Solid Waste Management Plans for Safi and El Jadida

Part 2
Waste Disposal Plan for El Jadida

Exchange Rate (as of July 1997)

1 Dirham = 0.115 US dollars = 13 yen

Abbreviation List

BMH	Municipal Health Service
CNE	National Council for Environment (Conseil National de l'Environement)
CRE	Regional Council for Environment (Conseil Régional de l'Environement)
DAHIR	Law, Decree, or other legal document signed by the King
DH	Dirham
EU	European Union, E.E.C
FEC	Fond D'Equipement Communal Communal Fund for Equipment
GDLC	General Department of the Local Government, MoI
HCS	Haul Container System
MoA	Ministry of Agriculture
MoC&I	Ministry of Commerce and Industry
MoE	Ministry of Environment
MoEM	Ministry of Energy and Mines
MoH	Ministry of Health
MoI	Ministry of Interior
MoPW	Ministry of Public Works
NP	National Promotion
ONEP	National Office for Drinking Water
SWM	Solid Waste Management
USE	Under Secretariat for Environment, MoI
Veh.	Vehicle

Final Report
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Current Book and Part are marked with "*".

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THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

INTRODUCTION

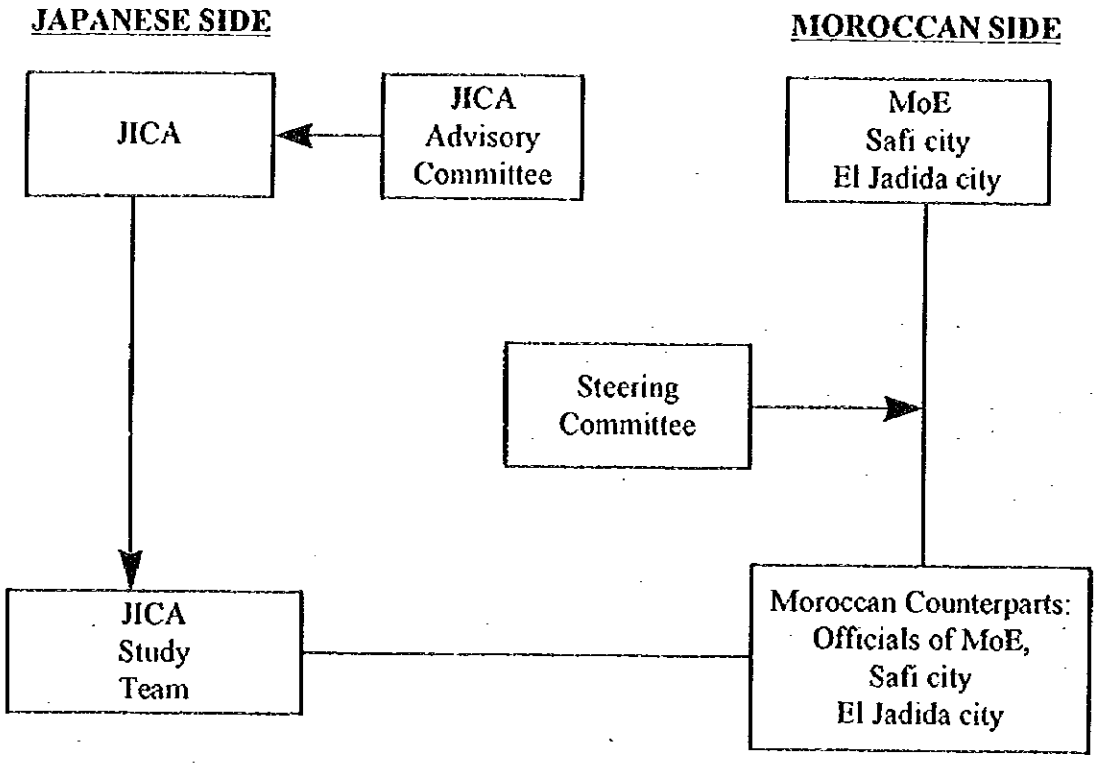
1. Objectives of the Study

The objective of the Study is to strengthen the capacity of solid waste management at both national and local levels. This study has been executed by Japan International Cooperation Agency (JICA) based on the request from the Government of Morocco. JICA commissioned the study to a joint venture comprising EX Corporation and Yachiyo Engineering Co., Ltd. The joint venture has organized a study team comprising of 11 specialists. The Study has been conducted jointly by Japanese consultants and their Moroccan counterparts.

The study period was about 18 months from January 1996 to July 1997. The Study is divided into two phases, the first phase being from the beginning up to September 1996, and the second phase being from October 1996 till the end. The objective of the first phase study is to formulate the guidelines and action plan for solid waste management at both national and local levels. The objective of the second phase is to apply the guidelines formulated and check their applicability. Two cities, i.e. Safi and El Jadida were selected for the second phase. The Study team in collaboration with the counterparts in Safi city have formulated a plan for improvement of solid waste management. In addition, we have implemented a public education campaign (demonstration project) aiming at strengthening citizens' understanding and cooperation concerning city cleansing. We have also formulated a plan for improvement of disposal of solid waste for El Jadida. It is expected that the plans will serve as a model for other local authorities in Morocco.

2. Study Organization

The study organization is shown in the figure below. This study has been conducted jointly by the Study Team led by Mr. Ohno and the Moroccan counterparts, i.e. officials of Ministry of Environment, Safi city and El Jadida city. A key counterpart agency on the Moroccan side is the Ministry of Environment. For the smooth execution of the study, the Moroccan side formed a steering committee comprising of representatives of the Ministry of Environment, Ministry of Interior, Ministry of Health, Ministry of Public Works, and Ministry of Commerce and Industry. Mrs. Layachi, Director, Department of Observation, Study and Coordination, Ministry of Environment served as chairman of the steering committee. On the Japanese side, an advisory committee was formed for the study. Dr. Masaru Tanaka, Director, Department of Waste Management Engineering, the National Institute of Health, served as chairman of the Advisory Committee.



MoE: Ministry of Environment

3. Reports

This study has produced the following reports:

1. Inception report
2. Progress report (1)
3. Interim report
4. Progress report (2)
5. Draft final report
6. Final report

The final report consists of the following Books:

Book 1 Guidelines for National Level Policies and Actions for Solid Waste Management
Part 1 National Strategy
Part 2 Laws, Institutions, and Finance
Part 3 Industrial and Hazardous Waste
Part 4 Infectious Waste

Book 2 Guidelines for Improvement of Solid Waste Management for Urban Communes and Communities
Part 1 Management and Institutions
Part 2 Technical Guidelines

Book 3 National Action Programs for Solid Waste Management

Book 4 Solid Waste Management Plans for Safi and El Jadida
Part 1 Solid Waste Management Plan for Safi
Part 2 Waste Disposal Plan for El Jadida

Book 5 Summary

Book 6 Supporting Report :
Current Conditions of Solid Waste Management in Morocco

Book 7 Data Book:
Appendices to Solid Waste Management Plan for Safi

Book 8 Japanese Summary

All the Book except for Book 8 has been prepared in English and French.

4. Solid Waste Management Improvement Plans for Safi and El Jadida (Book 4)

This book contains the following two Parts:

Part 1 Solid Waste Management Plan for Safi
Part 2 Waste Disposal Plan for El Jadida

The two reports were prepared as the result of the second phase study.

An objective of the second phase study is to improve solid waste management in the cities of Safi and El Jadida. In addition, the second phase study has the following important objectives: 1) to examine the applicability of the Guidelines, 2) to reflect findings obtained through these activities in the Guidelines.

CHAPTER 1 INTRODUCTION

1.1 Objectives

The objective of this study for El Jadida is to prepare a waste disposal plan. Main focus of the plan is a new sanitary landfill. It is expected that the disposal plan for El Jadida will serve as a model for Moroccan cities. Experience gained through this study has been reflected in the National Guidelines.

1.2 Study Method

To prepare a disposal plan for El Jadida, the following information was utilized: 1) answers provided by the province of El Jadida to the questionnaire sent by the JICA Study Team, 2) results of waste collection quantity survey conducted by the province using truck scale, 3) topographic maps of planned landfill site and the existing site, population and other information provided by the province. The JICA Study Team paid a few visits to the planned sites.

In the first stage, one site was selected out of the 2 candidate sites through the comparison and evaluation of the 2 sites.

Current waste collection was estimated mainly on the basis on results of waste collection quantity survey and assumptions about visitors' waste. Future waste generation was projected on the basis of the future population and assumptions about economic growth. Target rates of waste collection were proposed assuming that current rate is 85 %, and the collection rate should reach 100 % by 2010.

1.3 Study Organization

This study has been carried out by the JICA Study Team and the Counterparts of the Province and Municipality of El Jadida.

CHAPTER 2 WASTE GENERATION - CURRENT AND FUTURE

2.1 Current Generation

1) Generation Quantity

Estimated waste generation of the study area in 1996 is 102 ton/day, of which 76 ton/day is generated in the municipality of El Jadida, and the remaining 26 ton/day is in the 3 centers of the rural commune My Abdellah. Seasonal variations due to visitors are reflected in the estimation. In 1996, per capita generation rates are 608 gram/capita/day in El Jadida, and 3580 gram/capita/day in the rural commune. 83 % of the waste of the rural commune is generated by visitors.

2) Methods of Estimation

The current waste generation quantities of the study area were estimated on the basis of 1) the results of the waste collection survey conducted in November 1996 using a truck scale, and 2) assumption that the ratio of collection quantity to generation quantity is 0.85, and 3) other assumptions explained below.

a. El Jadida

According to the waste collection quantity survey conducted using truck scale, the average daily quantity collected by the municipality of El Jadida was 66.04 ton/day. It is considered that waste quantity varies by seasons. It is assumed that the waste generation changes in proportion to water consumption. As a result, average daily collection is estimated to be 64.6 ton/day. Assuming that the rate of collection is 85 %, the generation is estimated to be 75 ton/day. (64.6 ton/day ÷ 0.85 = 75 ton/day)

Table 2.1-1 Summary of Waste Collection Survey Conducted during 22 - 28 November 1996 Using Truck Scale

Survey Date	Day	Waste Collected by the Municipality of El Jadida (kg)	Waste Collected by the Rural Commune of My Abdellah (kg)
1st day: 22 November 1996	Friday	67005	5970
2nd day: 23 November 1996	Saturday	55725	20520
3rd day: 24 November 1996	Sunday	51640	8300
4th day: 25 November 1996	Monday	81670	11560
5th day: 26 November 1996	Tuesday	72860	9590
6th day: 27 November 1996	Wednesday	69835	17545
7th day 28 November 1996	Thursday	63520	16380
Total of the 7 days		462255	89865
Average per day		66036	12838

Table 2.1-2 Estimation of Waste Collection Quantity of the Municipality of El Jadida

	Base Quantity Surveyed in November (ton/day) (a)	Monthly Variation Nov.=1 (b)	Number of Days (c)	Monthly Collection (d)=a*b*c
January	66	0.83	31	1699
February	66	0.83	28	1535
March	66	0.83	31	1699
April	66	0.96	30	1902
May	66	0.96	31	1965
June	66	0.96	30	1902
July	66	1.12	31	2293
August	66	1.12	31	2293
September	66	1.12	30	2219
October	66	1.00	31	2047
November	66	1.00	30	1981
December	66	1.00	31	2047
Total			365	23582
			Daily Average	64.6

b. 3 Centers of Rural Commune of My Abdellah

Main assumptions used for estimating waste generation in My Abdellah are that 1) there are constantly 60,000 visitors staying each day at Sidi Bouzid during 4 months of summer period, and 2) there are 220,000 persons constantly during 3 weeks in August to participate in the festival of Moussem of Moulay Abdellah. 3) one visitor generates 0.6 kg of waste per day

According to the truck scale survey, the rural commune of My Abdellah collected 12.8 ton of waste per day during the survey period. Majority of this waste was collected because of special collection efforts made in response to the King's letter. It is assumed that regular generation is a half of this quantity. Based on the above assumptions, waste generation in the rural commune in 1996 is estimated to be 26.1 ton/day. See the table below.

Table 2.1-3 Estimation of Waste Generation in the 3 Centers of the Rural Commune of My Abdellah

	Regular Generation (ton/day) (a)	Tourists in Sidi Bouzid (ton/day) (b)	Tourists in My Abdellah (ton/day) (c)	Total (ton/day) (a+b+c)= (d)	Number of Days (e)	Monthly Generation (ton/month) d*e = (f)
January	6.4	0.0	0.0	6.4	31	198.4
February	6.4	0.0	0.0	6.4	28	179.2
March	6.4	0.0	0.0	6.4	31	198.4
April	6.4	0.0	0.0	6.4	30	192.0
May	6.4	18.0	0.0	24.4	31	756.4
June	6.4	36.0	0.0	42.4	30	1272.0
July	6.4	36.0	0.0	42.4	31	1314.4
August	6.4	36.0	89.4	131.8	31	4085.8
September	6.4	18.0	0.0	24.6	30	738.0
October	6.4	0.0	0.0	6.4	31	198.4
November	6.4	0.0	0.0	6.4	30	192.0
December	6.4	0.0	0.0	6.4	31	198.4
Total					365	9523.4
					Daily Average	26.1

2.2 Projection of Future Waste Generation

Waste generation in the study area will increase from 102 ton/day in 1996 to 185 ton/day in 2010, 1.8 times larger. Annual rates of increase will be about 4.1 % in the study area, 4.7 % in the area of municipality of El Jadida, and 3.2 % in the 3 centers of My Abdellah. Table 2.2-1 shows the projection of waste generation for the period 1996 - 2010.

Major assumptions are as follows:

1 Population growth during 1994 - 2010 are 3.21 %/year for El Jadida and 3.6 %/year for the 3 centers of Rural Commune of My Abdellah. (Source: General Census of Population and Houses) Population in El Jadida and the 3 centers are 125,111 and 7,288 in 1996.

2. Per capita economic growth of municipality of El Jadida and the 3 centers of Rural Commune of My Abdellah during 1994 - 2010 is 3 %/year. (JICA Study Team)

3. Economic growth of municipality of El Jadida and the 3 centers during 1994 - 2010 is 6.3 %/year and 6.7 %/year respectively (based on population growth and per capita economic growth)

4. Waste generation growth in municipality of El Jadida during 1994 - 2010 is 4.7 %/year (assumed to be 75 % of economic growth rate)

5. Waste generation growth in My Abdellah will be 3.2 %/year considering that the most (83 % of) waste is generated from visitors. It is assumed that generation of visitors' waste will increase by 2.8 % while, the generation of waste from local residents of the 3 centers will increase by 5.0 %/year. Calculation: (5% x 0.17) + (3% X 0.83) = 3.2 %

Table 2.2-1 Projection of Solid Waste Generation in the Municipality of El Jadida and the 3 Centers of the Rural Commune of My Abdellah

	Population			Generation							
				Per Capita (gram/capita/day)		Per Day (ton/day)			Annual Quantity (ton/year)		
		Centers of Rural		Centers of Rural		Centers of Rural			Centers of Rural		
Year	Municipality	Commune of		Municipality	Commune of	Municipality	Commune of		Municipality	Commune of	
	El Jadida	My Abdellah	Total	El Jadida	My Abdellah	El Jadida	My Abdellah	Total	El Jadida	My Abdellah	Total
1994	119083	6937	126020								
1995	122060	7110	129170								
1996	125111	7288	132399	608	6747	76	49	125	27742	17948	45690
1997	128239	7470	135709	621	6793	80	51	130	29046	18522	47569
1998	131445	7657	139102	634	6839	83	52	136	30411	19115	49526
1999	134731	7848	142579	647	6887	87	54	141	31841	19727	51567
2000	138099	8044	146143	661	6934	91	56	147	33337	20358	53695
2001	141552	8245	149797	676	6981	96	58	153	34904	21009	55914
2002	145091	8452	153543	690	7028	100	59	160	36545	21682	58226
2003	148718	8663	157381	705	7076	105	61	166	38262	22376	60638
2004	152436	8879	161315	720	7125	110	63	173	40061	23092	63152
2005	156247	9101	165348	735	7174	115	65	180	41943	23831	65774
2006	160153	9329	169482	751	7222	120	67	188	43915	24593	68508
2007	164157	9562	173719	767	7272	126	70	196	45979	25380	71359
2008	168261	9801	178062	784	7322	132	72	204	48140	26192	74332
2009	172467	10046	182513	801	7372	138	74	212	50402	27030	77433
2010	176779	10298	187077	818	7421	145	76	221	52771	27895	80667
									585300	338750	924050

CHAPTER 3 TARGET WASTE COLLECTION

It is estimated that collection rate in the study area in 1996 is 85 %. It is proposed that the municipality of El Jadida and the rural commune will strengthen their collection capacity so that the collection rates will increase by 1 percentage point every year, and the collection rate will reach 100 % by 2010.

If this target is achieved, collection quantity in 2010 will be 185 ton/day, 2.1 times larger than 87 ton/day collected in 1996. This means that the municipality of El Jadida and the rural commune of My Abdellah must increase their collection by 5.4 % on average every year, which is much faster than the rate of increase of waste generation (4.1 %/year).

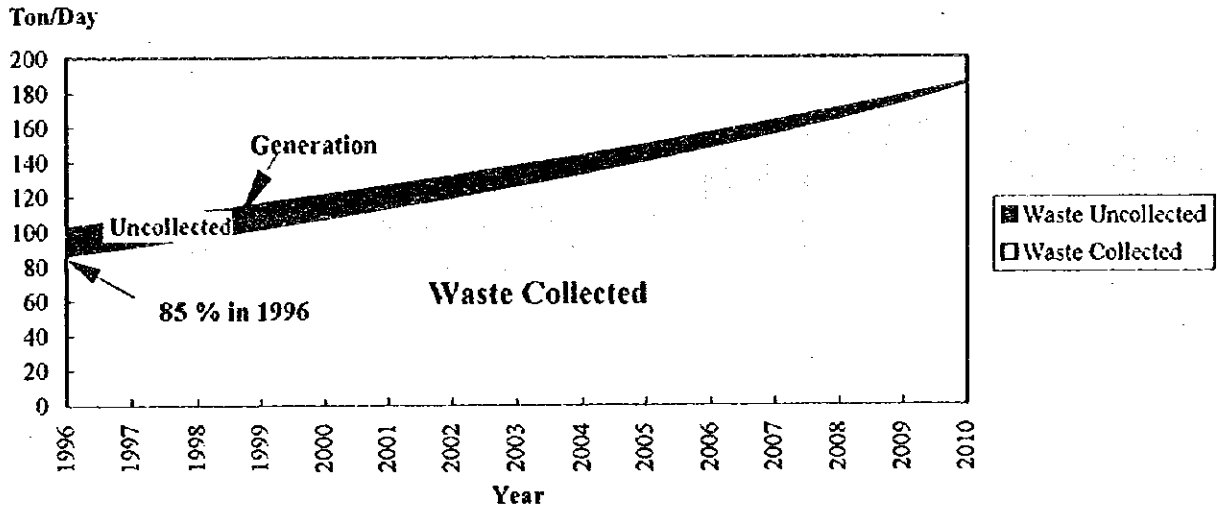
Target collection quantities by year are shown in Table 3.1-1 and Fig. 3.1-1.

Table 3.1-1 Target Waste Collection in the Municipality of El Jadida and the 3 Centers of Rural Commune of My Abdellah

Target Collection

	Target Collection Rate			Per Day (ton/day)			Annual (ton/year)		
		Centers of Rural			Centers of Rural			Centers of Rural	
Year	Municipality	Commune of		Municipality	Commune of		Municipality	Commune of	
	El Jadida	My Abdellah	Total	El Jadida	My Abdellah	Total	El Jadida	My Abdellah	Total
1994									
1995									
1996	85%	85%	85%	65	42	106	23581	15256	38837
1997	86%	86%	86%	68	44	112	24980	15929	40909
1998	87%	87%	87%	72	46	118	26458	16630	43088
1999	88%	88%	88%	77	48	124	28020	17360	45379
2000	89%	89%	89%	81	50	131	29670	18119	47789
2001	90%	90%	90%	86	52	138	31414	18908	50322
2002	91%	91%	91%	91	54	145	33256	19730	52986
2003	92%	92%	92%	96	56	153	35201	20586	55787
2004	93%	93%	93%	102	59	161	37256	21475	58731
2005	94%	94%	94%	108	61	169	39427	22401	61827
2006	95%	95%	95%	114	64	178	41719	23363	65082
2007	96%	96%	96%	121	67	188	44140	24365	68504
2008	97%	97%	97%	128	70	198	46696	25406	72102
2009	98%	98%	98%	135	73	208	49394	26490	75884
2010	100%	100%	100%	145	76	221	52771	27895	80667
							543982	313913	857895

Fig. 3.1-1 Target Waste Collection



CHAPTER 4 CONDITIONS AND ISSUES RELATING TO EXISTING MUNICIPAL DISPOSAL SITE

4.1 Site Conditions and Surroundings

The current municipal disposal site is located on a gently sloping hill-side which contained several old quarries, the depth of which are approx. 15 to 20m, and at a distance of approx. 2 km south of the city center. The access to the site is about 350m from IBN BADIS road.

Recently, a new housing area/estate, which has been expanding rapidly in accordance with city urbanization, is located very close to the site and surrounds it. Meanwhile, several housing development projects, called ERAC, AN II and OCP, have a plan to develop the current disposal site area for the housing estate/complex and park.

The area of the current municipal disposal site is approx. 40 hectares, and owned by Municipality of El Jadida. There are almost no disposal facilities, such as enclosed fence, inspection gate, proper operation road, storm-water drainage, signboard identified site usage, site office, water and electricity supply, etc. at the site.

4.2 Site Operation

The El Jadida municipal disposal site commenced its operation in 1983. Responsible for organization of the site management and operation is the Municipality of El Jadida. Current operational conditions of the site are described as follows;

- Hauled waste has not been controlled in any proper manner such as soil covering, waste compacting, etc. No landfill equipment is operating at the site.
- All types of waste; that is municipal, industrial and hospital waste (which may contain toxic/infectious waste), are accepted/hauled at the site in mixed form.
- No staff from the Municipality are present for site inspection, recording incoming vehicles and waste, site access control, etc.
- Operation road is in poor condition and inaccessible in case of heavy rain.
- Scavengers are active and animals are grazing at the site without any control.

4.3 Issues

In light of the location, facilities and operational conditions of the existing municipal disposal site, the following issues have been identified and should be taken into consideration for the new disposal site plan of "Grand El Jadida".

i. Sanitary/environmental conditions of the current municipal disposal site are very poor, because of lack of landfill operation control. Scattering of waste, diffusion of offensive odor, self-burning of the waste, breeding of vectors and insects, free discharge of the leachate, and so on, are observed at the site.

ii. No records of incoming collection vehicles, waste amount and waste types have been kept, because of lack of a SWM control plan and site facilities. Meanwhile, for the same reason, unlimited access to scavengers and animal grazing puts them in dangerous contact with potential hazardous wastes mixed with domestic waste.

iii. The current municipal disposal site is located too close to the city urban area, and it has created serious sanitary/environmental risks to the surrounding inhabitants. Further, in accordance with rapid city urbanization, several housing projects are being constructed close to the site. Therefore, it is urgently required to remove the disposal site to a new location.

CHAPTER 5 DISPOSAL PLAN

5.1 Planning Policy and Disposal Level

5.1.1 Planning Policy for Waste Disposal

The final disposal site is the ultimate termination point of the collected and/or accumulated waste, and the site should be planned in consideration of environmental protection measures to prevent environmental impacts to the surroundings; such as scattering of waste, diffusion of offensive odor, breeding of harmful vectors, self-burning of waste, contamination to public water bodies and groundwater by leachate, fire and/or explosion hazard caused by produced gases, etc.

Based on the Guidelines prepared by the JICA Study Team, and in consideration of environmental impacts to the surroundings, meteorological, topographical and hydro-geological conditions of the Bettioua site, financial capability of Province of El Jadida, etc., the improvement target for the Bettioua disposal site should be defined as Level-3 (Controlled Landfill-3). Its definition is described in the following Section 5.1.2. Meanwhile, details of waste disposal systems, Level-1 to Level-4, are described in the Guidelines.

5.1.2 Levels of Waste Disposal System

The Bettioua disposal site should be constructed as controlled landfill (Level-3), based on the following concepts:

i. Environmental impacts to be counter-measured

- Waste scattering
- Offensive odor, breeding of harmful insects, waste self-burning
- Ground-water and runoff contamination
- Inflammation or explosion hazard, destruction of ecological system

ii. Facilities to be provided

- Execution of daily soil covering, by adopting the cell method, in order to minimize adverse environmental effects on the surroundings, such as scattering of solid waste, diffusion of offensive odors, breeding of harmful insects, fire caused by spontaneous combustion, etc.
- Establishment of proper access to the disposal site
- Establishment of operational roads to maintain good operating conditions and smooth waste dumping.
- Procurement of landfill equipment for landfill work and soil covering, such as bulldozer, excavator, dump truck etc.
- Introduction of an inspection, control and operational recording system for incoming waste and trucks by using a truck scale.
- Establishment of an enclosing bund and/or on-site roads in order to distinguish the landfill site area and to maintain a proper landfill embankment.
- Set up litter control facilities and/or buffer zones.

- Set up safety facilities, such as enclosures, gates, site offices, lighting facilities, etc. in order to perform proper landfill operation and to control scavenging activity and animal grazing etc.
- Establishment of a drainage system in order to divert storm-water and seepage, in order to reduce leachate.
- Installation of liner (rubber sheet) in order to control seepage and to prevent contamination of groundwater by leachate.
- Establishment of a leachate control system by installation of liner, leachate collection facilities and aeration pond (w/re-circulation pump), in order to minimize contamination of surrounding water bodies (surface and groundwater).
- Installation of gas removal facilities in order to prevent fire and/or explosion hazards, destruction of the ecological system, bad odor to surroundings, etc. caused by gases produced at the landfill site.

5.2 Final Disposal Plan

5.2.1 Waste Type and Amount to be Accepted/Disposed

1) Type of Waste to be Accepted at Bettioua Disposal Site

Waste types to be accepted at the Bettioua new disposal site are domestic waste, commercial waste (which is comprised of market waste, store/shop waste and office waste), street/garden waste and demolition waste.

Regarding industrial waste (which may include toxic substances), it should be treated and disposed of under the producer's own responsibility. In Europe and Japan, industrial enterprises are responsible for management of industrial waste according to law. Meanwhile, the Ministry of Environment in Morocco has a plan to draft a law which requires industrial enterprises to be responsible for management of industrial waste. From this point of view, it is recommended that industrial waste should not be disposed of at Bettioua disposal site.

2) Outline of Bettioua Disposal Site and Waste Amount

Bettioua new disposal site is comprised of three zones; that is, Zone-I, Zone-II and Zone-III. An outline of the Bettioua disposal site, related to the waste amount to be disposed of at the site, is shown in the following Table 5.2-1.

Table 5.2-1 Outline of Bettioua Disposal Site

Items	Zone-I	Zone-II	Zone-III	Total
Site area (ha)	14	20	16	50
Landfill area (ha)	10	18	14	42
Waste amount disposed of (ton)	614,000	1,264,000	1,078,000	2,956,000
Operation period (year)	2000 - 2011	2012 - 2025	2026 -	Approx. 35 years

A schedule of Bettioua disposal site indicating the accumulated waste amount to be disposed of, is shown in Fig. 5.2-1.

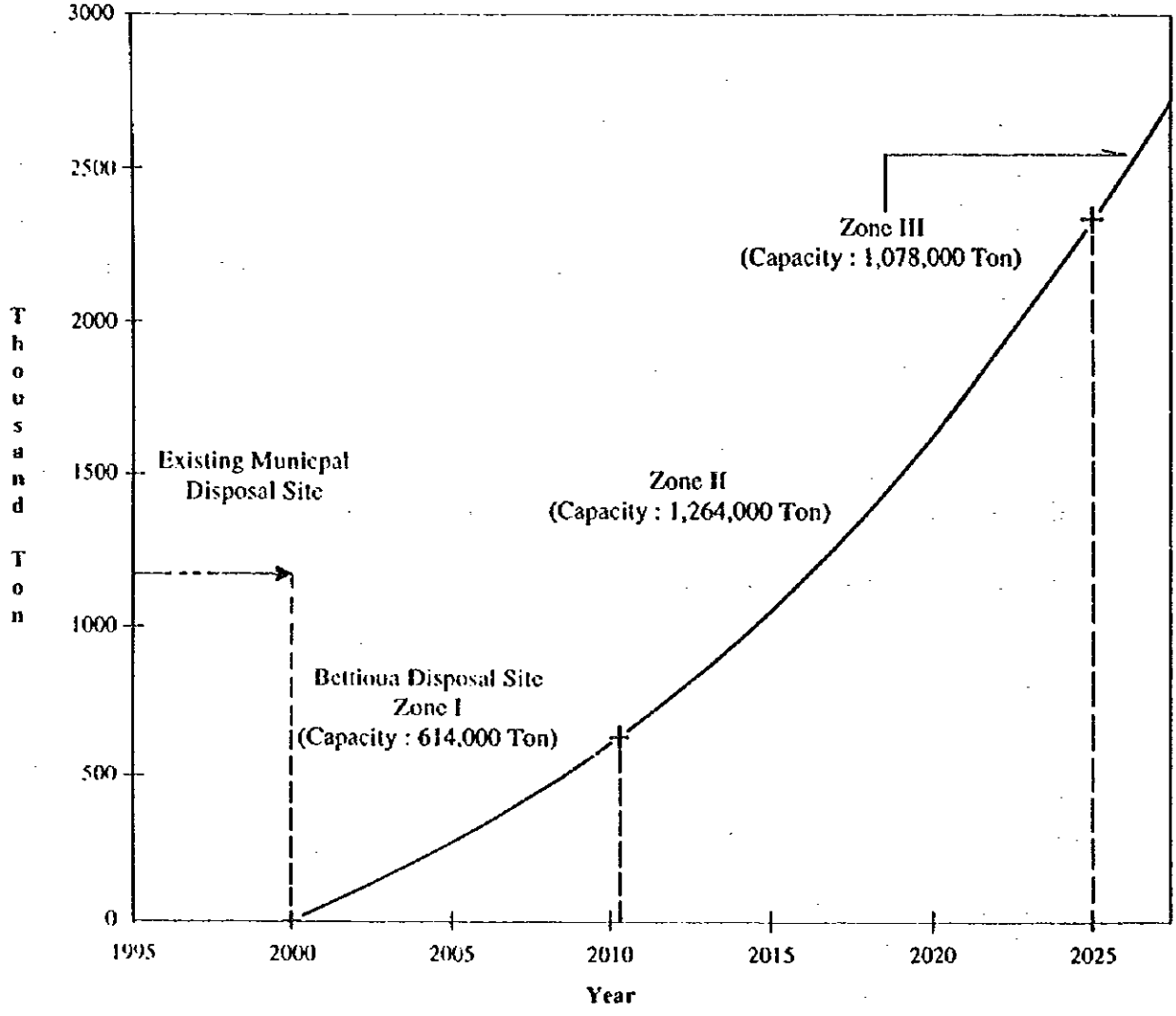


FIG. 5.2-1 **Schedule of Final Disposal**

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO

5.2.2 Selection of New Disposal Site

Two candidate sites for the new disposal site of Grand El Jadida, with a concept of inter-municipal waste disposal, have been selected by an official committee which was organized by the Province of El Jadida (Division of Technical Service and Urbanism), Municipality of El Jadida, Ministry of Public Works, President of Moulay Abdellah Rural Commune and Kaïdat (local authority from Ministry of Interior), in the middle of 1996. Characteristics of both sites are similar and summarized in the following Table 5.2-2.

Table 5.2-2 Characteristics of Two Candidate Sites for New Disposal Site

No	Items	Description	
		Site No. 1	Site No.2
1	Location	My Abdellah / Regragui	My Abdellah / Bettioua
2	Site area	36 ha	44 ha
3	Distance from El Jadida	13.2 km	14.0 km
4	Topographic condition	Gentle slope w/depression	Gentle depression at hill-side
5	Geological feature	Marl limestone (more than 15m)	Marl limestone (more than 15m)
6	Land ownership	Private land	Private land
7	Existing land-use	Agriculture	Agriculture

In response to the request by the Province of El Jadida, the JICA Study Team made an evaluation/comparison of the two sites regarding to their suitability as a waste disposal site, based on the Guidelines which have been prepared by JICA Team.

After several site visits/inspections and data analysis, JICA Team presented technical suggestions/advice to the Province of El Jadida, concluding that site No.2 is more suitable than No.1. Major evaluation/comparison points are summarized as follows;

i. Hundreds of people are living within a 500m radius of site No.1, while almost no houses are exist within same radius of site No.2.
ii. A public well for drinking water exists approx. 200m from site No.1, while it exists approx. 800m from site No.2.
iii. 2.5km of access road will have to be improved/paved in the case of site No.1, compared with 1.0km for site No.2.
iv. Public water supply can easily be acquired at site No.2 because of water conduit across the site, while approx. 2.5km of intake pipe is required for site No.1.

Existing conditions of two candidate sites correspond to each evaluation items and the results of the evaluation are shown in Table 5.2-3. Detailed evaluated items and scores are described in Table 5.2-4.

Table 5.2-3 Evaluation of Final Disposal Candidate Sites

Evaluation Items	Candidate Sites			
	Site No.1 Oulad Regragui		Site No 2 Bettioua	
	Description	Score	Description	Score
I Availability of Land				
1 Land ownership	Private	6	Private	6
2 Land use restriction	No restriction	25	No restriction	25
3 Administrative boundary	Outside of El Jadida	9	Outside of El Jadida	9
4 Land capacity (life expectancy of new disposal sate)	36 ha (30 ha expansion)	25	44 ha (30 ha expansion)	25
- Other considerations				
II Acceptability to Neighboring Citizens and Related Authorities				
1 Proximity to the nearest residential area	200-300 m	10	500 m	20
2 Achievement of consensus	(Provincial decision)	9	(Provincial decision)	9
3 Proximity to strategic public facilities	School'small (1.5 km)	12	School/small (800 m)	4
- Other considerations				
III Environmental Impacts and Disaster Prevention Measures				
1 Proximity to public water supply sources	200 m (public well)	5	800 m (public well)	15
2 Risk of dust, noise and odor hazard	Risky (resident is near)	12	Low risk	20
3 Ground water level	Approx. 8 m (Nov.1996)	15	Approx. 15 m (Nov.1996)	25
4 Permeability of base soil of the site (marl-limestone for both)	(unknown)	--	(unknown)	--
5 Impacts on ecological system	Little impact	20	Little impact	20
6 Impacts on man-made assets of historical'religious value	Little impact	20	Little impact	20
7 Impacts on natural landscapes	Visible from railway	9	Non-visible from sub-road	15
8 Impacts down-stream of prevailing wind	North-east (little impact)	20	North-east (little impact)	20
9 Impacts on disaster prevention measures	Little impact	15	Little impact	15
- Other considerations				
IV Economic Factors				
1 Land acquisition price	100,000 DH ha	12	100,000 DH ha	12
2 Compensation requirements	Several houses	9	Not necessary	15
3 Distance from waste generation areas (from El Jadida)	13 2 km (26 minutes)	15	14.0 km (28 minutes)	15
4 Topographic conditions	Gentle slope w'depression	16	Depression at hill side	20
5 Accessibility to the site (w/ access road condition)	2.5 km (poor condition)	5	1.0 km (poor condition)	15
6 Availability of covering material	Available at site	20	Available at site	20
7 Availability of public utilities'services (water, electricity etc.)	Water shall be provided	4	Available	12
8 Present land-use	Agriculture (wheat etc.)	--	Agriculture(wheat etc.)	--
- Other considerations				
Synthetic evaluation (Total score)		293		357

Table 5.2-4 (1/2) Score Sheet for Evaluation of Final Disposal Candidate Sites

No	Evaluation Screening Items	value	points	Evaluated Score No.1	Evaluated Score No.2
I	**Availability of Land**				
1	Land ownership	3			
	- Local/central government		5		
	- Private ownership (one owner)		3		
	- Private ownership (more than two owners)		2	6	6
	- Social/religious organization		1		
2	Land use restriction	5			
	- Little impact on surrounding land use		5	25	25
	- Medium impact on surrounding land use		3		
	- Large impact on surrounding land use		1		
3	Administrative boundary	3			
	- Within administrative boundary		5		
	- Outside administrative boundary but with integrated SWM concept		3	9	9
	- Outside administrative boundary		1		
4	Land capacity (life expectancy of new disposal site)	5			
	- More than 10 years		5	25	25
	- Between 5 - 10 years		3		
	- Between 3 - 5 years		2		
	- Less than 3 years		1		
II	**Acceptability to Neighboring Citizens and Related Authorities**				
1	Proximity to the nearest residential area	5			
	- More than 500 m		5		
	- Between 300 - 500 m		4		20
	- Between 200 - 300 m		2	10	
	- Less than 200 m		1		
2	Achievement of consensus	3			
	- Acceptance		5		
	- Being motivated		3	9	9
	- Being negotiated		1		
3	Proximity to strategic public facilities	4			
	- More than 2.0 km		5		
	- Between 1.0 - 2.0 km		3	12	
	- Less than 1.0 km		1		4
	- Airport must be located more than 3.0 km		x		
III	**Environmental Impacts and Disaster Prevention Measures**				
1	Proximity to public water supply sources (related to water pollution)	5			
	- More than 1,000 m		5		
	- Between 500 - 1,000 m		3		15
	- Between 300 - 500 m		2		
	- Between 200 - 300 m		1	5	
2	Risk of dust, noise and odor hazard (related to buffer zone)	4			
	- Low risk		5		20
	- Medium risk		3	12	
	- High risk		1		
3	Groundwater level (hydro-geological conditions)	5			
	- More than 10 m		5		25
	- Between 5 - 10 m		3	15	
	- Between 3 - 5 m		1		
4	Permeability of base soil of the site (geological conditions)	5			
	- Permeable coefficient : Less than 10^{-7} cm/sec		5		
	- Between 10^{-6} - 10^{-7} cm/sec		4		
	- Between 10^{-5} - 10^{-6} cm/sec		3		
	- Between 10^{-4} - 10^{-5} cm/sec		2		
	- Higher than 10^{-4} cm/sec		1		
5	Impacts on ecological system (fauna and flora)	4			
	- Little impact on surrounding ecological system		5	20	20
	- Medium impact on surrounding ecological system		3		
	- Large impact on surrounding ecological system		1		

Table 5.2-4 (2/2) Score Sheet for Evaluation of Final Disposal Candidate Sites

No	Evaluation/Screening Items	value	points	Evaluated Score No.1	Evaluated Score No.2
6	Impacts on man-made assets of historical/religious value	4			
	- Little impact		5	20	20
	- Medium impact		3		
	- Large impact		1		
7	Impacts on natural landscapes	3			
	- Little impact		5		15
	- Medium impact		3	9	
	- Large impact		1		
8	Impact down-stream of prevailing wind (direction)	4			
	- Little impact by main wind		5	20	20
	- Medium impact by main wind		3		
	- Large impact by main wind		1		
9	Impacts on disaster prevention measures	3			
	(flooding, stability of valley slope, catchment area of the site etc.)				
	- Little impact		5	15	15
	- Medium impact		3		
	- Large impact		1		
IV	**Economic Factors**				
1	Land acquisition price (related to land productivity)	4			
	- Low		5		
	- Medium		3	12	12
	- High		1		
2	Compensation requirements	3			
	- Low		5		15
	- Medium		3	9	
	- High		1		
3	Distance from waste generation areas (related to waste transport cost)	5			
	- Less than 5 km		5		
	- Between 5 - 10 km		4		
	- Between 10 - 20 km		3	15	15
	- More than 20 km		1		
4	Topographic conditions (related to site construction cost)	4			
	- Basin at hill side		5		20
	- Flat land		4	16	
	- Valley		3		
	- Wet land		1		
	- Steep slope		1		
	- Hidden ravine		1		
	- Others				
5	Accessibility to the site (w/ access road condition)	5			
	- Good		5		
	- Fair		3		15
	- Poor		1	5	
6	Availability of covering material	4			
	- Inside the disposal site		5	20	20
	- less than 5 km from the site		3		
	- more than 5 km from the site		1		
7	Availability of public utilities/services (water, electricity etc.)	4			
	- Within 200 m		5		
	- Between 200 - 500 m		3		12
	- More than 500 m		1	4	
		Total score :		293	357

5.2.3 Disposal Policy for Bettioua New Disposal Site

1) Basic Principles

Regarding the necessary functions of the Bettioua disposal site as a waste disposal Level-3 (Controlled Landfill-3) system, the basic principles for the execution of the preliminary design have been conceived of as follows.

i. The site plan and/or facility plan of Bettioua disposal site should be appropriately tailored to its topographical and geological features, and the surrounding environment.

ii. Bettioua disposal site should be constructed as a sanitary landfill to minimize adverse environmental effects on the surrounding areas.

iii. During and after completion of the landfill, the disposal site must not to be a source of pollution, or threaten the safety of surrounding residential areas.

iv. The completed site shall be harmonious with the surrounding environment.

v. The layout of the facilities for the disposal site shall take the need for smooth operation and maintenance into account.

vi. Administrative facilities should be located at the entrance area of the disposal site for the easy control and supervision of the waste collection vehicles and of the operation flow of the landfill.

vii. Leachate should be treated properly before discharge to public water bodies, as a pollution prevention measure. Meanwhile, taking into consideration of topographic feature of Bettioua disposal site as a gentle depression of 10 m depth, leachate shall not necessarily be discharged to outside of the site. Therefore, leachate re-circulation system facilitated with aeration lagoon shall be adopted.

viii. Location of the leachate treatment and/or re-circulation facility should be decided in light of the topographic features and re-circulation points of the leachate. Also, this facility shall be located as far away as possible from the surrounding residential area.

In addition, Bettioua disposal site shall also be fulfilled the requirements for the disposal standard of "Advanced Standard Type" which is under preparation by Ministry of Environment, at present.

Fig. 5.2-2 shows the location of Bettioua disposal site and surroundings.

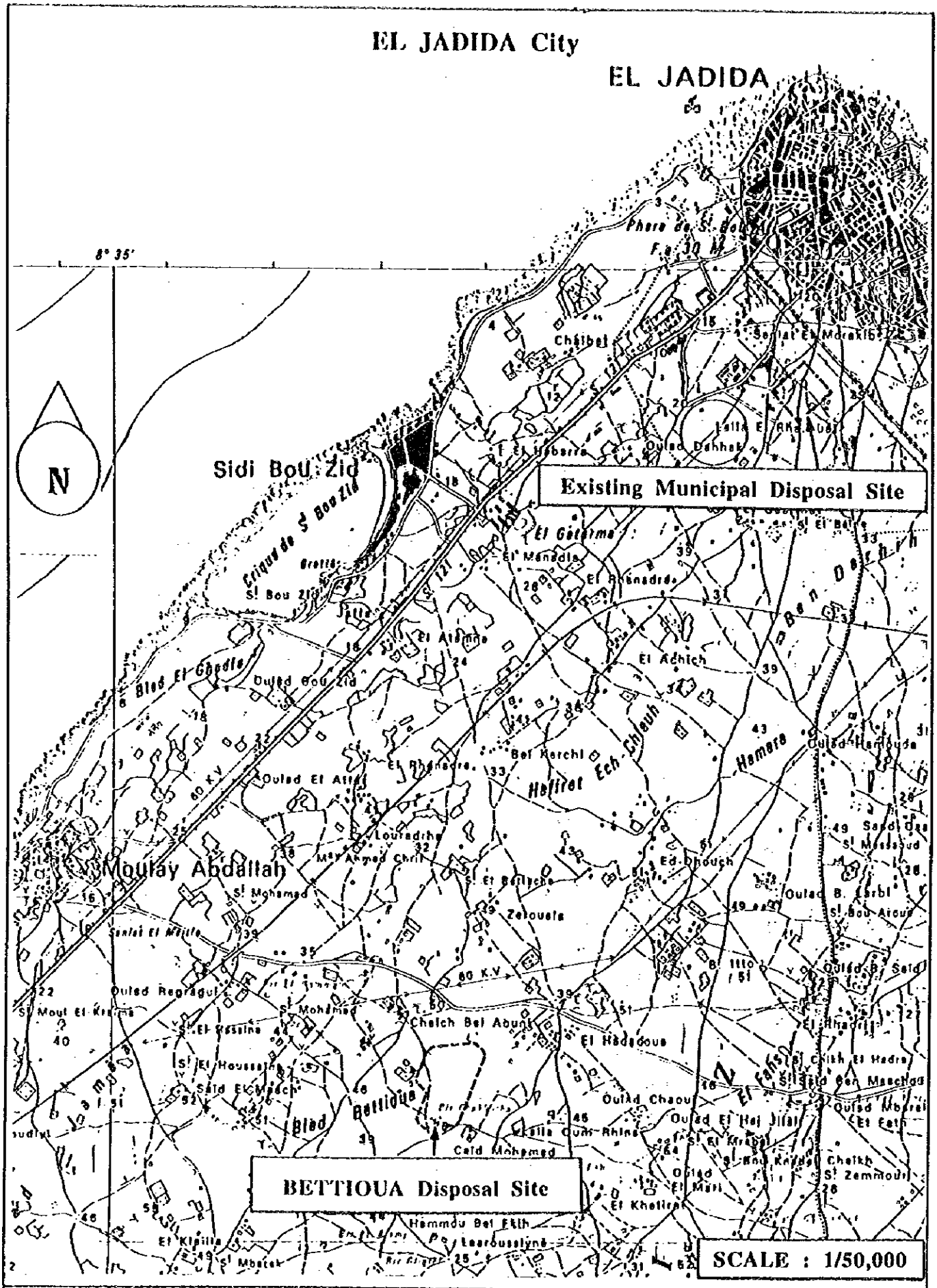


FIG. 5.2-2 **Location Map**

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2) Planning Conditions

It is proposed to construct the Bettioua disposal site at the location of Douar Regragui, Rural Commune of Moulay Abdellah. The total area of the Bettioua disposal site is 50 hectares and it is expected to be used for about 30 years.

The outline of the Bettioua disposal site is described as follows, and the layout plan is shown in Fig. 5.2-3.

- Site location : 8 km from city center
- Total site area : 50 hectare (Zone I : 14 ha, Zone II : 20 ha, Zone III : 16 ha)
- Landfill height : 18 - 11 m (including covering soil)
- Total landfill capacity : 2,956,000 ton
- Daily waste amount : 221 ton/day in year 2010
- Period of use : 2000 - 2030's (about 35 years)

The Bettioua disposal site will be developed in three (3) phases. The first project is called "Zone-I", which has an area of 14 hectares and can be used for approximately 12 years. It will be operated from the year 2000, after closure of the existing disposal site.

Planning conditions for the Bettioua disposal site Zone-I are the following;

- Site area : 14 hectare
- Landfill area : 10 hectare
- Landfill height : 18 m (7 waste layers including covering soil), 8 m from surrounding ground level ('.' depression is 10 m depth)
- Landfill capacity : 614,000 ton
- Period of use : 2000 - 2011 (twelve years)
- Landfill method : Controlled landfill
- Disposal standard : Advanced Standard Type
- Daily waste amount : 169 ton/day in year 2005
- Operation method : Cell method with waste push-up
- Service area : El Jadida Urban Commune, Sidi Bouzid and Moulay Abdellah
- Waste to be disposed of : domestic waste, commercial waste, street/garden waste, demolition waste
- Ultimate land-use : Inland amusement park, field athletics

The issues discussed below refer mainly to Zone-I of the Bettioua disposal site.

3) Topographic and Hydro-geological Features

Bettioua site is located in a gentle depression, its bottom level being EL+28.00m and surrounding higher level EL+40.00m. The lower area of this depression is occasionally inundated to form a pond, in rainy season. The maximum inundated water depth is

around 3 to 4m. Total area of the site is 50 hectares and with the possibility of expanding another 15 hectares in a westerly direction.

A detailed geological profile of the Bettioua site is not available at the moment because the specific data have not been obtained. However, it may be estimated, taking into consideration the neighboring soil conditions; that is, the site may be mainly composed of marl limestone, its depth is more than 15m, and its top layer contains roots and leaves of crops. Groundwater level at the site was GL-15m in November 1996, observed by using the well located at the bottom of the depression of the site.

5.2.4 Facility Plan

Fig. 5.2-4 shows the layout plan for the Bettioua disposal site Zone-I, and Fig. 5.2-5 shows its sectional elevation.

An outline of the facilities, that is, main facilities, environmental protection facilities and others, for construction of the Bettioua disposal site is shown in Table 5.2-5. Fig. 5.2-6(1/3), (2/3) & (3/3) show facilities of the Bettioua disposal site.

Table 5.2-5 Facility Outline of Bettioua Disposal Site (Zone-I)

Facility	Dimension	Unit	Quantity
I. Main Facilities			
a. Access road	Road width : 9.0 m (asphalt paved)	m	1,350
b. Onsite road (with dike)	Road width : 5.0 m, h = 3.0 m (asphalt paved)	m	1,350
c. Operational road	Road width : 8.0 m, h = 1.0 m (gravel paved)	m	1,050
d. Storm-water drainage	U-shaped gutter	m	1,350
	Open cut	m	2,100
II. Environmental Protection Facilities			
a. Site area	Site levelling/compaction	ha	14
	Earth cut	m^3	136,000
b. Liner	Rubber sheet (w/land levelling and protection soil layer)	m^2	112,300
c. Leachate collection facilities	PVC perforated pipe : dia. 200 mm (sub/branch)	m	1,920
	PVC perforated pipe : dia. 400 mm (main)	m	950
d. Gas removal facilities	PVC perforated pipe : dia. 70 mm (39 nos) (w/steel net and timber frame)	m	550
e. Leachate treatment/ re-circulation facility (aeration lagoon system)	10.4 m^3/ha/day (leachate amount) Re-circulation pump, aerator etc.	LS	1
f. Litter prevention facility / Buffer zone	Fence and trees	m	450
	Fence (only)	m	2,550
g. Monitoring well	120 mm dia.	unit	1
III. Other facilities			
a. Site office		m^2	60
b. Truck-scale	Load cell type, 30 ton capacity	unit	1
c. Washing station	High pressure spray, pump etc.	LS	1
d. Lighting facilities		LS	1
e. Water supply		LS	1
f. Surrounding works	Gate, parking, etc.	LS	1

1) Main Facilities

- Access road

The existing local road, the length of which is 1,350 m, should be improved as the access road of Bettioua disposal site. The function of this road will not only be for access to the site but for the use of surrounding inhabitants. In light of this, design conditions of the access road should be as follows.

i. The road should be wide enough for two-way traffic and a shoulder (or side-walk).
ii. The road should be asphalt paved.
iii. The road level should be 0.5 m higher than surrounding ground level.
iv. The width of the road is 9.0 m.
v. Stopping/waiting lane/area should be included along the access road for collection vehicles near the entrance of the site.

- Onsite road (with dike)

The major functions of the onsite road (with dike) are as follows.

i. To confine the waste which will accumulate to a height of 18 m.
ii. Access for collection vehicles.
iii. To confine the flood water to prevent water penetrating inside the site.

The onsite road should also be used for operation of the landfill work and site inspection. The design conditions of the onsite road are as follows.

i. The road width should be 5.0 m at its crest, and 4.0 m should be asphalt paved.
ii. The height of the road should be 3.0 m.
iii. Stormwater drainage should be located outside of the onsite road.

- Operational road

To maintain good operating conditions and smooth waste dumping, an operational road should be constructed in the landfill area.

The design conditions for the operational road should be as follows.

i. The road width should be 8.0 m at the crest of the road, and 6.0 m of it should be gravel paved.
ii. The height of the road should be 1.0 m from ground level.
iii. The slope on both sides of the road should be 1:4, for easy access of landfill equipment and collection vehicles.

- Stormwater drainage

In general, stormwater drainage can be divided into three types, based upon its location, that is, surrounding drainage, onsite drainage and drainage of the reclaimed area. Surrounding drainage should be installed along the outside of the onsite road. Rainwater collected by this facility should be discharged to the existing drain. Onsite drainage should be installed inside the landfill site, that is, along the onsite road. The rainwater collected from the non-landfill area should be discharged outside of the enclosing bund by using these facilities. Drainage for the reclaimed area should be established after completion of the final soil covering. The rainwater collected from this facility should be discharged outside the enclosing bund. Therefore, stormwater drainage should be constructed in several ways.

The purposes of the drainage system are listed below.

i. Eliminate rainwater which flows into the landfill site from the outside.
ii. Eliminate rainwater which flows into the landfill area from the non-landfill area of the site.
iii. Eliminate rainwater which flows into the landfill area from the completed landfill area.

2) Environmental Protection Facilities

- Liner

In order to prevent contamination of groundwater and polluting the public water bodies by leachate, and to mitigate adverse impacts of such pollution to surrounding areas, a liner made of rubber sheeting should be installed at the bottom of the whole landfill area and inner-slope of onsite road. Installation of rubber sheet is regulated in the "Advanced Standard Type" concept.

Rubber sheeting, with a thickness of 1.5mm in general, is the most popular liner system in the world and it has perfect seepage control. However, as rubber sheeting has weakness for the shearing resistance, the following points should be taken into consideration when installing it.

i. Land levelling of the ground on which the rubber sheet will be installed should be properly constructed.
ii. In-situ joining of each rubber sheet should be properly done.
iii. A protective layer of soil, with a thickness of 30 to 50cm, should be placed over the rubber sheet.

- Leachate collection system

Gravity leachate collection facilities should be installed in the landfill area, for the purpose of collecting leachate and directing it to the leachate re-circulation facilities which are located outside the landfill area. In consideration of the topographical features of the Bettioua disposal site, the flow of leachate is basically from east to west and from north to south, therefore the leachate re-circulation facilities should be located

at the south-west end of the site. Leachate collection facilities are comprised of horizontal and vertical collection facilities. Planning criteria of each leachate collection facility is as follows.

i. Based on the "Advanced Standard Type" concept, the horizontal leachate collection pipe should be made of perforated PVC pipe consisting of 400 mm dia. main pipe and 200 mm dia. sub/branch pipe. These pipes are arranged at the bottom of the landfill area and the maximum pitch of the branch pipe is 50 m. For the protection of these pipes, an earthen layer of 50 cm thickness should be laid on the top of the pipes. Flexible joints should be used at the connection points of the main pipe and branch pipe.

ii. A vertical leachate collection facility should be substitute for the vertical gas removal facilities and be connected to horizontal leachate collection pipes. For planning gas removal facilities, see the following section.

- Gas removal facilities

Generally, several kinds of gas will be produced by organic substances contained in the reclaimed waste during the process of putrefaction and decomposition; these are caused by microorganisms etc. which exist in the reclaimed waste layer. Main components of the gas produced in the landfill area are methane gas, carbonic acid gas and nitrogen, which are colorless and odorless. In addition, although in small amounts, ammonia, hydrogen sulfide, methyl mercaptane, methyl sulfide etc. which are malodorous gases, are also produced. These gases cause fire and/or explosion hazards, destruction of ecological systems, and offensive odor to surrounding areas.

For proper environmental countermeasures, gas removal facilities should thus be installed in the landfill area, as regulated in the "Advanced Standard Type" concept, planning criteria for gas removal facilities are as follows.

i. A vertical type gas prevention facility which consists of steel net, timber frame and PVC perforated pipe with surrounding gravel, should be installed at approximately 50 m intervals. This facility shall be installed in parallel with the reclamation operation.

ii. Horizontal type gas prevention facilities, which consist of PVC perforated pipe of 70 mm in diameter, and surrounding gravel, should be laid below the final earth cover.

- Leachate treatment re-circulation facility

Since the leachate or polluted water produced in the landfill area may be the cause of contamination to the surrounding bodies of water, it is necessary to prepare facilities to treat the leachate before discharge to outside of the site, as a pollution prevention measure. However, taking into considered the topographic features of the site as a gentle depression of 10 m depth, leachate shall not necessarily be discharged to outside of the site. Therefore, in the Bettioua disposal site, a leachate re-circulation system

should be adopted in order to keep or eliminate the leachate inside the disposal site. In addition, an aeration system shall be adopted here.

Aeration is the biological process to remove/eliminate biochemical oxygen demand (BOD), chemical oxygen demand (COD) and suspended solid (SS). The mechanism of aeration can be summarized as follows:

i. To provide oxygen/air to the leachate, aerobic microorganisms contained in the leachate will be activated.
ii. Aerobic microorganisms will eat organic matters contained in the leachate, in other words, biological decomposition of organic matter is carried out by aerobic microorganisms.
iii. Aerobic microorganisms will be settled at the bottom of the aeration lagoon.

a. Amount of Leachate

No reliable data regarding the amount of leachate is available in Morocco. The leachate amount should therefore be estimated based on the monthly rainfall data shown in the following Table 5.2-6, and calculated as follows:

Table 5.2-6 Monthly Rainfall

(unit : mm)

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1993	18	13	49	20	10	2	0	0	16	84	138	8	358
1994	66	69	4	17	9	0	0	0	2	5	23	11	206
1995	17	0	22	23	0	0	0	1	0	8	71	151	293
Average	34	27	25	20	6	1	0	0	6	32	77	57	286

(Source : Department of National Meteorology, Ministry of Public Works)

$$Q = 10 \times C (I - E) A$$

where, Q : Leachate amount (m^3/day)
C : Seepage coefficient (set to 0.7)
I : Average rainfall (mm/day)
E : Average evaporation (mm/day)
A : Landfill operation area (10 ha)

Results of the leachate amount estimation/calculation are shown in the following Table 5.2-7

Table 5.2-7 Leachate Amount

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
Rainfall (mm)	34	27	25	20	6	1	0	0	6	32	77	57	
Leachate amount (m^3/day)	63	50	47	37	11	2	0	0	11	60	144	106	44

b. Leachate re-circulation facilities

The facilities of the leachate re-circulation system are comprised of the following:

i. Pump pit for leachate intake
ii. Aeration lagoon with aerator
iii. Re-circulation pump

The capacity of the aeration lagoon should be decided taking into consideration seasonal variation in rainfall. To be on the safe side, rainfall data for the rainy season, from November to January, should be used to design the capacity of the lagoon which should be sufficient to hold the amount of leachate produced in five days during this period.

$(144+106+63)/3\ m^3/day \times 5\ days = 520\ m^3$

- Litter Prevention Facility/Buffer Zone

The direction of the wind is mostly from west to east throughout the year, as shown in the following Table 5.2-8. The litter prevention facility should therefore be installed mainly on the east side of the Bettioua disposal site. In order to shelter the village located 1.0 km east of the site from the site, it is also recommended to install buffer trees along the access road. Also, when the national road, which is planned to be constructed from south to north through western area of disposal site, buffer trees should be installed along the western boundary of the site.

Table 5.2-8 Wind Velocity and Direction in El Jadida

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1993	12	12	13	11	12	12	10	9	10	15	19	12
	WSW	N	NNW	W	W	WSW	N	NNW	W	WSW	WSW	NNW
1994	22	19	14	14	14	-	-	14	16	17	16	21
	NNW	SW	NE	WSW	W	-	-	ENE	ENE	WSW	W	WSW
1995	17	21	23	18	15	18	14	13	29	27	26	24
	W	NW	SSW	E	NNE	WSW	NNE	N	WNW	SSW	SW	SSW

Remarks, Upper row : Maximum wind velocity (m/sec)
Lower row: Average wind direction
(Source : Department of National Meteorology, Ministry of Public Works)

- Monitoring facilities

Monitoring wells should be installed at appropriate points in the landfill site and surrounding areas, in order to monitor the groundwater quality during the landfill operation and also after completion of the landfill. The diameter of the well should be a minimum of 100 mm. For environmental protection measures, monitoring of groundwater quality shall be carried out periodically.

3) Other Facilities

The following facilities should be constructed for the proper, smooth and safe operation of the Bettioua disposal site. The principal functions and planning conditions for each facility are as follows.

- Site office

A site office should be constructed for administration of the disposal site. It is recommended that the floor area of the site office should be 50-100 m^2 and the structure be of RC (reinforced concrete).

- Truck-scale

Installation of a truck-scale is the first and basic requirement for Solid Waste Management (SWM). This facility is to ensure that the landfill waste meets the requirement stipulated. The amount of hauled-in waste is also measured and recorded by this facility.

All hauled-in waste should be weighed by using a truck-scale so as to obtain several important data for SWM. The truck scale should be installed in a strategic position in the disposal site where the collection vehicles will pass through whenever entering and leaving the site. The entrance point of the site is recommended for the location of the truck-scale. Meanwhile, to secure access for other vehicles; such as site construction, site patrol, visitors vehicles, etc., an access road should also be built next to the truck-scale.

Waste type and quality should also be checked periodically. By understanding the type/quality of landfill waste, the type of gas production, leachate quality, and subsidence of waste, etc. can be predicted, so these data are very important for ultimate land-use planning of the site as well as for future disposal site planning. Meanwhile, if toxic substances are contained in landfill waste, they will cause environmental pollution. Therefore, hauled-in waste should be checked periodically. A waste-sampling facility should thus be installed beside the truck-scale.

Data which should be collected and analyzed regularly by using a truck-scale are shown in the following Table 5.2-9. Analyzed data shall be reported on daily, weekly, monthly and yearly, as required. These data are essential for the following control items of SWM:

i. Understanding the amount of waste disposed of should be the basic factor for future disposal site planning
ii. Understanding the type and quality of waste provides basic data for the ultimate land-use plan for the site
iii. Understanding the working time and the waste collected by each vehicle/truck, are necessary for planning effective collection routes and methods
iv. Checking hauled-in waste amounts are the basic data for collection of tipping fees

Table 5.2-9 Input Data of Truck Scale (example)

	Outgoing Vehicle		Incoming Vehicle
(1)	Date	(1)	Contractor's Name
(2)	Contractor's Name	(2)	Vehicle Registration Number
(3)	Vehicle Registration Number	(3)	Driver's Name
(4)	Driver's Name	(4)	Waste Type
(5)	Waste Type	(5)	Entry Time
(6)	Collection Route	(6)	Gross Load (kg)
(7)	Departure Time	(7)	Unloaded Weight (kg)
(8)	Gross Load (kg)	(8)	Net Load (kg)
(9)	Unloaded Weight (kg)		
(10)	Net Load (kg)		

The landfilled waste volume, waste type/quality, hauled-in place and time for each type of waste, etc. should be reported with above mentioned monthly report. These data are recommended to be prepared by using a plan and section drawing of disposal site.

The specifications of the truck-scale are as follows.

i. Weighing capacity : 30 ton / unit
ii. Load-cell type and four-point support system
iii. Automatic digital counter
iv. Control post with card reader
v. Connected with computer and printer to input and analyze the data

- Washing station

For the purpose of washing and cleaning landfill equipment and/or collection vehicles periodically, a washing station should be constructed at the administration area of the site. The facilities should contain a high pressure spray, pump etc.

- Fences and gates

To prevent the scattering of waste and free access by scavengers, suspicious persons and animals, an enclosing fence should be installed surrounding the disposal site. It is recommended to install fencing all around Zone-I, II and III of the disposal site, also to define the total site area.

- Lighting facilities

For safe night-time operation, lighting facilities should be installed at appropriate places in the landfill area.

- Water supply

Water supply should be provided at the site, in order to maintain sanitary and healthy working conditions for personnel stationed at the site, as well as for landfill equipment maintenance and washing.

5.2.5 Operation Plan

1) Landfill Operation Plan

Solid waste should be sufficiently spread and compacted when landfilling, so as to stabilize the landfill area and to prolong the lifetime of the disposal site. On the other hand, cover soil should be placed systematically and periodically after landfilling of each waste cell and/or waste layer, in order to prevent/minimize environmental impacts on the surrounding areas and living environment.

(1) Basic Concept of Landfill Operation

The basic concepts of landfill operation are as follows.

i. Solid waste should be spread and compacted sufficiently
ii. Scattering of solid waste should be minimized
iii. Diffusion of offensive odor should be minimized
iv. Breeding of vectors and insects should be minimized
v. Self-burning of the waste should be minimized
vi. Waste stabilization should be achieved as early as possible

(2) Landfill Method

In order to achieve sufficient spreading and compaction of the waste, the "cell method" by adopting "waste push up method" should be adopted for landfill operation.

The cell method required that waste cells topped with a layer of cover soil be created, where the size of each cell basically consists of one day's amount of waste. Since each cell is implemented independently the applied cover soil can prevent scattering of solid waste, emission of bad odor, breeding of harmful vectors, and self burning of the waste.

The push up method requires that when creating the waste cell, hauled waste should be pushed up from low to high areas and spread/compacted by using landfill equipment such as a bulldozer or wheel-loader. As a result, a sufficient compacted waste cell/layer can be created and landfill stabilization will be accomplished quickly.

The following items should be taken into consideration for waste spreading and compaction work;

i. Waste spreading should not be too thick. Normal waste thickness of one time spreading is about 30 to 50 cm.

ii. Landfill cells and/or layers should be made as uniform as possible by the push up method. Gradient of the waste slope should be 4:1 or less, to ensure effectiveness of landfill equipment.
iii. The height of each waste cell and/or layer should be approximately 2 m. When the site is planned to be used as early as possible after completion of landfilling, or when technically advanced usage of the completed landfill site is considered, the waste cell/layer should be less than 2 m in height.

A conceptual drawing of landfill operation is shown in Fig. 5.2-7, and detailed operating procedures for landfilling are shown in Fig. 5.2-8 (1/3), (2/3) & (3/3).

(3) Cover Soil

Together with the landfill operation by the push up method and cell method, cover soil, which consists of daily covering and final covering, should be carried out at proper times. The main purposes and thickness of each type of cover soil are shown in the following Table 5.2-10.

Table 5.2-10 Cover Soil Classification

Type of cover soil	Main purposes	Thickness
Daily covering	Prevent scattering of waste Prevent diffusion of offensive odor Prevent breeding of harmful vectors Prevent self-burning of waste Reduction of leachate amount Secure trafficability of landfill equipment & collection vehicles	50 cm (top of waste cell) 25 cm (slope of waste cell)
Final covering	Ultimate land use Landscaping Minimize the leachate amount Environmental prevention measures	50 cm (total 100 cm)

The volume of cover soil required for landfill operation of the Bettioua disposal site (Zone I) is 248,000 m³. During the construction stage of this site, 135,000 m^3 of surplus soil will be generated, and approx. 30,000 m^3 of it will be used as material for site construction, such as the onsite road, operation road, etc. Therefore, 105,000 m^3 out of 135,000 m^3 of surplus soil will be compensated for cover soil. Remaining cover soil required is 143,000 m^3 (= 248,000 - 105,000), which should be obtained by excavating Zone II of the disposal site. Approx. 630,000 m^3 of surplus soil will be generated by Zone II construction.

2) Landfill Equipment Plan

The landfill equipment listed in the following Table 5.2-11 should be prepared for the purpose of waste landfilling, soil covering, and maintenance of site facilities such as the enclosing dike, operational road, etc.

Table 5.2-11 Landfill Equipment

No	Equipment	Specification	Landfilling works etc.	Number
1	Bulldozer	200HP, blade (w/trash rack):10m^3	waste push-up, spread & compaction	1
2	Excavator	130HP, bucket:0.8m^3	excavation of covering soil	1
3	Wheel loader	150HP, bucket:2.0m^3	loading cover soil on to dump trucks	2
4	Dump truck	10m^3	covering soil transport	1
5	Tank truck	6,000litre	sprinkling with water	1
6	Pick up	2,500cc	site inspection, worker transport	2

3) Personnel Plan

The disposal site should be managed and/or operated by the administrative, technical and operational personnel, as shown in the following Table 5.2-12. Total manpower of Bettioua disposal site will be 15 persons in the year 2005.

Table 5.2-12 Required Personnel

	Personnel	Number of personnel
1	Site manager	1
2	Civil engineer/supervisor	1
3	Mechanical engineer/equipment maintenance	1
4	Administrative staff	1
5	Truck-scale operator	1
6	Landfill equipment operator/driver	6
7	Worker/watchman	4
	Total	15

4) Scavenging Activities

In principal, scavenging activity shall not be allowed at Bettioua disposal site, because of its sanitary conditions. However, in consideration of present social/economical conditions of El Jadida, it cannot help accepting scavengers at the site for the next certain period as recycling purpose. The following manner is recommended for temporary scavenging activity at the site controlled by El Jadida Province.

i. Waste hauling area and scavenging activity area shall be divided daily and cover soil shall be carried out after completion of scavenging activity.
ii. Scavenging activity shall be contractig-out to contractors. Each scavenger shall be registered.
iii. Introduction of measurement system of valuable materials collected by scavangers, at the site.

5.2.6 Ultimate Land-use Plan

1) Basic Conditions for Ultimate Land-use

Generally, at the landfill site, the following phenomena will be observed continuously for a long period even after completion of reclamation.

i. Land subsidence (approx. 5 years after landfill completion)
ii. Production of gas (over 15 years after landfill completion)
iii. Production of leachate

The above phenomena can sometimes be a hindrance to ultimate land-use. Therefore, the following facilities should be installed and operated in the landfill area from the beginning of the landfill. Also, these facilities can help to accelerate stabilization of the site conditions. Monitoring of the stability of the ground, the generated amount of gas and water, and quality of the leachate should be carried out continuously until the site conditions are properly stabilized for the planned ultimate land-use. The facilities are:

i. Drainage facilities for rainwater
ii. Gas removal facilities
iii. Leachate re-circulation facilities

2) Ultimate land-use plan

Generally, in the early period after completion of the landfill, the land occupied by the disposal site is suitable as farmland, or as a park, athletic field, playground, golf links, car parking, and so on. After a longer period, the site can be used for a school, office, housing complex and so on.

In consideration of its value to the surrounding residents, harmony with the existing landscape and characteristics as summer-time resort of El Jadida, Sidi Bou Zid and M. Abdallah, it is recommended that the ultimate land-use for the Bettioua disposal site should be as an amusement park and athletic field.

5.2.7 Plan for Closing the Existing Disposal Site

The JICA Study Team understands that the Province of El Jadida has a plan for the ultimate land-use of the existing municipal disposal site for housing and green space. If this plan is actually implemented, it is recommended that concerned officials in El Jadida take into consideration countermeasures for the phenomena (described above in Section 5.2.6 which will be observed continuously for a long period even after completion of reclamation.

5.3 Estimated Cost

Estimated costs of construction, procurement and operation and maintenance costs for Bettioua new disposal site are as follows, and details are described in Table 5.3-1.

a) Constuction and procurement

a.	Site construction:	DH 36.3 millions
b.	Procurement of equipment:	DH 10.5 millions
c.	Total (a+b):	DH 46.8 millions

b) Land purchase: DH 1.4 millions

c) Annual operation and maintenance

a.	Salary of personnel:	DH 490 thousand/year
b.	Cover soil:	DH 154 thousand/year
c.	Fuels:	DH 343 thousand/year
d.	Maintenance of equipment:	DH 437 thousand/year
e.	Indirect and miscellaneous costs:	DH 142 thousand/year
f.	Total (a+b+c+d+e):	DH 1,566 thousand/year

d) Annualized costs including depreciation

a.	Annual depreciation of construction:	DH 3.2 million/year
b.	Annual depreciation of equipment purchase:	DH 1.5 thousand/year
c.	Annual operation & maintenance:	DH 1.6 thousand/year
d.	Total (a+b+c):	DH 6.3 thousand/year

e) Unit disposal cost

a.	Construction:	DH 59.2/ton
b.	Procurement:	DH 27.3/ton
c.	Operation & maintenance:	DH 29.3/ton
d.	Land purchase:	DH 2.2/ton
e.	Total (a+b+c+d):	DH 118.0/ton

Costs are calculated as following assumptions:

1) Investment cost

i. Price level is that of November 1996.
ii. Annualized capital cost: construction cost divided by lifetime of the disposal site which is 10 years for Bettioua disposal site Zone-I.
iii. Land acquisition cost is based on counterpart/site hearing information
iv. Depreciation cost: 7 years for bulldozer, excavator and wheel loader, and 8 years for dump truck, tank truck and pick up.
v. Cost per ton is calculated as: total cost divided by waste capacity of disposal site which is 614,000 tons for Bettioua disposal site Zone-I.

2) Operation and maintenance cost

i. Annual equipment maintenance cost is 30% of depreciation cost.
ii. Indirect cost is 10% of {personnel salary + fuel cost + equipment maintenance cost}
iii. Cost per ton is calculated in same manner as investment cost.
iv. Site operation consists of one shift per day and 313 days per year.

Table 5.3-1 Investment and O/M Cost of Bettioua Disposal Site (Zone-I)

(Unit : DH)

Items	Unit	Quantity	Unit Price	Cost
1 Construction Cost				
1-1 Main Facilities				
a. Access road	m	1,350	3,400	4,590,000
b. Onsite road (with dike)	m	1,350	2,400	3,240,000
c. Operational road	m	1,050	800	840,000
d. Storm water drainage :U-gutter	m	1,350	600	810,000
- ditto - :open cut	m	2,100	100	210,000
1-2 Environmental Protection Facilities				
a. Site area : site levelling/compaction	ha	14	200,000	2,800,000
: earth cut	m^3	136,000	14	1,904,000
b. Liner : rubber sheet	m^2	112,300	150	16,845,000
c. Leachate collection facilities :dia 200	m	1,920	450	864,000
- ditto - :dia 400	m	950	550	522,500
d. Gas removal facilities	m	550	250	137,500
e. Leachate treatent/re-circulation facilities	LS	1	800,000	800,000
f. Litter prev. facilities/Buffer zone	m	450	500	225,000
: fence (only)	m	2,550	300	765,000
g. Monitoring well	m	30	1,000	30,000
1-3 Other Related Facilities				
a. Site office	m^2	60	5,000	300,000
b. Truck scale	unit	1	850,000	850,000
c. Washing station	LS	1	200,000	200,000
d. Lighting facilities	nos	14	7,000	98,000
e. Water supply	LS	1	100,000	100,000
f. Surrounding works	LS	1	200,000	200,000
Sub-Total				36,331,000
Annualized Capital Cost (1)				3,159,217
Cost per Ton (DH/ton)				59.2
2 Equipment Procurement Cost				
- Bull dozer	nos	1	2,300,000	2,300,000
- Excavator	nos	1	1,700,000	1,700,000
- Wheel loader	nos	2	2,000,000	4,000,000
- Dump truck	nos	1	700,000	700,000
- Tank truck	nos	1	800,000	800,000
- Pick up	nos	2	500,000	1,000,000
Sub-Total		8		10,500,000
Depreciation (2)				1,455,357
Cost per Ton (DH/ton)				27.3
3 Operation and Maintenance Cost (annual)				
3-1 Operation				
a. Personnel				
- Site manager	psn	1	60,000	60,000
- Civil engineer	psn	1	54,000	54,000
- Mechanical engineer	psn	1	54,000	54,000
- Administrative staff	psn	1	36,000	36,000
- Truck scale operator	psn	1	36,000	36,000
- Landfill equipment operator/driver	psn	6	26,400	158,400
- Worker/watchman	psn	4	22,800	91,200
b. Covering soil (annual)	m^3	110,000	14	154,000
3-2 Utilities				
a. Fuel				
- Bull dozer	nos	1	100,160	100,160
- Excavator	nos	1	62,600	62,600
- Wheel loader	nos	2	62,600	125,200
- Dump truck	nos	1	18,780	18,780
- Tank truck	nos	1	14,085	14,085
- Pick up	nos	2	11,268	22,536
Sub-Total (3)				986,961
Annual Equip. Maintenance Cost (4)=(2)x30%				436,607
Indirect Cost (5)=(3+4)x10%				142,357
Sub-Total (6)=(3+4+5)				1,565,925
Cost per Ton (DH/ton)				29.3
Total / Annual Cost (1+2+3+6)				6,180,499
Cost per Ton (DH/ton)				115.8
4 Land Aquisition Cost (annual)	ha	14	100,000	121,739
G. Total / Annual Cost				6,302,239
Cost per Ton (DH/ton)				118.0

5.4 Implementation Schedule

Implementation of the disposal site should be comprised of the following components.

i. Construction of the disposal site
ii. Procurement of landfill equipment

The implementation schedule for disposal site construction and equipment procurement is shown in Table 5.4-1

Table 5.4-1 Implementation Schedule of Disposal Site

		1997	1998	1999	2000	2001	2002	2003	2004	2005
1. Site Construction and Operation										
- Operation of Existing Municipal Disposal Site										
a. Construction of Bettioua Disposal Site (Zone-I)										
- Detailed Design and Tendering										
- Site Construction										
- Operation of Bettioua Disposal Site (Zone-I)										
2. Procurement of Equipment										
a. Bull dozer	200 HP, blade:10m^3 w/trush rack			1						
b. Excavator	130 HP, bucket: 0.8m^3			1						
c. Wheel loader	150 HP, bucket: 2.0 m3			2						
d. Dump truck	10 m^3			1						
e. Tank truck	6,000 litter			1						
f. Pick up	2,500 cc			2						

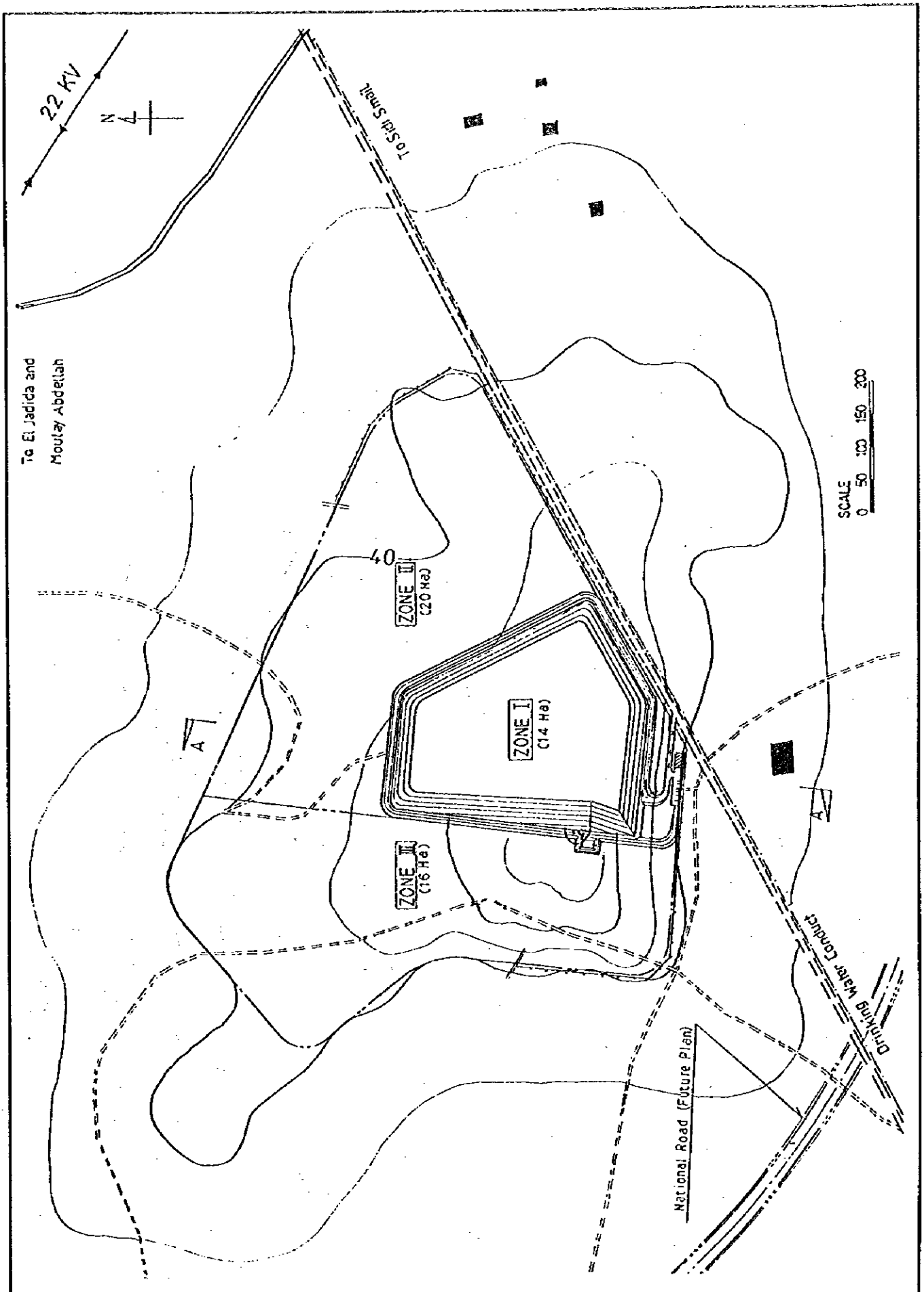

FIG. 5.2-3 **Layout Plan of Bettioua Disposal Site**

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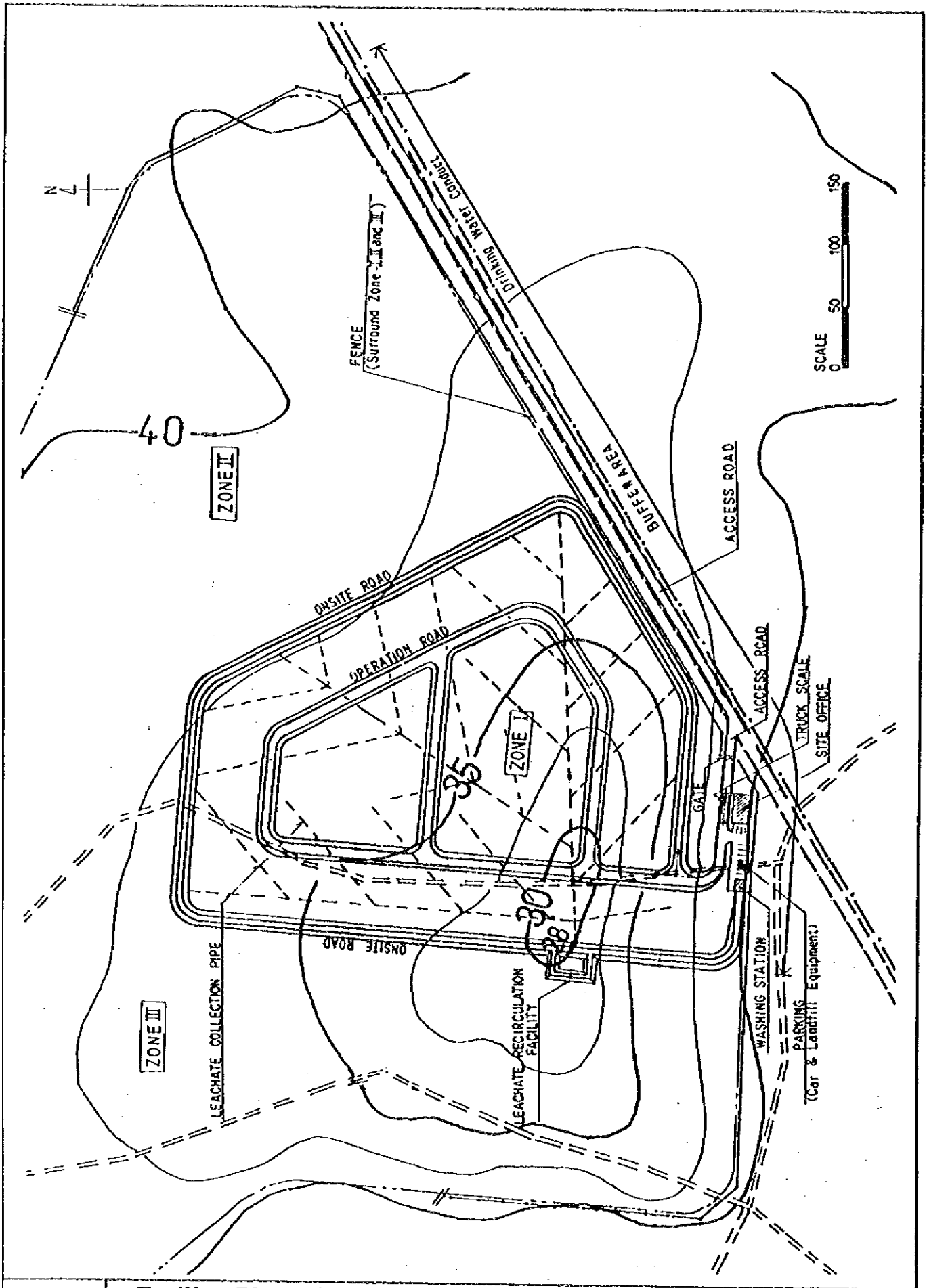

FIG. 5.2-4 **Facility Plan of Bettioua Disposal Site (Zone I)**

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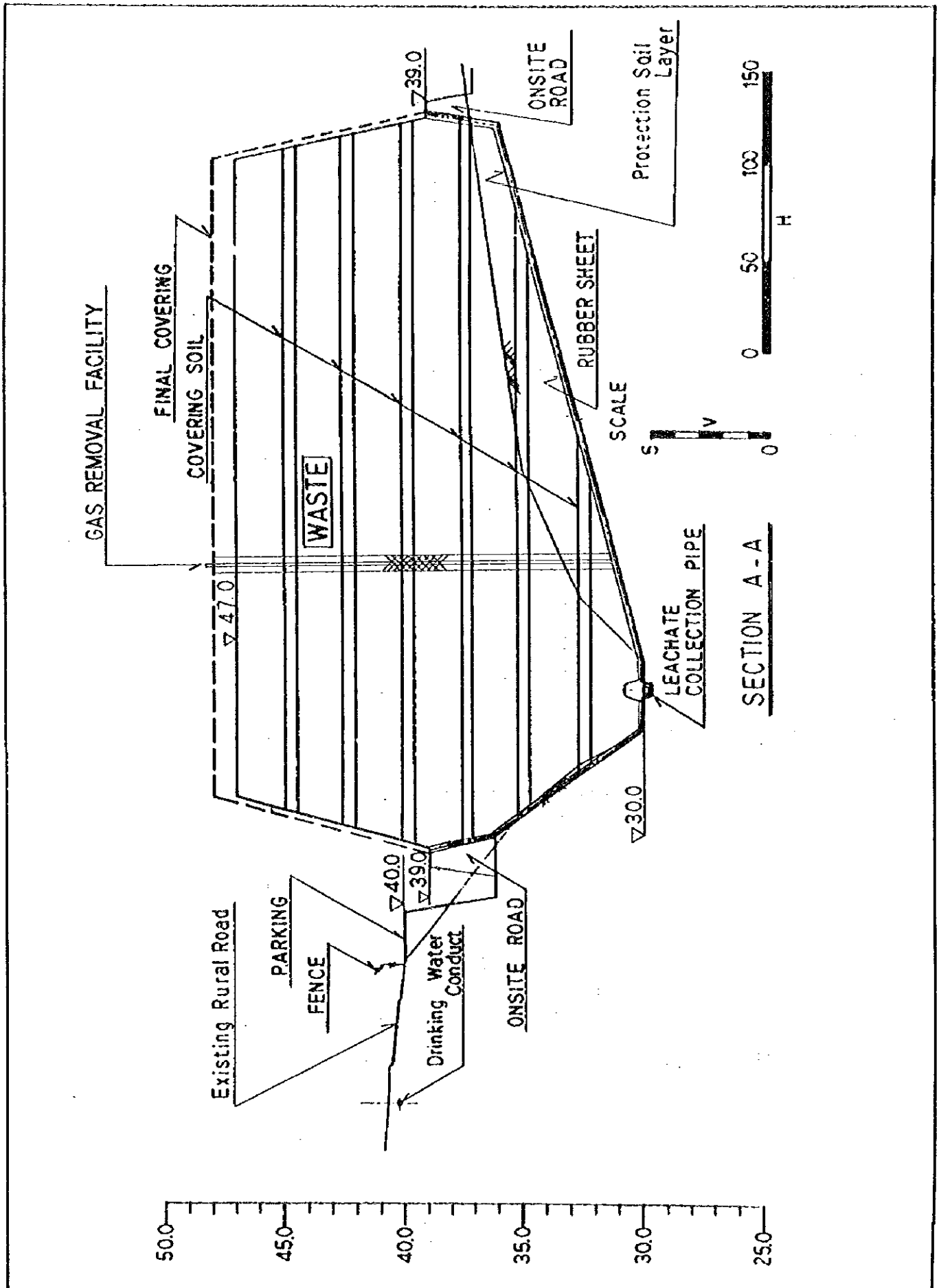
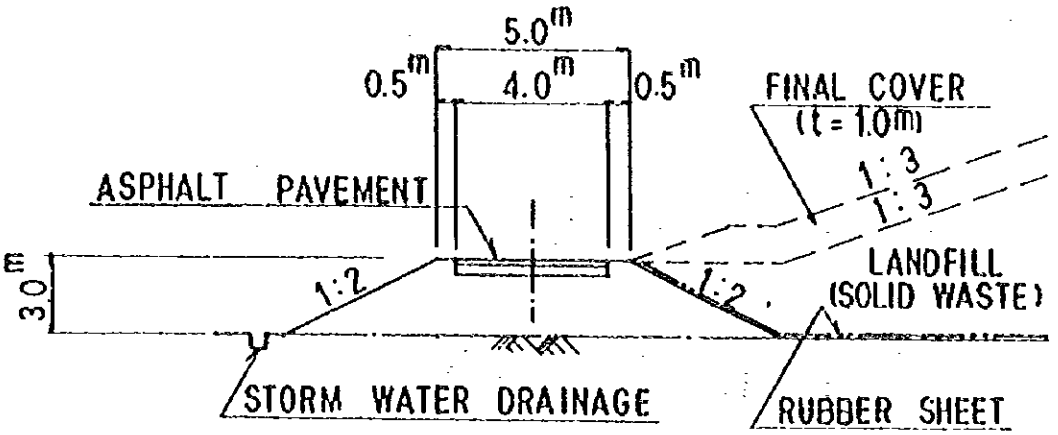
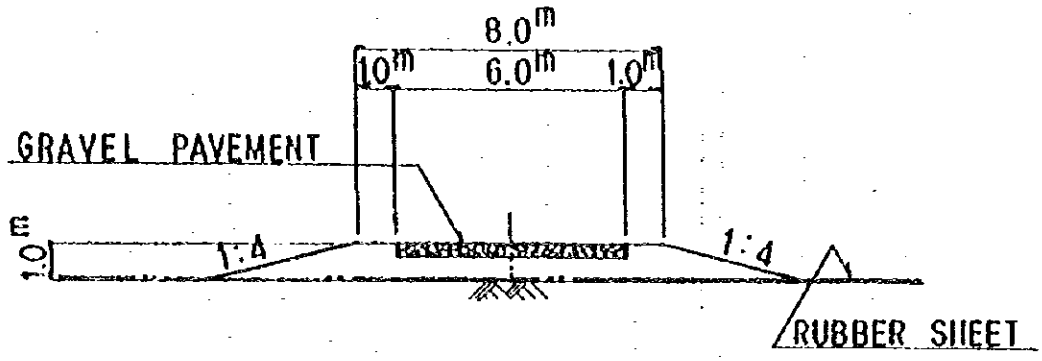


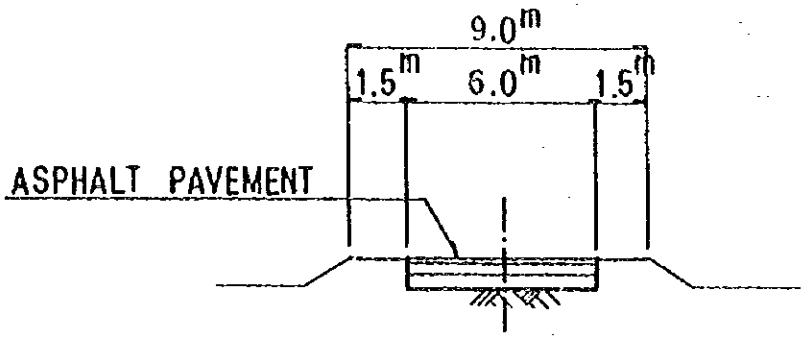
FIG. 5.2-5 Sectional Elevation of Bettioua Disposal Site (Zone 1)



ONSITE ROAD

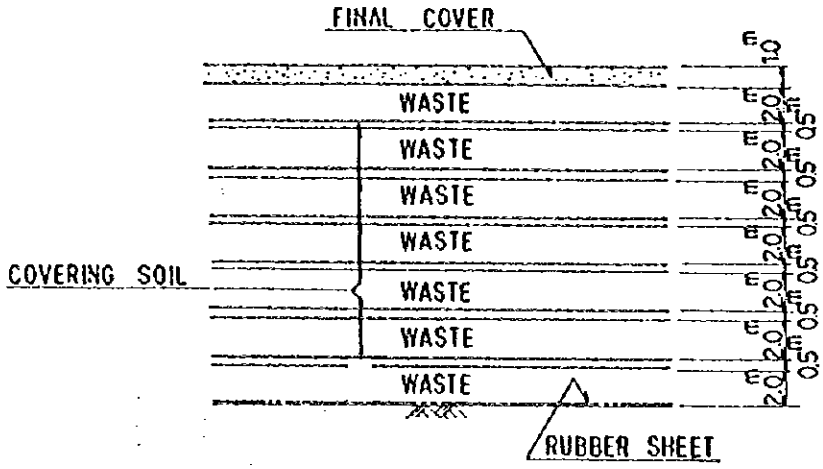


OPERATION ROAD

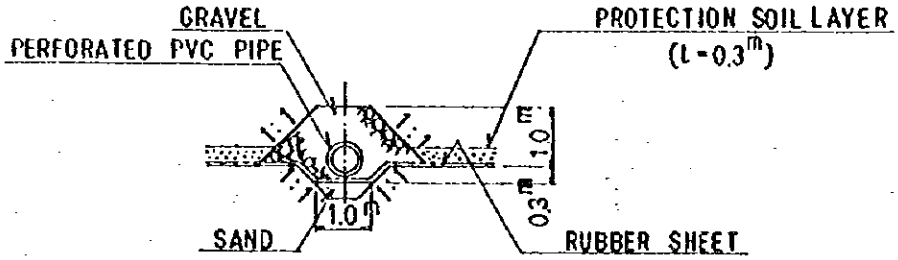


ACCESS ROAD

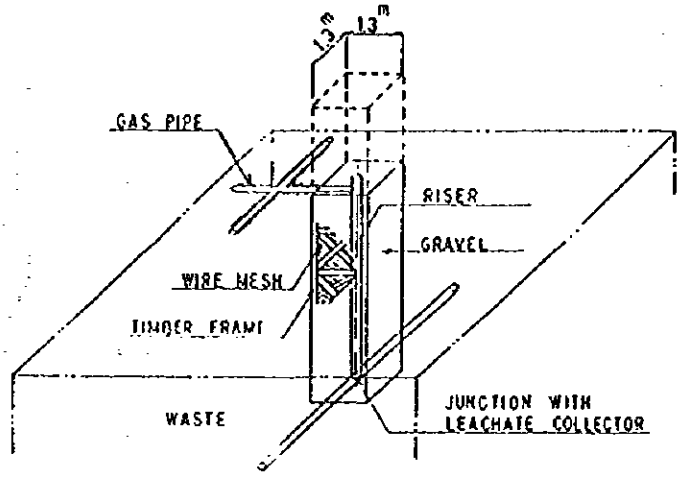
FIG. 5.2-6	Typical Facilities of Bettioua Disposal Site (1/3)



COVERING SOIL



LEACHATE COLLECTION PIPE



GAS VENT DETAIL

FIG. 5.2-6	Typical Facilities of Bettioua Disposal Site (2/3)

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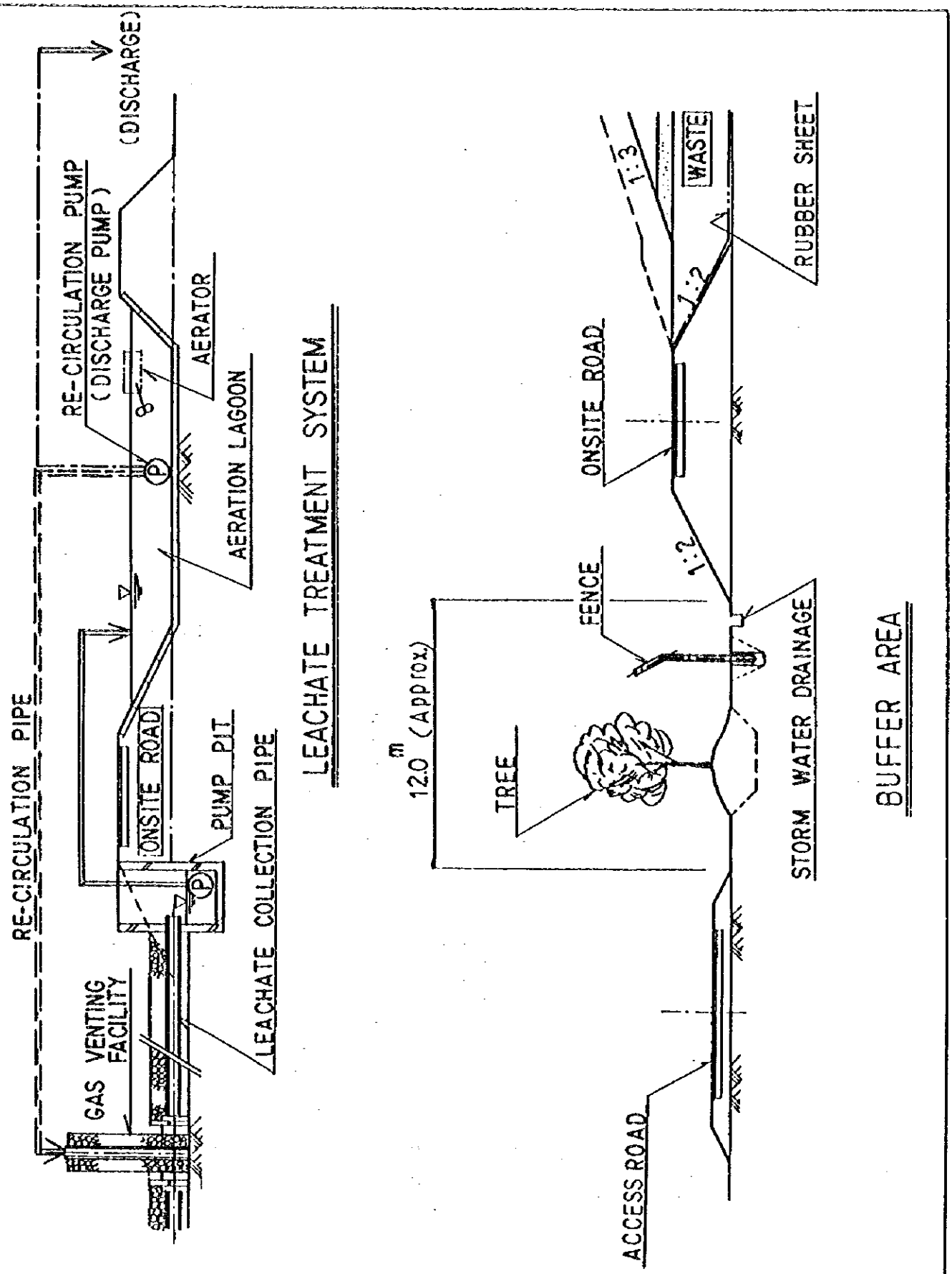

FIG. 5.2-6 **Typical Facilities of Bettioua Disposal Site (3/3)**

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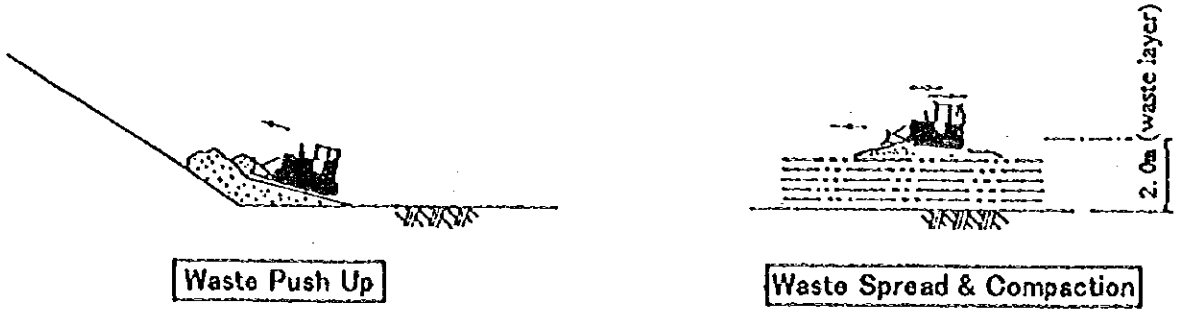
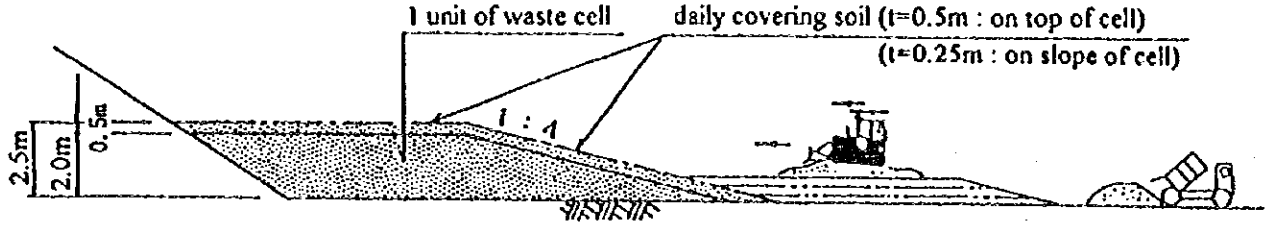
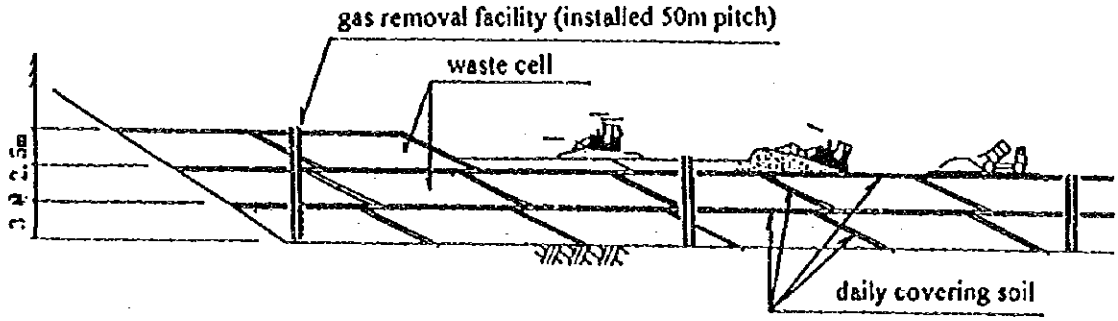


Waste Push Up

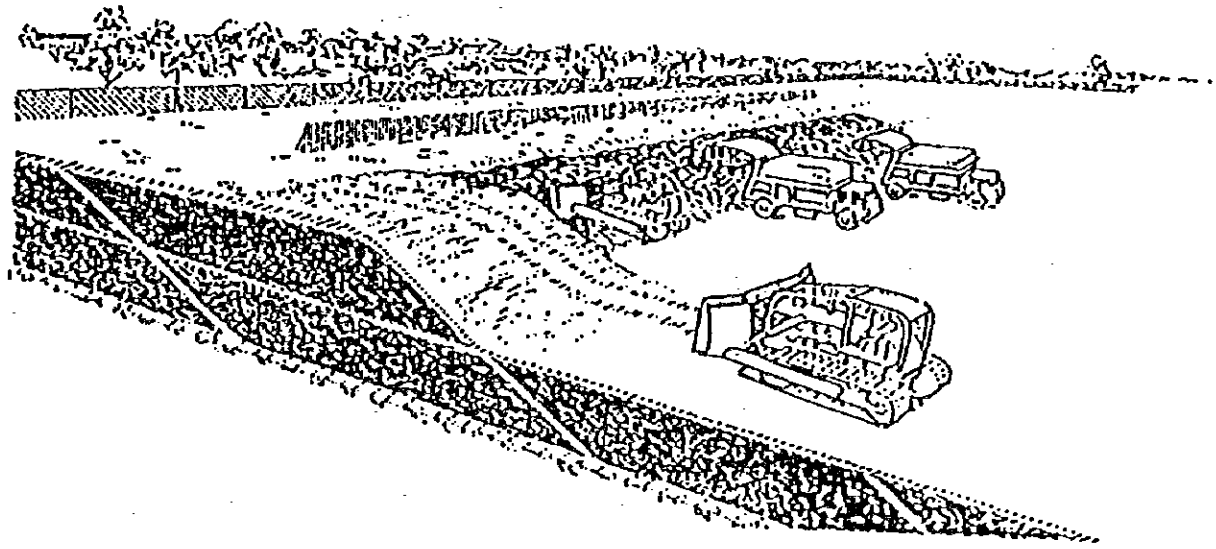
Waste Spread & Compaction



Cell & Cover Soil



Cell Method Operation - (1/2)



Cell Method Operation - (2/2)

FIG. 5.2-7 Conceptual Drawing of Landfill Operation (Cell Method)

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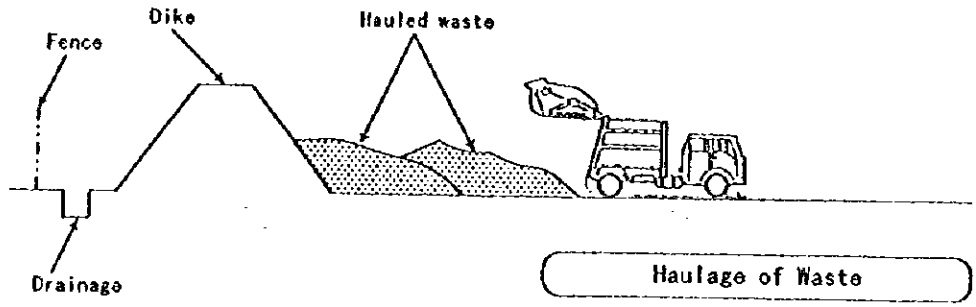
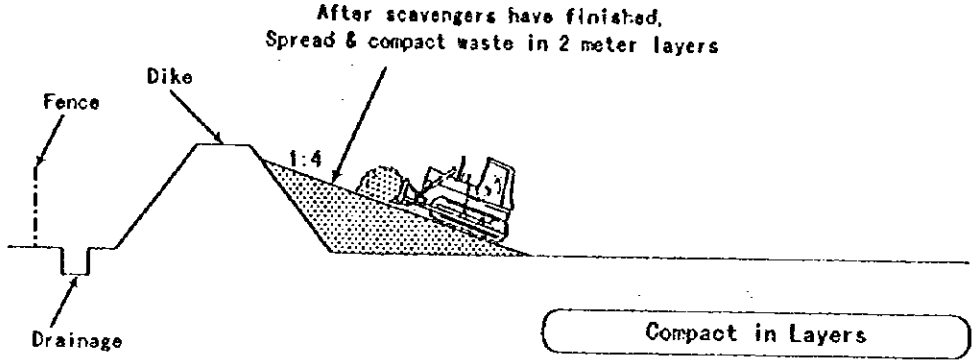
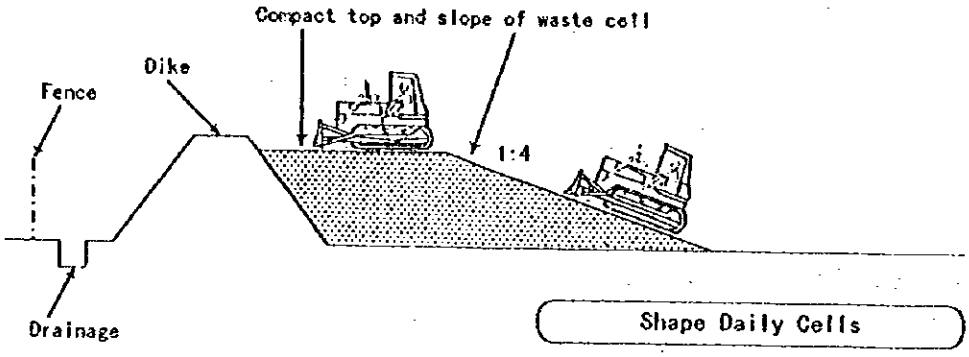






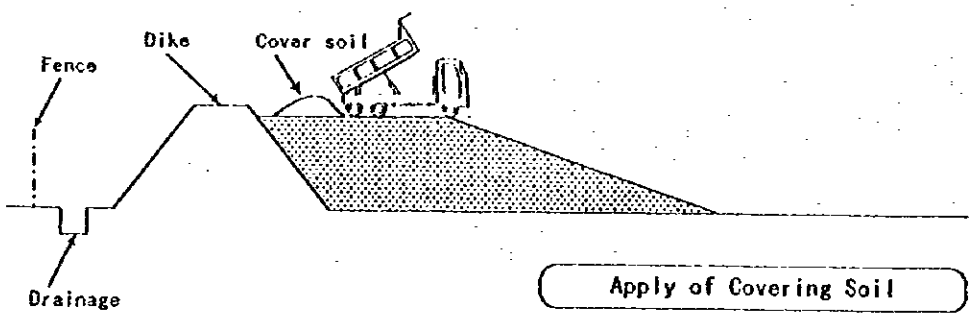
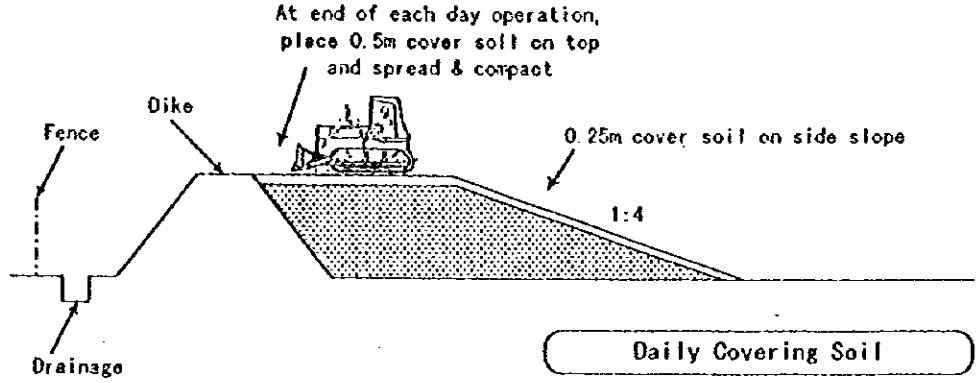
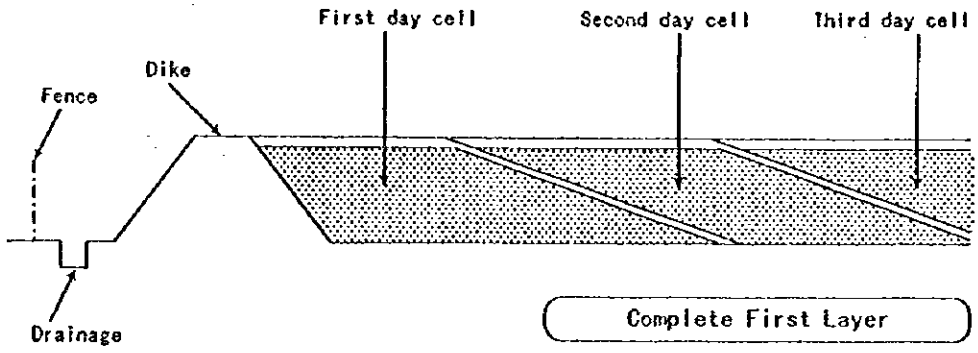
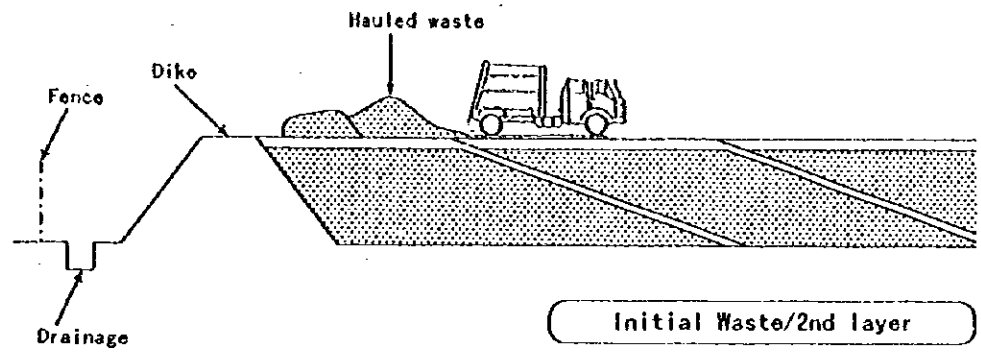


FIG. 5.2-8 Landfill Operation Procedures (1/3)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO







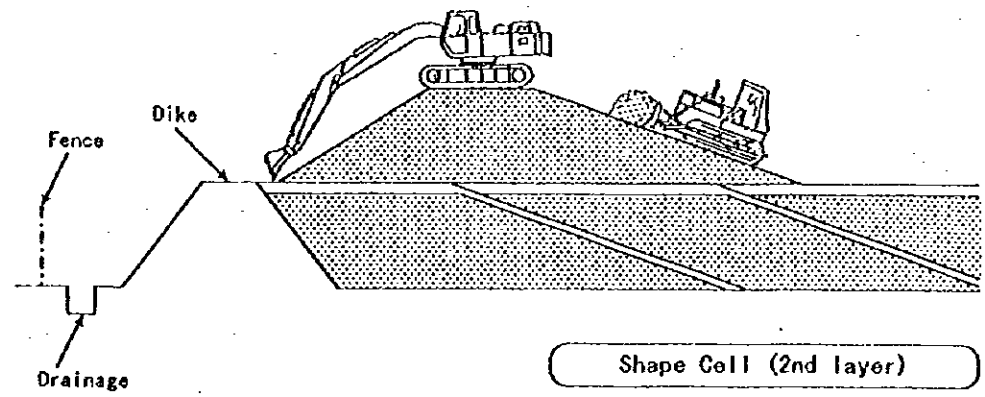
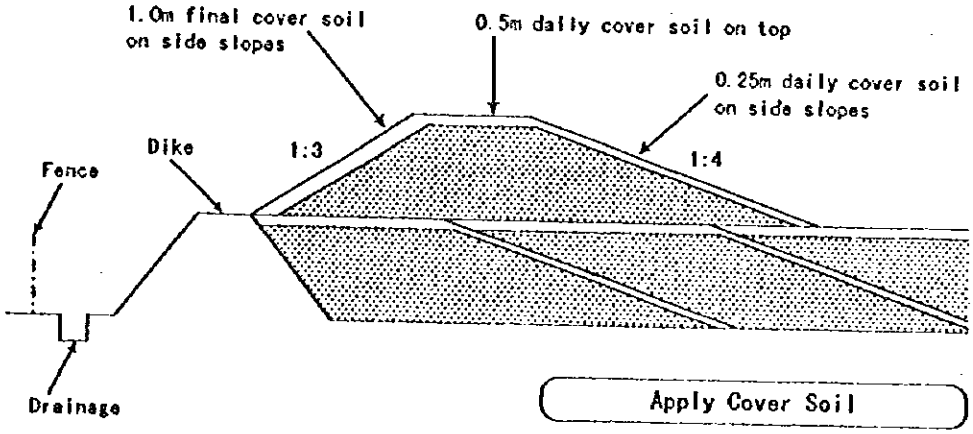
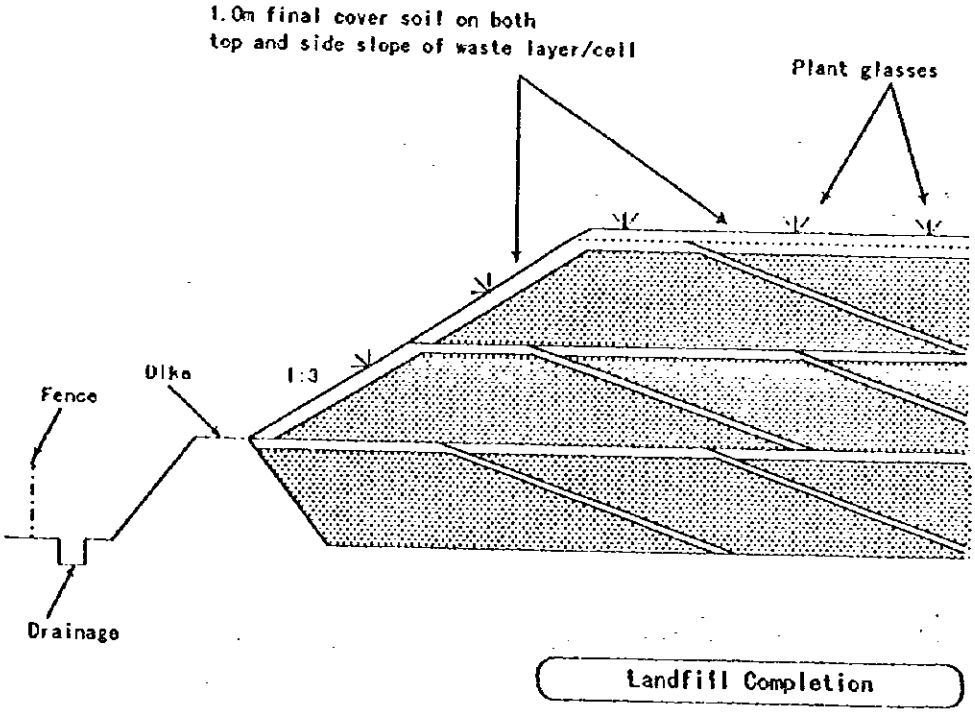


FIG. 5.2-8 Landfill Operation Procedures (2/3)

THE STUDY ON THE NATIONAL GUIDELINES FOR SOLID WASTE MANAGEMENT FOR THE KINGDOM OF MOROCCO





Source:
"Landfill Management Plan" by
International City Managers Association
(Washington D.C.) in 1992

FIG. 5.2-8 Landfill Operation Procedures (3/3)

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