Chapter 5

Night Soil Management Plan

5 Night Soil Management Plan

Night soil collection and management was not included in the original scope of work. This task was added in response to the request by Tanzanian side during the study. Therefore, only determination of the required number of cesspit empty trucks for DCC to collect night soil and determination of the required charge was covered.

The general situation of liquid waste management which was surveyed in the study was described in section 3.2.2 in Volume 2. In this section, the result of supplement survey on night soil management, night soil management plan and its financial analysis are described.

5.1.1 Supplement Description on the Current Technical System of Night Soil Management

a. Sewage Treatment

The collected sewage is being discharged into oxidation ponds and directly to the ocean. According to DSSD, about 25 % of the untreated industrial effluent is also discharged directly to the sewer pipes and about 75% to storm drainage systems without treatment in the premises of industries.

Out of 8 oxidation ponds for treatment of liquid waste in DSM, 4 are in operation including DSM university exclusive use, 1 is closed, 3 are in no use. They are normally named after their locations of oxidation ponds as shown in Table 5-1. The responsible organisation is DSSD with exceptions of Ukonga Air force and DSM university. Figure 5-1 shows the locations of oxidation ponds and dumping stations.

For operational and climatic reasons the most suitable treatment for DSM sewage is oxidation/stabilisation ponds which, although requiring large tracts of land are comparatively cheap and appropriate technology. However, some of the primary oxidation ponds have not been emptied for some time and are filled with sludge.

Table 5-1: Location of Oxidation Ponds and Dumping Stations in DSM

Location	Responsible body	Condition	Remarks
Ukonga Air force	Air force	closed	-due to problems -for air force officers' estate
University of DSM	University of DSM	operating	-exclusively for DSM university
Kurasini	DSSD	operating	-for domestic liquid waste covering residential and harbour commercial area.
Mabibo	DSSD	closed	-closed for about 3 years due to maintenance problems. -previously used for domestic liquid waste covering Morogoro Road commercial area and housing estates
Mikocheni	DSSD	operating	-for domestic liquid waste covering Bagamoyo Road residential area and commercial areas -restricted operation because of too near location to the residential area -receiving industrial liquid waste
Rugalo Military camp	DSSD	closed	-for military camp -oxidation pond is working - no dumping station
Vingunguti	DSSD	operating	-for domestic liquid waste covering (Part of) the Pugu Road commercial area -receiving industrial liquid waste
Gerezani*	DSSD	closed	-used to serve (part of) the Pugu Road commercial area before Vingunguti oxidation pond started to operate
Screen House**	DSSD		City centre area

Note:

* Gerezani is a dumping station without function of oxidation pond.

** Screen house is not an oxidation pond, which is occasionally used as a dumping station located at end station of the City Centre sewer, before feeding into the sea outfall.

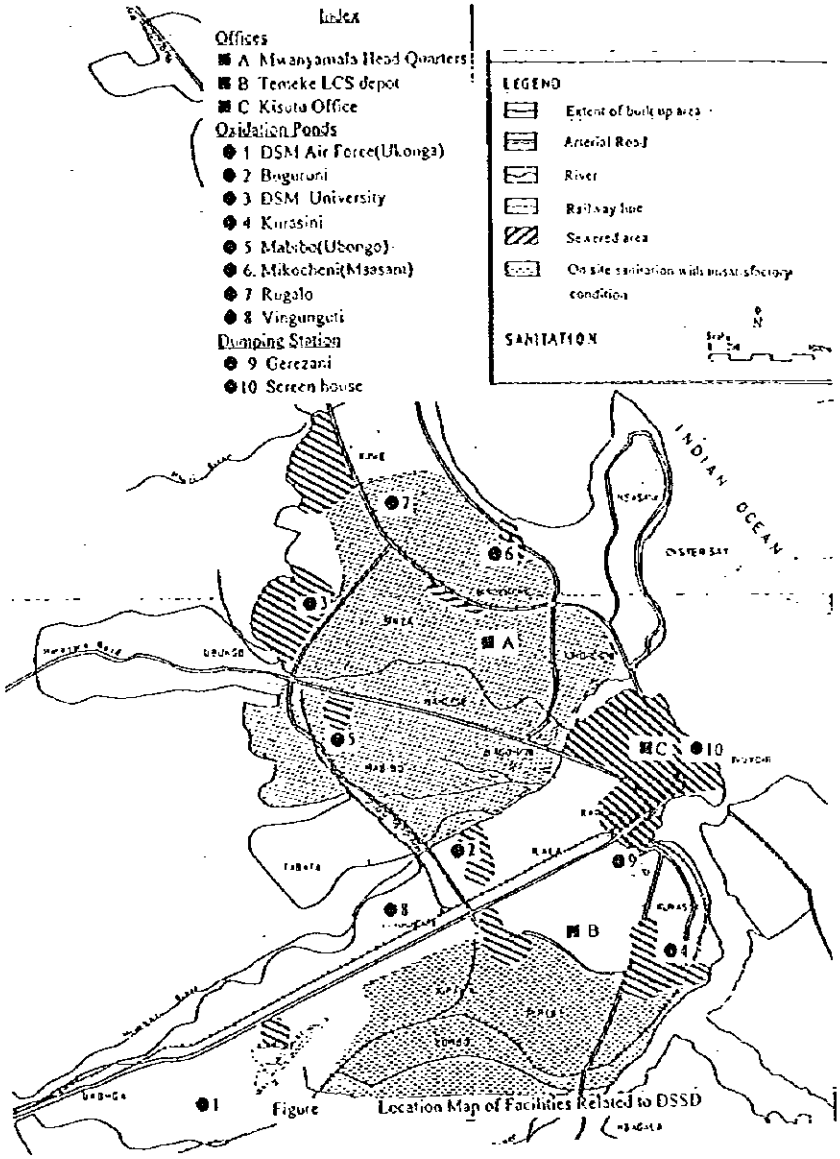


Figure 5-1: Location Map of Facilities Related to DSSD

b. Existing Cesspit Empty Trucks

Table 5-2 shows that cesspit emptying trucks made approximately 17,000 trips and emptied approximately 101,000 m^3 of cesspit in 1996. These data are based on information given by DSSD.

Table 5-3 shows the monthly variation of cesspit emptying trucks activities. It shows that the busiest month was February and the peak monthly factor was 1.2.

Table 5-4 shows the dumping records at oxidation ponds. Mikocheni, Vingunguti and Kurasini are used as dumping stations for domestic liquid waste.

Table 5-2: Situation of cesspit emptying services in 1996

Category	No	Organisation		No. of Trucks	Loading Capacity (m^3)	Model	Year	Donor	Trips	emptied volume (m^3)	truck use in 2002
Public (DCC)	1	DSSD(New Low Cost Sanitation Unit	Former Low Cost Sanitation Unit , DSSD	3(2) 3(1) 2(1) 4(2)	5 5 5 5	Leyland CD(UK) Leyland Master(UK) Fiat682(Italy) Fiat 110(Italy)	1987 1987 1986	UK UK Italy Italy	1,698	8,490	no
			Former Cleansing Unit , Health. Department.	8(4)	8	Mitsubishi(Japan)	1987	Japan	4,601	36,808	no
	2	Malaria Control Unit , Health Department.		4(4)	6	Nissan (Japan)	1994	Japan	3,334	20,004	in use
	Subtotal			24(14)					9,633	65,302	
Parastatal	1	Tazara(Tanzania Zambia Railway)		1(1)	5	Nissan(Japan)			852	4,260	no
	2	National Housing Corporation(NHC)		1(1)	5	Comet(UK)			1,034	5,170	no
	3	Bank of Tanzania		1(1)	5	Comet(UK)			253	1,265	no
	4	Cooperative and Rural Development Bank		1(1)	5	Bedford(UK)			19	95	no
	5	Tanzania Harbour Authority		1(1)	5	Tata(India)			1,131	5,655	no
	6	TANESCO(Tanzania Electric Supplies Company)		1(1)	5	Tata(India)			1,404	7,020	no
	7	TPDC(Tanzania Petroleum Development Company)		1(1)	5	Scania(Sweden)			304	1,520	no
	8	National Bank of Commerce		1(1)	5	Scania(Sweden)			1,287	6,435	no
	9	MAGEREZA(Ministry of Internal Affairs Prison Section)		1(1)	5	Scania(Sweden)			462	2,310	no
	10	BIMA(National Insurance Co-operation(NIC))		1(1)	5	Scania(Sweden)			0	0	no
	11	Post and Telecommunication		1(1)	5	Scania(Sweden)			0	0	no
	12	JESHI LA WANANCHI(Tanzania People Defense Forces)		1(1)	5	Tata(India)			3	15	no
	Subtotal			12(12)					6,749	33,745	
Private	1	MBK(Mohammed B. Khalid)		1(1)	6	Isuzu(Japan)			149	894	no
	2	KES(K. Environmental Sanitation Service)		1(1)	7	Volvo(Sweden)			69	483	no
	3	JJB(J and J Business Associates)		1(1)	5	Bedford(UK)			145	725	no
	Subtotal			3(3)					363	2,102	no
Total				39(29)					16,745	101,149	

Note: Values in ( ) show numbers of cesspit emptying trucks in operation in February 1997

Table 5-3: Number of Trips made by cesspit emptying trucks in 1996

Category	No.	Organisation		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Trips
public (DCC)	1	DSSD(New Low Cost Sanitation Unit)	Old Low Cost Sanitation Unit	48	199	150	200	186	126	200	203	173	68	95	50	1,698
			Former Cleansing Unit , Health, Department. *	328	502	456	326	313	346	400	387	411	394	358	380	4,601
	2	Malaria Control Unit , Health Department		260	268	195	135	263	377	288	307	307	382	212	340	3,334
	Subtotal			636	969	801	661	762	849	888	897	891	844	665	770	9,633
	Average Monthly trips/truck			45.4	69.2	57.2	47.2	54.4	60.6	63.4	64.1	63.6	60.3	47.5	55.0	57.3
parastatal	1	Tazara(Tanzania Zambia Railway)		98	108	101	20	85	86	65	6	70	56	114	43	852
	2	National Housing Corporation(NHC)		83	87	157	80	122	52	87	82	51	75	80	78	1,034
	3	Bank of Tanzania		15	27	51	48	10	35	0	4	30	33	0	0	253
	4	Cooperative and Rural Development Bank		** 0	** 0	** 0	** 10	** 9	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 19
	5	Tanzania Harbour Authority		118	98	111	80	84	78	100	87	86	155	30	104	1,131
	6	TANESCO(Tanzania Electric Supplies Company)		101	104	71	167	158	116	132	154	110	149	56	86	1,404
	7	TPDC(Tanzania Petroleum Development Company)		27	49	29	31	25	25	44	36	28	2	4	4	304
	8	National Bank of Commerce		176	124	0	106	136	95	116	131	132	121	70	80	1,287
	9	MAGEREZA(Ministry of Internal Affairs Prison Section)		83	112	74	35	26	20	35	36	30	10	1	0	462
	10	BIMA(National Insurance Co-operation(NIC))		** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0
	11	Post and Telecommunication		** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 0
	12	JESHI LA WANANCHI(Tanzania People Defense Forces)		** 0	** 0	** 0	** 0	** 3	** 0	** 0	** 0	** 0	** 0	** 0	** 0	** 3
	Subtotal			701	709	594	577	658	507	579	536	537	601	355	395	6,749
	Average Monthly trips/truck(except No.4+No.10+No.11+No.12)			87.6	88.6	74.3	70.9	80.8	63.4	72.4	67.0	67.1	75.1	44.4	49.4	70.1
private	1	MBK(Mohammed B. Khalid)										80	49	10	10	149
	2	KES(K. Environmental Sanitation Services)										15	19	13	22	69
	3	JJB(J and J Business Associates)										0	30	50	65	145
	Subtotal											95	98	73	97	363
	Average monthly trips/private truck											31.7	32.8	24.4	32.3	40.3
	Total			1,337	1,678	1,395	1,238	1,420	1,356	1,467	1,433	1,523	1,543	1,093	1,262	16,745
	Average Monthly trips/(public +parastatal + private truck)			60.7	76.3	63.4	55.8	68.5	61.6	66.7	65.1	69.2	70.1	49.7	57.4	63.3
	Ratio to the average monthly trips			0.96	1.21	1.00	0.88	1.08	0.97	1.05	1.03	1.09	1.11	0.79	0.91	1.00

Note: * Former Cleansing Unit of Health Department consolidated to Low Cost Sanitation Unit , DSSD in January 1997.
** These values are deducted for the calculation of average monthly trips of cesspit emptying vacuum trucks.

Table 5-4: Dumping Record of Cessipt Emptying Trucks in 1996

category	No	Organization		Mikocheni	Vingunguti	Mabibo	Gerezani (Dumping Station)	(1)Kurasini	Screen/ House (Dumping Station)	Total
Public (DCC)	1	DSSD(New Low Cost Sanitation Unit)	Old Low Cost Sanitation Unit	977	612	0	0	20	89	1,698
			former Cleansing Unit , Health Department*	1,278	2,531	0	0	792	0	4,601
	2	Malaria Control Unit , Health Department		1,421	1,665	0	0	248	0	3,334
	Subtotal			3,676	4,808	0	0	1,060	89	9,633
Parastatal	1	Tazara(Tanzania Zambia Railway)		844	8	0	0	0	0	852
	2	National Housing Corporation(NHC)		503	394	0	0	137	0	1,034
	3	Bank of Tanzania		251	2	0	0	0	0	253
	4	Cooperative and Rural Development Bank		19	0	0	0	0	0	19
	5	Tanzania Harbour Authority		1,131	0	0	0	0	0	1,131
	6	TANESCO(Tanzania Electric Supplies Company)		1,294	84	0	0	26	0	1,404
	7	TPDC(Tanzania Petroleum Development Company)		304	0	0	0	0	0	304
parastatal	8	National Bank of Commerce		1,287	0	0	0	0	0	1,287
parastatal	9	MAGEREZA(Ministry of Internal Affairs Prison Section)		394	57	0	0	0	0	462
	10	BIMA(National Insurance Co-operation(NIC))		0	0	0	0	11	0	0
	11	Post and Telecommunication		0	0	0	0	0	0	0
	12	JESHI LA WANANCHI(Tanzania People Defense Forces)		3	0	0	0	0	0	3
	Subtotal			6,030	545	0	0	174	0	6,749
Private	1	MBK(Mohammed B. Khalid)		149	0	0	0	0	0	149
	2	KES(K. Environmental Sanitation Service)		52	17	0	0	0	0	69
	3	JJB(J. and J. Business Associates)		135	10	0	0	0	0	145
	Subtotal			336	27	0	0	0	0	363
Total				10,042	5,380	0	0	1,234	89	16,745
Share of Total(%)				60.0	32.1	0.0	0.0	7.4	0.5	100.0

Note: * Former Cleansing Unit of Health Department consolidated to Low Cost Sanitation Unit , DSSD in January 1997.

5.1.2 Operation of Liquid Waste Management

a. Responsible Organisation for LWM in Dar es Salaam

a.1 Ministry of Waters, Energies and Minerals

Department of Sewerage was established under the Ministry of Land in 1979. It became under the control of Ministry of Water, Energies and Minerals in 1986. The Department covers the field of sewerage, drainage and environmental sanitation in the urban areas of the whole country. It is responsible for planning, fund seeking, implementation of the new construction projects. After completion, operation and maintenance of the facilities is handed over to the municipalities. The rehabilitation of the LWM facilities is conducted by the Prime Minister's Office as an upper structure organisation of municipalities.

a.2 DSSD

DSSD is one of the Departments under DCC, which is responsible for sewerage, sewage treatment, cesspit emptying and health education. DSSD is characterised as follows.

i. semi-autonomous

ii. basic wages are paid by the central government

iii. all expenditure including allowances except basic wages are covered by its own revenue.

The DSSD cesspit emptying services are executed by the Low Cost Sanitation (LCS) Unit. The roles of the Units related to cesspit emptying services are shown in Table 5-5.

Table 5-5: Roles of Units in DSSD related to Cesspit Emptying Services

Organisation of DSSD	Roles of the Unit
1. Mwananyamala Head Quarters	
1.1. Low Cost Sanitation (LCS) Unit	• execution of cesspit emptying services • booking of vacuum trucks upon request by local people • scheduling of vacuum truck
1.2. Sewerage Unit	• management of the dumping station and sludge treatment
1.3 Central Mechanical Workshop at Mwananyamala	• maintenance and scheduling of vacuum trucks and other vehicles
1.4. Finance Unit	• revenue and expenditure accountant • collection of charge prior to cesspit emptying service
1.5. Manpower Unit	• manpower management
2. Temeke DSSD LCS depot	• coordination and administration of vacuum truck services(booking of vacuum trucks upon request by the local people) • collection of charge before cesspit emptying service
3. Kisutu DSSD office	• coordination and administration of vacuum truck services(booking of vacuum trucks upon request by the local people) • collection of charges for cesspit emptying before the service

a.3 Malaria Control Unit, Health Department, DCC

This unit is in charge of cesspit emptying services in the malarial mosquito breeding areas which covers the whole DSM region. It collects cesspit emptying charges from the customers. Liquid waste is dumped at the oxidation ponds without any charges.

b. Financial Situation of DSSD

Table 5-6 shows the financial situation of DSSD. The major revenue source of DSSD is sewerage charge, which shares about 60 % of the total revenue.

The revenue from cesspit emptying service charge shares only 3 %. The expenditure for cesspit emptying service is 1.8 times more than revenue. Cesspit emptying charge is 5,000 Tsh/trip/truck for residential area, and 10,000 Tsh/trip/truck for institutions and commercial area.

The service charge is not allowed to increase by DCC independently, due to one of the matters decided by the Government.

Table 5-6: DSSD's Financial Situation in 1996 and Budget in 1997

unit: 1,000 Tsh

Item	1996 Proposed	1996 Actual	1997 Proposed
Revenue	**399,364**	**342,869**	**452,733**
• Head Quarter Finance(loans etc.)	12,053	9,236	8,382
• Technical and Machines(repair etc.)	4,075	2,919	14,927
• Cesspit Emptying charges from Users	13,500	12,729	15,295
• Waste water service	224,865	197,152	269,603
• Grant from Head Quarter	144,871	120,833	144,252
Expenditure	**419,763**	**392,549**	**446,002**
• Head Quarter(operation maintenance)	103,527	125,331	98,634
• Technical and Machines(tools etc.)	77,947	42,370.	54,823
• Administration	47,964	42,691	47,209
• Construction of VIP Latrine *[1]	12,718	15,055	20,353
• Health Education	3,802	7,249	9,638
• Cesspit Emptying Cost(fuel etc.,)	16,132	23,726	27,136
• Sewerage and Oxidation Ponds	157,675	136,127	188,209

Note: *[1] VIP Latrine stands for Ventilated Improved Pit Latrine

5.2 Improvement Plan of the Night Soil Collection System

5.2.1 Precondition for the Improvement of the Night Soil Collection System

The improvement of the night soil collection system was planned based on the following assumptions according to the data obtained through the field surveys.

i. The population using the toilets which need to be emptied periodically was assumed to be 27 % of the total population.

ii. The discharge amount of excreta was assumed to be 2 litres per person.

iii. The four sectors dealing with cesspit emptying services in DSM in 1997 will retain their shares as follows in future.

- DAWASA: 20.7 %
- DCC: 27.6 %
- Private cesspit empty service enterprises: 10.3 %
- Other ordinary private institutions: 41.4 %

iv. DCC will collect all night soil from its served population.

v. Four out of eight cesspit emptying trucks will stop their operation in 1999 as they are decrepit.

vi. The remaining four cesspit emptying trucks will work until 2003.

vii. The capacity of tank will be 6 m^3.

viii. The average number of trips per day will be 5 times.

ix. The average amount of night soil collected will be 21 m^3 per truck.

x. The night soil collected will be discharged into oxidation ponds or dumping points which are under DAWASA's control.

xi. DCC will pay a dumping charge of 3,000 Tsh, per truck of night soil, to DAWASA.

xii. The present capacity of oxidation ponds was assumed to be sufficient for receiving all night soil to be collected by the plan, because the study on the night soil reception capacity was out of scope of the study.

5.2.2 Night Soil Collection Plan

The night soil collection plan prepared based on the above assumptions are shown in the table below.

Table 5-7: Night Soil Collection Plan

Description	2000	2000	2001	2002	2003	2004	2005
Population	2,455,099	2,632,965	2,835,037	3,065,729	3,327,394	3,624,014	3,966,460
Population need cesspit empty services	662,877	710,901	765,460	827,747	898,396	978,484	1,070,944
Required amount collected	1,326	1,422	1,531	1,655	1,797	1,957	2,142
Required Number of Collection Trucks	64	68	73	79	79	79	79
Planned Number of DCC's Trucks	4	19	21	22	22	22	22

The productivity of 6 tons truck is determined by the following trucks.

$Q = V \times N \times K$

Q: Volume of sewage to be emptied and carried by a truck per day

V: Capacity of tank of a truck

N: Number of trips per truck/day

K: Work efficiency

Hence,

$$Q = 6.0 \times 5 \times 0.7 = 21.0\ m^3/day$$

5.3 Cost Estimation

a. Investment

Table 5-8 shows the investment schedule.

Table 5-8: Investment Schedule

Description	unit	1999	2000	2001	2002	2003	2004	2005
Planned number of trucks	units		19	21	22	22	22	22
Number of operational trucks	units	8	4	4	0	0	0	0
Number of trucks procured	units	15	2	1	0	0	0	0
Investment Amount	Mtsh	655	87	44	0	0	0	0

b. Operation & Maintenance Cost

Table 5-9 shows the O & M cost schedule.

Table 5-9: O & M Cost Schedule

Category	Description	unit	1999	2000	2001	2002	2003	2004	2005
Quantify	Driver	person	0	19	21	22	22	22	22
	Assistant	person	0	38	42	44	44	44	44
	Diesel	l	0	570	630	660	660	660	660
Cost	Labour	Mtsh	0	32	35	37	37	37	37
	Material	Mtsh	0	54	60	62	62	62	62
	Repair	Mtsh	0	66	73	77	77	77	77
	Dumping Fee	Mtsh	0	89	99	103	103	103	103
	Total	**Mtsh**	**655**	**329**	**310**	**279**	**279**	**279**	**279**

5.4 Financial Evaluation

5.4.1 Parameters and Presumptions

a. Financial Parameters

The financial parameters required for the financial evaluation of the night soil collection project are basically same as those for the waste collection project, which are tabulated below.

Table 5-10 Financial Parameters for Night Soil Collection Project

Financial Parameters	Condition
Price Level	same as the price level as of the end of February, 1997
Cut-off Rate	same as the real interest rate of the Bank of Tanzania (11.6% per annum)
Foreign Exchange Rate	same as the mean inter-bank rate among commercial banks as of the end of February, 1997
Residual Value	included into the revenue in 2006 at the residual market price

a. Project Cost

Considering the absolute shortage of night soil collection vehicles in DSM, 18 vehicles shall be newly procured during 3 years from 1999 to 2001 in addition to the current 8 vehicles in operation. The project cost includes the procurement cost of vehicles which amounts to 786 million Tsh., the operation and maintenance cost of relevant vehicles, and the night soil disposal fee, as shown below.

Table 5-11 Summary for Cost of Night Soil Collection Project

unit : million Tsh.

Cost Item	1999	2000	2001	2002	2003	2004	2005
Procurement of Vehicles	655	87	44	0	0	0	0
Operation and Maintenance	0	152	168	176	176	176	176
Night Soil Disposal	0	89	99	103	103	103	103
Total Project Cost	655	241	311	279	279	279	279

5.4.2 Scenarios

The following 6 scenarios are set up as alternative scenarios in terms of the cost stream of the project and the level of the collection fee, taking into consideration that there is a possibility that the project cost may not be recovered by the possible revenue sources.

Table 5-12 Scenarios for Financial Evaluation

Case	Cost	Tariff (per trip)
Case A-1	All the project cost shall be covered by loan.	Tsh. 5000
Case A-2	All the project cost shall be covered by loan	Tsh. 9000
Case A-3	All the project cost shall be covered by loan	Tsh. 13000
Case B-1	The project cost for the procurement of relevant vehicles for the first year shall be granted by a donor country	Tsh. 5000
Case B-2	The project cost for the procurement of relevant vehicles for the first year shall be granted by a donor country	Tsh. 9000
Case B-3	The project cost for the procurement of relevant vehicles for the first year shall be granted by a donor country	Tsh. 13000

5.4.3 Financial Evaluation

The financial planning tables for the above 6 cases are as per Table A - 1 to Table A - 6. The result of the calculations of FIRRs are as per Table A - 7 to Table A - 13, and illustrated in Figure A - 1. The summary of FIRRs for the night soil collection project are shown below.

Table 5-13 Summary of FIRRs for Night Soil Collection Project

Collection Fee / Project Cost	Case A	Case B
Case 1	-54.18%	-53.66%
Case 2	-36.61%	-31.27%
Case 3	-15.46%	38.41%

The major findings are :

a) In case of the all loan scheme (Case A-1, A-2, A-3), all the FIRRs remain unfeasible at all the FIRRs under the cut-off rate of 11.6% per annum, clearly indicating that it is absolutely required to supply a higher grant-element external sources such as a grant assistance by one of donor countries.

b) In case of the partial loan scheme together with the grant assistance for the procurement of night soil collection vehicles for the first year (Case B-1, B-2, B-3), the FIRR under the collection fee of Tsh. 13000 per trip (Case B-3) proved to be feasible at the FIRR of 38.41%.

c) In order to achieve the cut-off rate of 11.6% per annum on the condition of the grant assistance to the procurement of 15 night soil collection vehicles for the first year, the collection fee should be raised to the level of Tsh. 10500.

Chapter 6

Environmental Impact Assessment

6 Environmental Impact Assessment

6.1 Introduction

6.1.1 Introduction

This study is an Environmental Impact Assessment (EIA) for the proposed disposal site at New MECCO quarry in Kunduchi ward, in the rural part of Kinondoni district of Dar es Salaam (DSM) city. The study was carried out from January - April 1997 by the JICA Study Team in collaboration with the University College of Lands and Architectural Studies (UCLAS), DSM.

6.1.2 Background

There is only one official existing waste disposal site for DSM city, which is the Vingunguti site, operated by the Dar es Salaam City Commission (DCC). It is located about 10 km from the city centre and is a convenient site in terms of waste transportation. However, many complaints have been received from nearby residents since its opening. The Vingunguti disposal site has many associated environmental problems such as public nuisance, odour, smoke, dust, vibration and traffic congestion due to the current crude dumping nature of operation and being close to a densely populated residential area. Vingunguti road, which has recently been tarmaced, is used by refuse collection trucks for access to the disposal site and also as a main community road for Vingunguti residents. Refuse trucks increase traffic congestion on this road, which is narrow and has high pedestrian and vehicle densities.

As the reserve capacity of the Vingunguti disposal site is very limited and it is located within the Msimbazi river flood plain, funding for a planned extension of the site was rejected by the World Bank and to date, no other donors have been forthcoming. Thus, Vingunguti disposal site, although a cost effective and expedient short term waste disposal option, is not considered viable for long term use. The development of a new landfill is therefore a crucial and an urgent issue for the city of DSM.

Unlike the Vingunguti disposal site, the Kunduchi New MECCO quarry seems to be a potential site that satisfies many long term environmental requirements. This site was selected after the initial screening of seven candidate waste disposal sites by the JICA Study Tam. The current EIA study is part of the process of approving the site for waste disposal.

6.1.3 Scope of Study

The scope of the EIA study is as follows:

- field measurements, data collection and analysis required for the environmental impact assessment.
- production of the environmental impact statement.

The EIA consists of an evaluation of 16 environmental items, in accordance with JICA Environmental Guidelines[1]. These items were selected as a result of the Initial Environmental Examination (IEE) conducted by the JICA Study Team in Sept. - Nov. 1996. The items are:

Social Environment:

- economic activities
- traffic and public facilities
- public health
- waste
- hazards/risks

Natural Environment:

- topography and geology
- groundwater
- hydrological situation
- flora and fauna
- landscape/aesthetics

Pollution:

- air pollution
- water pollution
- soil contamination
- noise and vibration
- offensive odour
- litter

6.2 Legislative Requirements

6.2.1 Summary

A review of available literature and discussions with appropriate bodies (government agencies, the private sector and NGOs) have shown that environmental and natural resource management at the legislative level is presently not well defined in Tanzania. Current environmental legislation is contained in many Acts and Policies, most of which are sector specific, outmoded and not well understood. The responsibility for enforcing them is also shared by a number of sectoral institutions, from a local authority to national level.

Historically in Tanzania, environmental management has predominantly been sectorally based; a situation which has facilitated the growth of disparate regulatory institutions, some with overlapping roles. Thus enforcement of environmental related legislation has been generally ineffective, partially because of difficulties in implementing the inherent cross-sectoral nature of such legislation.

The National Environment Management Council (NEMC) was established by an Act of Parliament in 1983 as a response to this fragmented approach to legislation and policy

[1] "Environmental Guidelines for Infrastructure Projects No. VI Solid Waste Management"; JICA; 1992

management. The functions of NEMC, explained in more detail in section 2.2.1 below, include the coordination and stimulation of national environmental management and the prevention of pollution. However, NEMC only has an advisory function and lacks regulatory powers, meaning that presently pollution produced by industry or by human settlements is virtually not controlled.

A number of other initiatives are being undertaken by the government in environmental policy and legislation development. These are partially being done to bring Tanzania's environmental policies into line with the concepts and principles of sustainable development, to which it subscribed in the Rio de Janeiro World Environment Summit in 1992.

The Division of Environment under the Vice President's Office, responsible for the execution of government environmental objectives, has produced drafts of a National Environmental Action Plan (1994), National Environmental Policy (1995), and is currently working on the formulation of national environmental legislation. NEMC has also produced drafts of an Environmental Protection Bill and the National Conservation Strategy for Sustainable Development (NCSSD). The questions of pollution and protection and maintenance of environmental quality are well addressed by the above documents.

All of these documents recommend that Environmental Impact Assessment (EIA) should be mandatory to development projects in Tanzania. However, currently there is no legal requirement in Tanzania to undertake an EIA for development projects. Nevertheless, NEMC is currently preparing guidelines, procedures and environmental standards for conducting EIAs in Tanzania.

In the following sections, legislation and policies that address the quality of the environment and which may therefore be relevant to this project are described.

6.2.2 Existing Acts relating to Environmental Management

6.2.2.1 National Environment Management Council Act (1983)

This was enacted to legislate the establishment of the National Environment Management Council (NEMC) under section 3(1). The functions of NEMC are stipulated in section 4.0 of the Act. These include:

- formulation of proposals for legislation on environmental issues and recommending their implementation by the government.
- specification of standards, norms and criteria for the protection and maintenance of the quality of the environment.
- the evaluation of existing and proposed policies and the activities of the government directed to control pollution.
- the recommendation of measures to ensure that government policies, including those for development and conservation of natural resources take adequate account of environmental effects.

Thus, NEMC advises the government on all environmental matters in the country. Section 7 of the Act specifies the duties of the Director General, who is the Chief

Executive of NEMC. These include responsibility for considering means and initiating steps for the protection of the environment and for preventing, controlling, abating or mitigating pollution.

All ministries, local authorities, national institutions and other organisations in the country utilise the information available within NEMC. However the existence of NEMC does not relieve other ministries, local authorities and institutions of their responsibilities as regulated by various laws, which apply to the prevention of environmental damage.

6.2.2.2 Wildlife Conservation Act (1974) (as amended in 1978)

The Wildlife Conservation Act of 1974 and its 1978 amendment were enacted to promote the conservation of certain wildlife species (section 15). The Act protects both wildlife and vegetation and makes provision for the protection of game in both game reserves and game controlled areas as well as the protection of scheduled national game reserves anywhere in the country. Vegetation is also strictly protected in game reserves and may not be wilfully damaged without relevant approvals from the Ministry of Tourism, Natural Resources and the Environment.

This Act also operates within the limits and requirements of the Convention on International Trade in Endangered Species (CITES), the National Parks Ordinance and related regulations.

6.2.2.3 Forest Ordinance (1957) & Forests; Chapter 389 of the Laws (Principle Legislation), Supplement 57, Part V

This ordinance deals with the protection of forests and forest products in forest reserves and the restrictions and prohibitions which apply to forest reserves. These management plans are administered under the Forests Ordinance (1957). Under this ordinance, mangroves are officially recognised as forest reserves and their entry and use is regulated. Any contravention of the restrictions and prohibitions is considered an offence under this Ordinance and subject to prosecution. However, the Ordinance is rarely enforced.

6.2.2.4 Protected Places and Areas Act (1969)

This Act provides a process and mechanism to protect specific lands as necessary and provides for imprisonment and fines for persons unlawfully trespassing on protected lands.

6.2.2.5 The Water Utilisation (Control and Regulation) Act, 1974 (as amended in 1981)

The purpose of this Act is to control and protect water resources. The legislation defines water as all water flowing over the ground surface or contained or flowing in or from a spring or stream or natural lake, swamp or beneath a water course. The Act puts in place a regime of water rights to govern access to water use and which embody pollution control norms.

Furthermore, the Act puts in place a regime for granting consents for the discharge of effluent. Under Section 15 A(1) of the Act, no person may discharge effluent from any

commercial, industrial or other trade waste systems into receiving waters without a consent duly granted by a Water Officer. The Act also contains two schedules which set standards for receiving waters and effluent quality.

6.2.2.6 The Town and Country Planning Ordinance Cap. 378 of 1956 (as amended in 1961)

The Ordinance describes technical procedures for preparing land use plans, detailed schemes and urban development conditions in conformity with land use plans and schemes. The management of solid waste is included in the first schedule, Part II - Public Services. However, solid waste has never received any use class, under the Use Class Regulation of 1960 and 1994 (revised).

6.2.2.7 Local Government Act (District and Urban Authorities) of 1982

This Act details the responsibilities of urban councils in the administration of daily activities. Solid waste is included as one of the activities to be managed by urban authorities.

6.2.2.8 The Penal Code

The Penal Code stipulates that the voluntary spoiling of the atmosphere so as to make it noxious to the health of persons in the vicinity is an offence. This also applies to engagement in offensive trades, making offensive unwholesome smells and negligent spreading of diseases.

6.2.2.9 Land Use Planning Commission Act (1984)

The National Land Use Commission was established under this Act as the principal advisory organ of the government on all matters relating to land use. The Commission's duties include recommending measures to ensure that government policies, including those for development and conservation of land, take adequate account of their effects on land use, seek to apply relevant scientific knowledge and encourage the development of technology to prevent or minimise adverse effects that endanger man's health or welfare. The Commission should also specify standards, norms and criteria for the protection of beneficial uses and the maintenance of the quality of the land. In accordance with these functions, the Commission can indirectly help to prevent or minimise pollution by placing restrictions on the location of potential and actual pollution sources.

6.2.2.10 The Land Acquisitions Act (1967) and the Land Ordinance

The Land Acquisition Act gives powers to the President to take "land" from private occupants for public purposes when in the public interest to do so. The Land Ordinance declares all land in Tanzania as "public land" to be held by the state for public purposes.

6.2.3 Existing Policies Relating to Environmental Management

6.2.3.1 National Land Policy (1995)

The policy has proposed the formation of an Inter-Ministerial Coordination Committee for consultation on issues of granting mining claims, hunting licenses, timber harvesting licenses, water rights and other leases; these being particular kinds of land use which normally conflict with other land uses.

The policy provides for the protection of sensitive areas which include water catchment areas, small islands, border areas, beaches, mountains, forests, national parks, rivers, river basins and banks, seasonal migration routes of wildlife, national heritage areas and areas of biodiversity.

6.2.3.2 Forestry Policy (Draft)

The main objective of this policy is to increase the area of land under forestry cover. This policy addresses the whole process, to be managed by the government, and states that for it to be successful, the focus should be on grassroots participation in forest resource management. All efforts to centralise forest management should be avoided.

6.2.3.3 Water Policy (1991)

This policy is very comprehensive and intersectorally based. It recommends that water resources shall be conserved and that the use of pesticides and fertilisers that will cause water pollution should be avoided. So far, strategies and action plans have been prepared to implement the policy.

6.2.3.4 National Environmental Action Plan (NEAP) (1994)

NEAP is one of Tanzania's initial steps towards a comprehensive incorporation of environmental concerns into the fabric of national planning and development. It represents the integration of several environmental projects and numerous consultations into one comprehensive document. It's overall goal is "to achieve sustainable development that maximises the long term welfare of both present and future generations of Tanzanians". Specific objectives include:

- to ensure sustainable and equitable use of resources without degrading the environment or risking health or safety.
- to prevent and control degradation of land, water, vegetation and air.
- to improve the condition and productivity of degraded areas, including rural and urban settlements.

The use of EIA for major development projects is proposed as one of the key instruments to achieve these objectives. Other key instruments include the development of proper environmental legislation in order to implement the regulatory elements and the issuance of environmental indicators and standards.

Under the heading "Urban Environmental Pollution", solid waste problems are addressed and specific actions proposed to solve them:

- establish disposal, production, transportation standards and permitting requirements for solid wastes, enforceable by law.
- establish emergency sites for solid waste disposal, until permanent sites can be found.
- develop environmentally sound waste collection, transportation and disposal systems for urban and protected areas.
- establish facilities for the final disposal of hazardous wastes, including expired pesticides.
- conduct pilot projects on resources recovery, including recycling from waste and the development and use of refuse based fuels.

Solid waste is also addressed in the section on urban and industrial pollution in the chapter, "Sector Oriented Strategies", where it is stated that environmental related strategies should include "development of private sector provision of land service and of refuse and waste collection".

6.2.3.5 National Environmental Policy (NEP) (Draft) (1995)

This policy, now in the final draft stage, is very broad in scope and can be regarded as another step towards a comprehensive incorporation of environmental concerns into the fabric of national planning and development.

Six major environmental problems are identified as requiring urgent attention in Tanzania[2]; one of which is environmental pollution. In the section dealing with "Environmental Pollution", it is stated that the urban population is growing very rapidly with at least 3.5 million people now living in urban areas. Thus poor sanitation, inadequate solid waste management, noise and air pollution are all major environmental pollution problems in urban areas.

In the same section, the importation, transport and use of hazardous chemicals and wastes is addressed as a matter of concern especially since even the most basic knowledge of handling these substances is largely lacking in Tanzania. It is stressed that developing countries, such as Tanzania, are in danger of unknowingly or unwittingly becoming a dumping ground for these substances which are a danger to humans and the environment.

EIA is stated to be a key instrument for achieving the objectives of NEP and as part of the NEP's implementation strategy, guidelines and specific criteria for EIA conduct will be formulated. One of the cornerstones of the EIA process will be the institution of public consultations and hearings as part of the EIA procedures.

It is also acknowledged that Tanzania is a signatory and has acceded to a number of international conventions and protocols concerning the environment (see section 2.4). A review of these conventions and protocols will be made with a view to incorporating them into national legislation.

[2] These six problems were also identified in NEAP

6.2.3.6 Environmental Protection Bill (Draft)

Section 12(1)-(3) of the proposed bill deals with EIA and it is stated categorically that EIA should be adopted for the evaluation of development projects in order to attain sustainable development.

6.2.3.7 National Conservation Strategy for Sustainable Development (NCSSD) (Draft)

Together with NEAP, this provides the framework for national environmental management initiatives. NCSSD is a framework for integrating development and conservation, in the understanding that rational resource use will lead to sustainable development. NCSSD provides for the establishment of a legal regime requiring EIA to be mandatory to all development projects and seeks to involve government agencies, NGOs, the private sector and the general community in this process.

6.2.4 International Conventions and Protocols

As acknowledged in NEP, Tanzania is a signatory and has acceded to a number of international conventions and protocols concerning the environment, two of which are discussed below.

6.2.4.1 Convention on Biological Diversity

Tanzania is a party to the Convention on Biological Diversity (Rio de Janeiro, 1992), the objectives of which are "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources".

6.2.4.2 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

Tanzania is a party to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1992). This is a global environmental treaty that strictly regulates the transboundary movements of hazardous wastes and obliges parties to the treaty to ensure the environmentally sound management of such wastes, particularly their disposal. As such, its primary focus is on the movement of hazardous wastes across national boundaries; that is, from one country to another. However, the Convention recognises that the most effective way of protecting human health and the environment from the dangers posed by hazardous wastes is:

- the reduction of their generation at source to a minimum in terms of quantity and/or hazard potential.
- the treatment and disposal of hazardous wastes nonetheless generated as close as possible to their source of generation.

Locally produced or imported chemicals for industrial and agricultural use and other types of hazardous wastes may find their way into disposal sites in Tanzania and subsequently into the groundwater or surface waters, causing direct harm to humans and other organisms or indirect harm through the food chains.

Hence, policies for the disposal of hazardous wastes in Tanzania should be formulated, together with developing approved disposal places and methods for such wastes. Another way to reduce risks is for Tanzania to ban the importation of dangerous products and to enact laws which govern the transport and disposal of such hazardous wastes.

6.2.5 Institutional Framework

The focal point of environmental administration in Tanzania lies with the Division of Environment, formed in 1992. Formerly, this Division was in the Ministry of Tourism, Natural Resources and Environment but is now part of the Vice-President's office. NEMC has also been under the Division since 1996[3]. The Division's duties include looking at wider issues in the environmental field with an oversight mandate; providing environmental policy and technical backup; undertaking policy analysis and formulating strategic policy decisions; and coordinating and catalysing cooperation between major players in environmental programmes.

The existing institutional arrangement is still very new, and lacks the legal strength to define the parameters or to enforce an EIA process. However, the Director of Environment does have the administrative authority to demand an EIA for development projects. The involvement of the Vice-President's office through the Division of Environment encourages a multi-disciplinary approach to a cooperative and collaborative environmental assessment.

Other key agencies include:

- Ministry of Tourism and Natural Resources - forestry, wildlife and marine resources conservation.
- National Land Use Planning Commission - land husbandry.

No permanent responsibility for solid waste management is assigned to any of these institutions although NEMC does have control over the improper disposal of wastes in general. The Ministry of Health also plays a role, at least theoretically, in solid waste management as they are responsible for public health.

Local authorities are responsible for constructing, operating and maintaining economic, social and environmental infrastructure, including the establishment of environmental policies and regulations. As such, they have been empowered to make by-laws regarding protection of public health and welfare and several local authorities have issued environmental sanitation and abatement nuisance by-laws.

6.2.6 Evaluation of Existing Environmental Policies and Legislation

The current environmental management resource base is often not adequate to address the range of environmental impacts of a project. This lack of effectiveness may be attributed to the following factors:

- Absence of adequate environmental policy.

[3] Formerly, NEMC was also under the Ministry of Tourism, Natural Resources and Environment

- A development planning process that lacks a clear and systematic consideration of environmental risks. This is evident from the fact that no clear environmental strategy is followed.
- Lack of procedures for project screening, Environmental Impact Statement preparation and review. Although initial steps have already been taken by NEMC towards establishing national EIA procedures, no firm framework has yet been set up.
- Inadequate provision for collection, analysis and utilisation of data.
- Horizontal fragmentation of environmental responsibility, resulting in poor coordination of activities as well as a vague definition of areas of responsibility, thereby risking overlap or omission of effort.
- Ineffective implementation and enforcement of existing laws and regulations. This common problem is seen to be a result of a lack of appropriate implementation/enforcement agencies and staff and a lack of funds for operation, institutional strengthening and capacity building. In addition, it is not clear who reports to whom when it comes to taking legal measures against transgressors.

To address these problems, it is imperative that the various new policies and legislation in various stages of preparation and legal processing (NEAP, NCSSD, etc.) should be revised and ratified as soon as possible. Furthermore, the issue of improved enforcement of environmental policies and legislation is critical.

6.3 Description of the Project

6.3.1 Location of the Project

The proposed site for the new landfill is the New MECCO quarry located in Kunduchi Ward, Kinondoni District, DSM. The site is located in a rural area along New Bagamoyo Road, approximately 19 km north of the city centre of DSM. This road has recently been rehabilitated and provides good access for refuse collection vehicles from DSM. The location of the landfill site is shown in Figure 6-1.

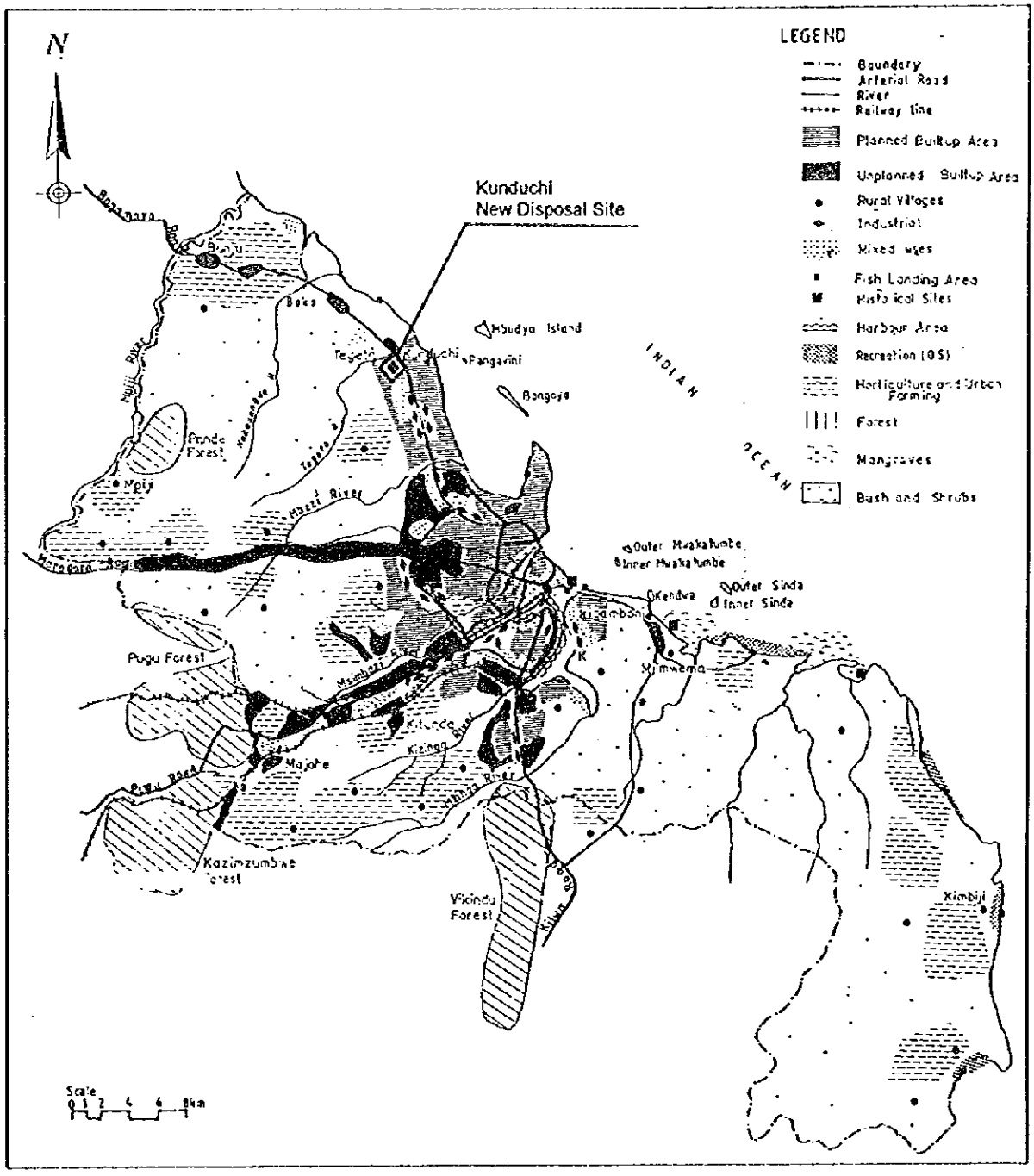


Figure 6-1: Location of the New Landfill Site in Kunduchi

6.3.2 Recommended Concept for the Landfill

The levels of sanitary landfill operation are classified by the JICA Study Team as follows:

- Level 1: Controlled tipping.
- Level 2: Sanitary landfill without bottom liner but operated with daily soil coverage of waste.

- Level 3: Sanitary landfill with bottom liner, leachate collection system and installations for circulation/evaporation of leachate.
- Level 4: Sanitary landfill with bottom liner, leachate collection system and installations for treatment of leachate.

For design of the proposed landfill in Kunduchi the concept of **Level 2, sanitary landfill without bottom liner and with permeation of leachate to the ground water/Indian Ocean**, is recommended. The reasons are:

- The proposed landfill site is located near to the Indian Ocean (~2.5 km) and the groundwater flow is towards the Ocean. Therefore, leachate to be generated in the landfill will have minimum impact on potential groundwater resources.
- The primary groundwater within the vicinity and downgradient of the landfill site is *saline.* All residents in the area are already provided with piped water from the municipal supply.
- According to the cost comparison of level 2 and level 3 of sanitary landfill operation made by the JICA Study Team, the unit cost of level 3 is twice as much as that of level 2 (3,002 and 1,475 Tsh/tonne of waste without interest). Based upon the "user pays" principle, the tipping fee for level 3 of landfill operation shall be almost four times greater than the present fee of 800 Tsh/tonne. This may lead to an increase in illegal dumping operations which will cause more serious adverse impacts on DSM city than the impact of the leachate on the groundwater.
- The installation and maintenance of the bottom liner entails not only considerable cost but also careful landfill operation to maintain impermeability of the liner. In addition the required installations for evaporation of leachate in the case of the construction of a bottom liner are not easily maintained. Due to ferrous compounds in the leachate, the installations require constant supervision and cleaning to prevent pipes from clogging. Treatment methods other than evaporation of leachate (e.g. combined treatment of leachate and sewage in a municipal sewage treatment plant) will not be feasible in the near future in DSM.

6.3.3 Basic Design Conditions

Landfill development and operation of the proposed Kunduchi New MECCO site is designed so as to satisfy level 2 of sanitary landfill operation established by the JICA Study Team. The basic conditions for the design of the landfill are summarised in Table 6-1 and described below.

Table 6-1: Basic Conditions for the Design of the New MECCO Quarry Landfill

Items	Basic Conditions		Remarks
1. Site Area	30 ha		
2. Acceptable Wastes for disposal	• domestic waste • commercial waste • garden waste • bulky waste (furniture, etc.) • market waste • institutional waste • street sweeping waste • non-hazardous industrial waste • non-infectious medical waste • construction and demolition waste		hazardous and toxic wastes, infectious wastes (syringes, etc.), radioactive and liquid wastes of any type are prohibited
3. No. of Refuse Vehicles: • 2000 • 2001 • 2002 • 2003 • 2004 • 2005	 326 units/day 413 units/day 508 units/day 196 units/day 237 units/day 280 units/day		The landfill will receive all waste in DSM from 2000 to 2002 but from 2003 only from Kinondoni District[1]
4. Expected landfill lifetime	11 years (2000 - 2010 inclusive)		
5. Level of Landfill	Level 2: without bottom liner		
6. Available disposal Area	26 ha		
7. Cumulative Disposal Amounts: • From 2000 - 2005 • From 2005 - 2010	Amount (tonnes/d): 4,530 3,290	Volume (1,000 m^3) 2,067 1,500	• Compacted waste density = 900 kg/m^3[1] • Volume includes 12 vol. % of cover soil
8. Construction and Operation Plan	Stages: 1A 1B 2 3	Construction: 1999 1999 2004 2007	Operation: 2000 - 2002 2003 - 2004 2005 - 2007 2008 - 2010
9. Scavenging Operations	to be prohibited		

The recommended land use on completion of landfilling is for agricultural or recreational use; this being compatible with the construction of a hilly landform, described below.

The proposed future landscape (Drawing No. L2), shall comprise a hill, the top of which will be at level approximately 72 m, (i.e. 10 m above New Bagamoyo Road) and situated at a distance of about 250 m from the road. The hill will have a moderate slope (1:15) towards New Bagamoyo Road while towards the western valley, the hill will be steeper but without ever exceeding a gradient of 1:3 in order to ensure long-term slope stability. The average and maximum filling heights will be about 13 m and 25 m respectively. Areas along the boundary of the disposal area should be filled with soil to provide an appropriate link between the surroundings and the waste hill.

Based on this landform concept, the total landfill volume is estimated at **3.5 million m^3**. Increasing the hill height would increase landfill capacity but this was not considered to be acceptable due to aesthetic reasons and the proximity of New Bagamoyo Road.

The area for waste disposal (26 ha) shall be divided into four sections (Drawing No. L3) each with a planned filling period of 2 to 3 years, primarily to minimise the generation of leachate. After having finished landfilling in one landfill section, it will be covered by a final 1 m thick layer of soil and landscaped appropriately (grassed and planted) according to the future land use. Ideally, the soil required for the final coverage of waste will be excavated on site when preparing areas for later sections of the landfill, thereby maximising total landfill capacity.

6.3.4 Design Features

6.3.4.1 Embankments

Embankments shall be constructed between the landfill sections. These must have a height of at least 1.5 m and be connected to leachate drains at the foot of the embankment in order to prevent the seepage of leachate to areas not yet opened for the disposal of waste.

6.3.4.2 Slope Stability

No slopes should be steeper than 1:3 due to the varying frictional strength of the waste and to avoid soil erosion caused by heavy rains.

6.3.4.3 Leachate Control

Leachate will either permeate through the landfill into the ground beneath the landfill or be captured by the leachate drains constructed along the embankments. These leachate drains will discharge leachate to leachate reservoirs from where the leachate will evaporate or infiltrate into the ground.

Once leachate enters the ground beneath the landfill, it will reach the groundwater table and flow with the saline ground water into the nearby Indian Ocean.

The final soil cover should be applied to completed sections of the landfill so as not to create shallow depressions and thus minimise the infiltration of rainwater into the waste.

6.3.4.4 Runoff Control

Clean runoff water from the surroundings will be diverted from the disposal area in order to restrict the generation of leachate by a system of drains constructed along the edge of the quarry excavation that will be used for landfill sections 1A and 1B. This drainage system will be extended as each new landfill section is constructed.

Additional drains will be constructed as required:

- for preventing soil erosion on steep landfill slopes caused by heavy rainfall.
- minimisation of infiltration of rainwater into completed sections of the landfill.

[4] According to the basic concept of solid waste management in DSM, new landfills should start operation in Ilala and Temeke districts in 2003

6.3.4.5 Gas Removal Facilities

It is expected that the utilisation of biogas from the landfill will not be feasible, and hence the landfill shall be furnished with installations for controlled ventilation of landfill gases to the atmosphere. Such installations will be constructed during the operation of the landfill and when furnishing the landfill with final soil coverage. They include:

- A permeable layer along the embankments of the present quarry (i.e. landfill sides) connected to the atmosphere by a number of gas vents to prevent gas migrating through the soil to neighbouring areas.
- A system of ventilated gas drains constructed along the border of the disposal area and at the top of the future waste hill.
- A final soil coverage providing some decomposition (biological treatment) of methane and odorous gases. The soil cover will be underlain by a layer of sand that is ventilated to prevent over pressure and uncontrolled migration of gases.

6.3.4.6 Waste Disposal and Daily Soil Coverage

Upon unloading waste at the tipping front, the waste will be compacted into 0.3 m thick layers on top of each other forming a daily waste layer of approximately 2 m thickness. At the end of each working day, the layer of waste and the tipping front and flanks will be covered by a thin layer of soil (10-15 cm) in order to minimise nuisances (odour, wind-blown paper and pests).

In order to minimise the quantity of soil required for daily soil coverage, as well as potential problems with odour, pests, etc., the unloading of waste must be confined to a tipping front that is as small as possible.

The soil for daily coverage must be stockpiled close to the tipping front and always available. Ideally, it shall be excavated from areas where later landfill sections will be constructed. If this is not possible or excavated quantities are insufficient, it shall be brought in by truck.

6.3.5 Environmental Protection Facilities

6.3.5.1 Waste Control

Ongoing monitoring of incoming waste will be conducted by landfill staff at the weighbridge and tipping face. Prohibited types of waste will be rejected.

Incoming soil as well as construction and demolition wastes should be directed to a soil deposit for stockpiling prior to utilisation as soil cover for waste or for the construction of temporary roads within the disposal area.

6.3.5.2 Monitoring Wells

Two 35 m deep boreholes for monitoring ground water should be constructed east of New Bagamoyo Road, i.e. downstream of the landfill, prior to or at least simultaneously with the initiation of the landfill construction works.

6.3.5.3 Vehicle Washing Facilities

A vehicle washing yard will provide washing facilities for landfill equipment and for refuse collection vehicles. Wash water from this yard will be treated as leachate and diverted to the landfill.

6.3.5.4 Pest Control

Pests, in this context, refers to vectors, vermin and birds, such as flies, mosquitoes, cockroaches, rats and seagulls.

The primary means of pest control will be by operating with a relatively small tipping face, the application of daily soil coverage and the elimination of standing water.

If these measures fail to keep pest populations under control, application of pesticides may be used as a secondary control method.

6.3.5.5 Fire

No fire is allowed on the landfill. If fires do occur, they will be confined, controlled and extinguished immediately by covering with soil.

Proper control and operation of the site as a sanitary landfill will minimise the occurrence of self-ignited fires, due to the relatively small tipping face, compaction and daily soil coverage of the waste.

6.3.5.6 Prevention of Littering

A moveable fence shall be erected near the tipping face and airborne litter should be removed frequently from the fence and surroundings.

Littering of public roads caused by dirty refuse collection vehicles will be limited by cleaning trucks as required at the washing yard before leaving the site.

6.3.5.7 Buffer zone

A buffer zone of 50 m shall be maintained around the site.

6.3.5.8 Noise

The soil embankments at the landfill, quarry side walls and the tree and plant cover which will be provided will contribute to a reduction in noise from the landfill.

6.3.6 Access Road and Reception Area

The reception area shall be located at the boundary of the site and as close to New Bagamoyo Road as possible. Facilities located in the reception area are an administration building, weighbridge, workshop, parking area for landfill equipment and washing yard.

The reception area will be provided with electricity, telephone and water and the landfill equipment parking area will be furnished with a fuel storage tank.

An approximately 150 m long asphalt access road will be constructed parallel to New Bagamoyo Road for refuse collection vehicles to queue along while waiting to complete

weighbridge entry procedures to the disposal site, thus avoiding obstructing traffic flows on New Bagamoyo Road.

A separate track, the "compactor track", will be constructed between the disposal area and the parking area for use by landfill equipment so that it does not use the refuse vehicle access road, thus preventing quick destruction of this road.

6.3.7 Equipment

The recommended permanent equipment for the sanitary landfill comprises:

- Two bulldozers (not less than 20 tonnes) to be used for waste handling and placement.
- an excavator for excavation and loading of soil for daily soil coverage.
- Two dump trucks for transporting soil for daily soil coverage and sand for the permeable sand layer along the edge of the quarry.
- a water tanker for sprinkling of internal roads during dry periods.
- a pick-up for inspection/monitoring purposes.
- a mobile workshop for the servicing of landfill equipment.

6.3.8 Fencing and Planting

Along the greater part of New Bagamoyo Road, existing planting and soil mounds already provide a visual shield to the disposal area.

Fencing and planting around the landfill area will be used to prevent airborne waste from being spread outside the sanitary landfill. Furthermore, the fencing is provided to prevent unauthorised access to the landfill (scavengers) and the planting is used as a visual shield to the disposal area.

6.3.9 Security

The whole reception area will be enclosed by a 2 m high brick wall with security gates, provided with electric illumination and patrolled by security guards.

Unauthorised persons including scavengers are not allowed on the landfill and will be denied access.

6.4 Existing Environmental Conditions

6.4.1 Topography and Geology

6.4.1.1 Topography of the Site

The work carried out for the topographical and geological surveys is described in detail in sections 2 and 3 of the Annex, while the results are presented here. The topographical map is shown in Drawing No. T1. The scale is 1:2000, contour interval is 1.0 m and measurements are in metric units, in accordance with the technical specifications.

Existing terrain features such as houses, roads, drainage, river banks, wells, electricity, telephone poles and other less prominent features are also shown.

The quarry site topography is pictured in Plates 4.1 to 4.3. The original ground elevation was 50 - 65 m a.m.s.l. but a substantial part of the site has been excavated for coralline limestone down to bottom levels of 43 - 48 m a.m.s.l. These excavations have created an extensive cavity of area approximately 30 ha.

6.4.1.2 Borehole Investigations

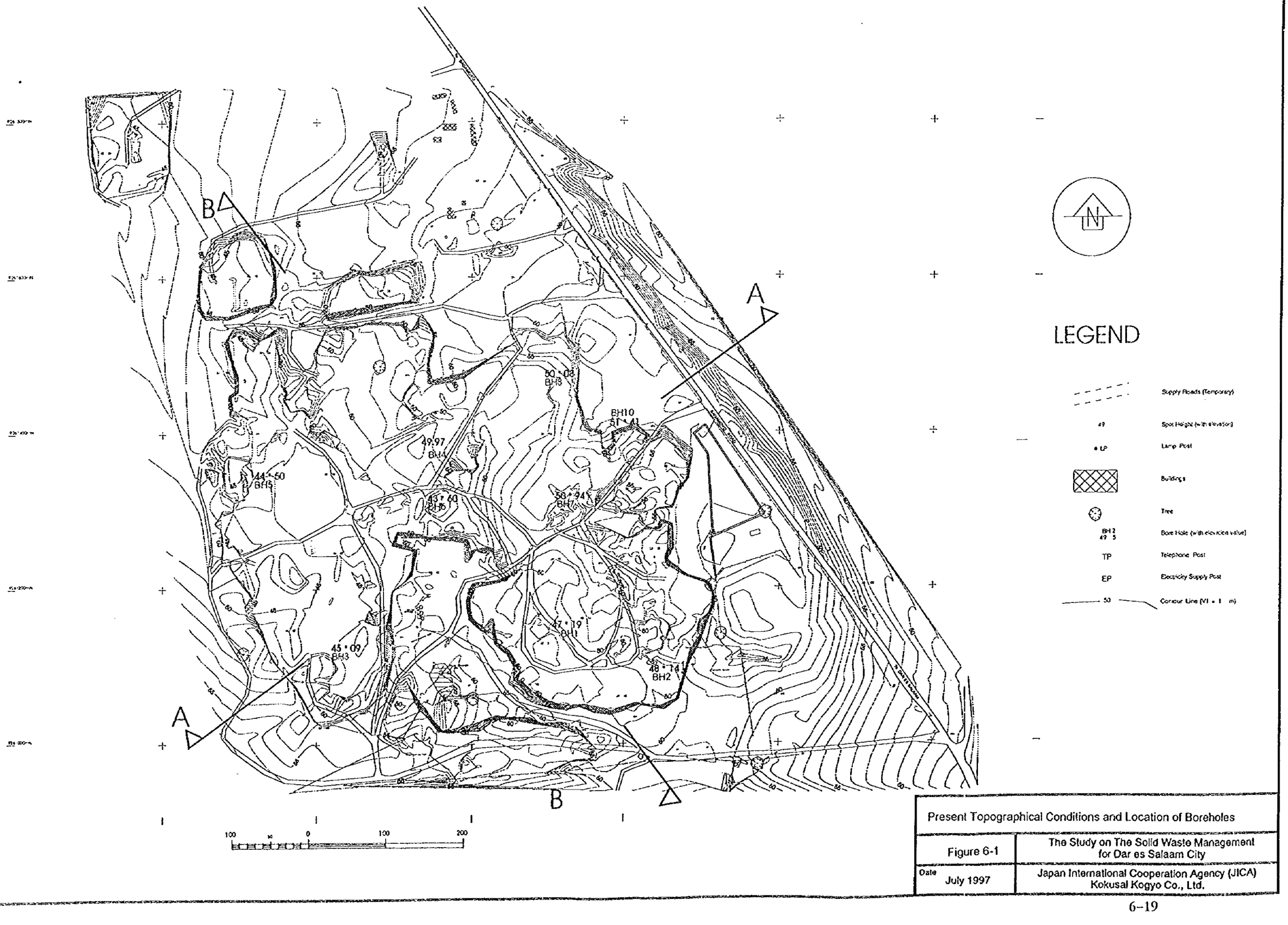
A total of twelve boreholes were drilled within the study area for investigating the geological and hydrological conditions, particularly beneath the bottom of the quarry site. Nine of these boreholes were drilled within the proposed landfill site (see Drawing No. T1) as BH1, BH2, BH3, BH4, BH5, BH6, BH7, BH8 and BH10. The remaining three boreholes were located outside of the landfill site but within the study area as explained further in section 6.4.2 where the hydrological results are also presented.

These boreholes were surveyed as part of the topographical survey. Their locations, height (ground level at top of borehole) and drilled depth are set out in Table 6-2. The drilling depth was variable, depending on the geological conditions for each particular borehole.

Table 6-2: Borehole Particulars

Name	Location	Height (m a.m.s.l.)	Depth (m)
BH 1	within quarry cavity	47.186	15.0
BH 2		48.136	3.5
BH 3		45.087	15.0
BH 4		49.970	3.0
BH 5		44.501	6.4
BH 6		43.603	1.3
BH 7		50.941	5.6
BH 8		50.084	6.2
BH 10		51.405	15.1
BH 11	in valley, west of site	---	4.0
BH 12	in valley, west of site	---	5.5
BH 13	near salt pans, east of site	---	9.2
Total Depth			89.8

Note: Location coordinates of drilled boreholes are specified in section 3 of the Annex



Present Topographical Conditions and Location of Boreholes

Figure 6-1	The Study on The Solid Waste Management for Dar es Salaam City
Date July 1997	Japan International Cooperation Agency (JICA) Kokusai Kogyo Co., Ltd.

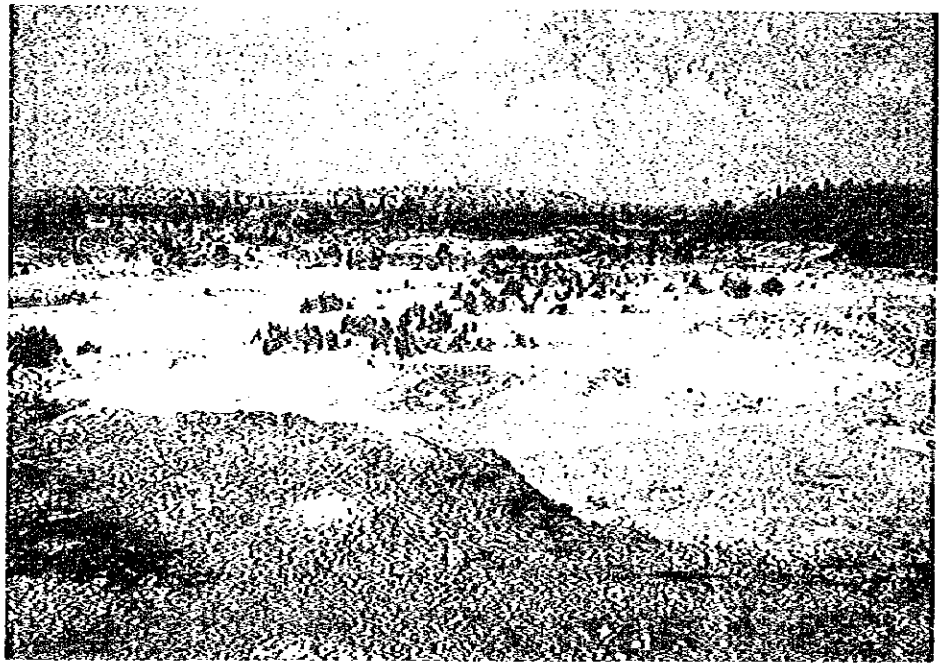


Plate 4.1: Cross-section of the quarry from the south-eastern quarry edge to the northern boundary. The cement factory at Wazo Hill is in the background.

Plate 4.2: South-eastern section of the quarry. Some of the buildings adjacent to New Bagamoyo Road are seen in the background.

Plate 4.3: From the south-eastern edge looking across to the west to the major unexcavated portion of the quarry where some New MECCO offices and facilities are located.

Plate 4.4: View of the quarry side wall near to BH 6. The coralline limestone formations are overlain by red soils which penetrate into cavities within the porous coralline formations.

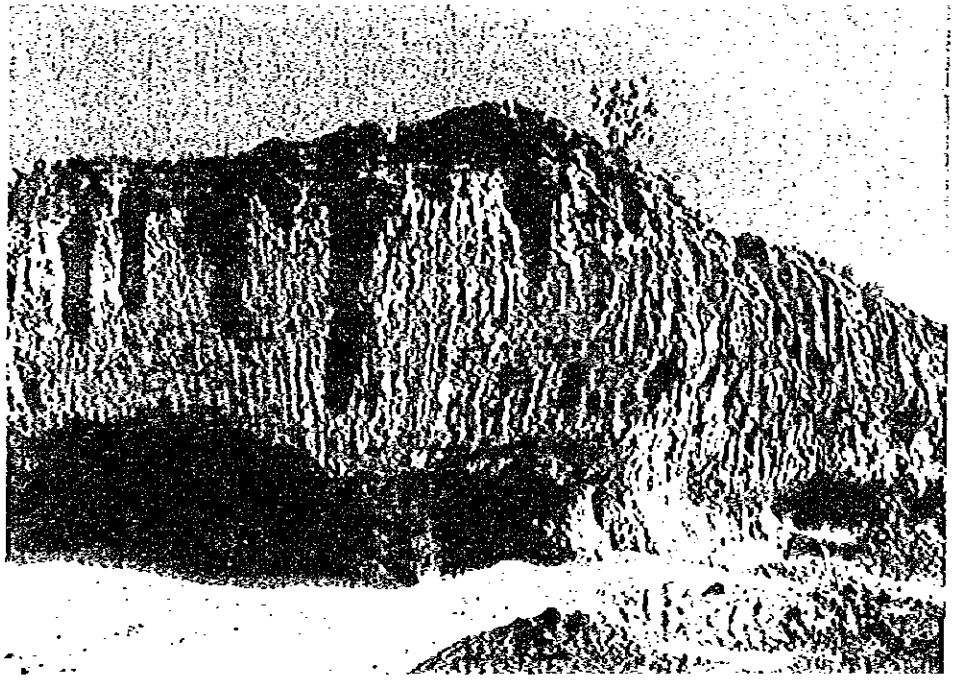


Plate 4.5: Typical section of the quarry side wall, showing the surface to bottom geological profile. This features a succession of rock formations where coralline limestone is being excavated to collect building aggregates. Red soils penetrate into cavities within the porous coralline limestone with shell debris at different depths.

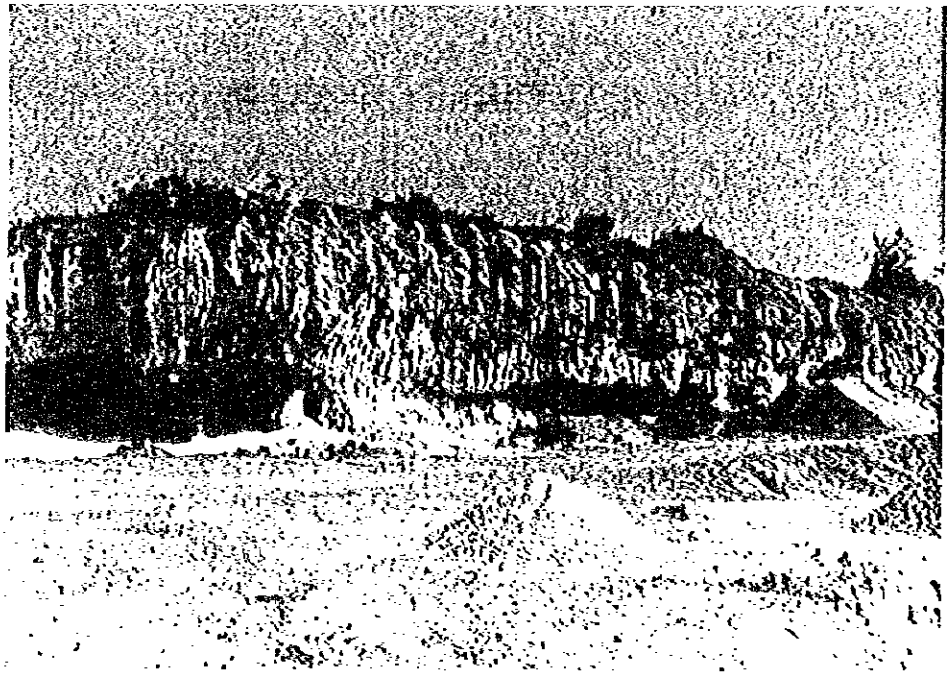


Plate 4.6: Another view of the surface to bottom geological profile. The hill tops are capped with red soils which support scattered bushes. Within the quarry in the foreground, there are two heaps of aggregates which have been manually excavated by small scale miners from the quarry pits to the left.

The soil characteristics of 18 samples taken from the boreholes drilled within the site is presented in section 3 of the Annex. The detailed soil characteristics (Atterberg limits and borehole log records are found in Appendices 1 and 2 of the Data Book respectively.

6.4.1.3 Geology within the Site

Observations of the geology were made along the sides of the quarry (see Plates 4.1 - 4.6). The geologic profile is dominated by a coralline limestone which is being excavated for use as building aggregates. The occurrence of old coral reefs about 2.5 km away from the sea at an elevation of about 43 - 65 meters above sea level is attributed to ancient, tectonic movements of the earth surface.

Two cross-sections, A-A and B-B, were plotted from Drawing No. T1 using soil profiles and borehole data near the lines of section (BH3, BH7, BH10 for A-A; BH1, BH6 and BH4 for B-B) and are shown in Figure 6-3 - Figure 6-4 respectively.

These cross-sections illustrate considerable variation in the site geology within and below the quarry site. Additional data from boreholes (see Data Book, Appendix 2) clearly show that this variation and geologic inconsistency occurs throughout the site. Some boreholes were drilled to a depth of 15 m without encountering limestone or sandstone while other boreholes encountered these rocks at depths of 1 to 6 m. Nevertheless, the geology can be described as consisting of coralline limestone with thin lenses of clay, silt and sand in varying proportions. Clay lenses, when encountered within boreholes, were thin (< 0.5 m), indicating the discontinuous nature of these deposits. Permeability of different soil layers varies from 1×10^{-5} m/s - 2×10^{-11} m/s.

Using this information, it is likely that layers of limestone or sandstone, separated by thin, discontinuous lenses of clay, silt and sand, continue to occur in this fashion at depth. However, it is beyond the scope of this study to confirm these relationships and it would require more extensive investigations to accurately determine the deeper geology of this site.

6.4.1.4 Clay Borrow Sites

Three sites were investigated as possible borrow areas for clay which could be used for the construction of a bottom liner for the proposed landfill. These were:

- The surroundings of the proposed landfill site at Kunduchi.
- A site at Kinzudi, located approximately 10 km from the proposed landfill site.
- A site at Pugu located approximately 45 km from the proposed landfill site.

Samples were taken from prospective clay formations identified within these areas and analysed (see Annex, section 3 for details). Only the bentonite (grey) clay taken from large formations of such clay at Pugu had a satisfactory permeability coefficient ($<10^{-10}$ m/s)[5]. Further tests with 4 mixtures of this bentonite clay and sand (from the bottom of New MECCO quarry) found that mixtures with a 25 - 75% clay content all had permeability coefficients of less than or equal to 2×10^{-10} m/s Thus, a bentonite clay/sand mixture with clay content as low as 25% could possibly be used for the construction of a bottom liner.

[5] Danish standard for maximum value of the permeability coefficient

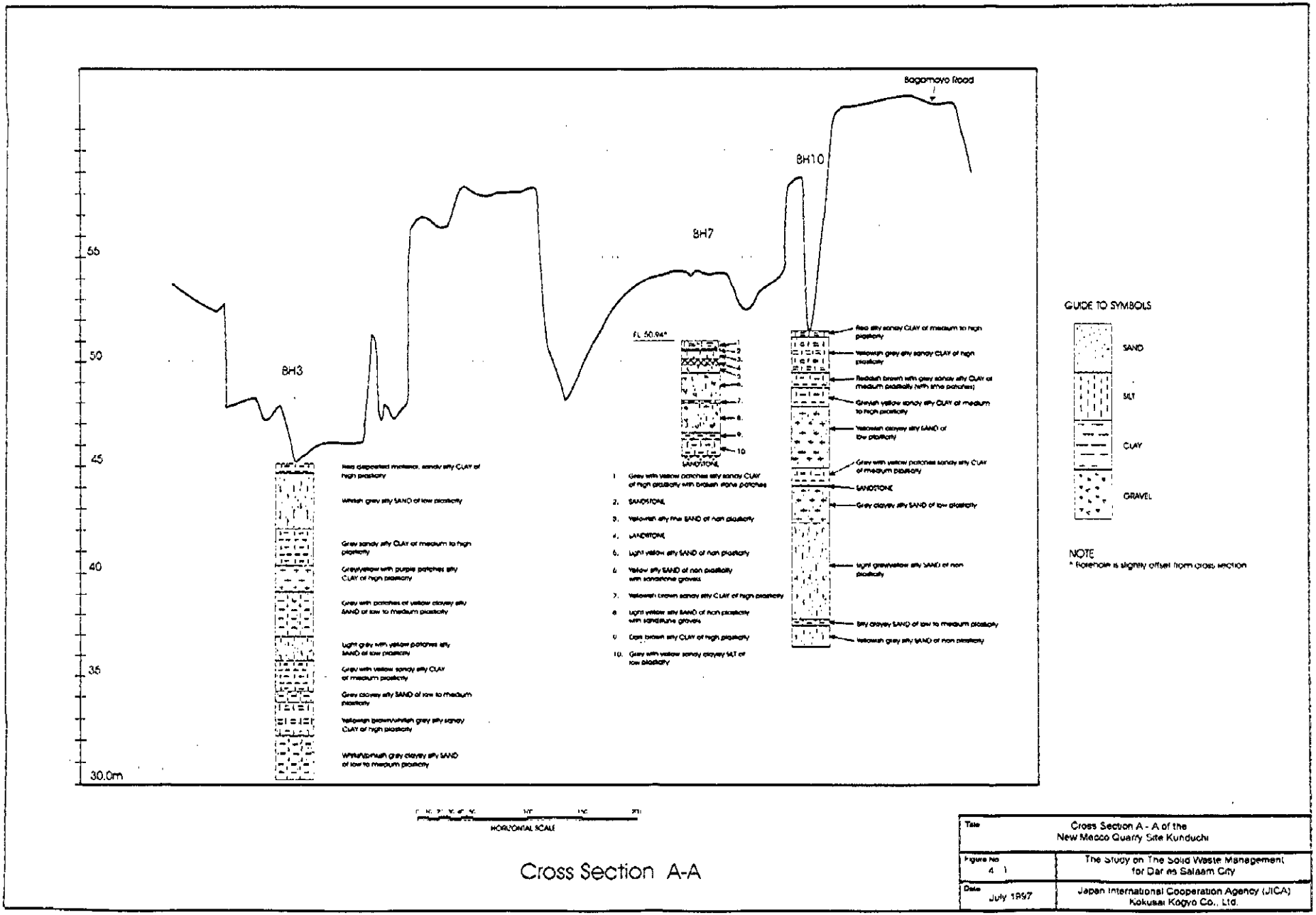
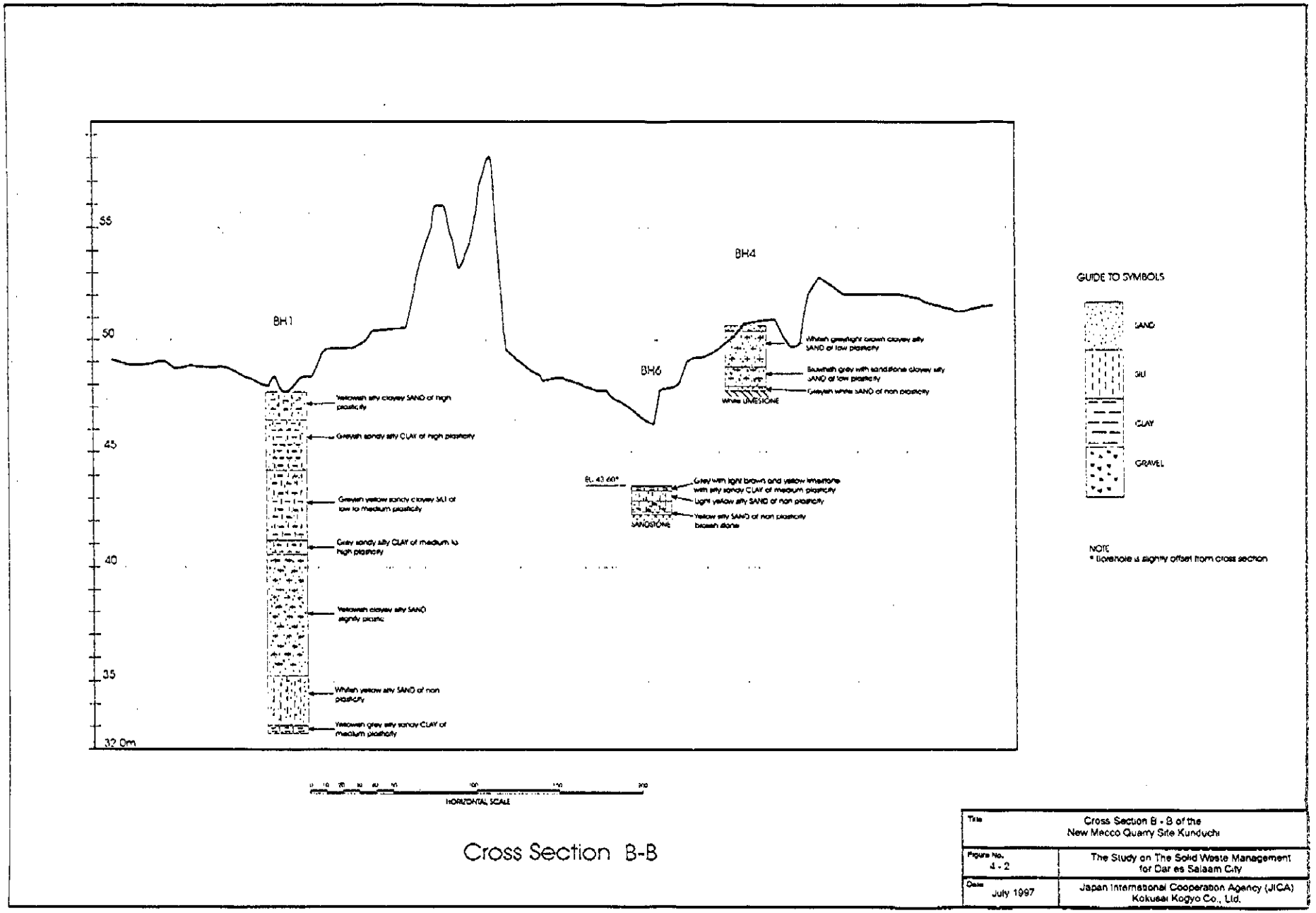


Figure 6-2: Cross-section A-A of the New MECCO Quarry Site, Kunduchi



Cross Section B-B

Title	Cross Section B - B of the New Mecco Quarry Site Kunduchi
Figure No. 4 - 2	The Study on The Solid Waste Management for Dar es Salaam City
Date July 1997	Japan International Cooperation Agency (JICA) Kokusai Kogyo Co., Ltd.

Figure 6-3: Cross-section B-B of the New MECCO Quarry Site, Kunduchi

6.4.2 Hydrological Conditions

6.4.2.1 Groundwater

The groundwater table level was investigated from the disposal site to the sea, using the 9 boreholes drilled for the geological survey within the disposal site (BH1 - BH8 and BH10 in Drawing No. T1) and 3 boreholes, located outside of the landfill site but within the study area (Figure 6-4). Two of these (BH12 and BH11) were drilled in the valley, approximately 450 and 750 metres west respectively of the western boundary of the landfill site while the third (BH13) was drilled near the salt pans located about 1,400 metres to the east of the site's eastern boundary, near the Indian Ocean. The groundwater conditions are described below with reference to Figure 6-5 which shows a cross-section of the area through the landfill site to the Indian Ocean.

Within the quarry site, no water was struck for any of the nine boreholes drilled during the survey period (January - March). Three of these boreholes (BH1, BH3 and BH10) were drilled to a depth of 15 m equivalent to 30, 32 and 36 metres a.m.s.l respectively (to the nearest metre). 29.72 metres a.m.s.l. was the greatest depth reached by any of these boreholes. Hence, it can be assumed that the groundwater table below the quarry site is located below 30 metres a.m.s.l.

In the valley to the west of the site, BH11 struck groundwater at an elevation of 44.5 metres a.m.s.l (4.0 m below the ground surface). There are some other dug wells within this valley with water levels at 0.3 - 1.5 m below the surface. These wells contain water, even during the dry season. The water from these sources is not saline. The geology of this valley is characterised by shallow patches of sand on top of clay (see borehole log diagrams for BH11 and BH12). The infiltration of water through permeable ground is halted by these clay lenses and hence localised areas within the valley, such as these, have their own perched water table.

East of New Bagamoyo Road and from the bottom of the Old MECCO quarries, the terrain falls relatively steeply to a level of about 10 metres a.m.s.l. where two saline water springs are found. From these springs, an approximately 2 km wide swampy area, populated by mangroves, slopes gently towards the Indian Ocean (Plate 4.7).

Within the swampy area, salt pans (Plate 4.8) have been built, north-east and south-east of the landfill site. The salt pan owners confirmed that the bottom of these pans never reach the groundwater, which must be true as otherwise the pans could not be used for the production of salt. The drilling of BH13 verified this as saline groundwater was struck at 0.6 metres a.m.s.l., 2.4 m below the ground surface and about 1 m below the bottom of the deepest salt pan.

The groundwater potential of the coastal region was studied as part of the 1979 Water Master Plan[6]. Generally, the groundwater is saline. Close to the coast, saltwater intrusion occurs. However, sometimes even far inland, water has been encountered exhibiting excessive chloride concentrations. A number of explanations have been suggested for this, including chloride being released by host minerals, chloride being present as a result of previous seawater inundation.

[6] "Coast/Dar es Salaam Regions Water Master Plan"; CBA Engineering Ltd.; Canada, 1979

Plate 4.7: A view from the saline springs across the wide swampy area, populated by mangroves towards the Indian Ocean.

Plate 4.8: Some of the salt pans, constructed north-east of the disposal site.

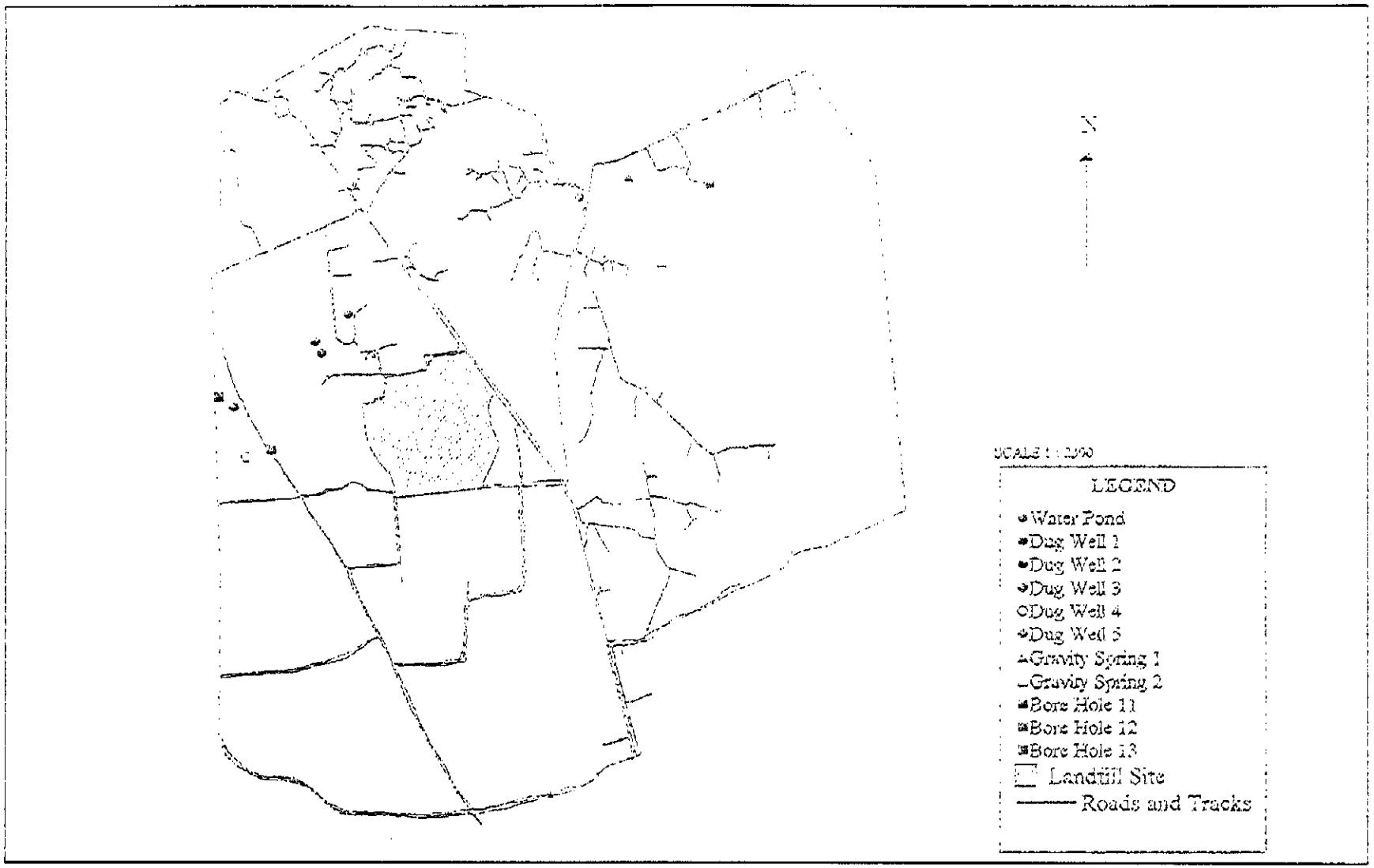


Figure 6-4: Water Sampling Points within the Study Area at Kunduchi

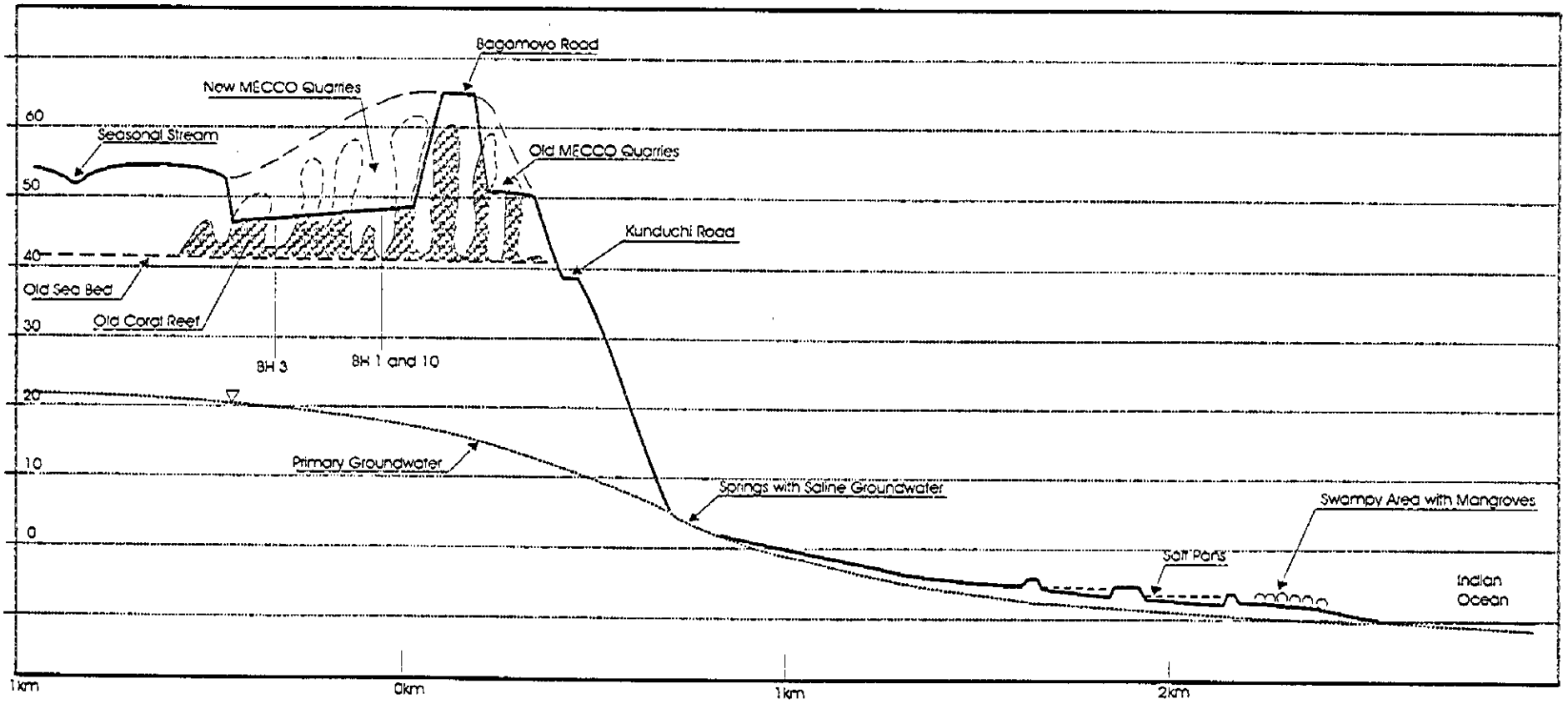


Figure 6-5: Cross-section of the Area through the Site to the Indian Ocean

Data was obtained from the Ministry of Water on existing boreholes within the Kunduchi area which were established more than 20 years ago before the expansion of the existing piped water supply (see Data Book, Data 7, section 4). At present, most of these boreholes are not in use, primarily due to salt water intrusion but also because of vandalism.

On the basis of these results and observations, the primary groundwater is saline, located at lower than 30 metres a.m.s.l. below the bottom of the New MECCO quarry and flows in the direction towards the Indian Ocean. As Figure 6-6 shows, it is expected that the groundwater table level below the landfill site is at approximately 20 metres a.m.s.l.

6.4.2.2 Surface Water

The surface water conditions within the study area are summarised below and illustrated in Figure 6-7.

There are only seasonal surface water sources around the proposed disposal site at Kunduchi. The major surface water source is Tegeta River to the north of the study area which flows into the Indian Ocean about 2 km north-east of the site. This river is a physical boundary of the Kunduchi/Salasala/Mtongani and Tegeta areas and is formed by tributaries from the adjacent catchment areas. During the entire three month survey period, the river and its tributaries were all dry. Hence, it was not possible to measure surface water flowrates during this time. Neither was it possible to use historical data for this purpose, as no discharge data was available from the Water Department (Hydrology section) as this river is not under a long-term monitoring programme. However, it is known that the lower reaches of this river experiences floods during heavy rains.

Within the quarry pits on site, virtually all of the surface runoff is trapped, thus creating large water pools in the pits during the rainy season.

Stormwater runoff from the areas outside the site on the north and west sides is drained off to the valley west of the site, where the approximate level at the bottom of the valley is 45 m. The valley contains a stream which is dry throughout most of the year. However, during the rainy season, the stream connects to Tegeta River as described above.

The areas outside the site on the south-east and eastern sides drain towards Mtongani village and into the swampy area near the salt pans.

Directly south of the site, there is a very shallow, seasonal water pond, which is only present during the rainy season, collecting and storing stormwater runoff from catchment areas to the south of the site, which subsequently evaporates on the cessation of the rains. No survey map for the area immediately south of the site is available and hence it is not possible to determine the size of this pond's catchment area, nor is there any historical data on the variation in water volume of this lake. However, during flood events, water may flow via an overflow channel from this pond to the New MECCO quarry.

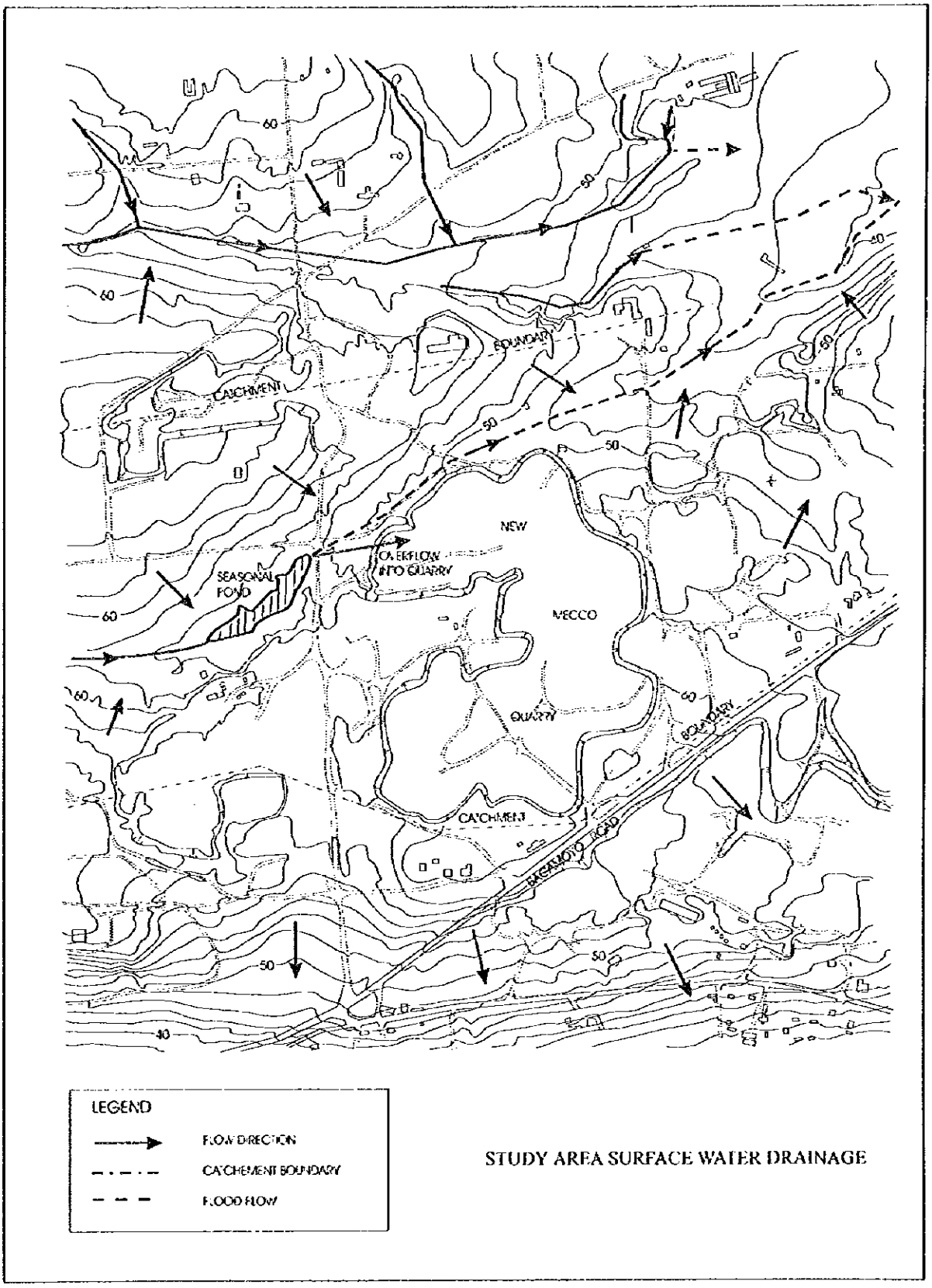


Figure 6-6: Surface Water Conditions within the Study Area at Kunduchi

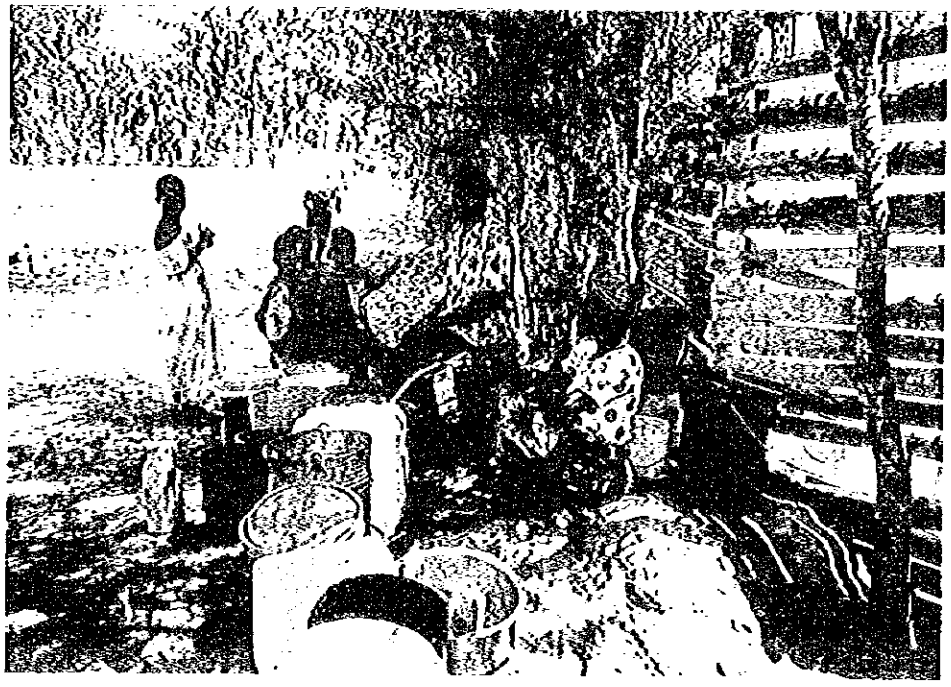


Plate 4.9: Local people filling water containers from a tap near the salt pans connected to the municipal piped water supply.

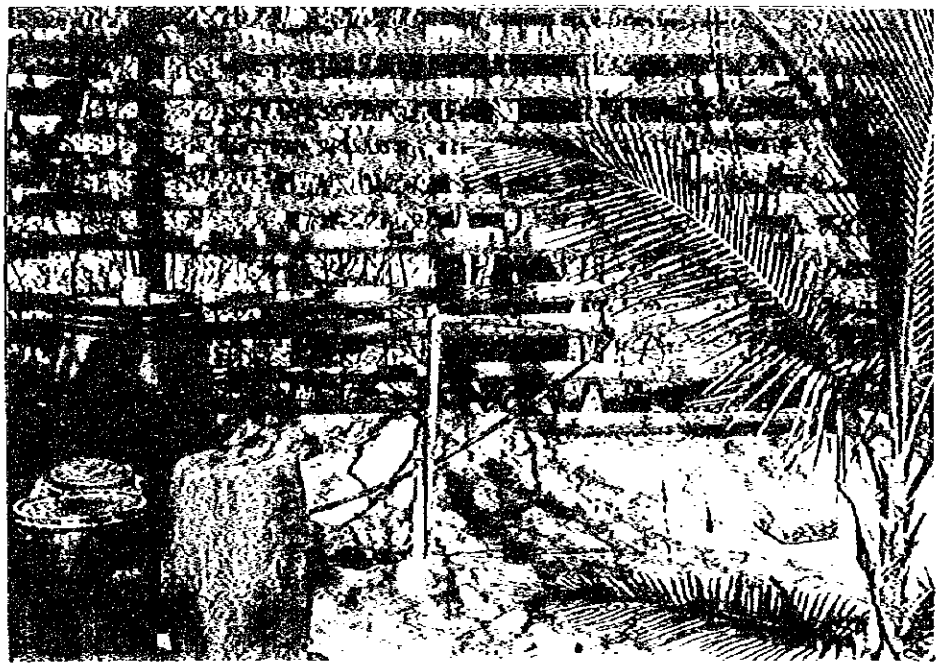


Plate 4.10: The tap the woman above is using to obtain water.

6.4.3 Water Use

Investigations were made of water use from surface water and groundwater sources within the study area (see Figure 6-5).

6.4.3.1 Regular Water Supply

The regular water supply for Kunduchi, Mtongani, Salasala and adjoining areas is piped water from the lower Ruvu Water Treatment Plant at Bagamoyo. This is the primary source of water for all people living in these areas and the supply is generally good with minimal interruptions.

6.4.3.2 Surface water use

All surface water sources within the study area are seasonal. The Tegeta River is the major seasonal surface water source. During the rainy season, this river is used as an alternative water source, especially if the piped water supply is cut. The water fetched from Tegeta river is used for laundry, bathing and other domestic purposes excluding drinking. During long dry periods, improvised wells are usually made at the river banks, especially near the Bahari Beach Road crossing.

6.4.3.3 Groundwater Use

The groundwater use survey covered a total area of more than 2 sq. km. In the western and north-western parts of the study area, groundwater from dug wells (mainly traditional) makes an important alternative source of water at periods of water shortages/cuts. Of these, only dug well No. 2 at an elevation of 44.5 m a.m.s.l. is used for drinking water purposes during times of water shortages. This well is reported to be used by more than 1,500 people residing in Salasala, Mtongani and Boko areas.

East of New Bagamoyo Road, at a level of approximately 10 metres a.m.s.l. are found two water springs. These springs have a high yield but are not used for drinking water purposes as the water is saline. Instead, the springs provide water for laundry and bathing purposes for residents not connected to the city water supply network. Borehole 13, drilled as part of this study further east of the springs near the salt pans, confirmed the salinity of the groundwater in this region.

6.4.4 Water Quality

A Water quality survey was carried out in the study area in conjunction with the Hydrological and Water use surveys as set out below. Water samples were taken from selected points, set out in Table 6-3 and located as shown in Figure 6-5, at approximately fortnightly intervals three times over a three month period.

These water samples were analysed for 21 parameters. The methodology and complete results are set out in section 6 of Data 7. The results for each sampling point over the sampling period were very consistent and consequently average values were calculated and are presented here in Table 6-5.

Table 6-3: Sampling Points

Water source	Sampling point	Nature of sampling point
groundwater	BH11	borehole in farm in valley to west of landfill site
	BH13	borehole at salt pans to east of landfill site
surface water	SP/1	gravity spring 1
	SP/2	gravity spring 2
	Pond	water pond in farm
groundwater	DW/1	dug well in farm (not for domestic use)
	DW/2	dug well in farm (used for domestic purposes)
	DW/3	dug well in farm
	DW/4	dug well in TANESCO premises on banks of Tegeta river

The average faecal coliform (FC) count for each sampling point varied from 77 - 2670 FC/100 ml which indicates that all the water sources, including the gravity springs, are contaminated. Hence, the consumption of any of these waters constitutes a health risk.

Groundwater from the springs (SP/1 and SP/2) and the borehole, BH13, located near the salt pans, shows a high average chloride content of 5690, 5313 and 8330 mg/l respectively, indicating that these groundwater sources are highly saline. Consequently, these groundwater sources are not likely to be used as drinking water sources, as was verified in the water use survey.

Furthermore, these springs and BH13 have high BOD_5 loadings of 125 and 628 mg/l and high COD loadings of 174 and 937 mg/l respectively, indicative of considerable pollution and/or organic loading in the associated aquifers.

BH13 also had cadmium and arsenic levels 10 and 7 times the WHO guidelines. This may be due to leaching of ions from the soil (see section 6.4.5).

6.4.5 Soil Contamination

Two soil samples were taken: one from the Old MECCO quarry (OMQ); the other from the New MECCO quarry (NMQ). Soil analysis results, set out in Table 6-4, indicate that cadmium (Cd), lead (Pb), iron (Fe), copper (Cu) and manganese (Mn) are present in measurable amounts in both samples. All of these elements occur naturally in soils, being produced from the natural weathering of rocks.

Because of their toxicity, the levels of cadmium, lead and copper are of particular interest. Comparing the measured concentrations with the average levels found in US soils, it can be deduced that the levels are not abnormal and thus attributable to naturally occurring deposits and not to man-made pollution sources.

Table 6-4: Soil Analysis results

Parameter	Units	Cd	Pb	Cr	Cu	Zn	Fe	Mn
OMQ	mg/l	0.215	0.9	<0.003	0.65	<0.002	1.36	0.23
NMQ	mg/l	0.16	1.1	<0.003	0.5	<0.002	0.910	0.365
Average Levels in US soils	mg/l	0.26[1]	10[2]	100[2]	30[2]	50[2]	not known	not known

Note: [1] "Soil Cadmium Monitoring Data, Memorandum"; Carey, A.E.; EPA, Washington D.C.; July 23, 1979; [2] Lindsay, 1979

Table 6-5: Water Analysis Results (Average values for three samples taken 14 Feb., 28 Feb. and 14 Mar.)

PARAMETER	UNITS	BH13	BH11	SP/1	SP/2	POND	DW/1	DW/2	DW/3	DW/4	Standards
Air Temperature	°C	31.5	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	
Water temperature	°C	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	28.9	
Weather		Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	Sunny	
Colour		34950	3500	6.0	13.0	13.0	40	25	127	550	50 (MAC)[1]
Turbidity	NTU	12200	2460	2.0	5.0	60.0	12.3	7.0	44.3	181	5 (AQ)[2]
pH		7.1	6.5	8.3	9.3	8.6	6.9	6.0	8.4	7.5	6.5 - 8.5 (AQ)[3]
Filterable solids (Dry matter)	mg/l	2350	433	0.43	1.6	1.6	1.4	0.75	2.5	1.29	none[2]
Electrical Conductivity	mS/cm	140	0.56	9.8	9.9	0.62	0.20	0.21	0.51	0.32	0.4[3]
Dissolved Oxygen	mg/l	4.3	5.6	6.7	6.2	4.9	6.4	6.4	6.5	6.0	> 4.0
Chemical Oxygen Demand	mg/l	937	96	179	169	74	150	43	129	153	< 10.0
Biochemical Oxygen Demand	mg/l	628	57.0	127	122	50	99	30	85.4	97	< 6.0
Suspended Solids	mg/l	31490	1680	2.3	4.4	55.7	13.6	5.0	47.0	146	none[2]
Faecal Coliforms	count/ 100ml	470	77	700	365	998	1350	160	87	2670	0 (MB)[2]
Total Nitrogen	mg/l	162	86.8	1.7	1.6	3.1	2.5	8.8	2.5	1.73	50 (MAC)[3,4]
Ammonia (NH_4^+)	mg/l	22.5	34.0	1.3	0.27	0.39	0.51	0.43	0.32	1.11	0.5 (MAC)[3]
Sodium (Na^+)	mg/l	2174	81.7	1611	1630	34.1	33.6	29.0	39.5	28.2	200 (AQ)[2]
Calcium (Ca^{++})	mg/l	453	1.29	614	367	114	383	44.8	267	352.8	200 (MAC)[1]
Iron (Fe)	mg/l	96.5	27.9	0.11	0.0	0.55	0.39	0.63	0.30	1.8	0.3 (AQ)[2]
Chloride (Cl^-)	mg/l	8330	278	5690	5313	73	58	66.0	220	88	250 (AQ)[2]
Sulphate (SO_4^{2-})	mg/l	7140	71	2518	1940	22.4	36.5	37.4	34.8	22.7	400 (AQ)[3]
Chromium (Cr^{6+})	mg/l	0.025	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.05 (IC)[2]
Cadmium (Cd)	mg/l	0.05	0.02	0.04	0.03	0.01	0.02	0.01	0.01	0.02	0.005 (IC)[2]
Lead (Pb)	mg/l	0.22	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	0.05 (IC)[2]
Arsenic (As)	mg/l	0.34	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.05 (IC)[2]

Note: AQ = aesthetic quality, IC = inorganic constituents of health significance, MB = microbiological and biological quality, MAC = maximum admissible concentration.

[1] = "International Standards for Drinking Water Quality"; 3rd edition; WHO; Geneva; 1971

[2] = "Guidelines for Drinking Water Quality"; WHO; Geneva; 1984

[3] = "European Economic Community Drinking Water Directives"; *Official Journal of the European Communities*; August 30, 1980; Vol. 23; Official Directives no. L229/11 - L229/23

[4] = The stated standard for total nitrogen is expressed here in terms of nitrate only.