b.1 Rules for scavengers working in the disposal site

The following set of regulations were put forward by the study team during the pilot project stage. These rules were developed with the cooperation of the scavengers and AMDC counterparts.

Table 15-10: Scavenger Regulations for the Disposal Site

1	Entrance to the landfill site is permitted between 7:00am and 4:00pm. At 6:00pm all scavengers should evacuate the site.
2	Only scavengers displaying a valid AMDC issued entrance card may enter the landfill site
3	The decision to allow anyone to enter lies ultimately with the chief engineer
4	Scavenging activities are only permitted in areas designated for such work.
5	Scavengers are strictly prohibited from climbing onto the back of vehicles entering the site
6	The chief engineer has the authority to eject any scavenger from the site that in his opinion is being disruptive to general operations. The ejected scavenger will only be allowed back onto the site following the permission of the chief engineer.
7	No alcohol or drugs shall be allowed into the landfill site. Anyone who, in the opinion of the site manager, is under the influence of alcohol or drugs will not be permitted on to the site.
8	Persons under the age of 18 years old are prohibited from entering the site. Students under the supervision of a teacher or other responsible adult may enter the site.
9	Scavengers must maintain areas used to temporarily hold recovered materials in a tidy manner. Landfill staff may request scavengers to clean areas adjacent to holding areas.
10	A maximum of 130 scavengers will be allowed to hold entrance cards.
11	No animals shall be allowed to enter the disposal site
12	Severe or repeated violations will result in the cancellation of the AMDC entrance card.

These rules are meant as a starting point and must be further developed over time. AMDC staff should maintain regular contact with scavengers and their leaders to smooth out problems associated with the implementation of regulations and revise them if the need arises and to monitor health and welfare issues. Moreover, it is crucial that all landfill staff and scavengers have the rules carefully explained to them in order that they are clearly understood.

b.2 System for scavenging at working face of landfill

In addition to the regulations a system for scavenging needs to be developed. This system must be clearly understood by scavengers and AMDC landfill staff and should be developed in accordance with developed landfilling procedures.

The main requirements of a scavenging system should include:

- Scavenging must not interfere with the dumping of waste by incoming collection vehicles (private and municipal)
- Sanitary landfilling requires that the deposited waste be regularly compacted in layers. There will only be limited time available for scavengers to look through and recover articles
- Areas need to be set aside for scavengers to temporarily hold recovered materials
- Scavengers must be aware of what materials can and cannot be recovered.

- Scavenging activities must respect the sanitary nature of the landfilling operations and not spread waste around excessively, disturb soil stockpiles, or dig into already covered or compacted waste

15.4.2 Improvement of Landfilling Methods

A detailed operation manual should first be prepared and made available to all staff at the sanitary landfill as well as to management and authorities clearly explaining sanitary landfilling methods. The manual should also describe actions to be taken in case of emergency e.g. defective equipment, fires, accidents etc.

The entire staff must read the operation manual before the operation of the sanitary landfill is initiated and later on by all new employees.

Further, proper operation of the landfill should be ensured by on-the-job training of all personnel, thus assuring the full understanding of personnel regarding biological processes, potential hazards and methods of minimizing environmental impact.

The following paragraphs summarize landfill methods proposed in this preliminary plan for the improvement of the Central District Disposal Site.

a. Landfilling by using cell method

It is proposed that waste be landfilled using the cell method. The cell method is used widely throughout the world and is an essential component of this plan to implement sanitary landfilling operations.

a.1 Cell construction

All solid waste received is spread and compacted into layers of approximately 60 cm in designated areas (see Figure 15-9). At the end of each day the waste is completely covered with a 15 cm compacted continuos layer of soil. The compacted waste and soil cover constitute a cell. A series of adjoining cells, all of similar height, makes up a lift. Cells and lifts are illustrated in Figure 15-10.

The volume of compacted waste brought into the disposal site each day determines the width and length of the cell. The height is determined in accordance with the ultimate planned height. For efficient use of cover material it is planned that lifts be in the range of 2.5 meters to 3 meters high. To maximize compaction the angle of slopes should not exceed 1 in 3.

An orderly operation is achieved by maintaining a narrow working face (that portion of the uncompleted cell on which additional waste is spread and compacted). It should be wide enough to prevent a backlog of trucks waiting to dump, but not be so wide that it becomes impractical to manage properly. A 30 meter face is tentatively proposed to start with taking into account the amount of waste being brought into the site each day. This width may be altered but should not exceed 50 m.

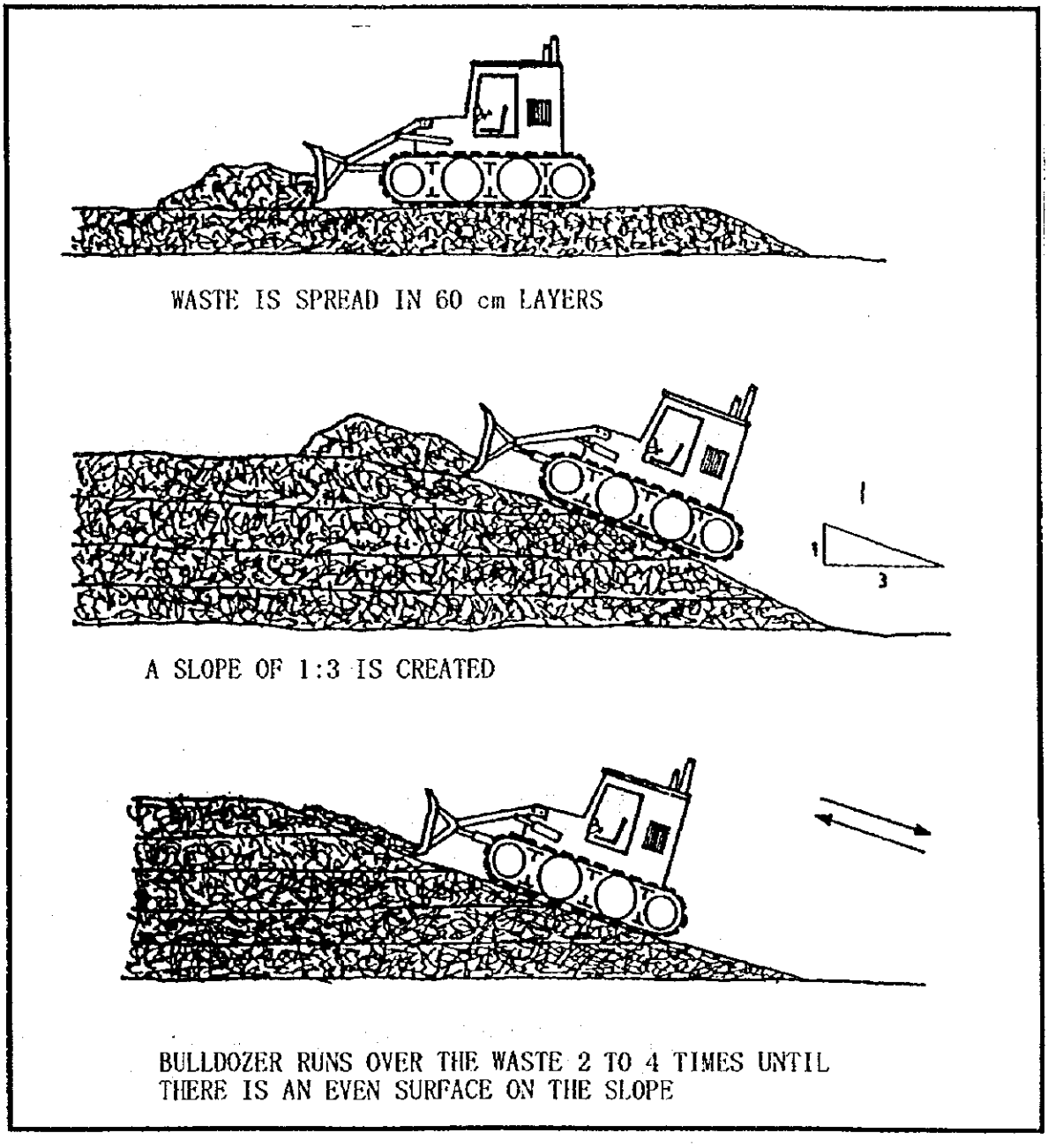
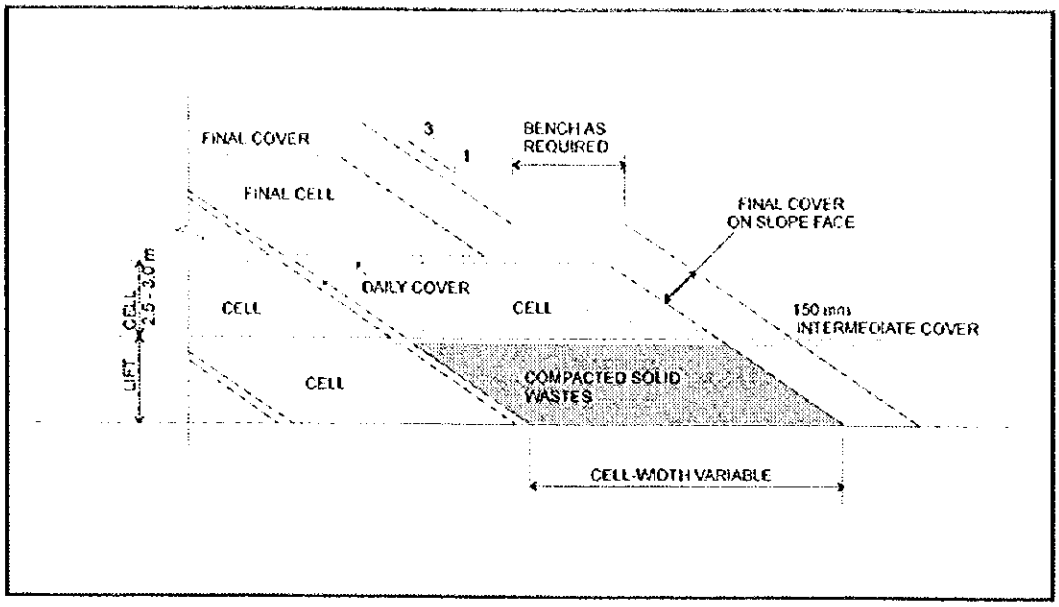


Figure 15-9: Cell Landfilling Method

Figure 15-10: Landfill Cells



a.2 Landfilling procedure

Continual filling using the cell method will result in the formation of waste hills as shown in Figure 8. The final shape of the landfilling is proposed to consist of steps gradually dropping with the existing topography, widening towards the eastern edge of the disposal site. The top layer of the steps should be sloped (min. 2% gradient) so that rainfall runoffs the surface.

Slopes greater than 18 meters in height (approximately 6 lifts) should be terraced to maintain slope stability. A terrace will run along the northern edge of the landfill separating the existing waste hill from new filling. Also the new filling Area A_1 is proposed to be terraced. Terraces, being at least 5 meters wide, slope towards the low side with a gradient of no less than 2%. Surface drains are desirable along terraces and the edges of flat areas to reduce the impact of erosion.

Excavation of cover material from Area A_1 is to be done so as to create a slope falling back into the excavation. This is proposed to prevent leachate generated from future landfilling from flowing out of the landfilling and into the surface runoff drainage network. Leachate generated will instead percolate into the ground.

During the wet season, however, while landfilling is occurring there will be ponding of rainwater following moderate to heavy downpours because of this back slope. Water should be removed by pumping it into the natural drainage course.

a.3 Disposal of infectious waste

As a temporary measure (until the incinerator problem is resolved) infectious waste is to be disposed at the final disposal site.

Figure 15-11: Section (North-South) through Area B1 in Proposed Landfill

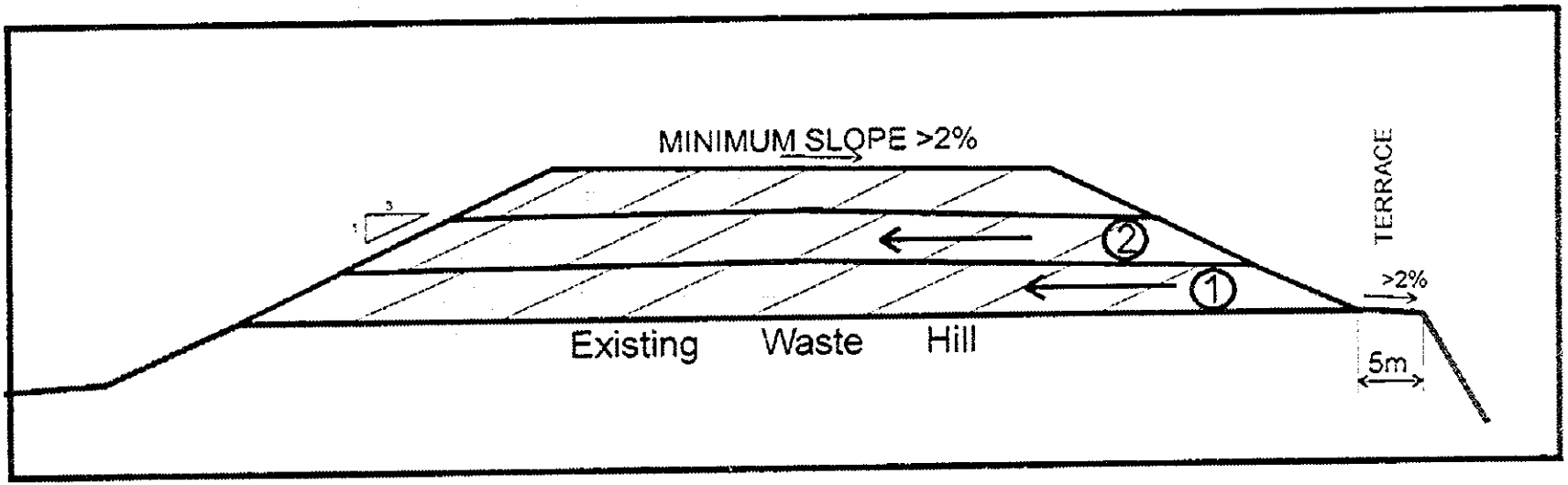


Figure 15-12: Profile (East-West) of Proposed Landfill

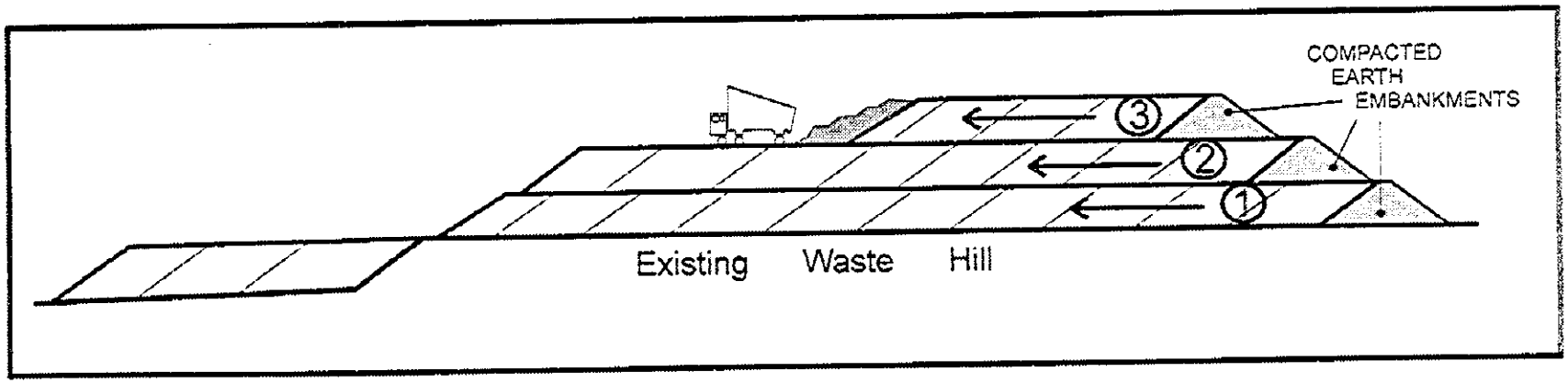
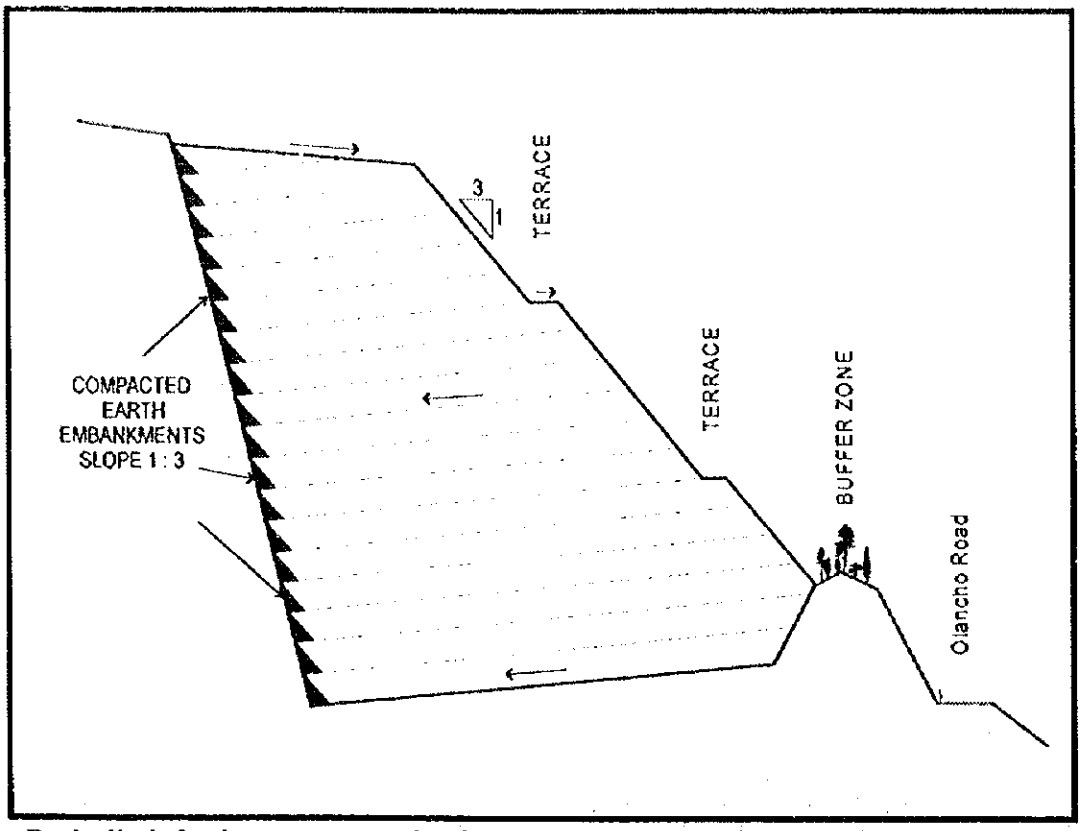


Figure 15-13: Section through Area A_1 of Proposed Landfill



Basically infectious waste coming into the site should be compacted and covered in a similar manner described for other wastes. However certain additional measures are necessary to ensure the safety of landfill staff and scavengers.

On arrival at the site the operator of any vehicle carrying infectious waste should report to the site engineer and receive directions on where the waste is to be buried. The site chosen should be in an isolated part of the disposal site that is protected from the wind. Landfill staff participating in the disposal should be properly outfitted with protective clothing, i.e., face masks, safety glasses, heavy-duty gloves, and coveralls. Once deposited the waste must be immediately covered with a disinfectant and covered and compacted, and the disposal area kept strictly off limits to scavengers.

a.4 Daily cover material

As described above the waste must be covered daily with a 150 mm continuous layer of soil. The type of cover material is restricted by what exists within the disposal site within areas A_1 and A_2. The soil that may be used for covering waste available at the disposal site is weathered rhyolite and volcanic ash (tuffs). Volcanic ash when excavated behaves like clay, while weathered rhyolite, on the other hand, disintegrates and becomes gravel.

Ideally an effective cover soil should exhibit the following characteristics: be able to restrain the flow of water and landfill gas, prevent flies and rodents getting at the waste, be workable in any weather, and prevent the spread of landfill fires. A well-graded material, i.e. a material containing gravel and a significant percentage of fines meets these requirements.

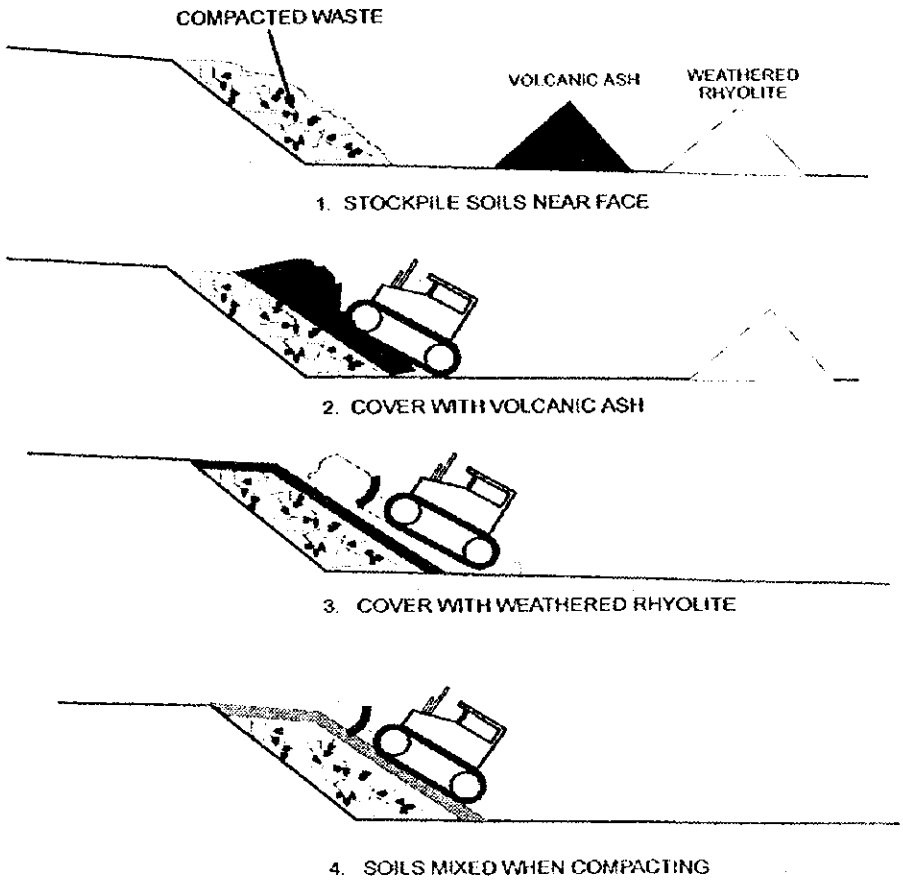
In order to obtain a well-graded material it is proposed that the two soils available at the landfill site be mixed. It was found that the best mix ratio is a 50% volcanic ash and 50% weathered rhyolite mix (Table 15-11). This mix is also proposed for the final cover layer and internal roads.

The 50/50 mix is easy to obtain under field conditions (see Figure 15-14). This mix ratio is quite robust so errors of a few percent in the actual percentages, as is likely to occur in the field, will not significantly effect the cover soil's characteristics.

Table 15-11: Characteristics of 50/50 soil mixture

Property	Value
Standard Proctor Test	1,631 kg/m³
Optimum moisture	19.4 %
USCS Percentages	
Gravel	41 %
Sand	30 %
Fines	13 %
Permeability Coefficient (k)	3.8×10^{-3} to 1.4×10^{-5} cm/sec

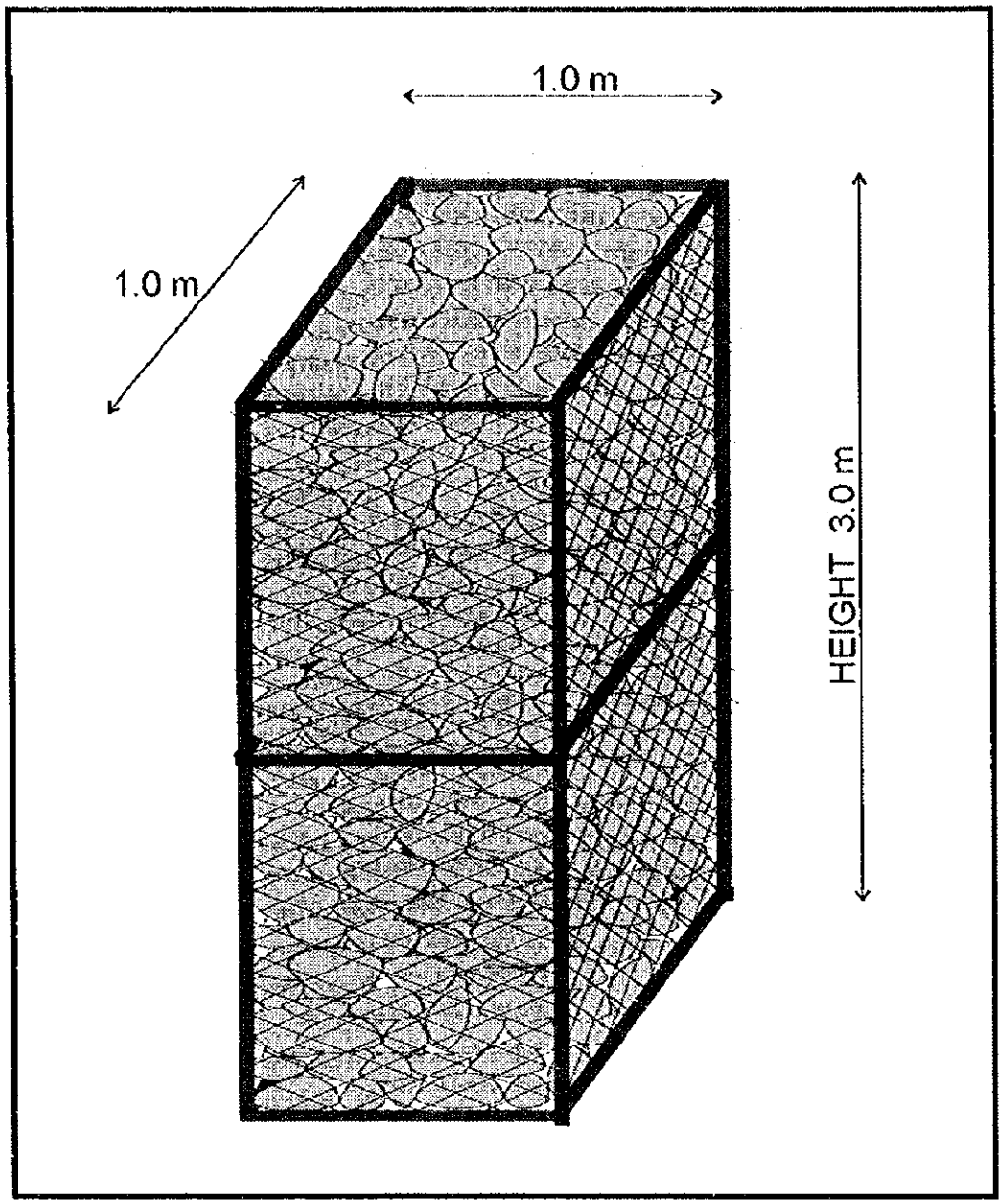
Figure 15-14: Cover Soil Application and Mixing Method



b. Gas Venting and Flaring

Landfill staff should place gas vents at 20-meter intervals to release dangerous landfill gases from the waste. Construct gas vents from timber (75x75 verticals and 50x50 laterals) and chicken wire, and fill with cobbles(see Figure 15-15).

Figure 15-15: Gas Vent



b.1 Installation

Gas vents are easily installed:

1. Excavate hole 1m x 1m x 1m into the surface and place empty cage.
2. Fill with stones (rounded river cobbles, 15 to 30 cm in size) from the back of a dump truck.

3. Waste is built up around the vent until level with the top of the vent. The top of the vent is leveled and another vent placed on it. This continues until the finished level of the landfill is reached.

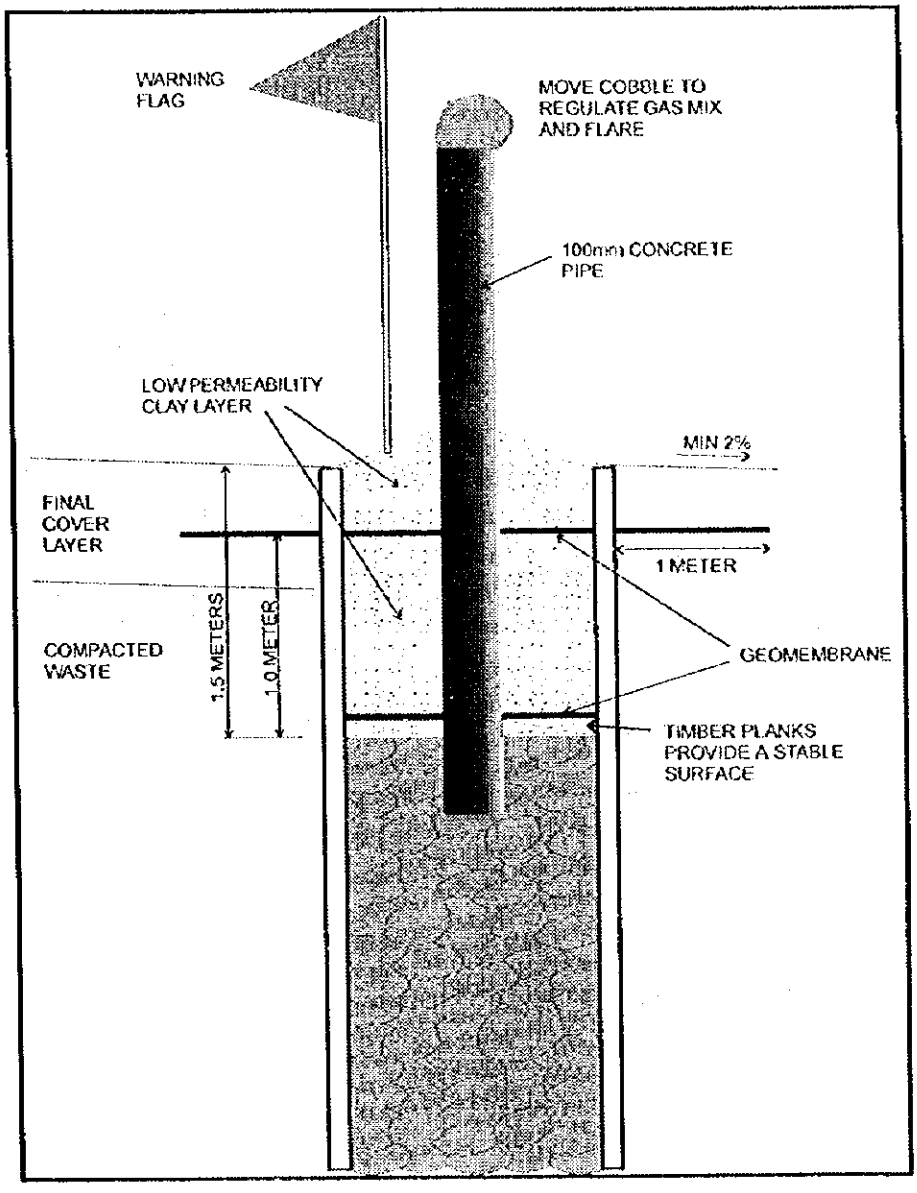
4. The vent is then capped and a pipe installed to assist in the burning of the gas.

b.2 Capping of vents

Immediately following the placement of the final cover layer, pipes should be installed into the gas vents in order to flare the gas. The following describes the installation method.

Firstly, however, workers must take extreme care when installing gas release vents. Installation should be done by at least 2 workers equipped with gas masks. One worker should remain outside the hole and a vehicle on stand by to assist the other worker if he should get into trouble.

Figure 15-16: Installation of Gas Flaring Pipe



1. Remove the cobbles to a depth of about 1.75 meters from the surface and insert a 3 to 3.5 m long ϕ75-100 mm concrete pipe and backfill with cobbles to 1.5 meters to hold the pipe in place. Steel pipes can be used, but it must be remembered that they will heat up.
2. Place timber boards and geomembrane over cobble base as close as possible to pipe in order to prevent gas escaping. Plastic tape can be used to attach geomembrane to pipe.
3. Backfill with 1 meter of impermeable soil and place another layer of geomembrane on top. Also excavate and place a 1 meter strip of geomembrane around the outside of the cage at the same level as the sheet in the cage.
4. Backfill top 50 cm with the impermeable soil and build a mound around base of pipe so surface water will flow away.
5. Place a suitable sized cobble into the pipe. The purpose of the cobble is to regulate the emission of landfill gas. It should be possible to manipulate the cobble to regulate the mix of air and landfill gas so that the gas will ignite.
6. Lighting the gas should be done with the wind behind in order to avoid injuries from sudden bursts of flames.
7. Once the vent is lit, place a bright colored flag beside it to mark the location.

c. Leachate Control

Controlling the generation and flow of leachate is achieved through the use of improved cover soil techniques and surface runoff control as discussed in other sections. An additional measure is proposed to treat the leachate flowing from the landfill. It is proposed that there be a leachate recirculation system.

Leachate recirculation is an effective method for the treatment of leachate. During the early stages of landfill operation leachate contains significant amounts of TDS (total dissolved solids), BOD_5, and COD, nutrients, and heavy metals (seeTable 15-9). When leachate is recirculated, the constituents are attenuated by the biological activity and by other chemical and physical reactions occurring within the landfill. In addition to the increase in the amount of leachate resulting, the rate of gas production will also increase with greater biological activity taking place as a consequence the leachate recirculation. Resulting in faster stabilization of the wastes and the site.

It is proposed to construct dams across the creeks to the north of the site into which leachate flows (see Figure 8) to catch the leachate. The dam cores should be constructed with a material of low permeability ($K>10^{-6}$ cm/sec). Clay will be imported to the site.

Sewage pumps (head at least 50m) are proposed to pump the leachate up onto the landfill via flexible hoses and the leachate is sprayed over the landfilling. Spraying of leachate onto the landfill should be done in a way that ensures the leachate either evaporates or infiltrates in the surface of the landfill—the flowrate must be well controlled. It is critical that leachate not be allowed to flow into surface runoff drains. The spraying of leachate should be suspended if odor problems are identified. If this situation occurs an alternative method is to pump the leachate into the open gas vents.

d. Internal Roads

The point where waste is dumped and covered (working face) is constantly moving meaning it is necessary for the landfill staff to be regularly constructing and maintaining temporary internal roads. Internal roads must be able to support heavy collection vehicles and bulldozers under variable weather conditions. It is therefore proposed that the internal roads have the following characteristics:

Minimum width	5 m
Side slope	2 %
Maximum longitudinal incline	15%
Surface material	Well graded, well compacted material, 50-50 mix

In the rainy season, however, it may be necessary to change the soil mix if traction becomes a problem because of frequent heavy traffic and rain. In which case the proportion of gravel (weathered rhyolite) should be increased.

Internal roads should be placed so they do not restrict the runoff of surface water. In some cases it will be necessary to install drainage culverts.

e. Waste Fences

Two types of waste fences are proposed for the disposal site, permanent and moveable. Waste fences are used to prevent light waste (plastic and paper) from being blown on to surrounding areas.

Permanent waste fences are proposed to be erected along the southern crest of the waste hills to prevent waste blowing onto the Olancho Road, while moveable waste fences are placed close to where ever the working face is. Because wind rarely blows from the south and because of the relatively sparsely populated areas to the north of the site neither permanent or moveable waste fences need to be placed along the northern edge of the landfilling.

Moveable waste fences and approximately 200 hundred meters of permanent waste fence were erected during the pilot project stage (see section 9.4).

f. Final Cover Layer

The construction of the final cover layer is an essential part of the closing of a landfill. Ideally the material should be able to retain moisture (aiding evapotranspiration) and retard the upward movement of landfill gas. Impermeable geomembrane liners are often used to provide impermeability but are expensive, therefore we propose to use materials found on the site.

The 50-50 mix of volcanic ash and the weathered rhyolite material will produce a well-graded mix suitable for making the final cover layer.

Another important characteristic of the final cover layer is its ability to support vegetation (topsoil). Thus the top 15 cm of the final cover layer should be mixed with a rich organic material. Therefore it is proposed to make compost at the site from organic waste material disposed at the site.

Further a minimum grade of the final cover layer of 2% is necessary to promote surface water runoff and a maximum grade of 18 % to prevent scouring and erosion of slopes.

g. Composting

Compost can be easily produced but requires a large area. The FENAFUTH land may be used for this purpose while the existing disposal site is being filled (provided acquisition is finalized).

A brief explanation of the aerobic composting method is outlined below:

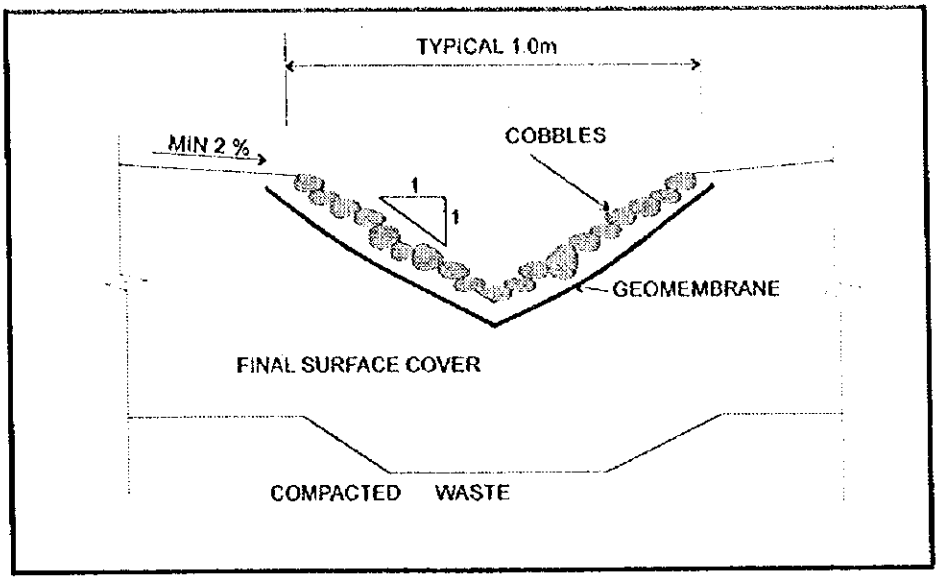
- Divert suitable organic material entering the landfill to the area specially set aside for making compost. A C/N ratio of between 15 and 40 % (dry basis) is optimum[6] for the production of compost. Grass clippings (20.1%), freshly fallen leaves (40 – 80 %), vegetable waste (25 – 35 %), and animal manure (15 – 25 %) are within this range. While paper (200 – 4,450 %), wood and sawdust (170 – 700%), and slaughterhouse waste (2%) should be used only in small proportions. Material to be composted preferably should be smaller than 7.5 cm (3 inches) in diameter.
- Form the waste into windrows, approximately 2 m high and 4 meters wide with bulldozer or wheel loader.
- Turn windrows with bulldozer or wheel loader 3 – 5 times a year to produce finished product in 14 – 18 months. More frequent turning will speed up production and reduce effects of odor.
- The optimum moisture content is in the range of 50 to 60 percent. This is roughly equivalent to the moisture content of Central District MSW when discharged.
- Mix compost with soils existing at the site to make sufficient amount of topsoil to cover the entire site, approximately 18 hectares.

h. Improved Surface Water Drainage

A system of drains to collect and divert clean surface runoff from the landfill and surrounding areas must be installed. Drains are proposed to be lined with cobbles to prevent scouring and have a geomembrane (polyethylene sheet) to prevent water infiltrating into the waste.

[6] Tchobanoglous, Teisen, Vigil, *Integrated Solid Waste Management—Engineering Principles and Management Issues*, 1993, p. 689.

Figure 15-17: Section of Surface Runoff Drain



To maximize runoff all areas within the landfill must be graded at no less than 2 %. Embankments should be no more than 18 % or 1 in 3. Locations of surface drains are shown on layout plan (Figure 8).

i. Landfill Equipment

Equipment necessary for landfilling activities is shown the in Table 15-12.

Table 15-12: Landfill Equipment

Equipment	NECESSARY MAJOR EQUIPMENT												
	Exists	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
D7 bulldozer	3	3	3(3)	3	4(1)	4	4	5(1)	5(3)	5	5(1)	6(1)	6
Wheel loader	1	1	1(1)	1	1	1	1	1	1	1(1)	1	1	1
Dump truck	3	3	3(3)	3	3	3	3	3	3(3)	4(1)	4	4	5(1)
Pick up	-	1	1(1)	1	1	1	1	1	1	1(1)	1	1	1
Water tanker	-	1	1(1)	1	1	1	1	1	1	1(1)	1	1	1
Motor grader	P	-	-	-	-	-	-	-	-	-	-	-	-

P: Equipment is hired for periodic use,
Numbers in parenthesis represent numbers acquired.

1) Bulldozer (track-type tractor)

D7 or similar size bulldozers must permanently be stationed at the disposal site. Initially two are proposed to be in use while another is on standby. In the year 2000, three(3) new bulldozers are needed to replace the existing bulldozers. These are expected to have a service life of 6 years when they need to be replaced. In 2002,

2005, and 2009 additional bulldozers should be purchased to deal with the increasing amount of waste.

The bulldozer is the most important piece of equipment at a sanitary landfill undertaking the central activity, i.e., the compaction and covering of waste. If this activity is not regularly carried out the landfill ceases to be sanitary. It is also used to push waste, excavate cover material, create internal roads, and grade slopes.

2) Wheel loader

One (1) wheel loader permanently stationed at the disposal site.

The wheel loader is used primarily to load soil onto dump trucks, but is also necessary to crush bulky waste, pick-up waste disposed in the wrong place, dump soil on landfill fires, and to periodically turn compost.

3) Dump truck (capacity 10 ton)

Initially three (3) dump trucks are proposed to be permanently stationed at the disposal site. In 2007, and again the in 2010 the number of dump trucks at the site will increase by one.

Dump trucks are used to haul cover soil from the borrow pits to the face of the landfill. They will also be used to haul soil for the construction of internal roads, embankments, haul cobbles for gas vents, and carry large and heavy items around the site.

4) Pick up truck

The pick up truck is necessary for site manager to supervise the site. It is important that the manager can move between points quickly as serious problems can arise suddenly at anyplace.

The pick up truck is also necessary to carry light materials quickly and efficiently, and to coordinate activities with other sections within the municipality.

5) Water tanker

One (1) water tanker 6 m^3 to be used solely for site operations.

Transportation of water to the site for filling the water storage tank used for washing. In addition, spraying roads and other areas to reduce the impact of dust and the watering of trees, shrubs, and lawn, especially in the dry season. And when necessary the spraying of cover soil to improve compaction.

6) Motor grader

One (1) motor grader on a temporary basis.

The motor grader is necessary to grade the final cover layer. Accurate grading of slopes as slight as 2 % is essential.

Finally, because of the high density and moisture content of the waste produced in the Central District, the use of landfill compactors on the landfill is not recommended. These machines were developed to achieve high in-place densities on landfills in

higher income countries where composition of the waste is different (it is much less dense) and has a lower moisture content.

15.4.3 Buffer Zone

Landfill activities even when undertaken in accordance with correct procedures are unattractive. Further noise, odor, dust, and wind-blown litter can never be totally eliminated. Therefore to make the site more visually pleasing from the outside and to dampen the effects of noise, odor, etc., buffer zones, in the form of tracts of treed land and the site's natural topography will be used. The areas set aside for the buffer zone is shown in Figure 8.

Some of the land proposed for the buffer zone is already thickly covered with trees so it is necessary to preserve these areas, while other areas have a sparse covering of trees or no trees, in which case additional trees should be planted. Trees take several years before they will be effective as a buffer zone so planting must begin as soon as possible.

Fast growing evergreen species planted close together are preferred. Deciduous varieties lose their leaves during the dry season and this is when the buffer zone is most necessary; conditions are right for the generation of dust and smoke. Moreover, tree species should be of varying heights and planted a close as possible to create a buffer zone.

Cover material should not be taken from the area marked as a buffer zone near the site's southwest that runs parallel to the Olancho Road. This should remain to form a natural embankment between the road and future filling area A_1.

15.4.4 Reduction of Litter along Olancho Road Approaching Disposal Site

Along Olancho Road leading up to the disposal site is heavily littered with litter from businesses dealing in recovered materials and waste that has fallen off the back of vehicles carrying waste to the landfill site. To combat this problem a number of measures are proposed:

- Establish littering ordinances and penalizing local businesses. Regular visits by a AMDC inspector to businesses in the vicinity of the disposal site informing the owners of the ordinances and if necessary fining
- Provide tarpaulins for collection vehicles (30 dump trucks and 2 container trucks)
- Include this section of Olancho Road in areas covered by street sweeping micro-enterprises.

15.4.5 Road Safety

The point on the Olancho Road where the landfill access road intersects it is a high-speed, gently curving section of highway. Vehicles often use this section of road to overtake often unaware that collection vehicles (exiting the disposal site) may enter the flow of traffic at anytime. To complicate matters the truck drivers exiting the site have their vision partially obstructed by an embankment. Near misses are a regular occurrence.

Therefore it is proposed to make the following changes to the existing intersection:

- Provide a merging lane for trucks exiting the disposal site
- Erect signs in both directions warning motorists of merging trucks
- Paint double lines on the road 300 meters in both directions from the entrance.

Figure 15-18: Proposed Merging Lane and Site Access

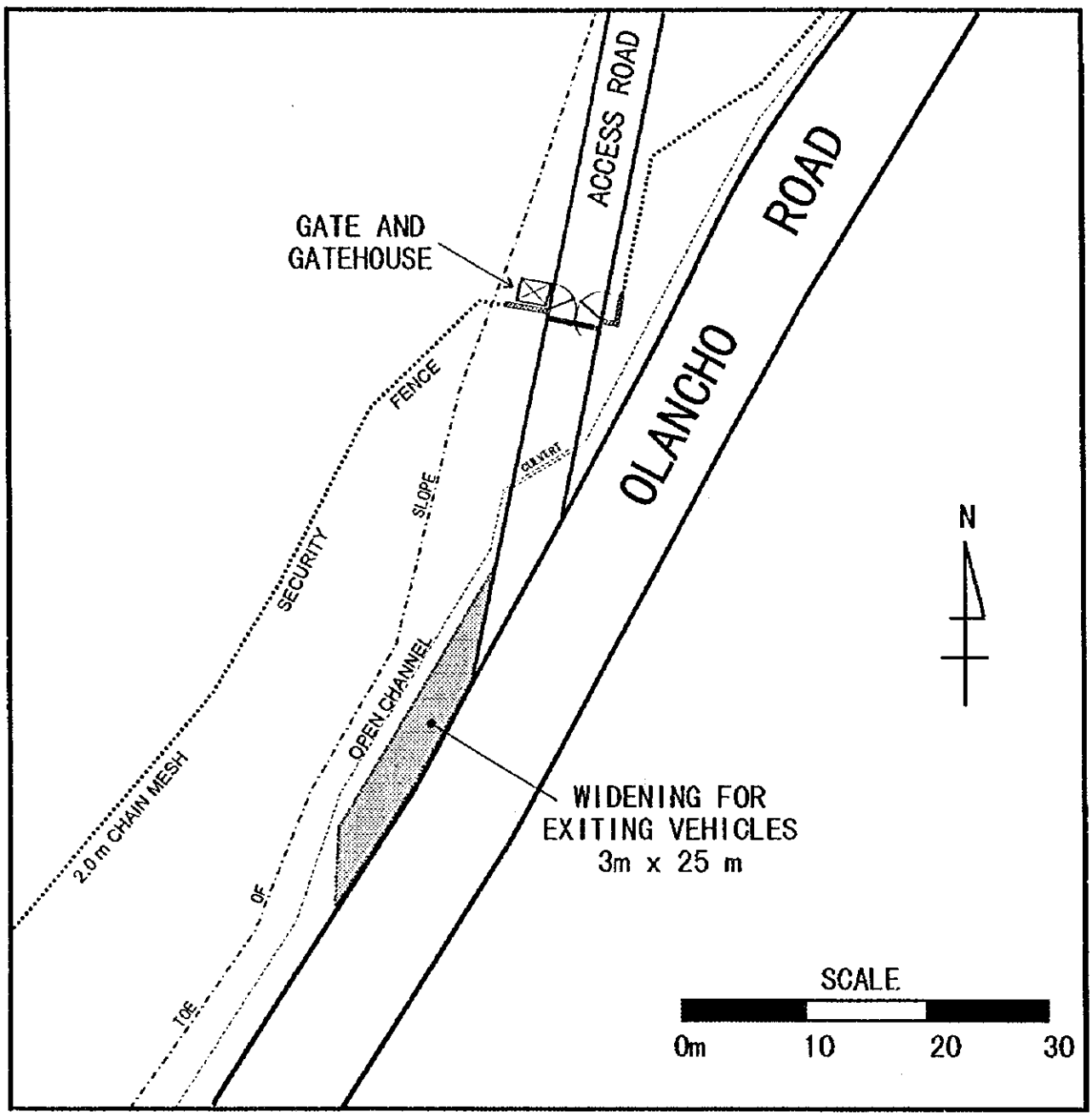


Figure 15-19: Proposed Warning Sign

Warning signs should be placed on the right hand side of Olancho Road in both directions at 200, 100, and 50 meters from the disposal site entrance.

15.4.6 Administrative Improvements

a. Landfill Staff

It is proposed that the following full time employees operate the sanitary landfill initially (staff numbers will gradually increase, see cost estimation section).

Position	Number
Manager (engineer)	1
Assistants to manager	2
Vehicle operators	6
General assistants	6
Security	6
TOTAL	21

1) Site manager having the overall managerial duties, including:

- Management and supervision of operations, maintenance of landfill equipment, and performance of control procedures, e.g. registration of waste and control of leachate recycling.
- Planning of future extensions to the landfill, e.g. the construction of further landfill sections and preparation of new excavation areas for soil coverage.

2) Truck scale operator (assistant to manager)

3) Traffic controllers (general assistants): Responsible for controlling the flow of trucks to the truck scale and guiding trucks to the correct site for unloading.

4) Operators of landfill equipment: Responsible for the operations at the disposal area (e.g. compaction and daily soil coverage of waste) and the preventive maintenance of landfill equipment.

5) General assistants: Undertake various jobs, including maintenance and cleaning at the landfill.

6) Security guards: Responsible for the security of buildings, landfill equipment, and the control of scavengers.

Working hours:

- Mondays to Fridays: 7:00 - 18.00
- Saturdays: 7:00 - 14.30
- Sundays and public holidays: closed

b. Administration Block

The administration block is proposed to (see) include:

- Administration building
- Parking area
- Change rooms
- Truck scale and control room
- Security lighting
- Water supply and sewage treatment system
- Garage
- Latrines for scavengers

b.1 Administration office

Constructed and equipped to allow observation of incoming vehicles, communication with the Cleansing Section head office in *Colonia 21 de Octobre*, regular meetings, reception area for visitors, cooking facilities for landfill staff, and storage and filing space for landfilling records.

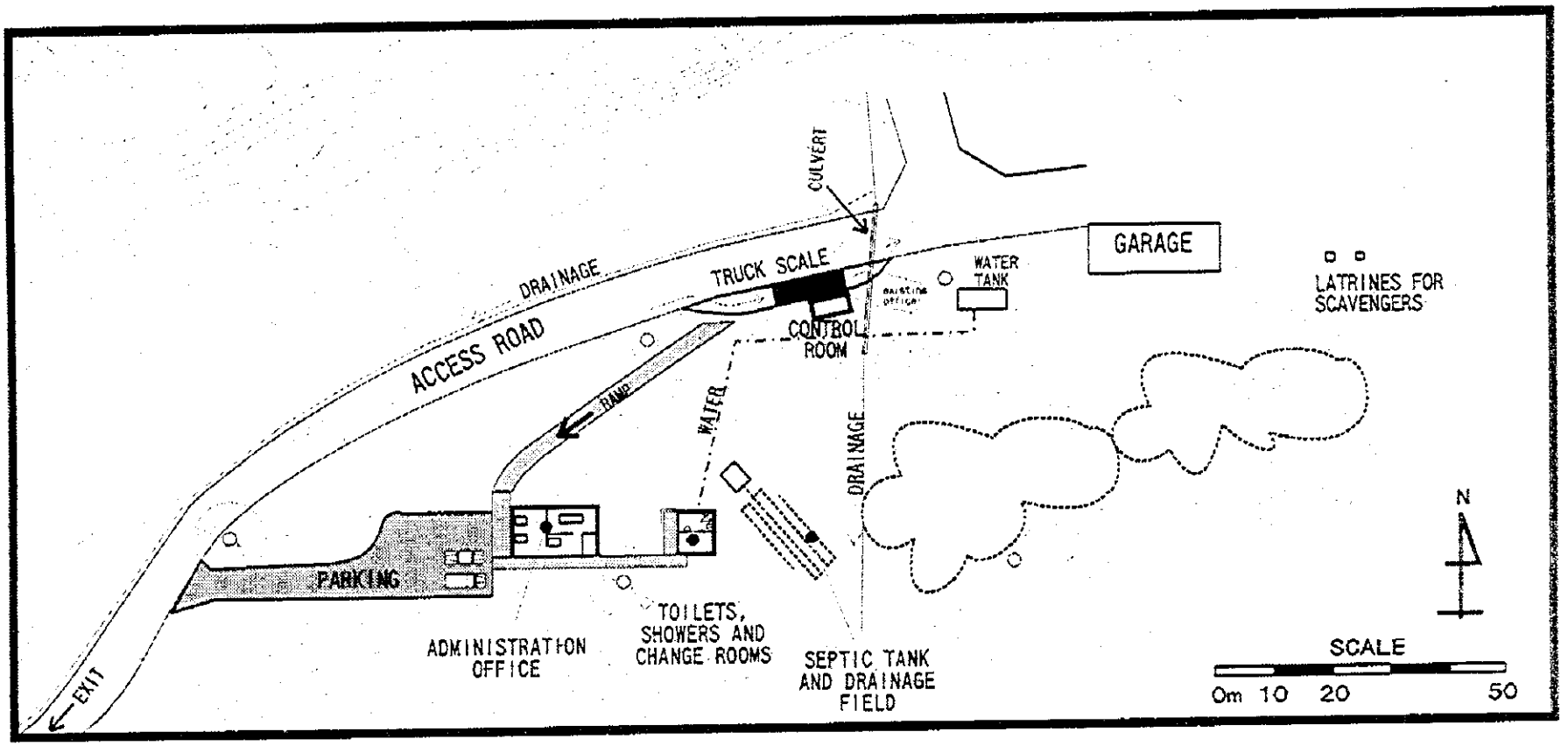
b.2 Parking area

Asphalt paved parking area for cars of workers and guests will be constructed next to the administration building.

b.3 Change rooms

Change room ("clean" room) where private clothes are stored during the working day; change room ("unclean" room), where the work clothes are stored at night; and toilets and showers with running water.

Figure 15-20: Administration Block



b.4 Truck Scale and control room

Waste registration at the control room serves the following purposes:

- Control of incoming waste.
- Collecting disposal fees.
- Collections of data for further planning of landfill extensions.

Installations inside the control room will comprise:

- A personal computer and printer.
- An intercom system for exchanging information with the truck drivers on the truck scale and the operators of the bulldozers working on the site.

Details of the truck scale include:

- 30 metric ton pitless type truck scale with concrete ramps. The recorded weight of a full truck is transmitted to the computer in the control room.
- Access control gate or traffic light controlled by the computer in the control room.

The truck scale and control room are proposed to be constructed in a manner that allows them to be relocated at a later date. When the filling of Area A_1 (see section 15.3.4) the truck scale and control room will be moved to a location convenient to Area A_1. And similarly when the FENAFUTH extension opens to landfilling.

b.5 Garage

The garage (approximately 10m x 25m) will be used for parking bulldozers and wheel loader as well as serving as an area for preventive maintenance of landfill equipment. It is recommended to service the landfill equipment at a mobile workshop and major repairs to be commissioned to private workshops. The garage will also have fuel storage tanks and security gates that will be locked each night.

b.6 Security lighting

Security lighting will be extended to light up the whole administration block and access road from the gatehouse.

b.7 Water supply and sewage treatment

A reinforced concrete water storage tank (capacity $10m^3$) is proposed to be placed as shown in Figure 15-20. This location provides for easy refilling and gravity supply to the change rooms and administration office. Also the tank is proposed to have a faucet for supplying water to landfill staff and scavengers.

A septic tank and drain field is proposed as shown.

b.8 Latrines

Three (3) 'FHS' type latrines are proposed for use by the scavengers.

c. Maintenance of Civil Works

Periodically maintenance of civil works should be carried out by landfill staff. This includes:

- Cleaning of surface water drains
- Maintaining slopes and grass covering
- Leachate pump and transmission pipe maintenance
- Repairing damages to fences (perimeter and waste fences)
- Road and pavement repairs
- Painting of structures
- Cleaning of sewage system

15.4.7 Monitoring

Monitoring of the disposal site and surrounding areas is critical for the long term assessment of the success or failure of landfill improvement activities.

Two types of monitoring are proposed. First, it is necessary to evaluate the effect on the target group (local residents, passing motorists, see section 15.1) of the disposal site improvements. Local residents or representatives should be assembled in a community group type meeting and asked specific opened ended questions regarding disposal site operation and improvements, for example, 'Have you noticed a difference in the odor emanating from the landfill recently?' 'Has the cleanliness of Olancho Road improved?' and general questions such as the 'Is the disposal of MSW causing problems?' 'Do you notice any improvement in conditions?' 'What should be done to improve the problem?' etc.

Second, environmental monitoring is necessary, i.e., monitoring of air and water. Water and leachate samples should be taken frequently (throughout the year) at points along the Los Limones and Los Jutes creeks and at the disposal site (leachate retention pond). As well as from wells and springs where ground water percolates out of the ground.

Table 15-13: Proposed Monitoring Program for Water Sources and Leachate.

Parameter	Ground water and streams	Frequency per year	Leachate	Frequency per year
PH	X	1	X	2
Conductivity	X	1	X	2
NH_4^+			X	2
Cl^-	X	1	X	2
SO_4^{2-}	X	1	X	1
Fe^{2+}	X	1	X	1
BOD			X	2
COD	X	1	X	2

Note: The program may be extended if suspicion of pollution arise.

15.4.8 Landfill Closure and Post-Closure

Landfill closure is proposed to begin once the capacity of the site has been reached. The closure and post-closure plan must be decided upon as early as possible and

revised if major changes to the filling occur. Further just prior to the closing of the site the plan is reviewed and the closure plan decided upon. Important elements regarding the closure are discussed below.

a. Long term use of site

It is proposed that an ecological park be created at the site after closure. Therefore a closure plan should be developed with the objective of growing plants. Factors that limit the growth of plants on completed landfills include toxicity of landfill-generated gases (e.g. CO_2 and CH_4) to root systems, low oxygen, thin cover soils, limited cation exchange capacity, low nutrient status, low water-holding capacity, low soil moisture, high soil temperatures, high soil compaction, poor soil structure, and improper choice of plants[7].

b. Establishment of the final cover layer

As proposed in earlier sections a 600 mm layer of well-graded soil will be used as a cover soil. This will include a 150 mm layer of soil mixed with compost produced at the site. The final cover layer thickness of 600 mm is the minimum allowable and is based on the availability of soil.

For growing plants a loosely textured surface must be created. While the cover layer should also be impermeable to the upward flow of landfill gas. It is therefore proposed that the lower 300 mm of the surface cover be very well compacted at near optimum moisture content (90% Standard Proctor). The upper 300 mm (including the 150 mm organic layer) should be only lightly compacted and the surface tilled.

Grasses because of their shallow roots will be the first plants to establish themselves so should be planed initially.

Areas were tree and shrub planting is planned should have a thicker final cover to allow for the development of their deeper roots (waste can be removed and a impermeable geomembrane placed or mounds created). Also trees will grow better in areas where non-biodegradable waste has been disposed.

c. Surface water drainage

Final surface water drainage as discussed in previous sections.

The main characteristics being that the surface slope of any finished area should be greater than 2%. While the maximum allowable finished surface grade is 18%. A motor grader is proposed to attain precise grades. Lined drains are proposed to transport quickly and efficiently from the site and into the drainage course.

Leachate and surface runoff must be kept separate. And open drains and culverts should be periodically cleaned following closure to avoid blockages.

d. Control of Landfill Gases

Gas flaring pipes must be installed as described above. Further it is important to remember that the vents are burning so shrubs, trees, and buildings should not be

[7] Gilman, E. F., I. A. Leone, and F.B. Flower, Influence of soil gas contamination on tree root growth, Plant and Soil, Vol. 65, 1982, p. 3-10

planted within a 10 m radius of vents. Vents pipes must be regularly maintained and should be left in place for at least 1 year after they cease to produce flammable gases.

e. Control of leachate

Leachate drainage collection and recycling should continue to be carried out as while the landfill is operating.

f. Environmental monitoring

Regular checks of the environment should be continued as described in monitoring programme 15-13. Further the closed site should be visited at least twice a year to check for problems resulting from subsidence and slope failure.

Usually it is 20 to 30 years after closure before a landfill site has fully stabilized and monitoring is no longer necessary.

15.5 Possible Environmental Effects

15.5.1 Environmental Impact of Improvement Activities

The improved operation of the landfill will result in new activities taking place that will impact the existing environment of the landfill and surrounding areas. Impacts on the surrounding areas will directly affect locals and passersby. Each of the activities is assessed in the following paragraphs.

a. Daily covering of waste

The impact of the daily covering of waste is expected to have the largest positive impact on the environment. The main environmental problems regarding the operation of the existing disposal site: odor from rotting waste, smoke from landfill fires, propagation of vectors, and leachate generation are all expected to sharply decrease with the introduction of daily soil covering.

Moreover, the proposed 600 mm final cover layer and landfilling to a maximum slope of 1 in 3 improves the future land-use possibilities.

On the negative side the resulting increase in the use of landfilling equipment is expected to increase the amount of noise and vibration generated. This however will be somewhat offset by the establishment of the buffer zone. Moreover, the noise and vibration will be considerably less than is now being generated by vehicles travelling along the Olancho Road.

b. Filling of Area A_1

Extending the landfill into Area A_1 is expected to place increased pressure on the environment, especially as this area is located nearer to Olancho Road than other areas. However negative impacts will be attenuated with the maintenance of the buffer zone and proper landfilling procedures. Particular care must be taken in regard to leachate and surface water drainage.

c. Recirculating Leachate

Recirculating of leachate will have the beneficial effect of reducing the strength of the leachate that is released into the environment.

On the negative side the ponding of leachate will increase odor and breeding of mosquitoes.

d. Venting of Landfill Gas

Controlled release of landfill gas has the overall beneficial effect of reducing the outbreak of landfill fires and the risk of landfill explosions.

e. Burning of landfill gas

Burning of landfill gas has the beneficial impact of reducing the amount of methane released into the atmosphere. However, because the gas will not be desulferized the burning of gas will emit a small amount of SO_x gas.

f. Control of Scavengers

It is difficult to predict and quantify benefits on the scavenger community. However, general disposal site improvements such as providing scavengers with water and latrines, and listening to their grievances will assist in relieving built up frustrations, creating a safer and more harmonious working environment.

g. Road Improvements

While the impact of placing the caution signs, road marking, and road widening will be negligible, a reduction in motor accidents will have a beneficial impact. Also a reduction in vehicle speed along this stretch of the Olancho Road will result in a corresponding decrease in noise and vibration.

h. Buffer Zone

The establishment of the buffer zone will have a strong beneficial impact, beautifying the site and increasing the number of native flora and fauna.

i. Closure and Post-Closure

The creation of an ecological park will have a very strong beneficial impact on the existing site and the surrounding area in much the same way as the creation of the buffer zone only greater.

15.5.2 Conclusion

The impact of improving the landfill operations will be clearly beneficial. The magnitude of odor, dust, smoke, vectors, and scattered litter problems will all sharply decrease resulting in an improved living environment for local residents and safer and better driving for passersby. In addition, the establishment of the buffer zone and the closure plan including the creation of an ecological park the aesthetic aspect of the site will be greatly improved.

Caution is essential, however, with extending the site to areas where previously landfilling has not yet been undertaken (areas A_1 and A_2). If current landfilling practices are carried over to these areas the environmental impact may be severe.

Table 15-14: Environmental Impact of Overall Plan

Environmental Impact of overall improvement plan on:	+++ very positive --- very negative
Air	
Smoke	+++
Dust	++
Vermin and Vectors	+++
SO_X	-
Odors	++
Water	
Ground water quality	++
Surface water quality	++
Aquatic life	+
Land use issues	
Native flora and fauna	++
Erosion	++
Land subsidence/slope failure	++
Soil quality	+
Future development opportunities	++
Aesthetic aspect	+++
Social aspect	
Scavenger earnings	0
Scavenger health and welfare	++
Noise and vibration	-

15.6 Disposal of Waste Beyond 2006

15.6.1 Background

A candidate site for landfilling works beyond 2006 is the land (approximately 11 hectares) to the east of the existing disposal site that currently belongs to FENAFUTH (Honduras National Soccer Federation). The primary concern regarding the use of this area as a landfill is whether or not acceptance of local residents can be gained.

The possible availability of this land only became known during the second study phase, so there was not sufficient time to carry out anything more than a short study and hence the plan for this area included in the Master Plan is only a conceptual plan. Furthermore taking into account the current poor landfilling practices in the existing site any detailed plan to develop this area at this time may meet with strong resistance from local residents.

If the activities described in the above preliminary improvement can be successfully implemented and local residents can see the existing landfill operating in a responsible manner. And if assurances are given that all environmental issues will be carefully addressed, such as the early establishment of a buffer zone, local residents will be less resistant to plans to develop the new area.

15.6.2 Existing Conditions of FENUFUTH Land

Of major concern is the 60 to 80 meter strip of land running between the southern boundary of the FENAFUTH land and the Olancho Road. This area contains some 10 to 15 residences.

Also cutting through the FENAFUTH land is a high voltage trunk line. Three towers are located on the land, though two are of no concern one is located near the middle of the site, and the line at its lowest point is approximately 17 meters above the level of the existing terrain.

The area is within the catchment of the Los Limones Creek, downstream of the existing landfill. And the geology is assumed to be similar to that within the existing disposal site.

15.6.3 Conceptual Design

The first activity is confirmation of the acquisition of the FENAFUTH land including the soccer fields. During the study it was determined that the area to the north and east of the soccer fields belongs to FENAFUTH. However it could not be confirmed who owns the soccer pitches. The soccer pitches are an integral part of the proposed extension of the landfill.

Once it has been confirmed that the area is available possible future environmental impacts must be assessed, possibly through the undertaking of an EIA, paying special attention to possible impacts on local communities. To help counter environmental impacts a green buffer zone should be planted as soon as possible.

Geology of the FENAFUTH site is similar to that of the existing disposal site, therefore it is assumed that cover soil will be taken from there. Prior to filling of new areas the underlying soil will be excavated to a depth of on average 10 meters and stockpiled for later use as cover soil. Assuming an area of approximately 6 hectares will be excavated approximately 480 cubic meters of soil is available for use as cover soil assuming 20% of the material consists of boulders. This is sufficient for the

Landfilling is proposed using the same methods that are proposed for the existing disposal site. As shown in Fig 21 the waste hill that runs parallel to the eastern boundary of the existing disposal site will be used as a base from which the filling of the FENUFUTH land will begin.

Assuming 6 hectares of the FENAFUTH land will be filled, on average 35 meters thick is landfilled, a total of 2.1 million cubic meters of space is available. This amount in addition to the 2.44 million cubic meters available within the existing disposal is sufficient space to last beyond the year 2010, provided future landfilling trends continue as forecast.

Figure 15-21: Future (2007-2010) East Extension to Existing Disposal Site

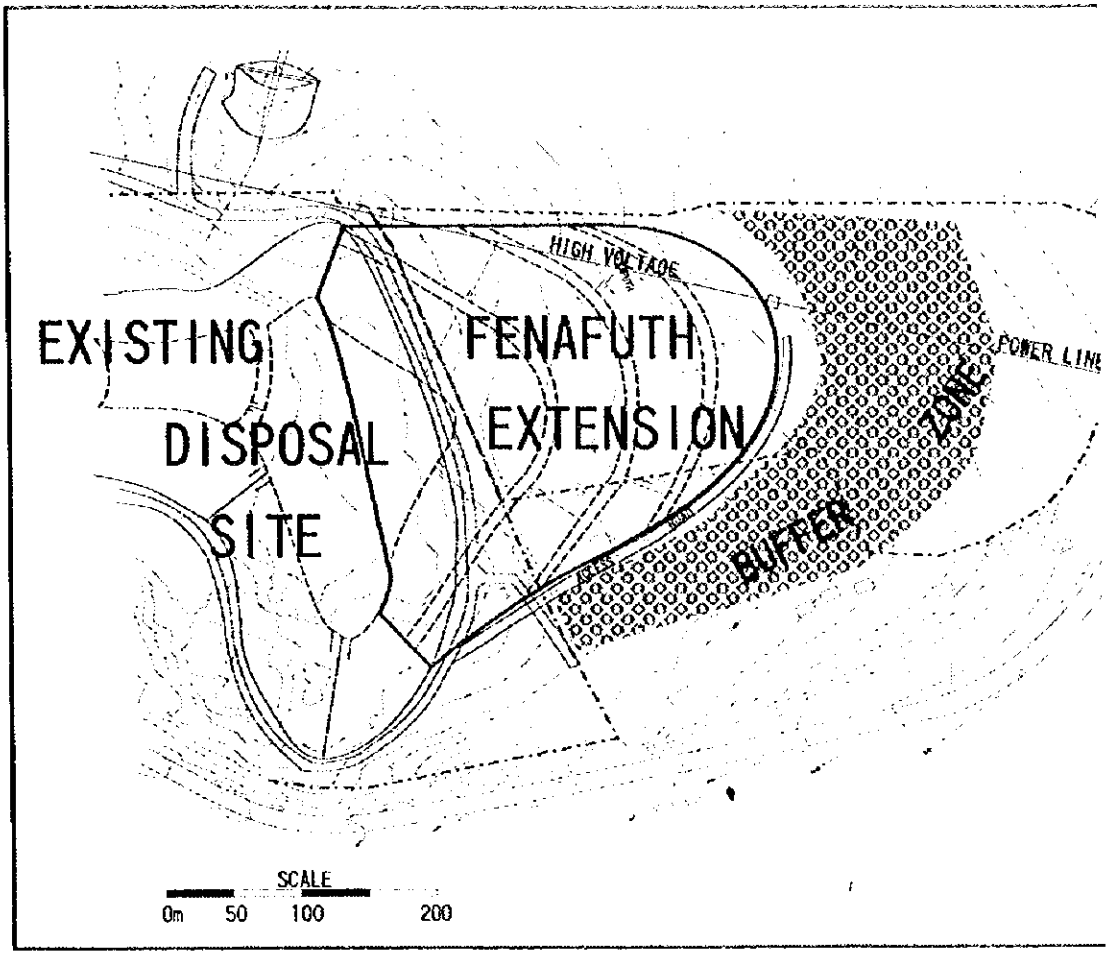
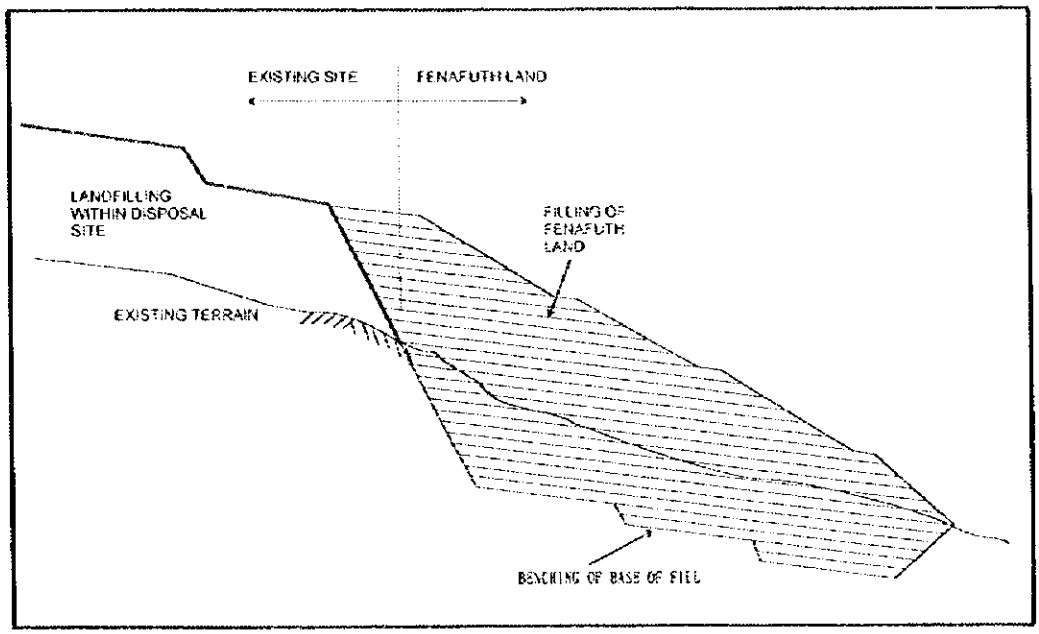


Figure 15-22: Profile of East Extension



Chapter 16

Diagnosis on
the Existing Final Disposal Site

16 Diagnosis on the Existing Final Disposal Site

16.1 Present Condition

16.1.1 Generalities

a. Location

The solid waste final disposal site for Tegucigalpa city is located approximately seven kilometers from the city along the highway that leads to Olancho.

The highway follows the topographical feature present at the base of the hills located in the northern sector; the site is located on the highway as mentioned previously. Although it is still under construction, an incinerator for hospital waste is located between the site and the highway. The area is known as Tustorique and is formed by Los Jutes and Los Limones creeks, both of which are tributaries of the Choluteca river.

b. Quantitative and Qualitative Characteristics of the Waste Disposed in the Site

As there are no signs or restrictions regarding the type of waste acceptable at the disposal facility, the site is subject to receiving various types of waste. Therefore, in addition to municipal solid waste such as domestic, commercial, administrative wastes, garbage from public areas, etc. other wastes enter the site, such as construction debris, industrial, agricultural and agro-industrial waste, hospital waste, etc.

According to the information given by the Cleansing Section; in 1997, 44,799 trips were made to the final disposal site and approximately 166,359 tons were disposed there. The amount of waste disposed was calculated from the weighing of vehicles at the final disposal site by the Team in February, 1998. From this figure, we can deduce that the average daily generation is 456 tons and 544 tons of waste per workday.

The estimated disposal amount only includes the amount of waste collected and transported to the final disposal site by the municipal service, private collectors or the generators themselves; this figure does not represent all the waste production in Tegucigalpa city. Some sectors of the city does not receive collection service and therefore it implies that the waste is disposed in some other way, for instance, by illegal dumping into creeks, vacant land, Choluteca river, etc. In order to estimate the total generation amount for Tegucigalpa City, the daily disposal amount (obtained by the study team from weighing the incoming vehicles) is increased by 20 or 30%, so that a realistic figure can be reached.

c. Surrounding Infrastructure

c1. Access Road

The disposal site can be reached through the Olancho highway, the 7 kms from the city leading to the site is in a good condition. However, the internal access route to the disposal area is via an unpaved road.

c2. Protection of the Perimeter

The distance from the highway to the working area is 500 m. The gate at the entrance, used to control the access of vehicles hauling waste, was destroyed approximately 1 year ago. From that time waste has been flowing into the site at any time, as restrictions in the type of vehicles that haul various types of waste, have not been in place. However, scavengers have always had free access to the site regardless of whether there was a gate.

Because the site does not have any fence at its perimeters, intrusion of domestic animals that seek food scraps at the site is a common occurrence, as shown in Picture 1.

Picture No. 1

c3. Facility for Control and Weighing

There is facility with equipment that enables the control of incoming waste and weighs all the vehicles that come into the site. However, there is one person who registers the incoming vehicles on a sheet of paper, who usually operates near the working area or discharge area.

c4. Office, Workshop, Warehouse, and Security House

Within the site, there is parking lot for vehicles that operate in the final disposal site, located near the working area. Next to the parking lot there is a wooden structure, which has a floor area of 15 m^2, that serves as warehouse and sometimes an office. Any repairs of the equipment is conducted in the open.

Above the working area, there is small concrete building for the security guard and is

used as a resting area at night.

c5. Water Supply and Electricity

The site does not have a water supply; it also does not have a water tank that could be positioned at a higher level or a basement to be used by the personnel working on site.

Some of the facilities at the site could be connected to the electric network; electricity is used for lighting.

c6. Sewage and Communications

The landfill site lacks sewage service and a telecommunication system. There are no toilets or facilities for personal hygiene. There are no means of communications to inform of any accidents or problems that could take place at the landfill.

c7. Drainage

There are no drainage channels that intercept and expel stormwater from the site in order to protect the access roads and as well as the workers.

d. Operational Facilities

d1. Cover Material

The landfill has adequate cover material at the site; three (3) areas have been identified as sources for cover soil of which two still has the capacity to supply the site with several more years of cover soil. There is no doubt that other areas are also suitable for cover soil excavation, either at the site or in neighboring areas.

d2. Liner and Leachate Control

Information on the installation of any liner, lagoon or reservoirs to prevent leachate infiltration, control, storage, and recirculation at the site is currently unavailable.

Leachate is usually controlled by a thick layer of soil, however, a large section of Los Limones creek does not have a soil cover and free flow of leachate to the bottom of the creek can be observed in several places.

d3. Biogas Control and Catchment

The landfill site does not house any facilities to trap and provide some sort of control of the biogas generated from the anaerobic decomposition of organic fractions in the waste.

d4. Retaining Walls

There are no structures that could serve as a barrier to provide some protection and safeguard those both inside and outside the landfill in the event of a landslide caused by waste.

d5. Fire, Vermin, Odor Control Systems

The landfill does not have any means or a future plan to implement facilities to control odor emission, vermin proliferation and fires generated inside the landfill.

d6. Control of Airborne Materials

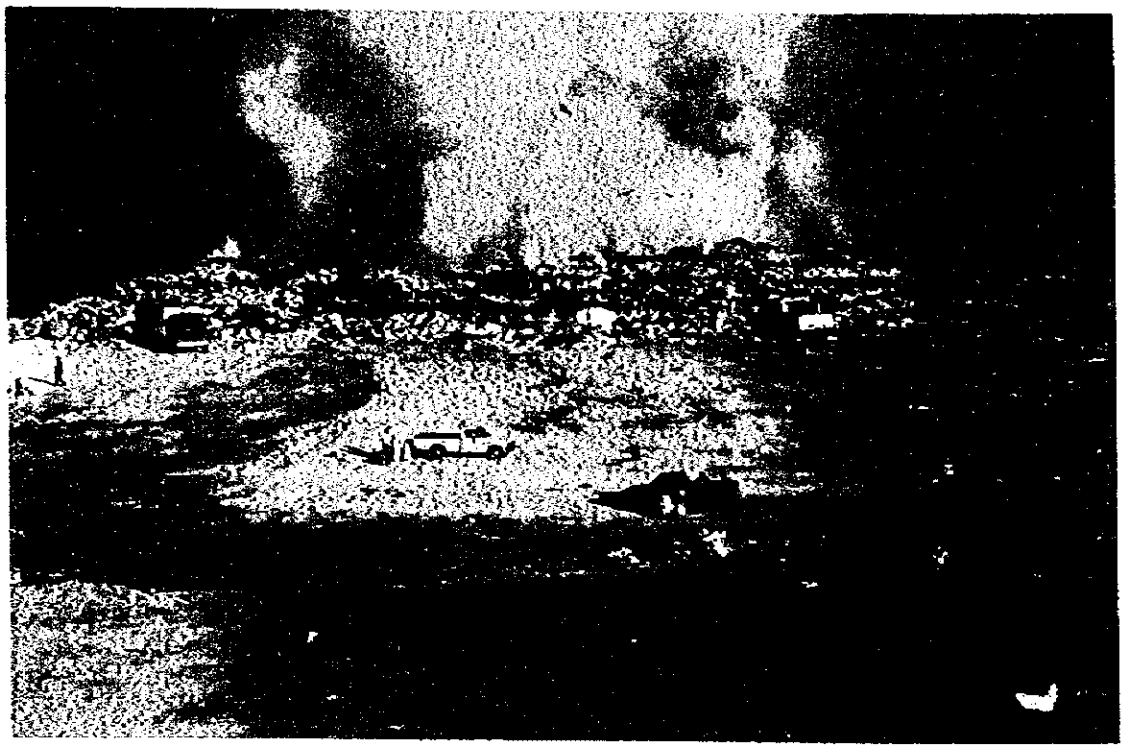
There are no physical barriers to hinder waste that can be scattered by the wind, such as paper, plastics and any other light materials found in the waste disposed. Waste sprinkling has not been conducted to avoid dust from rising.

16.1.2 Work Methodology

The landfilling method employed is the formation of terraces in the hillside and small creek. Currently, three terraces approximately 25 m and 10 m apart can be observed; the smallest one is located 35 m above the level of the highway.

Excavation of materials during the construction has left cuts and small leveled surfaces that are being used to construct the terraces. The leveled surfaces are covered and the waste is then pushed over the hillside; only the top segment is compacted and covered with soil.

The active landfill area is not defined and the waste is unloaded near and along all the periphery; therefore, an extensive working area is observed, as illustrated in Picture 2.



Picture No. 2

This operational method provides the scavengers ample time to select and retrieve materials that can subsequently be sold to middlemen; there is also enough time for animals to feed off the waste. Once scavengers and animals have processed the materials, the waste is pushed by two caterpillar bulldozers D7-H (1993) into the hillside with a gradient over 45 degrees. The waste is left there uncompacted and covered by soil from the higher sections. Several fires and a large amount of smoke can be seen, sometimes from several kilometers away. The fires are generally spontaneous or started by the scavengers as shown in Picture 3.

Picture No.3

16.1.3 Sanitary and Environmental Issues

Because of the deficiencies in the existing infrastructure (excluding machinery) and the landfill operation methods, there are a series of sanitary and environmental problems.

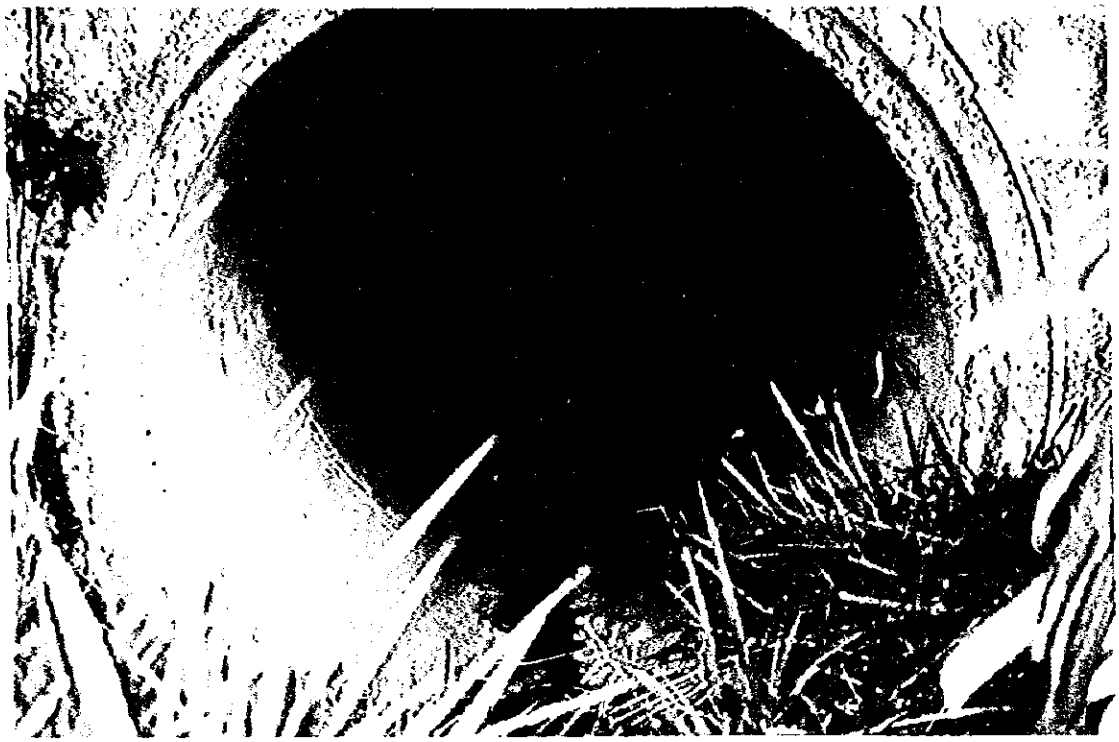
The sanitary problems are related to the incidence of pathogenic micro-organisms that proliferate in the final disposal site. The means of transmission are through domestic animals (mainly cattle) that feed off the waste, that are subsequently consumed by humans, and vectors that host various pathogenic micro-organisms which infest and multiply at site. They could carry these pathogens to populated areas. The vectors are usually a large variety of insects, rodents and birds. Women and children that scavenge at the site are in direct contact with the waste and thus exposed to pathogenic micro-organisms. Finally, food vendors who sell their merchandise to the scavengers at the disposal site, along with their goods, become host to various micro-organisms.

The most notorious environmental problems are scattering of paper, plastics, and other light objects around the disposal site caused by the wind. Middlemen aggravate this problem with their storage sites for recycled materials that are located near the landfill. This situation deteriorates the quality of the surrounding view resulting in a negative image and alteration of the landscape. The constant emission of smoke and bad odors from the landfill's hillside is caused by the lack of soil cover and the wind carries them over a long distance.

Leachate and biogas generation are probably less obvious as environmental problems, but they are extremely important because of the grave impact they may have on the

surroundings.

Leachate is discharged through Los Limones creek to Choluteca river below the highway (see picture No. 4), during the drier months such as January, February, May, and April, only a small amount of leachate is generated and percolates through the ground before reaching the river; it is probable that this process has polluted the groundwater and has rendered it unfit for consumption or irrigation. During the rainy season, the diluted leachate reaches Choluteca river but, nevertheless, still exacerbate the river pollution.



Picture No.4

Biogas is generated as the result of anaerobic decomposition of organic fractions contained in the waste and can depreciate environmental quality in three ways. Firstly, it can mix with air and produce an explosive or combustible substance. Secondly, it can alter air quality that can have an adverse effect on both humans and plants. Thirdly, water quality can be reduced as it turns acidic.

In the case of the disposal site, the first problem is seen to affect the environment, in fact, biogas contributes to the continuous fires on the hillside. There is always the risk of explosion, in one form or another, because of biogas accumulation. Houses and plantations are located a long distance from the disposal site for the inhabitants and vegetation to be affected by biogas. Also there are no surface or groundwater sources that can be affected by the biogas generated at the site.

16.1.4 Other Issues

a. Available Area

At this moment, the land earmarked for landfill use is approximately 30 ha, of which 12 ha has been used over the last 20 years.

By developing a suitable program regarding the source and method of obtaining cover soil, it is possible to produce new landfill space, once the current area has completed its useful life. If these areas can be used for landfill purposes as well as the other 8 to 10 ha that have not been used, it leaves about 8 to 10 ha. for security buildings or protection areas (buffer zone). Even if the landfill is not expanded to adjacent areas, it is possible to operate the present site for many years.

b. Equipment

In order to conduct landfill operations, two bulldozers [model D7-H(1993)], one payloader [Komatsu model W.A. 180/1993] and two dump trucks are being used; they are in a good condition. Furthermore, there is a caterpillar of the same model that is out of order, but can be fixed in a short time.

Bulldozers are used to spread, compact, and cover waste, they are also used to remove soil cover from the source. The payloader is used to load soil into the dump trucks. Finally, the dump trucks are used to haul cover soil to the landfill area.

The equipment is sufficient for current landfill operations, however, in order introduce sanitary landfill operations correctly, it is necessary to have an additional bulldozer by next year. Additionally, it would also be convenient to have an extra payloader as a stand by.

c. Neighboring Land

Houses are located sporadically in the neighborhood, but none is located less than 300 m. from the existing working area; to the south-east there are more houses (around 10 houses in 3 ha.). However, because of the prevailing wind directions, these houses are affected by waste burning, scattering of papers, plastics, and dust.

To the east and north-east of the site, there are several ha. of land appropriate for expansion or construction of a sound sanitary landfill.

16.2 Lifespan of the Current Final Disposal Site

16.2.1 Background

The area of the municipal landfill site reaches 30 ha. of which approximately 12 ha. have been used for landfilling purposes. However, only some of the remaining 18 ha. can continued to be used, the rest will act as a protection barrier (buffer zone) to the highway and neighbors.

When the lifespan of a sanitary landfill is considered, several factors should be taken into account. Among those factors are available area, geometric design of the works, technique used to make the cell, which is the basic structural unit of the sanitary landfill, and amount and forecast of solid waste to be disposed.

For the same type of work, if a larger area is available, the lifespan of the landfill will be larger. The geometric design would determine the volume of the disposal area which in addition to the space for waste landfilling, will contain daily soil cover, final soil cover, parapet or retaining wall, liner, and drainage. The geometric design is determined by safety factors which should guarantee that the structure will not collapse under certain conditions. The technique employed to make the cell would determine the density of the landfillll, cover soil to be used and degree of subsidence that would take place over time. Finally, using the forecast of waste amount, the density and subsidence percentage, the soil cover expected to be used, available area where solid waste will be disposed, and geometric design, it is possible to calculate the lifespan of the sanitary landfill.

16.2.2 Basic Information

a. Density of Compacted Waste, Soil Cover, and Settlement

a1. Density of Compacted Waste

With the type of caterpillar bulldozer D7-H and the characteristics of solid waste in Tegucigalpa (mostly organic), a density that may vary between 0.7 and 0.85 ton/m^3 can be obtained when disposing and scattering the waste adequately and the bulldozer has passed over the waste 4 to 6 times. The team adopts a density of 0.8 ton/m^3 for calculation purposes.

a2. Cover Material

The amount of cover material for a landfill is calculated based on the amount of waste compacted and type of cell designed. For this case, a cell 3 m high with a work front 30 m wide, a slope gradient of 1.3 for the exposed fronts, and a soil cover 20 cm thick is considered adequate to receive vehicles hauling waste at peak hours. Furthermore, on compaction the landfill density will be 0.8 ton/m^3; with this information, it is calculated that the cover material will amount to 15% of the compacted waste placed in the cell.

a3. Subsidence

Due to decomposition of organic matter that converts solid waste into liquid and gas, and water infiltration into the landfill, the incidence of subsidence is high in many sanitary landfills in Latin American countries. It is widely known that settlement reduce the landfill volume between 20 and 30% of the initial volume. For this study, it seems reasonable to expect a 20% reduction in landfill volume.

b. Waste Production and Forecast, Compacted Volume and Necessary Cover Material

Based on the figure provided by the Cleansing Section of Tegucigalpa that established an amount of 166,359 tons disposed in 1997 alone, a forecast for waste production is made until 2010. A 5% growth rate is assumed: this rate includes population growth, waste production per-capita growth, and improvement of collection services. All these factors will contribute to a larger amount of waste disposed in the landfill site. Table 16-1 shows waste production in tons, volume of compacted waste, and volume of cover material to be used until 2010. Additionally, cumulative values are shown year by year.

Table 16-1: Required Capacity of Final Disposal Site until 2010

Year	Annual Production in Tons	Cumulative Annual Production in Tons	Compacted Waste (m^3) (Density =0.8 Tons/m^3)	Cumulative Compacted Waste m^3	Cover Material (m^3)	Cumulative cover material m^3
1998	174,677	174,676	218,345	218,345	32,752	32,751
1999	183,411	358,088	229,264	447,604	34,389	67,141
2000	192,581	550,669	240,726	688,335	36,109	103,250
2001	202,210	752,879	252,763	991,098	37,914	141,164
2002	212,320	965,1999	265,400	1,204,498	39,810	180,974
2003	222,937	1,188,136	278,672	1,485,170	41,800	222.774
2004	234,084	1,422,220	292,605	1,777,775	43,891	266,665
2005	245,788	1,668,008	307,235	2,085,010	46,085	312,750
2006	258,077	1,926,085	322,596	2,407,606	48,389	366,139
2007	270,982	2,197,067	338,727	2,746,333	50,809	411,948
2008	284,530	2,481,597	355,663	3,101,996	53,349	465,297
2009	298,756	2,780.353	373,445	3,475,441	56,017	521,314
2010	313,695	3,094,048	392,119	3,867,560	58,818	580,132

16.2.3 Areas Available at the Current Site

Based on the land survey of 1992 that allows several isolines and surfaces in the area to be defined, aerial photographs, and several on-site visits to the final disposal site, it was possible to identify the areas available for continued landfill operations at the site. These areas are colored and identified in Figure No. 1 (in sky blue); the area reaches approximately 8 ha in size. Areas where some landfill operations have already taken place are illustrated in orange. Finally, the buffer zone for safety purposes and protection are shown in green.

16.2.4 Geometric Design and Volume Available at the Current Site

In order to maximize all available land and guarantee structural stability to operate the site safely, it is advisable to plan future landfilling based on different levels in the shape of the terrace. In this way, a large filling area of approximately 18 ha. will be constructed, including sections where filling have already taken place and more waste is due to be disposed with 4 or 5 terrace levels. Furthermore, another 2 ha. where no filling has taken place will have 2 or 3 terrace levels.

All different sections where landfilling will be conducted will have a thickness between 10 and 15 mts. As a result, the available volume in the current site is 2.5 million cubic meters.

16.2.5 Useful Life

The space needed to accommodate the waste up to the target year is calculated by adding the cumulative compacted solid waste amount, plus the required cover material, minus the estimated subsidence (in this case a 20% reduction in the volume).

As a result, the total volume for the next few years is estimated as follows:

Year	Cubic Meters
2005	2,085,010+312,750-(2,085,010+312,750) 0.2 = 1,918,208
2006	2,407,606+366,139-(2,407,606+366,139) 0.2 = 2,219,266
2007	2,746,333+411,948-(2,746,333+411,948) 0.2 = 2,526,625

Since the space available is 2.5 millions m^3, we can conclude that the useful life for the current disposal site will be approximately up until 2007.

However, in order to reach this target, it is necessary to undertake a detailed program for cover material extraction at the sources and a planned use of the available space.

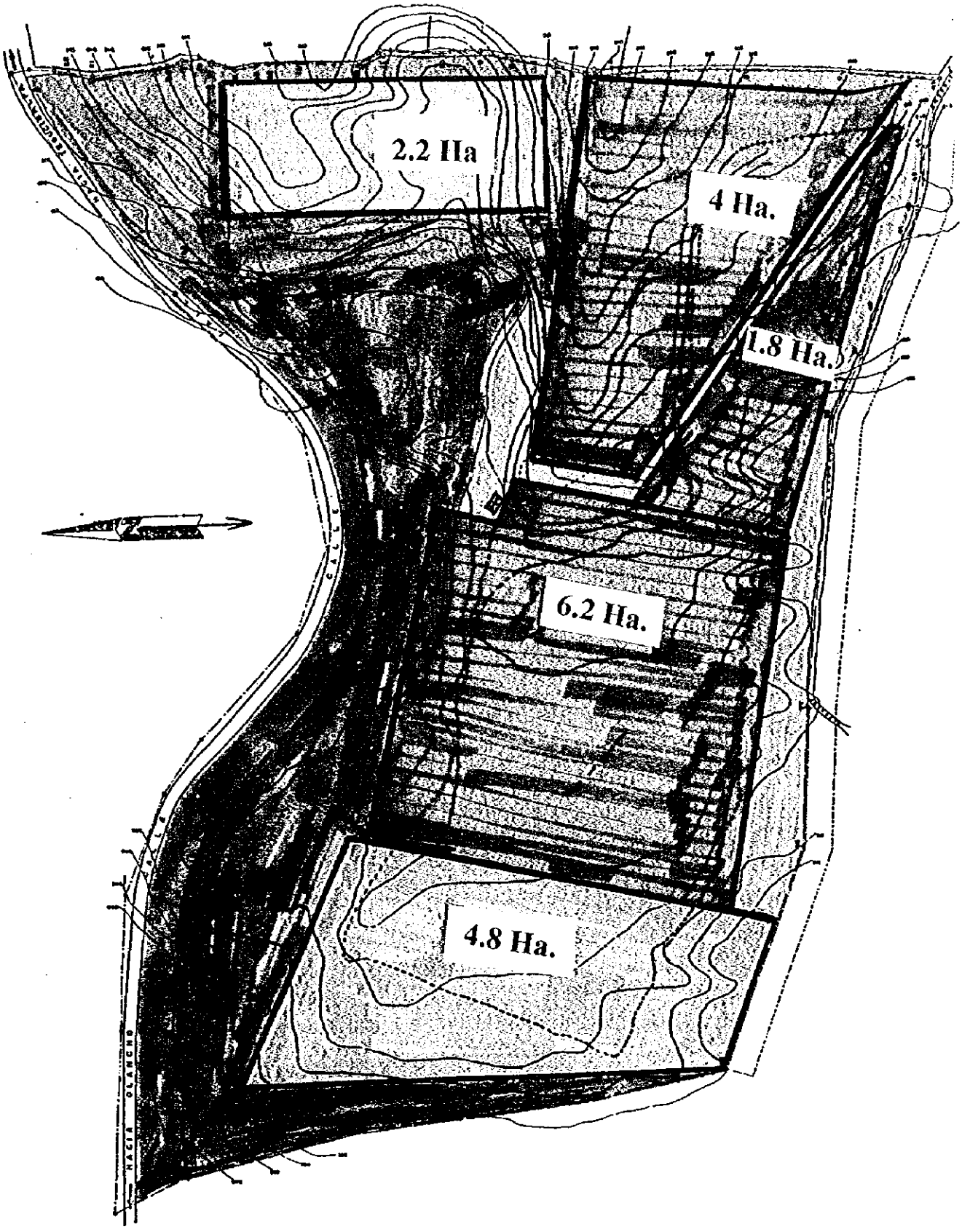


Figure 16-1: Development Layout of the Existing Disposal Site

16.3 Identifying Problems Caused by the Final Disposal Site

The landfill has a variety of problems, ranging from those related to infrastructure and operations to those related to sanitation and the environment. However, the latter goes beyond the limits of the landfill site; surrounding areas are affected with different levels of intensity. The most serious problems are identified and analyzed in the following paragraphs.

16.3.1 Propagation of Parasites and Micro-organisms

Because of the high organic content of municipal solid waste, it is a suitable medium for rapid proliferation of parasites and micro-organisms. The way the landfill is operated at present, it allows waste to remain uncovered over long periods; this situation causes all types of animals to feed on the waste and people who process the waste, including children, are in direct contact with the waste. This type of operation procedure converts the disposal site into a very important breeding ground of parasites and micro-organisms.

People and animals become mediums for parasites and micro-organisms; pathogens are transmitted to populated centers or their own homes. Some of these parasites and micro-organisms are the cause of serious diseases.

16.3.2 Water Resource Modification

Organic matter decomposition transform solid waste into gas and liquid. The gaseous product escapes into the atmosphere through the soil cover and border side that lack soil cover. The liquid is initially suspended in the waste layer until it becomes saturated.

Rainwater infiltrates the landfill layers and causes waste to become quickly saturated; water then begins to transport solid matter together with the saturated liquid substances that are the product of decomposition. As a result, leachate usually has high pollution levels, specially with organic characteristics.

Leachate can be in the form of surface run-off that pollutes channels, rivers, lakes, etc. or it can percolate and reach groundwater, thus polluting this water resource.

For the El Crematorio landfill , the amount of leachate produced is difficult to quantify because some of it infiltrates the ground and others drain over the hillside and runs toward Los Limones creek. During February, several observations were made, it was confirmed that leachate flow is no more than 100 ml/sec. Leachate does not reach Choluteca river. However, it is very likely that during the rainy season, leachate production is higher, but conversely the effluent becomes diluted.

The following table shows the result of leachate analysis taken at Los Limones creek, 200 m downstream from the landfill and two other samples taken in Choluteca river, next to Los Limones creek. These values are similar to the National Standard which regulate wastewater discharge into receiving bodies.

Table 16-2: Results of Leachate and River Choluteca Sample Analyses

Parameter	River Choluteca 1	River Choluteca 2	Leachate	Standard
COD	281.0 ml/l	451.2 mg/l	536.83 mg/l	200 mg/l
BOD	243.0 mg/l	382.7 mg/l	119.0 mg/l	50 mg/l
DO	NO	ND	4.7 mg/l	----------
N. Ammonia	20.26 mg/l	18.1 mg/l	16.0 mg/l	20.0 mg/l
P.Total	7.1 mg/l	32.6 mg/l	9.18 mg/l	5.0 mg/l
pH.	7.15	7.11	8.5	6.0-9.0
Cr. Hex.	ND	ND	ND	0.1 mg/l
S.S.	220.8 mg/l	308.6 mg/l	20.5 mg/l	100 mg/l
Total Solids	835.0 mg/l	933.0 mg/l	4,834.0 mg/l	----------
Dis. Sol.	614.2 mg/l	624.3 mg/l	4,813.5 mg/l	----------
Cd.	ND	ND	0.008 mg/l	0.05 mg/l
Pb.	ND	ND	0.025 mg/l	0.50 mg/l
Ni.	0.0255 mg/l	0.0115	0.1065 mg/l	2.80 mg/l
Zn.	0.027 mg/l	0.045	0.2025	2.00 mg/l
Cu.	0.1735 mg/l	ND	ND	0.50 mg/l
Fe.	4.56 mg/l	2.58	2.32	1.00 mg/l
Total Coliforms	$3.4x10^7$ UFC/100 ml	$1.75x10^7$ UFC/100 ml	$<1x10^5$ UFC/100ml	----------
E. Coli	$6.9x10^6$ UFC 100 ml	$1.16x10^7$ UFC/100 ml	$<1x10^5$ UFC/100 ml	----------

Analysis made by CESCO

DO: Dissolved Oxygen
COD: Chemical Oxygen Demand
BOD: Biochemical Oxygen Demand
UFC: Unit that Forms a Colony

Although the values from the leachate analysis provided by the Center to Study and Control Pollutants (under the Health Ministry in Honduras) surpasses the norm in such as COD, BOD, total P, Fe parameters, and also showed very high values for dissolved solids and E. Coli, the values are very low compared to other sanitary landfill operations in Latin America. This may be due to a large amount of leachate that infiltrates the ground and reappear on the creek's bank; however, the leachate has already undergone a filtration process and also some contaminants are trapped underground due to absorption and adsorption. On the other hand, the fact that waste is usually burned contributes to the reduction of organic matter in it and limits the activity of micro-organisms that decompose it.

In any event, leachate has been draining or infiltrating towards the creek for 20 years; as a result, there is not doubt that the creek and underground area where the water flows are completely altered. It is advised not to use the water flowing in the creek for any purposes.

It should also be pointed out that the creek is very limited as a water source because the areas that contribute to its basin are small. Furthermore, water quality from the creek should not alter river Choluteca's water quality because the quality of water from the river exceeds the parameters of the leachate; its flow is a lot larger than the creek's and also the E. Coli parameter is impressive and a lot higher than that found in leachate.

16.3.3 Air Modification

Dust, odor, biogas, and smoke emissions modify air quality negatively and the effects are felt outside the site boundary.

Smoke rising from the site is obvious and can be observed several hundreds of meters and sometimes kilometers from the site. This situation rarefies the atmosphere wherever the cloud passes by.

There is no biogas removal system that can serve to measure production as well as biogas combustion, which is the conversion of methane (CH_4) into CO_2 and H_2O; those two compounds cause less harm to the atmosphere. Methane is one of the greenhouse gases that causes global warming (greenhouse effect) and is recommended to remove it through combustion. For the case in the El Crematorio landfill site , it is likely that methane production may not be that high because organic matter is burned daily other parts are decomposed aerobically resulting in no methane being produced.

Odors coming from the site are caused by waste that is not covered, burned waste, biogas, and leachate. The intensity of this odor depends on the wind characteristics, when there is not wind, the odors diffuse, this situation deeply affects the receptor because the odor is intensified. This problem frequently affects few neighbors around the site and those living along the highway to Olancho.

Dust is the result of suspended particles caused by the transportation of cover material, by vehicle traffic into the landfill site, and by wind. This problem is the one that may have less effect on air conditions and only affects areas beyond the landfill limits occasionally.

16.3.4 Land and Landscape Deterioration

In addition to the deterioration of the landscape paper, plastic, and other light materials that are scattered due to wind can alter soil conditions that support vegetation and can also negatively transform the soil to be used by men and animals.

Soil extracted to be used for cover can change favorable characteristics of the soil to support life. Hence, it is necessary to take actions which will permit the recovery of these characteristics once the landfill has been closed.

In El Crematorio landfill, because a large part of waste spend a long time without compaction or cover material, the wind scatters it outside the final disposal site boundaries. This situation takes place very often and that is the reason why land and landscape do not have a pleasant view both inside and outside the final disposal site. Furthermore, this condition creates a problem with the soil use because it has to be cleaned up frequently in order to conduct landfilling operations.

16.4 Recommendations to Eliminate Problems Caused by the Final Disposal Site

The four big problems identified previously originate from some actions and situations that take place inside the sanitary landfill. The most apparent problems

are: uncovered waste; intentional waste burning; infiltration and flow of leachate; biogas not being used or burned; and dust caused by vehicles and wind.

If the waste is compacted and covered, access of unauthorized persons and animals can be controlled or prevented, uncontrolled waste burning can be avoided, and a large amount of paper, plastic and other light waste are prevented from scattering outside the landfill site in the wind.

Very little can be done about leachate infiltration in areas where landfill operations have already taken place, but with time, soil can undergo a saturation process that will make naturally impermeable which will attenuate underground pollution. For leachate flowing on the surface, it can be controlled by constructing parapets or small retaining walls in such a way as to contain most of the leachate. Biogas can be controlled by constructing vertical removal structures that can extract the gas and use it as an energy source or just burn it.

Dust problems can be mitigated through controlled sprinkling of access roads and centers for extraction and storage of cover material.

With a few measures, most of the existing problems can be solved, however, these measures should be applied carefully in order not to generate other kind of problems, especially those with social characteristics. Hence, some improvements should be made very quickly, for instance those related with facilities. On the other hand, some improvements should be done step by step, especially those that involve people not related to the operation, but whose lives depend on it.

Some recommendations to eliminate major problems at the final disposal site are as follows.

1) Construction of facilities that will provide control over the sanitary landfill. In order to eliminate most problems, it is necessary to undertake actions that require some kind of order inside. As a result, it is recommended to establish total control of the site and its operations. On the other hand, it is important that the community identifies the work as being made to benefit everybody, and that it should be protected and respected.

2) Reinforcement of an elaborate work program that would include technical aspects and produced to solve the existing problems. These solutions should also be compatible with the presence of scavengers.

3) Selection of a professional or official who should bear the responsibility to execute the work program. The professional or official should have leadership qualities and have the capacity to understand the proposed solutions fully .

4) The entrance of persons who take domestic animals in to the site to them to feed them with waste scraps should be prohibited.

5) The entrance of children should be prohibited.

6) Develop and execute a program that allows scavengers to work on-site. This program should be done with the participation of personnel from the Social Development Management of the Municipality.

The solution proposed should be integral; it should solve existing problems without creating new ones. Scavengers should not lose their means to earn a living. They are undertaking a labor that is useful for the country's economy, recycled material save hard currency to the country, non-renewable resources, etc. On the other hand, scavengers should work under a set of regulations. They should not become hosts to parasites and pathogenic organisms. A shower and change of clothing would be of great help. Scavengers are undertaking a task as a group, it is necessary to dignify and support this task to transform it into a profession.

Chapter 17

Current Situation of the Industrial Solid Waste Management

17 Current Situation of the Industrial Solid Waste Management

17.1 General

The 106 industries in the Central District are classified in Table 17-1 below.

Table 17-1: Industrial Activities in the Central District according to Code ISIC

	ISIC[1]	INDUSTRIAL ACTIVITIES IN TEGUCIGALPA	No.
1	1110	Agricultural production	1
2	3111	Slaughtering of cattle, preparation and preservation of meat	5
3	3113	Canning of fruits and vegetables	1
4	3115	Manufacture of oil, vegetable and animal fat	1
5	3116	Milling products	2
6	3117	Bakery	4
7	3118	Sugar refinery	1
8	3119	Manufacture of cacao, chocolate, confectionery goods	2
9	3121	Food processing factory	2
10	3134	Industry of non-alcoholic beverages, e.g., soft drinks	1
11	3211	Spinning, textiles and its finishing	2
12	3220	Clothes Factory	3
13	3233	Manufacture of leather goods and by-products of leather (except shoes and clothes)	1
14	3240	Manufacture of shoes (except vulcanized or molded rubber, or plastic)	3
15	3311	Wood mills, carpentry and other woodcutting work	8
16	3320	Manufacture of furniture and accessories except those made of metal	4
17	3410	Manufacture of paper and paper products	3
18	3420	Printing, editorials and related industries	8
19	3522	Manufacture of pharmaceutical products and medicines	4
20	3523	Manufacture of soaps and goods for cleansing, perfumes, cosmetics and other dressing table goods	3
21	3529	Manufacture of chemical products	6
22	3540	Manufacture of several products derived from petroleum and coal	1
23	3559	Manufacture of hard rubber products	1
24	3560	Manufacture of plastic products	3
25	3610	Manufacture of objects of clay and porcelain	2
26	3692	Manufacture of cement, lime and gypsum	3
27	3710	Basic industry of iron and steel	2
28	3812	Manufacture of metallic furniture and accessories	1
29	3819	Manufacture of metallic products	1
30	3825	Construction of office machinery	2
31	3839	Construction of electrical supplies	3
32	3843	Manufacture of vehicles and parts	4
33	3852	Manufacture of photographic apparatus and optic instruments	1
34	3909	Manufacturing Industries (not classified before)	2
35	5000	Construction	1
36	6100	Wholesale commerce	2
37	6320	Hotels, guest houses and other lodgings	1
38	7121	Transport by sea or coastal trade	1
39	7200	Communications	4
40	8201	Financial institutions	1
41	8322	Accounting services, auditing and bookkeeping	4
42	9331	Medical and dentistry services and other sanitary services	1
		TOTAL:	106

Source: National Association of Industries (ANDI), 1998

[1] International Standard Industrial Classification

17.2 Legal Aspects

Table 17-2 enumerates the industrial activities considered as infractions and offenses with respect to the environmental law, and the corresponding penalties imposed.

Table 17-2: Regulations and Penalties Related to Industrial Waste in the Central District

(General By-laws of the Environmental Law, 1993)

(a) INFRACTIONS		
Light	Medium	Serious
Article 110: - Pile up sawdust, coffee pulp, rice shells or other industrial waste in sites that may lead to soil and water resource contamination - Establish industries without the approval of the SERNA* - Discharge untreated industrial waste (non-toxic) into the ground, rivers, streams, etc. - Discharge human excreta into streets, vacant lots, green areas, public buildings, rivers, roadsides, roads and other prohibited areas.	**Article 111:** Repeat a light infraction	**Article 112:** - Unauthorized discharge of contaminating substances (liquids, solids or gases) into streams, tanks or the sewer system, without complying with the purification process - Discharge industrial waste into streets, vacant lots, green areas, public buildings, rivers, seas, etc. - Three penalties due to medium infractions
Fine (Lps.)		
Article 122: 1,000--5,000	Article 123: 5,000--100,000	Article 124: 100,000--1,000,000
(b) ENVIRONMENTAL OFFENSES (Article 104)		
- Produce, store, import, trade, transport, use or dispose toxic products or pollutants that are very harmful to public health and the ecosystem, without consideration of the environmental regulations - Allow the contamination of food and drinking water	- Atmospheric discharge of active pollutants or potentially dangerous products that are untreated or prohibited due to their serious effects on public health or the ecosystem. - Discharge of untreated or prohibited harmful pollutants into water systems (including water supply systems) or the ground thereby affecting groundwater resources, soil or subsoil, and consequently seriously affect public health and the ecosystem	
Sanction		
Article 107: - imprisonment of 1 to 5 years - permanent closure - temporary suspension - confiscation - canceling or revocation - compensation - replacement	**Article 106:** - imprisonment of 3 to 10 years - permanent closure - confiscation - canceling or revocation - compensation - replacement	

* SERNA: Secretariat of Natural Resources and Environment.

17.3 Responsible Institutions

The institutions in charge of enforcing the environmental regulations regarding the discharge of industrial solid or liquid waste are:

a. DECA (General Directorate of Environment Evaluation and Control)

DECA is under the jurisdiction of the Ministry of Natural Resources and Environment. It investigates reports received on environmental infractions and offenses, and evaluates actual conditions to make the appropriate recommendations. Due to limitations in personnel, actions are based on the reports received.

b. CESCCO (Center of Study and Control of Pollutants)

CESCCO has been placed under the Secretariat of Natural Resources and Environment in June 1997 (formerly under the Secretariat of Public Health since August 1986). It was established through an agreement between the Swiss Federal Council (COSUDE), the PHO/WHO, and the Government of Honduras.

CESCCO performs the following: a) laboratory analysis (including analysis of chemical pollutants, e.g., pesticides, heavy metals, hydrocarbons, parameters for water and air quality analysis, etc., b) training, and c) environmental assessments.

Up till 1997, CESCCO had performed 33 environmental assessments nationwide, eight of them in the Central District, and five are still ongoing or pending. It is equipped with a modern laboratory and has biologists, micro-biologists, industrial engineers, sanitary engineers, etc., in its employ.

c. Environmental Attorney's Office:

The Environmental Attorney's Office is in charge of taking to court all those accused of environmental offenses, especially serious offenses that could lead to imprisonment or compensation. To effectively carry out its responsibilities, the office works in cooperation with DECA.

d. Environmental Section of the AMDC:

This section has been created according to Article 13 of the By-laws of the National Environmental Impact Evaluation System (SINEIA), to support the DECA on the preparation of the terms of reference, revision of EIA documents, following up and control of environmental reports.

The section accompanies other inspectors called to follow up the SINEIA and conducts environmental inspections of shops and industries applying for a license to operate. The section also executes necessary field inspections and prepares and submits technical reports and recommendations to mitigate adverse environmental impacts.

17.4 National Program on Waste

This is a component of the Environmental Sanitation Program within the Environmental Sanitation Department of the General Directorate of Health, under the Sub-secretariat of Population Hazards of the Secretariat of Health. This program started in December 1997, mainly in the metropolitan area, and is planned to be

extended to several regions nationwide within a four year period.

a. Objectives:

- To establish at the national level, the proper treatment and final disposal of waste produced by households, hospitals, industries, including the special handling and disposal of toxic and hazardous wastes, to protect public health and the environment.
- To establish coordination among the municipalities, the Secretariat of Health and the Secretariat of Natural Resources and Environment for the development of an efficient waste management system.
- To contribute to the control of epidemics due to the inadequate management of waste.
- Promotion of financing to allow the efficient implementation of the selected waste management system.

b. Budget:

The budget of the National Program on Waste for the coming four years is as follows:

Table 17-3: Budget of the National Program on Waste

Year	1998	1999	2000	2001	TOTAL
Budget (Lps.)	5,315,300	6,717,300	8,127,933	10,243,882	30,404,415

Source: Proposal for the National Program on Waste, Secretariat of Health. Sept. 1997.

17.5 Discharge of Industrial Waste

In 1992 some students of the Faculty of Chemical Science and Pharmacy of the UNAH prepared a thesis on industrial waste in the Central District as a degree requirement. The students conducted a survey on the 34 main industries in Honduras, extracting samples from 1/3 of the existing industries. The survey was the only survey carried out that had a wide coverage.

The results of this survey are shown in Table 17-4. Although 6 years have passed since the survey was carried out, the results are considered useful as conditions have hardly changed. The industries have not improved their treatment and discharge systems as the Environmental Law has only been enacted for a short period, and the effluent standards have only been established for about 8 months.

Table 17-4: Survey on Industrial Waste in the Central District

No	Industrial Category	Liquid Waste	Solid Waste				Gaseous Emissions
			Remains of Products, etc.		Remains of Packing, etc.		
		Final Disposal	Treatment	Final Disposal	Treatment	Final Disposal	Final Disposal
1	Sausage Factory	AP	I	Ab	I	Ab	At
2	"	AP	N	B	N	B, Ab	
3	"	LC	I, others	R, Ab	N	BP	At
4	"	LC	N	R	I	Ab	At
5	Cereal Processing Factory	AP	N	R, At, Ab	I , N	Ab	At
6	"	AP	N	B, Ab	N	B	-
7	Flour Mill	AP	N	R, A, B	N	B	-
8	Herbs & Spices Factory	AP	N	B	N	B	-
9	Bread & Cookies Factory	AP	N, R	R, Ab	N	B	At
10	"	AP	N	R, Ab	N	B	At
11	"	AP	N	R	N	R, B	At
12	Water Purification Factory	AP	-	-	N	B	At
13	"	AP, C	N	B	N, R	B, R	At
14	Ice Factory	AP	-	-	N, R	B, R	At
15	Pastry Factory	AP	N	R	N	B	At
16	"	AP	I	Ab	I	Ab	At
17	Esp. Food Factory	AP	I, R	R	I	Ab	At
18	Food Processing	AP	N	B	N	B	At
19	Patisserie/Chewing Gum Factory	AP	R	-	N	B	At
20	"	AP	R	-	I	B	At
21	Manufacturing Industry	AP	N	B	N	B	At
22	Milk Products	AP	-	-	R, N	B	At
23	"	AP	N	AP	I	-	At
24	"	AP	N	B	N	B	At
25	"	AP	-	-	N	B	At
26	"	AP	N	R	N	B	-
27	Distillery	LC	LO	Stream	N	B.a.I	At
28	Slaughterhouse	River	Firing, etc.	BP, R	I	Ab	At
29	Beer/Soft Drinks Factory	River	N	B, R	N	B	At
30	"	Stream	-	-	N	B	At
31	Coffee Mill	AP	N	B	N	B	At
32	"	Stream	N	B.a.I.	N	B.a.I.	At
33	Poultry Farm	River	N	B, R	Ab	I	At
34	"	River	N	B	B	I	At

Note:
AP: Sewer system Ab: Abandoned in site At: Atmosphere B: Disposal site of the AMDC,
B.a.I: Open disposal site C: Road ditch BP: Own disposal site
I: Incineration LC: Collecting lagoon LO: Oxidation lagoon N: None
R: Recycling, either in the factory or by selling recoverable materials
Source: Study of Industrial Waste in Tegucigalpa, Thesis of Chemical Science and Pharmacy, Carol I. Ordoñez B., Eunice Barahona F., Jorge A. Ordoñez A. UNAH, Tegucigalpa, 1992.

The above table shows that 71% of the industries during the survey were discharging effluents directly to the sewer system, 18% to the rivers, and only 9% had collecting lagoons (Table 17-5). It is worth noting that the effluents discharged to the sewer system finally reach the Choluteca River. This is the reason why in a study made on 1994 by a Swiss student (a degree requirement at the Ecole Polytechnique Federale of Lausane, Switzerland) on the contamination of the Choluteca River, the study refers to the river and its tributaries as a "sewer network in the open". This study and others on Tahal (1993), recommended the construction of a treatment plant in order to

facilitate river water purification.

The table below shows that 62% to 74% of the wastes are not treated, 12% to 24% are incinerated, and 9% to 12% are recycled. For final disposal, 35 to 65% of the industries hires the services of the AMDC to haul their waste to the final disposal site. Around 18% to 21% of the waste are abandoned in the factories or in the open; 9% to 38% are recycled by the users, sold as recoverable materials or returned to the original manufacturer. The table also shows that all of the 34 surveyed industries emit gases (88%).

Table 17-5: Treatment and Disposal of Industrial Waste in the DC (1992)

Action /Source of Discharge	Liquid Effluents		Solid Waste								Gaseous Emissions	
			Remains of Products, etc.				Remains of Packing, etc.					
	Final Disposal		Treatment		Final Disposal		Treatment		Final Disposal		Final Disposal	
1. EFFLUENTS:	Case	%	Case	%	Case	%	Case	%	Case	%	Case	%
Sewer System	24	71										
Streams	6	18										
Collecting Lagoon												
2. TREATMENT:												
None			21	62			25	74				
Incinerated			4	12			8	24				
Recycled			4	12			3	9				
3. FINAL DISPOSAL:												
AMDC's Disposal Site					12	35			22	65		
Abandoned					7	21			6	18		
Recycled					13	38			3	9		
4. GASEOUS EMISSIONS:												
Atmosphere											30	88