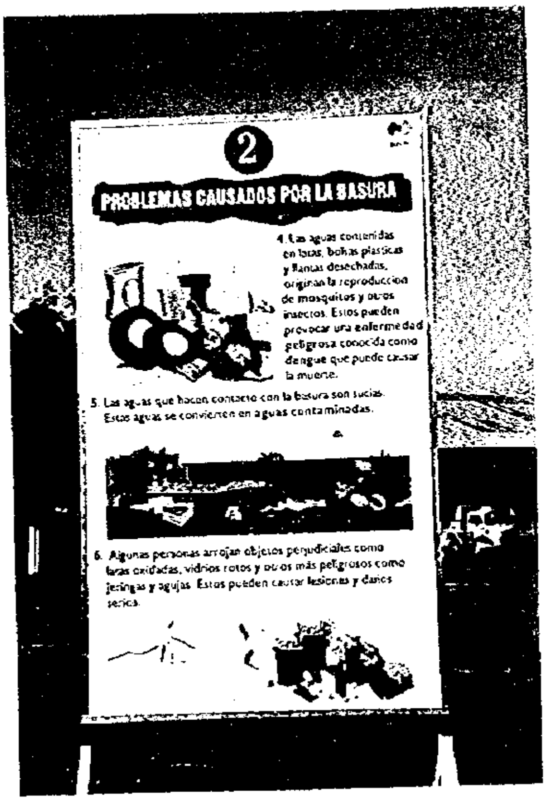
EDUCATIONAL PANELS

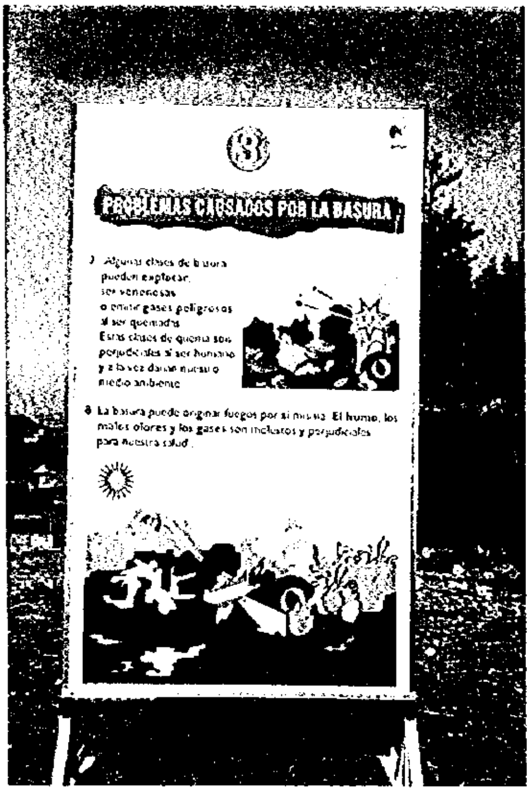
EXHIBITION OF EDUCATIONAL PANELS



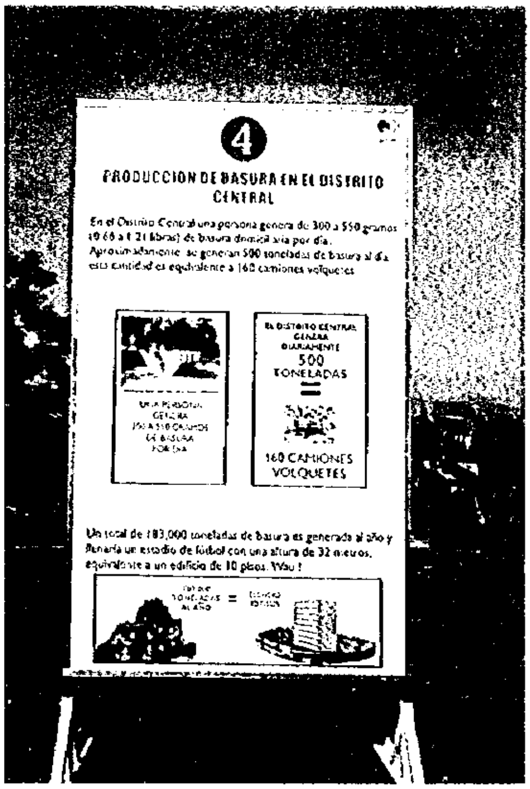
❶ PROBLEMS CAUSED BY WASTE

❷ PROBLEMS CAUSED BY WASTE

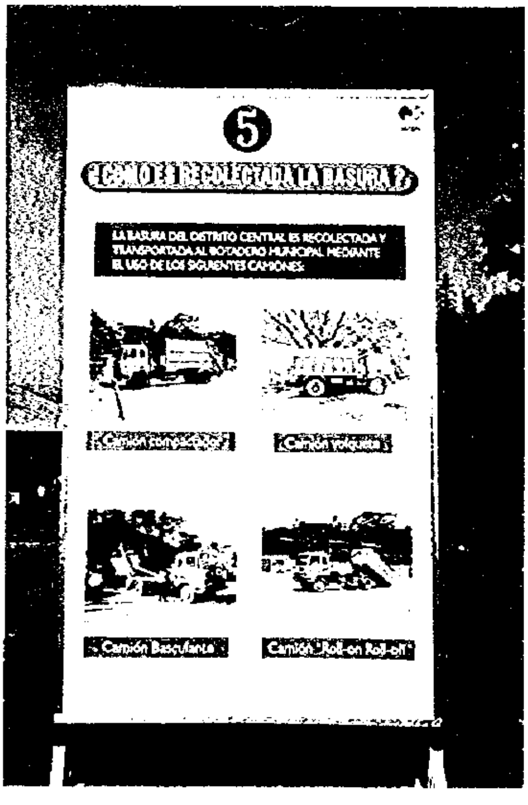
Figure 9-7: Educational Panels No.1 and 2



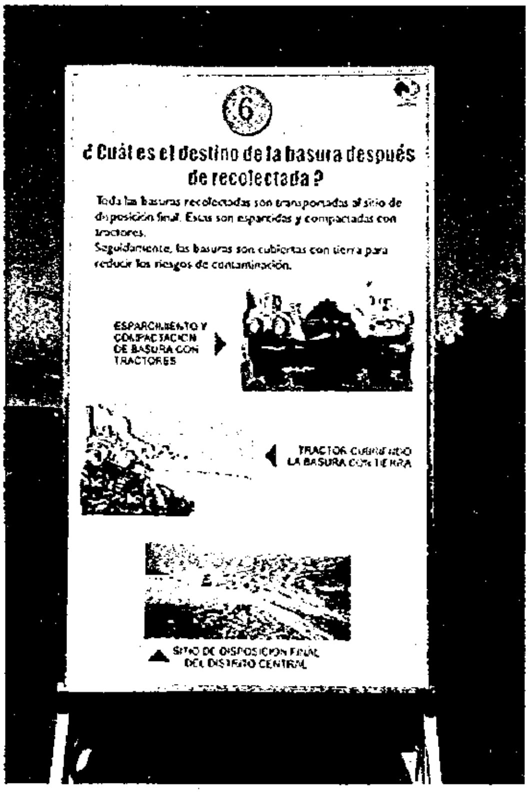
❸ PROBLEMS CAUSED BY WASTE



❹ WASTE PRODUCED IN THE CENTRAL DISTRICT

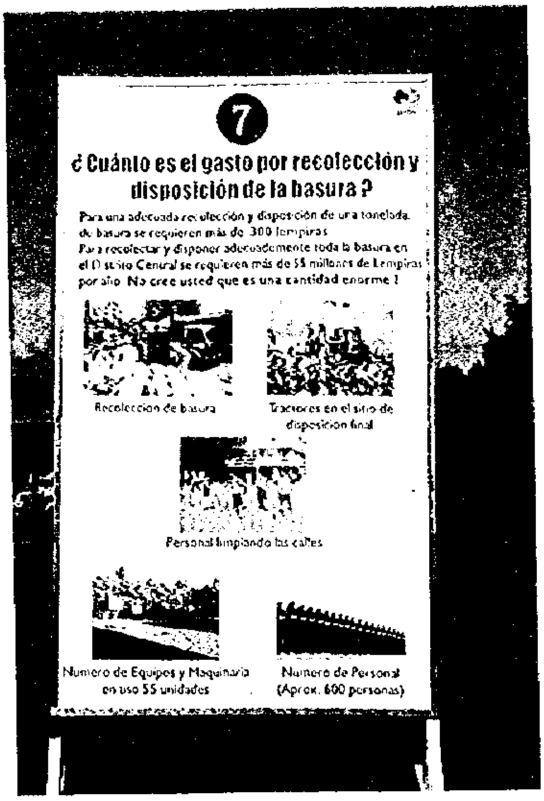


❺ WASTE COLLECTION METHODS

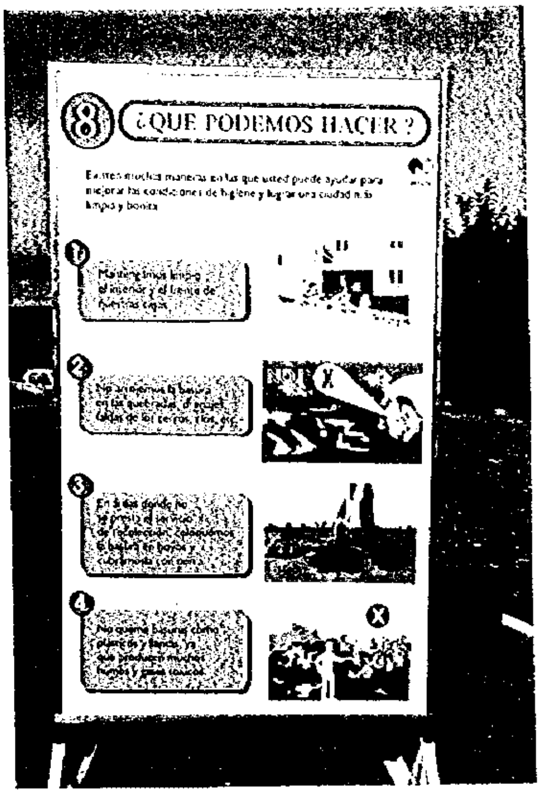


❻ FINAL DESTINATION OF WASTE AFTER COLLECTION

Figure 9-8: Educational Panels No.3 to 6

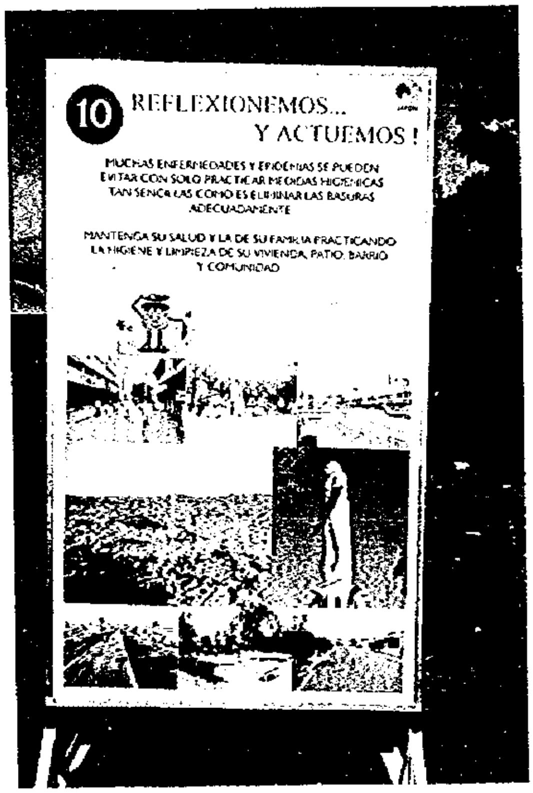


❼ WASTE COLLECTION AND DISPOSAL EXPENDITURES



❽ WHAT TO DO ABOUT WASTE ?

❾ WHAT TO DO ABOUT WASTE ?



❿ THINK ABOUT OUR ACTIONS AND ACT

Figure 9-9: Educational Panels No.7 to 10

9.3 Experiment on the Implementation of the Best Collection System for Marginal Areas

9.3.1 Implementation of the Best Collection System for Marginal Areas

As stated in the previous section, marginal areas do not receive satisfactory refuse collection service. The services are either irregular or, in some cases, not provided at all.

The lack of adequate refuse collection equipment, the unfavorable topography, and poor roads intensify collection service difficulties. Further, slopes and narrow roads are not easily accessible to collection vehicles especially in the raining season.

Since illegal dumpsites have been observed to exist especially in slopes and vacant lands, the topographical constrain of these areas has been raised as a critical sanitation and environmental problem.

To cope with this topographic impediment, the study team suggested, in the Master Plan, the adoption of the point collection system using containers. This system is expected to curtail service running expenses.

To confirm the feasibility of this idea, the study team requested AMDC to select an area where the proposed collection system may be experimentally executed. AMDC nominated several fringe areas for the experiment.

The study team surveyed these candidate sites in the engineering point of view and a questionnaire survey in March 1998 to check whether the areas were appropriate for the experiment. On the basis of the result of the surveys, the team had a meeting with the counterpart. Then the *colonias* of San Martín, Ayestas and Tres de Mayo were selected for the experiment.

9.3.2 Plan of the Pilot Project

The main purposes of the experiment are to determine the following:

1) Acceptability of a point collection system (using containers) to the residents. Although the system can reduce cost, it definitely needs the contribution of the residents to function effectively.

2) Willingness of the residents to form a community groups or associations that will supervise activities to keep the community and the surroundings of the containers clean.

3) Willingness of the residents to pay a waste collection fee fixed by the municipality and other fees to a member of the community to collect and discharge the waste into the containers.

The basic issues to be confirmed through the experiment are as follows:

i. Confirm whether the point collection system using containers is indeed the best collection system for marginal areas.

ii. Gain the residents' confidence by providing a periodical refuse collection service using containers.

iii. Gain the cooperation of the residents in the proper discharge of wastes and in the maintenance of the refuse collection points.

iv. Implementation of public education programs and explanation of the experiment by the municipality and/or the authorities concerned,

v. Data collection (amount of waste collected, collection frequency, etc.).

9.3.3 Execution of the Pilot Project

Prior to the experiment, the counterpart and the study team conducted a questionnaire survey to obtain data on refuse collection points using containers, residents willingness to cooperate in keeping the surrounding of the containers clean, and the residents willingness to pay a refuse collection fee.

The study team and the counterpart team, which consisted of the staff of AMDC and the Health Center of Tres de Mayo, held a series of meetings with community leaders and the residents, to explain the purpose of the pilot project, the project impacts on their daily lives, and the new refuse collection system.

The municipality and the Health Center of Tres de Mayo organized a car with loud speaker to broadcast to the residents that waste containers will be installed and to request their cooperation in keeping the community clean.

The experiment begun on July 18 in the steep area A1 (San Martín/Ayestas North) and on July 25 in the steep area A2 (Tres de Mayo/Ayestas West), in conjunction with the clean-up operation activities.

Due to time restrictions, the collection system experiment was implemented only for 3 weeks. However, during this period the residents were observed to be adequately and effectively using the system.

During the first week, the containers (5.5m^3) located in the steep area A1 (San Martin) and the steep area A2 (Tres de Mayo) become completely full in about 4 or 5 days, as they were used not only by the residents of areas without regular collection service but by all residents living nearby.

Thanks to the efforts of AMDC and Health Center of Tres de Mayo to disseminate information concerning the use of the containers, and especially to the cooperation of the residents of the areas involved, the experimental implementation of the system was effectively carried out.

9.4 Experiment on the Improvement of the Existing Final Disposal Site

9.4.1 Objective

This experiment aims to demonstrate sanitary landfill operation methods and to examine the applicability of the system proposed in the master plan. The experiment consists of part improvement of the final disposal site facilities, on-the-job training of the landfill staff, and the trial management of the scavengers.

Training in correct methods rather than improved landfill design has the greatest impact on improving landfill operations. Nonetheless, during the training, the selected engineer in charge of the landfill was also given notes regarding appropriate landfill design.

9.4.2 Background

As a result of the poor existing infrastructure and the manner the sanitary landfill operates, a number of serious sanitary and environmental problems exist (problems are discussed in greater detail in Annex 15):

- The propagation (by humans, insects, and animals) of pathogenic microorganisms that can proliferate in final disposal sites
- Aesthetic deterioration of the site due to scattering of paper, plastic, and other light objects by the wind
- Constant emission of smoke and odors emanating from uncovered waste on the slopes of landfilling, and transported many kilometers by the wind
- Leachate and landfill gas generation are environmental problems maybe less conspicuous, but are import because they can cause serious alterations to the environment

The main problems identified above have their origin in only a few actions which take place inside the disposal site, i.e., waste left uncovered, intentional burning of waste, generation of leachate, and landfill gas not burned nor utilized.

If the waste is compacted and covered in a timely manner, the number of humans and animals on site will fall, in addition to reducing uncontrolled waste burning. Furthermore, it prevents large amounts of paper, plastics, and other light waste from being scattered by the wind and transported outside the disposal site.

Regarding leachate infiltration into the ground, nothing can be done about the existing situation; however, over time the biodegradation of the waste and the overburden pressure maybe attenuate the groundwater contamination. Leachate generation will be somewhat reduced due to new cell filling methods and leachate moving over the surface is controlled by constructing small retaining walls in such a way as to contain as much leachate as possible within the landfill. Placing vertical gas vents, which redirect landfill gas in order to utilize it as an energy source or simply flaring it, can mitigate the impact of landfill gas.

Improving the condition of internal roads and the centers for extraction and collection of cover material can significantly assist in mitigating dust.

With these few measures, many of the existing problems can be solved, but these measures should be applied carefully so as to prevent other problems arising, especially those involving social issues, i.e., scavenger issues. Consequently some changes should be implemented immediately, for instance, those related with facility improvement. Whereas, others should be developed gradually, specifically those which involving the scavengers, whose activities are not directly linked to the works, but whose livelihoods depend upon it.

9.4.3 Pilot Projects Components

This experiment therefore planned to carry out the following three basic activities:

Activity 1: Selection and On-the-Job Training of AMDC Staff

Selecting a professional who has the responsibility for supervising the sanitary landfill procedures. This professional should have leadership capabilities and be able to firmly understand the solutions outlined. He/she will receive the most attention during the training process and execution of works, and be the primary initiator of the sanitary landfilling techniques through training the selected professional in the 'cell' method (see Annex, Ch. 15), installing landfill gas vents, and controlling surface water and leachate.

Activity 2: Installation and Demonstration of Essential Sanitary Landfill Facilities

Installing basic facilities necessary for maintaining control over the sanitary landfill and improving the appearance of the overall site. The control of the site is enhanced if everyone (landfill staff and scavengers) respects and recognizes the importance of the works. Improving the appearance of the site conveys to officials, landfill staff, scavengers, and local residents the advantages of a clean landfill site, and motivates continued action to improve the site.

Activity 3: Trial Management of Scavengers

Development and undertaking of a program which allows scavengers to continue working within the site. Because it is believed that the forced removal of scavengers from the site is unrealistic. The program should be done with the participation of personnel from the Social Development Manager's Office of the AMDC.

Seeking an integrated solution that solves existing problems while not creating new ones. Scavengers should not lose their livelihood; they are doing works that are positive for the economy of Honduras, recycling and reuse saves hard currency, energy, and non-renewable resources. However, they should not be carriers of parasites and microorganisms that cause diseases. Washing themselves and changing clothes would help. Also the activity of scavenging should be given dignity and social support with the eventual aim of becoming a normal job.

Prohibiting the access of persons who bring domestic animals into the site for the purpose of letting them feed on disposed waste.

Prohibiting access to children.

Undertaking a work program that includes technical aspects that are necessary to provide solutions to existing problems; these solutions should be compatible with the presence of scavengers.

9.4.4 Execution and Results of the Pilot Project

Activity 1: Selection and On-the-Job Training of AMDC Staff

The Cleansing Department fulfilled Activity 1 by appointing Marlon Aguilera a civil engineer. He met the profile of the required professional, having leadership capabilities and the ability to understand the solutions explained to him.

He was contracted a few days after the pilot project was initiated in July, and was present during the entire experiment.

The training of the engineer included:

- On-site preparatory explanation of all facilities to be constructed and the filling methods to be employed were given to the engineer.
- The pilot sanitary landfill site was selected and preparing the site began
- Instructions were provided on landfilling techniques such as the cell method of landfilling, the control of leachate, landfill gas, and light waste which can be scattered by the wind
- Instructions were provided regarding the extraction, use, and storage of cover material
- Instructions on measures to make the sanitary landfill operation compatible with the presence of scavengers

As a consequence of training the engineer and initiating the new landfilling procedures, the bulldozer operators, dump truck drivers, and other landfill staff learnt important new procedures necessary for establishing a sanitary landfill. Scavengers were also introduced to the new procedures.

Activity 2: Installation and Demonstration of Essential Sanitary Landfill Facilities

The construction of facilities and works that are executed with the objective of achieving control over the disposal site. Vital to this activity's success is scavenger recognition of the fact that the works are important and will also benefit them in the long run:

- Asphalt paving of the main access road (300 meters) serves as a dust control measure, as well as dramatically improves the appearance of the landfill site and traffic movements.
- Erection of a mesh and barbed wire perimeter fence (approx. 250 meters), concrete block wall, gate and gatehouse, and the placement of a signboard explaining conditions of entry at the entrance. In this way, access to the final disposal site is controlled and hence the scheduling of activities within the site can be made.

- Installation of a plastic mesh fence three meters high to prevent paper, plastic, and other light waste from being scattered by the wind toward residential and business areas located near the landfill. The mesh extends approximately 200 meters and consists of a fine mesh and lateral barriers to trap the light wastes.
- Construction of moveable screens to control light waste near the work face.
- Construction and installation of landfill gas vents in the pilot sanitary landfill sector.
- Forestation of area where erosion has taken place nearby the final disposal site with the objective of creating continuous vegetation screen (buffer zone).
- Planting grass in an experimental manner in a small sector of the sanitary landfill.
- Overall cleansing of the site was undertaken. This included picking up loose litter and covering and grading exposed areas with soil.
- Topographical study with the objective of getting basic information to define spatial use, to determine site service life and to develop work programs.
- Geological study and soil analysis in order to determine the amount of available cover material for the sanitary landfill which can be obtained at the site and to define the physical and mechanical properties of the material.
- Installation of a sign informing open hours, conditions of entry, and the fact that the site belongs to the AMDC.
- Also cones and signs to direct the traffic of vehicles, and fire extinguishers were provided. Fumigation of 5 hectares was undertaken at the final disposal site in order to control the proliferation of insects.

Activity 3: Trial Management of Scavengers

The organizing of scavengers so their work does not interfere with the operation of the sanitary landfill.

To implement sanitary landfilling is necessary that the chief engineer have complete control of the facility. Therefore all those working at the disposal site must cooperate with his commands.

Scavengers' current working habits are chaotic; it is difficult to get them to respond to requests for cooperation. Scavengers work wherever, however, and whenever they please. And middlemen behave in a similar way.

The methodology used to organize scavengers:

- Necessary demographic data and the their opinions were obtained through an interview survey.
- Leaders were identified.
- Talks were held with the chosen leaders to gain their confidence and to communicate to them what has been planned, and their reactions observed.

- The AMDC Section of Social Participation and Organization, Micro-Enterprises and Areas with Populations at Risk were included in the process.
- Group meetings were held with scavengers at the final disposal site.
- A preliminary registration of scavengers was done (recording name, age, and sex).
- Registration, printing, and issuing of ID card.
- Vaccinating scavengers for Tetanus and Hepatitis B took place.
- Leaders were officially recognized and introduced to other scavengers as such. Scavengers were then organized into a group.
- Scavengers were presented with items, such as caps and T-shirts to signify their identity as part of a group.
- Works that supported the creation of the micro-enterprise for scavengers were initiated.

In addition to what was previously stated, conditions of entry into the sanitary landfill will be set and a proposal for a regulation for scavengers is provided:

Table 9-9: Conditions of Entry into AMDC Disposal Site

1	The *Alcaldía Municipal del Distrito Central* (AMDC) reserves the right to admit or reject any person into the sanitary landfill.
2	Waste disposal is allowed only at the days and hours established. From Monday to Friday: 7:00 am to 6:00 pm Saturday: 7:00 am to 2:00 pm
3	Only those persons displaying a valid AMDC issued entrance card may enter the landfill site. Any other person wishing to enter the site should be approved by the chief engineer.
4	The AMDC reserves the right to inspect any load leaving or entering the site.
5	Waste disposal will be done in the area indicated by authorized personnel from municipality at the moment to go into the facility.

Table 9-10: Proposed Scavenger Regulations

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.

9.5 Improvement of the Managerial Capability of the Cleansing Section

This pilot project focuses mainly on the improvement of record keeping, cost control, and cost analysis systems by using computers. It also includes training staff on management methods by using computers.

9.6 Evaluation on the Proposed System in the Master Plan by Pilot Projects

9.6.1 Campaign for Raising Awareness on Solid Waste Issues

The execution of the campaign project and the presentation of educational panels and films opened the eyes of the people to the environmental problems that currently prevail. The majority of community leaders and residents participated and cooperated fully during the campaign project.

The experiment made the people realize how dirty their towns are and how important appropriate solid waste disposal is. The continuation of the sanitary education programs will further motivate the people to continually keep their towns clean and beautiful.

Many people understand that the conduct of the campaign and sanitary education programs would significantly contribute to solving current environmental and health problems, as these programs are instrumental to the proper conduct of waste collection and disposal services. This is why the residents were considerably grateful for the conduct of the pilot projects.

The method of community education on solid waste used for the experiment was found to be very effective in San Martin, Ayestas and Tres de Mayo. Aside from slight modifications in accordance with town/city characteristics, the method is considered applicable to many areas and other cities in Honduras as well.

9.6.2 Experiment on the Implementation of the Best Collection System for Marginal Areas

The results of the questionnaire survey carried out in March 1998 on 100 residents (See Annex 14) indicate that almost half of the pilot project areas (*colonias* of San Martín, Ayestas and Tres de Mayo) were not receiving an adequate waste collection services, resulting in the illegal dumping of wastes in sloped areas and vacant lands by almost 43% of the residents (mostly by the residents of San Martín).

From July 1998, however, the AMDC, with the help of the study team, provided waste collection service through the installation of containers in selected areas in San Martín (area A1) and Tres de Mayo (area A2).

The selection of the container collection system as the best collection system, was recommended in view of the poorly maintained access roads and the slopes, factors which limited the access of regular collection vehicles.

The results of another questionnaire survey, with 100 resident participants after the implementation of the "Campaign for Raising Awareness on SW Issues", clean-up operations, and the collection system experiment, indicated that 62% of the respondents used the containers. The remaining 38% stated that they either received regular collection services from AMDC or were unable to use the containers because of their distance.

The residents basically understood the container collection system, thanks mainly to the instructions given in the workshops. Due to time restrictions, however, it was impossible to confirm whether the residents kept the areas surrounding the containers clean. Nonetheless, there was no waste discharge in illegal dumpsites (area A1 & A2) after the cleansing activities.

The campaign project, clean-up operations, and the collection experiment, carried out in the pilot project areas, helped to promote SWM improvement in other neighboring *colonias*, such as Zapote Norte west of Tres de Mayo, that requested the AMDC to provide equipment and a container for cleansing activities. The clean-up operation of Zapote Norte which took place on August 8, was carried out by the initiative of the residents, with the AMDC providing the cleansing equipment and the container.

Although there was a time constraint, it was possible to confirm, through the evaluation of the proposed objectives, that the experimental collection system were successful. The results were promising as residents in beneficiary areas were highly cooperative. Further, public motivation in the project areas spread to other neighboring *colonias*, that undertook their own clean-up operations with the help of the AMDC. The residents efforts are highly commedable and are seen as an invaluable achievement of this experiment.

9.6.3 Experiment on the Improvement of Existing Final Disposal

Implementation of activities 1, and 2 were very successful. Engineer (Marlon Aguilera) quickly grasped all of the concepts that were explained to him, and attained the respect of fellow landfill staff and scavengers. His ability to manage, however, is greatly hindered by poor facilities, i.e., not having a vehicle or telephone to communicate with the Cleansing Department headquarters in *Colonia 21 de Octubre*. A vehicle is necessary to quickly move about the site and to obtain necessary materials from the city.

Equipment operators are skilled and after only a few days of instruction and trials, sanitary landfilling methods were being carried out smoothly and in a professional manner.

The installation of basic facilities was done without problems and all were operating as planned at the end of the pilot project stage.

Some other improvement measures were set in place. Scavengers cooperated and understood that the changes being made were also in their interests.

Even though every one was made clearly aware of the importance of sanitary landfilling methods and understood how to implement them. Once the experiment was over and the study team left, sanitary landfilling immediately ceased and the landfill staff reverted back to the previous landfilling methods. Because of institutional problems the AMDC administration is not supplying a sufficient amount of fuel for the bulldozers to continue applying the methods learnt.

Scavenging activities are again not being controlled. Frequent change is discouraging and confusing to them. Because constant supervision and assistance is necessary for the scavengers to gain confidence in the newly introduced methods.

Even though the condition of the disposal site markedly improved through the implementation of this experiment, sustained improvement is vital. And sustained improvement can only occur with institutional reform thus ensuring the provision of spare parts and fuel, the coordinating the use of landfill equipment, support for the proper management of the site and scavengers, and planning of future disposal activities.

9.6.4 Improvement of the Managerial Capability of the Cleansing Section

The SWM program for computer proved that the present record keeping system is unreliable because considerable data were found to be inconsistent. It can conclude that the improvement of basic information should go together with the improvement of management system.

Some of AMDC staff have realized the importance of monitoring the performance with the data.

Chapter 10

Preliminary Design for Improvements and Overall Development of Existing Disposal Site

10 Preliminary Design for Improvements and Overall Development of Existing Disposal Site

10.1 Introduction

The overall development objective to "Improve Existing Disposal Site Operations to Significantly Lessen the Impact on Locals and Passersby" is derived from the outcome of a meeting with concerned stakeholders held during the first study phase. The activities proposed to meet this objective form the basis of the preliminary improvement plan, and are described in section 10.3.

10.1.1 Policies for the Improvement and Overall Development of the Disposal Site

An assessment of existing conditions in the Central District indicates that there are various important factors limiting improvements. Taking into account these factors (i.e., lack of financial resources, low level of technical and managerial capabilities, etc) policies for the improvement plan and overall development of the disposal site are formulated.

- All improvements included in this plan propose applying suitable technologies, i.e., low cost technologies, facilities that can be constructed given the level of construction technology in Honduras, and can be operated and maintained by training available staff.
- The improvement plan proposes to continue using the existing landfill as preliminary studies have shown the existing site to have potentially several more years of use, and because new sites are traditionally difficult to develop due to environmental concerns of nearby residents.
- A safe and sanitary final disposal site. A major step towards achieving this is the proposed implementation of the cell method of landfilling. Waste is compacted in layers of no more than 3 meters, and covered daily with a thin layer of cover soil to significantly reduce odor, windblown waste, water and gas intrusion, landfill fires, and the breeding of disease carrying vectors. Further, leachate recycling is achieved by spraying collected leachate over the covered waste. Gas vents are installed at regular intervals to release gases generated by the anaerobic decomposition of organic waste.
- No plan for the installation of landfill gas energy recovery systems is proposed. Priority has been placed on getting the existing disposal site operating in an efficient and sanitary manner. Once this has been achieved a pilot project involving the processing of landfill gas could be undertaken.
- Supervision and monitoring of the site is maintained on a regular basis, during operation and after the site has reached capacity and has been closed, to ensure minimal impacts on the surroundings.
- Scavengers will be organized and controlled so that they do not disrupt the operation of the site. While landfilling activities take precedence over the

activities of scavengers, scavengers are included in future development plans because they provide a valuable resource recovery system.

10.2 Conditions of the Preliminary Improvement Plan

10.2.1 Site and Surroundings

Elevated between 1070 and 1150m above sea level and occupying 31.7 hectares of the valleys that form the Los Limones and Los Jutes creeks, the Central District Disposal Site is located north of the Central District urban area at KM 6.5 on the Olancho Road (Figure 10-1).

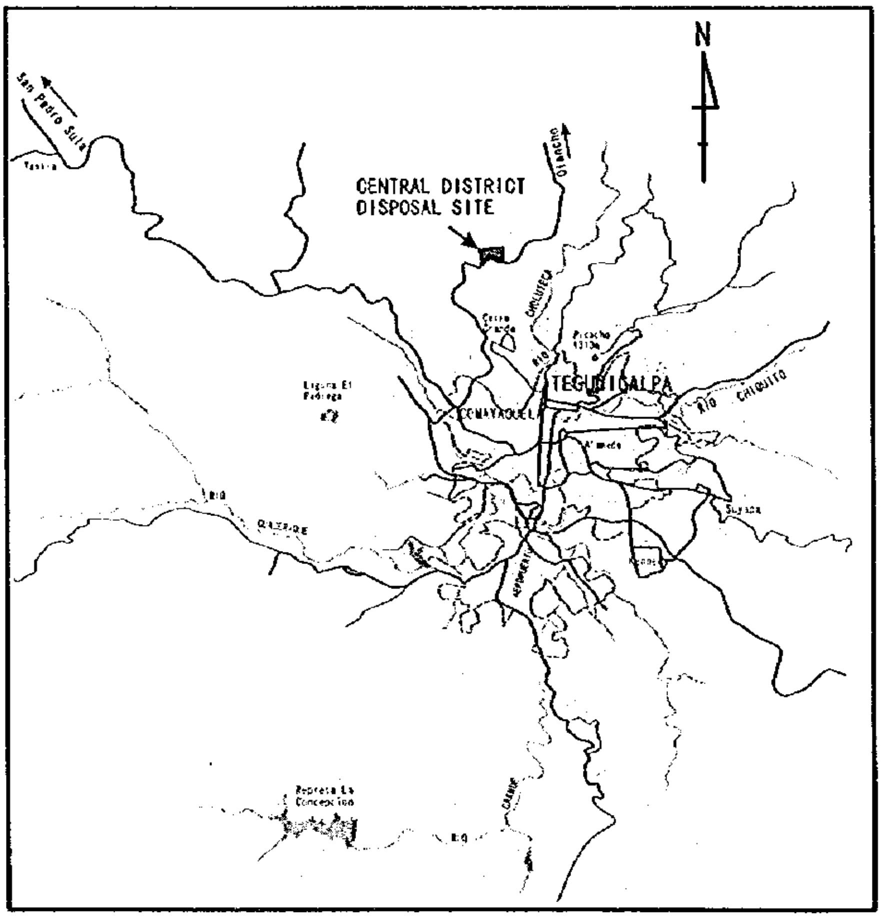


Figure 10-1: Location of Central District Disposal Site

Bounding the northern edge of the site, and running parallel to the Los Limones Creek, is a high-voltage electricity power line (see Figure 10-2). Beyond this and as far as the eye can see is sparsely populated undulating terrain, with patches of natural forest and small farms.

To the south lies the Olancho Road. Along the Olancho Road, in the vicinity of the disposal site, exist several factories, storage depots, warehouses, gas stations, small convenience stores, businesses dealing in recovered waste materials, and residential areas.

a. General Condition of Site

The disposal site receives, not only municipal solid wastes such as residential, commercial and institutional wastes, and garbage from public areas, but also construction debris, industrial, agricultural, agro-industrial, hospital wastes, among others. The Study Team estimated that in 1998 approximately 129,000 tons of waste will be disposed of at the final disposal site, that is equivalent to 450 tons of wastes are disposed of daily, except on Sundays, at the disposal site.

a.1 Existing Facilities within the Disposal Site

There is no gate or instruction board at the entrance of the disposal site and the site is also not fenced. Therefore, various types of waste can be brought in to the site and anybody, including children, can gain access to the site.

The site is equipped with only two small wooden huts, and there is no water supply or toilets.

a.2 Landfill Operations

Three 215 Hp bulldozers (D7 'Caterpillars'), a wheel loader and three 8 m^3 dump trucks are operated at the site. The bulldozers are used for waste compaction and soil covering: two have blades for spreading waste, while the third has a blade for spreading and leveling cover soil. The wheel loader is used to excavate and load the cover soil, and the dump trucks are used to transport soil from the borrow to the landfilling area. However, lack of diesel, at times the equipment is not being used to maximum effect. The bulldozers are operated for about four to five hours daily, and the excavation and hauling of soil can only be carried out a few days a week.

The AMDC employs four heavy equipment operators, three dump truck drivers and seven other staff, including supervisors, foremen and workers. In addition, three mechanics commute to the site from the central workshop daily. An AMDC staff member counts the number of incoming vehicles.

The landfill has no bottom liner or leachate collection facilities. To control leachate, a thick layer of soil is required, however, a large section of the landfill's embankment adjacent to the Los Limones Creek has no soil cover, allowing leachate -- as observed in several places – to flow freely into the creek.

The landfill site does not house any facilities to collect and control the landfill gas generated through the anaerobic decomposition of organic fractions in the waste. Neither does it have facilities or a plan to implement such facilities to control odor emission, vermin proliferation and the generation of fires inside the landfill. Further, there are no barriers to prevent the scattering of light waste, and spraying cover soil with water to reduce dust is not carried out.

The landfill method employed is the formation of terraces between a hillside and a small creek. There are three terraces constructed at intervals of approximately 25m and 10m; the smallest is 35m above the level of the Olancho Road.

10.2.2 Hydrological Conditions

a. Permeability of Existing Soils

Geology within the disposal site predominantly consists of the weathered rhyolite and volcanic ash. The permeability of the weathered rhyolite is estimated to be in the order of 10^{-1} cm/sec to 10^{-3} cm/sec, while for the volcanic ash it is 10^{-3} cm/sec to 10^{-6} cm/sec. It is concluded that the natural geology of the disposal site is moderately to highly permeable.

b. Permeability of Existing Waste Hill

The permeability of the existing waste hill has significant differences to underlying geology so it is assessed separately. The first layers of the landfill were placed in the late 1970s. The natural biodegradation process of the bottom layers is assumed to be now virtually complete meaning that the waste has broken down into fine particles. With the addition of the over burden pressure from above (the landfill hill is over 30 meters high in places) the material near the bottom of the landfill is assumed to have a low permeability. Moreover the pores of the underlying natural soil are assumed to have been saturated with the small particles resulting from the biodegradation process, further decreasing the permeability.

10.2.3 Cover Material

a. Background

Cover material has the purpose of isolating deposited solid waste from the surrounding environment, in order to create anaerobic conditions to obtain microbiological stability in the shortest possible period; additionally, it is needed to prevent the infiltration of rainwater. Cover material should be applied daily and be at least 15 cm thick to ensure conditions previously stated and to prevent fly larvae from migrating to the surface. In addition the final cover layer should be at least 60 cm thick, and designed to reduce infiltration and erosion.

b. Cover Material Available at Tegucigalpa's Final Disposal

Predominant soils found at the site are sandy silty gravel derived from weathered rhyolite and silty clayey sand derived from tuffs (volcanic ash); both materials are available at the borrow sites where they can easily be removed. They are easily distinguished; rhyolite's is purplish in color and the tuffs', yellowish in color.

In general, both can be used for cover material; although the gravel derived from weathered rhyolite can reach a higher degree of compaction.

c. Estimate of Amount of Available Cover Material

Calculations made estimated that in the southeastern sector there is approximately 40,000 m^3 and 290,000 m^3 in the southwestern sector of cover material available. Therefore there is sufficient cover material at the site to undertake sanitary landfilling until mid 2007.

10.2.4 Space Available for Landfilling and Future Utilization

The total amount of space required for the disposal of waste until the year 2010 was calculated based on waste quantity projections determined in earlier sections, and the assumption that the amount of cover soil necessary for sanitary landfilling is approximately 15% of the waste amount (Table 10-1). This percentage is conservative as it allows for the construction of additional works such as earth walls and embankments.

Table 10-1: Calculation of Disposal Site Space Requirements

Year	Waste Received tons/year	Cumulated waste amount tons (a)	Compacted waste (D^1=0.8) m³ (a/0.8)	Cumulated Compacted Waste m³(b)	Cover Soil m³	Cumulated Cover Soil m³ (c)	Required Capacity m³ (b+c)
1998	129,000	129,000	161,250	161,250	24,188	24,188	185,438
1999	131,000	260,000	163,750	325,000	24,563	48,750	373,750
2000	139,000	399,000	173,750	498,750	26,063	74,813	573,563
2001	166,000	565,000	207,500	706,250	31,125	105,938	812,188
2002	177,000	742,000	221,250	927,500	33,188	139,125	1,066,625
2003	189,000	931,000	236,250	1,163,750	35,438	174,563	1,338,313
2004	219,000	1,150,000	273,750	1,437,500	41,063	215,625	1,653,125
2005	235,000	1,385,000	293,750	1,731,250	44,063	259,688	1,990,938
2006	250,000	1,635,000	312,500	2,043,750	46,875	306,563	2,350,313
2007	266,000	1,901,000	332,500	2,376,250	49,875	356,438	2,732,688
2008	303,000	2,204,000	378,750	2,755,000	56,813	413,250	3,168,250
2009	323,000	2,527,000	403,750	3,158,750	60,563	473,813	3,632,563
2010	344,000	2,871,000	430,000	3,588,750	64,500	538,313	4,127,063

a. Available Space

Taking into account the information obtained from a visual inspection of the site, what long time workers conveyed to us, and estimations produced about cover material extracted from two sectors; we can make an approximation about the available space.

In Figure 10-2, 'Area A' all those areas where no landfilling has occurred and where cover material is presently being extracted. 'Area B' is all areas where landfilling has been done and landfilling can take place in the future. 'Area C' those areas where landfill has been done and waste can not be placed anymore. And 'Area Z' those areas that can not be used for landfilling and will be used as a buffer zone.

The Study Team proposes that landfilling should be done using terraces. The available space is estimated as shown in Table 10-2.

[1] D = specific gravity of compacted waste

Table 10-2: Landfilling by Area

Area	Period Filled	Area (m²)	Average landfill height	Available space (m³)
A_1	2005-6	40,000	20	800,000
A_2	2000	20,000	12	240,000
B_1	2000-4	84,000	12	1,008,000
B_2	1998-1999	27,000	16	432,000
C	-	30,000	no further filling	-
Z	-	116,460	no further filling	-
Totals		317,460	60	2,440,000

Current available space inside the final disposal site is 2,440,000 m³, which according to Table 10-1 is sufficient space to last until early 2007. This figure also corresponds with the amount of cover material presently available within the site.

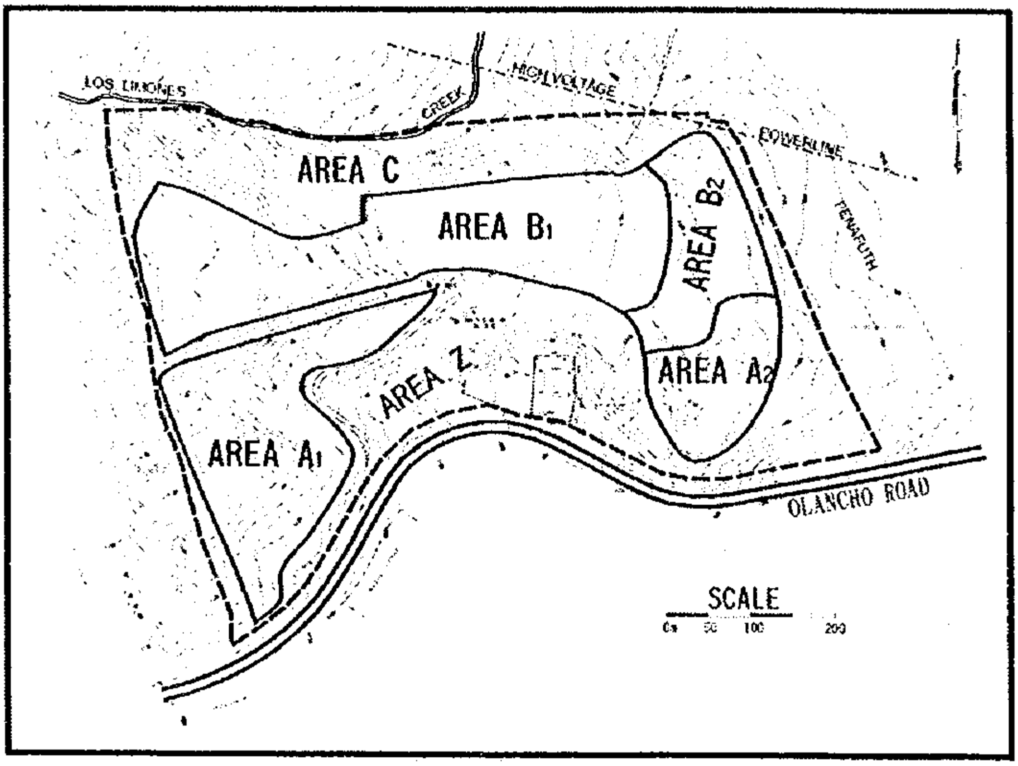


Figure 10-2: Division of Disposal Site

It is possible to use more of Area A_1, i.e., up to the boundary with Olancho Road for landfilling and as a source of cover material. However, due to aesthetic reasons and its proximity to Olancho Road, this is considered unacceptable and it is proposed that this area be preserved as a buffer zone.

10.2.5 Waste Composition

The landfill is expected to receive the following types of waste:

- Residential waste (e.g. food waste, paper, plastics, etc.)

- Bulky waste (furniture, refrigerators, etc.)
- Commercial waste (from shops and restaurants)
- Market waste (mainly vegetables and paper)
- Institutional waste
- Garden waste
- Street sweeping waste
- Industrial waste (non hazardous waste)
- Construction and demolition waste.
- Stabilized non-toxic dry sewage sludge

The most common type will be waste from residential areas, i.e. waste mainly derived from households and including a substantial portion (60 %) of organic matter.

Until the current problem concerning the incinerator situated adjacent to the disposal site is solved, infectious waste, hypodermic syringes, etc., from hospitals, clinics and dentists should be deposited in a separate section of the landfill.

The landfill will not receive the following types of waste.

- Hazardous and toxic waste from industries, commerce, institutions etc.
- Radioactive waste of any type.
- Bulk quantities of liquid waste of any type.

10.2.6 Landfill Gas

a. Landfill Gas Production at a Sanitary Landfill Site

Through a stoichiometric model and the chemical formula for organic waste, the maximum theoretical production amount of landfill gas can be determined.

It is calculated that maximum landfill gas production (derived from a stoichiometric model[2]) can reach between 800 and 1000 l/kg. This value is adjusted, taking into account:

- A large percentage of the waste is water
- Part of the waste is inorganic; and does not generate landfill gas
- Part of the organic content decomposes very slowly
- Some organic waste decomposes aerobically during the initial stage.

Thus the figure decreases to between 200 and 300 l/kg. And if we consider just the landfill gas amount that can be flared, the figure becomes even smaller due to surface and lateral landfill gas migration. Additionally, the methane concentration must be sufficiently high to burn, further reducing the figure.

Previous experimental results point out that it is possible to obtain between 50 to 80 m^3 of landfill gas per ton of domestic solid waste, as they are discharged in the landfill site over a period of 10 years.

[2] organic waste + $H_2O \xrightarrow{bacteria} CH_4 + CO_2$ + other gases

b. Landfill Gas Production at the AMDC Sanitary Landfill Site

To simplify the calculation and to obtain an approximate landfill gas useful production, it will be assumed that a ton of waste produces 70 m^3 of landfill gas over a 10 year period at a constant rate of 7 m^3/year; annual waste production will also be considered. As a result, landfill gas production until 2010 is shown in Table 10-3.

Table 10-3: Estimation of Annual Landfill Gas Production

Year	Waste Production (tons/year)	Landfill gas Production (m^3/year)	Landfill gas Production (m^3/day)
1999	131,000	917,000	2,512
2000	139,000	1,890,000	5,178
2001	166,000	3,052,000	8,362
2002	177,000	4,291,000	11,756
2003	189,000	5,614,000	15,381
2004	219,000	7,147,000	19,581
2005	235,000	8,799,000	24,107
2006	250,000	10,549,000	28,901
2007	266,000	12,411,000	34,003
2008	303,000	14,532,000	39,814
2009	323,000	15,876,000	43,496
2010	344,000	17,311,000	47,427

Figures in Table 10-3 do not include landfill gas generated as a result of waste discharged before 1999. Beginning in 2008, landfill gas production becomes stable with reduced annual increases due to the stabilization of older waste. Landfill gas production will decline after sanitary landfill closure and will be insignificant 10 years after closure.

10.2.7 Leachate Generation

Liquid that has percolated through solid waste is term leachate. Leachate from landfills usually contains extracted, dissolved, and suspended materials, some of which may be harmful.

The amount of leachate generated was calculated for two different conditions. Firstly, for leachate generated under the existing conditions, and secondly for leachate generated once improved landfilling methods are being carried out.

Leachate generation under existing conditions was estimated to be 500 mm/year/m^2 by estimating the flow of leachate in the Los Limones Creek. Estimates of 110 mm/year/m^2 under final cover layer conditions, 250 mm/year/m^2 under the intermediate cover conditions were made using the Top Layer Model (see Annex section 15.3.7). This model employs factors such as cover soil type and thickness, evapotranspiration, runoff characteristics, and precipitation.

The total annual leachate generation amount is then plotted (Figure 10-3) to show the trend. An immediate reduction in the amount of leachate generated as the new cell method is implemented and surface runoff is improved. This decrease continues until 2001, stabilizing once improved methods are being utilized in all existing and new areas.

Leachate generation will continue beyond 2010. However, over time the strength of the leachate decreases until the waste in the landfill has stabilized. This has possibly already occurred to a large degree in the lower layers.

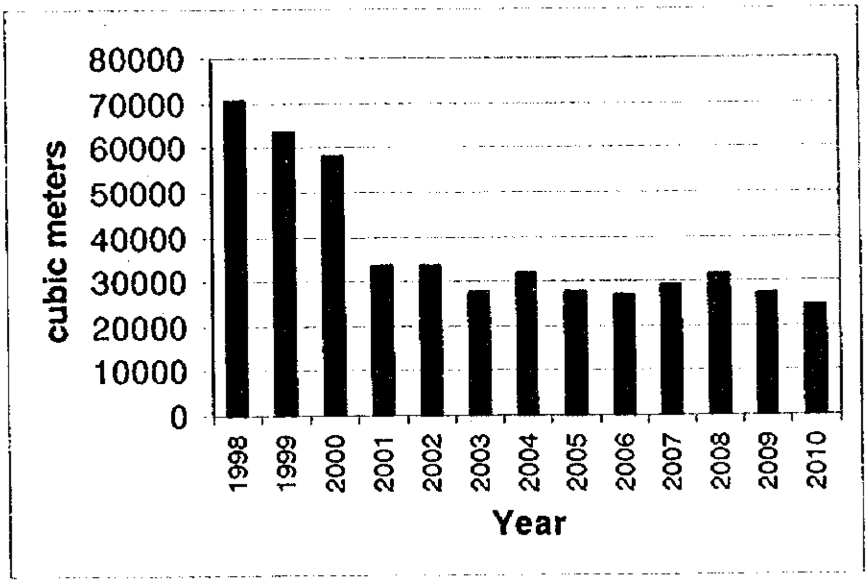


Figure 10-3: Leachate Production from Existing Disposal Site, 1998 to 2010

10.2.8 Identification of Problems

As a result of the lack of adequate infrastructure and the poor operation of the site the following problems are occurring. Problems do not just impact the immediate site but also the surrounding areas.

a. Propagation of Parasites and Microorganisms

The Central District's high proportion of organic municipal solid wastes and year round warm weather makes the waste a suitable medium for the rapid proliferation of parasites and microorganisms. The current operation leaves waste uncovered over long periods, allowing various types of animals to feed on the waste and scavengers, including children, to come in direct contact with the waste.

People and animals become mediums for parasites and microorganisms, and pathogens are transmitted to populated centers and homes, causing some of the serious diseases that prevail in the area.

b. Water Resource Modification

Flatter areas resulting from landfilling works are not provided with sufficient slope and ponding is common following rains. Ponding results in greater amounts of water infiltrating and generating leachate, provides a breeding ground for mosquitoes, and is an obstruction to incoming vehicles.

Catch drains have not been constructed so surface flows uncontrolled within the site. Uncontrolled runoff has resulted in leachate contaminated runoff flowing into the Los Jutes Creek, which until recently remained relatively untouched by landfill activities. Moreover, steep slopes formed by poor landfilling practice increase erosion of soil and result in sedimentation of nearby waterways.

Under existing conditions the amount of leachate produced is difficult to quantify as it either infiltrates the ground or is drained over the hillside and runs toward Los Limones Creek. Several observations made in February confirmed a leachate flow of no more than 1 l/sec. However, during the rainy season, leachate production is higher and was observed to be flowing at approximately 4 l/sec.

c. Air Modification

There is no landfill gas removal system or system to flare the gas, the latter resulting in the conversion of methane (CH_4) to CO_2 and H_2O – compounds that cause less harm to the atmosphere. Methane and other landfill gases are flammable and potentially toxic; posing a risk to public health as well as being an occupational hazard for landfill workers and scavengers. Collection and flaring is a recommended means of removing the harmful landfill gas.

Uncovered waste, the burning of waste, landfill gas and leachate all contribute to the emission of smoke and odor. Odor diffuses and affects nearby areas, including businesses and residences along the Olancho Road, to varying degrees depending on the velocity and direction of the wind.

Dust results from suspended particles generated by the transportation of cover material, vehicular traffic into and within the landfill site, and wind. This problem, however, has the least effect on air conditions and only occasionally affects areas beyond the landfill limits.

Compounding air pollution problems is the fact that the prevailing wind direction is from the north[3] meaning the populated areas to the south and southwest are specially impacted by emissions from the disposal site.

d. Land and Landscape Deterioration

Previous poor landfilling methods, in particular filling resulting in the steep slopes observed along the northern edge of the existing disposal site cause several problems. Firstly the risk of slope failure is increased, which has already occurred in some parts and is likely to occur more frequently as the waste hill increases in size. Secondly, it is very difficult to establish a compacted cover layer on steep slopes as vehicles cannot traverse such steep terrain, and leachate flows freely from the slopes, and fast flowing surface runoff erodes the cover layer. Moreover, the steep slopes is a hazard that will severely restrict future development.

Light wastes, mainly paper and polyethylene shopping bags, that are scattered due to wind also influence soil conditions and adversely affect humans and animals that make use of the surrounding vegetation.

[3] Source: Wind data recordings taken at Toncontin International Airport

The extraction of soil for use as cover material also affects soil characteristics. Hence, it is necessary to take measures that will allow the soil to recover after the landfill is closed.

As a large part of the waste in the disposal site is currently left uncovered or uncompacted over long periods, the wind often scatters the lighter waste outside the final disposal site boundaries, destroying the beauty of landscape. Furthermore, this phenomenon complicates the use of cover soil, and frequent soil cleaning (i.e. removal of waste from the soil) prior to use is necessary.

e. Visual Obtrusion

The height of the landfill has increased to the point that it is now clearly visible from the Olancho Road and nearby areas. This causes two visual problems firstly; motorists view the landfill hill as a barren and unattractive spectacle. Second, wind-blown waste now has no natural obstacle and freely scatters round areas to the south of the site, i.e., residences and businesses.

Further waste falling off the back of collection vehicles and the careless activities of dealers of recovered waste materials located along Olancho Road means that the road is heavily littered and is an eyesore to passersby.

f. Road Safety

The exit point from the landfill is a hazard. The section of the Olancho Road, near the junction with disposal site's access road, is a gentle curving high-speed section of road. This is one of the first sections of roads where vehicles can overtake slower ones as they leave the built-up urban areas of Tegucigalpa. The problem is acerbated by poor visibility caused by a large hill blocking the vision of the drivers.

During the study phases many vehicles were observed overtaking and several times resulting in near misses between smaller vehicles speeding away from Tegucigalpa and larger collection vehicles exiting the site. Because of the high speeds and vehicle size differentials any accident occurring at this point is likely to be catastrophic.

10.3 Preliminary Improvement Plan

The preliminary improvement plan for the existing disposal site has been set out in a logical manner, Figure 10-4 outlines the logical links between the activities and the overall development objective.

OVERALL DEVELOPMENT OBJECTIVE
Improve the operation of the existing disposal site to significantly lessen the impact of landfill activities on locals and passersby

↑

IMMEDIATE OBJECTIVES
A Landfill controlled
B Landfilling methods improved
C Buffer zone in place
D Litter reduced along main road leading to landfill
E Road safety at intersection improved
F The site is being supervised
G Surrounding areas are monitored
H Closure and post-closure plan in place

↑

ACTIVITIES

A. Control of landfill A1 Develop rules and system for scavenging activities A2 Construct fence, gates, & signboards at access points	E. Improve Road safety E1 Widen and mark intersection and erect caution signs
B. Improve landfilling methods B1 Train landfill AMDC staff in "cell" landfilling method B2 Instruct landfill staff on gas venting procedures B3 Instruct landfill staff on leachate control procedures B4 Place permanent and moveable waste fences B5 Placement of final cover layer B6 Construct internal roads B7 Adopt surface drainage plan	F. Administrative Improvements F1 Construct administration office F2 Install security lighting F3 Install water supply and sewage system F4 Pave and improve access road F5 Construct garage F6 Purchase truck scale F7 Maintenance of civil works
C. Buffer zone C1 Plant and maintain trees in areas designated for buffer zones	G. Monitoring G1 Regular monitoring of local water sources G2 Periodic questionnaires given to locals
D. Reduce litter along main road leading to landfill D1 Establish ordinances for businesses along road D2 Organize street sweepers D3 Purchase tarpaulins for dump trucks	H Establish Closure and Post-Closure Plan H1 Establish closure and post-closure plan

Figure 10-4: Logical Links between Activities and Objectives

In order to achieve the overall development objective in the first box of it is first necessary meet the 'immediate' objectives. And in order to achieve the immediate objectives it is necessary to successfully complete the 'activities' described in the lower box.

The smoothness of this process is dependent on external factors that must be overcome in order to implement many activities; most crucial being improvements in the managerial capacity of the Cleansing Section. For example, improved managerial capacity enhances coordination and funding capabilities, allowing timely acquisition and replacement of materials and spare parts, availability of fuel and oil, periodic replacement of major equipment such as bulldozers, and essential staff training (institutional improvements are discussed in detail in Chapter 11).

The improvement plan will be implemented by undertaking the above activities. These are described in 10.3.1 to 10.3.8. Many of these activities relate to the improvement of the existing disposal site. The layout plan of the proposed improved disposal site is shown in Figure 10-5.

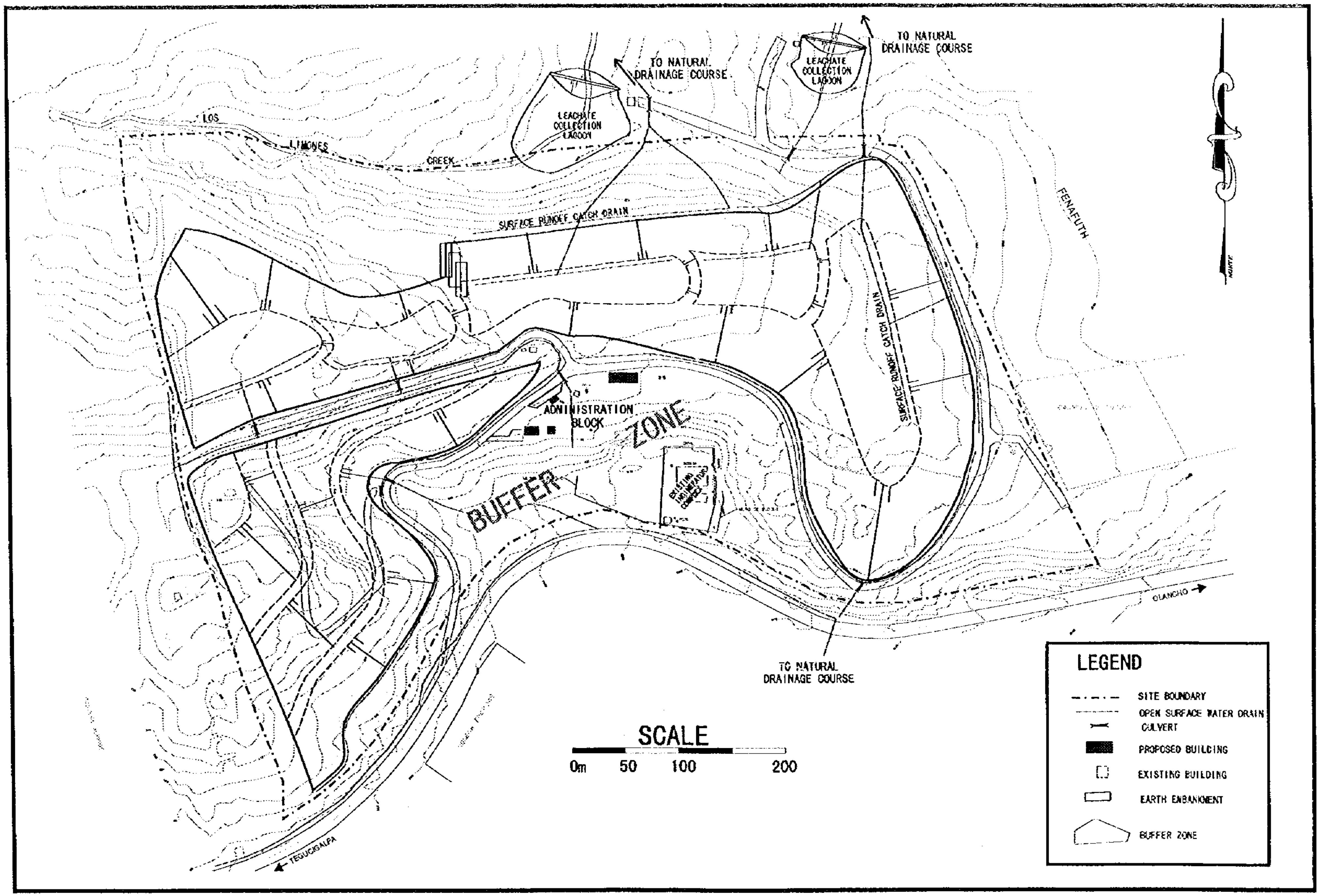


Figure 10-5: Layout Plan of Improved Disposal Site

10.3.1 Control of Disposal Site

To undertake proper landfilling procedures it is essential to first gain control of the site, i.e., control of what enters and exits the site and movements within the site. As described above at the present time there is little control of what is being brought into the disposal site and when it is brought in. Moreover, scavengers, children, and animals freely enter the site doing as they please, obstructing vehicles, spreading waste around the site, and being carriers of disease.

Two methods are proposed to control of the landfill site:

a. **Construction of fence, gates, and sign board at access point.**

b. **Develop rules and system for scavenging**

Regulations were proposed by the study team during the pilot project stage (see section 9.4). These rules were developed with the cooperation of the scavengers and AMDC counterparts.

The regulations 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 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.

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

10.3.2 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.

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. 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 10-6, below.

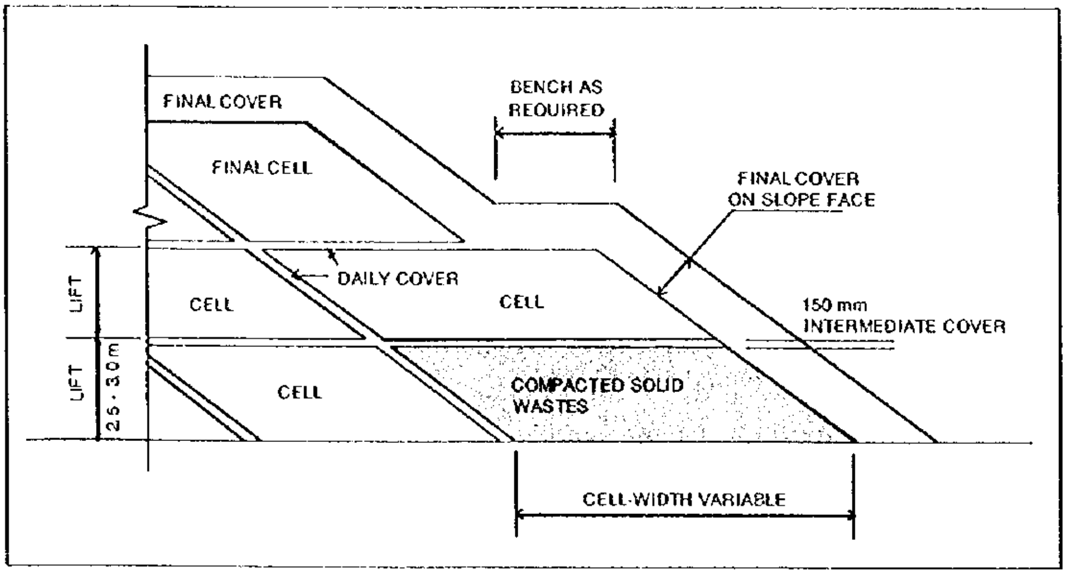


Figure 10-6: Landfill Cells

a.2. Landfilling Procedure

Continual filling using the cell method will result in the formation of waste hills. 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 (see Figure 10-5).

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.

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.

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.

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 with Soil

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 borrow areas A_1 and A_2.

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 10-4). This mix is also proposed for the final cover layer and internal roads.

Table 10-4: Characteristics of 50/50 soil mixture

Property	Value
Standard Proctor Test	1,631 kg/m³
Optimum moisture	19.4 %
USCS Percentages	
Gravel	41 %
Sand	46 %
Fines	13 %
Permeability Coefficient (k)	3.8×10^{-3} to 1.4×10^{-5} cm/sec

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 (75 x 75mm verticals and 50 x 50 mm laterals) and chicken wire, and fill with cobbles (see Figure 10-7).

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

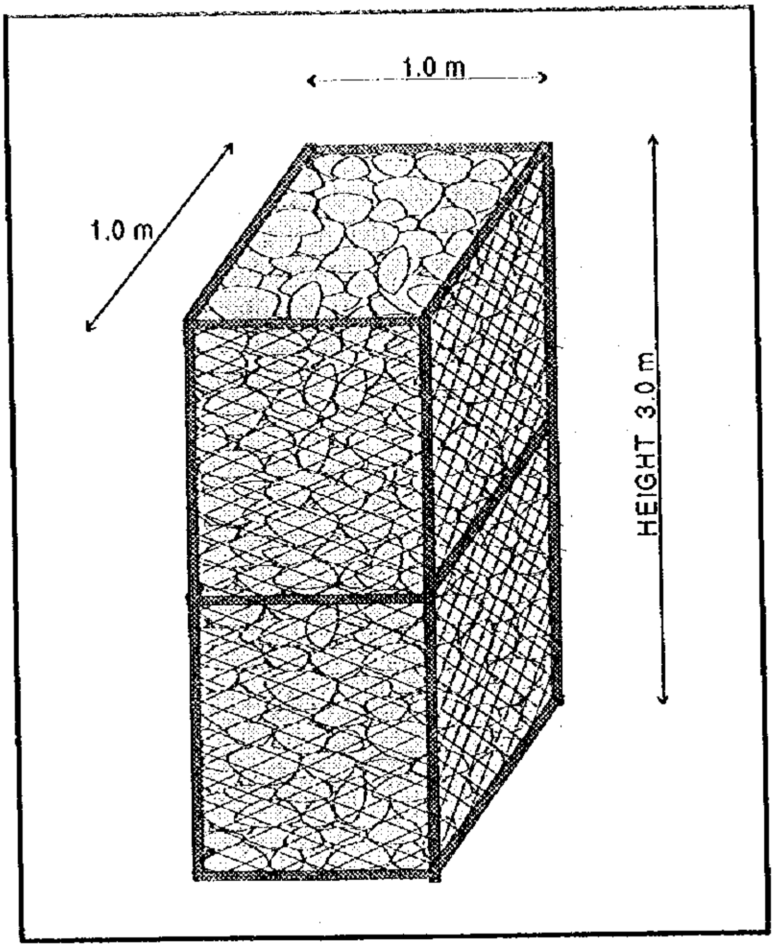


Figure 10-7: Gas Vent

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.

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
Lateral gradient	2 %
Maximum longitudinal incline	15%
Surface material	Well graded, well compacted material, 50/50[4] mix

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 whereever 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 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 it was proposed 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. It is proposed to make compost at the site from organic waste material disposed at the site.

Finally a minimum grade of the final cover layer of 2% is necessary to promote surface water runoff and a maximum grade of 33 % (1:3) 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 (if it becomes available) while the existing disposal site is being filled.

[4] 50% volcanic ash and 50% weathered rhyolite

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. Drains should be positioned at the top slope and along terraces in order to be effective.

To maximize runoff all areas within the landfill must be graded at no less than 2 %. Embankments should be no more than 1 in 3.

i. Landfill Equipment

Major equipment necessary for landfilling activities is shown in Table 10-5.

Table 10-5: Landfill Equipment

	NECESSARY MAJOR EQUIPMENT												
Equipment	Exist	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 number purchased

10.3.3 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 are shown in Figure 10-5.

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 A1.

10.3.4 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.

10.3.5 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
- To prohibit overtaking paint double lines on the road 300 meters in both directions (total 600 meters) from the entrance.

10.3.6 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

b. Administration Block

The administration block is proposed to (see Figure 10-8) include:

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

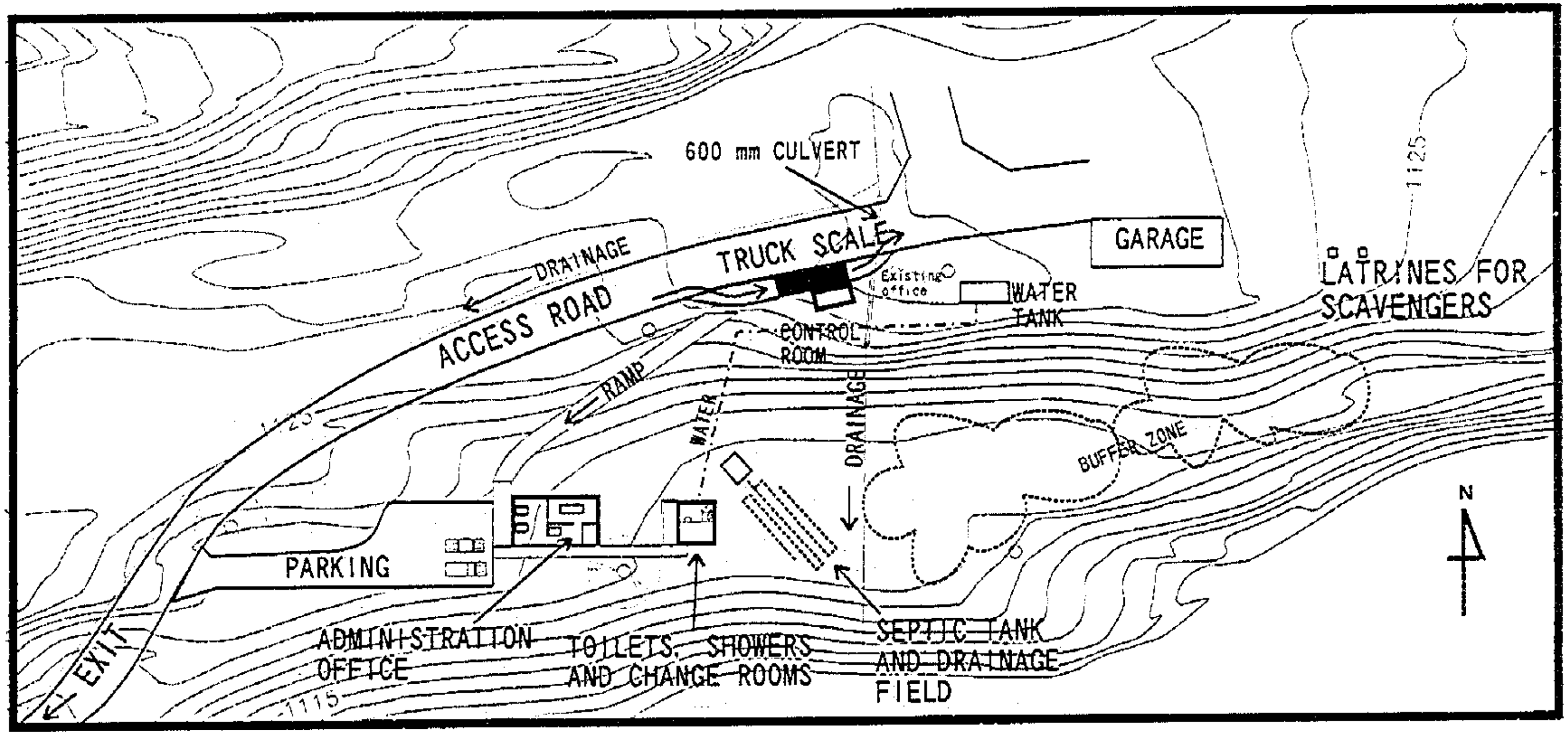


Figure 10-8: Proposed Layout of Administration Block

c. Maintenance of Civil Works

Periodically maintenance of civil works should be carried out by landfill staff. This includes the cleaning drains, carrying out repairs to security and waste fences and other structures around the site, cleaning of water and sewage facilities.

10.3.7 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) 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. As well as from wells and springs where ground water comes out of the ground.

10.3.8 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.

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.

These elements must be addressed in a landfill closure plan:

- Establishment of the final cover layer
- Surface water drainage
- Control of landfill gases
- Control of leachate
- Environmental monitoring

10.4 Possible Environmental Effects

10.4.1 Environmental Impact of Improvement Activities

The impact of improving the landfill operations will be mainly 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 passing motorists. 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 (see Table 10-6).

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 10-6: 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	-

10.5 Disposal of Waste Beyond 2006

10.5.1 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 who share a boundary with the FENAFUTH land can be gained.

Landfilling is proposed using the same methods that are proposed for the existing disposal site. 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.

Chapter 11

Improvement of Collection and Haulage System

11 Improvement of Collection and Haulage System

11.1 Design Condition

a. Average Haulage Distance to the Disposal Site

Although the distance from the city center to the existing disposal site is 6.5 km, the distance from the gravity center of the collection area to the existing disposal site is quite difficult to be determined due to undulating topography. In addition, the location of the future disposal site to be used after 2006 has not been decided. Therefore, the average haulage distance has to be assumed for the feasibility study.

The average haulage distances are assumed as follows.

- For compactor trucks and dump trucks: 30 km
- For container trucks: 36 km

b. Targets

Table 11-1 shows Targets for the Improvement of the Collection and Haulage System in Priority Projects.

Figure 11-1 shows the serviced population by the priority project.

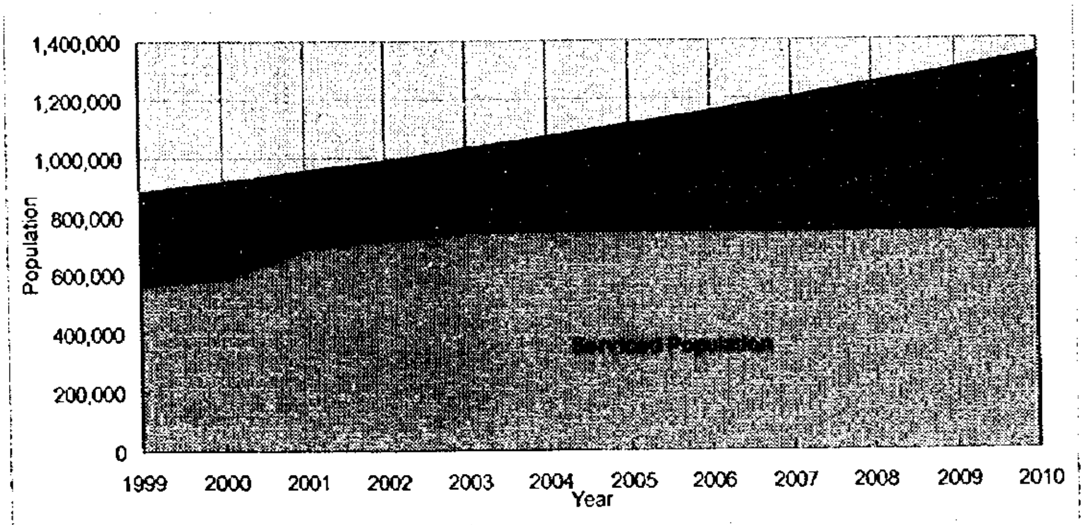


Figure 11-1: Serviced Population by the Priority Project

11 Improvement of [illegible]

11.1 Design Conditi[illegible]

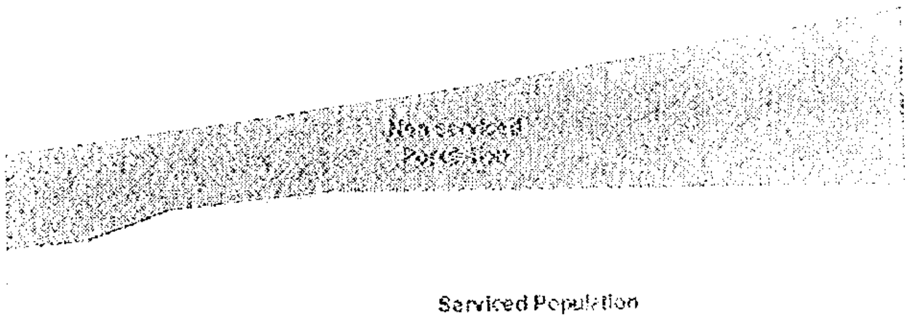


Table 11-1: Targets for the Improvement of the Collection and Haulage System in Priority Projects

Items	unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Collection Rate	%	64%	64%	64%	72%	72%	72%	70%	67%	64%	62%	60%	57%	55%
Recycling Rate	%	3%	3%	3%	4%	4%	4%	4%	4%	4%	4%	5%	5%	5%
Street Swept Length	km	180	180	180	180	190	190	190	200	210	220	230	240	250
Final Disposal														
1. Waste Generation Amount		**481**	**514**	**550**	**586**	**626**	**667**	**691**	**718**	**745**	**774**	**803**	**834**	**865**
Residential Waste	t/d	318	342	367	392	419	447	464	481	499	517	536	556	577
Non-residential Waste	t/d	134	144	155	166	177	190	197	205	213	222	230	239	249
Street Sweeping Waste	t/d	28	28	28	28	30	30	30	32	33	35	36	38	40
2. Waste Collection Amount	t/d	**309**	**330**	**352**	**422**	**451**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**
Collection of Residential Waste	t/d	213	229	246	294	314	336	336	336	336	336	336	336	336
Collection of Non-Residential Waste	t/d	67	72	77	99	106	114	114	114	114	114	114	114	114
Collection of Street Sweeping Waste	t/d	28	28	28	28	30	30	30	30	30	30	30	30	30
Direct Haulage	t/d	27	29	31	33	35	38	38	38	38	38	38	38	38
On-site Disposal	t/d	19	21	22	24	25	27	27	27	27	27	27	27	27
Recycling	t/d	0	7	8	10	10	11	11	11	11	11	11	11	11
Uncollected	t/d	-126	-128	-137	-98	-104	-111	-135	-162	-189	-218	-247	-278	-309
3. Service Rate	%	**64%**	**64%**	**64%**	**72%**	**72%**	**72%**	**70%**	**67%**	**64%**	**62%**	**60%**	**57%**	**55%**
High Income Residents	%	90%	90%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Middle Income Residents	%	70%	70%	70%	80%	80%	80%	90%	90%	90%	90%	93%	93%	93%
Low Income Residents	%	50%	50%	50%	55%	55%	55%	60%	60%	60%	60%	70%	70%	70%
4. Service Population														
4.1 Service Population	t/d	**543,270**	**565,568**	**588,781**	**685,868**	**714,392**	**744,099**	**744,099**	**744,099**	**744,099**	**744,099**	**744,099**	**744,099**	**744,099**
High Income Residents	t/d	152,795	154,848	156,825	176,353	178,350	180,232	180,232	180,232	180,232	180,232	180,232	180,232	180,232
Middle Income Residents	t/d	178,260	194,552	211,851	263,099	285,360	308,969	308,969	308,969	308,969	308,969	308,969	308,969	308,969
Low Income Residents	t/d	212,215	216,169	220,105	246,417	250,681	254,899	254,899	254,899	254,899	254,899	254,899	254,899	254,899
4.2 Unserviced Population	t/d	**305,589**	**316,754**	**328,323**	**267,389**	**276,443**	**285,796**	**326,396**	**368,596**	**412,459**	**458,052**	**505,442**	**554,700**	**605,901**
High Income Residents	t/d	16,977	17,205	17,425	0	0	0	1,753	3,363	4,818	6,102	7,200	8,094	8,768
Middle Income Residents	t/d	76,397	83,379	90,793	65,775	71,340	77,242	108,525	141,673	176,786	213,967	253,325	294,973	339,032
Low Income Residents	t/d	212,215	216,169	220,105	201,614	205,103	208,554	216,119	223,560	230,855	237,983	244,917	251,633	258,101
5. Final Disposal Amount	t/d	353	11	358	383	455	486	517	517	517	517	517	517	517
Municipal Waste	t/d	343	1	347	370	442	472	503	503	503	503	503	503	503
Others	t/d	10	11	12	12	13	14	14	14	14	14	14	14	14

11.2 Productivity of Collection Equipment

a. Productivity of Refuse Collection Vehicles

This section compares seven different waste collection trucks in terms of unit collection cost.

a.1 Equation for Calculating Productivity

The following equations were adopted for calculating productivity.

$$Tr = \frac{60 \times t1 - t2 \times E}{D \div V + t3 + t4}$$

Tr: Number of trips per day (trips)
D: Travel distance per trip (km)
V: Velocity of a vehicle (km/h)
t1: Working hours per day (hours)
t2: Time of daily service for inspection and fuelling, etc. (min)
t3: Time of loading waste (min)
t4: Time of unloading waste (min)
E: Work efficiency

$$Qd = q \times d \times f \times Tr$$

Qd: Waste carried per day
q: Volume capacity of a skip container or a tipping truck (m^3)
d: Density of waste when it is being transported (ton/m^3)
f: Work efficiency

a.2 Determination of Waste Collection Truck Productivity

Table 11-2 shows the determination of waste collection trucks' productivity in accordance with the equation shown above.

Table 11-2: Determination of Waste Collection Truck Productivity

Items	unit	Hoist truck	Hoist truck	Armroll truck	Tipper truck	Com-pactor	Com-pactor	Com-pactor
Capacity in weight	t	6	8	10	8	6	10	10
Capacity in volume	m3	5.5	8	10	12	8	15	13
One trip distance	km	36	36	36	30	30	30	30
Velocity of vehicle	km/h	35	35	35	35	35	35	35
Spesific gravity of waste	t/m3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Density of waste when hauled	t/m3	0.2	0.2	0.2	0.3	0.45	0.45	0.45
t1:Working hour	h	7.5	7.5	7.5	7.5	7.5	7.5	7.5
t2:Daily service time	min	30	30	30	30	30	30	30
t3:Loading time per trip	min	5	5	5	120	45	120	120
t4:Unloading time	min	5	5	5	5	5	5	5
E:Working effeciency of haulage		0.9	0.9	0.9	0.9	0.9	0.9	0.9
f:Work effeciency of haulage		0.9	0.9	0.9	0.9	0.9	0.9	0.9
Nos of trips per day	times	5.27	5.27	5.27	2.14	3.73	2.14	2.14
Adjusted Nos of trips per day	times	5.27	5.27	5.27	2.00	3.00	2.00	2.00
Waste carried per trip	t/trip	0.99	1.44	1.80	3.24	3.24	6.08	5.27
Waste carried per day	t/d	5.22	7.59	9.49	6.48	9.72	12.15	10.53
Waste carried per month	t/month	125	182	228	156	233	292	253
Waste carried per year	t/year	1,503	2,186	2,732	1,866	2,799	3,499	3,033

11.3 Cost Comparison of Equipment

In order to select the bast combination of collection equipment, the unit O & M cost was calculated.

15m3 Compactor

Category	Item	unit	Quantity	Unit Rate Lps	Amount Lps/year
Labor	Driver	person/y	1	33,040.00	33,040
	Collector	person/y	4	33,040.00	132,160
Material	Diesel	liters/y	24,185	4.22	102,062
	Lubrication Oil	15%		102,061.98	15,309
	Spare parts	10%		750,181.44	75,018
Repair		5%		750,181.44	37,509
Total					395,098
			Say	(10^3 Lps)	395
Waste amount collected				(tons/year)	3,499
O & M cost per ton				(Lps/ton)	113

8m3 Compactor

Category	Item	unit	Quantity	Unit Rate Lps	Amount Lps/year
Labor	Driver	person/y	1	33,040.00	33,040
	Collector	person/y	3	33,040.00	99,120
Material	Diesel	liters/y	18,347	4.22	77,426
	Lubrication Oil	15%		77,426.33	11,614
	Spare parts	10%		495,119.75	49,512
Repair		5%		495,119.75	24,756
Total					295,468
			Say	(10^3 Lps)	295
Waste amount collected				(tons/year)	2,799
O & M cost per ton				(Lps/ton)	105

12m3 Tipper Truck

Category	Item	unit	Quantity	Unit Rate Lps	Amount Lps/year
Labor	Driver	person/y	1	33,040.00	33,040
	Collector	person/y	5	33,040.00	165,200
Material	Diesel	liters/y	17,059	4.22	71,987
	Lubrication Oil	15%		71,987.29	10,798
	Spare parts	10%		495,119.75	49,512
	Tarpaulin		1	3,000.00	3,000
Repair		5%		495,119.75	24,756
Total					358,293
			Say	(10^3 Lps)	358
Waste amount collected				(tons/year)	1,866
O & M cost per ton				(Lps/ton)	192

5.5m3 Hoist Truck

Category	Item	unit	Quantity	Unit Rate Lps	Amount Lps/year
Labor	Driver	person/y	1	33,040.00	33,040
	Collector	person/y	1	33,040.00	33,040
Material	Diesel	liters/y	17,059	4.22	71,987
	Lubrication Oil	15%		71,987.29	10,798
	Spare parts	10%		495,119.75	49,512
	Tarpaulin		1	3,000.00	3,000
Repair		5%		495,119.75	24,756
Total					226,133
			Say	(10^3 Lps)	226
Waste amount collected				(tons/year)	1,503
O & M cost per ton				(Lps/ton)	150

10m3 Armroll Truck

Category	Item	unit	Quantity	Unit Rate Lps	Amount Lps/year	
Labor	Driver	person/y	1	33,040.00		33,040
	Collector	person/y	1	33,040.00		33,040
Material	Diesel	liters/y	18,347	4.22		77,426
	Lubrication Oil	15%		77,426.33		11,614
	Spare parts	10%		630,152.41		63,015
	Tarpaulin		1	3,000.00		3,000
Repair		5%		630,152.41		31,508
Total					252,643	
			Say	(10^3 Lps)		253
Waste amount collected				(tons/year)		2,732
O & M cost per ton				(Lps/ton)		93

Maintenance Cost for Containers			
5.5m3 Container	5% of Basic Price	16.80	th Lps/year
10m3 Container	5% of Basic Price	39.20	th Lps/year

11.4 Planning of Collection Equipment

a. Proposed Collection Equipment

The following waste collection equipment were selected by taking the result of Chapter 5 and the unit O & M calculated.

Table 11-3: Proposed Collection and Haulage Equipment

Type of equipment	Area
15 m^3 compactor	high and middle income residential areas,
13 m^3 compactor	high and middle income residential areas,
8 m^3 compactor	old city center
12 m^3 dump truck	low income residential areas
5.5 m^3 container truck	marginal areas, collection station for street sweeping waste
10 m^3 container truck	marginal areas, collection station for street sweeping waste
6 m^3 leased truck	low income residential areas, adjustment for required number of equipment

b. Plan of Expanding the Private Sector's Involvement to Collection Work

The concept of work allocation to the public sector's direct operation and the private sector was set up as follows.

Type	Assignment	Examples
Direct Operation	Problematic areas	a) where roads are narrow, traffic is congested and difficult for passing b) where infrastructure, especially roads, is poor
Contracting-out	Standard areas	Standard residential areas

Table 11-4 shows the rate of the direct operation work and the contracting-out work which was supposed for priority project planning.

Table 11-4: Planned Rate of Direct Operation and Contracting Out Works

Category	Items	unit	1999	2000	2001	2002	after 2003
Collection Amount	Direct operation	ton/day	230	252	222	251	280
	Contracting-out	ton/day	100	100	200	200	200
	Total collection amount	ton/day	330	352	422	451	480
Rate	Direct operation	%	70%	72%	53%	56%	58%
	Contracting-out	%	30%	28%	47%	44%	42%

c. Planned Number of Equipment to be Directly Operated

Table 11-5 shows the planned number of equipment to be directly operated by the SWEU or the MCC.

Table 11-5: Planned Number of Equipment to be Directly Operated

Equipment	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15m^3 compactor	11	11	10	10	10	10	10	10	10	10	10	10
13m^3 compactor	9	9	0	0	0	0	0	0	0	0	0	0
8m^3 compactor	0	0	0	0	3	3	3	3	3	3	3	3
12m^3 dump truck	10	10	0	5	5	5	5	5	5	5	5	5
5.5m^3 hoist truck	1	1	0	9	9	9	9	9	9	9	9	9
10m^3 armroll truck	1	1	0	0	9	9	9	9	9	9	9	9
5.5m^3 container	11	11	0	90	90	90	90	90	90	90	90	90
10m^3 container	13	13	0	0	90	90	90	90	90	90	90	90
Rental truck	0	3	29	16	8	8	8	8	8	8	8	8

d. Procurement Schedule of Equipment

Table 11-6 shows the procurement schedule of the waste collection equipment in accordance with the previous schedule.

Table 11-6: Procurement Schedule of the Waste Collection Equipment

units

Equipment	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15m3 compactor		10							10			
8m3 compactor				3							3	
12m3 dump truck			5							5		
5.5m3 hoist truck			9							9		
10m3 armroll truck				9							9	
5.5m3 container			90							90		
10m3 container				90							90	

11.5 Cost Estimation of the Priority Projects

11.5.1 Final Disposal

a. Investment

Table 11-7 shows the investment schedule for the final disposal.

Table 11-7: Investment Schedule for Final Disposal

unit: 1000 Lps

items	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Equipment												
Bulldozer, 210Hp	0	8,884	0	2,961	0	0	0	8,884	0	2,961	0	0
Wheel loader, 150Hp	0	891	0	0	0	0	0	891	0	0	0	0
Dump truck, 10tons	0	1,733	0	0	0	0	0	1,733	0	0	0	0
Water tanker	0	422	0	0	0	0	0	422	0	0	0	0
Pickup	0	234	0	0	0	0	0	234	0	0	0	0
Facilities Improvement	6,332	1,128	1,158	808	1,403	2,458	1,620	1,879	1,614	1,562	1,628	1,617

b. O & M Cost

Table 11-8 shows the required O & M cost for final disposal. The required O & M cost after 2003 will be constant.

Table 11-8: O & M Cost for Final Disposal

unit: 1000 Lps

Category	Items	1999	2000	2001	2002	after 2003 annually
Diesel	Bulldozer, 210Hp	726	726	726	726	968
	Wheel loader, 150Hp	145	145	145	145	145
	Dump truck, 10tons	145	145	145	145	145
	Water tanker	0	19	19	19	19
	Pickup	0	19	19	19	19
Lubricant	15% of diesel	152	158	158	158	195
Spareparts	10% of basic price	921	973	973	973	1,210
Repair	5% of basic price	460	487	487	487	605
Labor	Manager	132	132	132	132	132
	Assistant Manager	116	116	231	231	231
	Operator	231	297	297	297	330
	Truckscale operator	66	66	66	66	66
	Worker	330	330	330	396	396
	Security guards	99	99	99	99	99
	total	3,525	3,714	3,830	3,896	4,563
Miscellaneous	10% of direct O&M cost	352	371	383	390	456
Rental	Motor grader	120	120	120	120	120
Total O&M		3,997	4,205	4,333	4,405	5,139

11.5.2 Collection and Haulage

a. Investment Schedule of Equipment

Table 11-9 shows the investment schedule for waste collection equipment

Table 11-9: Investment Schedule for Waste Collection Equipment

unit: 1000Lps

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
15m3 compactor		10,503	0	0	0	0	0	0	10,503	0	0	0
8m3 compactor		0	0	2,080	0	0	0	0	0	0	2,080	0
12m3 dump truck		0	3,466	0	0	0	0	0	0	3,466	0	0
8m3 hoist truck		0	6,239	0	0	0	0	0	0	6,239	0	0
10m3 armroll truck		0	0	7,940	0	0	0	0	0	0	7,940	0
5.5m3 container		0	1,512	0	0	0	0	0	0	1,512	0	0
10m3 container		0	0	3,528	0	0	0	0	0	0	3,528	0
Total		10,503	11,216	13,547	0	0	0	0	10,503	11,216	13,547	0

b. Operation and Maintenance Cost

Table 11-10 shows the required cost for operation and maintenance. This table contains the required cost for the contracting-out work.

Table 11-10: Required Cost for Operation and Maintenance

unit:1000 Lps

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Direct Operation												
15m3 compactor	4,345	4,345	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950	3,950
13m3 compactor	4,230	4,230	0	0	0	0	0	0	0	0	0	0
8m3 compactor	0	0	0	0	885	885	885	885	885	885	885	885
12m3 dump truck	1,074	1,074	0	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790	1,790
6m3 dump truck	0	0										
5.5m3 hoist truck	226	226	0	2,034	2,034	2,034	2,034	2,034	2,034	2,034	2,034	2,034
10m3 armroll truck	253	253	0	0	2,277	2,277	2,277	2,277	2,277	2,277	2,277	2,277
5.5m3 container	9	9	0	76	76	76	76	76	76	76	76	76
10m3 container	25	25	0	0	176	176	176	176	176	176	176	176
Rental truck	0	1,404	13,572	7,488	3,744	3,744	3,744	3,744	3,744	3,744	3,744	3,744
Sub-Total	10,163	11,567	17,522	15,338	14,932	14,932	14,932	14,932	14,932	14,932	14,932	14,932
Contracting out												
Sub-total	10,950	10,950	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900
Total O&M Cost	21,113	22,517	39,422	37,238	36,832	36,832	36,832	36,832	36,832	36,832	36,832	36,832

11.5.3 Overall Cost for the Priority Projects

Table 11-11 shows the whole cost for the priority projects.

Table 11-11: Project Cost Summary of the Priority Projects

unit:1000 Lps

Category	Items	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Collection & Haulage	Investment	0	10,503	11,216	13,547	0	0	0	0	10,503	11,216	13,547	0
	O & M	10,163	11,567	17,522	15,338	14,932	14,932	14,932	14,932	14,932	14,932	14,932	14,932
	Contract out	10,950	10,950	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900	21,900
Street Sweeping	Investment	0	656	0	0	0	0	0	0	656	0	0	0
	O & M	2,840	2,840	3,316	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
	Contract out	6,730	6,730	6,730	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104	7,104
Recycling	Investment	0	0	0	0	0	0	0	0	0	0	0	0
	O & M	0	0	0	0	0	0	0	0	0	0	0	0
Disposal Site	Investment	6,332	12,164	0	2,961	0	0	0	14,043	0	2,961	0	0
	O & M	3,997	5,334	5,491	5,214	6,542	7,597	6,759	5,139	6,753	6,701	6,767	6,756
General Expense	Rate	15%	15%	18%	18%	18%	18%	18%	18%	18%	18%	18%	18%
	OM	2,550	2,961	4,739	4,329	4,495	4,685	4,534	4,243	4,533	4,524	4,536	4,534
Total	Investment	6,332	23,323	11,216	16,509	0	0	0	14,043	11,159	14,178	13,547	0
	O & M	19,550	22,702	31,069	28,381	29,470	30,715	29,725	27,814	29,719	29,657	29,735	29,722
	Contract out	17,680	17,680	28,630	29,004	29,004	29,004	29,004	29,004	29,004	29,004	29,004	29,004
	Total	43,562	63,705	70,915	73,894	58,474	59,719	58,729	70,861	69,882	72,838	72,286	58,726

Chapter 12

Improvement of the Institutional System

12 Improvement of the Institutional System

12.1 Introduction

a. Importance of an Institutional System in SWM

Solid waste management (SWM) stems from a community need; the city's external outlook often leaves a firm impression on both residents and visitors. It differs from other public services because it is an absolute necessity, which must be provided even if the clients make no financial contributions to support it. The service can not be withdrawn or suspended even if beneficiaries do not pay, and as a result the community either benefits or is affected negatively depending on the attitude or degree of participation from the residents.

Resident participation is only possible when the community becomes aware of the importance of living in a clean and healthy environment that will protect their health and the environment. Success will depend on the establishment of a well planned collection service with a broad coverage; frequencies and schedules should be followed with punctuality, and cleanliness of public areas should be maintained with the assistance of the general public. Programs for waste reduction, reuse, and recycling should be implemented and MSW final disposal should be done only at a sanitary landfill where the environment – such as the surrounding water quality, air quality, and soil quality -- is sufficiently protected.

These activities will function smoothly through a modern institutional framework. It will also enable an efficient administration that will lead to the development of a sustainable SWM system.

b. Identification of the Existing Institutional Problems

Tegucigalpa's rapid urban expansion and GDP growth rate, which is expected to be between 6% and 7%, will double the amount of MSW generated over the next decade. This important demand for services will require a new institutional structure that should respond effectively and efficiently to public need.

The institutional model selected should minimize current limitations that prevent the provision of good MSW services in Tegucigalpa. The existing problems observed are listed below.

a) The institution's low hierarchy level within the municipal structure.

b) Weak organizational structure.

c) Limited capacity to make decisions.

d) Slow administrative procedures.

e) Human resources in SWM lack motivation.

f) Large number of clients are not registered for payment.

g) Fees and tariffs do not correspond to the services provided.

h) No reliable accounting records to register revenue and expenditure.

i) The real service cost is unknown.

j) Collection and cleansing routes that are unevenly balanced.

k) Low coverage (80 ton/day of domestic waste are not collected).

l) There is neither punctuality nor order with respect to collection frequencies and schedules.

m) The dumpsite deteriorates the environment and jeopardizes public health.

n) Machinery and equipment are damaged due to lack of maintenance and delays in the supply of spare parts.

o) There are neither objectives nor goals; services are unplanned and undeveloped.

p) There is a lack of control and supervision of those working under contracts.

c. Key Issues to Improve SWM

The evaluation of SWM in the Central District revealed that the most important area for improvement lies in institutional reform. There is an urgent need, therefore, to achieve a sound organizational system to respond to the future demands in SWM and to reach the goal of "beautifying" the Central District. With these in mind, the following should be achieved.

a) An autonomous institution should be established.

b) The technical capacity should be improved for technical, commercial, and financial planning; service costs, service quality, and human resources should also be controlled thoroughly.

c) All clients and recipients that receive this service should be identified and located so that the service can be continuously improved through their active participation.

d) Private sector participation should be encouraged.