



Course on Environmental Risk Control
CEPIS, Lima-Peru, 6-10 June 1994

SMALL (MANUAL) SANITARY LANDFILLS (*)

(Notes on the conference dictated by
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(*) Partially adapted from "Manual for the Design of Sanitary Landfills in Developing Countries". ISWA; Mexico City, Mexico; March 14-16, 1994.

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Pan American Health Organization
Division of Health and Environment
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SMALL (MANUAL) SANITARY LANDFILLS

1. INTRODUCTION

With small operations (up to 20 tons/day), reasonable modifications can be made in the application of the basic principles of landfilling. Reasonable modifications are those that can be made without significantly adverse environmental consequences and detrimental effect on the public health and safety. The ideal should be to adhere as closely as possible to the elements that distinguish sanitary landfilling from open dumping, namely:

- 1) spread and compact incoming wastes
- 2) cover the wastes with a 15-20-cm layer of soil at the end each day
- 3) top completed areas with a final layer of soil to a depth of about one meter
- 4) site and operate the fill such as not to endanger the public health and quality of air and water resources

The manual sanitary landfill is a technically and financially viable alternative for small localities. A manual landfill only requires the use of heavy equipment for site preparation, the construction of internal roads, and excavation of cover material. All other required tasks can be carried out manually. This would allow small communities to share or rent heavy equipment.

1.1. Permissible Modifications

1.1.1. Site Selection

Available sites may be limited because of the probable need to select land that is unusable or minimally usable for essential purposes such as housing, farming (food production), and community facilities. At the minimum, the site should be such that water resources are not endangered in terms of deterioration of water quality. The site should be accessible to collection and transport vehicles of all types – from pushcarts to trucks. Limitations on distance between point of waste generation and site of disposal should reflect this wide latitude of vehicles. In general, site selection should follow the basic principles indicated for sanitary landfills.

In the absence of a natural depression on the site, some excavation will be involved. The dimensions of the excavation should be such as to accommodate the waste output from the community. The amount of soil needed for covering the waste should be extracted through manual or mechanical excavation. Otherwise, the soil should be acquired in sufficient quantities to guarantee continuous operation.

1.1.2. Other Modifications

Other modifications, particularly operational modifications, involve equipment and equipment selection.

Equipment: Even in a developed country, the costs involved in owning and operating a small bulldozer may be too high for a community that disposes of only 20 tons or less per day. The same would be especially true for a community in a developing country. However, if excavation and stockpiling of cover soil are necessary for preparing a site, a piece of heavy equipment may be needed until the excavation and stockpiling are completed. Equipment can be rented from another municipality or from a construction company. Daily operation of the fill, i.e., spreading and compacting solid waste, can be done manually or with the use of a farm tractor equipped with a blade or bucket. Unfortunately, the degree of compaction will not be much, even if the wastes are spread in a thin layer before being compacted. Poorer compaction means a larger fill area requirement.

Equipment Selection: The machine used in a one-machine operation must not only be rugged and able to spread and compact the incoming waste and cover soil, it may also have to be used to excavate trenches and cover material. The preferred type of machine would be a track loader. However, if the machine will be used elsewhere part of the time, a wheeled loader would be more suitable because of its mobility.

Dependability of the machine is a key requirement in a one-machine operation. The reasons are obvious. Dependability is especially essential, if a replacement machine is not

immediately available in case of a breakdown, as would be the case in a developing country.

The operation of a manual landfill requires the equipment shown in Figures 1 to 3. Typical use of the equipment is shown in Figure 4. At the end of the working day, all tools and equipment should be cleaned and repaired. Equipment that cannot be repaired should be substituted immediately.

1.2. Methods

The topography of the site determines the selection of either the area, trench, or combination method. If the trench method is selected, it is advisable that a sufficiently large trench be excavated each time such that it can hold the wastes produced during a 30 day period.

1.3. Access Roads

The sanitary landfill should be accessible by means of a good public, all-weather road. This road should be connected to the working face by means of a simple, well packed road with suitable drainage channels. The internal roads should be carefully planned since they are continually moved and periods of wet weather can cause serious problems. Rainy weather can lead to poor circulation of collection vehicles especially over completed cells since manual compaction cannot achieve high densities. A method that has been used to alleviate this problem is the construction of artificial roads. These roads can be built using boards or trunks to form a plank of about 3 m by 3 m as shown in Figure 5. The trunks should be tied with wire of about 2 to 3 mm in diameter. The planks are then covered with material that would improve traction. The road is built as the fill advances. This allows for re-use of the planks as the location of the road changes.

Drainage of Surface Water: Guidelines for building drainage ditches should follow those presented in Section 6. The ditches can be built manually and should be sized to meet local conditions.

1.4. Construction Method

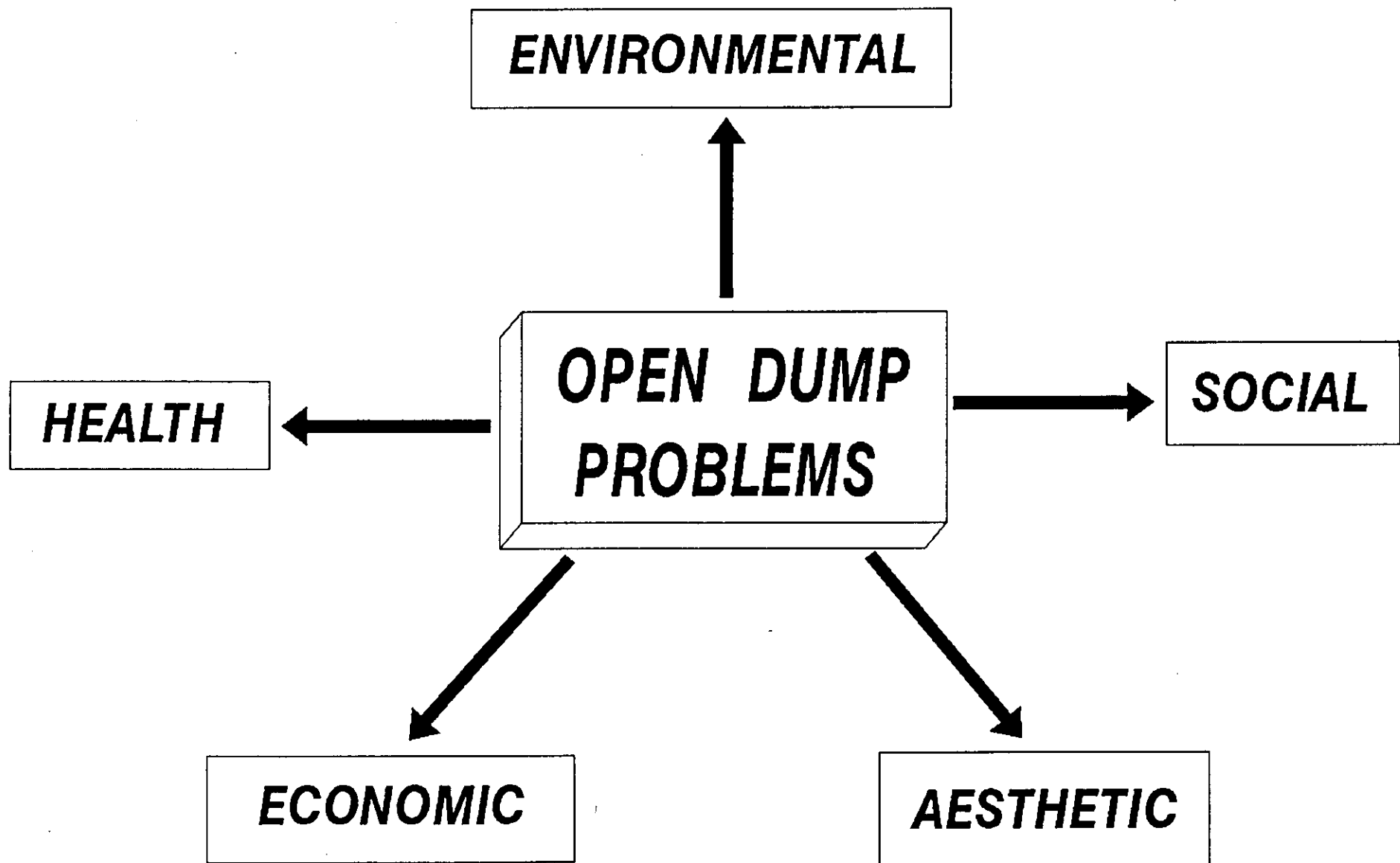
The construction method to be used for a small landfill depends upon the same factors as those indicated in Section 5 of this report. Some of these factors include: topography of the site, characteristics of the soil, and the depth of the groundwater table. The procedures for building a fill using the area method are shown in Figures 6 through 13 and those for the trench methods are shown in Figures 14 through 17. In either case, the solid waste is discharged from the collection vehicle and distributed over the base of the landfill or over a completed cell. The distribution is carried out using rakes or pitchforks into successive layers 20 to 50 cm deep. The surface and sides of the layers should be carefully leveled and the wastes kept against the slope of the site or the finished cell. The wastes are then compacted by means of a hand compactor until the cell is relatively uniform and reaches a height of about 80 cm.

Distribution and compaction of the wastes should be conducted in horizontal layers. The layers should be placed with a slope of 1 to 3. Once finished, the cell is covered with a layer of soil on the order of 15 to 20 cm. The soil can be distributed with wheelbarrows or a small tractor and then compacted as shown in Figures 11 and 17.

Typically, one individual can deal with 10 tons of refuse per day. Thus a municipality that generates 20 tons per day would require two laborers at the landfill. Since these individuals would be in close proximity to the wastes, they should be provided with boots, gloves, and clean clothing (if at all possible). In addition, they should have access to sanitary facilities.

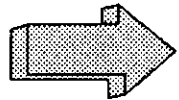
REFERENCES

1. Gobernación de Antioquia, Guía para el Diseño, Construcción, y Operación de Un Relleno Sanitario Manual, Medellín, Columbia, April 1988.
2. Flintoff, F., Management of Solid Wastes in Developing Countries, World Health Organization, 1976.
3. OPS/Programa de Salud Ambiental. Serie Técnica 28 "Guía para el diseño, construcción y operación de rellenos sanitarios manuales". Washington D.C.

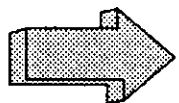


MANUAL (SMALL) SANITARY LANDFILLS

A TECHNICALLY AND FINANCIALLY VIABLE ALTERNATIVE FOR SMALL COMMUNITIES

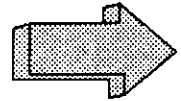


**- WITH SMALL OPERATIONS (UP TO 20 TON/DAY)
REASONABLE MODIFICATIONS CAN BE MADE IN THE
APPLICATION OF THE BASIC PRINCIPLES OF LAND
FILLING**

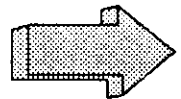


**- THOSE MODIFICATIONS CAN BE MADE WITHOUT
SIGNIFICANTLY ADVERSE ENVIRONMENTAL
CONSEQUENCES AND DETRIMENTAL EFFECT ON THE
PUBLIC HEALTH AND SAFETY**

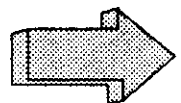
MANUAL (SMALL) SANITARY LANDFILLS



- A MANUAL LANDFILL ONLY REQUIRES THE USE OF HEAVY EQUIPMENT FOR SITE PREPARATION, THE CONSTRUCTION OF INTERNAL ROADS, AND EXCAVATION OF COVER MATERIAL

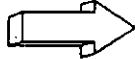
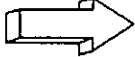

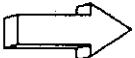
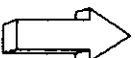
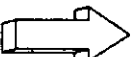
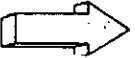


- ALL OTHER REQUIRED TASKS CAN BE CARRIED OUT MANUALLY



- THIS WOULD ALLOW SMALL COMMUNITIES TO SHARE OR RENT HEAVY EQUIPMENT

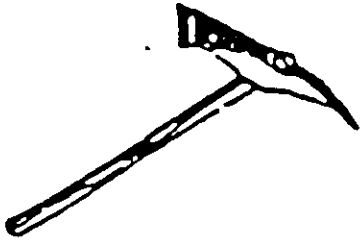
SITE SELECTION CONDITIONS

-  **PREVENTION OF SURFACE OR GROUNDWATER POLLUTION**
-  **EASY ACCESS (ROADS)**
-  **NEAR OF URBAN AREA**
-  **LIFE SPAN > 5 YEARS**
-  **AVAILABILITY OF COVER MATERIAL**
-  **WIND DIRECTION**
-  **LAND PROPERTY**

MANUAL SANITARY LANDFILL BASIC PRINCIPLES

- ✓ **CONSTANT SUPERVISION**
- ✓ **CELL HEIGHT = 1 m (80 cm wastes, 20 cm cover material)**
- ✓ **DAILY COVER**
- ✓ **THICK OF WASTES LAYER = 20 - 30 cm**
- ✓ **FINAL COVER = 60 - 100 cm**
- ✓ **POPULATION \leq 40 000 inhab.**

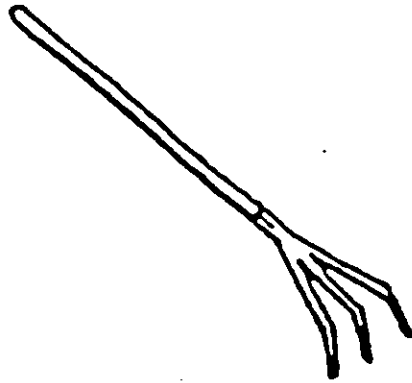
FIGURE 1 TOOLS



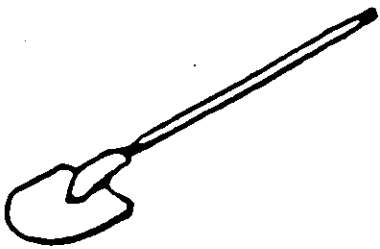
Pick



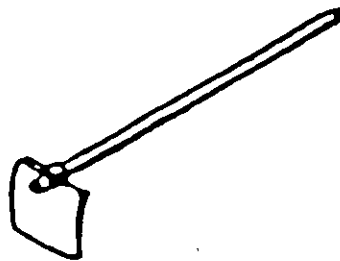
Manual
Compactor



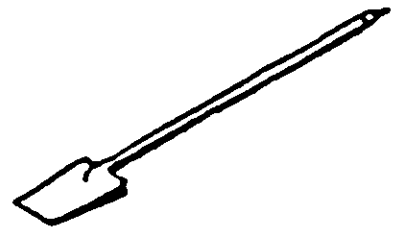
Pitchfork



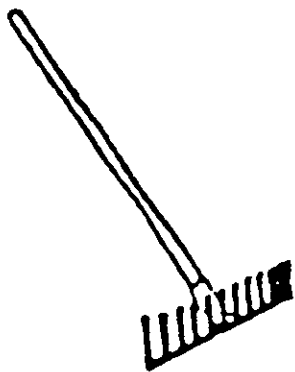
Shovel



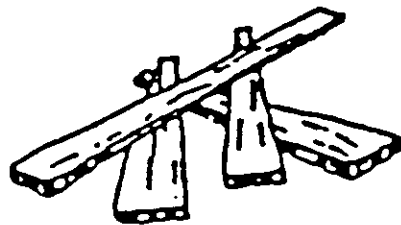
Hoe



Spade



Rake



Planks

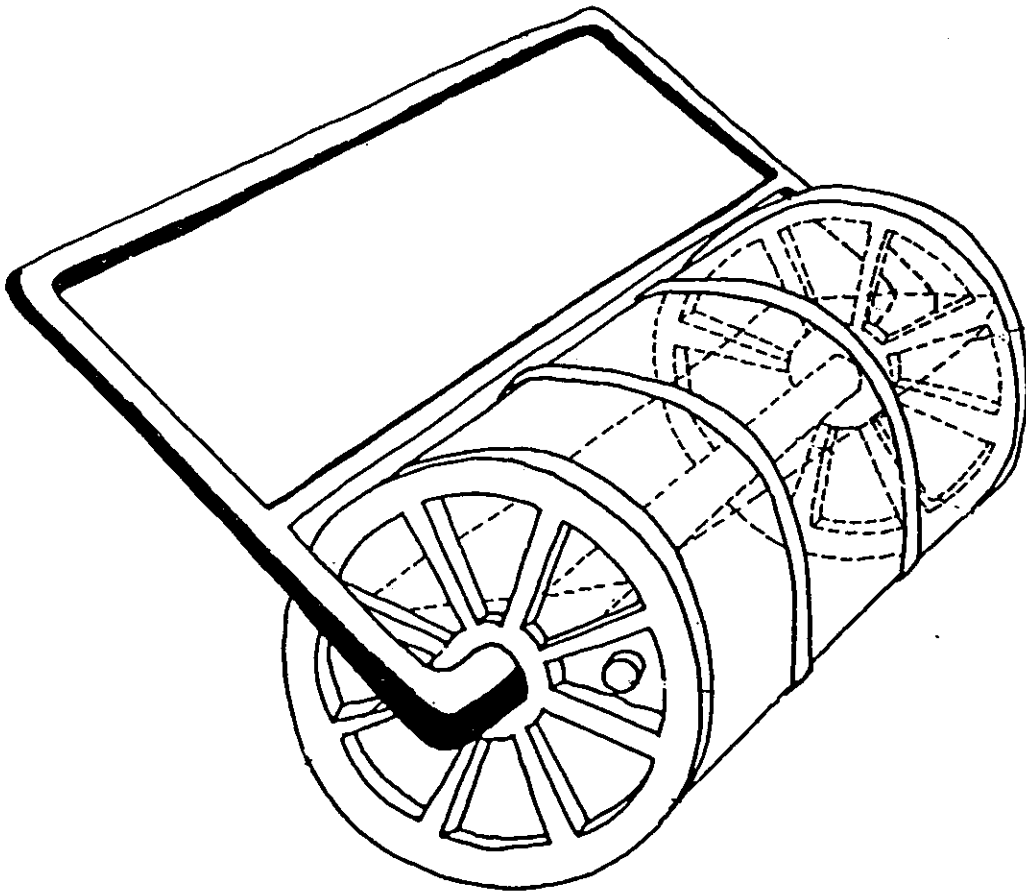


FIGURE 2. RECONDITIONED 55-GALLON DRUM FILLED WITH OIL FOR USE AS A COMPACTOR

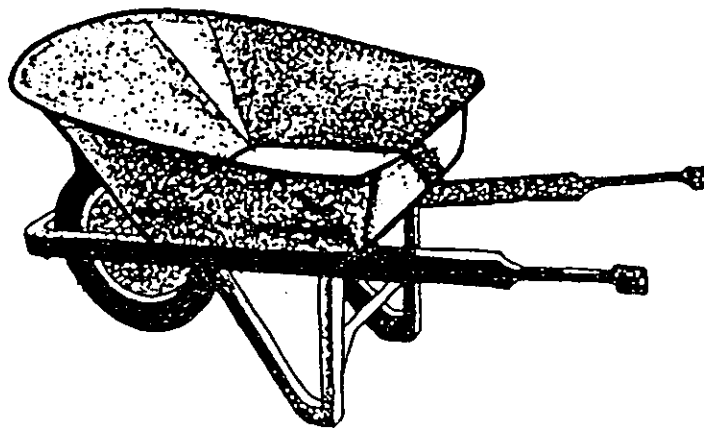


FIGURE 3. WHEELBARROW

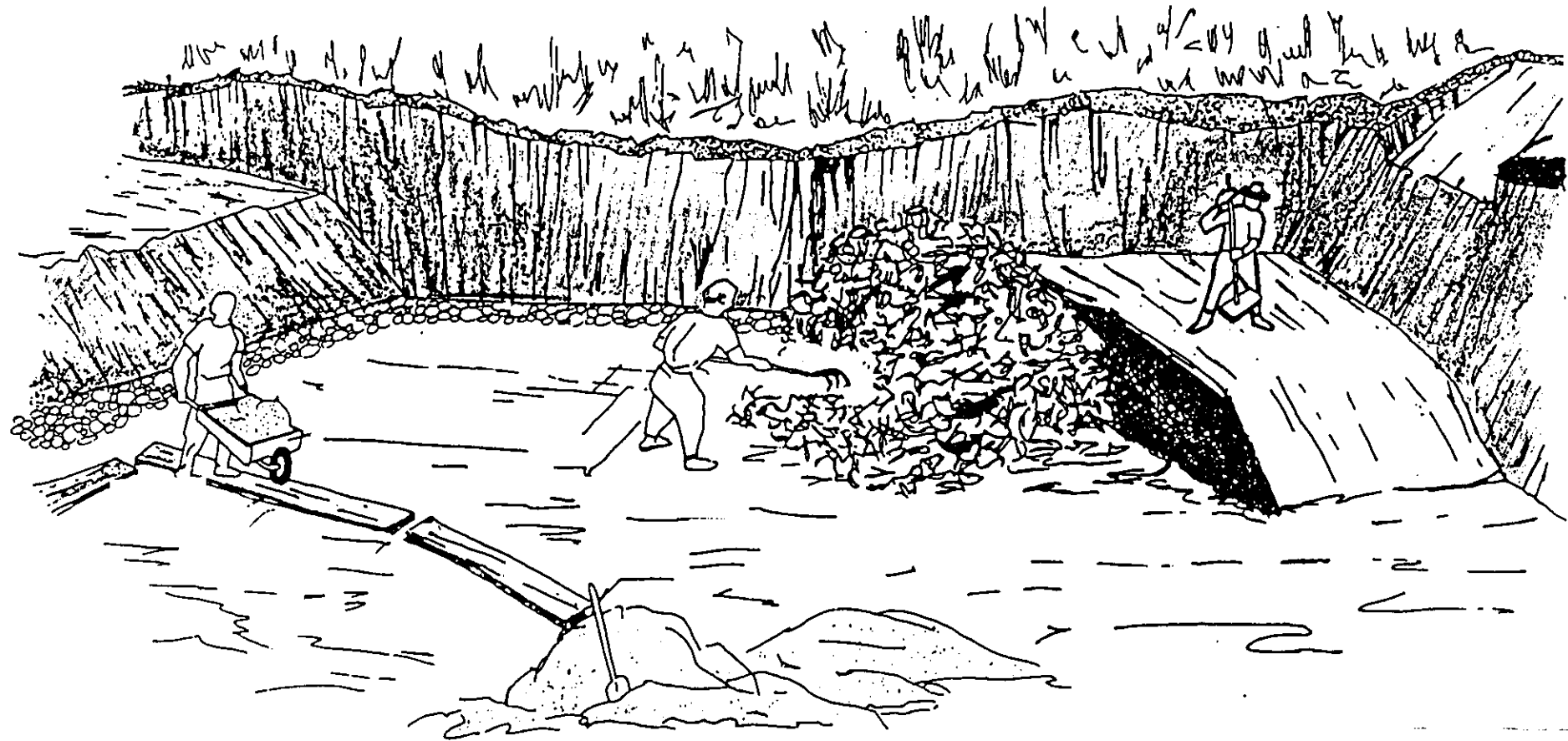
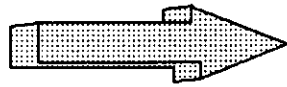
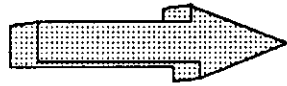


FIGURE 4. EQUIPMENT USE

MANUAL SANITARY LANDFILL OPERATION METHODS :



AREA



TRENCH



COMBINED

A. AREA METHOD

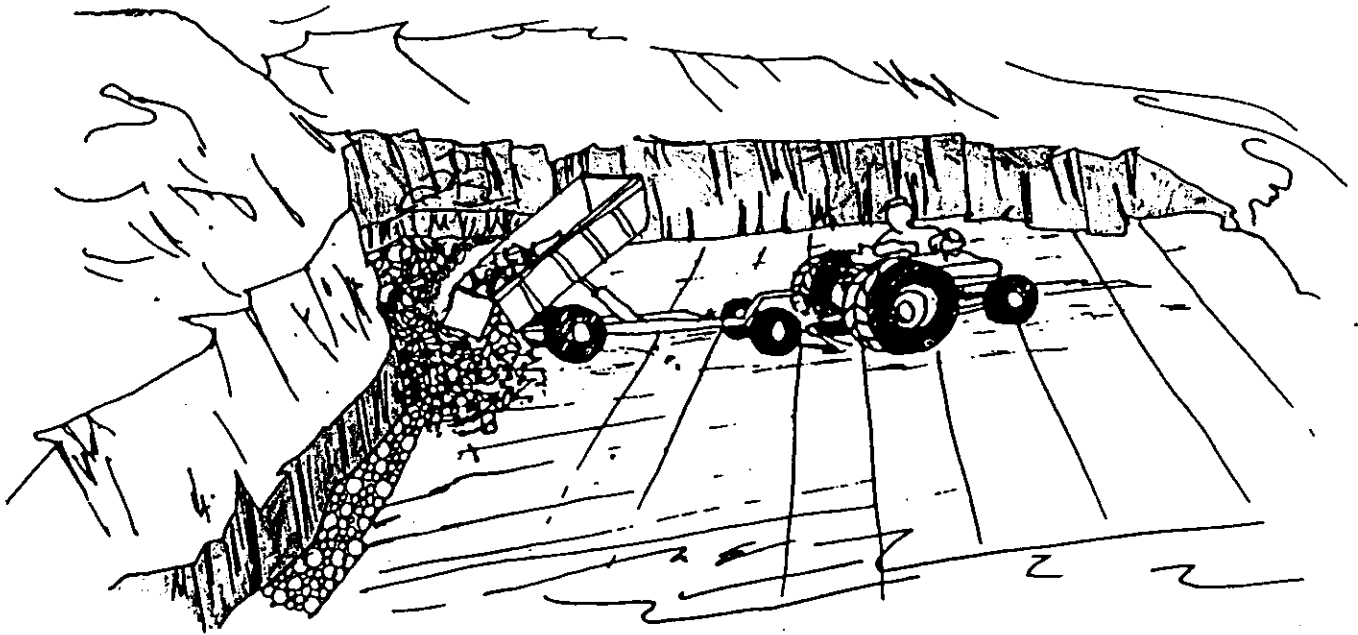


FIGURE A.1 DISCHARGE OF WASTES



FIGURE A.2 DISTRIBUTION OF WASTES



FIGURE A.3 COMPACTION



FIGURE A.4 EXTRACTION OF SOIL FOR COVER



FIGURE A.5 APPLICATION OF COVER

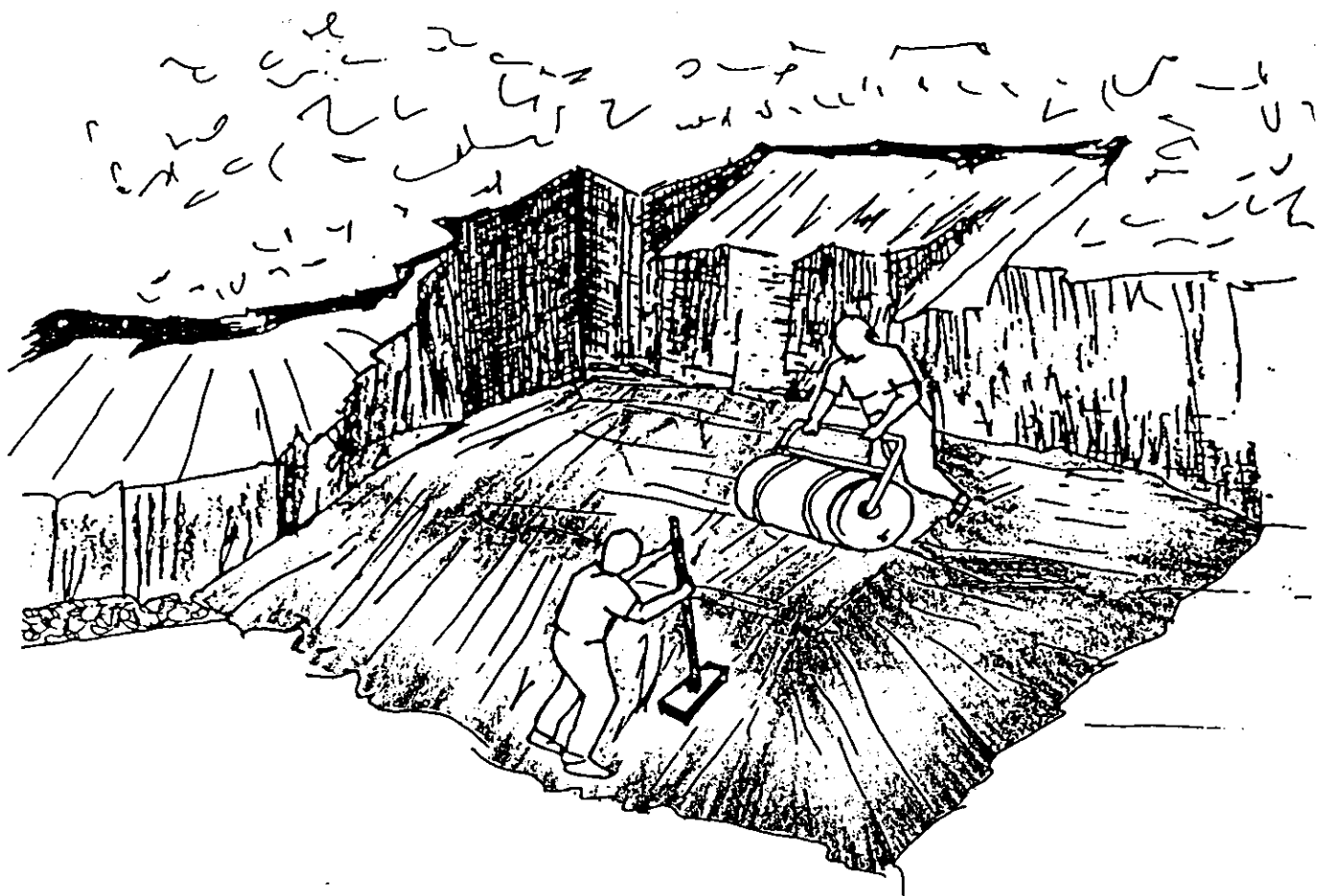


FIGURE A.6 COMPACTION OF A COMPLETED CELL



FIGURE A.7 CONSTRUCTION OF A GAS VENTING SYSTEM

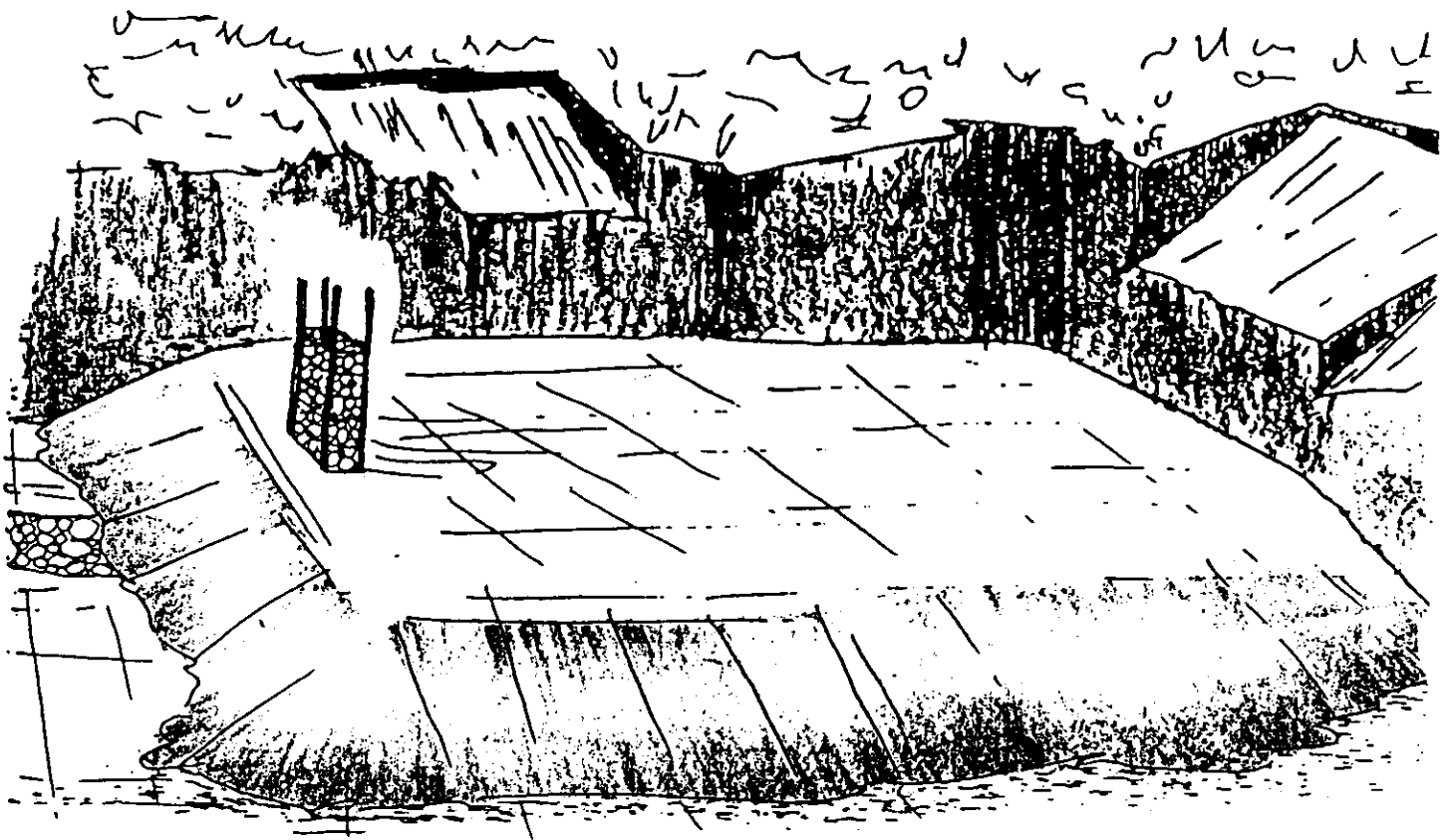


FIGURE A.8 CONSTRUCTION OF A NEW CELL

B. TRENCH METHOD

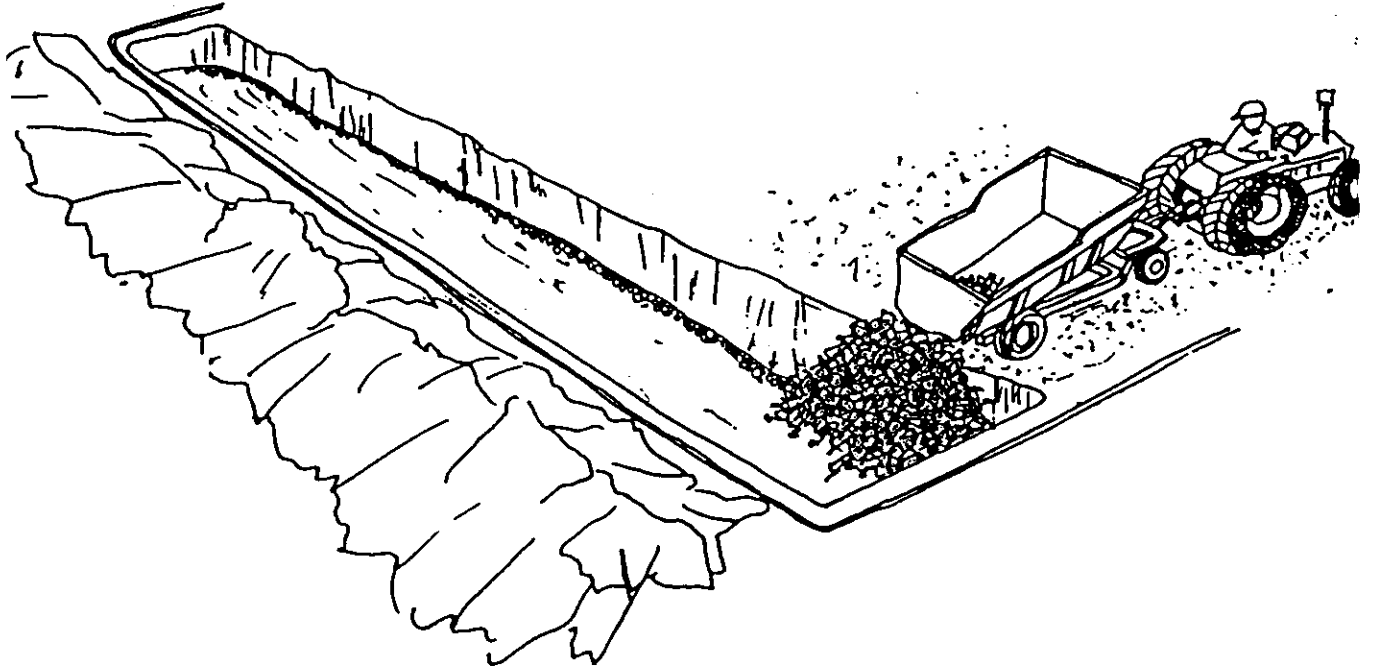


FIGURE B.1 WASTE DISCHARGE

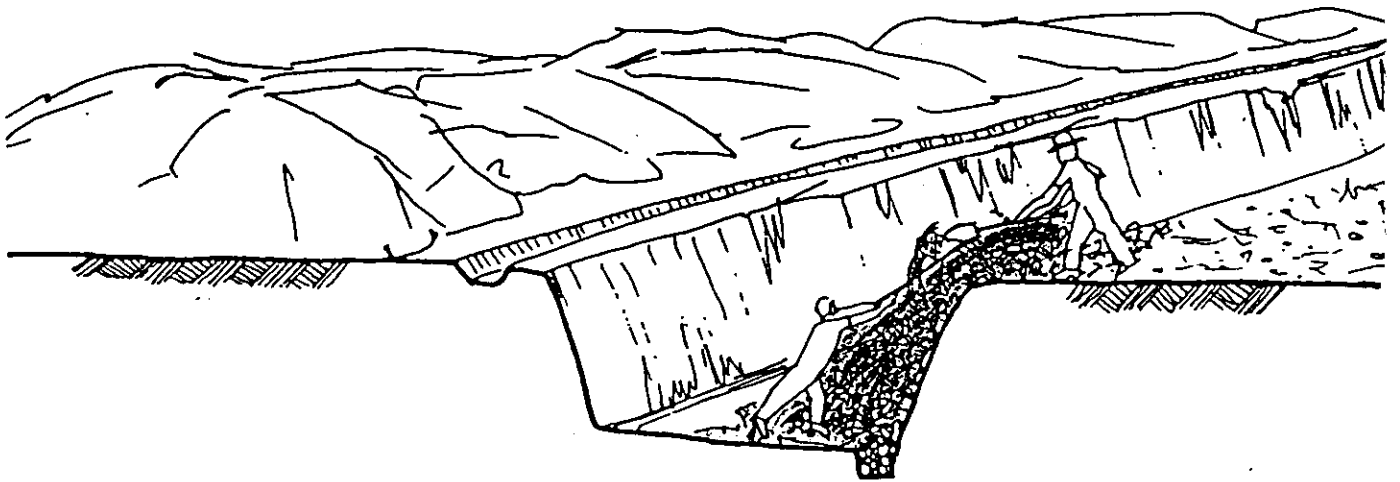


FIGURE B.2 LAYERING OF WASTES

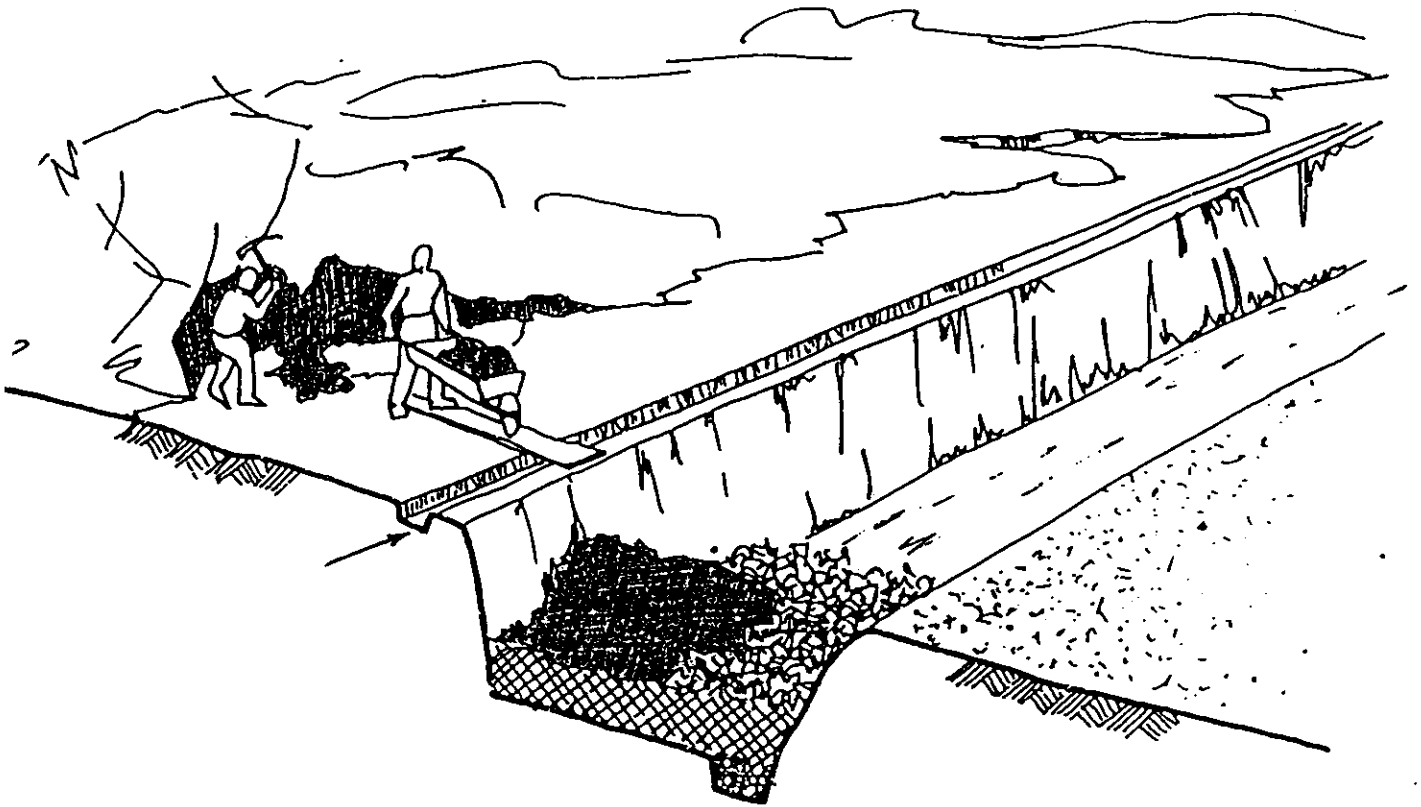


FIGURE B.3 DEVELOPMENT OF CELLS AND APPLICATION OF COVER

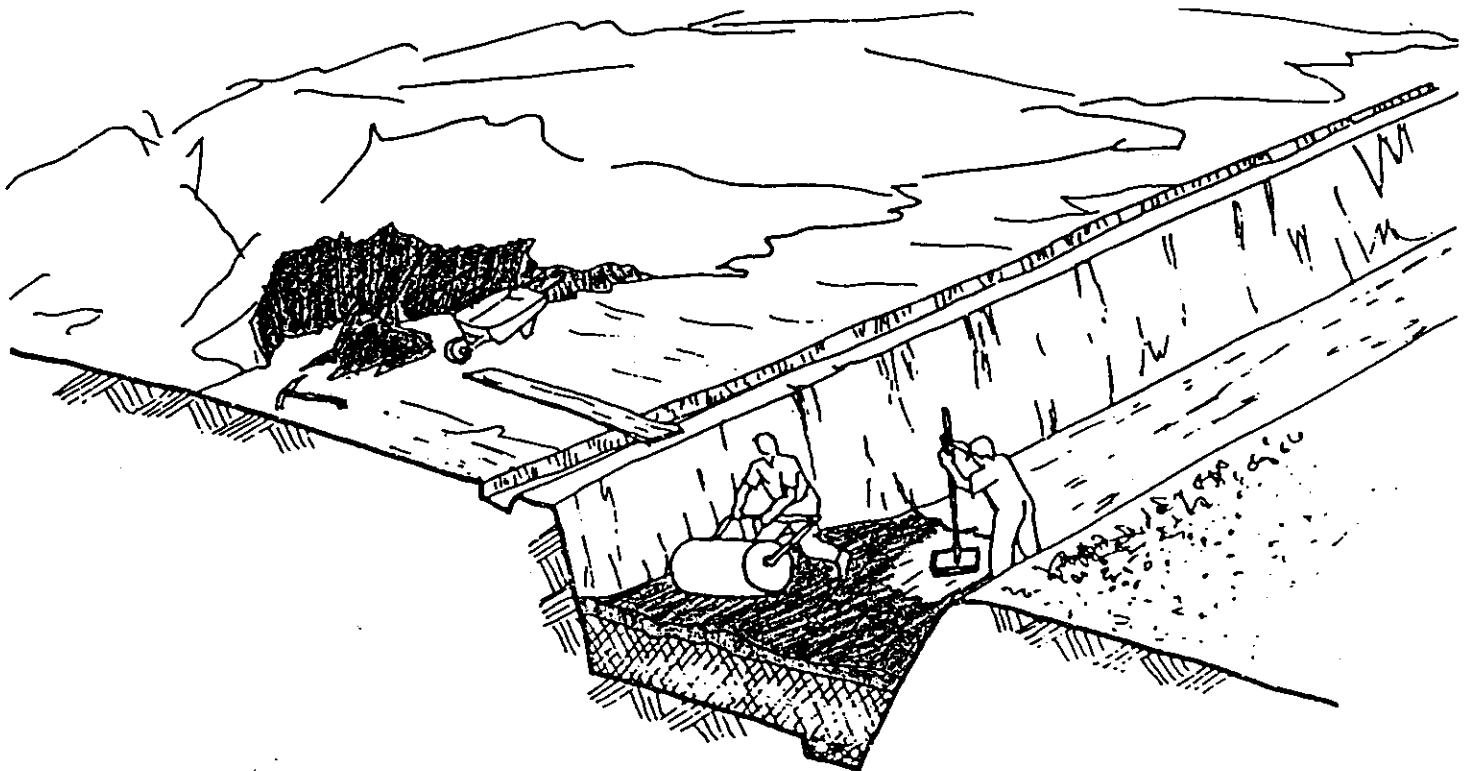
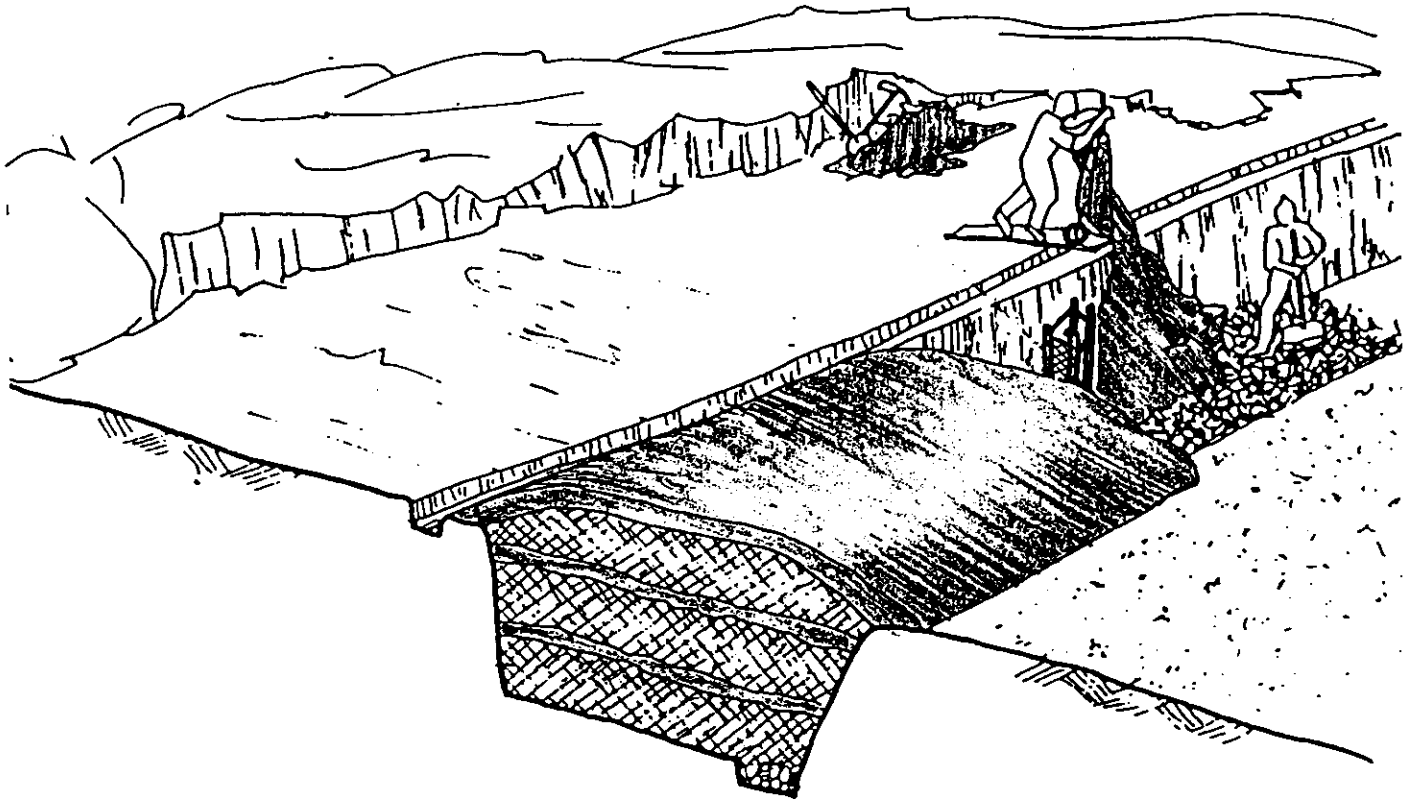
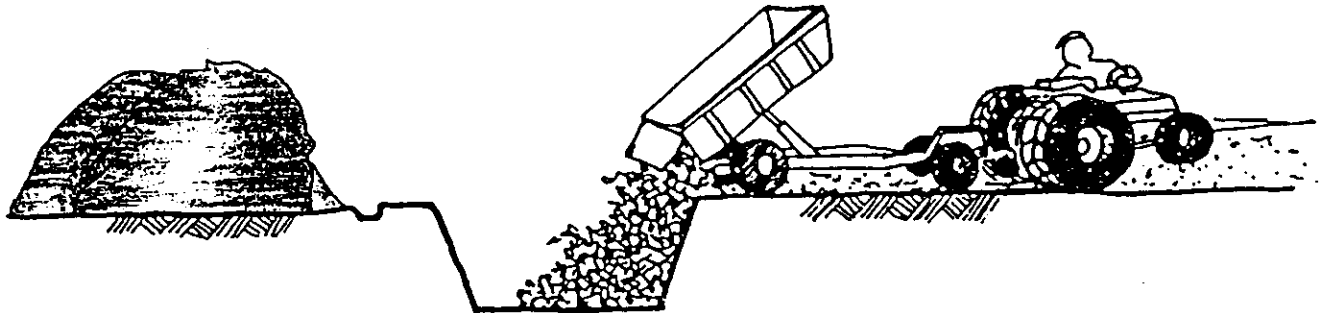


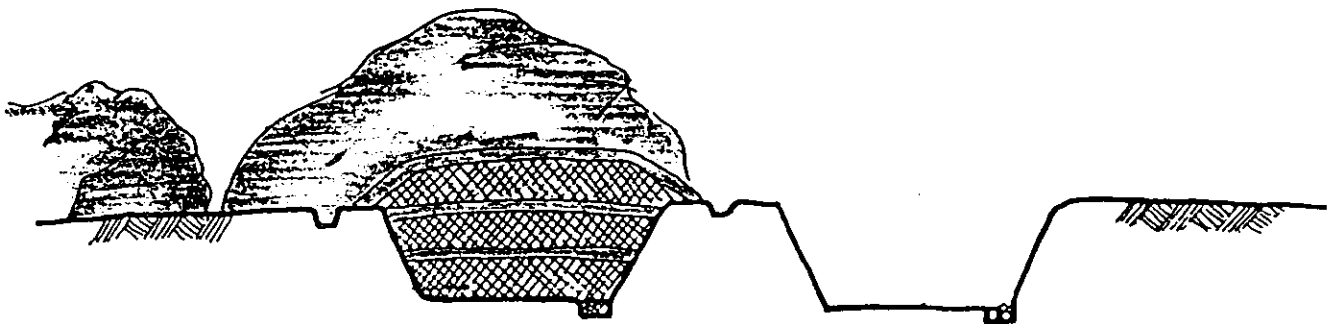
FIGURE B.4 COMPACTION



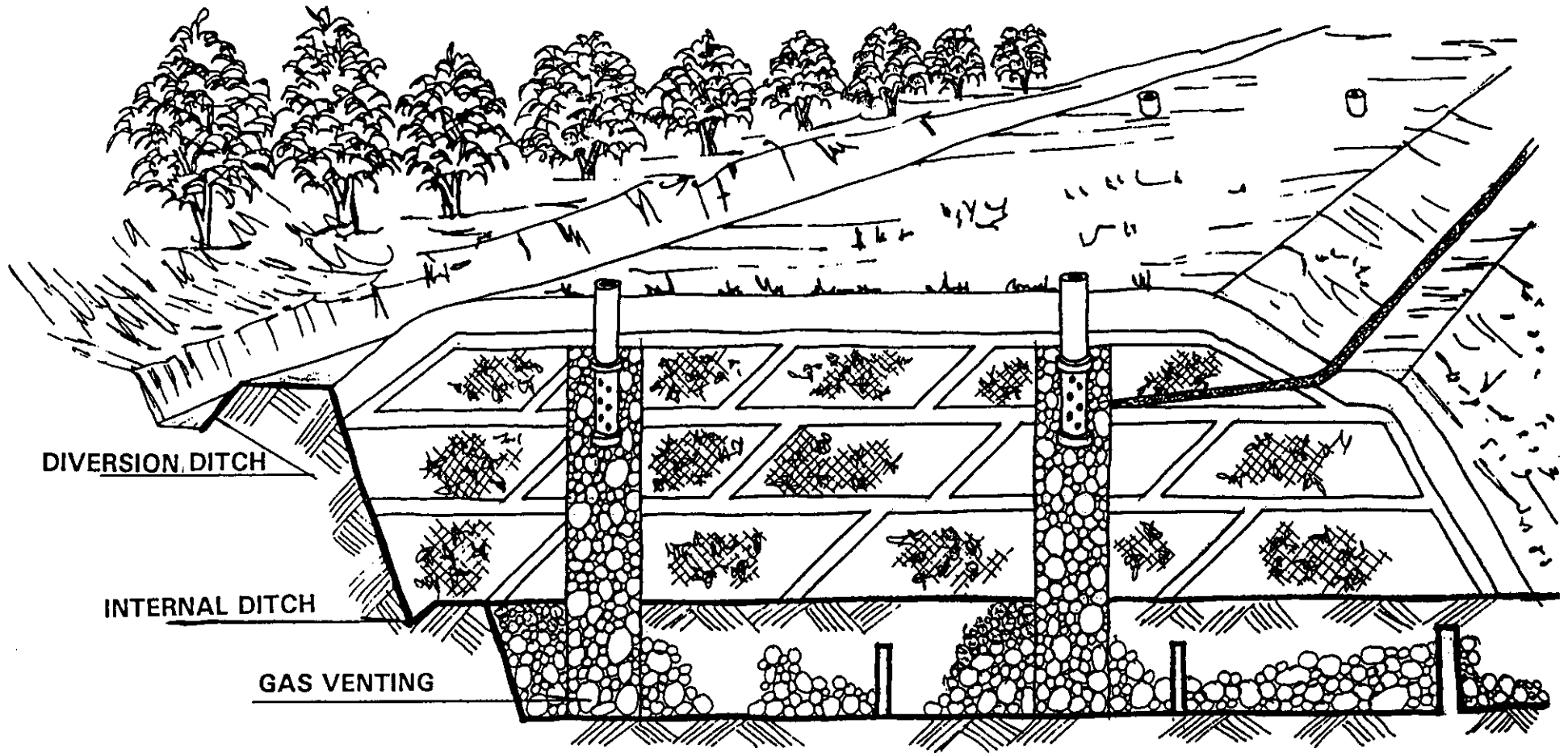
B.5 SANITARY LANDFILL TRENCH METHOD



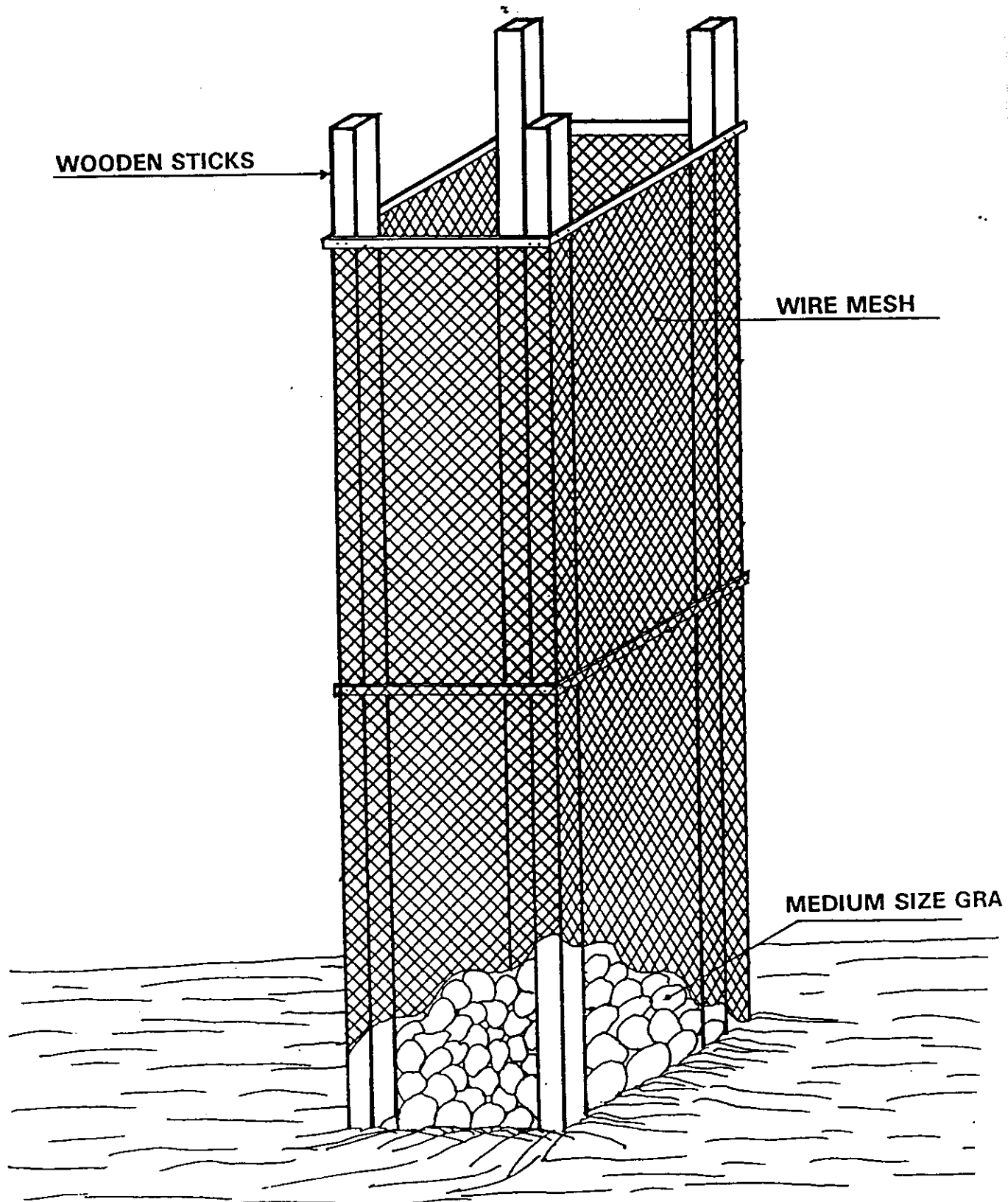
B.6 DISCHARGE OF WASTES INTO THE FIRST TRENCH



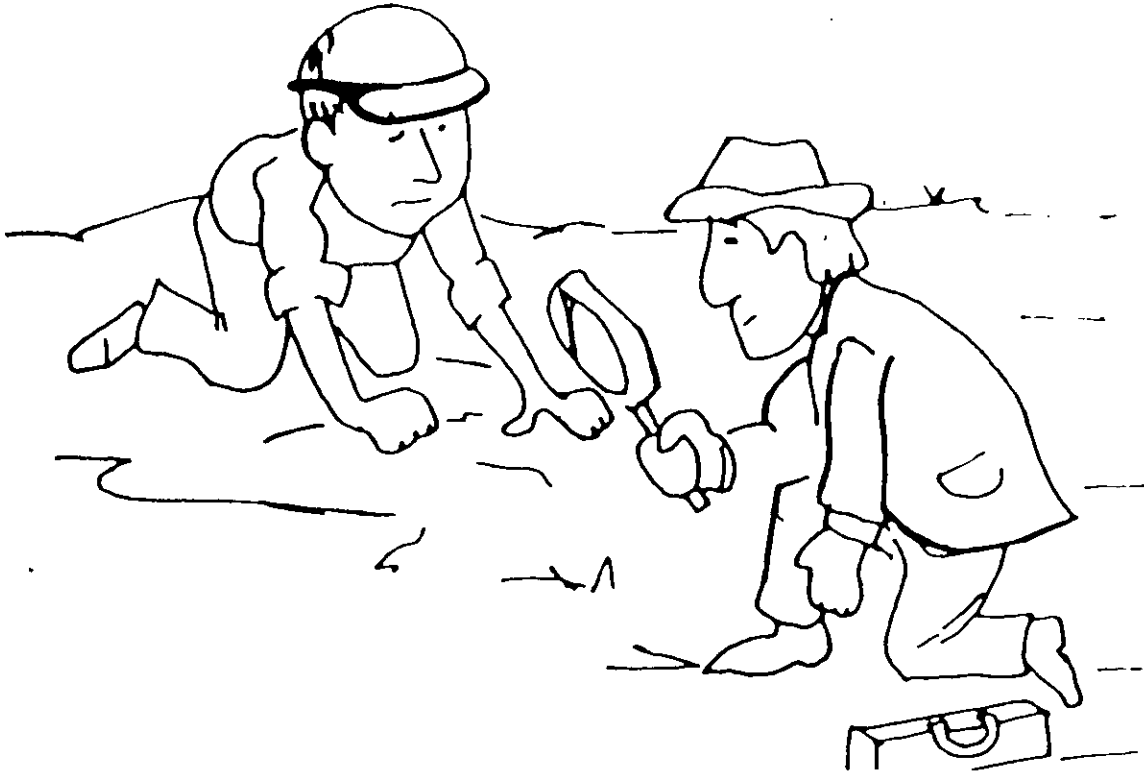
B.7 ACCUMULATED EXCAVATION MATERIAL ON THE COMPLETED TRENCH



GAS VENTING CHIMNEY



***STEPS FOR A
MANUAL
SANITARY
LANDFILL
CONSTRUCTION***



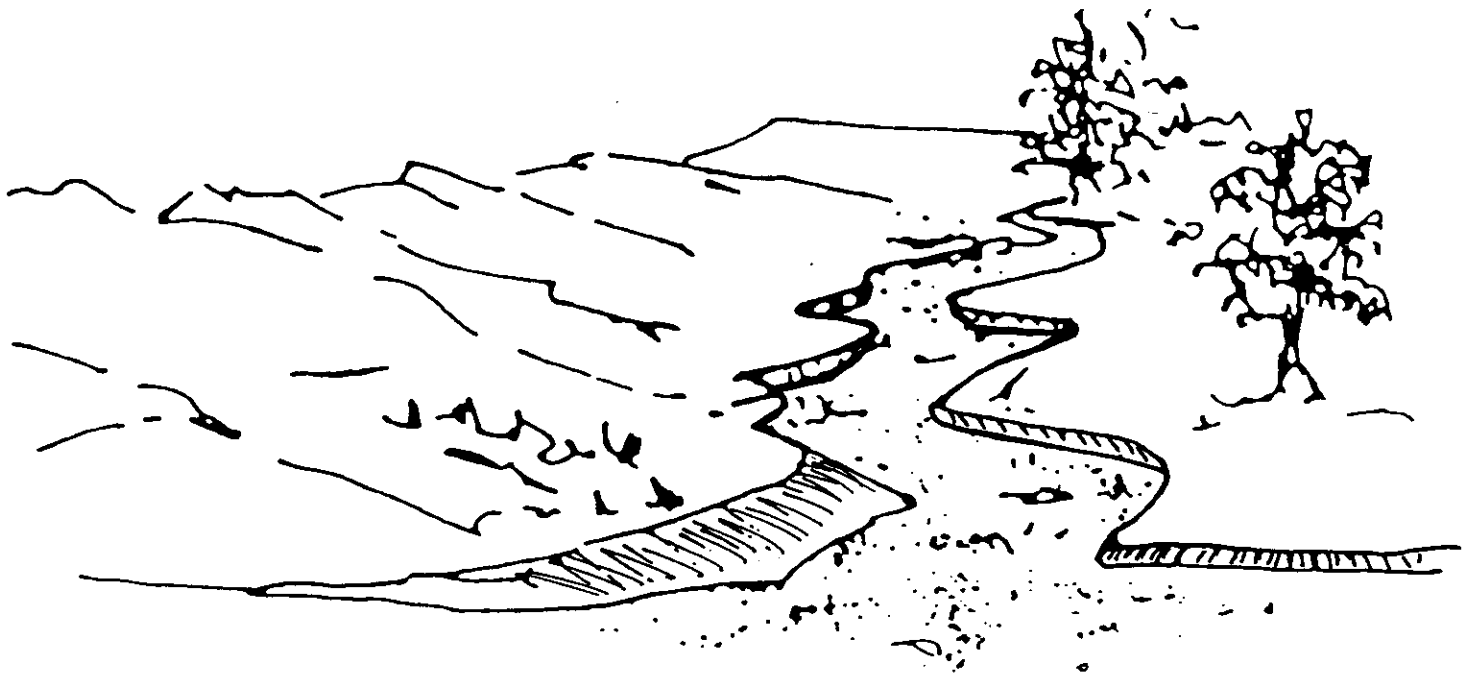
1. IDENTIFICATION OF THE LANDFILL SITE AND SURROUNDING AREAS



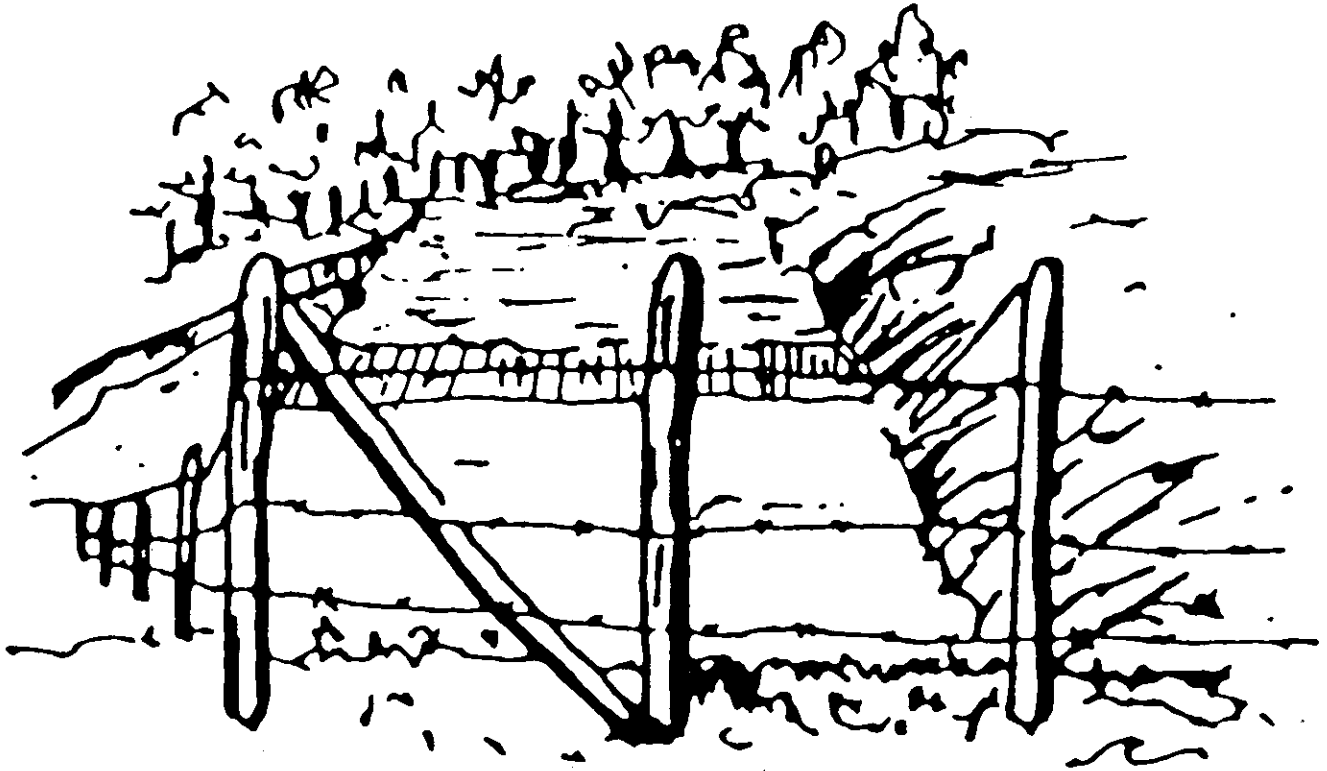
2. TOPOGRAPHIC SURVEY



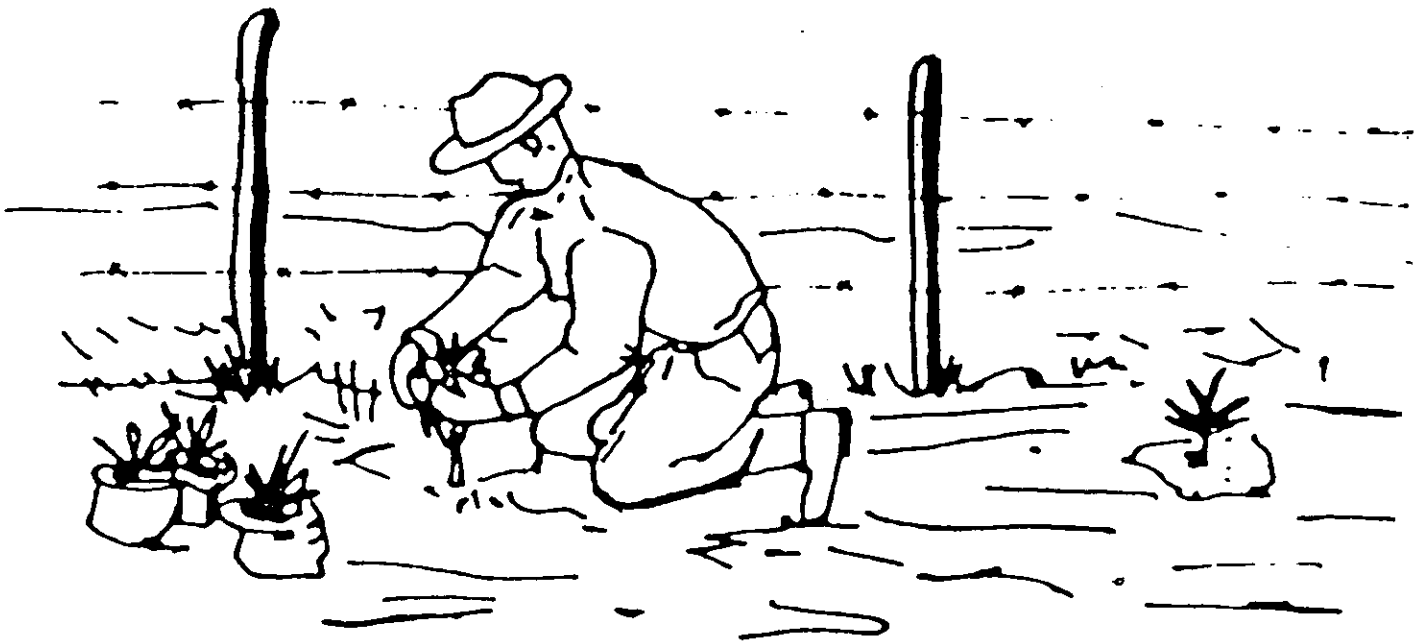
3. PREPARATION OF THE SITE



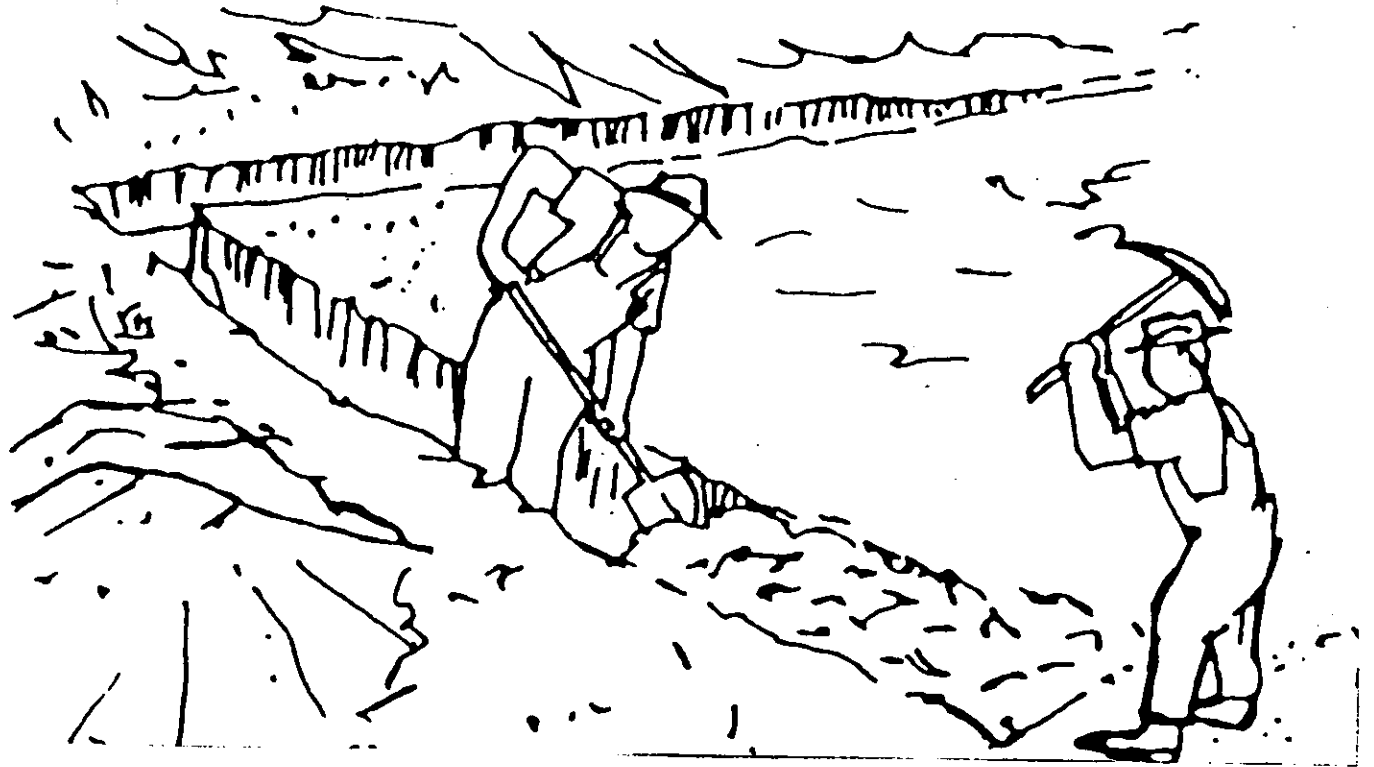
4. ACCESS ROAD CONSTRUCTION



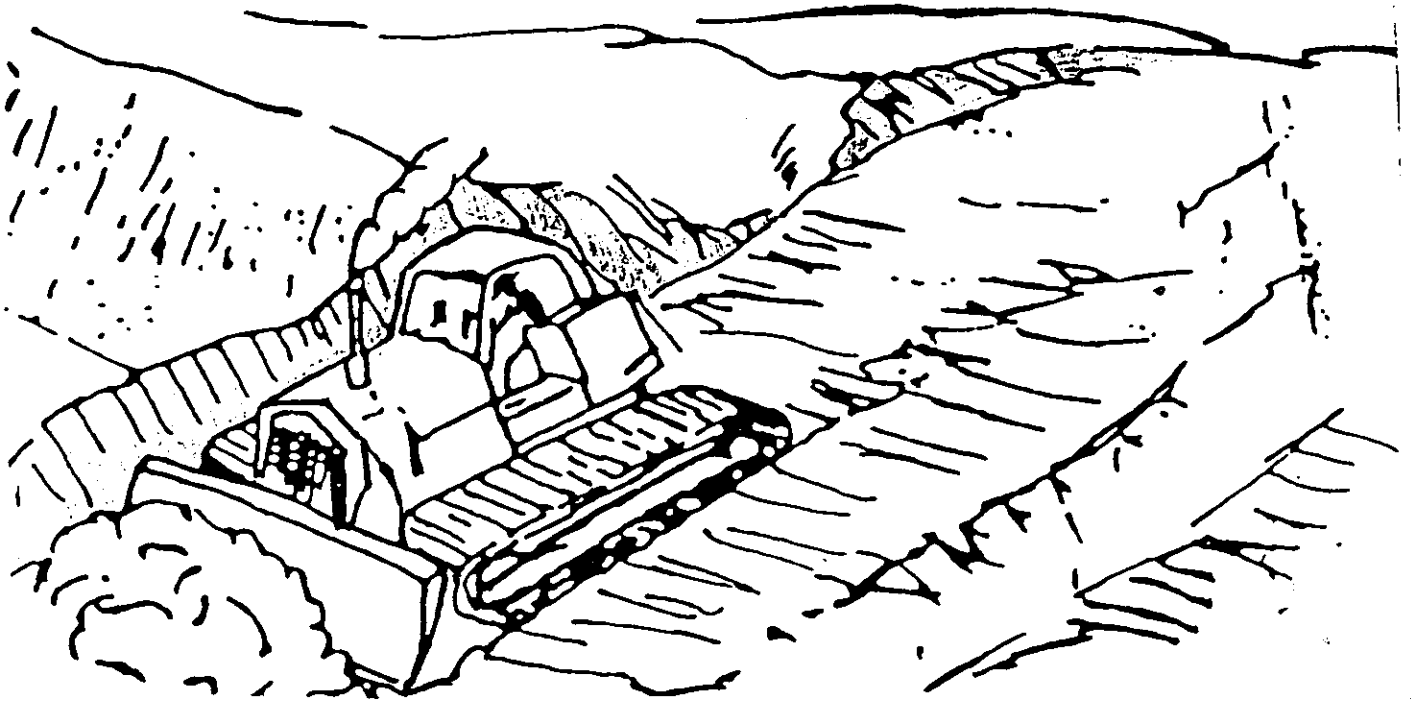
5. WIRE FENCE CONSTRUCTION



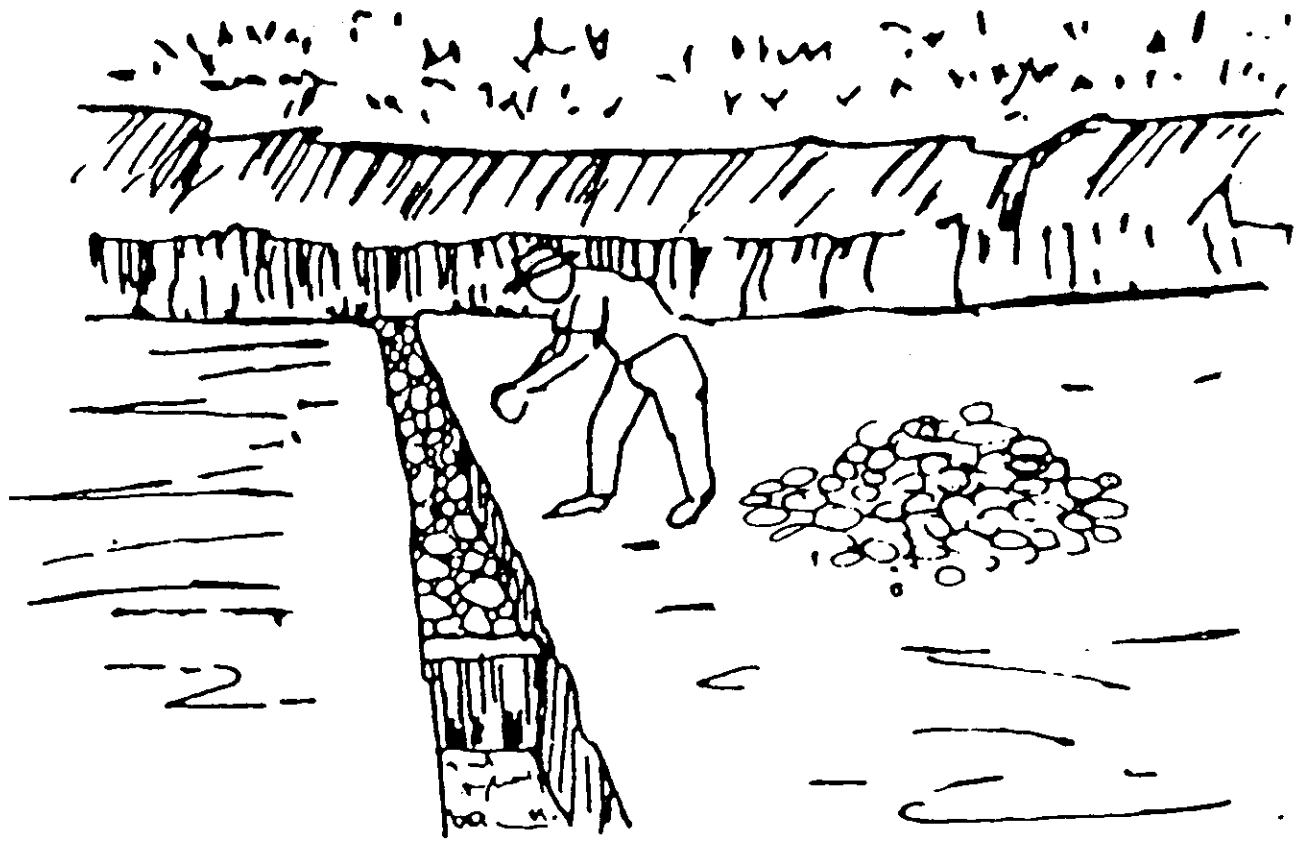
6. PLANTING A BARRIER OF TREES AND BUSHES



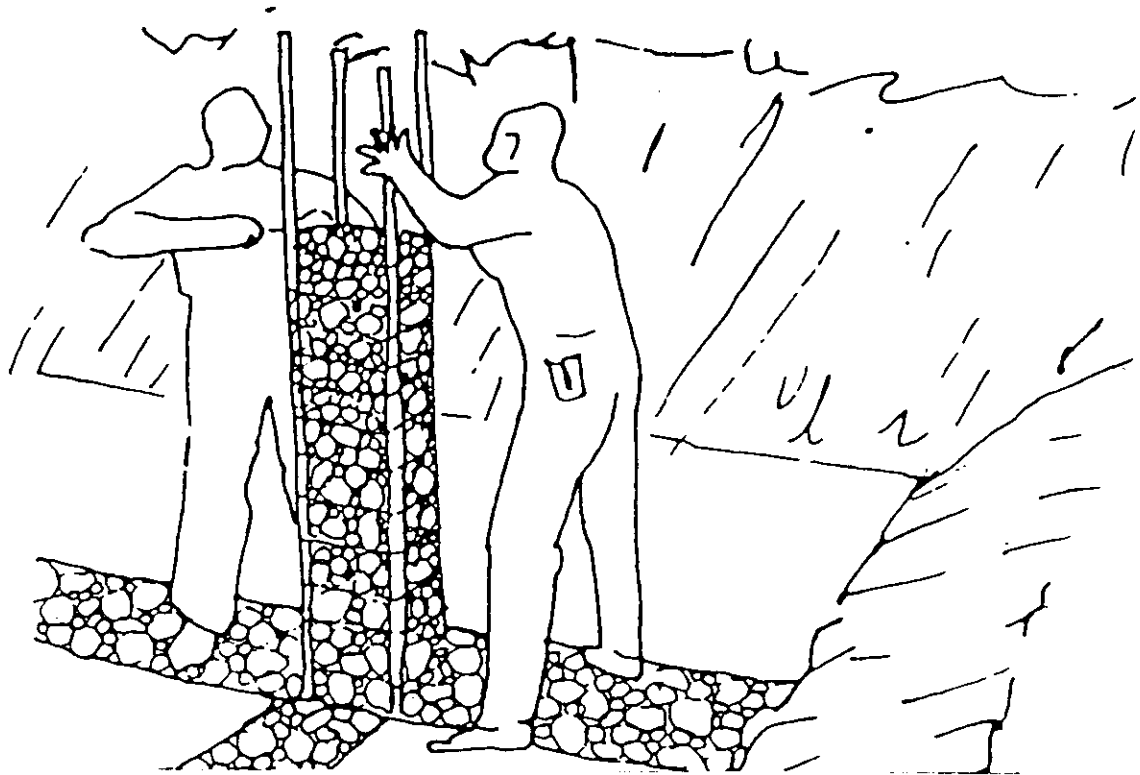
7. PERIPHERAL DRAINAGE CONSTRUCTION



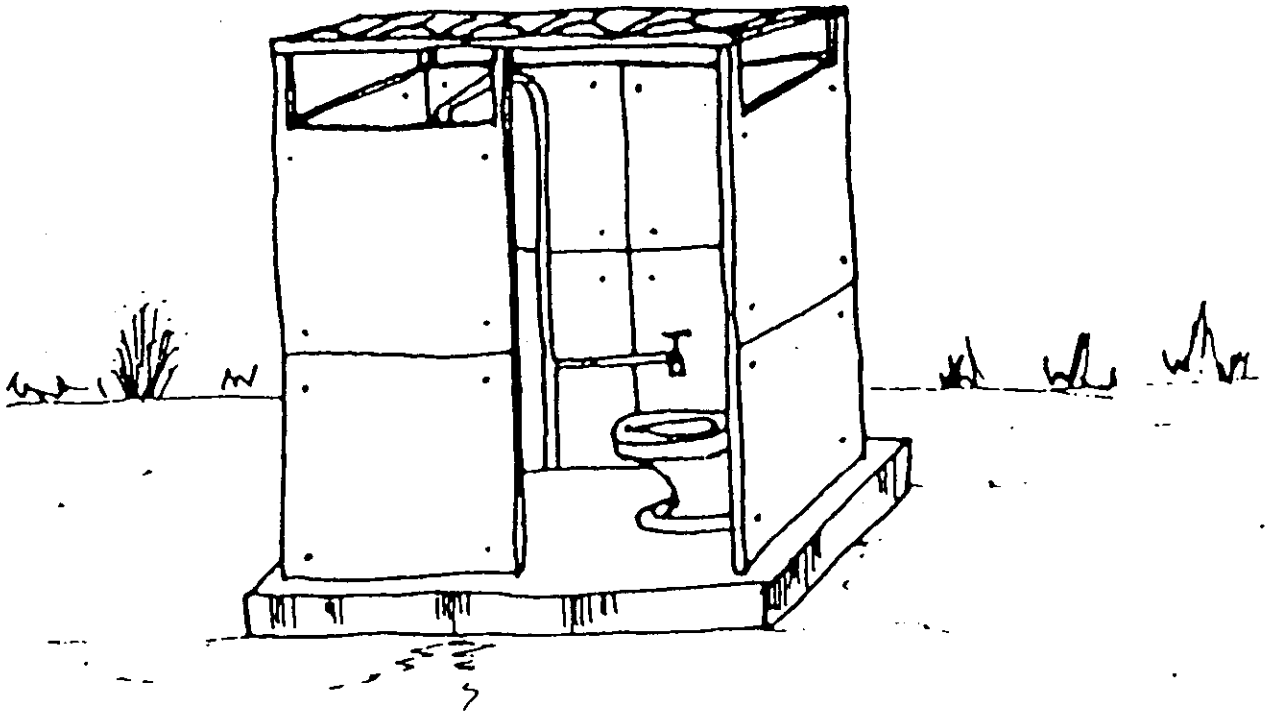
8. SOIL BASE PREPARATION



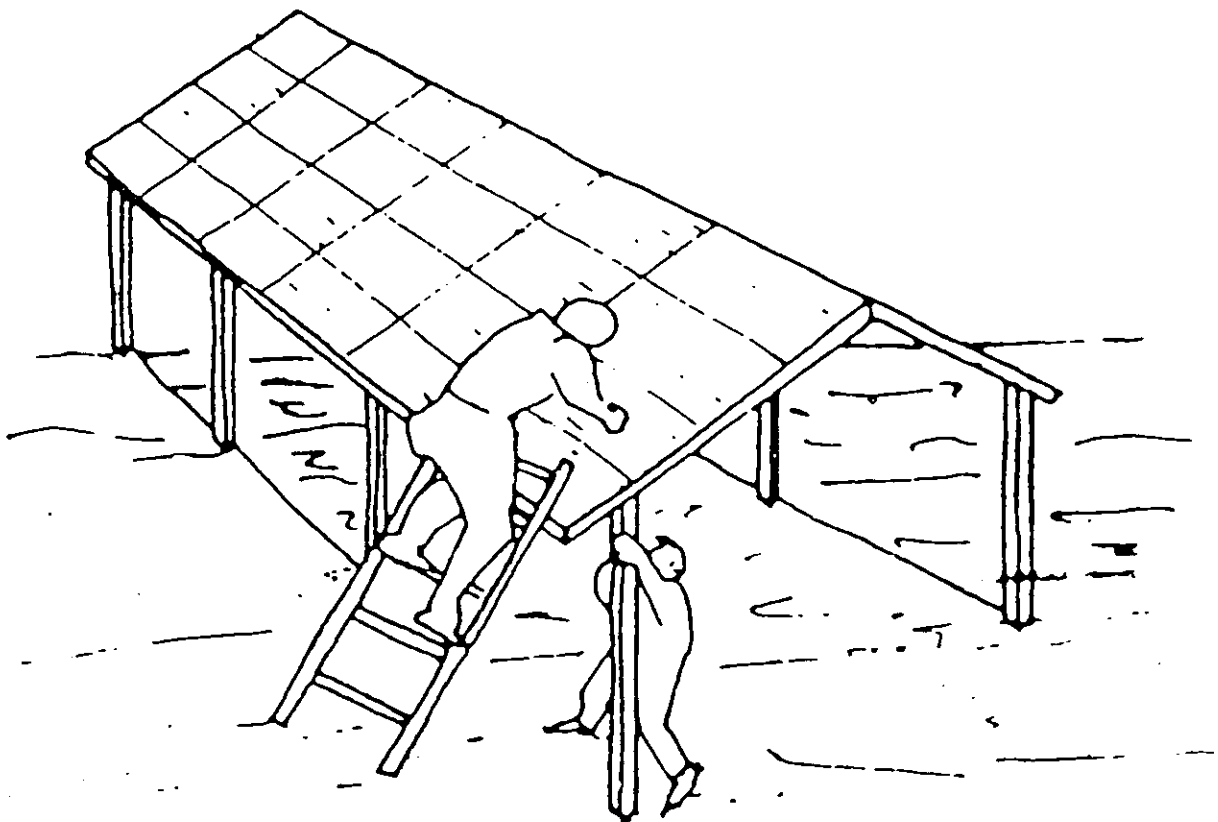
9. INTERNAL DRAINAGE CONSTRUCTION



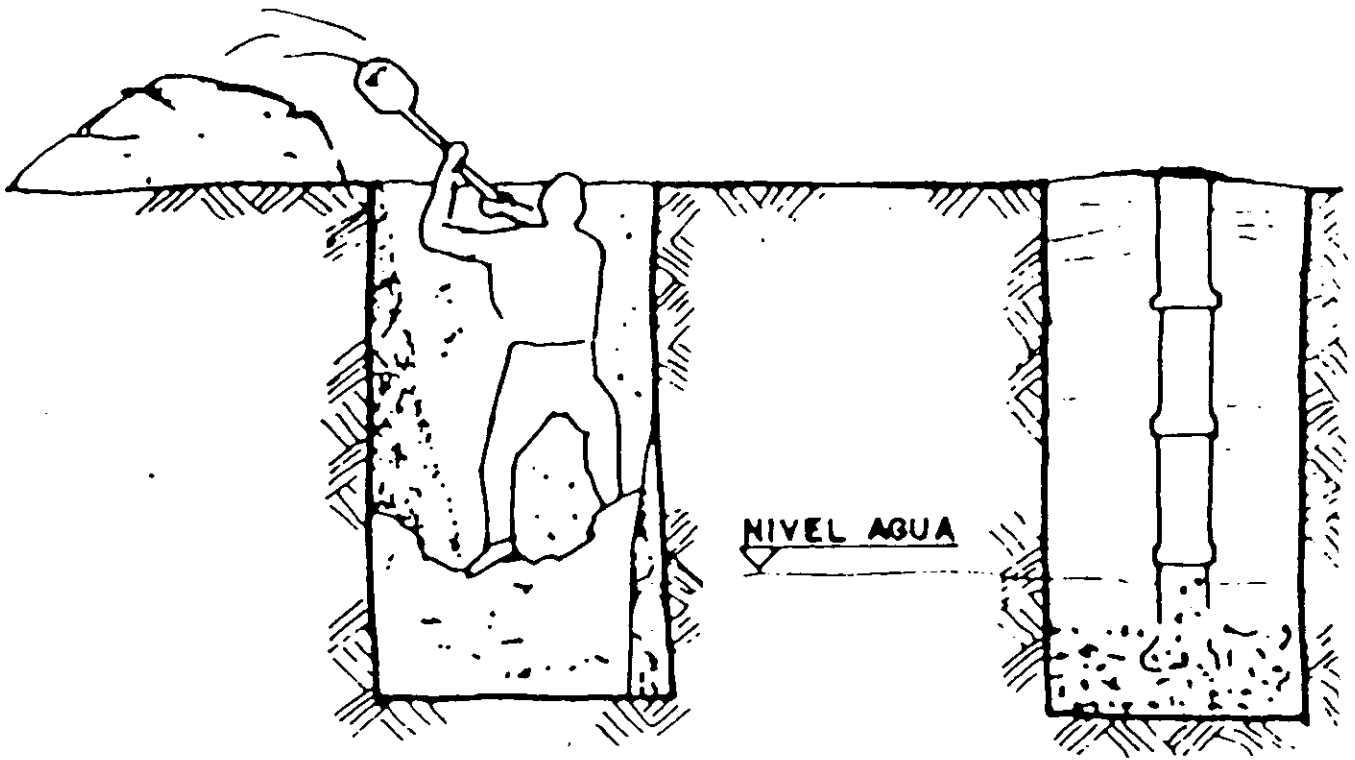
10. GAS VENTING CONSTRUCTION



11. LATRINE CONSTRUCTION / BASIC SANITATION



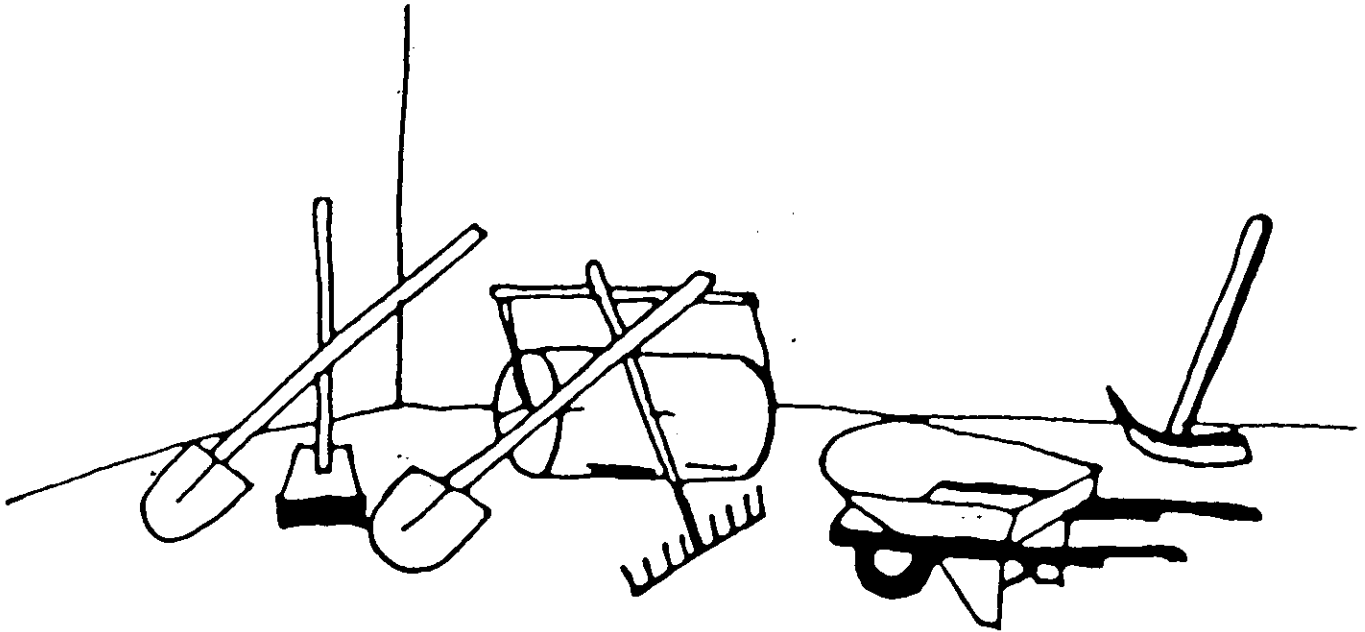
12. CONSTRUCTION OF THE LANDFILL KEEPER'S BOOTH



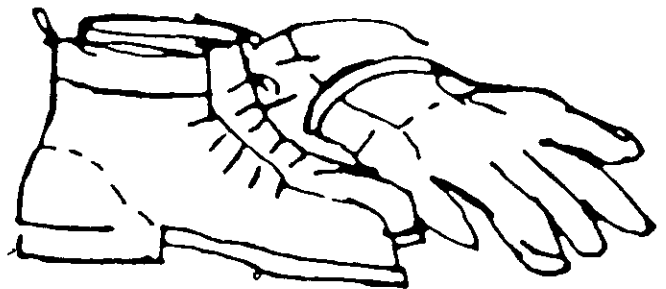
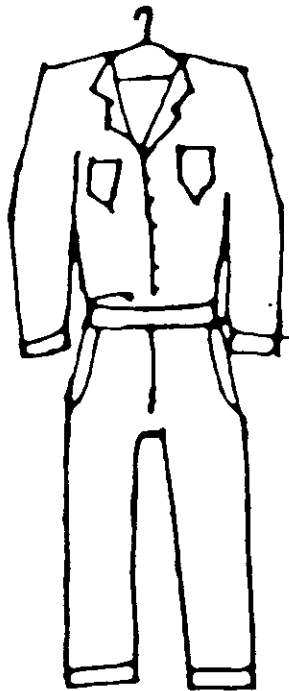
13. DIGGING THE MONITORING WELL



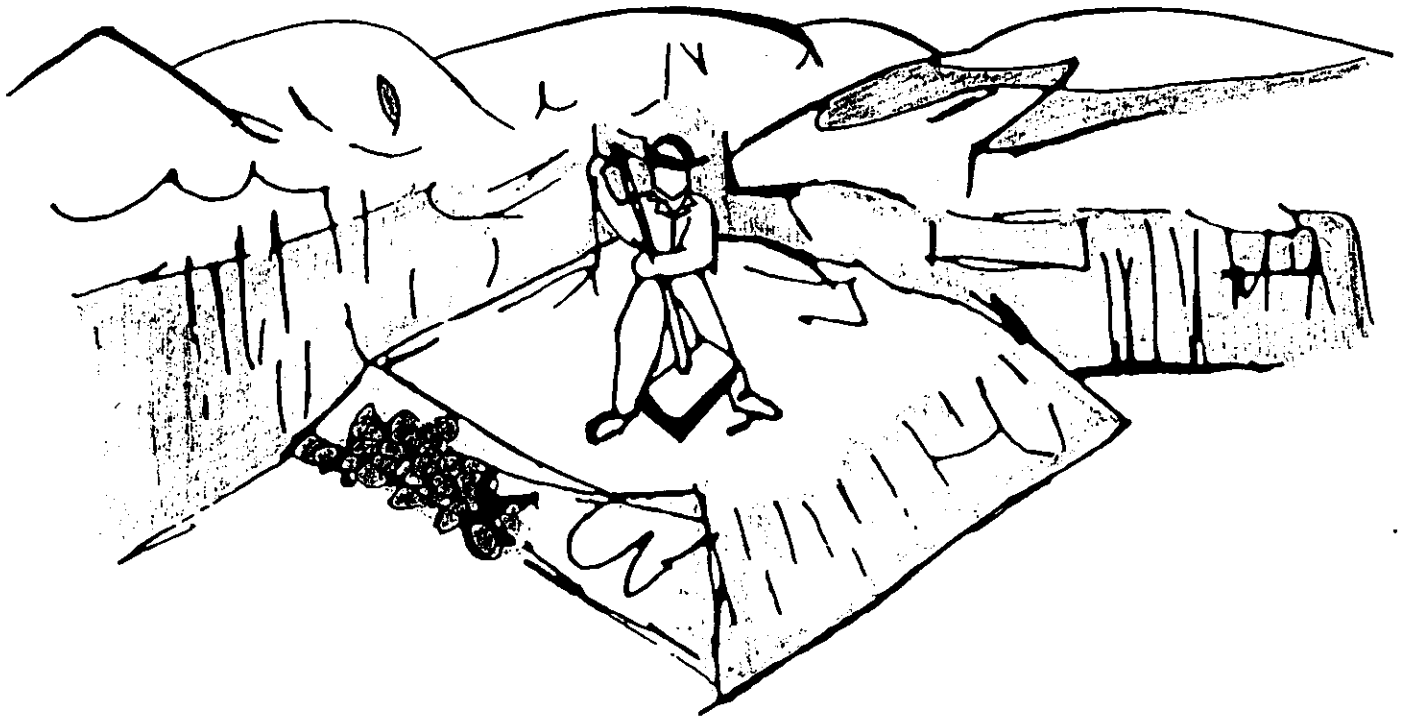
14. CONSTRUCTION AND PAINTING OF THE IDENTIFICATION SIGN



15. TOOLS ACQUISITION



16. ACQUISITION OF PERSONAL PROTECTION EQUIPMENT



17. OPERATION START UP



18. CLOSURE OF THE MUNICIPAL OPEN DUMPING

MANUAL SANITARY LANDFILL CONSTRUCTION COSTS

COMMUNITY (*)	A	B	C
INHABITANTS	3 600	10 500	15 800
LEACHATE TREATMENT SYSTEM	SEPTIC TANK	PRIMARY SETTLING	PRIMARY SETTLING ANAEROBIC FILTER
EFFLUENT DISPOSAL	RECIRCULAT.	SEWERAGE	STABILIZATION PONDS
LIFE SPAN (YEARS)	5	10	22
COST (\$)	20 000	32 000	80 000 (**)

(*) COLOMBIA

() WITH SOIL IMPERMEABILIZATION**

SANITARY LANDFILL

ORGANIC MATERIAL DEGRADATION PHASES

- 1 AEROBIC PHASE**
- 2 ACIDOGENIC ANAEROBIC PHASE**
- 3 UNSTABLE METHANOGENIC ANAEROBIC PHASE**
- 4 STABLE METHANOGENIC ANAEROBIC PHASE**