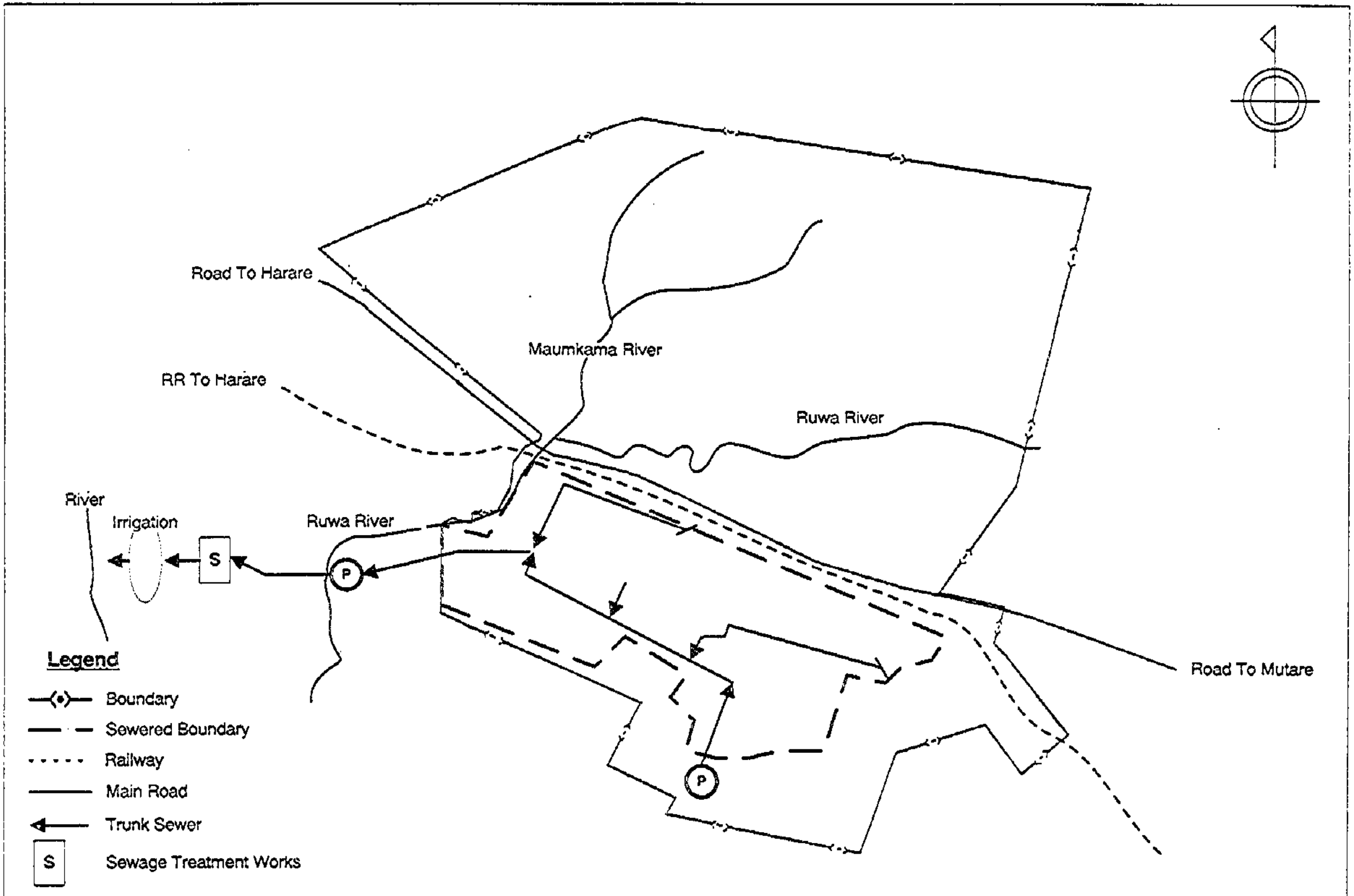


Figure 4.2.4 Existing Sewerage System in Ruwa

removed. At this point, the Ruwa Local Board does not have a clear policy for sludge disposal, but it is probable that the dried sludge will be reused for pasture/agricultural land.

(5) Summary

The treatment systems currently employed in each municipality are the following four types:

- AP+WSP+irrigation : Marlborough, Donnybrook, Ruwa
- AP+TF+irrigation : Zengeza
- PST+TF+irrigation : Crowborough (No.1 and No.2 units), Firle (No.1 and No.2 units), Norton
- PST+BNR : Crowborough (No.3 unit), Firle (No.3 and No.4 units)

The secondary treatment processes are WSP, TF, and BNR. These three methods have long been used by the local authorities, and their operation and maintenance are being properly conducted. Each process is functioning effectively, so it is appropriate that these methods continue to be used. Table 4.2.5 shows the general comparison of sewage treatment processes.

As for sludge treatment and disposal, the following four methods are being used:

- AP+SDB+reuse : Marlborough, Donnybrook, Ruwa
- No-treatment (sludge from PST, SST)+SDB+reuse : Norton
- AP and no-treatment (sludge from SST)+irrigation : Zengeza
- SDT+irrigation : Crowborough, Firle

The sludge from small and mid-scale STWs is untreated or treated in APs, while the sludge from large-scale facilities is stabilised in SDT. All the sludge is eventually reused on farm land. Since the environmental capacity of the receiving farm land is relatively large, such irrigational reuse will not cause any serious impact.

Table 4.2.5 General Comparison of Sewage Treatment Processes

Sewage Treatment Process	Outline	General Features
Wastewater Stabilization Pond (WSP)	A relatively shallow body of wastewater contained in an earthen basin of controlled shape, in which biological oxidation of organic matter is effected by natural or artificially accelerated transfer of oxygen.	A large area is needed. Easiest in O&M due to Non-equipped process. Ponds should be drained periodically, once in 1 to 10 years. Sludge should be hauled/disposed after drying.
Aerated Lagoon (AL)	A natural or artificial wastewater treatment pond in which mechanical or diffused-air aeration is used to supplement the oxygen supply.	O&M is easy since there's simple equipment like aerators.
Trickling Filter (TF)	A very coarse filter used to provide secondary treatment of wastewater. A film of aerobic microorganisms on the filter media metabolizes the organic material in the wastewater trickling downward to underdrains; biofilm that sloughs off is subsequently removed by sedimentation.	Stable to load fluctuation of sewage. Treatment method is simpler than AS. Attention shall be paid to flies/odor generation.
Conventional Activated Sludge (AS)	A biological wastewater treatment process in which a mixture of wastewater and activated sludge is agitated and aerated. The activated sludge is subsequently separated from the treated wastewater (mixed liquor) by sedimentation and wasted or returned to the process as needed.	A large area is no need. A log of energy and mechanical equipment is necessary.
Extended Aeration	A modification of the activated sludge process which utilizes long aeration periods to promote aerobic digestion of the biological mass by endogenous respiration.	Waste activated sludge will be in stable condition due to a long retention time.
Biological Nutrients Removal (BNR)	The processes are for organic matter and nutrients removal. Most of these use a form of the activated sludge process but employ combinations of anaerobic, anoxic and aerobic zones or compartments to accomplish nitrogen and phosphorus removal. One of the most commonly used processes for combined nitrogen and phosphorus removal is the Bardenpho process.	A lot of energy is necessary.

4.2.2 Industrial Wastewater Treatment Works

In every authority areas concerned, the wastewater from industry is controlled in compliance with the Urban Council Act (1995), the requirements of which are as follows:

pH	:	6.8-9.0
Settleable Solids (cm^3/l)	:	less than 10.0
Fats (mg/l)	:	less than 400.0
Mineral Oils	:	Nil
Organic Solvents	:	Nil
Individual Heavy Metals (mg/l)	:	less than 50.0
Calcium Carbide	:	Nil
Bitumen	:	Nil
Cyanides (mg/l)	:	Nil
Temperature (°C)	:	less than 60

The purpose of this law is to prevent damage to the sewer itself and to protect the health of people employed at the sewage works, who would enter the sewer. In other words, the law is to protect the sewers and to keep the safety of sewage workers.

There are no BOD or COD regulations, and highly concentrated organic wastewater from factories are accepted into public sewers. Wastewater is analysed both to ensure water quality standards and the industrial wastewater load.

In Harare City, the quality and amount of wastewater is periodically monitored at the Central Laboratory in the Department of Works. These checks are conducted about once a month, and the water inspected is usually from comparatively large industrial facilities. In the laboratory, each factory is given a ranks A, B, C or D based on water quantity. The water quality checked analysis items are three items,pH, heavy metal and settleable solids,out of the above ten items that are controlled by the law. This water quality analysis reveals an infraction, the directive for improvement is issued to the offending company in the form of a letter. If the next inspection also reveals that the law is being violated, the laboratory is required by law to notify the police.

In Harare City, sewage tariff are collected based on the amount and the strength (permanganate value) of the industrial wastewater. Therefore, in addition to the items mentioned above, the wastewater PV (permanganate value) is also measured. The sewage tariff is calculated from this PV, the industrial wastewater amount and a coefficient. The amount of industrial wastewater is equivalent to be public water consumption plus well water, minus water for office use, such as flush toilet water.

Each factory has a pre-treatment facility within its grounds. Accordingly, a slaughterhouse, the affiliate facility of a food process and stuff industry discharges its wastewater into a pre-treatment facility along with water from other processes and is discharged to the sewer after treated.

The questionnaire regarding the water quality of factories presents the current status of their pre-treatment facilities as shown in Table 4.2.6. Relatively large factories were selected for the survey, and it was conducted at 49 factories; 14 of these factories have pre-treatment facilities. The method of treatment is primarily settling, along with fat and oil traps.

4.2.3 Urban Drainage

The Study Area has a comparatively highly developed infrastructure. This is because an urban drainage system has been constructed simultaneously with the roads and sewer pipes of the area. Urban areas employ a separate sewer system, wherein all sewage from houses and factories goes to the public sewers, while the stormwater is released through the urban drainage system.

In the urban areas, pipes and channels are laid underground (beneath sidewalks), but in the rural areas, stormwater is released into channels without screen protection. In the dry season, there is almost no rainfall, so drainage is not a problem. But in the wet season, October to March, wherein 90 % of the annual rainfall occurs, there are sometimes flooding problems and some channels are obstructed by dumped solid wastes, which compounds the already insufficient flow capacity. These problems occur mainly in high density residential areas. On the whole, however, the drainage channels are laid at an appropriate topographical grade, and there is relatively good drainage in urban areas.

Table 4.2.6 Current Status of Pre-treatment Facilities

	Type of Industry	Municipality	Name of Company	Number of Employees	Production Goods	Avg. Water Consumption & Water Source m^3/month	Avg. Discharged Wastewater Volume m^3/month	Receiving Water Bodies	Pretreatment Facility: Treatment Method	Pretreatment Facility: Capacity of Facility	Pretreatment Facility: Water Quality: Inlet	Pretreatment Facility: Water Quality: Outlet	Note
1	Processed Foodstuff	Harare	C	250	Opaque Sorghum Beer	Piped Water supply 18,535	2,250	Sewer	Settlement	36m^3/days	N/A	N/A	
		Harare	O	1,500	Cooking Oil Bakers fats Soaps	Pipped Water Supply 30,000	25,000	Sewer	Fat/Oil Seperators	25,000m^3/month	N/A	N/A	
		Harare	S	275	N/A	Piped Water Supply 11,076	8,860	Sewer	N/A	N/A	N/A	N/A	
		Harare	C	1,100	Pork Products	Pipped Water Supply 25,000 Well 2,000	20,000	N/A	Settling Tanks and Filtration	1,000m^3/day	N/A	N/A	
		Harare	L	1,200	Detergent Powders Soap Fats & cooking Oil	Piped Water Supply 23,287 Borehole 5,733	15,381	Sewer	Soaps pH Control & Fat trap NSD Sulphonation pH adjustment & separator	40m^3/day 27m^3/day	pH < 7 pH < 7	pH 7 - 8 pH 7 - 8	
		Chitungwiza	C	350	Beer	Piped Water Supply 14,000	400	Sewer	Settlement	100m^3/day	N/A	N/A	
4	Pulp, Papers & Related Products	Norton	H	650	Pulp, Paper & Boards	Piped Water Supply 110,000	84,000	Sewer	Clarifier and Lagoon	3,000m^3/day	BOD 100mg/L SS 500 COD 100 T-P 2.8 T-N 2.6	BOD 10mg/L SS 200 COD 70 T-P 1.0 T-N 0.5	
6	Chemicals	Harare	D	120	Paints	Piped Water Supply 600	200	Sewer	Settlement	30m^3/day	N/A	N/A	
9	Leather & Related Products	Harare	I	172	Finished Leather	Piped Water Supply 6,116 Well 1,584 Recycled 1,100	6,600	Sewer	Oxidation & Flocculation	500m^3/day	N/A	SS2.08mg/L pH 8.55	
11	Ceramics Store & Clay Products	Harare	T	550	Fibre Cement Sheets	Piped Water Supply 3,500 Well 1,000	2,000	Sewer	Settling	N/A	N/A	N/A	
13	Nonferrous Metals	Harare	C	457	Aluminum, Copper and Brass profiles	Piped Water Supply 2,742	2,194	Sewer	Settlement & Floatation	N/A	N/A	N/A	
17	Transportation Equipment	Chitungwiza	G	460	Service Industry	Piped Water Supply 600 Borehole 800	N/A	Sewer	Oil/Water Separators	N/A	N/A	N/A	approx 30m^3 oil/water waste
19	Others	Harare Norton	C C	400 30	N/A Ostrich meat	Piped Water Supply 2,000 Piped Water Supply 800	1,950 800	Sewer Sewer	Process dust separated with water Settleable solids & fats skimming	N/A through flow	N/A N/A	N/A N/A	

4.3 Present Solid Waste Collection and Disposal

4.3.1 General

The government of Zimbabwe is prompting decentralisation aiming at upgrading the administrative ability of local governments as a basic policy regarding solid waste management. There are management plans at the national and local levels; the former is the "Zimbabwe Urban Solid Waste Management Study, August,1995, MLGRUD", while the latter is the "Regional, Town and CountryPlanning Act, 1996".

Under the supervision of the relevant authorities, the MHCW, MET and the MLGRUD, each local government is managing its solid waste administration. The present conditions of solid waste collection and disposal of the local governments are enumerated as follows.

4.3.2 Harare City

The solid waste collection is being handled by the Amenities Section headed by the Amenities Manager belonging to the Department of Works. Trucks and tractors are utilised to collect solid waste in Harare City. Plastic bags are used to dispose solid waste in low and high density suburbs, while communal storage is used for Mbare musika and metal bins are used for commercial and industrial stands.

Up to four bags on average are used per year, while one metal bin is used per stand for every five years. Collection service is provided once a week for high density areas and twice a week for low density areas, commercial and industrial stands. A service charge is collected monthly.

The number of existing collection vehicles together with the additional needs determined by the City Council are shown below.

Type of Vehicles	Total	Functional	Additional Need
Trucks	91	35	45
Tractors	18	10	15

The average number of employees per collection truck including the driver is about five. The volume of solid waste collected is in the range of 600 - 650 tonnes per day, of which 110 tonnes are from high density areas, 130 tonnes from low density areas and the remaining amount is from commercial, industrial and other public places. According to the "Zimbabwe Urban Solid Waste Management Study, August,1995, MLGRUD", general composition of solid waste is shown in Table 4.3.1.

Table 4.3.1 General Composition of Solid Waste in Harare

Type of Solid Waste	Percentage (%)
Paper & Cardboard	20 -25
Glass & Ceramics	5
Metals	4
Plastics	4
Leather & Rubber	5
Textiles	1 - 5
Vegetables/putrescibles	10 -15
Miscellaneous	10 - 25

Two dumping sites located at Warren Park and Pomona, are presently used as landfills. At these dumping sites, some private companies contracted by the City Council are collecting recyclable waste. Figure 4.3.1 shows the location of two dumping sites.

The problem areas affecting the efficiency of solid waste collection are:

- shortage of functional collection vehicles
- allocation of unsuitable vehicles for collection work
- shortage of dumping sites

Among others, the shortage of dumping sites is forcing the City Council to look into the possibility of getting a new site outside the City and it will certainly increase the operation costs of collection and dumping. Funding for solid waste management is through the World Bank and the City Council.

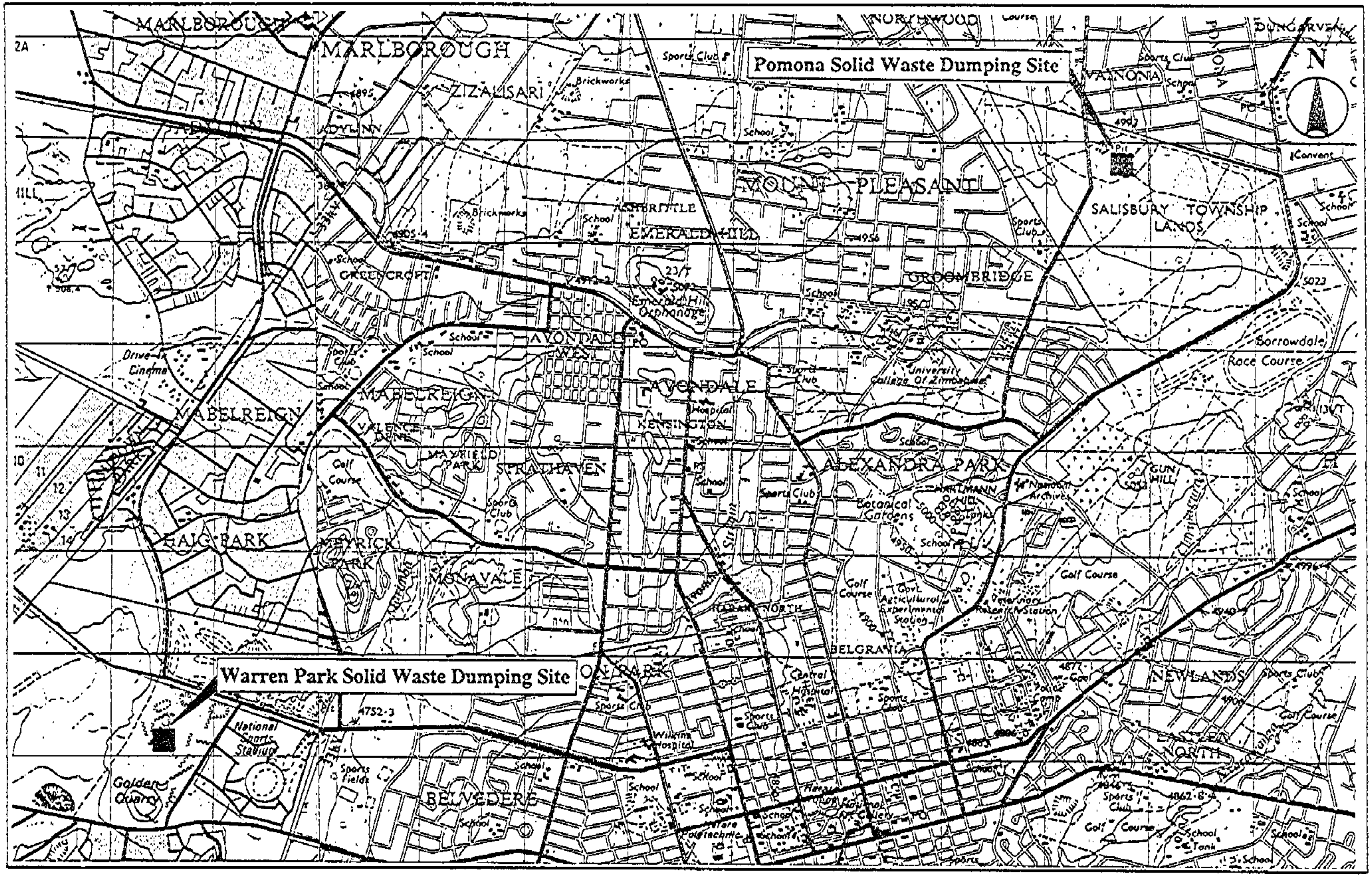


Figure 4.3.1 Location of two Dumping Sites in Harare (S=1/50,000)

4.3.3 Chitungwiza Municipality

(1) Solid Waste Collection

Solid waste collection is provided to both residential and industrial areas by means of trucks and tractors. People from residential areas dump their refuse into plastic bags which are supposed to be emptied twice a week by the Municipality. Most industrial projects have skip dishes which are supposed to be collected by the council trucks every week and emptied.

The existing collection vehicles and additional requirements considered by the Municipality to improve collection efficiency are as follows:

Types of Vehicles	Total	Additional Need
Trucks	11	16
Tractors	4	8

The collection vehicles collect about 6.5 tonnes of solid waste and its composition is shown in Table 4.3.2.

Table 4.3.2 General Composition of Solid Waste in Chitungwiza

Type of Solid Waste	Percentage (%)
Paper & Cardboard	30 -35
Glass & Ceramics	1 - 3
Metals	1 - 3
Plastics	1 - 3
Leather & Rubber	20 - 30
Textiles	1 - 5
Vegetables/putrescibles	30 - 40
Miscellaneous	5 - 10

The situation of the existing collection vehicles clearly demonstrate a need to improve the service efficiency in order to serve the population of about 400,000 in the Municipality. Sometimes, solid waste is collected in two week intervals. Under such circumstances, residents having full uncollected garbage in plastic bags or bins tend to dump them in the open areas or in the storm water drainage system. These attitudes lead to the creation of a health hazard and to the disturbance of the storm water drainage flow.

Another problem is that many residents are reluctant to pay a monthly service charge to the municipality, unless service is otherwise improved.

(2) Solid Waste Disposal

The normal disposal method is dumping, compaction and covering with gravel to prevent flies, odour and nuisance. However, the municipality does not have tippers to ferry gravel to the dumping site. As a result, offensive odours and blowing papers are a problem. Figure 4.3.2 shows the location of the dumping sites.

4.3.4 Norton Town Council

The Norton Town Council has an open area (358 m x 275 m = 9.845 hectares) north of the existing sewage treatment works. This site caters to private companies discharging solid wastes which can not be incinerated within the industrial areas. Large scale companies, i.e. Hunyani Pulp and Paper, Tinto Industries, Lucas, Tanwood Trading and Dos Santos, are dumping their solid waste at this site. An average of 80 tonnes of solid waste are dumped at the site daily. Figure 4.3.3 shows the location of the dumping sites.

The current problem is indiscriminate dumping at this site owing to in proper control, leading to site maintenance difficulties and high costs to the Council. To solve this problem, the Council is erecting a fence around the dumping site which will be guarded 24 hours a day. The Council is also planning to charge a fee for every tonne of solid waste to all companies which utilise the dumping site.

The following are schedule of solid waste collection for residential and industrial areas in Norton Town Council:

Monday	: Ward 7	- Town centre ; shopping centre and industry
Tuesday	: Wards 11 and 12	- All schools
Wednesday	: Wards 8 and 9	- Town centre ; shopping centre and industry
Thursday	: Wards 5,6 and 10	- All schools
Friday	: Wards 1 to 4	- Town centre ; shopping centre and industry

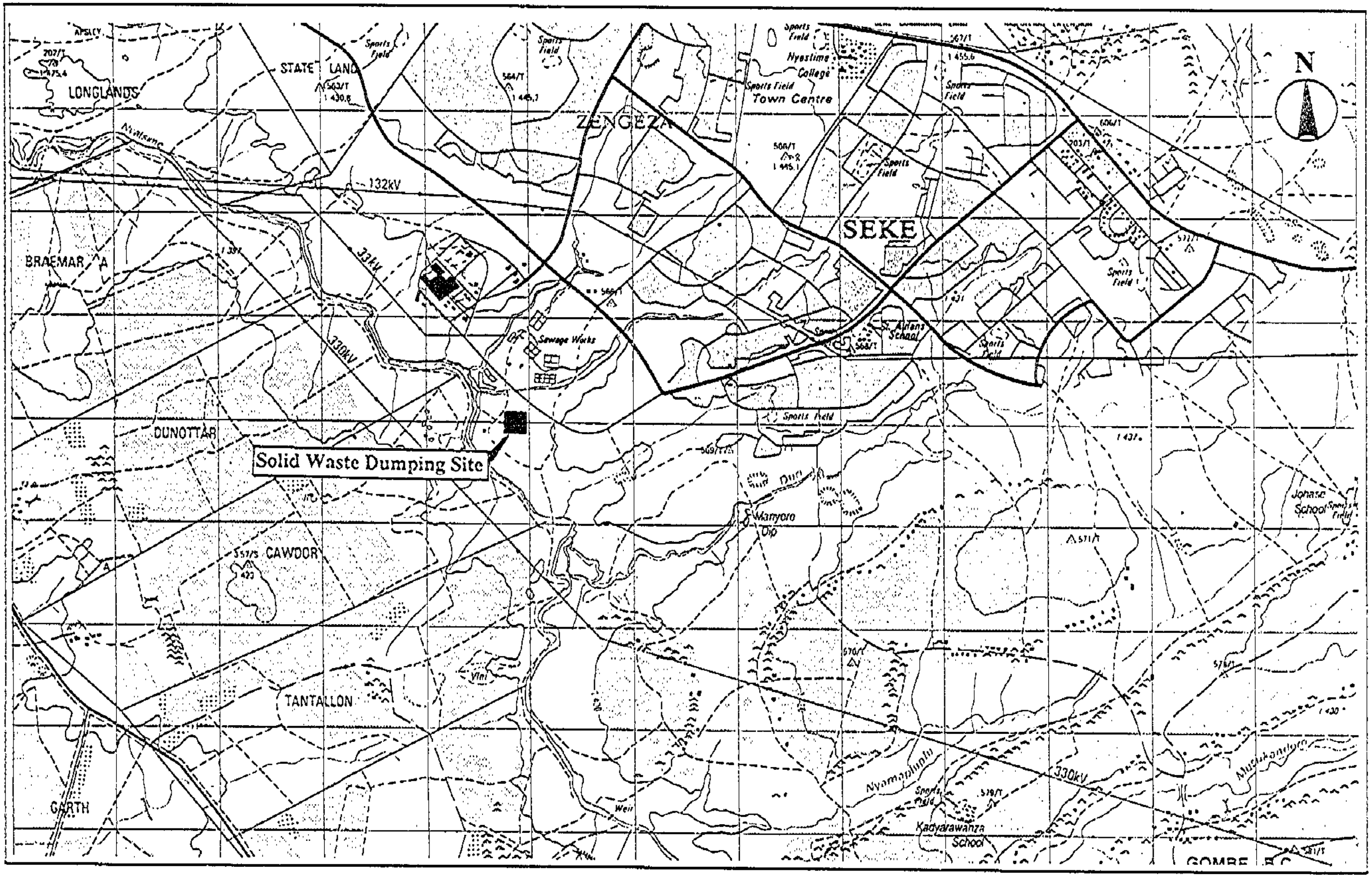


Table 4.3.2 Location of Dumping Site in Chitungwiza (S=1/50,000)

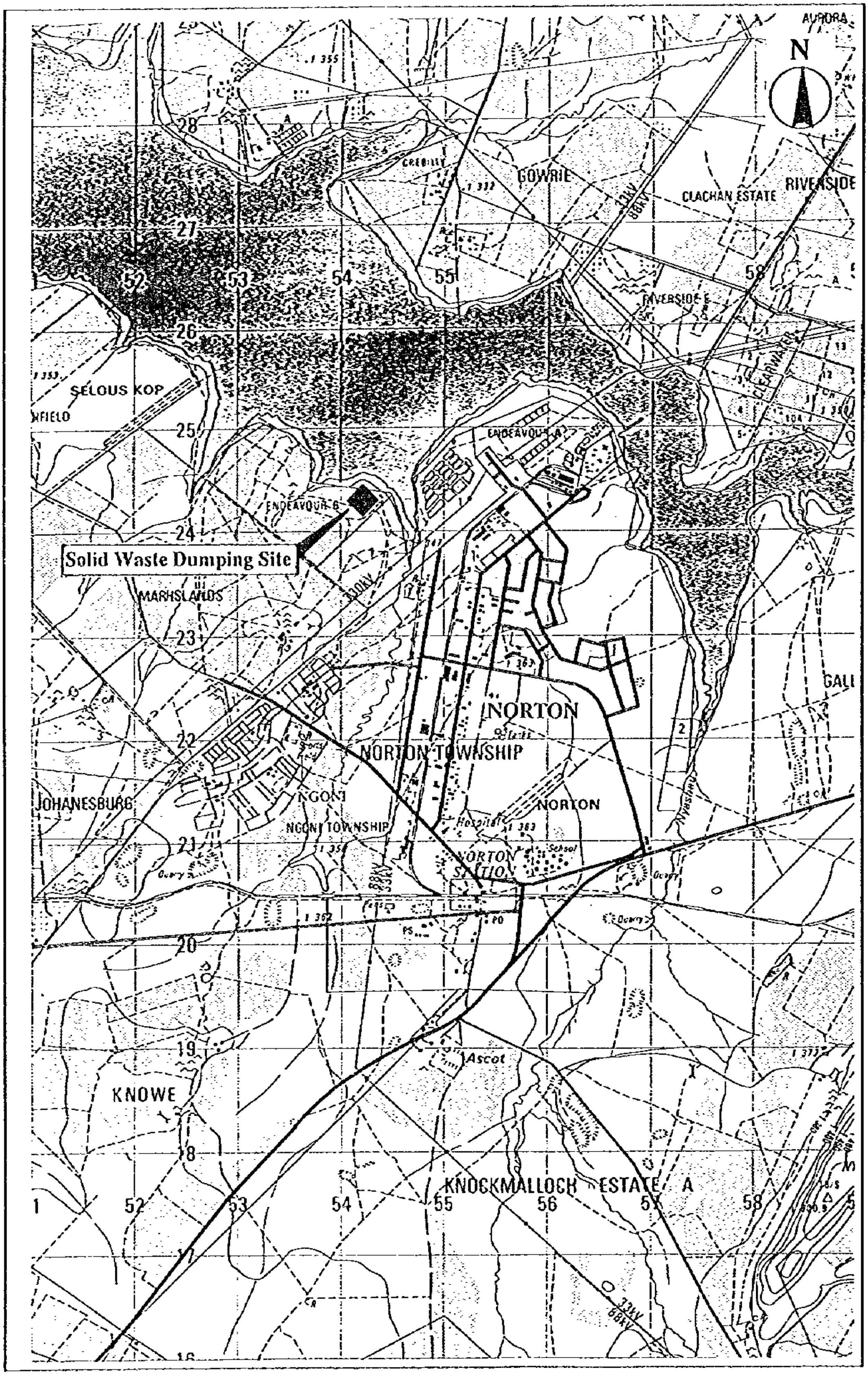


Table 4.3.3 Location of Dumping Site in Norton (S=1/50,000)

4.3.5 Ruwa Local Board

(1) Solid Waste Collection

Solid waste is collected three times a week in the industrial areas and once a week in the residential areas by means of tractor and a 5 tonne trailor.

(2) Solid Waste Disposal

Old dumping site

The old dumping site is located at the Chiremba primary school site east of Chiremba Road. The site was planned primarily to construct the said school when needed and utilised as a dump solid waste by the few industries being operated nearby.

However, the site was situated only about 30 metres from a residential area, due to the lack of proper site investigation. The site is an open area accessible to the public (scavengers) and is not properly managed or controlled. No drainage facility is provided for the site and it is a breeding ground for flies and other pests, which can be seen all over the site. Owing to these unsanitary conditions, a new site was considered by the Board. Figure 4.3.4 shows the location of the dumping sites.

New dumping site

The new dumping site is located within the jurisdiction of the Epworth Local Board, across the Ruwa River from Ruwa. This site with a total area of 0.8 hectares was identified based on the recommendations stemmed from geotechnical site investigations.

The site is far from residential and industrial areas. The transportation of refuse to the dumping site will be a problem when the size and speed of the tractor and trailer used for the job are taken into account. The provision of a refuse hauling truck is deemed an urgent countermeasure to cope with the increase of solid waste.

The site is durawalled and gated for proper management. The solid waste is to be treated by earthcovering and compacting. Solid waste needed for recycling is going to be collected by registration. Only registered collectors will be granted entry into the site.

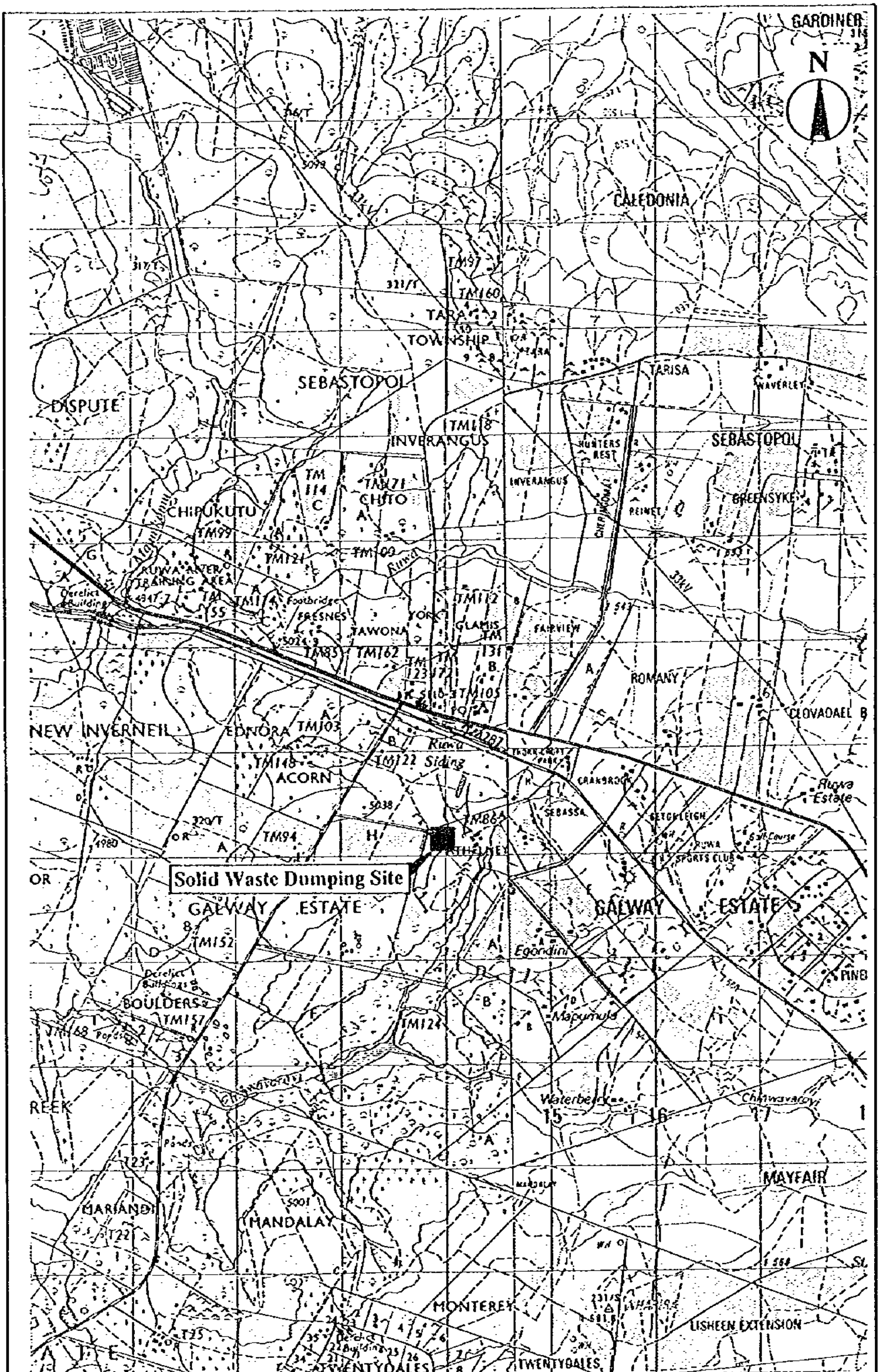


Table 4.3.4 Location of Dumping Site in Ruwa (S=1/50,000)

4.4 Present Status of Wastewater Treatment at Water Treatment Works

The Prince Edward WTW and the Morton Jaffray WTW are situated in the Study Area. Effluent, such as the back washing discharge and settled sludge, at the WTWs are regarded as point pollution sources.

The Prince Edward WTW and the Morton Jaffray WTW have production capacities of 90,000 m^3/day and 614,000 m^3/day, respectively. The water treatment process consists of the sludge blanket type clarifier, rapid sand filter and chlorination. Aluminium sulphate is used as the coagulant for the removal of suspended solids. Wastewater treatment has not been provided for the WTWs yet, and presently the generated wastewater is either discharged into the river through a retention tank or pumped up to farm land for irrigation use.

Table 4.4.1 shows the data in the last three years on the intake water and wastewater amount at these NWWS.

Table 4.4.1 Relationship between Intake and Wastewater

Unit: m^3/day

Year	Prince Edward WTW				Morton Jaffray WTW			
	Intake	Produced	Wastewater	Wastewater/ Intake (%)	Intake	Produced	Wastewater	Wastewater/ Intake (%)
1994					391,900	303,800	88,000	22.5
1995	36,400	31,700	4,700	12.9	483,300	340,100	143,200	29.6
1996	22,300	19,600	2,700	12.1	423,600	309,400	114,200	27.0

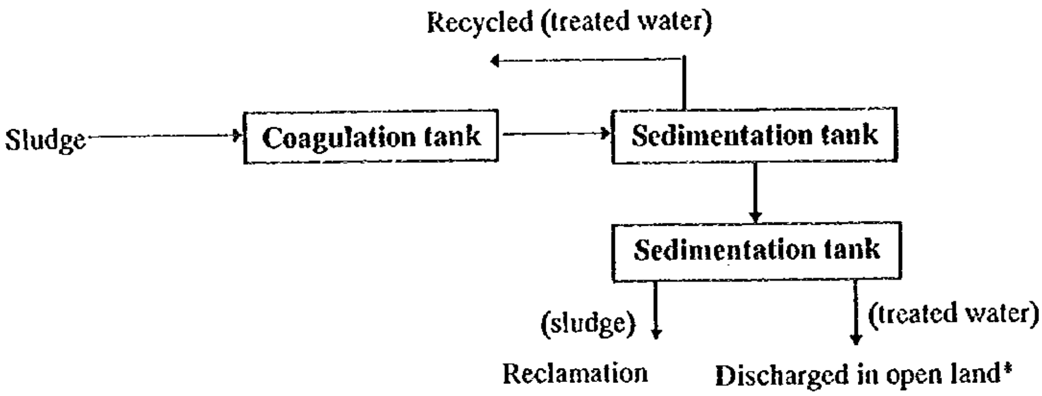
The water losses at both the WTWs are considerable compared with the experiences of ordinary WTWS. This is attributed to the frequent back washing and the high dosage of coagulant due to deteriorated water quality affected by the increased algae in the raw water. In this regard, the following problems are pointed out:

1) Additional treatment cost
   The generation of surplus wastewater requires additional electric charge and chemicals.
2) Influence of the residual coagulant
   A high content of residual aluminium in the discharged water affects the farm land making the soil harder, resulting in the obstruction of the agricultural production.
3) Discharge of concentrated nutritious substances into rivers/lakes
   The concentration of nutritious substances such as T-N and T-P is achieved in the water treatment process. Direct discharge of the wastewater with sludge into the river causes eutrophication in the lake.

To improve these problems, the construction of a wastewater treatment facility has been planned under the loan project extended by the Israeli Government; however, it has not yet been commenced. The plan of the treatment system is shown in Figures 4.4.1 and 4.4.2. The planned capacity of wastewater treatment facility is 42,000 m^3/day, which is less than 50% of the current need (wastewater volume of 88,000 - 143,200 m^3/day). The planned capacity, 7% of the present water production amount, may be adequate if the reduction of wastewater could be achieved at the same level of common WTWs. Sludge dewatering equipment is a requisite for the final disposal of generated sludge.

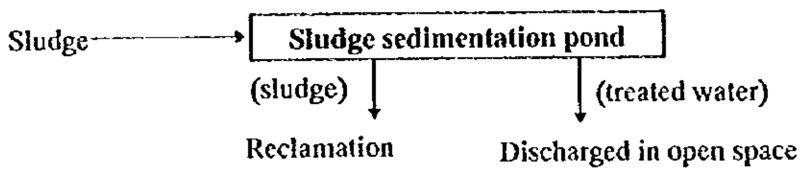
The Morton Jaffray WTW's original treatment process of filter backwashing sludge and surplus sludge from its sedimentation tank are as follows;

1) Backwashing Sludge



* NOTE: The treated water containing chemicals, remaining coagulant, etc. can not be used for irrigation.

2) Sludge from sedimentation tank



The treatment process for backwashing sludge is no longer available due to the mechanical failure that occurred about one year ago and the sludge is discharged directly to the river near the sludge sedimentation pond without any treatment. Since the sludge contains SS, chemicals and organic substances, countermeasures should be taken immediately.

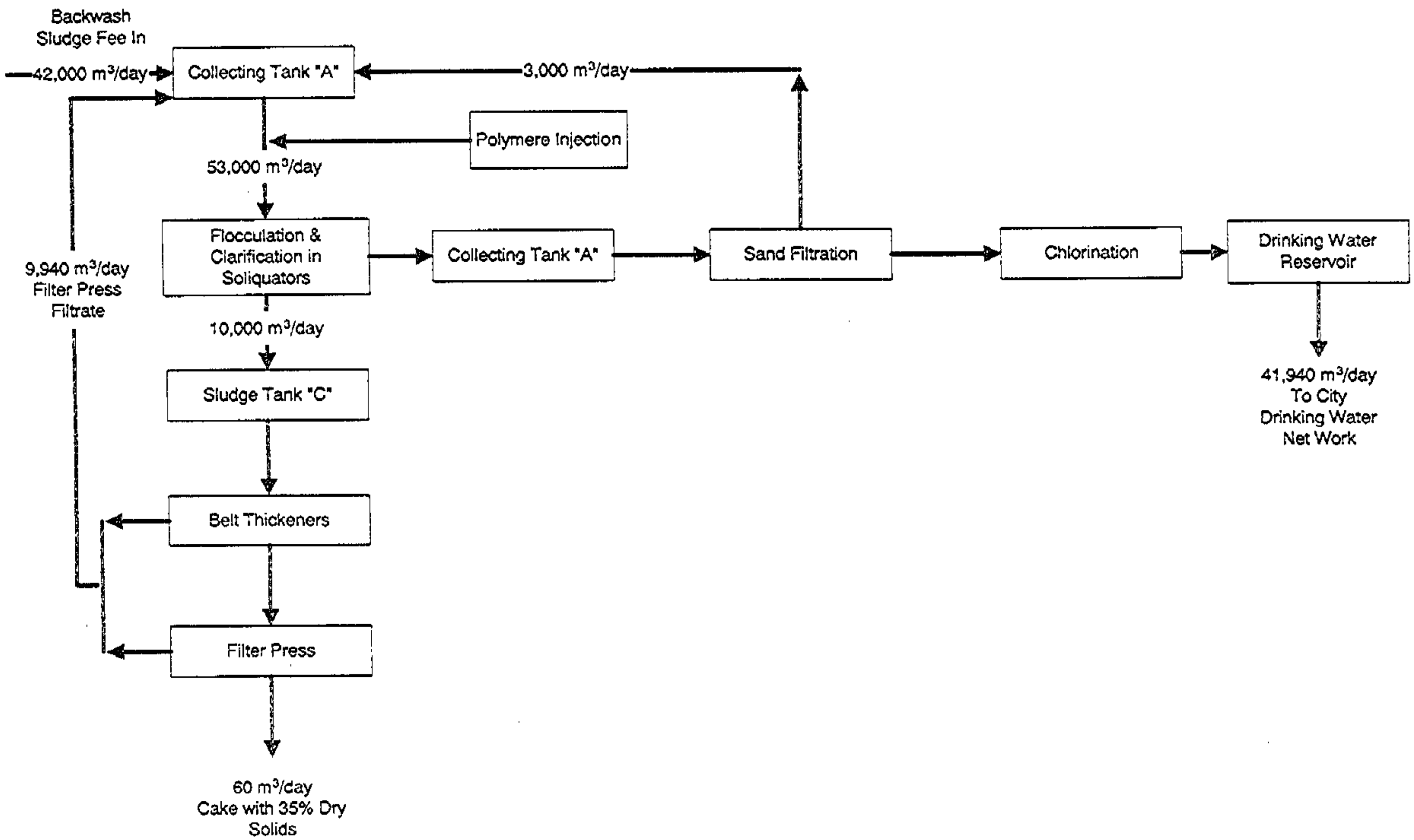
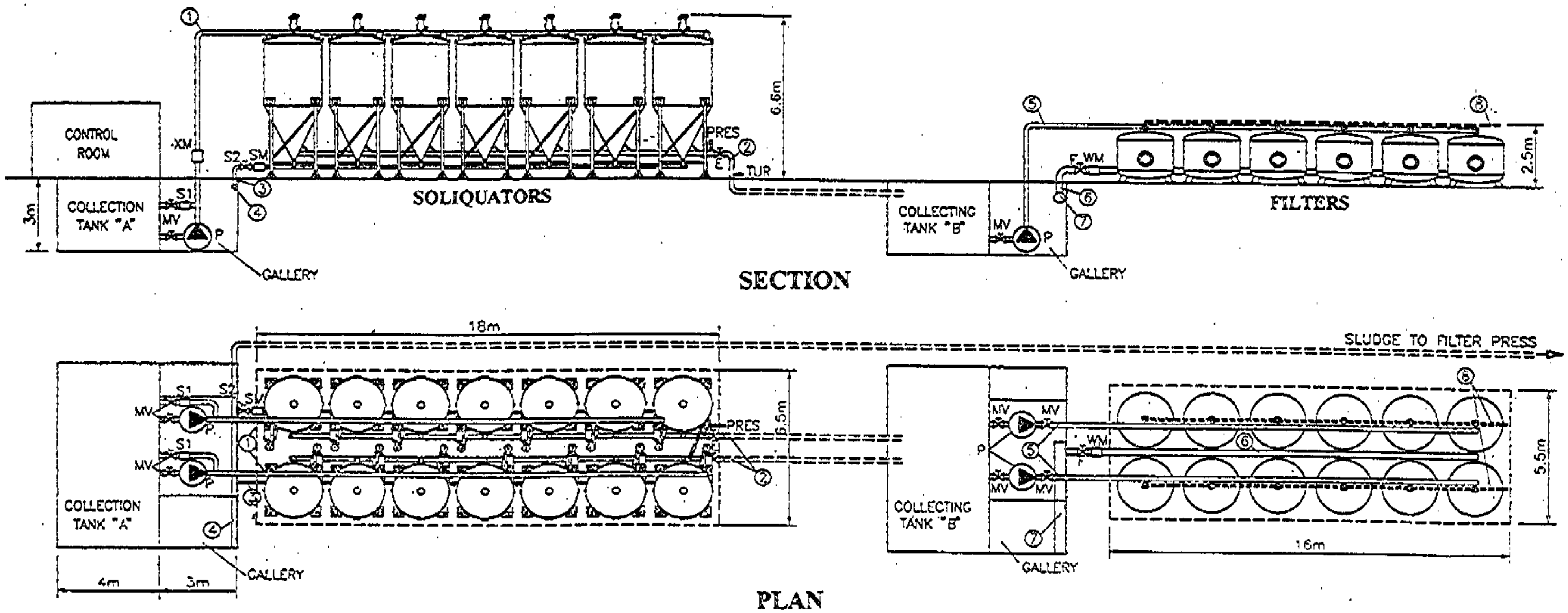


Figure 4.4.1 Morton Jaffray WTW Flow Sheet for Treatment of Backwash Sludge (On-going Project)



S1 - INLET FLOW VALVE
XM - FEED IN MAGMETER
S2 - SLUDGE EVACUATION VALVE
SM - SLUDGE MAGMETER
E - PRESSURE CONTROL VALVE FOR EFFLUENT
F - FILTER EXIT VALVE
MV - MANUAL VALVE
WM - WATER METER
P - FEEDING PUMP
TUR.- TURBIDITY PROBE
PRES - PRESSURE SENSOR

Figure 4.4.2 Morton Jaffray WTW Section Plan of Backwashing Sludge

Recently, Harare City was offered a loan for the construction plan of a new sludge treatment plant by the Israeli Government.

The Prince Edward WTW 's existing treatment process of backwashing sludge and primary sedimentation tank sludge are as follows:

1) Backwashing sludge

Backwashing sludge is recycled. It is returned by gravity to the low pump station, which also pumps raw water from Seke Dam to the primary sedimentation tank and treated.

2) Primary Sedimentation Tank Sludge

It is withdrawn from the primary sedimentation tank by gravity and sent to the sedimentation pond. After sedimentation, the treated water is sent back to Seke Dam by gravity and the sludge is withdrawn by sludge pump and disposed into an open field. The pond is comprised of two units of concrete open channel and they are operated alternately to allow the channels to be drained and cleaned.

4.5 Planned/On-going Water Pollution Control Plans

4.5.1 Harare City

There are several planned/on-going projects for sewerage expansion as follows :

(1) Firle STW expansion project

This project is to expand the STW's existing treatment capacity from 72,000 m^3/day to 144,000 m^3/day to cope with the rapid increase of influent sewage. The construction work is underway and expected to be completed by 1997. This project is sponsored by the European Investment Bank (EIB).

(2) Hatcliffe STW rehabilitation project (Outside of the Study Area)

The existing oxidation ditch has already deteriorated. Thus, a new ditch, with a capacity of 2,810 m^3/day was designed and construction work is about to commence financed by the City Council.

(3) Crowborough STW expansion project

This project includes expansion of the existing STW and construction of trunk sewer. No financial source has been found and it is only in the design stage.

(4) Mabvuku Tafara STW construction project

This project is to divert sewage from the existing Donnybrook STW to the New STW. The existing STW, adopting the stabilization pond method, is located nearby a residential area and there are complaints from the residents about its odour. Also, the STW is overloaded. The proposed site is located in the south, 15 to 20 km away from the existing STW. At present, only a tender for consultancy services has been adjudicated, but it is not yet awarded.

(5) Chisipite sewage pump station construction project

There is an existing pump station in the Chisipite District, belonging to the Umwinsi Catchment, north east of Harare and this pump station is mainly serving a shopping center. This project aims to serve a part of the catchment, at present covered by septic tank, by conventional sewerage reticulation in the future. As a first step, a new pump station will be implemented under the financing of the City Council. After the completion of new pump station, the existing one will be abandoned. Also this project includes the installation of a rising main (D = 250 mm, L = 1,950 m), a gravity sewer (D = 300 mm , L = 1,600 m), and an upgrading of the existing trunk sewer (D = 450 to 525 mm, L = 4,900 m). The sewage will pumped to the Mukuvisi outfall trunk sewer and finally be treated in the Firle STW. The construction work will start this coming August and is expected to be completed in early 1998.

(6) Mukuvisi outfall trunk sewer construction project

This trunk sewer is now being installed in parallel with the existing trunk sewer to mitigate the overloading in the existing one. The diametaer ranges from 1,050 mm to 1,200 mm and its total length is about 18 km. This sewer will be connected to the Firle STW. The sewer is anticipated to be completed in early 1998 under financing of the World Bank.

(7) Firle catchment subsidiary sewer construction project

This subsidiary sewer will cover the developing area within the Firle Catchment. At present, a tender for consultancy service has been adjudicated but it has not yet been awarded.

4.5.2 Chitungwiza Municipality

The planned/on-going projects to reduce water pollution were grouped into three phases.

Phase-1

The main objective in this phase was to stop the treated water being discharged into the Nyatsime River and eventually into Lake Chivero. The projects which were undertaken are as follows :

(1) Construction of an effluent pump station which handles 35,000 m^3/day
(2) Construction of an effluent force main to the Imbgwa Farm with a diameter of 750 mm
(3) Construction of an effluent sludge pond to hold all the sewage that is being pumped to Imbgwa Farm

Phase-2

This phase is currently under way. It involves the construction of a 6,850 m^3/day anaerobic pond unit. By constructing this pond, the municipality hope to lessen the load on the existing ponds and therefore improve the quality of the effluent.

Phase-3

This is intended to be a very comprehensive phase. The works are supposed to be upgraded from their present capacity to a capacity of 55,000 m^3/day. Part of the works which were constructed around 1979 are going to be refurbished, because they are almost at the end of these design life.

4.5.3 Norton Town Council

There is an on-going rehabilitation project for the sewage treatment works with the following scope:

- Replacement of screen and grit chamber
- Replacement of gates and guides where necessary
- Replacement of flowmeters
- Service and repair of primary clarifier sludge scraper equipment
- Service and repair of primary effluent pumps
- Replacement of all electrical cabling and control panels
- Replacement of broken trickeling filter distributor arm
- Service of sludge scraper systems secondary sedimentation tank
- Replacement of sludge pumps and pipework
- Repair of concrete where necessary with cement/epoxy mixed

- Provide of improved change room and toilet facilities for workmen
- Replacement of pumps, pipe-work, electrical supply cables and control board in the sewage pump station
- Rehabilitate the satellite sewage pump station
- Construct additional ablutions.

To cope with the projected sewage flow, a future plan was also prepared. The plan describes the construction of new treatment works south of the existing works, and there are two alternatives :

(1) Primary Sedimentation Tanks with Biological Filter

- Screen and grit chamber
- 6 number primary sedimentation tanks
- 4 number biological filters (38 m diameter, 4 m depth)
- 3 number digesters
- 4 secondary sedimentation tanks
- Sludge drying beds (expansion to 6,000 m^2)

Treated effluent will be discharged of by land disposal

(2) Biological Nutrient Removal (BNR)

- Screen and grit chamber
- BNR plant (basin volume 7,200 m^3)
- 2 number secondary clarifiers
- Waste activated sludge thickener
- 5 digesters (anaerobic)
- Thickener
- Sludge drying bed (6,000 m^2)

The treated effluent will be discharged directly to a watercourse or used as industrial water followed by land disposal.

4.5.4 Ruwa Local Board

The existing stabilisation ponds, with an area of five (5) hectares together with two (2) hectares of irrigation land, which were given to the Ruwa Local Board, are located within the jurisdiction of the Epworth Local Board.

To cope with the area's economic growth and population increase, a plan for the expansion of the existing stabilisation ponds and irrigation land has been prepared. Engineering design and cost estimates for the expansion of the grit chamber/channel and sump tank have also been accomplished and implementation is expected to be started soon.

However, there are two options to the above plan:

- land for expansion
- alternative sewage treatment methods, such as biological nutrient removal process

No decision has been made on the issue by the Ruwa Local Board.

CHAPTER 5

SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE

CHAPTER 5 SOCIO-ECONOMIC PROFILE AND LAND USE AT PRESENT AND IN THE FUTURE

5.1 Socio-Economic Perspective

5.1.1 National Perspective

Settlement densities

Zimbabwe covers a land area of 390,757 km^2 and had an estimated population at the end of 1995 of 11,424,531 people[1/]. Settlement densities across the country vary from province to province and between urban centres and rural areas. The average population density is 29.24 people/km^2, ranging from 1,703 people/km^2 in Harare Province (99% of the province comprises the two (2) cities of Harare and Chitungwiza), to a sparse nine (9) people/km^2 in the western provinces of the country.

As elsewhere in the southern African region, the rate of urbanisation in Zimbabwe is high, an estimated six percent growth per annum. Whereas in 1982, only 25.7 percent of the national population was urbanised, this had risen to 30.6 percent in 1992 and is expected to reach 38.9 percent by 2007.

Demographic profile

The population of Zimbabwe is relatively youthful. Forty-five percent of the population is aged 15 years or below and only three (3) percent is aged 65 years and above. As a result the population is growing at a rapid 3.14 percent per annum and is expected to double by the year 2015. The average household size in the country is 4.8 people. Thirty-three (33) percent of the household are female headed across the country as a whole (20 percent of households in urban areas).

The gender ratio of the population is approximately 95 males per 100 females. Gender ratios vary among provinces (largely in relation to employment opportunities). For example, there are a low 88 males per 100 females in Masvingo province, compared to a high 108 males per 100 females in Harare.

Table 5.1.1 overleaf shows the distribution of the population by age and sex.

1/ Extrapolated from the 1992 National Population Census

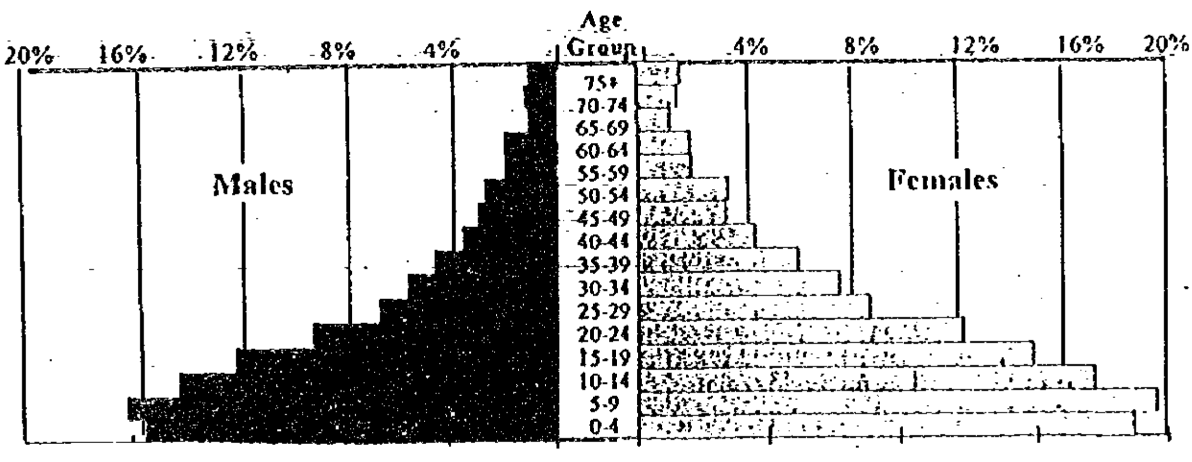
Table 5.1.1 Percent Distribution of the National Population by Age and Sex, 1992

Age Group	Males	Females	Total	Sex Ratio
0 - 4	15.22	14.93	15.22	99.15
5 - 9	16.16	15.62	15.88	98.66
10 - 14	14.26	13.73	13.99	99.05
15 - 19	12.11	11.87	11.99	97.35
20 - 24	9.18	9.82	9.51	89.25
25 - 29	6.60	7.07	6.84	89.17
30 - 34	5.51	6.12	5.82	85.83
35 - 39	4.51	4.87	4.70	88.37
40 - 44	3.43	3.56	3.49	91.96
45 - 49	2.86	2.69	2.77	101.39
50 - 54	2.26	2.76	2.69	90.45
55 - 59	1.86	1.63	1.74	109.21
60 - 64	1.88	1.48	1.73	113.41
65 - 69	1.01	0.96	0.98	100.59
70 - 74	1.15	1.17	1.16	93.28
75+	1.02	1.28	1.16	76.06
NS	0.31	0.34	0.33	88.46
Total	100.00	100.00	100.00	95.39
Total Number	5,083,537	5,329,011	10,412,548	

Source: Central Statistics Ofice "Census 1992, Zimbabwe National Report", Harare 1995, p.15.

The population distribution is shown in Figure 5.1.1, being a population pyramid based on the 1992 national census data. The pyramid is broad-based but narrow at the top, highlighting the large proportion of the population being in the younger age groups. One of the main reasons for this is the relatively high fertility and high but declining mortality rates. The noticeable dent in the pyramid for the 0 to 4 years cohort may be due to either a decline in fertility and/or an increase in the under 5-year olds' mortality rates in recent years.

Figure 5.1.1 Population Pyramid, 1992



Socio-Economic Profile

Zimbabwe is ranked as a low-income economy[2/] by the World Bank. The summary indicators below provide an overview of the socio-economic status of the Zimbabwean population.

GNP per capita (1993)	US$520
GNP per capita annual average growth 1980-1993	-0.3
Life expectancy at birth	53 years
Adult illiteracy (total)	33%
Adult illiteracy (female)	40%
Infant mortality rate/1,000 live births	67
Under 5 mortality rate/1,000 live births	83
Percentage of age group enrolled in primary education	119
Percentage of age group enrolled in secondary education	48

5.1.2 Study Area

The Study Area encompasses the four urban centres of Harare[3/] (1992 population: 1,189,103), Chitungwiza (1992 population: 274,912), Ruwa (1992 population: 1,447) and Norton (1992 population: 20,405), as well as the communal tenure areas of Seke and Chihota and privately owned commercial farms. The Study Area has an area of 2,700 km^2 and a population in excess of 1,508,000[4/].

Settlement densities are among the highest in the country, with the Harare-Chitungwiza urban areas accounting for 47 percent of the national urban population. Harare's urban area has a settlement density of 1,703 people/km^2. Settlement density in the rural parts of the Study Area are a lower average of 27 people/km^2.

The three urban centres of Chitungwiza, Ruwa and Norton are all designated growth points, enjoying tax concessions for newly locating industries. This, coupled with Harare, makes the Study Area one of the fastest growing areas in the country. The area's population growth rates have been estimated at between 6.5 percent to 8.1 percent per annum.

2/ Low income economies are those with a GNP per capita of US$695 or less in 1993.

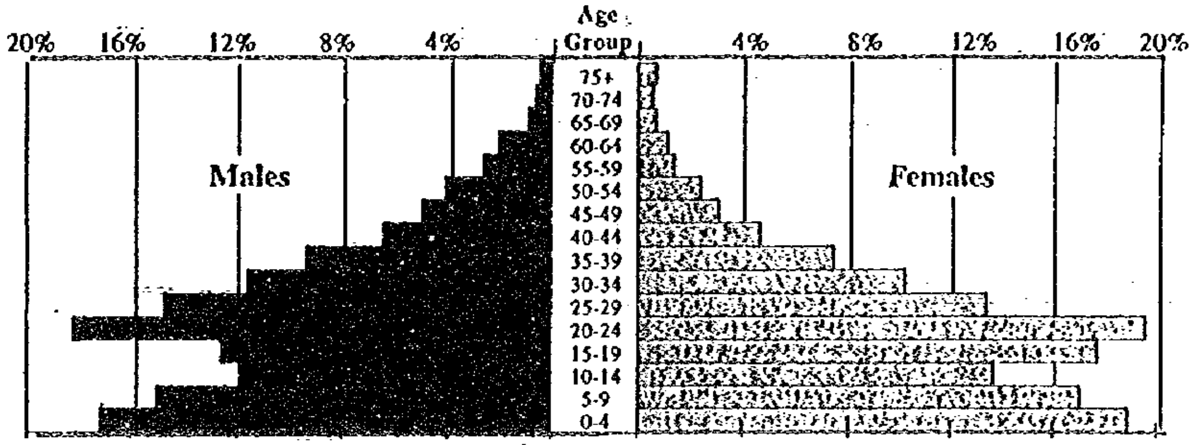
3/ Excluding the north east suburbs, Borrowdale, Helensvale and Glen Lorne.

4/ Precise population figures are not available as the Study Area boundary does not coincide with the unumeration aras delineated for the national population census.

Demographic Profile

The distribution of the population by age group and gender is shown in the population pyramid in Figure 5.1.2.

Figure 5.1.2 Population Pyramid, Harare Province, 1992



It can be seen from Figure 5.1.2 that the 0-4 years and 20-24 years age cohorts had the highest proportions of the population each (14 percent). Thirty-five percent of the population is under 15 years. Whilst high, this is 10 percent less than the national percentge of under - 15's, indicating that there is a predominance of working age population in the study area. This is also borne out by the gender ratio. There are more males than females in all the working age cohorts, i.e. between 20 to 70 years old. The sex ratios for Harare Rural, Harare Urban and Chitungwiza are 114, 110 and 101, respectively.

Socio-economic profile

The summary indicators below provide an overview of the socio-economic status of the Study Area population.

Desegregated income data for the population within the Study Area is not available.

Table 5.1.2 sets out the average annual household incomes of rural and urban based households across the country as a whole.

Table 5.1.2 Average Annual Household Net Income, 1990 (Z$)

Income Source	Male Heads of Households	Femal Heads of Households	Male Heads of Households	Femal Heads of Households
Net Cash Income	5,628	2,011	9,515	5,330
Capital Changes	211	245	794	2,040
Employer	24	2	45	7
Contribution	1,261	1,583	1,108	1,230
Total Net Income	7,124	3,841	11,462	8,607

Source: Central Statistics Office "Consumption, Income Expenditure Survey, 1990/91", Harare, 1992

The table shows that both male and female headed households have substantially higher net incomes than the national average (60.9 percent and 124.1 percent higher than the national average, respectively).

As the bulk of the Study Area population live within urban areas, it may be anticipated that household incomes in the Study Area are higher than the national average.

The following indicators compare the status of the urban population within the Study Area with the national (urban and rural) situation. Overall the population in the Study Area is better than the national average.

Table 5.1.3 Socio-Economic Indicators of Harare Province and Zimbabwe

Indicator	Harare Province	Zimbabwe
Average Household Size	4.01 perple	4.8 people
Male Headed Households	83%	67%
Education for Population aged 5+		
Never been to school	7%	17%
Currently at school	27%	34%
Left school	65%	49%
Mortality (per 1,000)		
Crude death rate	6.77	9.49
Infant mortality	54	66
Under - 5	19	26
Maternal mortality (per 100,000 live births)	404	395
Activity and Labour Force		
Economically active	66%	33.6%
Unemployed	21%	22%
Housing Conditions		
Electricity	64%	28%
Safe water	98%	77%
Toilet facilities	99.7%	66.0%

Sources: Central Statistics Office, GOZ: Census 1992 Zimbabwe National Report, Harare, 1994
Census 1992 Provincial Profile, Harare, Harare, 1994
Census 1992, Provincial Profile, Mashonaland East, Harare, 1993
Indicator Monitoring Survey, 1993, Harare, 1994
Consumption, Income, Expenditure Survey 1990/91, Harare, 1995
World Bank: World Development Report, OUP, 1995

5.2 Present and Future Land Use

Land use in the Upper Manyame River Basin is broken into cultivated land (cropped and fallow), grazing land, forest land, and residential and business-related land. The present land use in the Lake Chivero catchment area is presented in Table 5.2.1 in use of the investigation results on Lake McIlwaine in 1982. About two thirds of the catchment is vegetated and two thirds of the remaining third is cultivated.

Table 5.2.1 Land Use of the Lake Chivero Catchment Area

Land Use Category	Area (km^2)	Percentage
Grazing Land	1,444	67.6
Cultivated Land	492	23.0
Developed Area (Residential & Commercial)	166	7.8
Lakes, Dams, Sewage Works	32	1.5
Others	2	0.1
Total	2,136	100.0

The future land use in the urban areas was prepared by urban local authorities for the years 2000, 2005 and 2015. The following outlines the plans of the city/municipality/local boards.

(1) Harare City

About 50 percent (278.64 km^2) of the city area (557.45 km^2) is currently used for the residential purposes. Future expansion of the city area is expected southward as well as its periphery. The land use plan for the year 2012 in the "Master Plan for Water Distribution", prepared by Department of Works in 1995, is employed as that of the final target year for planning purposes. While, those for the medium target years are projected within the final target area.

Table 5.2.2 show the present and future land use by purpose (residential, business, commercial, etc.). Figure 5.2.1 show the land use plan in the final target year 2015, and Figure 5.2.1 (1) to (3), Section 5.2, Chapter 2, Supporting Report shows the land use in the present and medium target years (2000 and 2005), respectively. Table 5.2.3 presents those by sub-basin in Harare City.

Table 5.2.2 (1) Present and Future Land Use

Unit : km²

Land Use			Present	2000	2005	2015
Harare City	Residential Area	Low Density	210.13	215.06	217.79	233.46
		Medium Density	12.21	24.26	37.02	37.02
		High Density	45.57	58.15	94.45	123.78
		Low/Medium Mixed Density	2.00	2.00	7.83	13.67
		Medium/High Mixed Density	6.01	6.01	6.01	7.47
		High Density High Income	2.72	2.72	2.72	2.72
		Sub-Total	278.64	308.20	365.82	418.12
	Central Business Area		3.83	3.83	3.83	3.83
	Suburban Business Area		0.00	0.00	0.00	14.38
	Industrial/Commercial Area		26.96	31.12	53.00	69.95
	Airport Area		0.00	15.13	15.13	15.13
	Cemetery Area		0.00	0.00	3.65	3.65
	Open Spaces		248.02	390.32	307.17	223.54
	Total		**557.45**	**748.60**	**748.60**	**748.60**
	Inside of Study Area		447.10	638.25	638.25	638.25
	Outside of Study Area		110.35	110.35	110.35	110.35
Chitungwiza Municipality	Residential Area	Low Density	0.00	0.00	0.00	2.14
		Medium Density	3.35	3.35	3.35	8.26
		High Density	19.47	21.22	21.22	26.67
		Sub-Total	22.82	24.57	24.57	37.07
	Industrial Area		1.35	1.35	1.35	9.41
	Town Centre (Commercial) Area		0.85	0.85	0.85	0.85
	Institutional Area		0.74	0.74	0.74	0.74
	Sewage Treatment Works Area		0.93	0.93	0.93	0.93
	Open Spaces		15.31	13.56	13.56	5.50
	Total		**42.00**	**42.00**	**42.00**	**54.50**

Table 5.2.2 (2) Present and Future Land Use (cont'd)

Unit : km^2

Land Use			Present	2000	2005	2015
Norton Town Council	Residential Area	Low Density	1.83	2.92	5.39	17.95
		Medium Density	0.20	0.20	2.12	5.50
		High Density	3.25	5.15	5.15	8.00
		Sub-Total	5.28	8.27	12.66	31.45
	Industrial Area		2.73	2.73	3.86	10.83
	Commercial Area		0.18	0.18	0.18	0.31
	Institutional Area		0.29	0.29	0.29	1.36
	Farm Land Area		0.00	0.00	1.04	4.90
	Sewage Works Area		1.22	1.22	1.22	1.22
	Refuse Dumping Area		0.00	0.00	0.00	0.56
	Open Spaces		9.80	8.81	7.65	8.97
	Total		**19.50**	**21.50**	**26.90**	**59.60**
Ruwa Local Board	Residential Area	Low Density	2.95	3.89	9.44	9.44
		Medium Density	0.18	0.18	0.18	2.66
		High Density	1.76	4.89	6.50	7.50
		Sub-Total	4.89	8.96	16.12	19.60
	Industrial Area		2.11	5.06	5.06	5.06
	Commercial Area		0.18	0.18	0.59	0.76
	Institutional Area		0.47	0.47	0.47	0.68
	Open Spaces		23.75	23.73	16.16	12.30
	Total		**31.40**	**38.40**	**38.40**	**38.40**
Grand Total			**650.35**	**850.50**	**855.90**	**901.10**

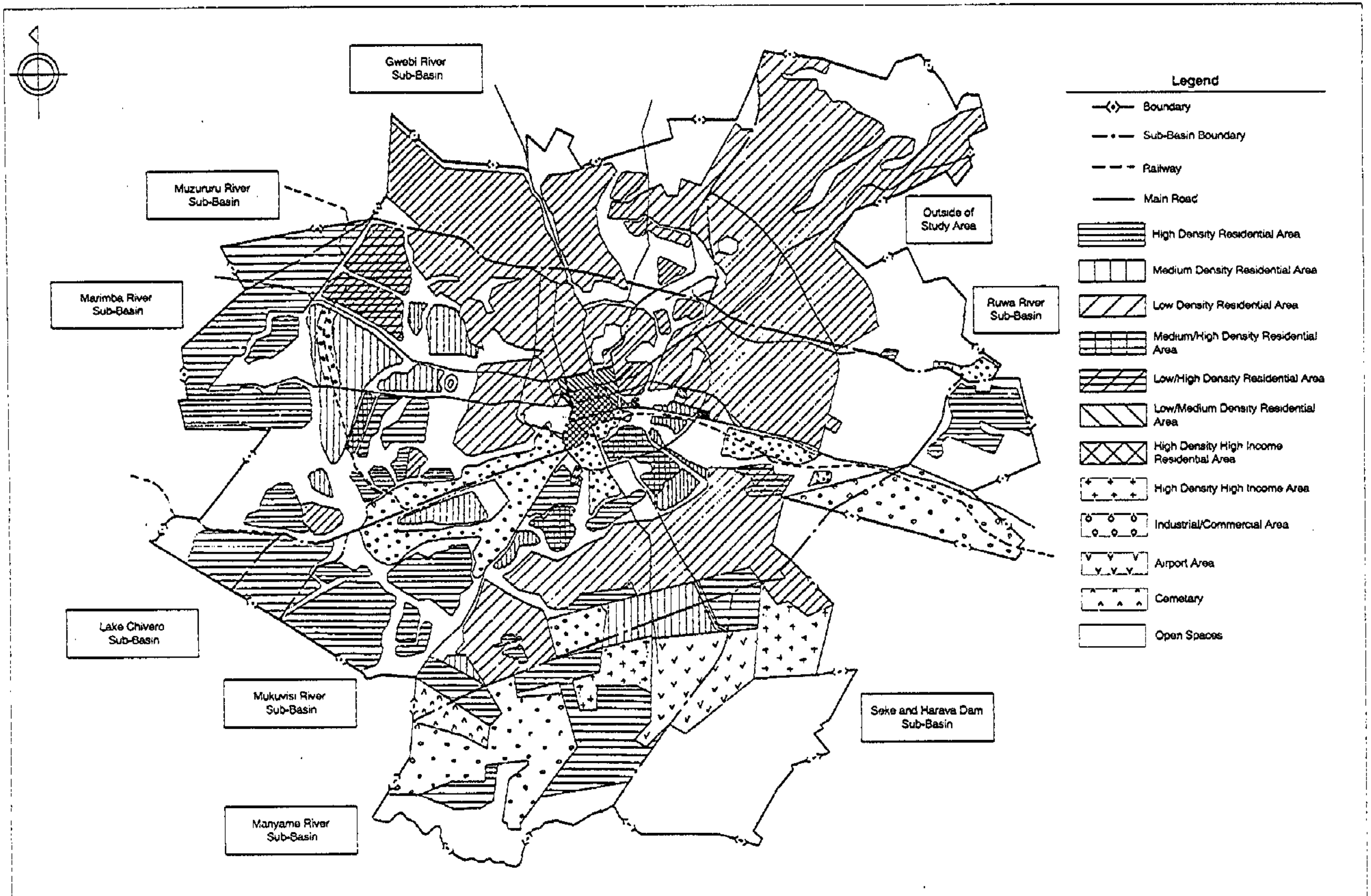


Figure 5.2.1 Land Use Plan in Harare City (2015 Year)

Table 5.2.3 (1) Land Use of Harare City by Sub-Basin

Unit : km^2

Sub-Basin	Land Use		Present	2000	2005	2015
Gwebi River Sub-Basin	Residential Area	Low Density	31.89	32.98	34.80	45.92
		Sub-Total	31.89	32.98	34.80	45.92
	Open Spaces		34.11	33.02	31.20	20.08
	Total		**66.00**	**66.00**	**66.00**	**66.00**
Muzururu River Sub-Basin	Residential Area	High Density	0.00	0.00	7.50	7.50
		Sub-Total	0.00	0.00	7.50	7.50
	Open Spaces		0.00	7.50	0.00	0.00
	Total		**0.00**	**7.50**	**7.50**	**7.50**
Lake Chivero Sub-Basin	Residential Area	High Density	0.00	2.55	8.10	9.74
		Sub-Total	0.00	2.55	8.10	9.74
	Open Spaces		11.20	8.65	3.10	1.46
	Total		**11.20**	**11.20**	**11.20**	**11.20**
Manyame River Sub-Basin (Mukuvisi River to Seke Dam)	Residential Area	Medium Density	0.00	4.58	4.58	4.58
		High Density	0.00	1.28	5.66	22.79
		Sub-Total	0.00	5.86	10.24	27.37
	Suburban Business Area		0.00	0.00	0.00	5.65
	Industrial/Commercial Area		0.00	0.88	22.76	22.76
	Airport Area		0.00	8.93	8.93	8.93
	Cemetery Area		0.00	0.00	2.37	2.37
	Open Spaces		0.00	64.91	36.28	13.50
	Total		**0.00**	**80.58**	**80.58**	**80.58**

Table 5.2.3 (2) Land Use of Harare City by Sub-Basin (cont'd)

Unit : km^2

Sub-Basin	Land Use		Present	2000	2005	2015
Marimba River Sub-Basin	Residential Area	Low Density	39.73	39.73	39.73	39.73
		Medium Density	4.74	7.84	19.32	19.32
		High Density	17.50	21.15	35.65	41.13
		Low/Medium Mixed Density	0.00	0.00	5.83	11.67
		Medium/High Mixed Density	0.00	0.00	0.00	1.46
		High Density High Income	0.36	0.36	0.36	0.36
		Sub-Total	62.33	69.08	100.89	113.67
	Industrial/Commercial Area		6.56	6.56	6.56	6.56
	Open Spaces		86.71	94.46	62.65	49.87
	Total		**155.60**	**170.10**	**170.10**	**170.10**
Mukuvisi River Sub-Basin	Residential Area	Low Density	73.27	73.81	74.72	76.35
		Medium Density	7.47	11.84	13.12	13.12
		High Density	22.60	25.51	29.88	32.60
		Low/Medium Mixed Density	2.00	2.00	2.00	2.00
		Medium/High Mixed Density	6.01	6.01	6.01	6.01
		High Density High Income	2.36	2.36	2.36	2.36
		Sub-Total	113.71	121.53	128.09	132.44
	Central Business Area		3.83	3.83	3.83	3.83
	Industrial/Commercial Area		18.76	22.04	22.04	24.23
	Cemetery Area		0.00	0.00	1.28	1.28
	Open Spaces		61.10	66.58	58.74	52.20
	Total		**197.40**	**213.98**	**213.98**	**213.98**
Seke & Harava Dam Sub-Basin	Residential Area	Low Density	0.00	3.30	3.30	3.30
		High Density	0.00	2.19	2.19	2.19
		Sub-Total	0.00	5.49	5.49	5.49
	Suburban Business Area		0.00	0.00	0.00	8.73
	Airport Area		0.00	6.20	6.20	6.20
	Open Spaces		0.00	45.54	45.54	36.81
	Total		**0.00**	**57.23**	**57.23**	**57.23**

Table 5.2.3 (3) Land Use of Harare City by Sub-Basin (cont'd)

Unit: km^2

Sub-Basin	Land Use		Present	2000	2005	2015
Ruwa River Sub-Basin	Residential Area	High Density	5.29	5.29	5.29	7.65
		Sub-Total	5.29	5.29	5.29	7.65
	Industrial/Commercial Area		0.00	0.00	0.00	14.76
	Open Spaces		11.61	26.37	26.37	9.25
	Total		**16.90**	**31.66**	**31.66**	**31.66**
Outside of Study Area	Residential Area	Low Density	65.24	65.24	65.24	68.16
		High Density	0.18	0.18	0.18	0.18
		Sub-Total	65.42	65.42	65.42	68.34
	Industrial/Commercial Area		1.64	1.64	1.64	1.64
	Open Spaces		43.29	43.29	43.29	40.37
	Total		**110.35**	**110.35**	**110.35**	**110.35**
Grand Total			**557.45**	**748.60**	**748.60**	**748.60**

(2) Chitungwiza Municipality

Currently the residential area comprises high and medium density areas without any low density areas. Furthermore, most of the area is covered by high density development (22.82 km^2) accounting for more than 50% of the municipal area. Future expansion of the municipal area is projected on the left bank area of the Nyatsime River. A future land use plan was prepared by the Engineering Services Department based on the "Harare Combination Master Plan, 1992".

Table 5.2.2 shows the present and future land use by different land use purposes. Figure 5.2.2 shows the land use plan in the final target year 2015, and Figure 5.2.2 (1) to (3), Section 5.2, Chapter 2, Supporting Report shows the land use in the present and medium target years (2000 and 2005) respectively. Table 5.2.4 presents those by sub-basin in the municipality.

(3) Norton Town Council

About 30 percent of the town area is presently used for residential purposes. Of the residential area, more than 60 percent is occupied by high density development. The ratio of industrial area to the town area is comparatively high (14%). Development of the town area will be directed towards south, east and west of the town center through the future. A future land use plan, the "Norton Master Plan, October, 1995" was prepared by the Norton Town Council.

The land use for the year 2015 in the plan is adopted for this planning and those for medium target years were prepared by Town Engineering Department as shown in Table 5.2.2 and Figure 5.2.3 and Figure 5.2.3 (1) to (3), Section 5.2, Chapter 2, Supporting Report. The town area in 2015 is projected at about three times of present area (19.5 km^2 to 59.6 km^2). Table 5.2.5 presents those by sub-basin in the town.

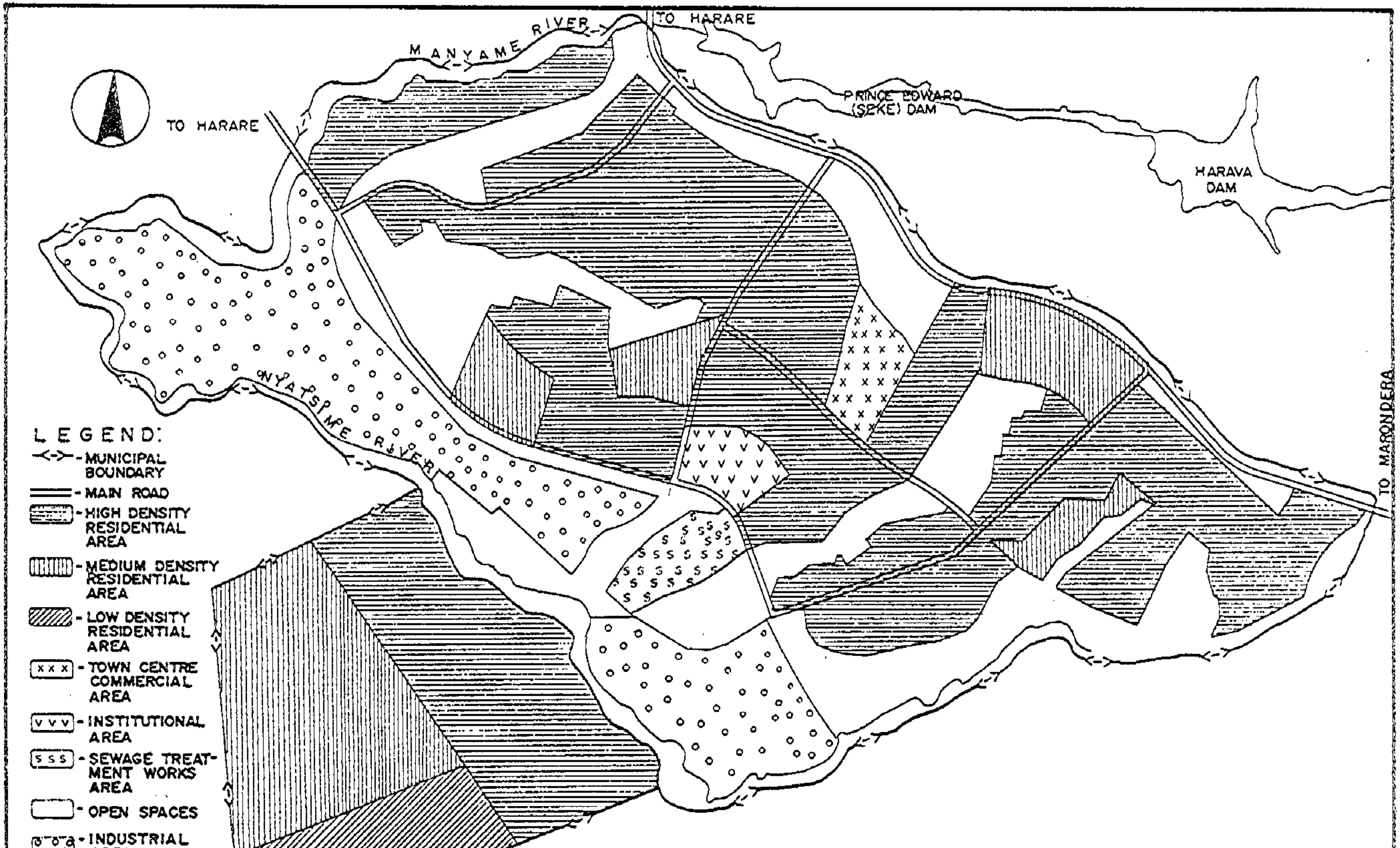


Figure 5.2.2 Land Use Plan in Chitungwiza Municipality (2015 Year)

Table 5.2.4 Land Use of Chitungwiza Municipality by Sub-Basin

Unit : km^2

Sub-Basin	Land Use		Present	2000 Year	2005 Year	2015 Year
Manyame River Sub-Basin (Mukuvisi River to Seke Dam)	Residential Area	High Density	1.69	3.44	3.44	3.44
		Sub-Total	1.69	3.44	3.44	3.44
	Industrial Area		0.00	0.00	0.00	1.48
	Open Spaces		7.21	5.46	5.46	3.98
	Total		**8.90**	**8.90**	**8.90**	**8.90**
Nyatsime River Sub-Basin	Residential Area	Low Density	0.00	0.00	0.00	2.14
		Medium Density	3.35	3.35	3.35	8.26
		High Density	17.78	17.78	17.78	23.23
		Sub-Total	21.13	21.13	21.13	33.63
	Industrial Area		1.35	1.35	1.35	7.93
	Town Centre (Commercial) Area		0.85	0.85	0.85	0.85
	Institutional Area		0.74	0.74	0.74	0.74
	Sewage Treatment Works Area		0.93	0.93	0.93	0.93
	Open Spaces		8.10	8.10	8.10	1.52
	Total		**33.10**	**33.10**	**33.10**	**45.60**
Grand Total			**42.00**	**42.00**	**42.00**	**54.50**

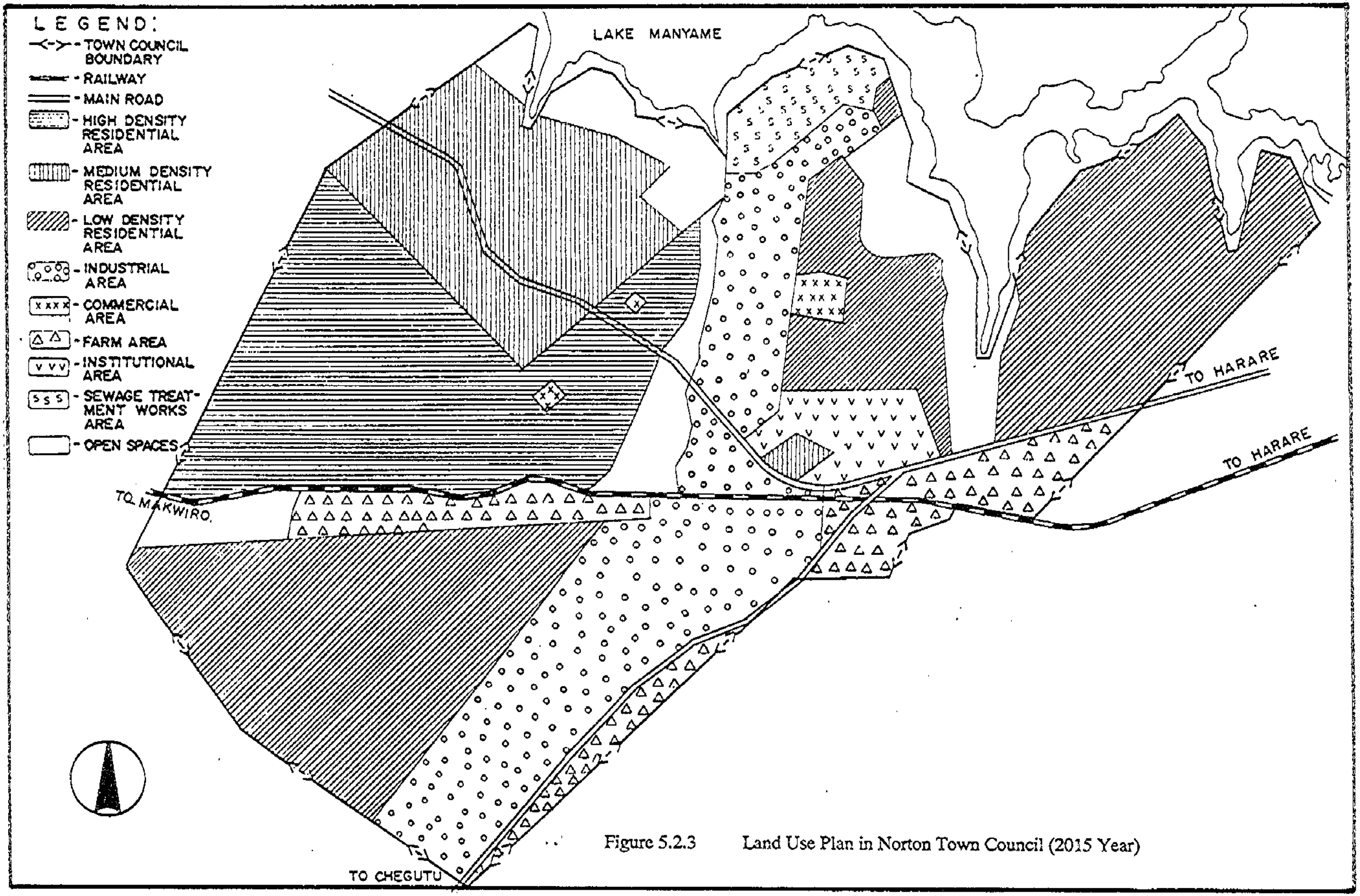


Figure 5.2.3 Land Use Plan in Norton Town Council (2015 Year)

Table 5.2.5 Land Use of Norton Town Council by Sub-Basin

Unit : km^2

Sub-Basin	Land Use		Present	2000	2005	2015
Lake Manyame Sub-Basin	Residential Area	Low Density	1.83	2.92	5.39	17.95
		Medium Density	0.20	0.20	2.12	5.50
		High Density	3.25	5.15	5.15	8.00
		Sub-Total	5.28	8.27	12.66	31.45
	Industrial Area		2.73	2.73	3.86	10.83
	Commercial Area		0.18	0.18	0.18	0.31
	Institutional Area		0.29	0.29	0.29	1.36
	Farm Land Area		0.00	0.00	1.04	4.90
	Sewage Works Area		1.22	1.22	1.22	1.22
	Refuse Dumping Area		0.00	0.00	0.00	0.56
	Open Spaces		9.80	8.81	7.65	8.97
	Total		19.50	21.50	26.90	59.60

(4) Ruwa Local Board

Presently the residential area is only 15 percent of its jurisdiction, while more than 70 percent is not yet utilized (open space: 23.75 km^2). Future urbanization is expected in the undeveloped area, especially north area of railway. Further expansion of the urban area is also projected in the southwestern and southeastern areas of the town. The future land use plan prepared by Ruwa Local Board for the "Ruwa Growth Point" is used for the planning.

Table 5.2.2 and Figure 5.2.4 and Figure 5.2.4 (1) to (3), Section 5.2, Chapter 2, Supporting Report shows present and future land use in the Study Area. Table 5.2.6 presents those by sub-basin in the Local Board.

(5) Epworth Local Board

No data is available as of July, 1996.

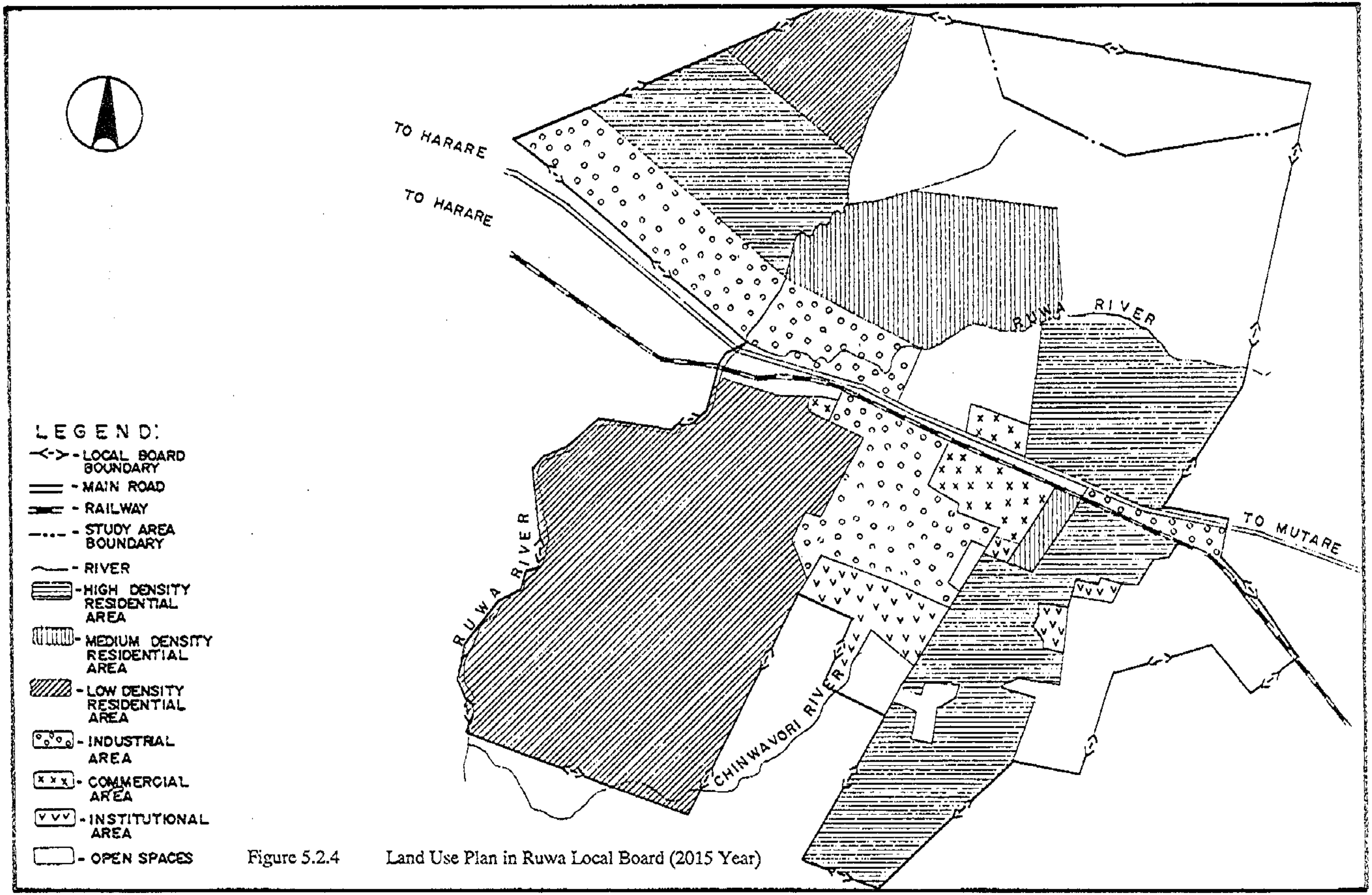


Figure 5.2.4 Land Use Plan in Ruwa Local Board (2015 Year)

Table 5.2.6 Land Use of Ruwa Local Board by Sub-Basin

Unit : km²

Sub-Basin	Land Use		Present	2000	2005	2015
Ruwa River Sub-Basin	Residential Area	Low Density	2.95	3.89	9.44	9.44
		Medium Density	0.18	0.18	0.18	2.66
		High Density	1.76	4.89	6.50	7.50
		Sub-Total	4.89	8.96	16.12	19.60
	Industrial Area		2.11	5.06	5.06	5.06
	Commercial Area		0.18	0.18	0.59	0.76
	Institutional Area		0.47	0.47	0.47	0.68
	Open Spaces		23.75	23.73	16.16	12.30
	Total		31.40	38.40	38.40	38.40
	Outside of Study Area		0.60	0.60	0.60	0.60
Grand Total			32.00	39.00	39.00	39.00