Cairo Air Improvement Project

Lead Pollution Abatement Component

Landfill Development and Operation Plan for the Abu Zaabal Quarry

Chemonics International, Inc.
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Landfill Development and Operations Plan – Abu Zaabal Quarry

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EXECUTIVE SUMMARY

In 1997, the Governorate of Qualiobiya (Governorate) began placing solid waste into the Abu Zaabal quarry. This quarry is adjacent to an industrial zone that has been designated for relocation of lead smelters and foundries from Cairo. The overall quarry is divided into three distinct sections as shown in Figure 1.1. Currently, solid waste is being placed in Quarry #1 by pushing the waste into the quarry from the top of the quarry face.

This Landfill Development and Operations Plan (Plan) has been developed to address a number of important issues and problems associated with the use of the quarry as a long term disposal site for the Governorate. These include:

1. Uncontrolled fires along the side slope of the solid waste accumulation in the quarry
2. Safety problems associated with the instability of the solid waste accumulation especially at the top of the accumulation where mechanized equipment is operating.
3. Potential groundwater contamination because of the placement of solid waste into the water accumulated in the base of Quarry #1.

To address the above problems, the Plan seeks to accomplish the following objectives:

1. Eliminate all fires and manage disposal activities to minimize fire potential in the future.
2. Develop a sustainable landfill design on the base of the quarry and operational procedures that minimizes environmental damage particularly to groundwater resources.
3. Develop a landfill design and operational procedures that safeguard the health and safety of operators and others visiting the site for any purpose.
4. Establish a sustainable landfill configuration that allows the quarry to be used as a cost effective, environmentally sound and safe solid waste disposal location for as many years as possible.

A number of near and long-term recommendations have been made to accomplish the above objectives. These are primarily aimed at ultimately developing a controlled landfill on the base of either Quarry #1 or Quarry #2.

Currently, there is an accumulation of water at the base of Quarry #1. There is no information available to define the depth of this water. The Evaluation Team believes that the water accumulation is of groundwater origin and may be caused by seepage from the Ismalia Canal or from excessive irrigation of land in the vicinity of the quarries. The Evaluation Team strongly recommends that an attempt be made to dewater Quarry #1 through pumping. This will accomplish three very important results. First, the base of Quarry #1 will be exposed through dewatering to define actual conditions (topography, surface characteristics, etc.) for design of a controlled landfill at its base. Second, dewatering will help to prevent the migration of pollutants in the water that have resulted from the placement of solid waste into the quarry. Third, the water from Quarry #1 may be used to put out the uncontrolled fire in the solid waste accumulation along the quarry face at the current disposal location.

Uncontrolled fire in the solid waste accumulation is one of the most visible problems associated with the current use of the quarry as a disposal site. These fires are a source of major complaints concerning the site and could significantly influence the development of industry on land adjoining the quarry.

Limited evaluation during the development of this Plan shows that, once dewatered, it should be practical to control the inflow of water into the quarry. This management of water inflow to the quarry will be an important element of a controlled landfill design on the quarry base. It will also be important in determining that there will be no long term environmental damage caused by the placement of solid waste into the quarry.

If dewatering of Quarry #1 is not successful, consideration should be given to the development of a controlled landfill on the base on Quarry #2. This quarry segment appears to be at a higher elevation than the base of Quarry #1. Although there are some indications of a shallow depth to groundwater (limited standing water, wetlands), the base of Quarry #2 is generally above the groundwater level and provides a working surface on which a controlled landfill can be constructed including the installation of a low permeability soil lining system.

The Plan provides a description of the manner in which a controlled landfill can be constructed and operated on the base of either Quarry #1 or #2 to mitigate the problems currently experienced at the disposal area. The issues and problems associated with the current disposal practices at the site cannot be eliminated if landfill operations are not transferred to the base of the quarry area or to another location if development on the quarry base is not feasible.

This Plan also outlines the specific procedures that should be used to operate the controlled landfill once it is constructed. Although they will not eliminate the current disposal problems, some of the recommended procedures can assist in the near term to help improve safety conditions at the current disposal site at the top of the quarry.

Section 1

Introduction

In 1997, the Governorate of Qualiobiya (Governorate) began placing solid waste into the Abu Zaabal quarry. This 96-feddan quarry is adjacent to the Qualiobiya Governorate industrial zone that has been designated for relocation of lead smelters and foundries from Cairo. The relocation of lead smelters and foundries is an integral part of the Lead Abatement Component of the Cairo Air Improvement Project (CAIP). Because of the concern about the impact of the quarry disposal site on existing and proposed adjacent land use, the Governorate has requested assistance in upgrading the quarry for use as a long-term landfill site that is environmentally sound and compatible with its surroundings.

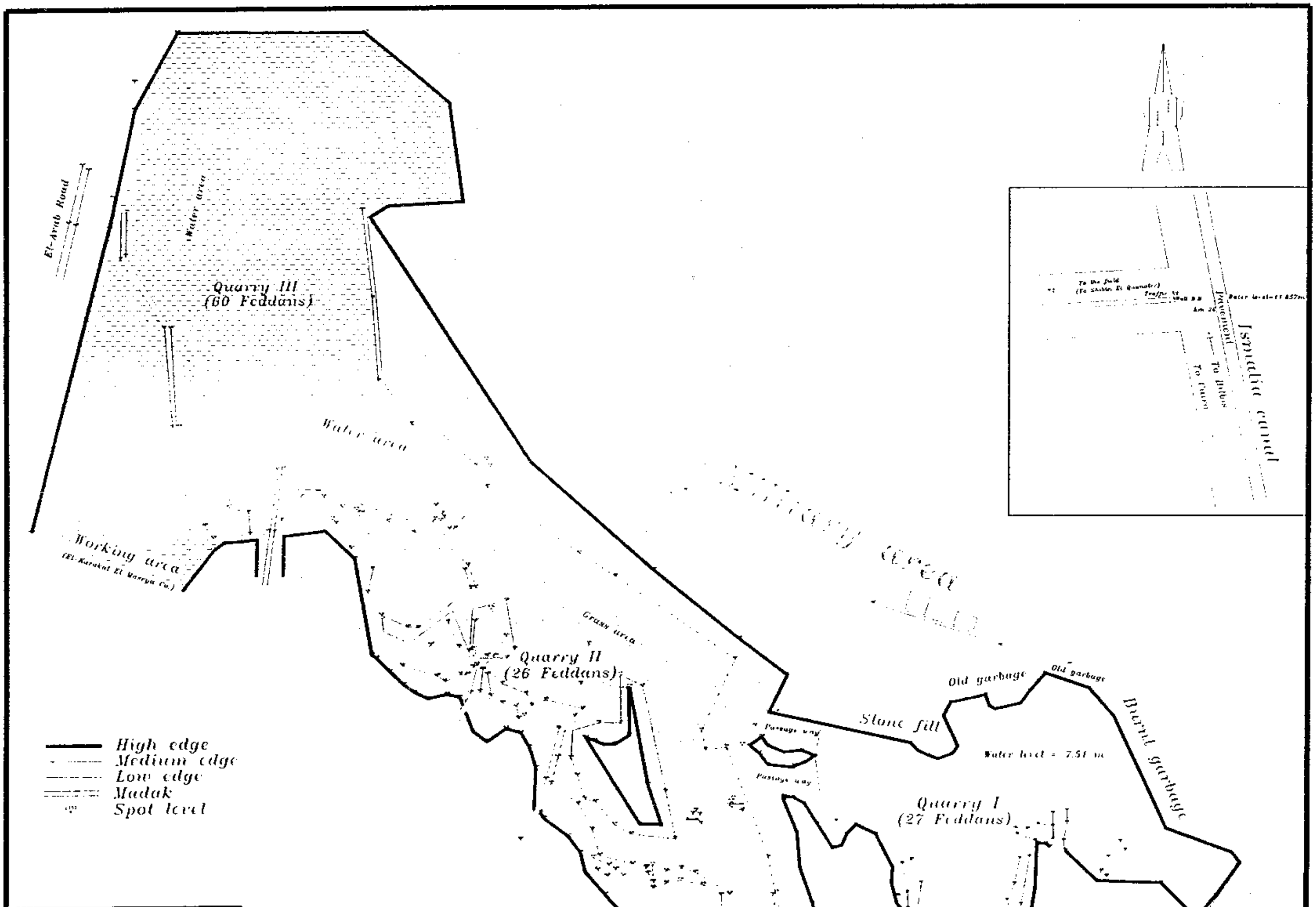
1.1. The Site

The Abu Zaabal quarry site is located in the northeastern portion of the Qalioubiya Governorate and is approximately 35 kilometers northeast of Cairo. It is approximately 2 kilometers west of the Ismalia Agricultural Highway and the adjacent Ismalia Irrigation Canal. Al Madares St. and the Msaken Abu-Zaabal area bound the site on the east. An area to the north of the quarry is currently undeveloped and is the proposed site of an industrial area that will include the relocated lead smelters. To the northwest of the current disposal site is a military area and to the west is an extension of the basalt quarry excavation.

The quarry excavation resulted from 42 years of basalt mining by the Abu Zaabal Basalt Company. This company is no longer in existence and the site has remained unused until the beginning of solid waste disposal operations in 1997. For the purpose of this evaluation, the overall quarry excavation has been subdivided into three components designated as Quarry #1, Quarry #2 and Quarry #3 as shown in Figure 1.1 on the following page.

Currently, solid waste is being placed in Quarry #1. At the time of an initial visit to the site in November 1998, a member of the evaluation team observed that there was water within the base of Quarry #1. In a recent site inspection on November 21, 1999, however, water was less evident from the lip of the quarry. On closer investigation at the base of the quarry in December 1999, water was clearly observed even though floating plastic bags and solid waste has covered most of the surface of the water. Because of this, the water is not as readily evident from the top of the quarry as was the case in November 1998.

The existence of this standing water at the bottom of the quarry excavation indicates that the Quarry #1 water accumulation is most likely fed by groundwater. This leads to serious questions about the operational and environmental aspects of the landfill:



CAIRO AIR IMPROVEMENT PROJECT
(CAIP)
CHEMONICS INTERNATIONAL

ABU ZAABAL LANDFILL PROJECT

CADASTRAL MAP FOR CLIFF AREA

Surveyed by:
INTERNATIONAL FOR SURVEYING WORKS

SCALE 1:2000 | Date 19-1-2000

1. Can the landfill be designed and operated effectively without dewatering Quarry #1?

2. Can the water from the quarry accumulation be put to a practical use by putting out fires and for dust control without posing an environmental hazard?

3. What environmental risk does the quarry water now contaminated pose to people and the environment?

4. Can the landfill be operated in the current manner and in the current location without continuing the significant safety hazards and environmental damage potential that currently exists?

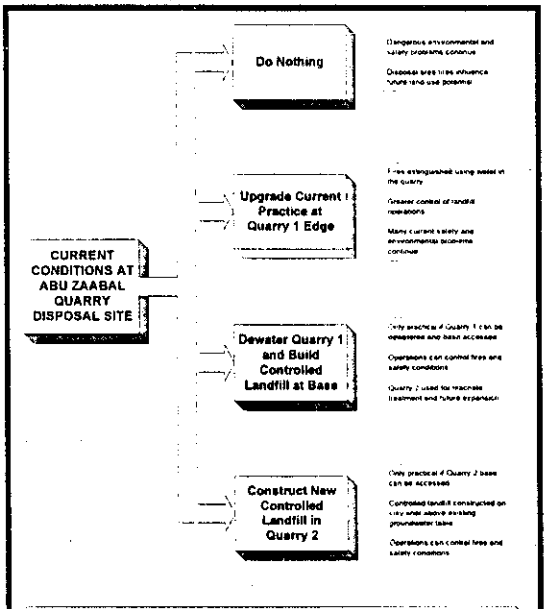


Figure 1.2
ABU ZAABAL QUARRY DISPOSAL AREA DEVELOPMENT CHOICES

In order to answer these questions, additional information must be generated regarding the overall geometry of the quarries, the quantity and quality of the water in Quarry #1, and groundwater inflow rates. These issues and others are discussed later in this report. However, it cannot be over emphasized that answering the above questions is very important in defining the practical alternatives for establishing an environmentally sound and safe landfill at the quarry site. Figure 1.2 presents action alternatives for the Governorate in using the site for long-term disposal.

Quarry #2 is located to the northwest of Quarry #1. While there is evidence (wetlands and limited standing water) of groundwater in Quarry #2, much of the base of Quarry #2 appears to be above the groundwater elevation and is generally free of standing water.

There are active quarry operations in Quarry #3. Most of the physical surface of Quarry #3 is similar to that of Quarry #2.

Currently, operators of the disposal site have access to the base of Quarry #1 because of the existing access road that once served the original quarry operators. If Quarry #2 were ever to be used as a landfill site, physical and legal access to Quarry #2 must be resolved because of adjacent land use such as the military area located to the north of Quarries #1 and #2.

1.2. The Problem

The uncontrolled practice of simply dumping and pushing municipal solid waste into the quarry excavation creates a number of problems that should be addressed if the site is to be considered for long-term use. Some of the major problems experienced at the site are described below.

Operational Issues - The current waste management practice at the quarry landfill is to simply off-load waste delivery trucks on the ground at the lip of the quarry and periodically push the material into the quarry. The solid waste then drops along previously placed material until it lodges in the waste accumulation or reaches the water at the base of the quarry. A significant portion of the solid waste pushed into the quarry is currently burning and, as a result, there was considerable smoke being emitted from fires in the quarry that, depending on wind directions, can reach residential areas in the vicinity of the quarry site or the area proposed for industrial development. Because of 1) the continual addition of fuel (solid waste) to the burning material along the side slope of the quarry and 2) their inaccessible location, the fires are difficult to extinguish.

Noteworthy safety issues exist at the site because of exposure to the smoke emanating from the fires as well as from the physical process of pushing waste into the quarry excavation. It is our understanding that, at least on one occasion, a loader began slipping down into the quarry as a result of the instability of material on which it was driving at the top of the quarry face. Such situations will be very difficult to avoid when dealing with a near vertical wall configuration of the quarry and steep angle of repose of solid waste being pushed into the landfill. In effectively designed and operated landfills, slope stability is a very important issue because of the possibility that large solid waste accumulations will suddenly fail creating a general safety hazard and potential environmental damage. The fires that exist along the side slope of the solid waste accumulation compound these problems. These fires burn out the organic fraction of the waste accumulation thereby creating void space that enhance slippage and ultimate slope failure. As a result, there is the potential for slippage of the solid waste due to vibration or compaction caused by a loader or bulldozer pushing waste over the lip of the quarry. This potential for slippage will increase with time as more solid waste is placed into the quarry. There currently is physical evidence at the quarry lip of surface separation because of gravitational forces causing material slippage. This can eventually lead to slope failures and landslides that can create dangerous conditions for any personnel or others (visitors, scavengers, delivery vehicle personnel, etc.) at the top of the slope.

Environmental Issues - There are a number of environmental concerns that must be addressed if the landfill operation is not to cause significant environmental damage beyond that already created by placing solid waste into the water at the bottom of the quarry. These include the following:

1. **Air Pollution** – Significant air pollution results from the inability to control fires at the site. Fires along the sideslope of the quarry wall accumulation are generally inaccessible and are allowed to burn out of control. During site visits, it was also observed that waste loads received at the landfill were sometimes already on fire and that no effort was made by the operators to extinguish these fires before the material was pushed into the quarry. Smoke from fires at the site is the source of major complaints from local residents and is considered by Government officials as their most pressing problem.

   One other form of air pollution commonly created in solid waste disposal operations is dust associated with vehicles using the site and the composition of travel surfaces. While this may not be currently perceived as a significant problem at the landfill, it will become more important as industrial development occurs near the disposal area and access roads to the site.

2. **Water Pollution** – Through contact with the waste placed in the quarry, it is expected that the quarry water has become grossly polluted. The migration of these contaminants via the groundwater pathway away from the site is of major environmental concern. This contaminated groundwater is a potential hazard to crops that may be irrigated with groundwater, to people who may drink the water, and to the environment in general.

1.3. Program Objectives

In developing this plan to upgrade the quarry site for use as a long-term effective landfill, the evaluation team felt that it is important to set operational and environmental objectives aimed at eliminating or, at least, minimizing the above problems. In doing so, performance standards must be set and the site must be managed to reduce risks. The following presents how such an approach is recommended for the Abu Zaabal Quarry landfill.

Setting Operational and Environmental Goals and Objectives - The proper function of any controlled landfill requires both effective design and operational procedures. In a basic sense, the principal goal of developing a controlled landfill at the Abu Zaabal quarry must be to allow for the effective disposal of solid waste in operational and environmental problems associated with the long-term use of the quarry as a disposal site. As policies and standards are adopted in Egypt, the design and operation of the landfill may have to be adjusted to meet these new standards.

1.4. Meeting these Objectives

The Evaluation Team recognizes that the financial resources necessary to achieve all of the defined objectives are limited. Therefore, the Evaluation Team subdivided recommendations into near-term and long-term activities that can be phased to eliminate or, at least, minimize current problems and eventually achieve the overall goal. Figure 1.3 on the following pages illustrates this approach and schematically shows the major hazards as well as the near term and long-term management procedures that may be employed to overcome them.

The final definition of near-term and long-term activities to meet project objectives will be a function of the availability and interpretation of sufficient data defining the landfill requirements and the physical characteristics of the quarry site particularly that information that defines whether Quarry #1 can be effectively dewatered. At a minimum, the following additional information will be required to completely define future activities:

- **Depth and Groundwater Recharge Of Water In Quarry #1** – This will determine the feasibility of dewatering Quarry #1 for development of a controlled landfill at its base. The final configuration of the Quarry #1 base will determine the overall capacity of a landfill developed on its base. This will also determine the overall cost of building the base-oriented landfill and the access road necessary to allow trucks to reach the base. The depth of water will also determine the feasibility of filling the quarry with imported material such as demolition material to a level above the water level.
- **Test Well Data To Determine Groundwater Flow Direction And Groundwater Quality** – This will help to define the priority that must be given to the protection of groundwater quality in evaluating and improving the landfill as well as monitoring its environmental performance after construction.

The report presents our current knowledge of the quarry site and a proposed approach toward constructing and managing an improved Abu Zaabal landfill in the quarry.

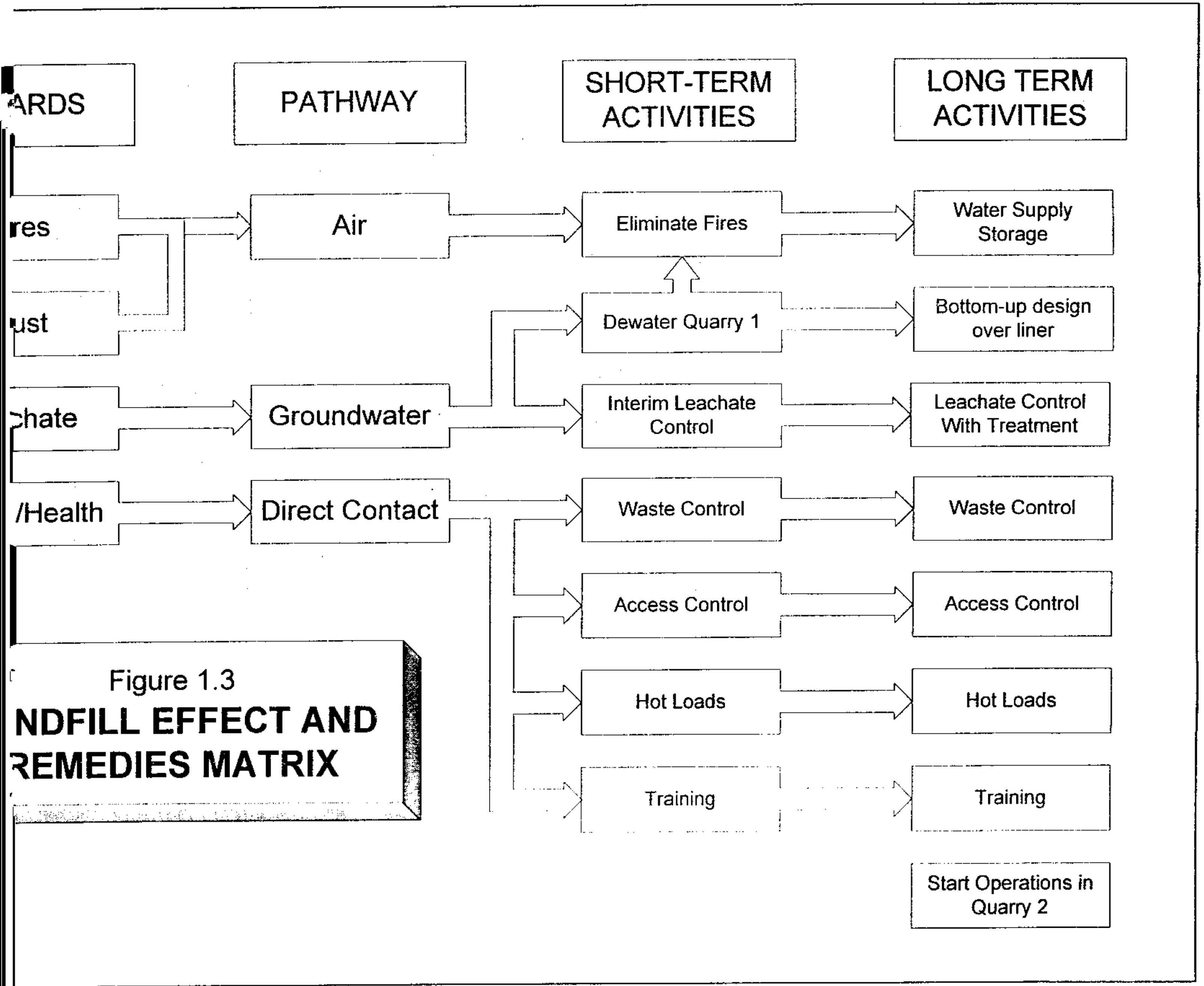


Figure 1.3
NDFILL EFFECT AND REMEDIES MATRIX

Section 2

Site Characteristics

The climatic and hydrogeological characteristics of any proposed landfill site are important in defining the design criteria and operational procedures required for effective and safe disposal. Climatic conditions such as rainfall and evaporation can greatly effect the creation of leachate and movement of hazardous substances away from the point of disposal. Areas with low rainfall and high evaporation present less risk of externally generated leachate than areas with high rainfall and low evaporation. For example, the average rainfall over Egypt as a whole is only 10 mm/year while evaporation rates are high, about 3,000 mm/year. This will minimize leachate production and, as a result, pollutant mobility from landfills. Leachate, however, will still be generated because of the inherent moisture contained in some solid waste streams. While the quantity of leachate may be low, its pollutant loading is apt to be high because of a lack of dilution that would be created through rainfall or surface water contact. The low average rainfall rate at the landfill site will also affect the amount of landfill gas that will generated as waste material decomposes in the landfill.

The vulnerability of groundwater is also based on a number of hydrogeological factors including: 1) the leaching capacity of soils or bedrock in contact with the base of the landfill, 2) the depth of groundwater, and 3) the groundwater flow direction. At solid waste disposal sites, the leaching capacity of the upper soils and the depth to groundwater determines the rate at which natural attenuation will treat the leachate emanating from the landfill. Natural attenuation is a term given to the natural chemical or physical treatment processes that pollutants are exposed to as leachate flows through soil. Low permeability soils, such as silt or clay, will impart greater attenuation than high permeability soils, such as sand and gravel. Chemical composition of soils also affects their natural attenuation properties.

Depth to groundwater directly relates to the length of time that pollutants are in contact with attenuating soils in the unsaturated zone. Once pollutants reach the groundwater, the attenuation processes continue but are generally not as effective as during the time that leachate is flowing through the unsaturated zone above the groundwater table. This is particularly crucial in Quarry #1 because of the water standing at the base that the Evaluation Team believes is directly attributable to groundwater flow.

Groundwater flow direction is important in determining the potential for transport of pollutants to nearby, down gradient receptors, such as wells and springs. The potential health effect of pollutants is decreased if flow of groundwater that has been exposed to contaminants is away from potential receptor sites. Similarly, the natural dispersion of pollutants in groundwater flow usually decreases the concentration of the pollutant as it travels away from the point of origin. This emphasizes the importance of the distance from pollution sources to potential receptor sites such as wells and springs.

The following presents a brief overview on the physical characteristics of the Abu Zaabal Quarry. It is based on a review of existing information on the site compiled by the Cairo Air Improvement Project (CAIP) under the Lead Smelter Action component and on physical surveys completed because of the preparation of this Plan.

2.1 Topography

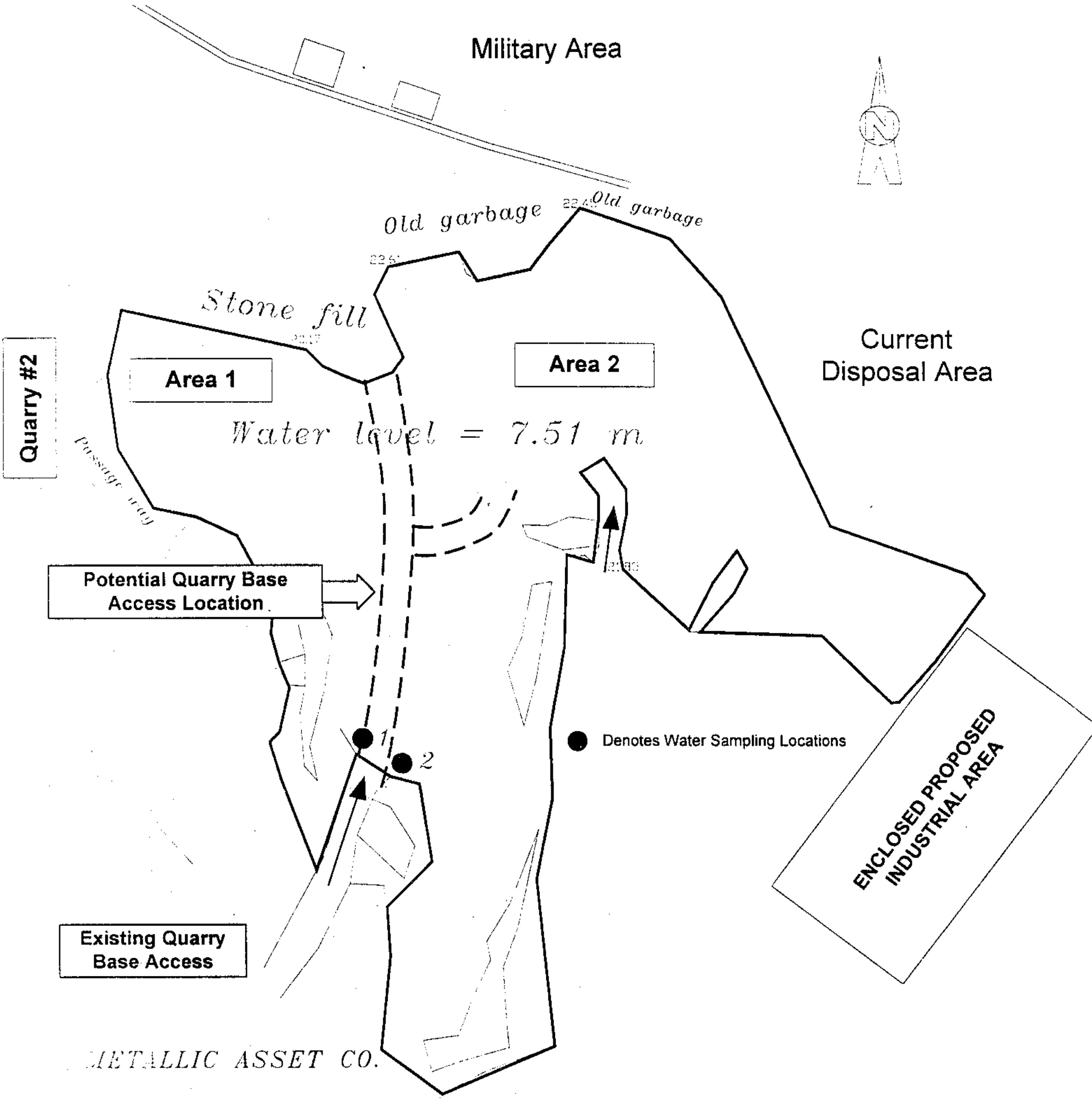
The quarry lies adjacent to and due south of a proposed industrial area. This area is relatively flat with a total relief of about 4 to 5 meters. The most distinguishing topographic feature of the site is the quarry into which the solid waste is currently placed. This quarry excavation, shown in Figure 1.1, is divided into three parts separated by ridges of basaltic rock. The northern portion of the quarry, identified as Quarry #1, is currently being used for solid waste dumping. Quarry #1 consists of about 27 feddans and is shown in Figure 2.1 on the following page. The top of the quarry wall in this area has an elevation approximately 21 meters above mean sea level and drops almost vertically to a lake. Based on the topographical survey completed for this evaluation, the elevation of the water surface at the base of the quarry is approximately 7.5 meters. Because of the inability to measure the depth of the water in Quarry #1, the exact elevation of the base is unknown. No records exist from the original quarry operation that shows the depth of the base of Quarry #1. It is estimated that the bottom of the quarry may be as deep as 30 meters below ground level at the edge of the quarry. As will be discussed later in this report, the depth of water is important in defining whether the quarry can be effectively dewatered and in determining the overall capacity for solid waste disposal after dewatering.

Directly to the south of the landfill site is the 26-feddan Quarry #2. The elevation of the bottom of this quarry appears to be about 5 meters higher than Quarry #1. The topography at the bottom of this quarry is undulating and, for the most part, above the water table. However, there are small pools of water that contain marsh grasses that, more than likely, indicate that the depth to groundwater is close to the physical surface of the base of Quarry #2.

2.2 Geology

Geologically, the site is located along the edge of the Nile River Valley. Quaternary sediment in this area consists of Pleistocene aged silt, sands and gravels with lenses of clay. Underlying this unit is a Tertiary Basalt of Oligocene age. The contact between the basalt and the upper unit is due to an erosional unconformity that effectively eliminated upper Tertiary-aged sediments from the area. Underlying the basalt is sandstone also of Oligocene age. About 2 to 3 kilometers west of the site is a major normal fault that separates the Pleistocene sediment and the basalt to the east from the younger sediment to the west. This fault effectively has allowed for the thickening of sediment within the center portion of the Nile River Valley.

Based on a series of geotechnical investigation holes drilled by Chemonics-Egypt (1999) during the site evaluation of the proposed industrial area, the area is underlain by the following sequence of material:

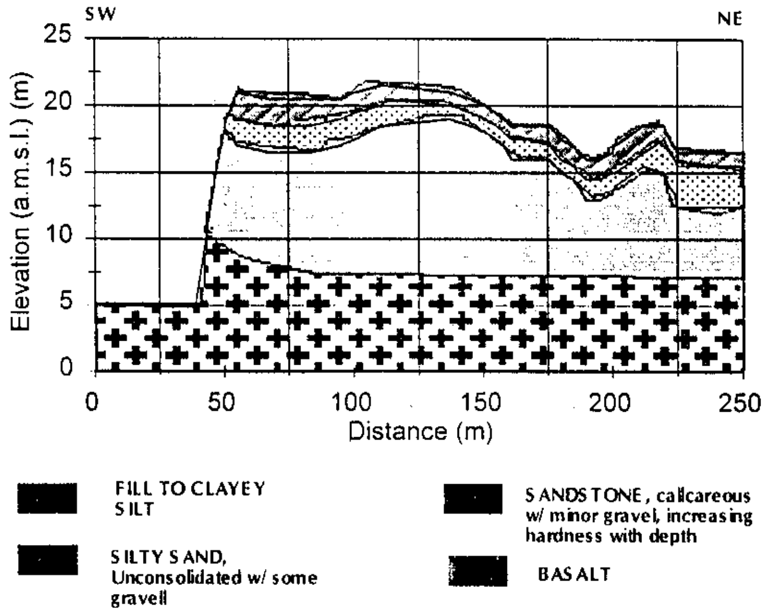

Military Area
Old garbage
Old garbage
Stone fill
Quarry #2
Area 1
Area 2
Current
Disposal Area
Water level = 7.51 m
Potential Quarry Base
Access Location
Denotes Water Sampling Locations
1
2
ENCLOSED PROPOSED
INDUSTRIAL AREA
Existing Quarry
Base Access
METALLIC ASSET CO.

QUARRY #1

1. Fill consisting of a mix of sand, silt, and gravel with fragments of sandstone.
2. Silty sand to silt with minor clay and gravel.
3. Sandstone that is highly weathered and calcareous with dissolution voids and some gravel.

The underlying basalt appears to be massive. However, rock debris from the former quarrying operation effectively conceals exposures of the basalt and the overlying sandstone. Figure 2.2 presents a geologic cross section of the site.

Figure 2.2
Abu Zaabal Quarry
GENERALIZED GEOLOGIC CROSS-SECTION

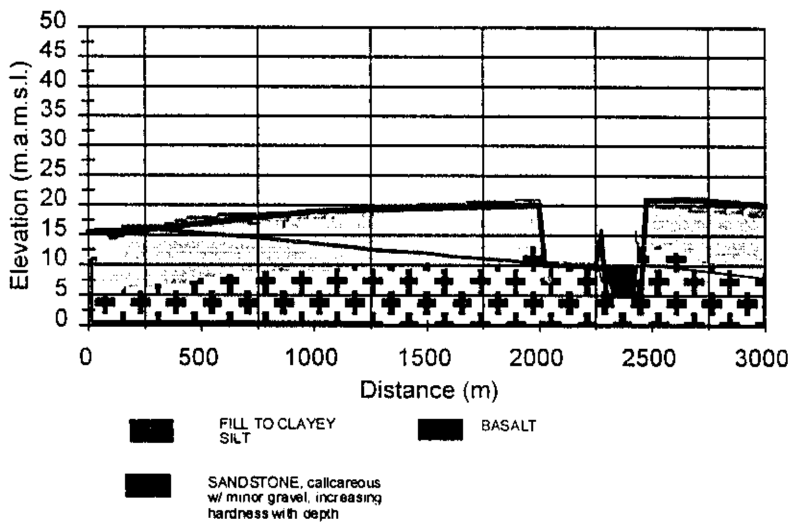


2.3 Hydrogeology

In terms of the hydrogeology of the site, the most important factors are the existing quarry water accumulation and the possible recharge of the aquifer system by the Ismalia Canal. The following presents a brief overview of the site hydrogeology in terms the nature and extent of the aquifers and the hydrochemical nature of the groundwater. It is based on the regional hydrogeology as delineated in the 1:10000 HYDROGEOLOGICAL MAP OF EGYPT – CAIRO 1989 by the Research Institute for Ground Water (RIGW) with technical assistance by IWACO B.V, Consultants for Water and Environment, Rotterdam, The Netherlands. Figure 2.3 presents a generalized hydrogeologic cross-section of site. The conceptual hydrogeology of the site is described below.

Nature and Extent - In general, there are two hydrogeologic units within the site area: 1) the Pleistocene sands and 2) the Oligocene basalt. The first unit is believed to be the primary aquifer at the site and consists of Pleistocene aged sands and gravels.

Figure 2.3
Abu Zaabal Quarry
GENERALIZED HYDROGEOLOGIC CROSS-SECTION



According to RIGW, this unit is a moderate to high producing aquifer capable of well yields between 5000 and 10000 m^3/day. This aquifer appears to be mostly recharged from seepage from the Ismalia Canal that is between 1.8 and 2 kilometers west and southwest of the site. Groundwater flows toward the quarry from the canal and flows away from the quarry toward the north at a relative flat hydraulic gradient of 0.0025 m/m. The saturated thickness of this aquifer is uncertain. Geotechnical boreholes drilled by Chemonics Egypt (1999) to a depth of 15 meters indicate unsaturated conditions. Therefore, it is believed that maximum saturated thickness of this unit is about 2 meters. However, this is uncertain at this time.

The second hydrogeologic unit is the Oligocene basalt. This massive unit, which is up to 30 meters thick, is considered by RIGW (1989) as "non-aquiferous" with occasional occurrences of groundwater flowing in fractures and fissures. In general, groundwater in basalt usually occurs along tops of these igneous flows or along weathered interfaces. At this site, it is uncertain as to the groundwater contribution of the basalt aquifer into the quarry water accumulation. It is known, however, that where the pit has been excavated, water is standing to the top of the saturated interval.

Groundwater Quality - Limited water quality data in the region of the site indicates that the water ranges between sodium-bicarbonate to sodium-chloride type with total dissolved solids ranging between 700 and 1450 mg/l. The water chemistry of the water accumulated in the quarry is not certain at this time and, with little doubt, has been adversely affected by the wastes placed into it. Results from limited sampling and testing are shown in Table 4.2. Most likely, there are dissolved organics and inorganic constituents in the water that have migrated down gradient (to the north) from the site.

2.4 Prevailing Winds

The primary wind is from the northwest and northeast to the south. Tentative plans for the development in the area call for locating residences in the northern part of the industrial site. However, site visits indicate that the wind direction is quite variable. On one visit, the wind was found to be blowing directly to the north from the landfill site.

Section 3

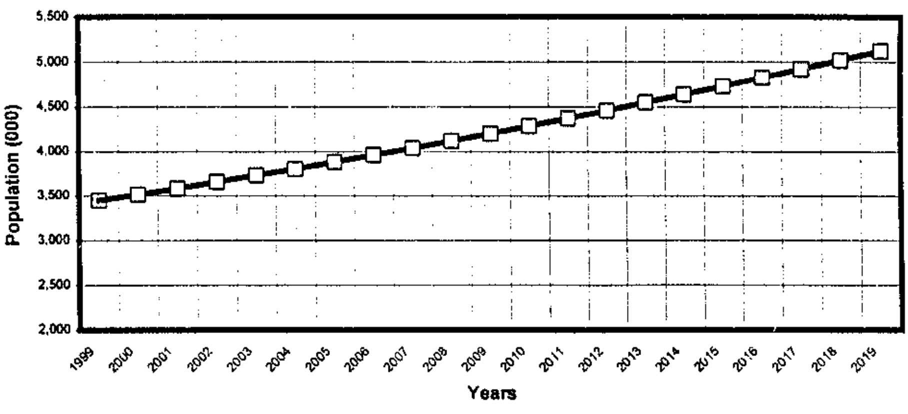
Waste Generation

Local officials have estimated that the landfill currently receives approximately 800 tonnes/day of about 1500 tonnes/day of municipal solid waste generated in the Qalioubiya Governorate. However, they have also stated that they intend to increase the amount of solid waste delivered to the site for disposal. The amount and type of solid waste received at the site is important in determining both design conditions and operational procedures. It is also important in determining the expected life to the landfill so that appropriate planning can occur for ongoing solid waste management needs.

The amount of municipal solid waste received at the site is generally a function of the population within the landfill service area. The amount of industrial waste received is a function of the type, size and number of industries within the service area. As will be discussed later in this report, the nature of industrial waste received at the landfill will be very important in determining the environmental performance of the landfill as well as potential health and safety hazards for operators who must handle these materials as they are received at the disposal area. Many forms of industrial waste are hazardous and pose a danger to both the environment and to operators who must handle them.

Figure 3.1

Population Projection



3.1 Population

Due to changing economic conditions, it is very difficult to determine actual population in many areas of Egypt with a high degree of accuracy. Previous estimates have placed the approximate population of the Qualiobiya Governorate at approximately 3,302,000. Based on official planning projections, this population is expected to grow at the rate of 2.16% per year for the near future. For the purposes of this report, we have assumed a 1999 population of 3,446,000 and a growth rate of 2.16% through a 20-year planning period. This results in a population projection shown graphically in Figure 3.1 - Population Projections. As shown on the graph, the landfill service area population of the Qualiobiya Governorate at the end of the 20-year planning period is approximately 5,120,000 people.

3.2 Municipal Solid Waste Generation Rates

It has been estimated that the average daily municipal solid waste generation in Qualiobiya Governorate is approximately 0.5 kg per person per day. Actual waste generation will vary throughout the region, based on socio-economic conditions, and housing densities. On a per capita basis, waste generated in market areas and urban centers will, more than likely, exceed the 0.5 kg per capita estimate, while generation in the poorer areas will be significantly less. For the planning purposes, 0.5 kg per capita per day of waste generation was applied to the entire population within the service area.

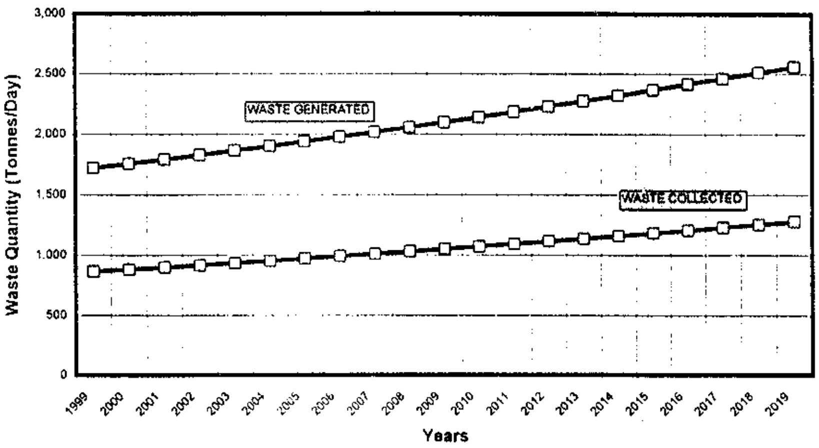
3.3 Municipal Solid Waste Generation and Disposal

Prior to evaluating specific aspects and requirements for a controlled landfill at the Abu Zaabal quarry site, a municipal solid waste generation database was prepared. This database includes population estimates, waste generation, collection efficiency and landfill size estimates. The database calculates these variables throughout a 20-year planning period. This database is intended to be a planning tool for the Governorate as it proceeds to upgrade solid waste management practices. It should be revised periodically to adjust for actual conditions encountered that differ from the assumed values. This database forms the basis for the population and municipal solid waste generation projections shown in Figures 3.1 and 3.2, and many of the numerical values presented in this report. The database summary is presented in Appendix 1.

The estimated waste generation (based on population and the unit generation rate) adopted for this evaluation is shown graphically in Figure 3.2 - Waste Generation and Collection. Municipal solid waste generation in 1999 for the Governorate is estimated at 1,723 tonnes per day that increases to 2,560 tonnes per day at the end of the 20-year planning period.

The quantity of municipal solid waste placed into the landfill in the future will be a function of increasing population and the expansion of the landfill service area to other areas thereby increasing the effective population served by the landfill. The amount for solid waste generated in the Governorate may be different that the amount actually received for disposal. The difference between generation and collection rate is the result of informal disposal. animal feeding and recycling that occurs in the service area. Figure 3.2 presents the amount of solid waste received at the disposal site based on a 50% collection rate. As the collection rate increases the quantity of solid waste reaching the disposal area will also increase. While it may be the objective of the Governorate to increase the percentage of waste collected, this disposal estimate assumes the 50% collection percentage will remain constant throughout the 20-year planning period. An increase in the collection/generation ratio will lead to a faster depletion of the landfill capacity. The last column in the waste generation database in Appendix 1 shows the depletion rate of a quarry #1 landfill based on the quarry volume from the existing water surface to the lip of the quarry. The actual depletion rate and the time that it takes to completely deplete the landfill design capacity is a function of the exact depth of the quarry and the potential for vertical expansion above the quarry lip. Generation of waste receipt data as solid waste is received at the landfill will become an important planning tool to estimate the time remaining before the quarry will be completely filled.

Figure 3.2
Waste Generation/Collection



3.4 Industrial Waste

The characteristics of industrial waste that may be received at the disposal site is a function of the type of industry generating the waste. For example, the relocation of lead smelters and foundries to land adjacent to the disposal site will lead to the generation of residual slag that will need proper disposal. The physical (quantity, particle size gradation, etc.) and chemical (leachability of lead and other substances, etc.) characteristics of this form of industrial waste will determine the environmental and operational effects of disposing of this material in the landfill. Initial analytical results based on USEPA Toxicity Characteristic Leaching Procedure (TCLP) testing of typical lead smelter slag by Chemonics for lead leachability indicated that the material would not be classified as a hazardous waste under United States hazardous waste regulations that are the most stringent in the world. The TCLP test is the most common laboratory test used in the United States for characterization of solid waste as either hazardous or non-hazardous waste.

The collection of data on hazardous and non-hazardous solid waste in Egypt has been hampered by the lack of a national classification system. A critical element in the management of hazardous and non-hazardous solid waste is a clear definition of what constitutes a hazardous waste. In Egypt, the process is still evolving for defining hazardous waste and developing regulations and procedures for managing those wastes. The Egyptian Environmental Affairs Agency (EEAA), in conjunction with six ministries, is developing a national hazardous waste classification system. The Ministry of Industry has prepared a draft document that identifies and lists a number of hazardous wastes that are either specific to a particular industrial sector or common to all sectors. This draft document is shown in Appendix 2. The document, however, has not been finalized.

In the United States, the European Union, and the Basel Convention, hazardous wastes are defined through a number of physical and chemical characteristics such as corrosivity, reactivity, ignitability, and toxicity. In addition, some waste materials are listed as hazardous waste because of their distinctively dangerous properties. Listed wastes do not have to be tested for the physical and chemical properties to be designated as hazardous waste. In case of off-spec and discarded chemicals, the United States system also includes a list of specific hazardous constituents of industrial chemicals that, if present in the waste stream, make it a hazardous waste. Under all of these systems, if a waste is generated from combined industrial processes, and cannot be accurately identified as a specific listed waste (such as dewatered sludge filter-cake from an industrial wastewater treatment system), the characteristic waste criteria are used to determine if it is a hazardous waste. The use of characteristic waste criteria requires some laboratory tests.

In the case of the Abu Zaabal landfill, a survey should be completed to define the sources and characteristics of industrial waste generated in the Governorate. The criteria for this survey should be based on that under development by the Environmentally Friendly New Industrial Cities (EFNIC) initiative by EEAA. Currently, that project is focusing on industries in the 10th of Ramadan industrial city. Through a similar survey, the Governorate can begin the process of determining if there are any hazardous wastes that should be precluded from the quarry landfill. An example of a generic industrial waste definition survey form is shown in Appendix 3.

There are approximately 1,577 industrial establishments in Qalioubiya Governorate. Each industry is responsible for the transportation of its own waste materials to the disposal site. The Governorate estimates that about 50 truckloads of industrial waste are received at the disposal site each day. The following table presents a general characterization of the types of industries found within the Governorate.

Table 3.1
Governorate Industrial Base

Industrial Sector	Number Of Industries	Percent Of Total
Chemical	339	21.5
Construction Materials	79	5.01
Metallic	73	4.63
Engineering	337	21.37
Xylose	60	3.8
Textile	475	30.12
Paper	41	2.6
Food	168	10.65
Other	5	0.32

3.5 Nature of Wastes (Hazardous, Non-hazardous, Medical, etc.)

Concern about "hazardous" waste is universal. In many cases, this type of waste can cause significant environmental damage if not handled or disposed of properly. Additionally, direct exposure to this type of material can be very dangerous for the people who must manage and handle the material as well as for those who inadvertently are exposed to it such as scavengers or those receiving materials extracted from disposal sites. Disposal facilities required for management of hazardous waste are usually designed based on the dangerous characteristics of these materials. As a result, they are very costly to build and operate. (It is important to note that the terms "hazardous and non-hazardous" are relative. Municipal and non-hazardous industrial solid waste will still have properties that can cause environmental damage or pose a danger to public health if not managed properly.)

In Egypt, hazardous wastes are regulated through a number of Articles in Law #4. (The Law for the Environment). A permit process exists and permits are issued through the Ministries responsible for the sector in which the hazardous waste is generated. For example, the competent agency for any industrial facilities within the Qualiobiya Governorate is the Ministry of Industry. The Ministry of Industry has established two lists of hazardous waste. One is specific to particular industrial sectors while the other is a general list of hazardous waste common to all sectors. These lists are shown in Appendix 2.

Hazardous waste, by their nature, can cause significant environmental damage and can be very dangerous for the people who come into direct contact with them. Disposal sites such as the Abu Zaabal quarry landfill will need to guard against the receipt of hazardous waste. Operators will need to be trained to identify materials that may be hazardous so that appropriate measures can be taken to block the receipt of such materials and to effectively manage and handle them if they are inadvertently received.

Other materials such as waste derived from medical facilities such as the 177 hospitals in the Governorate may also have dangerous properties that must be carefully managed. Typically, some components of waste from medical facilities may still contain infectious properties that can be dangerous to anybody exposed to these wastes. In many countries, medical waste generators are required to eliminate the infectious properties of their materials prior to transport to disposal sites or to ship their infectious waste to private companies who are equipped to manage and destroy the wastes' infectious properties. In the Abu Zaabal service area, medical waste may be transported to the quarry site for disposal. Site operators will need to be trained to identify these materials so that they can be safely managed without exposing site operators and others to the dangerous properties of the material.

The receipt of potentially infectious and hazardous waste is one of the important reasons why scavengers should not be allowed to forage through the waste received at a disposal site looking for materials with intrinsic value. Exposure to hazardous and infectious waste during scavenging can affect the health of scavengers as well as to those eventually exposed to materials that are removed from the landfill by the scavengers.

3.6 Waste Collection Practices

The interface between the waste collection system and the disposal area is very important in defining landfill access design as well as operational procedures required to effectively handle truck traffic and waste receipt. One basic objective of landfill operations is to keep the area where waste is received as small as possible. This is especially important if daily cover is applied to the solid waste placed in the landfill since the amount of daily cover required is a function of the surface area to be covered. Since the size of the active waste receipt area will be a function of the number of trucks at the landfill at any one time, the function of the waste collection system greatly influences operations at the landfill. Different truck designs affect the time that it takes to empty the truck at the disposal site. It often takes more time to empty a small static bed truck than it does to empty a large capacity waste packer. Currently, waste is delivered to the disposal area by public and private trucks. Typically, was delivery is accomplished by about 100 public collection trucks, 50 private sector waste haulers and 50 trucks owned by the industries in the Governorate. Ultimately, the success of operations at an upgraded landfill will require close cooperation between then operators of the landfill and those involved in delivering waste to the site.

Section 4
Environmental

4.1 Hazards

Because of the nature of uncontrolled solid waste management, environmental hazards to potential receptors via air and water are numerous. Common hazards, pathways and receptors associated with solid waste landfills are shown schematically in Figure 4.1 on the following page. Based on our site visits, there are four principal hazards specifically identified as the most significant factors at the quarry disposal site. These are described as follows:

1. **The smoke generated from the fires.** This smoke can contain toxic substances that not only endanger the lives of operators but also nearby neighbors of the Abu Zaabal quarry site. Smoke can cause respiratory ailments. Due to the toxic nature of some of the substances disposed on in the landfill exposure can increase the risk of cancer or other significant maladies to those who inhale the smoke. The smoke can also significantly affect the industries that will be developed on the land adjacent to the quarry.

2. **Dust generated by the movement of vehicles on unpaved roads.** Dust particles inhaled by workers and others could pose a serious risk of silicosis and other respiratory ailments through long-term exposure.

3. **Leachate.** Leachate from the landfill can severely pollute large portions of adjacent aquifers and because dangerous, toxic compounds are commonly a part of the overall composition of the landfill leachate, the contamination of the accumulated water in the quarry is of particular concern. Leachate from solid waste disposal sites is a highly mineralized liquid containing constituents such as chloride, iron, lead, copper, sodium, nitrogen, and various organic chemicals. Manufacturing wastes can add hazardous constituents such as cyanide, cadmium, chromium, chlorinated hydrocarbons, and PCBs. Table 4-1 shows the ranges in leachate concentration for various chemical constituents and physical properties from typical municipal solid wastes.

   For the Abu Zabaal landfill, it is not possible to fully address the chemical characteristics of the quarry water at this time because of lack of chemical data. Samples have been collected and analyzed for total dissolved solids, pH, specific conductance, and temperature. Sample locations are shown on Figure 2.1. Test results are shown in Table 4.2. These preliminary results seem to support the fact that the water in the quarry has become significantly polluted because of the disposal of solid waste into the quarry.

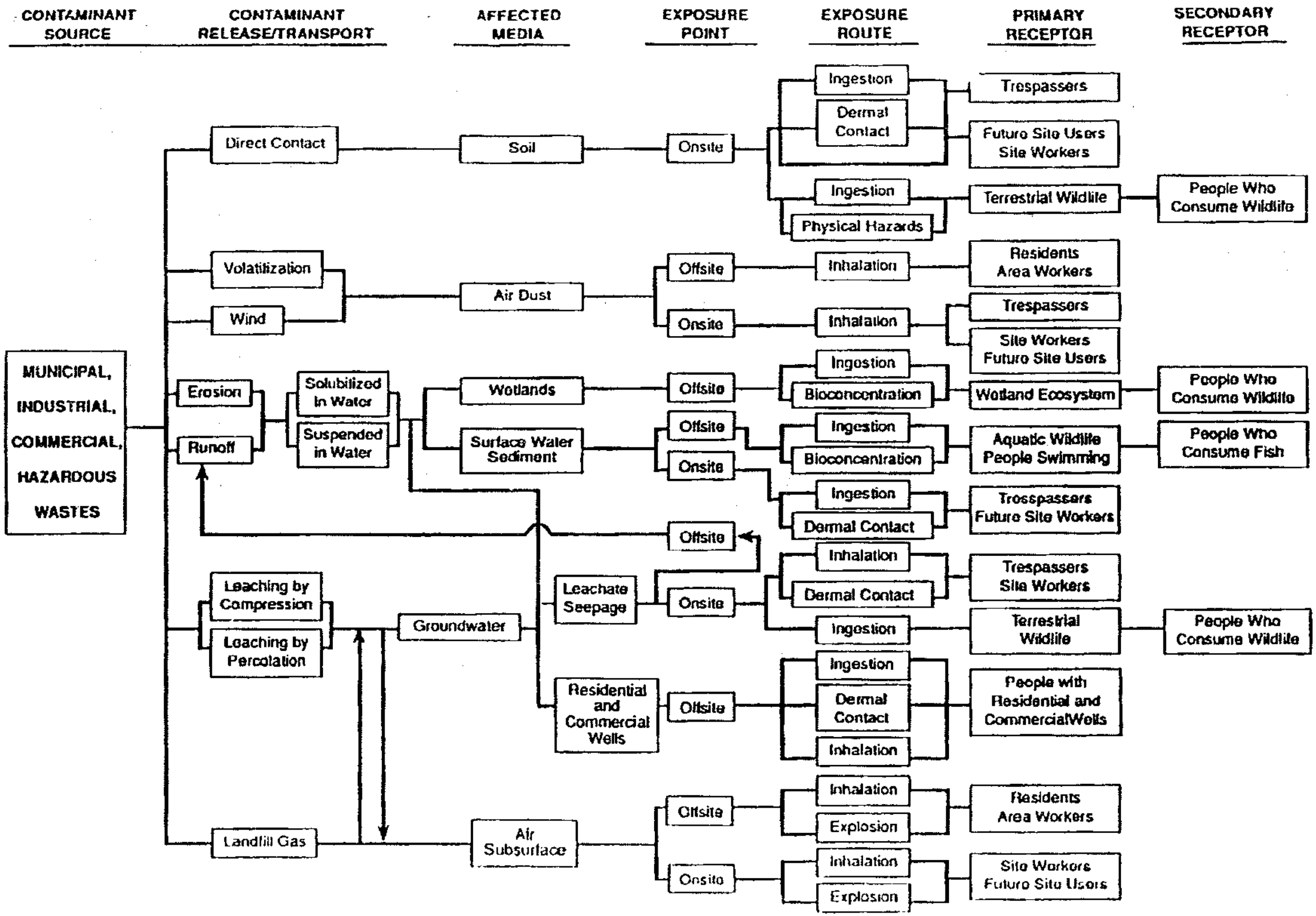


Figure 4.1
Landfill Hazard/Pathway/Receptor Schematic

4. **Landfill Gas Migration.** Waste decomposition in any landfill will lead to the generation of gases that can be dangerous. Adequate venting is required to assure that landfill gases do not migrate from the landfill site.

5. **Chemicals that could come into direct contact with workers**. Because of the nature of any landfill, workers and operators can come into direct contact with wastes that could consists of solvents, PCBs, medical wastes, paints, and other waste forms that are hazardous to human health.

Table 4-1
Leachate Characteristics from Municipal Solid Wastes

Components	Median Value (mg/l)	Ranges of All Values (mg/l)
Alkalinity	3,050	0 – 20,850
Biochemical oxygen demand (5 day)	5,700	81 – 33,360
Calcium	438	60 – 7,200
Chemical oxygen demand (COD)	8,100	40 – 89,520
Copper (Cu)	0.5	0 – 9.9
Chloride (Cl)	700	4.7 – 2,500
Hardness as $CaCO_3$	2,750	0 – 22,800
Iron, total (Fe)	94	0 – 2,820
Lead (Pb)	0.75	<0.1 – 2.0
Magnesium (Mg)	230	17 – 15,600
Manganese (Mn)	0.22	0.06 –125
Ammonium-N (NH_4)	218	0 – 1,106
Potassium (K)	371	28 – 3,770
Sodium (Na)	767	0 – 7,700
Sulfate (SO_4)	47	1 – 1,558
Total Dissolved Solids (TDS)	8,955	584 – 44,900
Total Suspended Solids (TSS)	220	10 – 26,500
Total phosphate (PO_4)	10.1	0 – 130
Zinc (Zn)	3.5	0 – 370
pH	5.8	3.7 – 8.5

Table 4.2
Quarry Lake Sample Testing Results

Parameter	Sample 1	Sample 2
pH	7.22	7.16
Electrical Conductivity, µm	7,600	7,300
Total Solids, ppm	15,270	13,800
Total Dissolved Solids, ppm	5,431	4,956

4.2 Environmental Impact Pathways

There are three possible pathways to people for the hazards presented above. These are air, groundwater and direct contact. The following presents a brief evaluation of these pathways and the potential receptors that are at risk. In addition, a management approach is presented that will be incorporated into the overall landfill development and operations plan for the site. Because of the limited data available, the following analyses should be considered as preliminary based on our current knowledge of the site. As more information becomes available, more detailed analyses can be made to further quantify the potential impact on identified receptors.

Air – The direct pathway to workers and the adjacent population for smoke and dust generated at the site is through inhalation of polluted air. As mentioned earlier, the primary wind is from the northwest and northeast to the south. However, it is believed that the winds at the sites are quite variable. It should be noted that detailed modeling of potential air pollution was not a part of the scope of work for this project. However, a Gaussian Plume Model was performed by Chemonics Egypt in November 1999. The results of this model are presented in Appendix K of a document entitled *Support for Selected Activities under the Lead Smelter Action Plan: Industrial Relocation in Abu Zaabal.* This model assessed the environmental impact of the effect of stack emissions in the proposed industrial site on the ambient quality of the air. Although not directly applicable to the smoke and dust generated at the landfill site, the model did indicate that, to minimize air quality impacts, the heights of any stacks should be at least as high a the highest building plus 1.5 times the smallest building. Given the current dust and smoke pollution generated on site near ground level because of burning waste in the landfill, the impacts from the landfill to the air would probably be greater than any industrial sources moved to the area.

Water – Groundwater is the only pathway for the polluted water in the quarry to reach receptors. At this time, little information is available on the groundwater at the site. There are no monitoring wells nearby to determine water levels or water quality. No pumping tests have been performed to determine the hydraulic properties of the aquifer and the depth of water in Quarry #1 is not known. In addition, it is uncertain at this time as to whether or not the basalt or the sediment above the basalt is the main aquifer feeding the quarry water accumulation.

We do know that the water in the lake has to be maintained by groundwater inflow. Otherwise the quarry would be dry given the difference between precipitation and evaporation rates in the region in which the quarry is located. This water may come from the Ismailia Canal whose elevation is approximately 5 meters above the level of water in the quarry. We also know that the regional groundwater hydraulic gradient is 0.0025 m/m to the north. Samples taken at the site by Chemonics Egypt indicate that the mean grain size D_{50} is approximately 0.6 mm and D_{10} is about 0.02 cm. These sediments consist of medium to fine grained sand. Assuming that the aquifer at the site has similar characteristics, then the permeability of the sediment can be calculated through a formula based on Hazen (Freeze and Cherry, 1979) where:

$$K = 1.0d_{10}^2$$

The permeability of the sediment is calculated to be 0.0004 cm/sec (3.45 m/day). Assuming a porosity of 30%, the groundwater travel velocity can be calculated using Darcy's law where:

$$v = ki/n \text{ where:}$$

v = velocity (m/sec)
i = hydraulic gradient (m/m)
n = porosity

The approximate groundwater travel velocity for the site aquifer is calculated to be 0.028 m/day or 11 m/year. Because of preferred pathways along the top of the basalt or through paleochannels, this travel time could be substantially higher. Further evaluation is required before doing any additional detailed analysis of the groundwater pathway.

Additional work has been completed by Dr. Mohamed Ibrahim Elenbawy (Geologist) from CEHM of Cairo University to evaluate the hydrogeological characteristics of the quarrys in question. Dr. Elenbawy has submitted a technical report to EEAA regarding geological and hydrogeophysical analysis for the quarries. This his evaluation, Dr. Elenbawy believes that the source of water in the quarries is coming from over irrigation of agricultural lands near the site and rather than from the Ismailia canal for the following reasons:

- The high salinity of the water from both Quarry #1 and #3 (Water analysis completed as part of Dr. Elanbawy's work is shown on the following page.)
- The springs that appears in many spots of Quarry #3
- The quantities of water that pumped from Quarry #3 every day should have some impact on Ismailia canal If it is the major source of this water.

Dermal Contact. The most direct pathway for chemicals and other hazards deposited in the landfill is by direct dermal contact. This most likely happens every day to the workers and operators. Improving landfill operations will help in eliminating this pathway. In addition, proper training can help site operators understand the dangers associated with the materials that they handle and the procedures that they should follow to minimize their contact with the material.

4.3 Receptors

A receptor is either a person or an animal that is most likely at risk due to the hazards posed by the landfill. A receptor could inhale the smoke generated by the fires or dust from the movement of vehicles. He or she could also come into direct contact with the solid waste and particularly dangerous substances such as hazardous or infectious waste. Contaminated water resulting from landfill operation can be consumed by people who use nearby wells, passed through the irrigation of crops with contaminated water, or consumed by animals drinking directly from the lake.

The principal receptors to the hazards posed by the current landfill operation are the operators, workers, truck drivers, and near-by residents who are exposed to the smoke, dust and solid waste at the landfill every day. In addition, scavengers, dogs, birds, and rodents at the landfill are also considered to be major receptors. At this time, potential receptors of contaminated groundwater have not been identified. To do

Table 1 TDS Analysis

Sample No.	Location	Conductivity µs	TDS Mg/L
1	Quarry III	6020	3630
2	Quarry III (springs)	6620	3980
3	Quarry I	6290	3780
4	Ismailia Canal	408	249

Table 2 BOD Analysis

Sample No.	Location	BOD (mg/L)	Water Pollution
1	Quarry III	10.8	Non
2	Quarry III (springs)	3.5	Non
3	Quarry I	225	Polluted
4	Ismailia Canal	2.5	Non

Table 3 TSS Analysis

Sample No.	Location	Total Suspended Solids (TSS) (mg/L)
1	Quarry III	Almost Zero
2	Quarry III (springs)	Almost Zero
3	Quarry I	1026
4	Ismailia Canal	Almost Zero

Table 4 Heavy metal Analysis in ppm

Sample No.	Location	Zn	Cu	Ni	Cd	Pb	Ar	Se
1	Quarry III	0.194	0.001	0.15	0.001	0.04	0.0008	0.0002
3	Quarry I	0.255	0.037	0.032	0.001	0.031	0.003	0.0005

4.4 Managing to Reduce Risks

In the development of this landfill development and operations plan, special emphasis is placed on managing the landfill to reduce risks to people and the environment. Priority is given to improving operating conditions that affect the health and safety of the operators and the area surrounding the landfill. By improving the physical handling of the solid waste, the Evaluation Team believes that risk of death or severe injury of machine operators can be reduced. An important aspect of the landfill development and operations plan is, therefore, (if at all possible) to operate the landfill from the bottom of the quarry up. In doing so, Quarry #1 would have to be dewatered. This water could then be used to put out fires and for dust control. By eliminating the fires and reducing dust, the risk to operators and neighbors of respiratory illness due to inhalation of smoke that could lead to disabilities or even death would be greatly reduced. Finally, by dewatering the quarry, contaminated groundwater will flow toward the quarry pit and reduce the contamination of the surrounding aquifer. This would reduce the hazards that contaminated water would pose to irrigated crops and to drinking water supplies downgradient from the landfill.

Section 5

Near Term Management Recommendations

In developing this landfill development and operations plan, the importance of establishing both near and long-term management recommendations to mitigate existing and potential negative effects was recognized.

5.1 Objectives of Near-Term Management Recommendations

The objective of the near-term management recommendations is to describe a number of steps that can be taken now to help address some of the problems currently experienced at the disposal site. These steps are aimed at achieving quick results that can also help foster the development of the longer-term management recommendations described later in this report.

5.2 Quarry Dewatering

One of the biggest problems facing the Abu Zaabal Quarry is the water accumulated at the bottom of the quarry excavation. As mentioned earlier, this accumulation is believed to be fed either by groundwater whose source is the Ismalia Canal or over irrigation of land near the quarry landfill site. The source of the groundwater is believed to be the sandy aquifer overlying the basalt. Irrespective of its source, this water poses many difficulties on the operation of a landfill in the quarry, including:

- The inability for the Governorate to build the landfill from the bottom up at the base of the quarry.
- The inability of equipment to operate at the bottom of the pit to physically handle the solid waste to form safer slopes or to compartmentalize the landfill.
- The development of a pathway for pollution to surrounding areas.
- The inability to place a soil or other lining system on the bottom of the quarry to prevent or minimize pollution should that be necessary based on the condition of the base of the quarry.

By dewatering the base of Quarry #1, these difficulties could be mitigated. In the short term, water from the quarry could be used for putting out fires and dust control. At the same time, the pumping of water from the quarry would form a cone of depression preventing polluted water from leaving the landfill. Currently, the exact depth of the water (and therefore the volume of water held in the quarry) is not known. It is also uncertain as to the flow rate of the groundwater feeding the quarry. Before the development of any dewatering plan is completed, these factors must be evaluated further for both short- and long-term planning.

The following presents rough estimates for the volume of water in the quarry and groundwater pit inflow. These estimates are used for planning purposes only and to present an approximate estimate of the volume of water that the operators would be dealing with in attempting to dewater Quarry #1.

Figure 5-1 is a stage volume curve of the quarry accumulation based on an assumed area of 27 feddans. From this graph (if the accumulation is 0.5 meters deep) the total volume would be 56,709 cubic meters. It is estimated that the depth of the water is 3 to 4 meters deep. Again from the graph, this would imply that there is approximately 340,251 to 453,668 cubic meters of water that would have to be pumped out of the quarry to allow for operations in the bottom of the quarry pit.

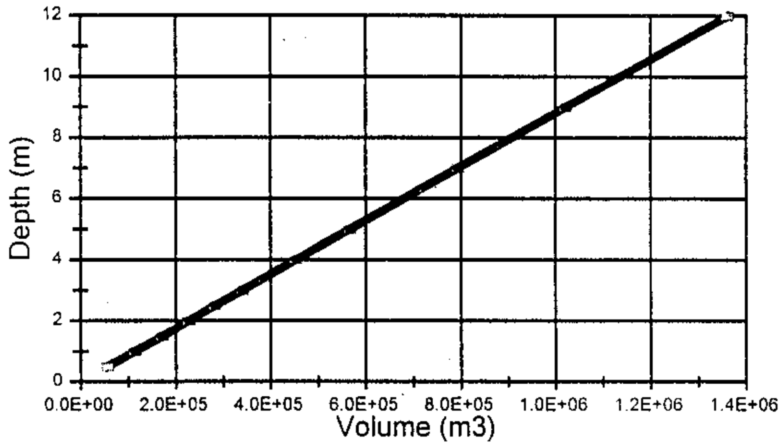


Figure 5.1 - Stage Volume Curve

Groundwater inflow into the quarry was determined using an analytical model based on the method developed by Muskat (1937). This model simulates groundwater inflow into an open pit by defining a line sink of finite length and width, rather than a circular well. The equation for the steady-state draw down caused by a finite length line sink is presented as follows:

$$s(x',y') = [(Q/2BT)\{\ln(b+c^2+b^2)^{05}/c\}]-\cosh^{-1}[H(x',y')]$$

where:

s(x',y') = drawdown at point x',y'
Q = discharge
T = transmissivity
B = radius of influence
C = ½ of length of line sink
x' = one component of the vector from the middle of the line sink to the point of interest
y' = the other component of the vector from the middle of the line sink to the point of interest

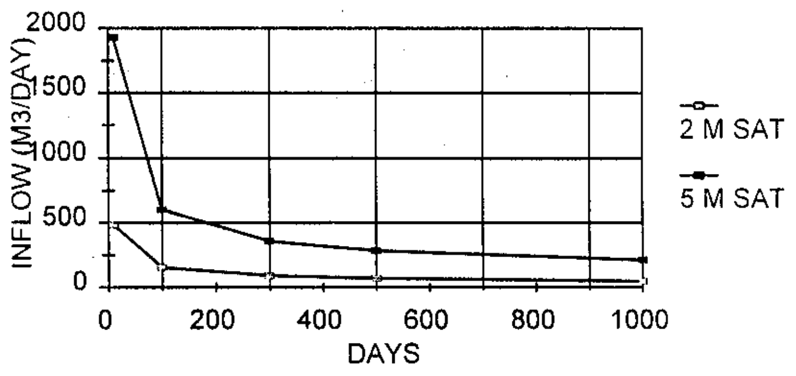
$$H(x',y')= (x^2+y^2+c_2+[(x^2+y^2+c_2)^2-4x_2c^2]^{.5}/2c^2)^{.5}$$

This equation was developed into an analytical model by Koch (1983) to approximate inflow and recharge into open pits using a method of successive steady-states to simulate changes with time.

For the modeling of the Abu Zaabal quarry, two line sinks were used to simulate the final quarry floor below the water table; one trending to east-west 337 meters long and the other to the north-south 337 meters long. These sinks were based of measured pit area of 113,569 m^2. For the modeling effort, a value of hydraulic conductivity of 3.45 m/day based on grain size distribution was used for pit inflow calculations. Storativity was estimated to be 0.3 based on the assumed porosity of the sand aquifer. It was assumed that the saturated thickness of the sand aquifer was between 2 to 5 meters and that the basalt was effectively non-aquiferous. The results of the model are presented in Figure 5-2. Assuming a saturated thickness of 5 meters, peak inflow into the pit would be about 2000 m^3/day (about 23 liters/seconds) decreasing to about 215 m^3/day (2.5 liters/min) 1000 days after the quarry pit was allowed to infill. **These flows are considered relatively low and can be easily managed.**

It has come to the Evaluation Team's attention that El Karakat El Masrya is operating Quarry III which is south of Quarry I and II. Quarry III has an area of approximately 60 Feddans. To dewater this quarry, it takes nine pumps operating at 66 l/s over 24 hours. At this rate, about 51,000 m^3 is being pumped every day. For an adjacent quarry used by the Dredges Company, many seeps have observed with water flowing to the bottom of the quarry. This water is believed to be coming from the Ismailia canal or from over irrigation of land near the quarry. The Dredges Company is currently using about 6 pumps to dewater the quarry to the operating level and another series of pumps to discharge a canal. It took about a month to dewater that quarry. With this in mind, it would imply that the estimates presented above may be too low for dewatering the quarry and that the current conceptual hydrogeologic model should be evaluated in more detail.

Figure 5.2: ABU ZAABAL LANDFILL
PIT INFLOW ASSUMING K= 3.45 M/DAY



For the planning purposes let us assume that the project inflow into the Quarry I is roughly one-half that of what is being pumped from El Karaka El Masrya based on the difference in area between the two pits. This would imply that it would take 3 pumps operating at 66 l/s to continuously dewater the quarry. This value, however, does seem high considering the fact that operators of the landfill indicated to us that Quarry #1 was dry during its initial operational period.

Using these estimates, a water management plan can be developed for both short- and long term management planning. Dewatering for the short-term would begin with the use of large capacity pumps to dewater the quarry as quickly as possible. The rate of this initial pumping would largely depend on the types of pumps available and the ability of the operation to store and utilized the water for fire and dust control. It is recommended that high capacity turbine pumps with trash racks that could be placed on floating barges be used. After using pumped water to put out the fires along the face of the current dumping location, water from Quarry #1 may be pumped into Quarry #2.

Once the quarry is dewatered, long-term management of the groundwater seeping into quarry pit (that is estimated to be relatively low) will have to be considered. This will be discussed later in this report.

If Quarry #1 cannot be dewatered effectively because of lack of equipment or due to cost, serious consideration should be given to the use of Quarry #2 as a site for new controlled landfill at its base. However, it is recommended strongly that every effort be made to dewater Quarry #1 using rental equipment if necessary. In the long run, this would add greatly in protecting the groundwater and the environment from the pollution that has already occurred in the water contained in Quarry #1.

5.3 Interim Leachate Control

Currently, any leachate originating from the solid waste placed in the quarry seeps directly to the water at the base of Quarry #1. The water is contaminated not only by the leachate but also by direct contact with waste that falls down the fill slope and rests directly in the water. The ability to control leachate originating from the current disposal configuration depends on the ability to dewater Quarry #1 as described above. If dewatering can be accomplished and quarry water inflow seepage is determined to be minimal (as expected based on the above calculations), leachate and a minimal amount of contaminated polluted seepage water can be collected and treated through a series of evaporation ponds in Quarry #2. Outflow from the evaporation ponds could then be diverted to existing wetlands in Quarry #2 for treatment and seepage. The feasibility of achieving this form of interim leachate control depends on the information gained on the amount of water in the base of Quarry #1 and the rate of inflow seepage into it. A more detailed discussion of leachate generation and control is presented in Section 6 later in this report.

5.4 Fire Management

One of the most visible and important problems associated with the current operation of the quarry landfill are the fires along the side slope of the solid waste accumulation. Because of their side slope location, it is difficult to extinguish these fires. This difficulty will continue so long as waste is placed into the quarry in the current manner.

In the near term, an attempt should be made to manage fires using the water from the Quarry #1 accumulation. As discussed above, quarry dewatering is an important element in eliminating the potential groundwater resource effects of using the quarry as a landfill. During any evaluation of quarry dewatering using pumping, consideration should be given to using the pumped water to extinguish the existing fires. Once current fires are extinguished, new fires should be controlled in the following manner:

- Any waste loads received at the landfill site that are on fire or smoldering should be off loaded in a special designated area where the fire can be extinguished before placement into the landfill. Fires can be extinguished by smothering with soil materials or through the use of Quarry #1 water.
- If the pump system is available or if water has been stored at a location where it is accessible to operations personnel, any fires that are accessible should be extinguished as soon as possible and not allowed to spread.
- It should be disposal area policy that all fires are to be extinguished every day. Fire prevention and elimination should be one of the top priorities of landfill operators in ongoing operations.

5.5 Waste Receipt Control

In the near term, waste control procedures should be adopted at the landfill to minimize environmental and health/safety effects relating to some types of waste materials. Initially, landfill operators should be trained to identify particularly dangerous waste materials to limit exposure to their properties. At a minimum, the following waste receipt rules should be adopted and operators trained in accomplishing them:

- Only authorized waste transporters should be allowed to use the disposal facility. The current permit program should be expanded to require permit scrutiny and inspection of all loads received from industrial sources.
- No liquids should be allowed to be deposited in the landfill including full or partially full containers.
- Any loads with evidence of fire should be offloaded in the hot load area and the fire immediately extinguished using soil cover or water from the quarry.
- Scavengers should not be allowed to forage for any materials deposited at the landfill.
- All waste delivery vehicles should be required to leave the disposal site as soon as the have completed off-loading.
- No waste should be allowed to be delivered at any time when the disposal site is not staffed.

5.6 Access Control

The ability for trucks to access the disposal site at any time when the landfill is not staffed should be limited. Locking gates should be installed that would prohibit trucks from entering the site outside of designated hours of waste receipt. If possible, the landfill access road should be configured so that trucks or any other vehicles cannot get into the disposal area when the facility is closed. Strategically placed and maintained rock or soil piles could aid in this purpose.

5.7 Training

Landfill operators should be trained on a number of matters for effective operation of the disposal site. These include:

- Operating responsibilities
- Identification of dangerous waste
- Effective management and handling of dangerous materials, if received
- Health and safety
- Waste control and receipt procedures
- Landfill administrative procedures (permit review, etc.)
- Field mechanized equipment operation and maintenance procedures (for equipment operators)
- Environmental monitoring primarily groundwater
- Fire elimination and prevention

Specifically, training should be presented to landfill managers and personnel based on their particular responsibilities. Sample agendas for training for 1) managers and supervisors, 2) equipment operators and 3) laborers are presented in Appendix 4.

Section 6

Long Term Design and Construction

6.1 General

As soon as possible, the site should be converted to a controlled landfill in either the base of Quarry #1 or Quarry #2. The ability to accomplish this is a function of many factors, including the:

- Ability to dewater Quarry #1 (As an alternative to dewatering the quarry, consideration may be given to filling the base of the quarry with demolition or other rock based material to a level above the current elevation of water. The ability to consider this alternative is a function of the depth of water in the quarry.)
- Development and control of site access to the base of either quarry.
- Management of water entering the quarry excavation after construction of the controlled landfill at the base of either quarry.
- Maintenance of environmental controls to manage potential effects.
- Management of leachate.
- Control and management of landfill gas.

With these in mind, the design and construction of a safer and more environmentally sound landfill can be developed.

6.2 Landfill Capacity and Airspace

The waste generation database, presented in Section 3, includes estimates of required landfill capacity based on several variables. These include current population, expected population growth, per capita waste generation, solid waste collection efficiency and landfill operations.

One of the objectives of the database was to estimate the life expectancy of any landfill developed within the quarry proper. The results of the database indicate that the full 53 feddan quarry #1 and #2 configuration will last approximately 10 years when filled to the current lip of the quarry excavation. If only Quarry #2 is used because of an inability to dewater Quarry #1, it is expected that it will take approximately 5 years for the site to be filled to the quarry lip level. Any change in the waste generation variables list above can influence the length of time that it will take to fill the quarry.

The actual design capacity of the landfill will need to be revised depending on the actual elevation of the base of the Quarry #1 excavation beneath the current water level. Based on a preliminary visual assessment and preliminary topographical survey of the quarry size, the quarry may have a usable volume of approximately 1,922,000 m^3 if it is assumed that the water depth is a uniform 5 meters. Based on the assumptions used in the waste generation database, the usable volume would last for about 5 years assuming effective solid waste placement, cover and compaction practices in the operation of the site. This estimate of life expectancy is based on controlled landfill practices (compaction, cover, etc.) as outlined in this report.

It should be noted that the actual use capacity for the quarry site is greater than the above estimates of available volume. Vertical expansion above the lip of the quarry is possible so long as reasonable fill placement and compaction practices are followed. Many controlled landfills are constructed above grade. Generally, an above grade landfill should have a specified maximum side slope to assure structural stability. For example, once the quarry waste accumulation in Quarry #1 has reached the lip of the quarry, filling may continue vertically with a constructed landfill growing with a 25% side slope from the lip to an eventual 5% grade at its apex. This is illustrated in Figure 6.1 that shows the additional airspace that can be achieved within the quarry #1 area. It is very important to note that such a landfill configuration will only be successful if effective compaction and cover practices are followed in operating the landfill.

6.3 Site Access

The development of a controlled landfill at the base of Quarry #1 (dewatered) or Quarry #2 requires access to the base area. Currently, an access road exists on the southwesterly side of Quarry #1. Access to this location would require redirection of waste delivery vehicles to a new site access point. This may be accomplished by building a new access road connecting the northerly side of Quarry #1 to the southerly side at the current access road. This is illustrated in Figure 2.1. Such a dual access would allow for one directional traffic flow where trucks entering the quarry excavation would come in from one side and exit to the other. This would assist in managing traffic to and from the active disposal site. The access road would allow a number of trucks to access the tipping area located at the base of the quarry. The size of the tipping area would be based on the maximum number of trucks that would be expected to be received at any one time during an operating day.

A controlled access point to the base of the quarry area will provide the benefit of centralized control to the disposal area. This, along with the strict enforcement of a no dumping policy outside of the designated disposal area, will provide effective site access control. The steep slopes of the quarry will also help to keep scavengers from reaching the waste placement area and removing recovered materials.

6.4 Water Management

Providing that Quarry #1 can be effectively dewatered, the management of water in the quarry will be straightforward. To control leachate and develop a source of water to control fires, it will be important to divert seepage into the quarry base pit to a low point or sump for collection. From this point, collected water can be used for dust control and extinguishing fires. Designing and excavating a ditch at the base of the sand aquifer at the side of the quarry from which the groundwater is flowing can do this. Seepage into the quarry would be directed to the sump. Water then can either be stored in the sump or pumped. Because of the relatively low inflow rate expected over time (<0.2 m^3/min) much of the water will most likely be lost to evaporation. Should this be the case, leachate and pit inflow water as mentioned earlier from Quarry #1 could be pumped to designed wetlands in Quarry #2 for treatment.

As shown in Figure 2.1, the area in Quarry #1 may be subdivided by a constructed access road that allows trucks to get to the base of the quarry. Initial solid waste placement should begin in Area 2 against the back wall of the quarry. Area 1 could initially serve as an evaporation pond for leachate management. Once solid waste placement in Area 2 reached the location and elevation of the access road, solid waste filling in area 1 could begin and a new leachate evaporation pond may be constructed in Quarry #2.

6.5 Leachate Management

Ultimately, leachate migration and contact with groundwater poses one of the most significant environmental issues associated with the use of the quarry as a landfill. Groundwater resources, once polluted, are extremely expensive to clean up. Contaminants, particularly organic pollutants, can travel far and affect wells long distances from the disposal area. As a result, considerable attention needs to be paid to effective leachate management if long-term environmental damage is not to result from the quarry landfill.

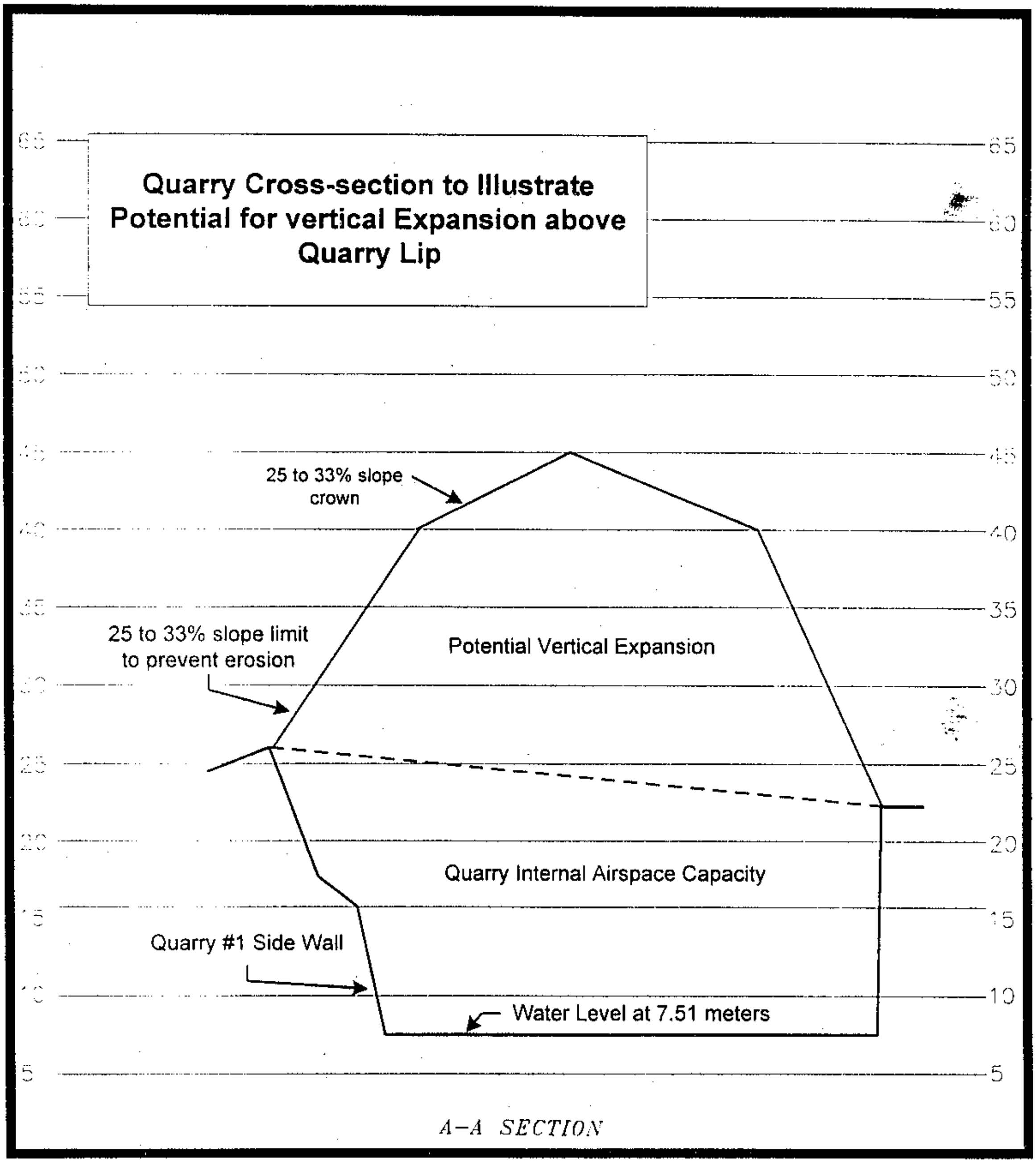
Leachate Generation - Leachate generation is a result of the organic decomposition of organic waste and will be a function of many variables. The chemical composition of leachate will be determined by the nature of the waste placed in the landfill. Qualiobiya Governorate is predominantly a residential/agricultural area with minimal commercial and industrial waste. This will result in a waste composition that is high in organic material and low in industrial/commercial waste that can contain organic pollutants and heavy metals. Industrial solvents and other such wastes can create pollutants that will travel greater distances in the soils under and adjacent to the landfill. Leachate produced in a quarry controlled landfill application will have a relatively high organic content (BOD) and low heavy metals content as compared to typical leachate produced in a landfill that receives a higher percentage of industrial waste.

The quantity of leachate generated in a landfill will be a factor of the initial moisture content of the waste (estimated at approximately 50%), rainfall and evapotranspiration. Evapotranspiration is the loss of water through evaporation and uptake by plants, and is a factor of sunshine, relative humidity and temperature. The analysis of rainfall and evapotranspiration is called a water balance. In addition to rainfall and evapotranspiration, waste in a landfill has a water storage capacity, which can be compared to a sponge. The waste storage capacity is called the field water capacity. The waste placed in a landfill will not produce significant leachate, until its water storage capacity is nearly full. This storage potential also allows uncovered waste to absorb water during periods of rainfall and then release that water during non-rain periods through evapotranspiration. The field capacity of the solid waste placed in the landfill can also serve as a means for diverting pumped water from the dewatering process.

The average annual rainfall in the area of the quarry, based on the recorded average, is 25.5 mm (1 inch), most of which falls between November and March. Typical rainfall distribution in the quarry area is as shown in Figure 6.2.

Figure 6.1

Quarry #1 Cross-section

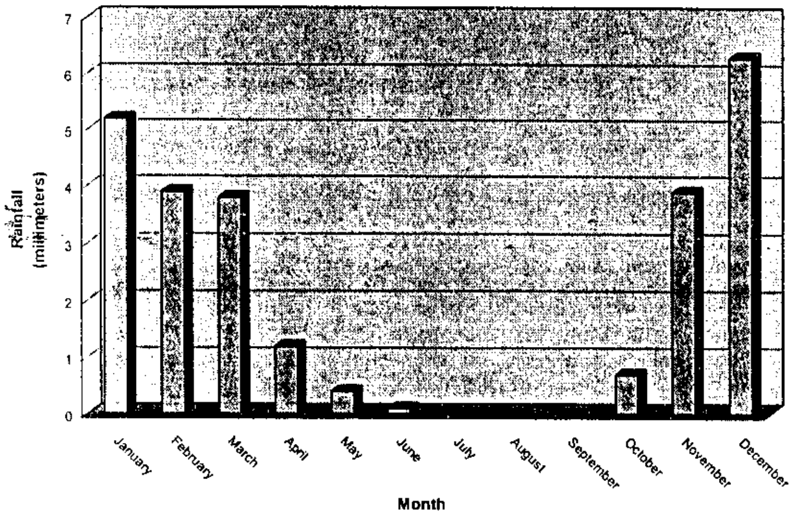


Note: 1. Base configuration of quarry to be be determined after dewatering
2. Internal Airspace Capacity Determined by quarry wall location and configuration
3. Vertical Expansion Airspace above quarry lip determined by side slope limitations (25 to 33% grade)

The combined effect of high evaporation and waste material field capacity should minimize the quantity of leachate generated and therefore increase the potential for effectively managing it. However, contaminants released in the water at the base of

Table 6.1

Monthly Rainfall Rates - Cairo Area



Quarry #1 cannot be controlled since they are potentially in direct contact with groundwater and can migrate through any groundwater flow paths currently available to the water in the quarry. If these flow paths are through fissures in the underlying basalt at the site, pollutants can flow significant distances without being treated through attenuation processes.

Leachate Management – Most soils on which surface landfills are placed have natural leachate attenuation properties. Attenuation is a technical term used to describe the many physical and chemical treatment processes that occur as leachate flows through natural soil. Depending on the characteristics of the soil on which the landfill is placed, these attenuation processes can be very effective in removing most of the pollutants typically found in leachate. Low permeability soil provides more effective attenuation treatment process that highly permeable soil or bedrock fissures. For example, very sandy soils will have few significant attenuative properties. Additionally, groundwater flow paths that are through bedrock fissures rather that soil provide little, if any, attenuation treatment.

The amount of leachate flowing from the landfill will vary based on rainfall patterns, depth of the landfill and the use of cover soil. A leachate evaporation pond may be used to collect and confine any leachate that may drain from the landfill. Depending of its base conditions, the pond should be lined with a clay soil to prevent leachate from entering the ground and to maximize evaporation potential. The pond should be shallow and have a large surface area to promote evaporation of the collected leachate. Initially, area 1 in Quarry #1 may be used for leachate evaporation followed by construction of a leachate evaporation pond in Quarry #2 once landfill operations begin in Quarry #1 – Area 1.

Leachate Collection - Leachate can only be collected if solid waste is placed over an impermeable surface that directs its flow to a point where it can be collected and treated. In many countries where landfill leachate collection is mandated in landfill design, low permeability clay liners or artificial prefabricated liners such as high density polyethylene (HDPE) are used to create the impermeable surface required for leachate collection and control.

In the current disposal configuration at the quarry, leachate collection is impossible since it flows directly into the water at the base of Quarry #1. In the development scenario where dewatering of Quarry #1 is possible, a soil liner may be installed as the first construction step to allow for diversion of any leachate to an interim collection point followed by transfer to a treatment location consisting of evaporation ponds and wetlands treatment in Quarry #2. The necessity of a soil liner will be a function of the final configuration and physical characteristics of the base of Quarry #1 and the nature of the basalt surfaces at the base. This can only be determined once dewatering has been completed. Such a system will be practical because of the low leachate quantity expected in the landfill operation resulting from prevailing local conditions.

6.6 Landfill Gas Generation and Management

Landfill Gas Generation - The same factors which control leachate generation also control landfill gas generation. Landfill gas contains methane, which can be explosive if it is permitted to migrate to and accumulate in a confined space. Both leachate and gas are products of the biological decomposition of organic waste. Landfill gas becomes a major concern if there is a potential for the gas to travel off-site and into nearby houses or other structures where explosions may occur when the gas comes into contact with an ignition source. During normal landfill activities, landfill gas will escape to the atmosphere through uncovered waste or through sandy intermediate cover soil.

Landfill gas problems normally occur only after the landfill has been completely filled and a final layer of impermeable soil cover is applied and compacted. This final cover soil may block the escape of gas to the atmosphere and gas vents are normally required through the final cover soil at the upper grades of the landfill to prevent a pressure buildup within the waste accumulation in the landfill. If gas pressure in the solid waste accumulation is allowed to increase, landfill gas can seek available points of least resistance such as pipe trenches, permeable soils, ledge fissures, etc. to flow to offsite locations. If these gases flow to a location where an ignition source is present such as house or garage, an explosion or fire can occur.

While landfill gas generation and management may be an issue in later years, it is not expected to affect required operating procedures in the near term other than to periodically monitor for landfill gas during operations. Regular monitoring for landfill gas production should occur in any location where an ignition source may be present.

Landfill gas is produced naturally as solid waste decomposes because of the biological action of microorganisms. In many countries, attention was drawn to the production of landfill gas because of explosions that occurred in areas where methane gas migrated from landfills. The effective management of landfill gas is important in the design and operation of a landfill for a number of reasons. If not properly controlled, landfill gas can:

1. Damage a closure cap system.
2. Destroy the vegetation that is important to the landfill cap structure. This destruction can occur because of the depletion of soil oxygen due to its physical displacement or biological reduction. The presence of primary landfill gas components (methane and carbon dioxide) cause a replacement of oxygen and vegetation effectively asphyxiates.
3. Create explosive conditions in the landfill or on at off-site locations.
4. Contribute to air pollution emissions in the form of trace organic compounds and "greenhouse" gases such as methane.
5. Create dangerous conditions for humans because of explosions, and the health effects of air emissions.

There are a number of factors that affect the production of landfill gas. Some of these factors are site specific to the location of the landfill while others are based on general characteristics that are experienced at all landfills. The properties of landfill gas are a function of the chemical constituents from which the gas is composed. Table 6.1 shows the typical composition of landfill gas resulting from the disposal of municipal solid waste. The actual composition of landfill gas generated from solid waste accumulated in the quarry landfill will be a function of the type of solid waste placed in the landfill.

The production of landfill gas is also influenced by moisture content and temperature in the landfill. Higher moisture and temperature generally increase the level of gas production by enhancing the solid waste decomposition process. Generally, between 7 to 9 cubic feet of gas can be generated per pound of dry organic matter. Based on the pace and phases in which this gas is created, between 0.05 to 0.2 cubic feet of landfill gas can be generated each year for every pound of solid waste disposed in the landfill.

Table 6.1
Major Inorganic Constituents of Landfill Gas

Constituent	Formula	Volume %
Methane	CH_4	0-85
Carbon Dioxide	CO_2	0-88
Carbon Monoxide	CO	0-3
Hydrogen	H_2	0-3.6
Oxygen	O_2	0-31
Nitrogen	N_2	0-82.5
Ammonia	NH_3	0-0.35 (vol. ppm)
Hydrogen Sulfide	H_2S	0-70 (vol. ppm)

The major gases generated inside of landfills are methane and carbon dioxide. The following outlines the characteristics and concerns associated with each gas.

Methane - Methane is a by-product of the anaerobic decomposition of the solid waste. Because of its explosion potential and its effect as an "greenhouse" gas, it is the landfill gas constituent of most concern. Methane is:

1. Colorless;
2. Odorless;
3. Tasteless;
4. Highly explosive (where its presence in air ranges from 5 to 15%)
5. Lighter than air; and
6. Insoluble in water.

Carbon Dioxide - Carbon Dioxide is a by-product of both aerobic and anaerobic decomposition that will increase water hardness and decrease water pH. Carbon dioxide is:

1. Colorless;
2. Odorless:
3. Heavier than air
4. Highly soluble in water; and
5. Noncombustible.

A combination of methane and carbon dioxide will displace soil oxygen and interfere with plant growth, possibly resulting in plant death.

Some of the other gases that are typically found in landfill gas at lower concentrations include:

- **Hydrogen Sulfide** - Hydrogen sulfide is a colorless gas that has a very strong and distinctive "rotten eggs" odor. This odor begins at very small concentrations (5 parts per billion). This gas is extremely dangerous and can be fatal at higher concentrations. One of the problems associated with hydrogen sulfide is that there is very little difference in odor between low and high concentrations of the gas. There have been a number of deaths associated with hydrogen sulfide exposure in sewer construction and maintenance projects. Death or serious illness can occur at about 300 parts per million (ppm) and OSHA recommends an that preventative actions be taken at exposures of 10 to 20 ppm. Hydrogen sulfide can be found in high concentrations in landfill gas when gypsum ($CaSO4$) is disposed of in significant quantities.
- **Other Trace Gases** - Other landfill gases produced include trace gases (usually 5% or less of the total volume). Hydrocarbons such as benzene and toluene may also be present in trace amounts. Other organic trace compounds include vinyl chloride, alkanes and esters. Nitrogen is produced initially at high levels, then drops rapidly until it stabilizes at trace levels.

A landfill contains an excellent environment in which to generate gas. The amount and quality of landfill gas generated in a landfill is important for a number of reasons. Both the type and amount of gas is a function of the type of waste placed in the landfill. The total amount of combustible gases emitted is a decisive factor in determining whether gas energy recovery is cost effective. The rate of landfill gas generation is governed by a number of factors, including:

1. Waste composition
2. Moisture content
3. pH, and
4. Nutrient availability

The movement of gas within the landfill is based on the characteristics of the landfill, surrounding soils conditions and gas properties. In general, gas migrates in response to pressure gradients. As the pressure of gas in the landfill builds, it will begin to escape since the pressure of gas in the landfill will exceed atmospheric pressure. The migration path is a function of the direction where the gas faces the least resistance toward its movement. The points of least resistance that determine the exit path for landfill gas are by:

1. Vertical migration through soils and cracks;
2. Lateral migration through coarse textured soil adjacent to the landfill when vertical migration is restricted; and
3. Migration along paths of least resistance until vertical openings permit the release into the atmosphere.

The presence of restrictive layers including clay or synthetic liners reduce vertical movement. However, this may have the potential of increasing the horizontal migration distances traveled by the gas. When considering the explosive nature of methane, this can present a significant danger. When coarse textured soils are used for daily cover, landfill gas migration usually occurs vertically through the cover. When the material used for cover is fine textured and impermeable, migration may be predominantly horizontal. Landfill gas will continue to migrate until the forces that caused migration are removed or until the migration path is intercepted. Things that can intercept gas migration routes are:

1. Pipes, conduits, drain tiles, sewers;
2. Building basements and crawl spaces;
3. Cracks in floors;
4. Barriers; and
5. Gas collection systems.

The rate and direction of landfill gas migration is dependent on several factors. These include:

1. Design of the landfill
2. Amount of soil cover;
3. Existing soil type;
4. Quantity of gas produced;
5. Air temperature;
6. Precipitation;
7. Barometric pressure;
8. Presence of natural or man-made barriers;
9. Presence of conduits/ventilation systems; and
10. Amounts of carbon dioxide and methane in gas.

An initial review of any landfill to determine the potential for gas migration should include consideration of the following information:

1. Depth and age of the landfill;
2. Types of solid waste in landfill;
3. Existing soil profile (layers, types and permeability of soil) at the landfill;
4. The possible existence of coarse soils (old gravel pits, etc.) adjacent to landfill.

The evaluation team believes that ongoing monitoring at the landfill should include monitoring for landfill gas migration at any locations where danger may exist. Passive gas vents may be installed as sections of the landfill are closed so as to relieve the pressure that may be created as landfill gas is generated, The simplest type of landfill gas collection systems are passive systems that make use of the vent trenches and vent wells without the use of mechanical devices such as pumps and blowers. The design premise of these systems is that gas movement can be accomplished by providing a pathway for gas to leave the landfill in a controlled location. In some landfills, passive systems are used to protect landfill caps. An example of a typical landfill cap passive vent system is shown in Figure 6.2.

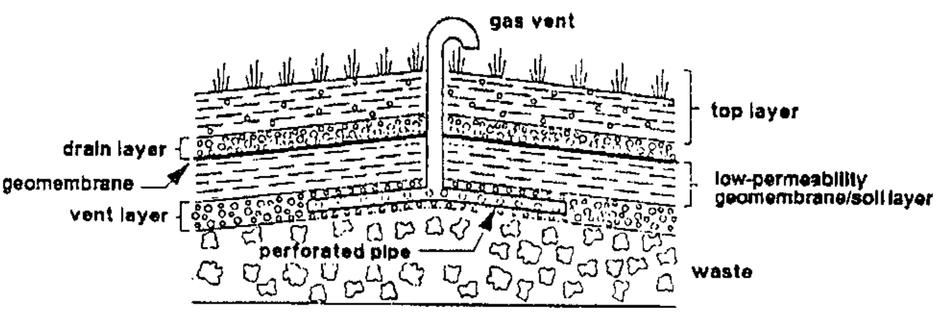


Figure 6.3 – Passive Gas Vent

In such systems, landfill gas flows through the porous layer such as coarse sand, just below the impermeable component of the cap. Once it reaches the vent, it flows out into the atmosphere because the vent provides the path of least resistance. This type of system relieves gas pressure under the cap and keeps the gas out of the root zone of the cover vegetation. The porous layer through which gas flows, can be made out of graded stone, sand or a synthetic material such as geonet.

Advantages of passive gas systems include the fact that they are inexpensive and require very little maintenance. In addition, passive gas systems may be converted into an active system by interconnecting passive vents to a header system and applying the mechanical action that forms the basis for the active system design.

In active gas systems, a vacuum or a positive air pressure is applied to extraction wells or trenches. In a common active gas system, a vacuum is applied to a network of extraction wells that are interconnected with a series of pipes. The vacuum serves the purpose of drawing the gas from the landfill to the vicinity of the extraction wells and then into the collection system. The gases that are drawn into the collection system are then either vented into the atmosphere, burned in a flare or used as a fuel. Active systems are more apt to meet the conflicting practical and environmental goals of landfill gas control. Such systems can prevent the lateral migration of landfill gas while still allowing the landfill gas to be treated through incineration or use in energy recovery.

6.7 Landfill Construction

The development of a controlled landfill at the base of either Quarry #1 or #2 requires considerable construction. Any construction associated with the development of a controlled landfill at the base of Quarry #1 is a function of the ability to dewater that quarry and control inflow or to fill the quarry with inert material to a grade above the water level. However, the general construction processes to be used in constructing a controlled landfill are the same in Quarry #2 as they are in Quarry #1 after dewatering.

Initial Construction - The initial construction must include the construction of the access road to the base of the quarry, landfill liner (depending on the condition of physical surfaces at the base of the quarry), berm, leachate collection system and leachate evaporation pond. The landfill berm is intended to confine the first lift of the landfill and act as a watertight dam for the collecting of any leachate that may be generated in the landfill. One or more pipes, installed through the bottom of the berm will allow collected leachate to flow into the evaporation pond. The final configuration of any berm and the final design and location of a leachate collection sump will be a function of the actual shape and elevation of the base of quarry #1. This can only be determined once the quarry has been dewatered.

If dewatering is successful in Quarry #1, the site will contain all of the waste dumped in an uncontrolled manner over the last 2 years. During the initial construction period, this waste should be pushed into storage piles to allow for construction of the soil liner and the interim landfill berm. An interim dumping area should be created to accept waste during the initial construction period and for waste that has been removed from the existing waste accumulation. After the initial construction has been completed, the stockpiled waste should be pushed and compacted to form the initial cells of the first landfill lift.

Lift and Cell Construction - Each phase of the landfill will be constructed with multiple layers of waste and cover material called lifts. A cell is defined as a volume of waste to be landfilled within a period of time. The dimensions of each cell and lift are a function of how the landfill is operated and the equipment available for spreading and compacting the waste as well as for placement of periodic cover. This will be discussed in more detail in a Section 7 of this report.

Closure Plan - The preliminary design of the landfill assumes a design capacity equivalent to reaching the lip of quarry #1 along its full periphery and extending vertically as shown in Figure 6.1. This design configuration has been used to calculate the estimated life of the landfill. The specific volume of the available landfill capacity will be a function of the topographical configuration of the quarries (Quarry #2 only if dewatering of Quarry #1 is not feasible and both quarries if Quarry #1 can be dewatered and inflow controlled).

The final contours rise from the lip of the quarry through vertical expansion at a slope of 3:1 or 4:1 (25%) but flatten to 3 to 5 percent on the top. These slopes are designed to drain rainwater from the landfill without causing excessive water infiltration or side slope erosion during any rainfall event.

Section 7

Management, Staffing and Equipment

7.1 General

Any work associated with the landfill requires that there be effective management and staff to operate the facility in the consistent, correct and cost efficient manner. The basic role of management is to provide direction for individuals who will be directly responsible for performance of all day-to-day tasks at the landfill. The evaluation team believes that a clear line of responsibility must exist to assure that all operations at the landfill is done in the manner recommended in this report and adopted by the Governorate. Once a final landfill development and operations plan has been adopted by the Governorate, proper management controls need to be in place to assure that the Plan is followed and that consistent procedures are used. Effective program management must also maintain the performance accountability necessary to assure that the Plan is followed and to make adjustments in the Plan once actual effective operations begin.

7.2 Management Structure

Management of the landfill will be provided by the Governorate. The recommended management structure for the landfill is presented in Figure 7.1. The Evaluation Team recommends that the same individual who is responsible for public solid waste collection should be given management responsibility for the landfill. This will help to coordinate activities in both solid waste management processes (collection and disposal) and to achieve the required cooperation in for effective operations in each of these two important functions.

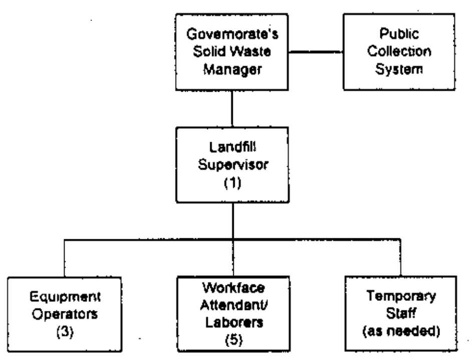


Figure 7.1
LANDFILL MANAGEMENT MATRIX

7.3 Staffing Levels

An adequate number of people are required to perform the tasks outlined in this report. The Evaluation Team has recommended a modified area method of landfill operation in a controlled landfill configuration at the base of the quarry. Through this approach, some operating tasks will only have to be done periodically and full time staff or equipment will not be necessary to perform them. All of the work tasks required to effectively operate the landfill may be accomplished using a combination of full time and temporary staff and municipal equipment or equipment from outside contractors.

Permanent Staff - Currently, 8 full time people are employed to operate the disposal area The project team believes that that this number of full-time employees may be sufficient so long as their operating tasks are specifically defined and performance of required tasks closely monitored. Once the collection system becomes more effective and more waste reaches the landfill because of population growth, additional staffing may be required. The permanent landfill staff will be responsible for the following general activities at the landfill

- Controlling traffic at the landfill and directing trucks to the correct location for dumping
- Recording all solid waste deliveries
- Inspection of waste loads
- Limited site clean-up
- Regular communication with the Governorate's solid waste manager concerning conditions at the landfill and coordination with the collection staff
- Collecting leachate and groundwater samples for analysis.

Recommended individual responsibilities for the full time staff will should, at a minimum include the following work tasks:

Landfill Supervisor

The landfill supervisor will be responsible for all activities at the disposal area. At a minimum this will include the following:

1. Supervision of all landfill staff
2. Definition and monitoring of all landfill operating tasks
3. Control and supervision of all landfill equipment maintenance
4. Development of all reports required by be Governorate's solid waste manager
5. Monitoring of all activities to assure that they conform to the accepted operations plan
6. Conducting all site tours
7. Coordination of temporary staff and equipment and private contractors for periodic work tasks.

Equipment Operator

The equipment operators will be responsible for the following activities:

1. Provide effective operation of all landfill Equipment
2. Control placement of solid waste into required cell configurations
3. Provide limited maintenance of equipment operated by performing daily routine checks in maintenance tasks.
4. Report to landfill supervisor on the condition of equipment and the need for any maintenance and repair.

5. Provide deployment of periodic cover for construction of each lift within the landfill
6. Provide compaction of placed solid waste to minimize airspace use
7. Provide regular maintenance of all access roads and areas to assure effective truck transport into the landfill

Work Face Attendant/Laborer

Landfill work face attendants and laborers will be responsible for the following:

1. Direct all truck traffic to the appropriate dumping location
2. Inspect all material received to assure that only acceptable solid waste is placed in the landfill
3. Assist in site maintenance and clean-up as required by the landfill supervisor
4. Review all landfill permits as required by the Governorate's solid waste policies

Additional permanent staff may be necessary depending on the following:

- The results of the quarry dewatering process may eventually require that dewatering equipment operation and maintenance continue throughout the operation of the landfill. This may require staff for operations and maintenance activities associated with the dewatering process.
- If waste will be received at the site at hours when the landfill is not fully staffed, additional full time personnel may be required to monitor off hours deliveries. If waste will not be allowed to be delivered outside of set hours of operations, full time security personnel may be required to assure that waste is not delivered or that waste is not simply dumped along the landfill approach road.

Part Time/Temporary Staff - The Evaluation Team is also recommending that temporary staff and equipment be periodically used for tasks that do not have to be performed every day. Generally, temporary staffing should be used to accomplish labor-intensive tasks such as:

- Periodic site clean-up.
- Access road maintenance
- Periodic placement of intermediate cover for construction of new lifts
- Placement of final cover in areas that have reached capacity
- Periodic and regular maintenance of quarry dewatering system
- Preparation and construction of new landfill areas

Staff Training - Fundamental training should be provided to all staff involved in the operation of the landfill. This training will be important in assuring the health and safety of landfill staff and to establish the importance of effective operations. During initial operations where only eight full time staff will work at the landfill, training should be provided on the subjects shown in Section 5. It is important to note that the recommended training applies to any of the development configurations including both near term and long term. The importance of proper training also applies to the current operation of the landfill. Sample training agendas for the relevant staff positions shown in the Figure 7.1 matrix are shown in Appendix 4.

7.4 Mechanized Equipment

Periodically, mechanized equipment will be required for operation, maintenance and expansion tasks at the landfill. Common mechanized equipment work tasks include the following:

- Access road maintenance and improvement
- Soil liner installation
- Landfill area preparation

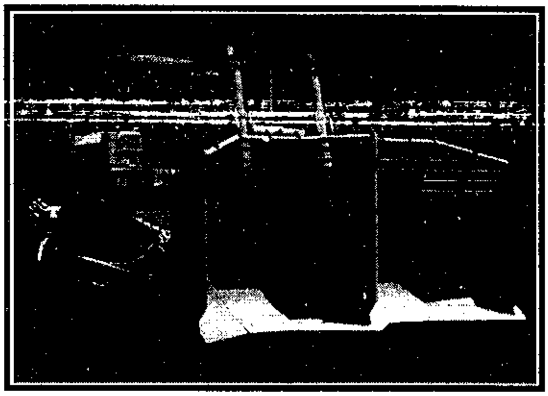


Figure 7.2 - Typical Landfill Bulldozer

- Evaporation pond maintenance
- Waste distribution and compaction
- Periodic cover excavation, transport and application

Experience in controlled landfill operations in many countries has led to basic knowledge on the minimum amount and type of equipment required for effective operations. This is shown in Table 7.1. At a minimum, the mechanized equipment required to operate a controlled landfill on the base of the quarry include:

- 2 Bulldozers (Caterpillar D-4 or equivalent) (for compaction and waste placement)
- 1 Dump truck (minimum 8 cm^3 capacity) (for periodic light clean-up and material transport)
- 2 Front-end loaders (for waste placement and workface activities)

Through the procedures outlined in this operations plan, the above mechanized equipment will be regularly required and should be dedicated to the operation of the landfill. The actual amount of waste received will determine the frequency at which new landfill cells must be constructed and temporary equipment employed at the landfill.

In addition to the above, temporary equipment and operators will need to be used to perform periodic tasks associated with the landfill. These will include the following tasks:

- Preparation and construction of new areas for waste placement
- Periodic transport and placement of intermediate cover to construct lifts at the landfill
- Periodic access road clean-up and maintenance

Some of the above activities can also be accomplished using private contractors if other equipment and operators are not available through the Governorate.

Table 7.1
Recommended Mechanized Equipment for Effective Operations

Approximate Population	Daily Wastes Tons	Equipment Number	Equipment Type	Equipment weight, lbs	Accessory[a]
0-20,000	0-50	1	Tractor, crawler	10,000-30,000	Dozer blade Front-end loader (1-2 cu/yd) Trash blade
20,000-50,000	50-150	1	Tractor, crawler	30,000-60,000	Dozer blade Front-end loader (2-4 cu/yd) Bullclam Trasn blade
		1	Scraper or dragline		
		1	Water truck		
50,000-100,000	150-300	1-2	Tractor, crawler	30,000+	Dozer blade Front-end loader (2-5 cu/yd) Bullclam Trash blade
		1	Scraper or dragline[b]		
		1	Water truck		
>100,000	300[c]	1-2	Tractor, crawler	45,000+	Dozer blade Front-end loader (2-5 cu/yd) Bullclam Trash blade
		1	Steel wheel compactor		
		1	Scraper or dragline[b]		
		1	Water truck		
		—[a]	Road grader		

a. Optional, depends on individual needs.
b. The choice between a scraper or dragline will depend on local conditions.
c. For each 500-ton increase add one more of each piece of equipment.

Source: G. Tchobanoglous, *Integrated Solid Waste Management: Engineering Principles and Management Issues, 1993*

Table 7.2

RECOMMENDED AND OPTIONAL ACCESSORIES FOR LANDFILL EQUIPMENT

Accessory	Dozers		Loaders		Landfill Compactor
	Crawler	Rubber Tired	Crawler	Rubber Tired	
Dozer Blade	O	O	-	-	O
U-Blade	O	O	-	-	O
Landfill Blade	R	R	O	O	R
Hydraulic Controls	R	R	R	R	R
Rippers	O	-	O	-	-
Engine Screens	R	R	R	R	R
Radiator Guards - Hinged	R	R	R	R	R
Cab Air Conditioning	O	O	O	O	O
Ballast Weights	O	O	R	R	R
Multiple Purpose Bucket	-	-	R	R	-
General Purpose Bucket	-	-	O	O	-
Reversible Fan	R	R	R	R	R
Steel-guarded Tires	-	R	-	R	-
Life-arm Extensions	-	-	O	O	-
Cleaner Bars	-	-	-	-	R
Roll Bars	R	R	R	R	R
Backing Warning System	M	M	M	M	M

O-Optional R-Recommended M-Mandatory

Section 8

Controlled Landfill Operations

8.1 General

Effective landfill operations require a sufficient level of definition and detail to meet acceptable operation guidelines. The procedures also need to be defined sufficiently so that those responsible for the overall function of the landfill can monitor the performance of tasks assigned to other individuals or private contractors.

A controlled landfill located at the base of the quarry will be constructed in lifts, as shown in Figure 8.3. The actual number of lifts will be determined by site conditions and configuration determined after dewatering and the resources available to the landfill operators.

8.2 Operations Procedures

The following procedures are recommended for the operation of the quarry base controlled landfill. These are intended to achieve reasonable operating and environmental standards through the application of a minimum of financial resources.

Landfill Area Preparation - Periodically, mechanized equipment will be used to prepare new landfill areas for waste receipt. Preparation work will consist of surface grading, soil liner placement and general grading for truck access. Initial placement of solid waste in Quarry #1 will be a function of the physical characteristics of the base of the quarry once dewatering is complete. The first area prepared will be used to place the solid waste accumulated on the base of the quarry because of the current process of placing solid waste into the quarry from the top of the quarry wall.

Site Access Control - Site access should be controlled to prevent unauthorized dumping, scavenging and animal feeding. The overall quarry configuration may be conducive to good access control since the base of the quarry is served by only one access road. While the landfill is operated below the quarry lip, access control will be provided by the existing walls of the quarry that will preclude easy access by scavengers, vehicles and others not authorized to enter the landfill site.

Truck access should be controlled by providing a full time landfill staff at all times that trucks are expected at the landfill. All trucks must be required to use the designated access road. All other access points to the landfill must be blocked. This is especially true of access to areas where solid waste may be deposited at the top of the quarry as is currently the practice. Trucks should only unload waste at locations designated by the landfill staff. Uncontrolled truck access often leads to dumping in improper locations that may impede effective operations, require considerable clean-up effort or cause environmental damage. The hours of operation of the landfill (defined as the hours that the full time staff works at the landfill) should be coordinated with the anticipated time (hours per day, days per week) of collection and delivery of solid waste to the landfill. Private haulers should be made aware of the hours of solid waste receipt at the landfill and these hours should be strictly enforced.

Commencing Operations - Waste placement in new landfill areas should begin with a back to front configuration. Care must be taken to assure that the first material placed in the new area is along and against the back boundary of the area furthest away from the access point to make effective use of the entire area. A common starting point in the quarry base configuration is against one of the quarry walls that will also provide a base against which compaction can occur.

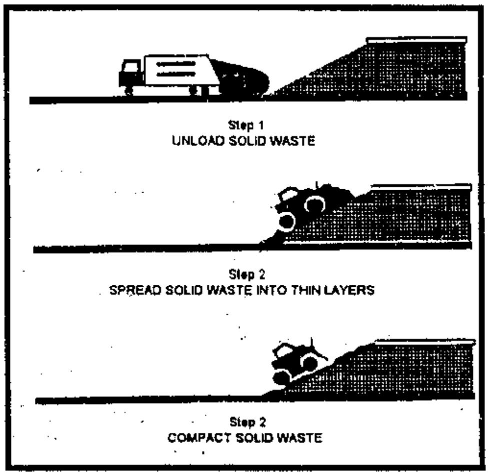
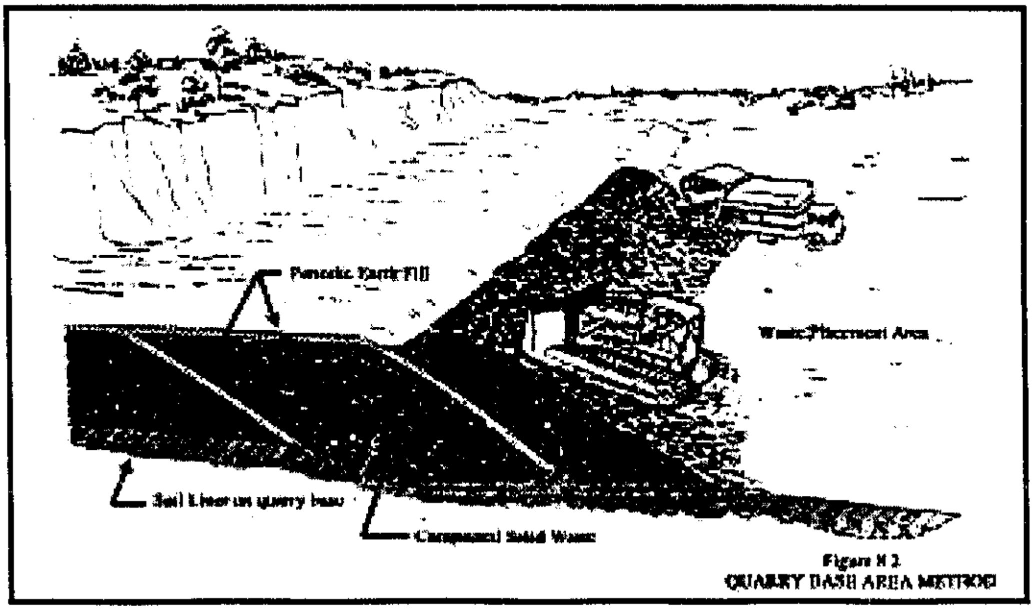


Figure 8.1 - Waste Placement Schematic

Once an area has been prepared and operations are to begin, trucks will enter from the internal access road and proceed to the discharge point where they are directed by workface attendants to dump. Waste loads will be dumped in a row along the back boundary as close to the quarry wall as possible. As more loads are delivered, progressive rows will be accumulated along the previously placed rows. As a result, the rows will progress toward the internal access road. After sufficient material has been accumulated, mechanized equipment will be used to spread the waste piles, compact the material and cover the waste. The periodic cover operation will be important in creating a proper travel surface for further placement of solid waste once a new lift commences. Additionally, reasonable compaction is required to assure that the cover material placed over the waste provides a sufficiently sound surface for further truck access when waste is placed in the next lift. The initial operations of the landfill are shown graphically and summarized in Figure 8.2 – Quarry Base Area Method.



Waste Receipt and Placement - Waste should be placed only in locations designated by the landfill staff. Waste delivery truck drivers should be directed to place each load as close as possible to allow for the maximum number of loads to be placed in each area. This will help to decrease the frequency of periodic compaction and coverage of the waste. Once the entire surface area of each area has been covered and all material has been compacted into a cell and covered, the next area will commence by repeating the same steps used in waste placement for the initial area.

Waste will be placed into each area of the landfill in 2-meter lifts that will accomplish the design grade for each area. As shown in Figure 8.3, waste will be placed in multiple lifts to eventually reach the lip of the quarry.

Cell Development - If effective cover is utilized as recommended in this report, the landfill will be constructed using a conventional cell configuration as shown in Figure 8.3.

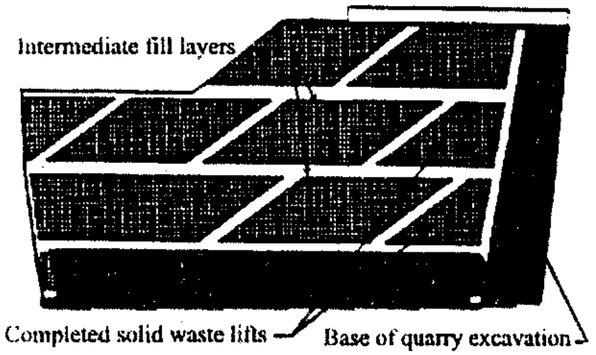


Figure 8.3
SOLID WASTE LIFT CONFIGURATION

Load Tracking and Inspection - All trucks delivering waste to the landfill should be recorded by the landfill attendant to keep basic records of waste delivery. At a minimum, the waste receipt record should include the following information:

- If public, truck number (license plate, etc.)
- Municipality or sector of waste origin
- If private, hauler name and truck number
- Time waste received
- An estimate of the amount of waste delivered in m^3
- Type of waste delivered
- Any unusual characteristics or circumstance associated with that particular load

The information collected through the record keeping process will be important in overall landfill monitoring and planning and may also assist the Governorate in determining the efficiency and cost effectiveness of its collection system. In the future, more accurate information concerning waste delivery may be required. While truck scales are often used in landfills to determine the exact quantity of waste delivered, this is not recommended for initial operations at the quarry base controlled landfill because of the costs associated with their installation and operation.

In addition to recording all trucks, a landfill attendant should also inspect all loads as the trucks are being emptied to verify that only materials appropriate for the disposal area are received. In particular, a landfill attendant should watch for large containers that may contain liquids that could cause significant groundwater pollution or contribute to leachate quantity.

Mechanized Equipment Procedures - Periodically, mechanized equipment will be used to spread, compact and cover the waste that has been accumulated. The mechanized equipment procedures are illustrated in Figures 8.2 and 8,3 which presents the general sequence of accomplishing the mechanized operations in each lift in a landfill cell. During the mechanized equipment work at the landfill, the following procedures are recommended:

- Mechanized equipment work at the landfill will be coordinated with municipal equipment and/or contracted with a private contractor.
- A bulldozer will be used to push the accumulated piles of solid waste into a uniform cell configuration.
- The bulldozer will compact the solid waste with a minimum of 3 passes over the material after it has been spread.
- Once the waste has been compacted, an intermediate cover layer of 30 cm of soil cover will be applied. All cover soil must be excavated from an offsite location and transferred to the landfill in dump trucks. Only material that will provide an appropriate surface for eventual truck traffic should be used as intermediate cover.

Cover Application - Due to the lack of resources and equipment, the Evaluation Team is not recommending the application of daily cover during the initial operation of the landfill. The standard practice in controlled landfills is to provide three forms of waste cover, including daily, intermediate and final cover. Generally, the application of daily cover to solid wastes can:

- Reduce litter, odors, vectors and other nuisances
- Reduce infiltration of water and potential leachate generation
- Minimize fire danger
- Improve the landfill aesthetics to improve public perception of the operation

Intermediate cover is normally applied as landfill lifts are completed, to provide improved storm water runoff, thereby reducing the amount of leachate produced. It is also necessary to provide a working and driving area for trucks to bring waste onto the next lift of the landfill. It is recommended that intermediate cover be placed on an accumulated lift of material after there are sufficient waste piles from delivery vehicles to justify the use of mechanized equipment to spread and compact the waste. The initial period is recommended to be monthly. After spreading the waste piles, and forming a waste cell, 30 cm of intermediate soil cover will be placed over the waste and compacted. This intermediate cover will serve the functions of both daily and intermediate cover as defined above. More frequent application of cover may be warranted depending on actual conditions observed during operations. For example, daily cover is usually effective in controlling fires at a landfill. The continued use of quarry water to quench fires that develop can create additional leachate flow.

Final cover is used once a landfill has been filled to capacity. Generally, soils are used for final cover that stabilizes the final landfill surface. Final cover should be installed once individual areas within the landfill have reached capacity.

Since only periodic cover will be applied, the landfill will experience some conditions that would otherwise by eliminated by daily cover. For example, increased vectors and litter may result from the waste material that remains exposed between cover placement. Procedures aimed at controlling vectors and other nuisances are presented later in this report. An increased number of vectors, such as flies, should only be a problem at the landfill site itself. Increased litter, however, may require a greater effort to keep the landfill site clean. This should be minimal so long as the controlled landfill operation remains below the quarry lip.

The lack of daily cover may increase the potential for periodic fires. To the degree possible, fires should be put out as they occur because of the dangerous effects of exposure to smoke from solid waste fires. Cover material stockpiled at the workface for eventual application could be used to smother any fires that develop or fires associated with hot loads.

As discussed in Section 6.6 - Leachate Management, the quarry base controlled landfill is expected to generate leachate. The application of periodic cover soil will impact the amount of leachate generated. Cover soil should be applied and graded to shed rainwater away from the active areas of the landfill.

Consideration should be given to the use of accumulated quarry tailings and various piles of construction and demolition materials as cover materials. This can accomplish the ancillary benefit of cleaning up areas where these materials have accumulated along the roadways in the quarry area.

Compaction - In initial operations, the Evaluation Team is recommending limited compaction only at the time that accumulated waste piles are spread by the landfill bulldozers and during cover application. In large landfills, specialized equipment is often used solely for the purpose of compaction. A basic level of compaction will be provided during periodic mechanized equipment operations through a minimum of 3 passes by a D4 bulldozer at the time waste piles are spread and formed into cells.

Scavenging/Recycling - Scavenging for materials that can be sold or reused is common practice at many waste sites. The removal of recovered materials, including paper, plastic, metal, glass, wood or reusable items is beneficial to landfill operation by reducing the amount of waste to be landfilled. Unfortunately, the removal of these items from the landfill exposes scavengers to injury and disease. Long-term programs should be initiated to encourage removal of these materials at the source of generation or during collection rather than through scavenging at the landfill. Scavenging should not be allowed at any time at the landfill.

Nuisance Control - The primary nuisance conditions associated with landfill operations are disease vectors, dust, blowing litter and odor. Procedures that will be used in controlling each are as follows:

- **Disease Vectors** - Typical landfill vectors can include birds, rodents and insects. Through contact with waste materials placed in the landfill, these can all transmit disease. Vectors include birds, insects, and rodents, which are capable of carrying a pathogenic disease-causing bacteria, virus, fungus, or organism from one host to another. Experience has shown that daily soil cover (20 mm minimum) is the best means for achieving vector control. (Typically, it is also the best means for controlling odor and blowing litter.) However, since daily cover will not be applied in the initial operation, the landfill attendant should monitor the general level of landfill vectors to determine if vector control techniques must be implemented. As a result, vector control may become a factor in determining the frequency of mechanized equipment operations at the site or may ultimately lead to a conclusion that daily cover is required.

- **Insects** - Based on our observations at the existing dumping area, we believe that insects will be the most **problematic** vectors. However, the quarry location of the site should help to keep the vector problem isolated to the landfill. Flies and mosquitoes are two types of insects that are of concern at landfills because they both spread diseases and are nuisances. Flies can spread many food-borne diseases by carrying bacteria from the waste materials to food. Adult flies, eggs, and larvae often arrive at a landfill in the solid waste. There they continue to develop and/or reproduce since they are supplied with food, water, and shelter because of the physical conditions of the solid waste.

  Mosquitoes breed in water or in very wet waste and can carry diseases from many sources to human beings. Effective control includes eliminating areas where water is found and effective use of cover soil.

- **Rodents** - Rodents can spread diseases such as rabies, rat bite fever, typhus and plague. They can damage a landfill by burrowing through cover or even gnawing liner material, buildings, electrical wires and insulation. Rodent populations can be introduced to a landfill by being brought to the site in waste loads or by migrating to the landfill from surrounding areas. They will remain at a landfill facility if there is available food, water and shelter. Shelter areas for rodents can include structures, as well as salvage storage areas and the open spaces that can occur between bulky materials. A rodent infestation can be identified by looking for droppings, evidence of gnawing, burrows, holes in buildings or berms, rodent runs, or by physically observing them in the landfill. Normally, rodents are not visible during working hours as most of their activity takes place at night.

- **Dust** - Dust at landfill sites is normally caused by vehicular traffic. At landfill sites where an appropriate source of water is present, water is often used to suppress dust along access roads and other areas where vehicular traffic is anticipated. A truck or trailer mounted tank can be used to wet down roads to keep dust levels down.

- **Litter** - All windblown or dropped litter from waste delivery or waste piles in the landfill cells should be periodically collected and placed in the landfill cell. Litter should be periodically collected by the permanent or temporary staff on a regular basis. Since waste loads are to remain uncovered for extended periods, an effort should be made to collect litter at least monthly at the landfill and along the access road leading to it. This is important for a number of reasons including:

  - The Governorate is attempting to demonstrate that an effectively operated landfill is important in environmentally sound solid waste management. Uncontrolled litter defeats the purpose of this demonstration.

  - Staff attitudes concerning the environmental control aspects of the landfill will be enhanced by recognizing the importance of a clean site.

  - Uncontrolled litter can provide breeding areas for vectors away from the landfill cells.

  - Depending on the number of trucks that go to the landfill and the time required to direct them, the landfill attendant should work toward controlling litter in the vicinity of the active dumping area. This will help to prevent the accumulation of material and reduce the amount that will have to be periodically collected by temporary staff.

- Litter control can be improved by planting trees or cactus around the landfill in the direction of the predominant wind. This will especially be the case once the waste accumulation has reached and surpassed the lip of the quarry.

Water Management - In most landfills located in arid area, water is not available for fire or dust control. The Abu Zaabal quarry is unique in that a significant amount of water is available at the base of Quarry #1. This water may be significantly polluted because of the solid waste already placed into the quarry. However, the water may serve a number of useful purposes associated with the landfill operation. The water may be used to put out fires and for dust control.

The initial effort to dewater Quarry #1 will help determine the means by which water can be regularly used in operation for the above purposes.

Section 9
Landfill Maintenance

9.1 General

Effective operations can only be sustained if there is effective maintenance of the equipment, systems and structures required for operations. Maintenance procedures must include all equipment and structures whose function is important in the long-term operation of the landfill. This will certainly include any mechanized equipment but will also include fixed landfill site structures such as the completed landfill areas, quarry water dewatering and access structures and access roads.

There are two classifications of maintenance used in the care of the above structures and equipment. These include:

- **Repair Maintenance** - In this form of maintenance, equipment or structures are repaired when they breakdown or do not function in the proper manner. In some cases, repair maintenance must occur immediately since an operating function cannot be accomplished without the completion of the repair. In some cases, the nature of the required repair can allow the repair to be deferred to a more convenient time. Some care, however, must be taken to assure that deferred maintenance does not lead to more significant breakdowns that require more time and money to fix.
- **Preventative Maintenance** - In this form of maintenance, work is done on the structures or equipment to try to keep breakdowns from occurring. In the case of mechanized equipment, preventative maintenance needs to be sufficient to assure that the equipment will be effective for the longest possible time.

Generally, manufacturers of mechanized equipment specify a minimum level of preventative maintenance that, through their experience, will give the most effective use of the equipment overtime. At a minimum, such recommendations should be used as a basis for preventative maintenance work done on any specific mechanized equipment. Experience has shown that a lack of effective preventative maintenance often leads to an increased level of repairs and decrease life expectancy. This can have a major impact on the cost associated with operating mechanized equipment through increased repair costs and premature replacement of the equipment so as to maintain its function. It is important to note that effective preventative maintenance also includes the simple tasks of making inspections to verify that conditions exist for continued optimum performance. Effective daily operation of mechanized equipment, for example, normally begins with an inspection of the equipment and a check of operating fluids and other critical factors for the operation of the equipment. Regular preventative maintenance inspections can include mechanized equipment as well as fixed structures such as drainage diversion ditches and berms.

9.2 Maintenance Procedures

The Evaluation Team recommends the following minimum maintenance requirements for the landfill:

Access Road Maintenance - The site access road must be maintained so that there is a minimum of disruption in getting waste to the landfill. If the landfill access road becomes difficult to use, waste will be deposited in other areas away from the landfill site that are perceived to be more convenient.

The level of maintenance required for the access road will be a function of the natural and man-made factors that can damage surface condition of the road. For example, traffic may require periodic grading of the roadway using a bulldozer or grader. At a minimum, the project team recommends annual maintenance of any area where conditions could disrupt the travel of trucks to and from the landfill site. The person responsible for the landfill operation should review such locations to determine the actual frequency at which access road maintenance tasks must be performed. At a minimum, following tasks should be used in access road maintenance:

- Periodic grading using the bulldozer provided for the landfill operation. If required, this may be limited to those areas needing the greatest amount of work. Consideration should be given to the utilization of a Governorate or private contractor grader to periodically grade the landfill access and approach roads.
- Filling in any major holes that develop in the access road. This may be done by mechanized equipment when on site, temporary staff when available or by the landfill attendant for those areas near the active landfill cell.

The benefits that will be realized from effectively maintaining the landfill access road include:

- Easy access to the landfill will prevent waste deposit in other locations where there is greater potential for environmental and public harm.
- A well maintained access road will decrease the wear and tear on vehicles that must travel to the landfill. As a result, vehicle maintenance cost will be decreased.

Site Clean-up - At a minimum, general site cleanup should occur on a regular basis. If possible, the landfill's permanent staff should collect litter at the time that it occurs. This will diminish the amount of litter that will need to be collected weekly or monthly.

Equipment Maintenance - In latter phases of the landfill development and operation, more dedicated equipment may become available. If landfill staff becomes responsible for that equipment, an effective maintenance program should be incorporated into the landfill's operating procedures. If new equipment becomes available, the maintenance procedures should, at a minimum, conform to the program recommended by the manufacturer of the equipment. Specific assignments should be made to assure that one individual is responsible for performing all daily and periodic tasks required in the preventative maintenance program.

The use of used equipment in the future does not diminish the need for effective maintenance. If anything, there is a greater need for effective maintenance in older equipment since parts are more apt to wear out faster. In some cases, used equipment is not accompanied with any documentation presenting the manufacturers recommendation for maintenance procedures. However, information can usually be obtained from the manufacturer. At the very least, a preventative maintenance program can be established based on that used for similar equipment.

Water Management Maintenance - Any mechanical systems such as pumps and controls should be included in a regularly scheduled monitoring and maintenance program so that water is always available for fire fighting.

Section 10

Health and Safety

10.1 General

Landfill workers are exposed to many potentially dangerous materials and situations as they supervise and direct the disposal of waste. Landfill staff must be properly trained and equipped to safeguard themselves from the dangerous properties of the waste materials placed in the landfill. Universally, the most common basis for health and safety procedures is to minimize the contact between the waste and the people whose health could be affected by contact. This is particularly the case for dangerous materials such as medical or toxic wastes.

In Egypt, where environmental management is just evolving, all of the different forms of solid waste are apt to be received at the landfill. This reinforces the need for effective health and safety control at the landfill. Ultimately, policies and regulations may exist in Egypt, as in other countries, where there is strict enforcement of separation of hazardous materials from the normal waste stream. However, in the near term future, the health and safety approach for the quarry base controlled landfill must assume that all forms of toxic solid waste are included in the solid waste received at the landfill. The landfill staff should be trained to identify the various types of solid waste that will be brought to the landfill so that they are cautious when working around particularly dangerous materials.

10.2 Health and Safety Plan

The health and safety of landfill staff and others (waste delivery vehicle drivers, equipment operators, scavengers) at the site can be affected by a number of factors, including:

- Vehicular Operations
- Exposure to waste materials particularly dangerous materials such as medical and toxic waste, etc.
- Exposure to air emissions from toxic wastes or fires at the landfill

The following are basic health and safety procedures that are recommended to be adopted at the landfill to control the risks associated with health and safety hazards.

Personnel Protective Clothing - Personnel protective clothing should be provided to the landfill staff. At a minimum, this should include:

- High visibility vests for working around mobile equipment,

- Leather work gloves,
- Rubber boots.

Any temporary landfill staff that will come into contact with waste materials by collecting litter should be temporarily issued leather work gloves and rubber boots for the period of time that they work at the landfill.

The following work rules should apply to personal protective clothing:

- The landfill supervisor should be responsible for maintaining an inventory of personal protective clothing so that it is available for permanent and temporary landfill staff.
- Permanent or temporary staff required to handle any waste materials will be required to use leather work gloves and rubber boots when handling or working around waste materials. This will include landfill area operations as well as site litter clean-up.
- The use of this personal protective clothing should be made a prerequisite for work at the landfill and all operators that are issued equipment should be responsible for its care while they have it. (Personal protective clothing will wear out in time. As a result, leather work gloves may have to be issued to the landfill full time staff every six months. Replacement rubber boots may need to be issued once a year. Temporary staff required to handle solid waste materials should be issued gloves and boots that will be collected and stored upon the completion of their work at the landfill.
- All staff required to work around vehicles delivering waste to the landfill or around mechanized equipment involved in waste spreading, compaction and cover should be required to wear high visibility safety vests to aid in preventing vehicle/pedestrian accidents.

10.3 Health Exposure Control

Long-term exposure to certain components of the waste received at the disposal site can be harmful to the health of operating personnel. As a result, landfill operations should be organized so that there is a minimum of exposure and contact to waste materials. Personnel who must work in proximity to the waste material placed in the landfill should be trained as to the particular hazards of certain types of waste. At a minimum this should include:

- Exposure to various forms of medical and hazardous waste
- Containers with liquids
- Possibility of harm and infection from sharp objects
- Long term danger from exposure to smoke from burning waste

To the degree possible, fires should be prevented at the landfill. Exposure to smoke from landfill fires can have a damaging affect to the landfill staff and to other people away from the landfill who are exposed to it. If a fire does occur, an attempt should be made to put the fire out using soil cover or water from the quarry. However, this attempt should only be made where there is no direct danger to the personnel attempting to put out the fire.

The overall principle of operations should be to prevent exposure and contact with solid waste placed in the landfill. Where contact cannot be avoided (site clean-up, etc.) personal protective clothing should be used.

10.4 Equipment Safety

The landfill supervisor should assure that all site staff (permanent and temporary) are aware of the dangers associated with working around landfill equipment. The landfill supervisor should also be responsible for making sure that all equipment operators operate their equipment in a manner that does not endanger other people (landfill staff, scavengers, etc.) at the site.

Section 11

Environmental and Performance Monitoring

11.1 General

One of the keys to sustainable effective operations is performance monitoring. The following minimum monitoring program is recommended for the landfill.

11.2 Environmental Control

The landfill is intended to perform an important environmental function in the Governorate. The simple fact of getting the waste to the landfill accomplishes an important part of that function. However, the design and operation of the landfill must attempt to control the environmental effects of the material after it is placed in the landfill. Landfill environmental monitoring includes the placement and sampling of groundwater monitoring wells to determine that the landfill is not damaging groundwater. In addition, surface water accumulations are also tested to verify that surface water is not being contaminated through contact with waste materials.

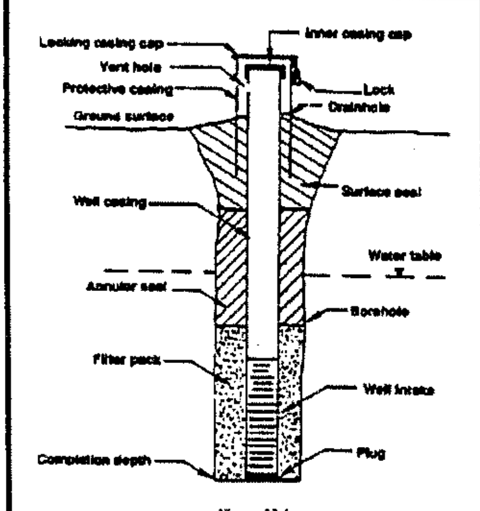


Figure 11.1
TYPICAL GROUNDWATER MONITORING WELL

In order to measure the effectiveness of any leachate collection program, it is important to develop a groundwater monitoring program. For the Abu Zaabal site, it is recommended that at least five monitoring wells be installed, two upgradient to the southeast and southwest of the landfill and three downgradient. These wells should be installed by trained personnel using proper installation methods. Based on the results of water quality analyses, a Sampling and Analysis Plan should be developed for this monitoring program. At minimum, it is recommended that groundwater samples be collected and water levels measured from each of the wells on at least a quarterly basis for field parameters including specific conductance, pH, temperature, and water levels and at least twice a year for the following parameters:

Alkalinity
Biochemical oxygen demand (5 days)
Calcium
Chemical oxygen demand (COD)
Copper (Cu)
Chloride (Cl)
Hardness as $CaCO_3$
Iron, total (Fe)
Lead (Pb)
Magnesium (Mg)
Manganese (Mn)
Ammonium-N (NH_4)
Potassium (K)
Sodium (Na)
Sulfate (SO_4)
Total Dissolved Solids (TDS)
Total Suspended Solids (TSS)
Total phosphate (PO_4)
Zinc (Zn)
PH
Specific Conductance

Based on our experiences with laboratories in Egypt, such a program can be carried out effectively provided that operating personnel are trained to properly collect the samples and measure field parameters. In addition, it is also recommended in order to properly determine dewatering requirements that the monitoring wells be hydraulically tested to determine the permeability of the aquifer and flow direction of groundwater.

The quarry base controlled landfill will have a leachate evaporation pond. The pond should be checked daily to determine the depth and the estimated volume of leachate contained in the pond. These should be recorded in the operator's log book.

11.3 Landfill Gas Monitoring

If migration of landfill gas is suspected during the operation of the landfill, it can be verified by testing for the presence of landfill gas in the soil and at various locations around the landfill. Methane is easiest to test for because:

1. It can be done on-site at the landfill;
2. No sample collection is needed to test for the gas;
3. The testing equipment is portable; and
4. Immediate results are obtained.

Sample depth for testing for landfill gas varies depending on geology of the site and distance from the landfill. Initial testing is normally done 2-3 feet below grade due to the limited capability of the testing equipment. Testing should occur in the area of concern. This is usually in the direction of potential targets, areas of vegetative stress, buildings and property lines. The physical design of the monitoring systems is dependent on the geological strata in the monitoring location. For example, in soils that have varying strata, monitoring well clusters may be required to monitor different levels beneath the surface. This is similar in concept to the design of groundwater monitoring wells. In actuality, the only major difference between a gas and groundwater monitoring well is the location of the screened portion of the well. In the groundwater monitoring well, the open section is below the water table while it is located above the water table in the gas monitoring well.

If elevated levels of methane are observed through monitoring, remedial action may be required. If high levels of methane gas are observed in buildings, the building may have to be evacuated and the gas vented. Discovery of elevated levels in landfill structures such as manholes, should lead to venting and any other procedures required to achieve safe conditions. This is especially the case in structures that must be entered for any reason. Monitoring should also precede any entry and if required, appropriate steps must be taken before any entry is allowed.

Monitoring of landfill gas levels is important for a variety of reasons. As landfill gas production will vary from landfill to landfill and from time to time in the same landfill, monitoring becomes important to provide the design basis for collection and treatment. The levels of landfill gas determined from effective monitoring will also provide information by which processes such as energy recovery can be evaluated. Because of the potential hazards due to landfill gas, it needs to be monitored closely so as to control the potential hazard.

Instruments that can be used to measure landfill gas concentrations are commercially available. In some cases, monitors are selected that can effectively measure one of the typical components of landfill gas (methane, for example). Portable methane meters and explosimeters can be used to detect the presence of landfill gases. Methane meters indicate the percentage of methane present while the explosimeters measure the combustibility of the gas as a percentage of the lower explosive limit. Equipment is available to detect gas in a variety of ways. These include:

1. Personal monitors;
2. Stationary monitors that activate audio alarms;
3. Stationary monitors that activate visual alarms;
4. Lower explosive limit (LEL) monitors; and
5. Gas (actual gas) concentration monitors.

Purchase of LEL equipment is recommended as it can effectively monitor the danger or threat of explosion. The LEL of methane is 5% in air. LEL is the lowest concentration of gas that will result in an explosion if an ignition source is present. The upper explosive limit (UEL) of methane in air is 15%. The UEL is the highest concentration of gas that will cause an explosion if an ignition source is present. Methane gas concentrations of above 15% will burn but not explode.

A gas monitoring program must be:

1. Systematic and regular, based on generation rates;
2. Based on soil type (profile characteristics);
3. Based on closeness of structures; and

4. Increased in frequency if gas is found or when conditions conducive to lateral migration (frost, wet soil conditions, etc.) exist.

In addition to site perimeter landfill gas detection wells, the following areas (if present) should be monitored to detect the presence of gas:

1. On-site structures;
2. Basements;
3. Crawl spaces;
4. Cracks;
5. Trenches;
6. Manholes;
7. Conduits;
8. Soil cover;
9. Paved area;
10. Site boundary;
11. Areas of vegetative stress

11.4 Vector Monitoring

The use of periodic intermediate cover rather than daily cover may permit vectors such as insects and rodents to increase above acceptable levels. These vectors should be monitored daily to determine if preventive action is required. More frequent covering, especially during the wet season, may be necessary to control these vectors.

11.5 Operations/Performance Monitoring

Performance monitoring for tasks at the landfill is simply a conscious effort by the person responsible for the landfill to regularly visit the landfill and make sure that tasks are being performed in the manner required. It has been the project team's experience that close monitoring in the form of a daily visit to the landfill by the person responsible for its operation is important in assuring that reasonable conditions and performance are maintained.

11.6 Site Operations

The time for developing cells and performing mechanized equipment tasks will be a function of how much waste is actually received at the landfill. While the overall goal of solid waste management in a quarry base controlled landfill should be the delivery of as much waste as possible to the landfill, there are issues (costs of collection, etc.) that may keep waste from reaching the landfill.

Close monitoring of the waste will determine the pace at which certain activities are undertaken. For example, the frequency at which deposited piles of material are spread, compacted and covered will, more than likely, be based on how much waste needs to be covered. This can be determined by summarizing waste deliveries by the day, week, month and year. A yearly plot of waste deliveries (TPD) will identify trends in waste deliveries that may effect future operations.

Section 12
Implementation Plan

12.1 General

The implementation plan for a quarry base controlled landfill includes several components designed to terminate the existing dumping at the lip of the quarry and to prepare a site for revised operation at the base of the quarry floor. The following implementation tasks are listed in a general order of priority.

12.2 Additional Studies

There are a number of additional studies that are required to further evaluate the options presented in this implementation plan. These studies are also intended to provide additional information required for final design of the proposed controlled landfill.

- **Depth Of Water in Quarry #1** – This will determine the feasibility of dewatering or filling Quarry #1 for development of a controlled landfill at its base. As an alternative to measuring the depth of water in Quarry #1, dewatering may be attempted through rental or purchased pumps.)
- **Topographical Survey Of The Quarry #1 (If Dewatered) And Quarry #2** – This will determine the physical definition of a controlled landfill configuration within either quarry. It will also help to determine expected life of the controlled landfill at a greater detail than that shown in this report.
- **Hydrogeological Investigation** - The landfill site has some significant hydrogeological problems which were not fully evaluated when the site was originally selected for solid waste disposal. A more in-depth hydrogeological study is recommended, including the installation of groundwater test wells. Such a hydrogeological investigation could be carried out by the Research Institute for Groundwater of the National Water Research Center.

12.3 Interim Operations in Current Dumping Area

Until preparation of the controlled landfill area at the base of either Quarry #1 or #2, operations must continue in the current location. However, procedures by which the current disposal site are operated should be altered to include the following:

1. To the degree possible, all fires should be eliminated before placement of solid waste into the quarry.

2. Scavengers should not be allowed to search or remove materials from waste received at the disposal site.

3. A controlled access should be constructed to preclude any truck traffic into the site at any times when the landfill is not staffed.

4. Operators should be trained concerning the receipt of waste materials and the identification of particularly dangerous waste materials such as some forms of industrial waste and medical waste. Sample training agenda are presented in Appendix 4.

5. A survey should be completed of industries and medical facilities in the Governorate to determine the amount and type of waste that these facilities generate. An example industry survey form is shown in Appendix 3.

6. Record keeping for solid waste received at the disposal area should be upgraded to include information on the source and quantity of material received.

7. All operators and waste delivery vehicle drivers should be advised of the dangerous conditions associated with the instability of the solid waste accumulation at the side slope of Quarry #1. To the degree possible, landfill operators should not allow any mechanized equipment to function near the lip of the quarry because of the possibility of slope failure at any time.

12.4 Quarry #1 Dewatering

The development of a controlled landfill on the base of Quarry #1 is a function of the success in dewatering Quarry #1. The following general procedure is recommended in dewatering the quarry and recording observations associated with the process:

1. Appropriately size pumps should be purchased or rented to attempt to dewater Quarry #1. Pumps will need to be equipped with screens or other such devices to prevent solid waste materials in the water from affecting pump operations. Pumps should be of sufficient capacity and pressure to allow for water to be pumped to Quarry #1 and to the side slope of Quarry #1 to extinguish fires

2. Pumps may be float-mounted to allow for pumping from various locations in the Quarry #1 lake. Such an arrangement may be required depending on the configuration of the bottom of Quarry #1.

3. During this activity, careful observations should be made of water draw down levels, pumping rates, seepage locations and any other factors that influence the quantity of water removed in dewatering Quarry #1. Such observations will also be important in developing the ongoing quarry dewatering plan for continued use of the quarry.

4. To the degree possible, water from the Quarry #1 dewatering process should be used to extinguish the fires in the side slope accumulation of the current disposal area.

5. Excess water above and beyond what is required to eliminate side slope fires should be pumped to Quarry #2 or another location to prevent backflow into Quarry #1

6. If the dewatering process is successful, a topographical survey should be completed of the base of Quarry #1 for actual design of the controlled landfill.

7. After dewatering, inflow observations should be made to estimate the quantity of water recharging back into the quarry. This can be accomplished by monitoring the rate of water build-up in the lowest portion of Quarry #1 after initial dewatering.
8. Once the quarry is dewatered, pumps should be utilized to prevent the accumulation of water in the quarry that could impede construction and operation of a controlled landfill configuration on its base.

12.5 Quarry #1 and #2 Base Access Road Development

Subject to the successful dewatering of Quarry #1, an access road should be constructed in the general configuration shown in Figure 2.1. If dewatering of Quarry #1 is not successful, access to Quarry #2 should be constructed for access to a controlled landfill at the base of Quarry #2. Procedures to accomplish this include the following:

1. The general configuration of an access road to the base of Quarry #1 shown in Figure 2.1 is a function of a number of factors including:
    a. The availability of overland routes to get to the access road location. Particular attention will need to be paid to the extent of the military area adjacent to the quarry.
    b. Material stability at the beginning and end of the proposed quarry access road will need to be evaluated. Particular attention must be paid to those areas where solid waste was previously placed. Any such waste that was also allowed to burn (as is the case in the current tipping area) will include significant void spaces that may not allow the proper structural bearing for road construction. This is a crucial issues if safe operation of a new access road is to be realized.
    c. The base topography of Quarry #1 will determine the overall grade that must be overcome to gain access to the quarry bottom. The final grade of the access road cannot exceed that required to accommodate the most limiting of waste delivery vehicles.
2. If Quarry #1 cannot be dewatered, access to quarry #2 should be evaluated to determine the means by which a controlled landfill can be constructed and operated at the base of Quarry #2.

12.6 Landfill Construction

Once dewatering of Quarry #1 is completed and the required access road has been constructed, the construction of the controlled base landfill can begin. The following are general construction procedures that should be employed. These procedures will depend on the physical configuration of the Quarry #1 base determined once dewatering is completed. In addition to the physical shape of the Quarry #1 base, the surface characteristics (basalt fissures, etc.) must also be evaluated so as to determine the necessity of liner installation. The procedures will also depend on the physical characteristics of groundwater inflow into the quarry.

1. Quarry dewatering should help to determine major groundwater seepage points into the base. A seepage collection point should be established to keep the base of the quarry dry.

2. To the degree possible, all solid waste accumulated on the quarry base after dewatering should be pushed to a selected location in the corner of the quarry so that it can be ultimately placed in the controlled landfill. The selection of a location for collection of accumulated solid waste will be based on the characteristics of the quarry base to be determined after dewatering.
3. After dewatering, the base of Quarry #1 should be surveyed to determine the final configuration of a controlled landfill operation that commences at the point furthest away from the constructed access road against the quarry wall
4. The basalt surface of the base of the quarry should be geologically evaluated after dewatering to determine whether a base lining system (clay, etc.) should be installed to protect groundwater flow and aid in collecting leachate.
5. After installation of the base lining system, if required, solid waste placement should begin following waste receipt and placement controls outlined in this Plan.
6. Depending on the final configuration of a dewatered Quarry #1 base, a leachate evaporation pond should be constructed in Area 1 shown on Figure 2.1.
7. As Quarry #1 is filled, access to Quarry #2 should be constructed for eventual transfer of leachate evaporation pond and eventual relocation of controlled landfill operations into Quarry #2.

12.7 Landfill Operation

Once basic features of the controlled landfill configuration have been constructed. Controlled operations can commence. The following are the general procedures to be followed in beginning operations in the new base configuration.

1 All materials solid waste accumulated from the base of the quarry should be placed as the first lift in the new configuration.

2 The Governorate should communicate to all waste generators and waste haulers the date on which the new controlled landfill will be placed into service.

3 Once trucks are diverted to the new tipping location, strict enforcement of a no dumping policy at the former disposal site must be imposed and monitored.

4 The lift configuration of the base controlled landfill should accomplish controlled placement of solid waste, compaction and periodic cover application to create a working surface for the construction of the next lift.

5 The general sequence of waste placement and periodic cover should be as follows:

6 Waste and cover placed in Area 2 as shown in Figure 2.1 up the grade of the main access road constructed from one wall of the quarry to the other.

7 Relocate leachate evaporation ponds from Area 1 to Quarry #2

8 Begin waste placement in Area 1 until the fill grade has reached to level of waste in Area 2.

9 Continue filling in Areas 1 and 2, adjusting the grade of the access road as necessary as the fill grade increases toward the lip of the quarry.

10 Once Quarry #1 has been completely filled, operations should then transfer to Quarry #2. Access to Quarry #2 may be constructed using the Quarry #1 access road with a diversion to the ridge between Quarry #1 and Quarry #2 followed by direct access to Quarry #2.

12.8 Development Timeline

A preliminary project timeline is shown on the following page. While the timeline presents the estimated time that it will take to accomplish major tasks, the final time required will be a function of the success of quarry dewatering. Specific tasks that are included in the general task categories shown in the timeline are as follows:

Task 1-Dewatering Mobilization

1. Determine initial pumping installation requirements
2. Rent or purchase pumps for quarry #1 dewatering
3. Select location for initial dewatering pumping
4. If necessary, secure barge for dewatering pump installation and access to quarry central locations
5. Select location for dewatering pumping discharge
6. Determine means by which water from the dewatering process can be used for putting out the fires on the existing disposal area side slope

Task 2-Quarry #1 dewatering

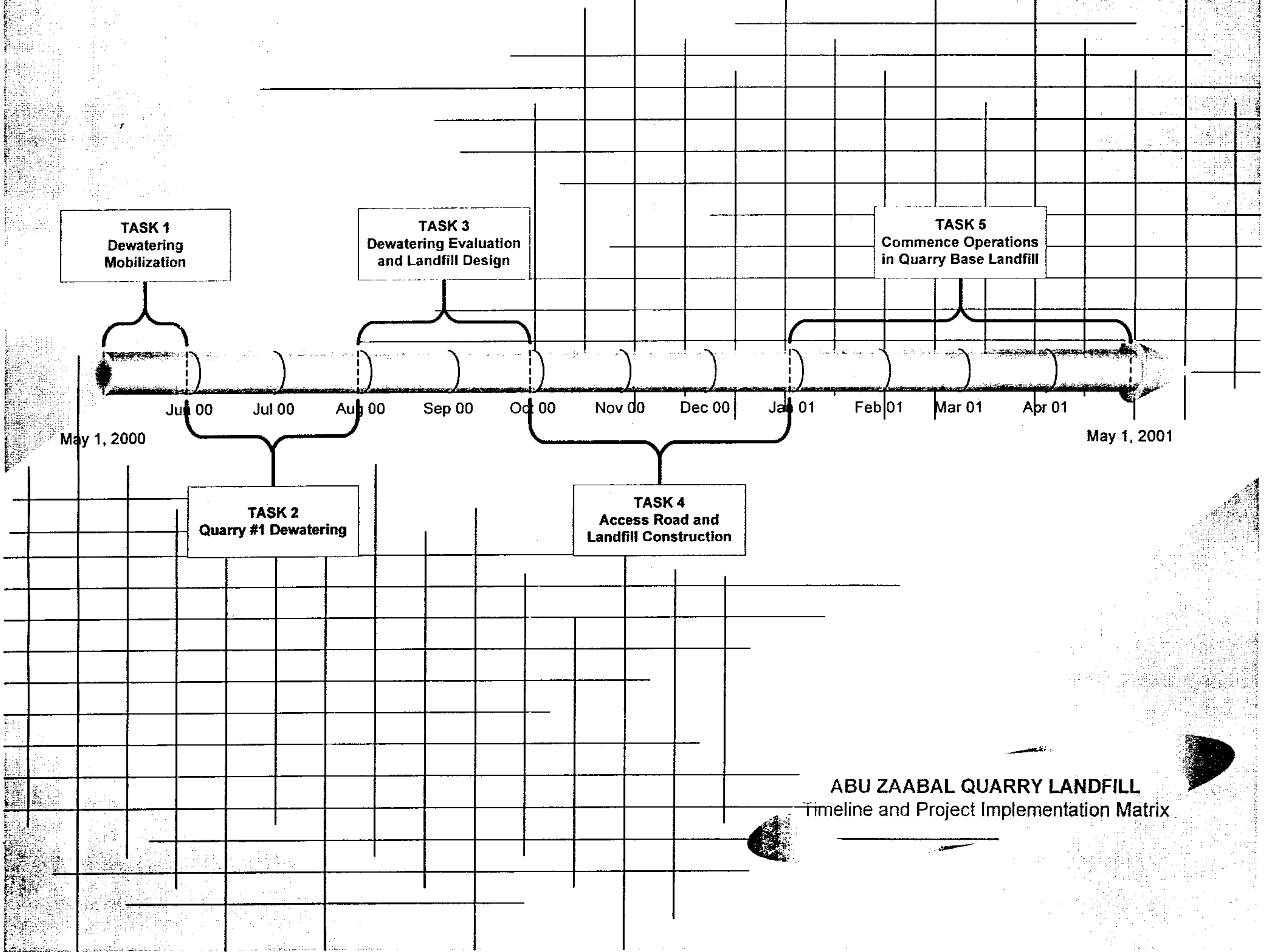
1. Begin dewatering process
2. Monitor dewatering pumping rate vs. quarry water level fluctuation
3. Use pumped water to put out and control fires that currently exist at the quarry sideslope disposal area.

Task 3-Dewatering evaluation and landfill design

1. Based on the observations made during the dewatering effort, a determination must be made that the quarry can be effectively dewatered on a long-term basis to prevent environmental damage because of the proposed landfill.
2. Once dewatering has been completed and it has been determined that it is practical to develop a landfill on the base of Quarry #1, the topographical survey should be completed of the entire base of Quarry #1.
3. Based on the actual configuration and topography of the base of Quarry #1, the landfill design and layout should be completed.
4. A dewatering plan should be developed based on observations made during the initial dewatering effort.

Task 4 - Access Road and Landfill Construction

1. Depending on the surface configuration of the base of Quarry #1 determined after dewatering, the existing accumulation of solid waste on the base of the quarry should be pushed into one central location to allow construction of the landfill and access road. Depending on the depth of the base of the quarry, access to the quarry for management of the accumulated solid waste may be gained from the existing access road opposite the current disposal location.



ABU ZAABAL QUARRY LANDFILL

Timeline and Project Implementation Matrix

2. After the accumulated solid waste has been pushed into a common location, Construction of the permanent access road can commence.
3. The final design of the access Road must be able to accommodate the type that number of trucks that will eventually use the site once the new landfill at the base of the quarry is placed into operation.
4. Once access to the base the quarry has been gained through construction of the new access road, the base of the proposed landfill will be prepared a begin accepting solid waste. An evaluation of the surface of quarry #1 after dewatering will be required to determine is additional soil lining is required to protect groundwater
5. Once sufficient area has been prepared to receive solid waste, the existing accumulation of solid waste from the base of the quarry will be placed and covered.

Task 5 - Commence operations in Quarry #1 Base landfill

After construction of the access road and landfill area has been completed, base operations can begin in accordance with the procedures finally adopted as the landfill's operations plan.

12.9 Future Considerations

As controlled landfill operations occur in Quarry #1 and Quarry #2, information should be generated concerning the pace at which airspace capacity is being depleted. Projections should be completed as to the point in time when airspace as defined by the physical configuration of the quarry is depleted. Consideration will then have to given to the vertical expansion of the landfill or to relocation into another site.

Section 13
Construction Cost Estimate

Table 13.1 on the following page presents a preliminary cost estimate for construction of the proposed access road and base landfill. The actual cost associated with developing a landfill of the base of Quarry #1 may differ significantly from the cost shown. The following are the factors that can influence the overall cost of the project:

1. There is very little information of the configuration and nature of the base of the quarry #1. This will only be determined after dewatering.
2. The cost and means of keeping the quarry free of water will only be determined through evaluation of the initial dewatering effort.
3. The final configuration of both the base landfill and the proposed access road will only be determined by the actual grades and configuration of the quarry base that will only be determined once dewatering is complete.
4. The cost of materials top be used to construct the quarry base access road will be a function of available sources of the material in the vicinity of the quarry. The use of quarry tailings and other soil stockpiles near the quarry my significantly decrease the cost of materials for the access road.
5. The necessity for a landfill liner will only be determined once dewatering is completed.
6. The cost for landfill equipment assumes the purchase of new equipment for operation of the landfill.

Table 13.1
PRELIMINARY COST ESTIMATE
Abu Zaabal Controlled Landfill Development

Work Task	Quantity	Units	Unit Cost	Cost[6]
1 *Dewatering Mobilization*				
Pumps for dewatering[1]				
Pumps	6	Each	25,000	150,000
Accessories	6	Each	10,000	60,000
Install pumps[2]	1	Lump	15,000	15,000
			Task Subtotal	225,000
2 *Quarry #1 Dewatering*				
Operate pumps[3]				
Technician/Operator	480	Hours	40	19,200
Labor	2400	Hours	15	36,000
			Task Subtotal	55,200
3 *Dewatering Evaluation and Landfill Design*				
Complete Quarry #1 base topographical plan	1	Lump	5,000	5,000
Prepare hydrogeological and dewatering plan	1	Lump	15,000	15,000
Design base landfill	1	Lump	15,000	15,000
Install monitoring wells	6	Each	3,000	18,000
			Task Subtotal	53,000
4 *Access Road and Landfill Construction*				
Construct new approach roads	1500	M^2	13	19,500
Construct Quarry #1 access road[4]				
Loader with driver	40	Day	500	20,000
Bulldozer with driver	40	Day	500	20,000
Laborers	120	Day	15	1,800
Trucks with Drivers	40	Day	350	14,000
Fill material for Roadway	200,000	m^3	5	1,000,000
Collect and stockpile accumulated waste				
Bulldozer with driver	10	Day	500	5,000
Laborers	30	Day	15	450
Install base liner[5]				
Loader with driver	40	Day	500	20,000
Bulldozer with driver	40	Day	500	20,000
Laborers	120	Day	15	1,800
Trucks with Drivers	40	Day	350	14,000
Soil materials for liner	138,000	m^3	5	690,000
Construct leachate collection berm				
Loader with driver	10	Day	500	5,000
Bulldozer with driver	10	Day	500	5,000
Laborers	30	Day	15	450
Trucks with Drivers	10	Day	350	3,500
Soil material for berm	3000	m^3	10	30,000
Construct leachate evaporation pond				
Loader with driver	10	Day	500	5,000
Bulldozer with driver	10	Day	500	5,000
Laborers	30	Day	15	450
Trucks with Drivers	10	Day	350	3,500
			Task Subtotal	1,884,450
5 *Commence Operations in Quarry Base Landfill*				
Purchase landfill operations equipment[7]	1	Lump	2,500,000	2,500,000
Tools, protective equipment, supplies	1	Lump	3000	3,000
			Task Subtotal	2,503,000
			Contingency (10%)	472,065
			Preliminary Landfill Construction Cost	5,192,715

otes
1 Assumes pump purchase - pumps may be rented for initial dewatering
2 Initial dewatering to determine need for barge installation
3 Assumes 24/day operation for two months
4 Construction depends on final Quarry #1 base configuration
5 Depends on Quarry #1 quarry base characteristics
6 All costs shown in Egyptians pounds
7 Mobile equipment based on following:

Caterpillar D4C Series III	2	Each	475,000	950,000
Caterpillar Wheel type Loader Model 914G	2	Each	385,000	770,000
Truck ($8m^3$)	1	Each	350,000	350,000
				2,070,000

Appendix 1
Solid Waste Database Printout

Waste Generation Database

	Variable Entry
Location	Qualioubiya Governorate
Population (Census)	3,446,000
Per Capita Generation (Kg/Cap/Day)	0.5
Population growth per year (%)	2.16%
Percent of Waste Collected (%)	50%
Loose Density (Kg/M^3)	450
Truck Compact Density (Kg/M^3)	600
Landfill Density (Kg/M^3)	800
Cover Soil (%)	10%

Year	Population	Waste Generation (Tonnes/Day)	Waste Collected (Tonnes/Day)	Daily Loose Volume M^3/Day	Daily Compactor Truck Volume M^3/Day	Annual Landfill Volume Waste M^3/Day	Annual Landfill Volume Cover M^3/Day	Annual Landfill Volume Total M^3/Day	Annual Landfill Volume Depleted M^3/year	Quarry Volume Depletion M^3/year
1999	3,446,000	1,723	862	1,914	1,436	1,077	108	1,185	369,584	4,454,956
2000	3,520,434	1,760	880	1,956	1,467	1,100	110	1,210	377,567	4,085,372
2001	3,596,475	1,798	899	1,998	1,499	1,124	112	1,236	385,722	3,707,806
2002	3,674,159	1,837	919	2,041	1,531	1,148	115	1,263	394,054	3,322,084
2003	3,753,521	1,877	938	2,085	1,564	1,173	117	1,290	402,565	2,928,030
2004	3,834,597	1,917	959	2,130	1,598	1,198	120	1,318	411,260	2,525,465
2005	3,917,424	1,959	979	2,176	1,632	1,224	122	1,347	420,144	2,114,205
2006	4,002,040	2,001	1,001	2,223	1,668	1,251	125	1,376	429,219	1,694,061
2007	4,088,484	2,044	1,022	2,271	1,704	1,278	128	1,405	438,490	1,264,842
2008	4,176,796	2,088	1,044	2,320	1,740	1,305	131	1,436	447,961	826,352
2009	4,267,014	2,134	1,067	2,371	1,778	1,333	133	1,467	457,637	378,391
2010	4,359,182	2,180	1,090	2,422	1,816	1,362	136	1,498	467,522	79,246
2011	4,453,340	2,227	1,113	2,474	1,856	1,392	139	1,531	477,621	546,769
2012	4,549,532	2,275	1,137	2,528	1,896	1,422	142	1,564	487,937	1,024,389
2013	4,647,802	2,324	1,162	2,582	1,937	1,452	145	1,598	498,477	1,512,327
2014	4,748,195	2,374	1,187	2,638	1,978	1,484	148	1,632	509,244	2,010,804
2015	4,850,756	2,425	1,213	2,695	2,021	1,516	152	1,667	520,244	2,520,047
2016	4,955,532	2,478	1,239	2,753	2,065	1,549	155	1,703	531,481	3,040,291
2017	5,062,572	2,531	1,266	2,813	2,109	1,582	158	1,740	542,961	3,571,772
2018	5,171,923	2,586	1,293	2,873	2,155	1,616	162	1,778	554,689	4,114,733
2019	5,283,637	2,642	1,321	2,935	2,202	1,651	165	1,816	566,670	4,669,421

Appendix 2

Ministry of Industry Hazardous Waste Criteria

MINISTRY OF INDUSTRY

Following are the Hazardous Waste lists. They comprise two lists, a specific one with hazardous wastes specific to this sector, and a general list with hazardous wastes common to all sectors.

Waste types present on the specific list are to be considered hazardous unless the waste producer provides documentation to the competent authority giving evidence that his/her specific waste is not hazardous.

A - Specific List:

The text printed in bold are headlines. The waste fractions being on the hazardous waste list are mentioned after the bullets "•".

1. **Waste resulting from exploration, mining and dressing and further treatment of minerals and quarry Excluding waste belonging to the hazardous waste list of the Ministry of Petroleum and the list of the** Ministry of Electricity

2 Chemical **industry e.g. manufacture, formulation and supply of basic** organic **chemicals, plastics, synthetic rubber, man-made fibers, dyes, pigments, pesticides, pharmaceuticals, fats, grease, soaps, detergents disinfectants, cosmetics and fine chemicals. Excluding waste belonging to the hazardous waste list of the Ministry of Petroleum.**

• All waste types e.g. off-dated substances, wastewater, sludge, solvents, spent catalysts, filter cakes, spent absorbents and filter dust

3 **Photographic industry**

• All waste types e.g. developer, activator solutions, offset plate developer solutions, fixer solutions, bleach solutions, bleach fixer solutions, silver containing waste from on-site treatment of photographic waste

4 **Wood preservation**

• Waste containing wood preservatives. e.g. outdated preservatives, spills, contaminated materials and sludge. Wood treated with wood preservatives are not covered by this entry.

5 **Wastes from pulp, paper and cardboard production and processing**

• Bleaching sludge from hypochlorite and chlorine processes

6 **Leather Industry**

• Degreasing wastes containing solvents
• Tanning liquor containing chromium
• Sludge containing chromium
• Buffing dust containing chromium

7 **Textile industry**
- Halogenated wastes from dressing and finishing
- Dye stuff and pigments
- Wastes from waterproofing

8 **Iron and steel industry**
- Solid wastes from gas treatment
- Sludge from gas treatment
- Other sludge
- Soil/dust from scrap handling, storing and cleaning

9 **Aluminium thermal metallurgy**
- Tars and other carbon containing wastes from anode manufacture
- Skimming
- Primary smelting slags/white drosses
- Spent pot lining
- Salt slags from secondary smelting
- Black drosses from secondary smelting

10 **Lead metallurgy**
- Slags (first and second smelting)
- Dross and skimming (first and second smelting)
- Calcium arsenate
- Flue gas dust
- Other particles and dust
- Solid waste from gas treatment
- Sludge from gas treatment

11 **Zinc thermal metallurgy**
- Slags (first and second smelting)
- Dross and skimming (first and second smelting)
- Flue gas dust
- Solid waste from gas treatment
- Sludge from gas treatment

12 **Copper thermal metallurgy**
- Flue gas dust
- Waste from electrolytic refining
- Solid waste from gas treatment
- Sludge from gas treatment

13 **Wastes from casting of ferrous and non-ferrous pieces**
- Furnace dust
- Organic binders (off-specification, out-dated or unfit for its originally purpose)

14 Manufacturing of glass and glass products
- Flue gas dust

15 Metal treatment and coating of metal e.g. galvanic processes, zinc coating processes, pickling processes, etching, phosphatizing, alkaline degreasing, hydrometallurgical processes, tempering processes
- Spent solutions
- Sludge

16 Shaping and surface treatment of metals and plastics
- Waste machining oil and emulsions
- Synthetic machining oil
- Machining sludge
- Sludge from grinding, honing and lapping
- Polishing sludge
- Degreasing wastes, sludge and liquids

17 Power production
- Oil fly ash

18 Metal scrap shredding and cutting
- Light fraction from shredding ("fluff")
- Filter dust
- Filter sludge
- Soil/dust from scrap handling, storing and cleaning

19 Metal scrap incineration
- Ash from the incineration of insulated copper wire
- Ash from incineration of printed circuit boards

20 Incineration, pyrolysis and vitrification of waste
- Fly ash
- Bottom ash (not slag)
- Boiler dust
- Solid waste, sludge and liquid from gas treatment

B General List:

- Oil and grease waste

(E.g. hydraulic oils, brake fluids, engine oils, gear oils, lubrication oils, insulation oils, heat transmission oils, bilge oils, oil/water separator solids and sludge, oil/water interceptor sludge etc.)

- Solvent waste, halogenated and unhalogenated

(E.g. from cleaning, degreasing, machinery maintenance, solvent recovery, textile finishing etc.)

• CFC/Solvent waste with CFC's
(E.g. from coolants, foam/aerosol propellants, coolant recovery etc.)

• Waste acidic solutions
(E.g. sulphuric acid, sulphurous acid, hydrochloric acid, hydrofluoric acid, phosphoric acid, phosphorous acid, nitric acid, nitrous acid and other acids, electrolyte from batteries and accumulators)

• Waste alkaline solutions
(E.g. calcium hydroxide, soda, ammonia and alkaline)

• Catalysts containing hazardous transition metals

• Spent Liquid catalysts

• Catalysts contaminated by use.

• Spent activated carbon except spent activated carbon from the treatment of potable water and processes of the food industry and vitamin production

• Paints, varnish and printing inks containing solvents, heavy metals or pesticides

• Powder paints not hardened

• Adhesives, glue and sealant containing solvents, pesticides or PCB

• Liquid waste from automobiles

• Laboratory chemicals and other chemicals not specified

• Batteries containing lead, cadmium or mercury
• Waste electrical and electronic assemblies or scrap with batteries containing lead, cadmium or mercury

• Transformers and capacitors containing PCB or PCT

• Waste electrical and electronic assemblies or scrap with transformers and capacitors containing PCB or PCT)

• Demolition waste (e.g. insulation materials), filters and other materials containing free asbestos

• Industrial gases in high pressure cylinders, LPG containers and industrial aerosol containers (including halons)

• Cables consisting of oil and tar

• Saturated or spent ion exchange resins

- Solutions and sludge from regeneration of ion exchangers

- Waste tarry residues (excluding asphalt cements) arising from refining, distillation and any pyrolytic treatment of organic materials

- Waste from transport or storage tank cleaning containing oil or chemicals

- Absorbents, wiping cloths, filter materials and protective clothing contaminated with hazardous waste

- Packaging containing residues of hazardous substances

C. Safe handling of Hazardous Waste:

Measures to follow in order to ensure safe handling of hazardous waste have to be decided upon on a case-specific basis. As a general rule, however, measures to safe handle the waste can be based on the safety measures required for handling each hazardous constituent of the waste.

D. Properties causing waste to be "hazardous":

Hazardous Waste is waste with any of the following properties:

- **Explosive** substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene.

- **Oxidizing** substances and preparations which exhibit highly exothermic reactions when in contact with other substances, particularly flammable substances .

- **Flammable** waste having a flash point less than or equal to 55 degree Celsius.

- **Irritant** non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.

- **Corrosive** substances and preparations which may destroy living tissue on contacts.

- **Harmful** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve limited health risks.

• **Toxic** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may involve serious, acute or chronic health risks and even death.

• **Carcinogenic** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.

• **Teratogenic** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce non-hereditary congenital malformations or increase their incidence.

• **Mutagenic** substances and preparations which, if they are inhaled or ingested or if they penetrate the skin, may induce hereditary genetic defects or increase their incidence.

• **Infectious** substances containing viable micro-organism or their toxins which are known or reliably believed to cause disease in man or other living organisms.

• **Ecotoxic** substances and preparations which present or may present immediate or delayed risks for one or more sectors of the environment.

• Substances and preparations which release toxic or very toxic gases in contact with water, air or an acid.

• Substances and preparations capable by any means, after disposal, of yielding another substance, e.g. a leachate, which possesses any of the characteristic listed above.

Appendix 3

Example Industrial Waste Characterization Form

INDUSTRIAL SOLID WASTE CHARACTERIZATION PROFILE

Name of Organization/Company ______________________________

Person Completing Solid Waste Inventory Form ______________________________

Mailing Address ______________________________

____

____

Telephone ______________________________

Fax Number ______________________________

Email ______________________________

Primary Product(s) Manufactured ______________________________

____

Primary Service(s) Performed ______________________________

____

Types of Solid Waste Generated

- Office/Employee-based solid waste ☐
- Production by-product waste ☐
- Wastewater treatment sludge ☐
- Other ____________________ ☐

Please complete a solid waste characterization form for each type of solid waste generated.

Waste Characterization - Office/Employee-based Solid Waste

Number of Employees ____________________

Quantity of Solid Waste Generated ____________________

How is the quantity of solid waste measured? ____________________

Is any component of the employee-based solid waste recycled? Yes ☐ No ☐

If yes, what components are recycled? ____________________

What percentage of the component is recovered? ____________________

Are these materials sold to outside markets? Yes ☐ No ☐

If yes, to whom are the materials solid? ____________________

____

____

____

Current means and location of disposal for materials not recycled ____________________

____

Current means of waste transportation to disposal location ____________________

____

Waste Characterization – Production By-product Waste

Is more than one type of production waste generated? Yes ☐ No ☐

If yes, Please list the types and quantity of production solid waste generated

1 - ____________________

2 - ____________________

3 - ____________________

4 - ____________________

How is the quantity of solid waste measured? ____________________

Is there a seasonal variation in the solid waste quantity? Yes ☐ No ☐

If yes, please describe the extent and cause of seasonal variation in quantity.

____

____

Is there a seasonal variation in the solid waste quality? Yes ☐ No ☐

If yes, please describe the extent and cause of seasonal variation in quantity.

____

____

Current means and location of disposal for materials not recycled ____________________

____

Current means of transport to disposal location ____________________

____

Are laboratory test results available for any of the production waste? Yes ☐ No ☐
If yes, please provide copies of any test results.

Waste Characterization – Wastewater Treatment Sludge

Type of Wastewater Treatment Process Generating the Material ______________

____

If yes, Please list the types and quantity of wastewater treatment sludge generated

1 - ____

2 - ____

3 - ____

4 - ____

Current means and location of disposal for materials not recycled ______________

____

Current means of transport to disposal location ______________________

____

Are laboratory test results available for any of the production waste? Yes ☐ No ☐
If yes, please provide copies of any test results.

Appendix 4
Sample Training Agendas

Sample Landfill Staff Training Agendas

Sample Manager and Supervisor Training Agenda

1. Introduction
2. Unit Basics
   a. Siting
   b. Waste Containment
   c. Daily Operations
3. Owning and Operating Machines
4. Machine Types
5. Equipment Maintenance
6. Maximizing Airspace
7. Labor Management
8. Production Analysis
9. Application of Production Rate Data
10. Budget and Data Tracking
    a. Operating Budget
    b. Cover Soil Budget
    c. Airspace Budget
11. Identification and Handling of Hazardous Materials
12. Waste Handling Techniques
13. Waste Management Techniques
14. Cover Soil Placement
15. Safety Issues and Safety Meetings
16. Record Keeping
17. Emergency Response Plan
18. Monitoring
    a. Operational
    b. Environmental
19. Regulatory requirements

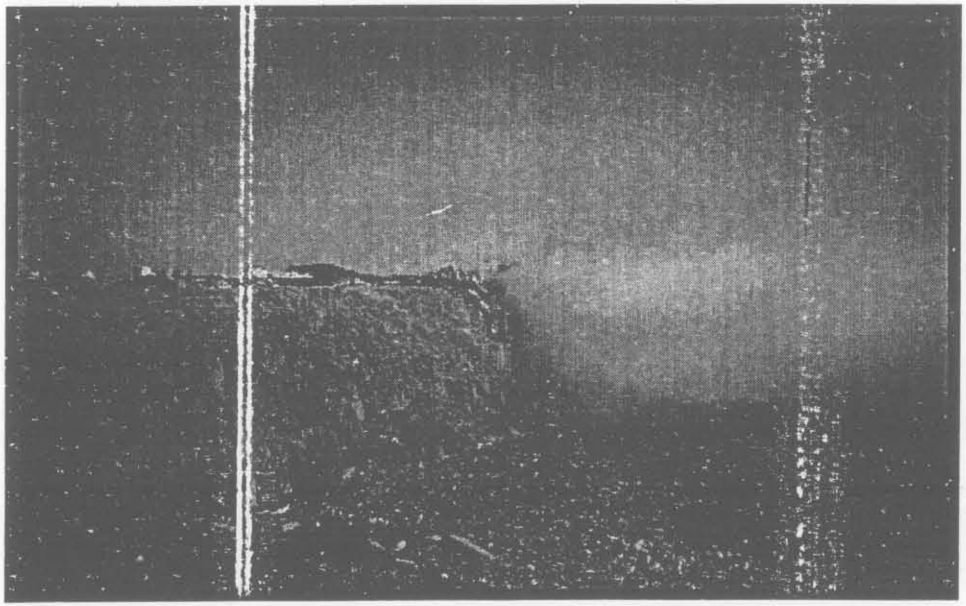
Sample Laborer Training Agenda

1. Introduction
2. Unit Basics
   a. Waste Containment
   b. Daily Operations
3. Traffic Management and Safety
4. Interacting with the Public
5. Load Segregation and Placement
6. Hazardous Materials Identification Procedure
7. Unit Equipment Types and Applications
8. Cover Operations
9. Equipment Maintenance
10. Unit Safety
    a. Heavy Equipment Safety
    b. Traffic Safety
    c. Personal Protective Equipment
11. Emergency Response Plans

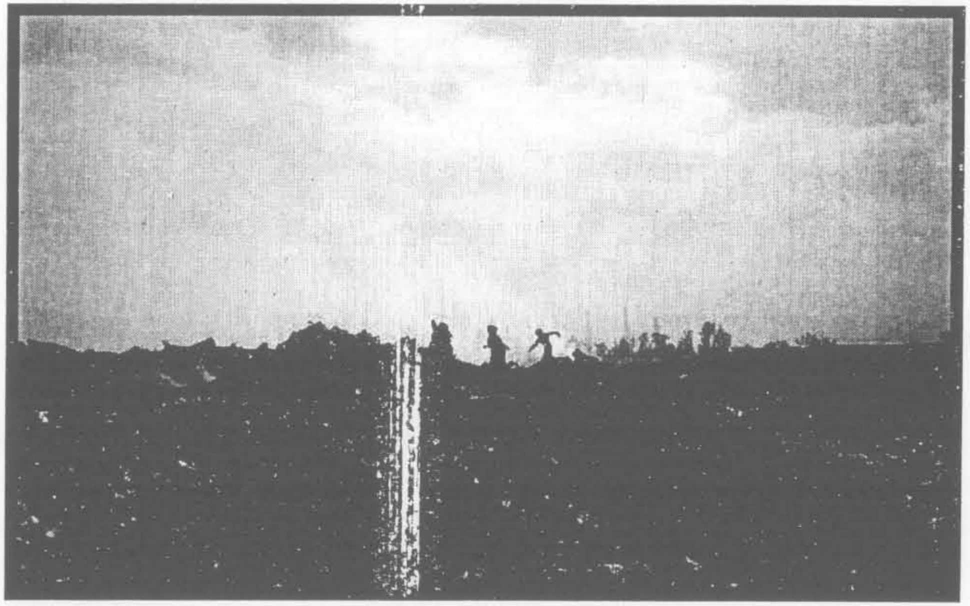
Sample Equipment Operator Training Agenda

1. Introduction
2. Unit Basics
   a. Waste Containment
   b. Daily Operations
3. Heavy Equipment Types and Applications
   a. Scraper, dozer and compactor operations
   b. Support Equipment
   c. Fluids
   d. Fueling, Maintenance and its Hazards and Fuel Spill Prevention
4. Cover Operations
   a. Types of Soil Cover
   b. Placement of Soil Cover
5. Drainage Control
6. Surveying and Staking
7. Unit Safety
   a. Emergency Response Plans
   b. Safe Operating Techniques
8. Owning and Operating Costs

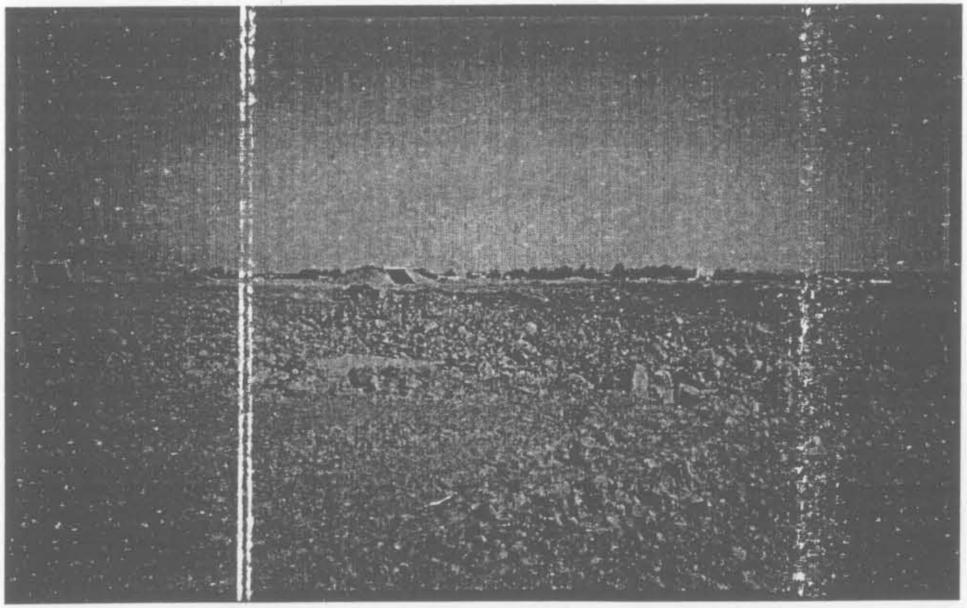
Appendix 5
Photographs



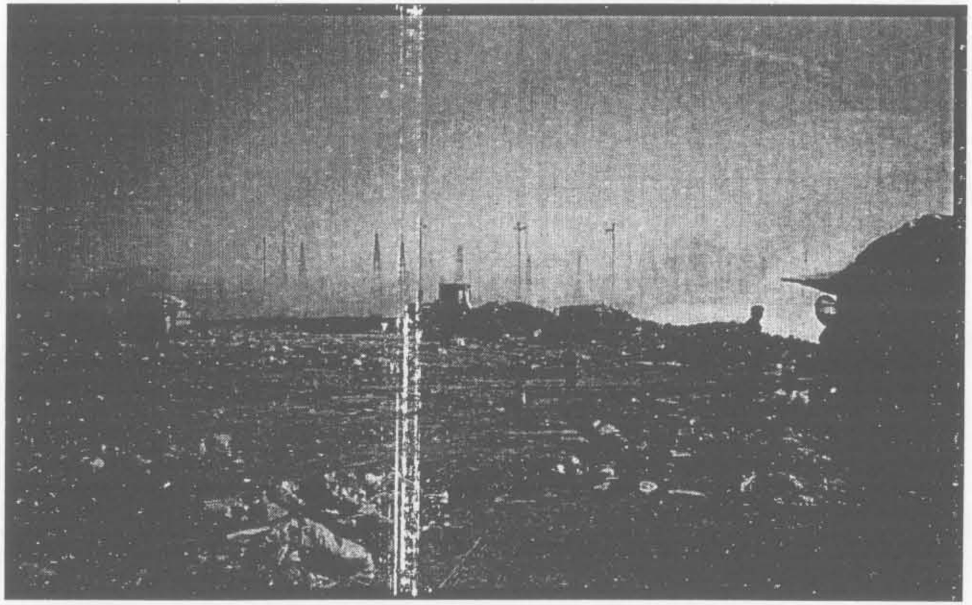
Picture 1
Burning Waste on Quarry #1 Side Slope
Note: Floating Waste in Quarry #1 Lake



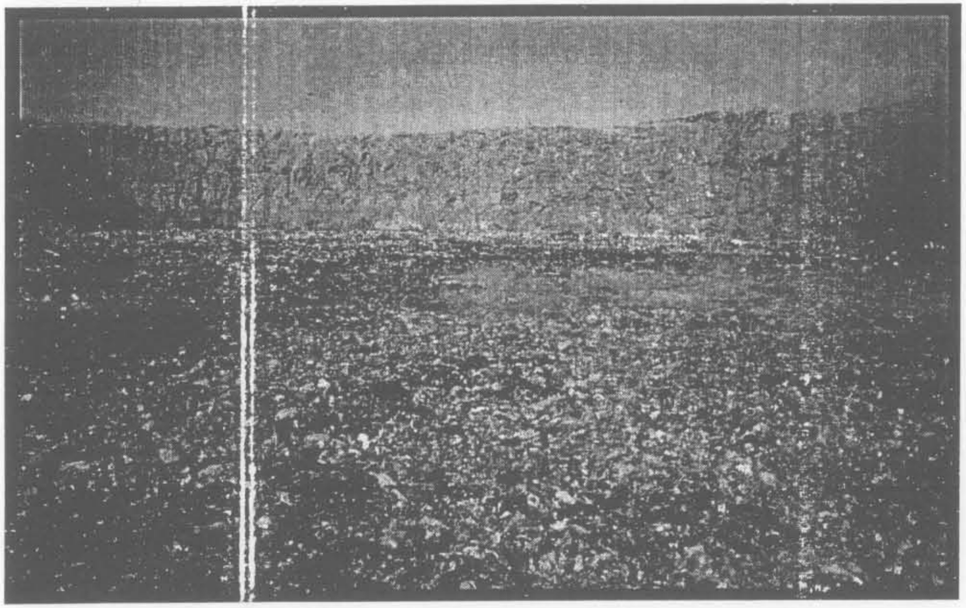
Picture 2
Scavengers at Tip Area



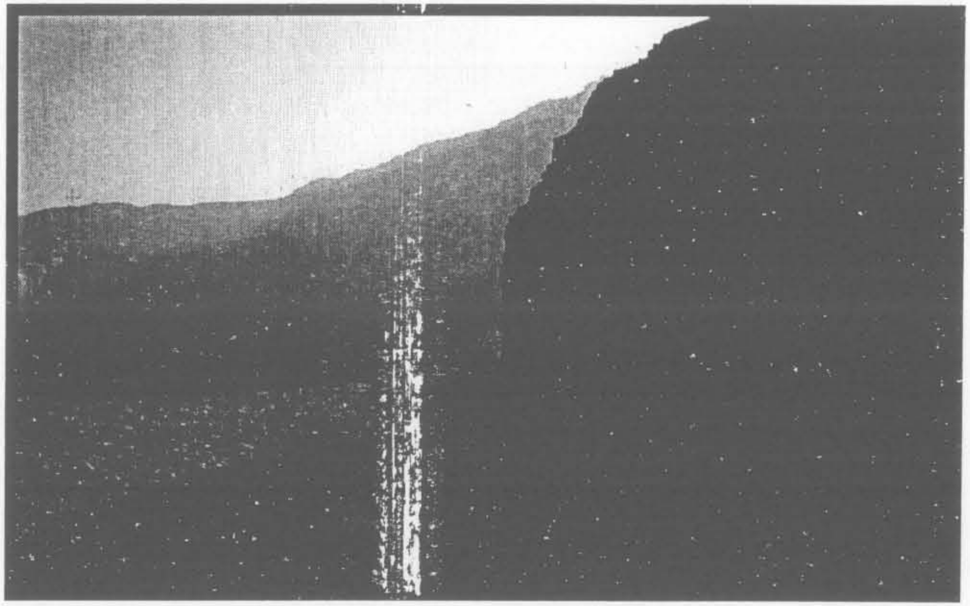
Picture 3
Military Area to Rear of Tip Area
Note: Specific location may be key to access road location



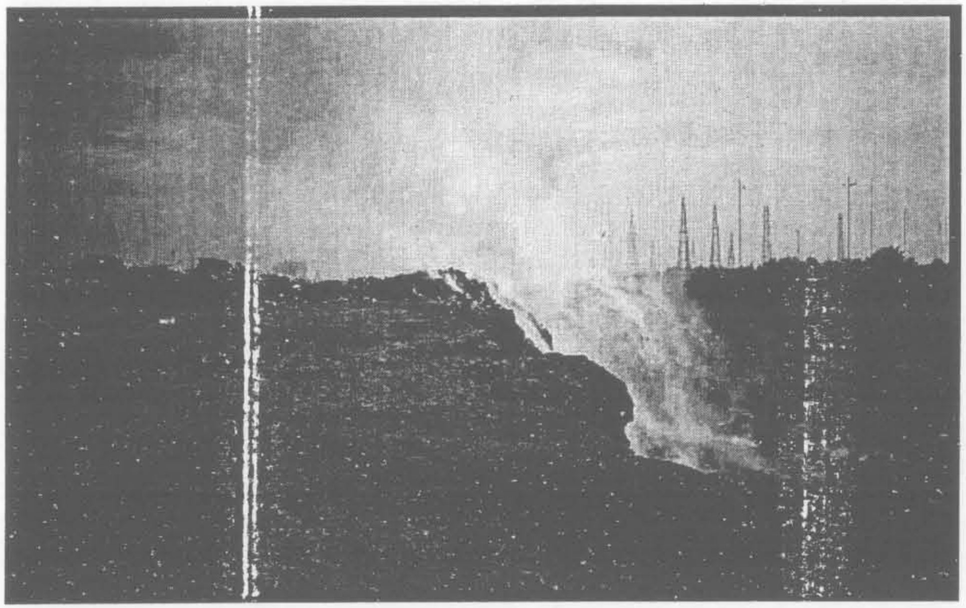
Picture 4
Tip Area Activity



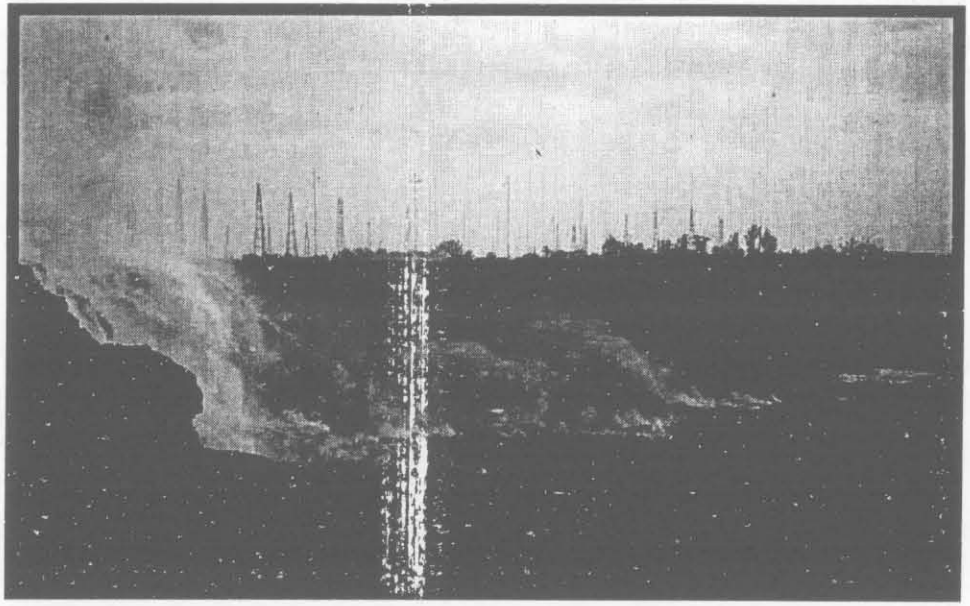
Picture 5
Waste at bottom of Quarry #1
Note: Some waste floating on water surface still burning.



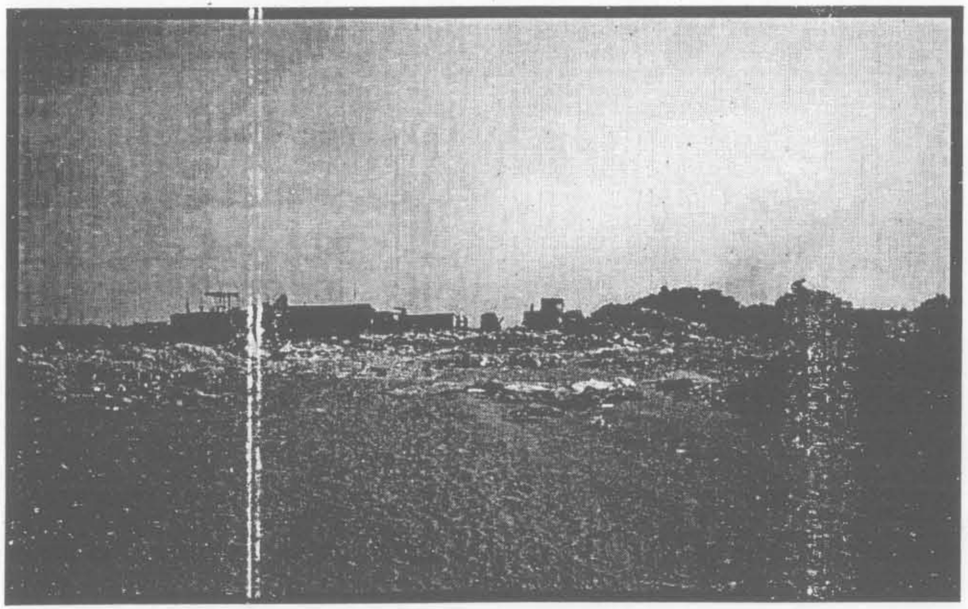
Picture 6
Quarry #1 Side Slope
Note: Quarry walls irregular throughout both quarries.



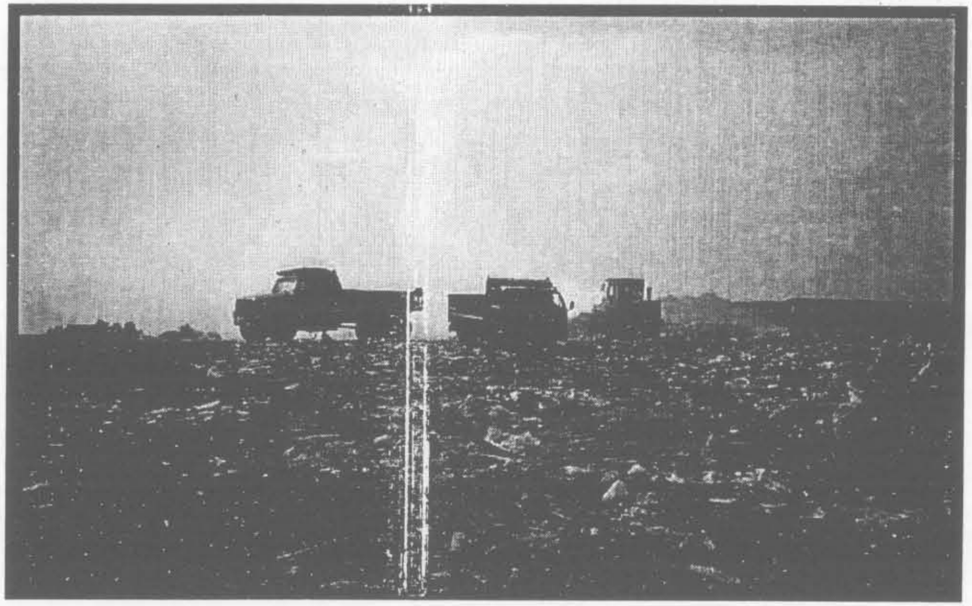
Picture 7
Burning Waste on Quarry #1 Side Slope
Note: Note potential drop should side slope fail.



Picture 8
Burning Waste on Quarry #1 Tip Area
Note: Wind Direction variable. Note developed area in background



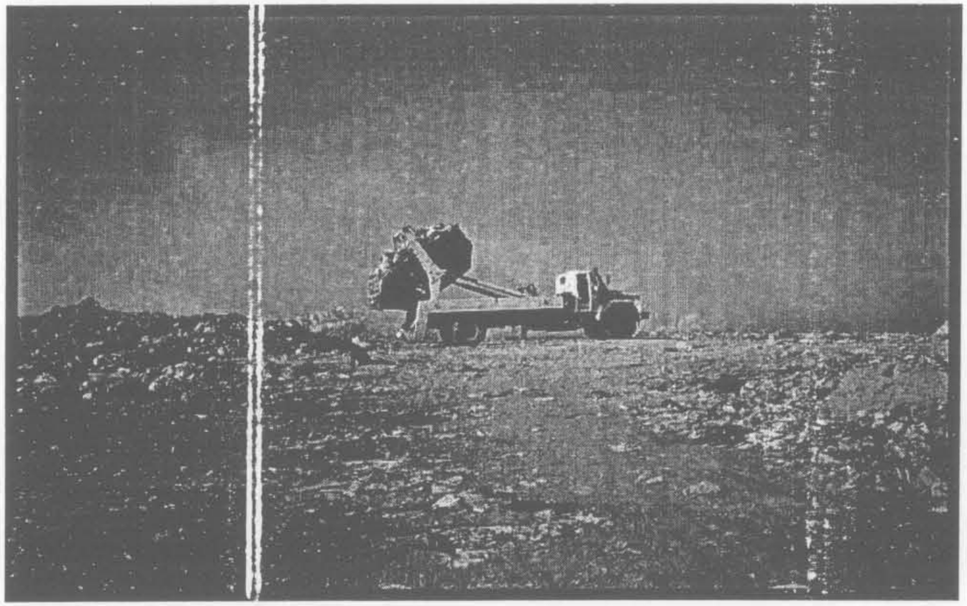
Picture 9
Tip Area Activity
Note: Site generally clean except at immediate quarry tip area.



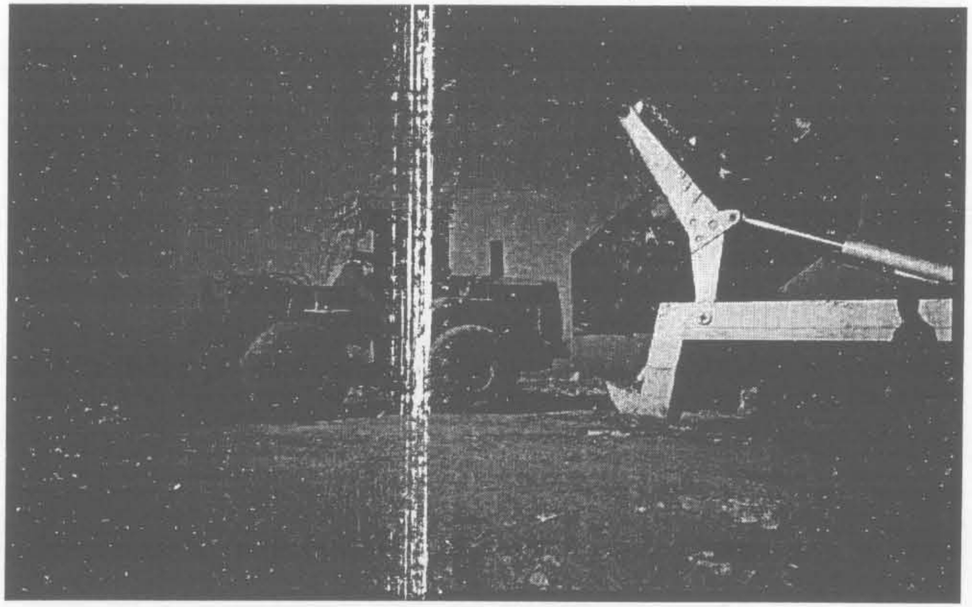
Picture 10
Waste Delivery Trucks at Tip Area
Note: Landfill staff do provide reasonable control of traffic at site.

Picture 11
Waste Delivery at Tip Area
Note: Different types of vehicles used for waste delivery – will be a factor in controlled landfill operations.

Picture 12
Waste Delivery at Tip Area

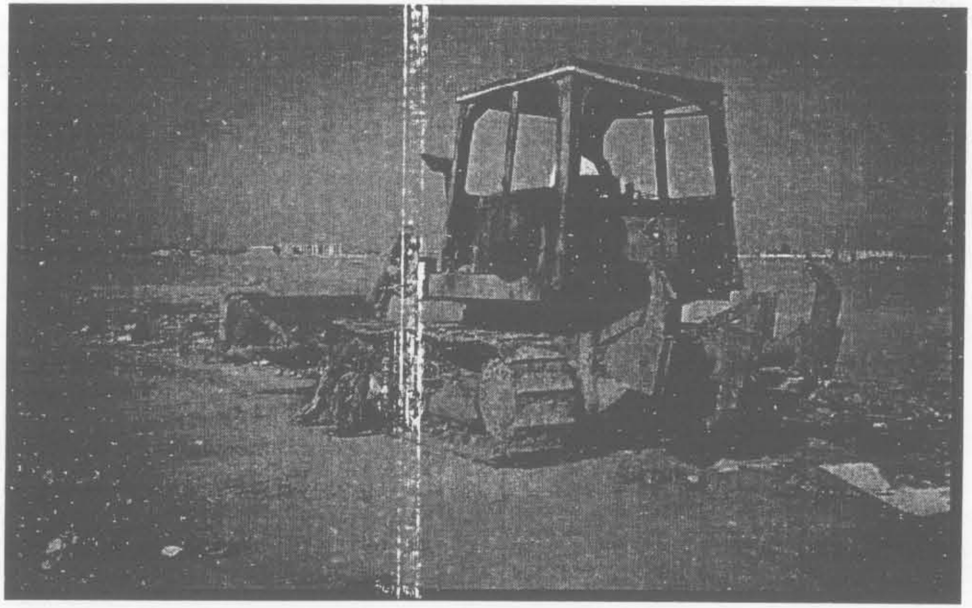


Picture 13
Waste Delivery at Tip Area

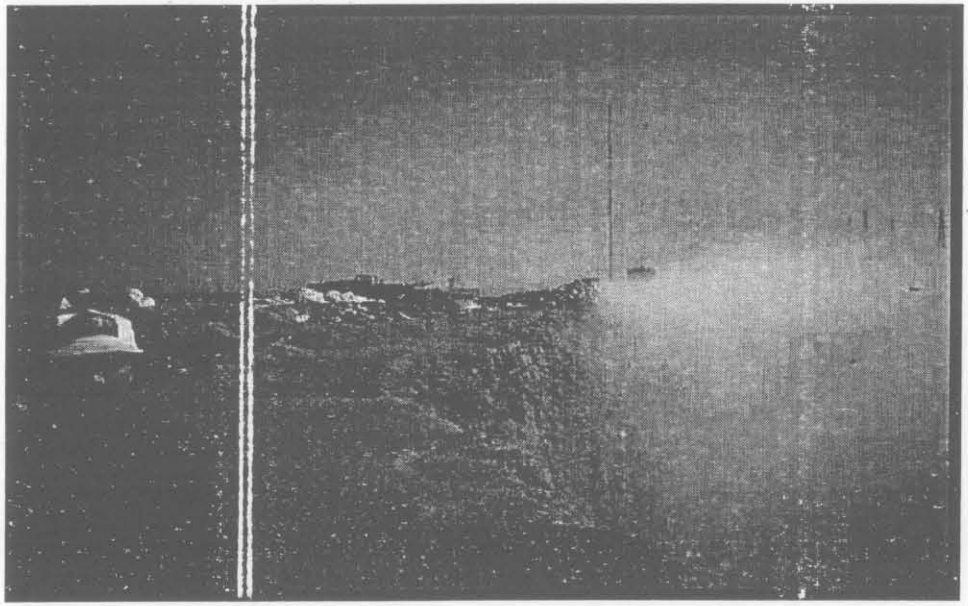


Picture 14
Landfill Front-end Loader
Note: Only functioning loader

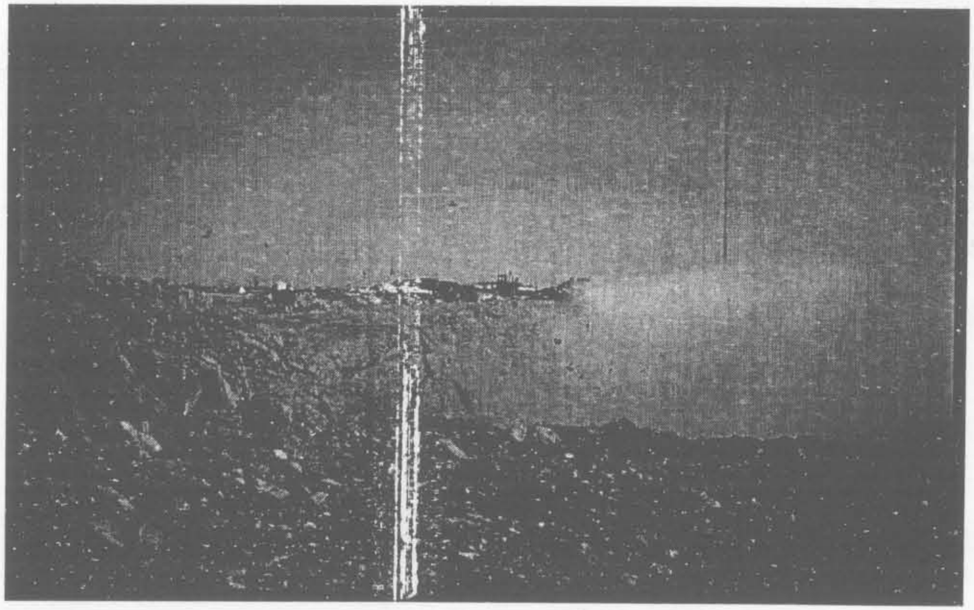
Picture 15
Landfill Loader Pushing Waste Into Quarry



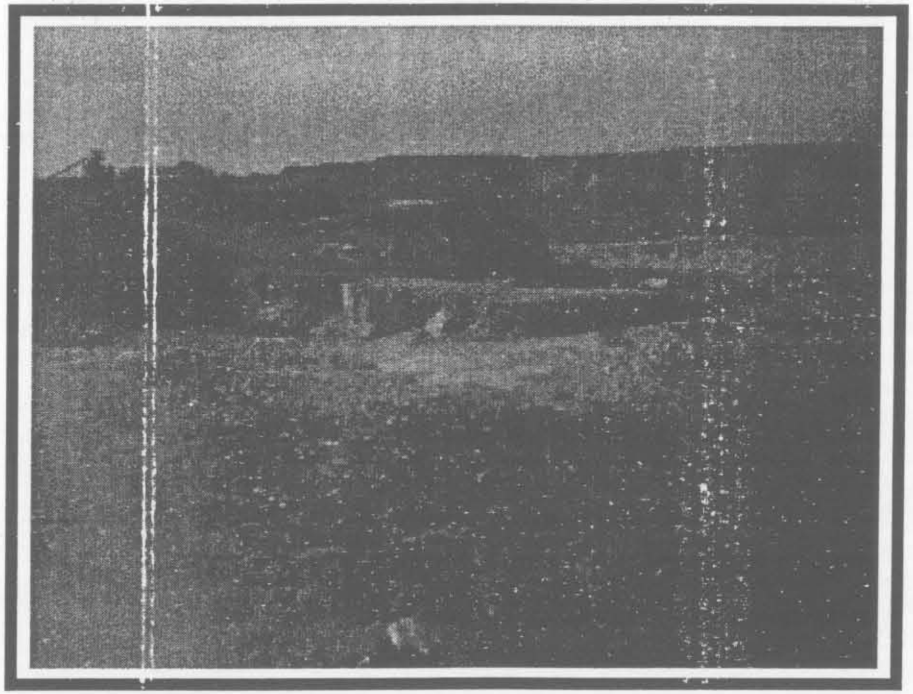
Picture 16
Landfill Bulldozer



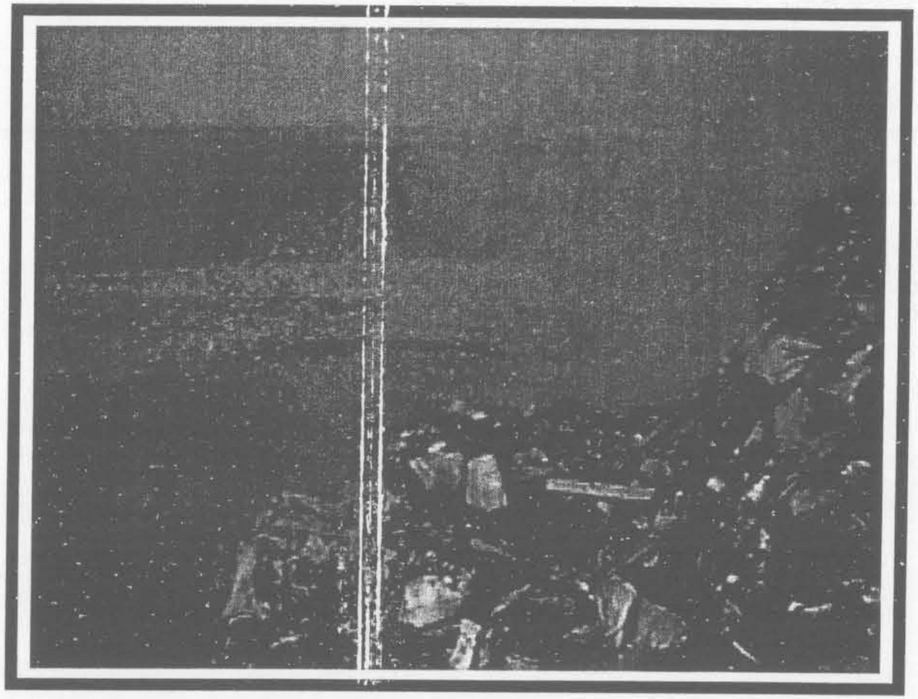
Picture 17
Smoke at Quarry #1 Side Slope



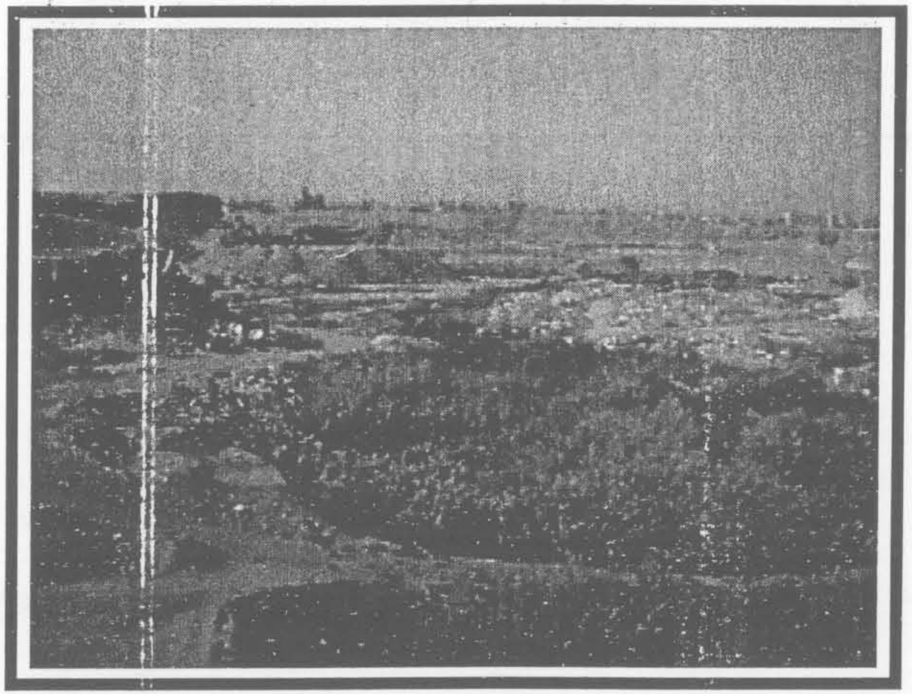
Picture 18
Smoke at Quarry #1 Side Slope



Picture 19
Access Road to Quarry #1 Base
Note: Located opposite current quarry tip area



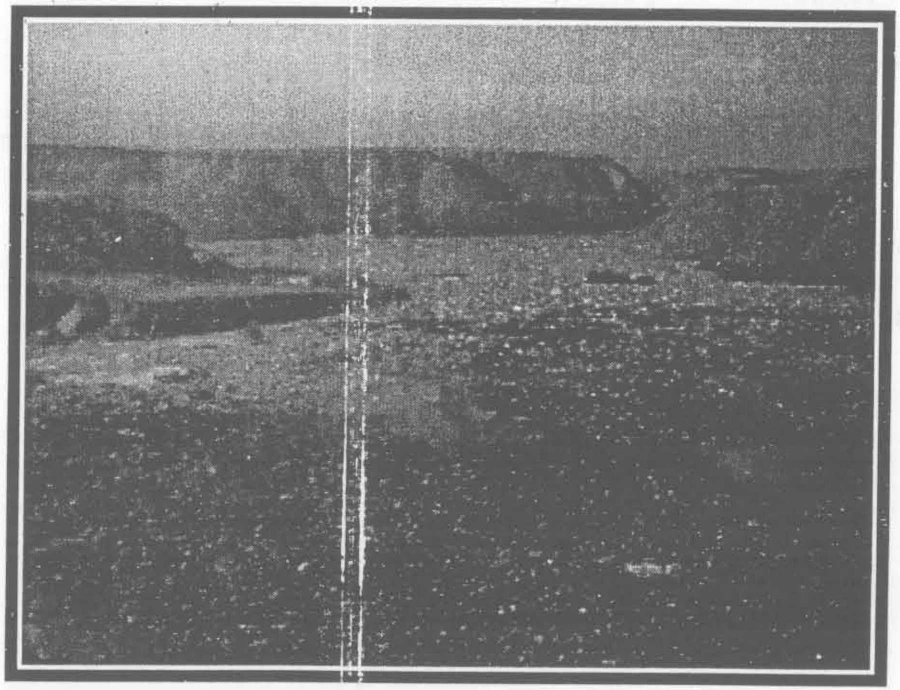
Picture 20
Waste on Quarry #1 Side Slope



Picture 21

Base of Quarry #2

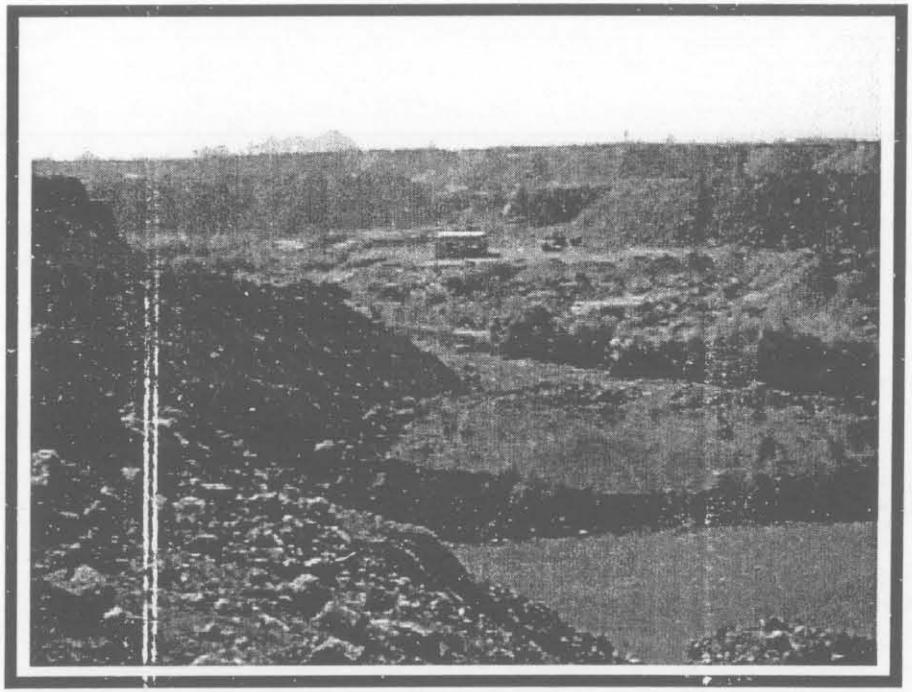
Note: Wetlands and limited exposed water shows that base elevation typically higher than Quarry #1



Picture 22

Base of Quarry #1

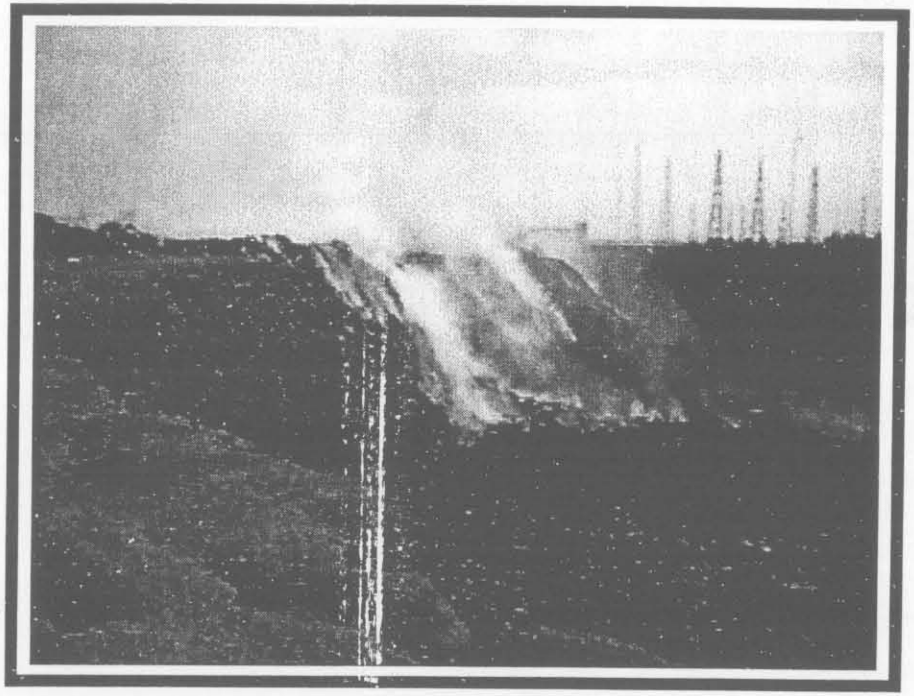
Note: Floating solid waste completely covering Quarry #1 lake



Picture 23

Base of Quarry #3

Note: Active quarry operations in background



Picture 24

Quarry #1 Tipping Area

Note: Burning waste along full face of tip area. Note extent of drop as safety hazard.

Appendix 6
Quarry #1 Water Test Report

HOUSING AND BUILDING RESEARCH CENTER
SANITARY AND ENVIRONMENTAL ENGINEERING DEPT.

WATER ANALYSIS REPOT

Sampling Date:	19/1/2000
Sampling Time:	12:00 PM
Sampling Area:	Abo-Zaabal, Qalubia, Egypt.
Sampling Location:	Cliff bottom.
Water Type:	Stagnant water mixed with solid waste.
Sample color:	Light green transparency.
Sample smell:	Waste septic smell.
Air temperature at sampling location:	18.5 ^{o}C
Water temperature at sampling location:	20.5 ^{o}C (At depth 1.00 m)

	Sample (1)	**Sample (2)**
pH	7.22	7.16
Elec. Conductivity, µm	7600	7300
Total Solids, ppm	15270	13800
Total Dissolved Solids, ppm	5431	4956

Lab Eng.	**Lab Manager**	**Head of Dept.**
A. Abd El Meguid	A. Karakish	M. Hassan

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- Law Number 4 for 1994 and Its Executive Regulations – Law for the Environment - Egypt