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FINAL DRAFT

INTEGRAL CONSULT

ENVIRONMENTAL IMPACT ASSESSMENT

AL HAMMAM LANDFILL PROJECT

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Integral Consult was contracted by Onyx Alexandria to conduct an Environmental Impact Assessment (EIA) study for the proposed extension of Al-Hammam waste disposal site located south of Al-Hammam city. The project has been classified as Category C and a full EIA is required in accordance with Egyptian environmental impact assessment guidelines. The site is located approximately 80 km away from Alexandria to the South of Al-Hammam city occupying a total area of 1.9 $km^{2.}$ The surrounding areas are not developed nor cultivated. And the nearest residential area is located 10 km away from the site.

The site has been in use since 2003, where one cell has been filled and closed. The proposed extension does not involve expanding to other areas, but establishing 13 new waste disposal cells. The site lifetime of Al-Hammam landfill has been estimated to allow for accepting waste from Alexandria for 31 years. Detailed hydrological studies indicated that the site is located above local and moderately productive aquifers. The depth to groundwater of the aquifer exceeds 50 m, and the soil composition is clay.

The ecological studies showed that the site has no ecological importance and no wildlife of special importance were found in the project location. The flora and fauna present in the site and the surrounding environment are widespread in the region and neither endangered species nor species of historical or ecological importance exists in the vicinity of the project site. Geological studies showed that the site soil characteristics has a low permeability coefficient, which thereby presenting little or no risk that leachate could seep into the underground water. The, site soil characteristics are ideal for establishing a landfill. The site and its surrounding areas are virgin places. No indications of air pollution problems were observed during site survey activities.

The proposed design specifications of the project are in conformance with the World Bank standards for constructing and operating sanitary landfills. Integral consult conducted a preliminary assessment of potential impacts of the proposed project and the significance of these impacts. Recommended measures to manage and monitor environmental impacts were proposed. The predicted impacts are positive in terms of the regional and state environmental levels; however, this project as any engineering project will also have the potential for adverse effects on local environment.

The EIA indicates that the expected impacts are of minimal significance. The impact analysis focused on the following areas:

- Social, socio-economic and cultural heritage;
- Hydrogeology, hydrology and water quality;
- Air quality
- Ecology (flora and fauna);
- Health and safety;
- Noise; and

- Off-site traffic.

The proposed mitigation measures were evaluated and other needed mitigation measures were proposed in order to mitigate/ minimize the expected impacts. A monitoring plan was developed in order to regularly check the environmental performance of the facility. Several recommendations were made in order to maintain the landfill operation inline with the best practice standards. The alternatives analysis showed that the site location is the best available alternative and that the proposed technologies are more effective than other available alternatives.

It was concluded that the site location is appropriate for establishing a landfill. The proposed mitigation measures and treatment technologies are suitable for pollution control. However, it is highly recommended that Onyx Alexandria implement all the stipulated mitigation measures, monitoring plan and the recommendations mentioned in this study. These recommendations are already including or planned to be included in the procedures that ONYX Alexandria implemented as part of its ISO Certification . (ISO 9001,14001,18001).

Section 2 Introduction

Within the framework of solid waste privatization in Egypt, Alexandria Governorate contracted Onyx for the integrated management of municipal solid waste in all districts of the Governorate. Onyx Alexandria was the first foreign company to enter the waste management market in Egypt in September 2000. Under the contract with the Governorate, Onyx is responsible for the collection of household wastes, sweeping and washing streets, as well as cleaning beaches. Management of the sanitary landfills where the waste is finally disposed is included in the responsibilities of Onyx Alexandria.

According to the contract with the Governorate, Onyx Alexandria started on October 2001 dumping waste in Borg Al- Arab landfill, a site located on the north coast close to some tourist villages, another site to the south of El- Hammam city for disposing the waste during summer months (May to September) while Borg El Arab site would be used for the remaining months of the year.

Because of the concern about the impacts of the proposed landfill on the surrounding environment and to comply with the national environmental regulations, Onyx Alexandria contracted Integral Consult to undertake an environmental impact assessment study. The purpose of the study is to investigate the environmental consequences, identify the impacts of the proposed landfill, and to propose mitigation measures for the new landfill.

Onyx started to utilize Al- Hammam landfill in 2003. Since this starting date, a cell of dimensions 170*170*7 m has been filled and closed. Onyx Alexandria is proposing to establish 13 new cells, taking in consideration the national and international standards for landfill construction and operation. In order to comply with the existing environmental laws and regulations, this environmental impact assessment (EIA) study is submitted for approval by EEAA. This report addresses the environmental impact assessment (EIA) of the establishment of 13 new cells in Al- Hammam landfill for municipal solid waste. The EIA evaluates its methods of construction and operation, and draws conclusions regarding environmental protection of the surrounding environment and areas close to the site.

This report considers the EIA guidelines of the Egyptian Environmental Affairs agency (EEAA). Where no specifications are found in these guidelines, such as landfill lining systems, World Bank specifications are used. The EIA guidelines provide a list of projects for which EIA reports are required and outlines the contents of an EIA report. Moreover, involved authorities and procedure for approval of EIA studies are included in the guidelines. The EIA represent a part of the technical documentation which are necessary to be submitted with other relevant documentation for obtaining the license from authorities. A list of projects which require the development of a full EIA is given in the guidelines. According to EEAA guidelines, waste treatment facilities and sanitary landfill are listed as class C projects where a full EIA study is required. For this category of projects, scoping of the environmental impact analysis, setting mitigation measures, alternatives analysis and setting a monitoring plan should be carefully studied.

2.1 SOLID WASTE MANAGEMENT IN ALEXANDRIA

The city of Alexandria is located on the Mediterranean Sea. The city extends for over 120km along the shore of the Mediterranean where its width varies from 300 m to 60 kilometers. The city is famous for its historical cultural heritage. Alexandria Governorate is comprised of 3 cities and 18 districts hosting over 5 million people in winter and over a million visitors in summer. Alexandria generates about 2,300 tons / day of municipal waste (about 0.5 kg / person / day) and this amount increases in summer to over 2,700 t/day. According to Onyx database, the composition of municipal waste in Alexandria is presented in table 2.1, shown below.

Table 2.1. Waste Composition in Alexandria

Item	Organic matter	Paper	Glass	Plastics	Metals	Textiles	Dust/ inorganic matter	Others
Percent (%)	50	14	3	13	6	2	8	4
Quantity (ton/day)	1150	322	69	299	138	46	184	92

According the State of Environment in Egypt Report (2004), published by the Ministry of state of Environmental Affairs, the collection efficiency in Alexandria Governorate is 77%, which is the highest collection efficiency among the country Governorates.

Waste in Alexandria is either disposed of in the sanitary landfills in Al Hammam landfill during summer time or Borg Al- Arab landfill during other periods of the year. A portion of the waste is directed to the composting plants operated by the company. The company already administers three recycling plants which produce compost. These plants process only approximately 650 tons per day of solid waste. Table 2.2, shown below, shows the current operating composting plants in Alexandria and their nominal design capacities.

Table 2.2. Composting Plants in Alexandria

Composting Plant	Construction Date	Design Capacity (T/h)
Abbis 1	Jan 1985	10
Abbis 2	Jan 1998	12
Montazah	Mar 1998/Sept 2004/Sept2005	40
Total		62

Street scavengers collect a portion of valuable waste manually. There is no accurate data about the quantity of waste sorted and collected by these scavengers.

2.2 PURPOSE OF THE ENVIRONMENTAL ASSESSMENT

The extension of the landfill is proposed to make a significant positive impact on the quality of the environment in Alexandria Governorate. However, this extension of the site has the potential to create some adverse environmental impacts. The overall purpose of the EIA is to identify the potential environmental impacts which may result from the proposed extension of the existing landfill at Al- Hammam. Assessment of the significance of these impacts, identification of mitigation measures, and the development of a management and monitoring plan are key outcomes of the study.

2.3 METHODOLOGY OF STUDY

The methodology that have been followed in developing the EIA was as follows:

- Carrying out a site survey;
- Identifying baseline environmental conditions in the vicinity of the site;
- Discussing and evaluating development alternatives;
- Presenting and discussing different features and components of the proposed landfill engineering design and operational plan;
- Identifying and evaluating the range of potential environmental impacts from the extension of the Al- Hammam landfill;
- Identifying the measures required to mitigate these impacts additional to those already included in the proposed design and operational plan;

3.1 SITE LOCATION

Al- Hammam Landfill site is located approximately 80 km from the city of Alexandria, 35 km to the south of the coastal road. The coordinates of the site are 30°45'22.5" N and 29°25'16.0" E. The total area of the site is 1.190 squared kilometers (1700 m X 700 m). The site hosts administration buildings, car parking area and gas monitoring room. The landfill land is a public property and is surrounded from the north and northwest by military camps. The nearest military camp is Mubark military city where it is located 10 km away from site. No residential areas are close to the site. The nearest village is Al- Bangr village, 12 km away from the site.

The area around the site is neither developed nor cultivated. During a site visit to identify the characteristic of the baseline environment, no commercial or grazing activities were noticed, and therefore no migration problems exist. The landfill is designed to accommodate all municipal wastes from Alexandria Governorate during summer time only (May 1st to October 1st). Currently, the landfill receives a maximum 2,600 ton/ day of waste produced from Alexandria Governorate and its districts.

The site is connected to Al- Hammam city and Alexandria through an already existing paved road. Therefore, the construction of a new road is not needed. The map presented in appendix 1 depicts the location of the landfill where the distribution of residential areas close to the site and the main roads which connects the site to Al-Hammam city are shown.

3.2 SITE LAYOUT / FACILITIES

The site is designed to only receive municipal waste. Currently, there are no plans to establish any waste treatment facilities within the site. During the last two years, A single cell was filled and closed. The closed cell dimensions were 170*170 m, with a variable depth between 3.5 to 7 m above sea level.

Currently Onyx is operating cell number 2 and constructing a new cell. These two cells are of dimensions 285*170*12 m and 110*235*12, respectively. The site facilities consist of administration buildings, workshop, landfilling cells, leachate ponds, parking area and a fence around the site. Figure 3.1, shown below, depicts the general layout of the landfill.

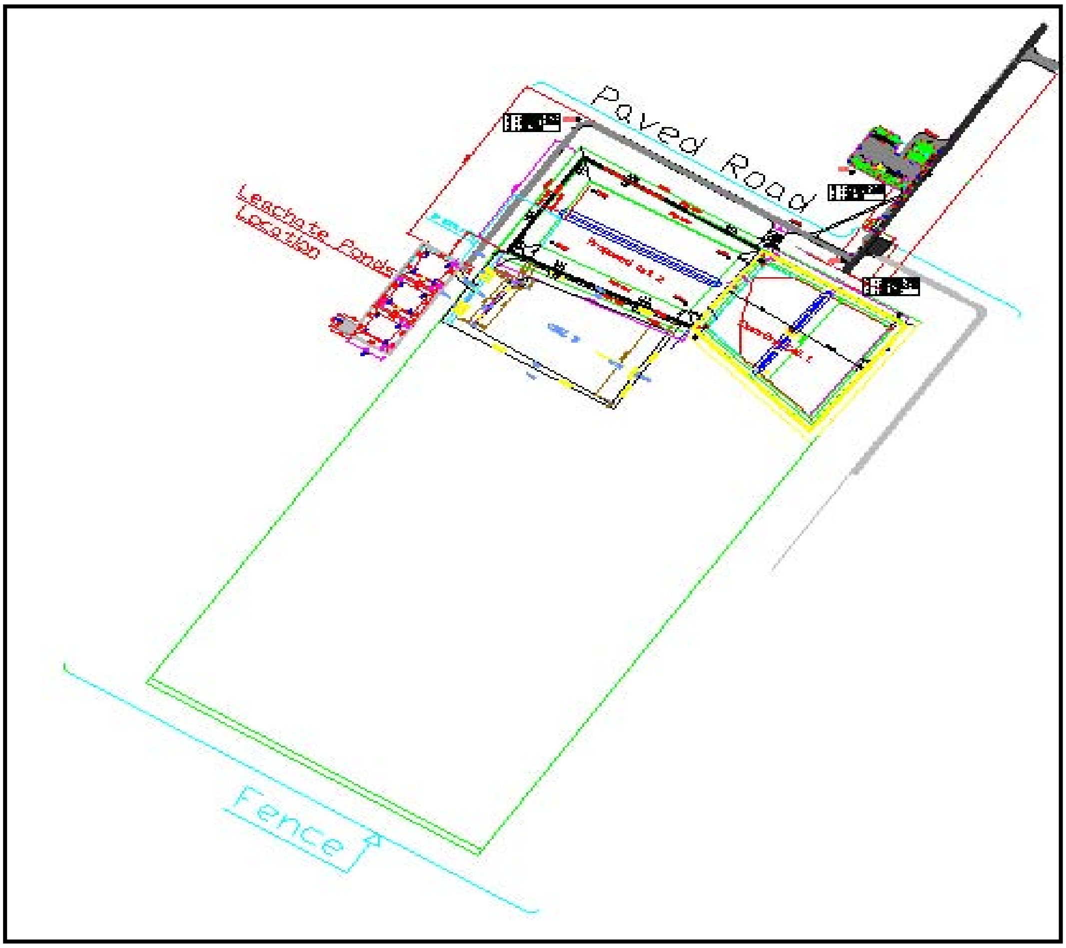


Figure 3.1. General Layout of Al- Hammam Landfill

The administration area lies in the upstream of the predominant wind direction during the whole year to avoid adverse effects from the landfilling operation. Figure 3.2, shown below, presents the administrative area of the site.

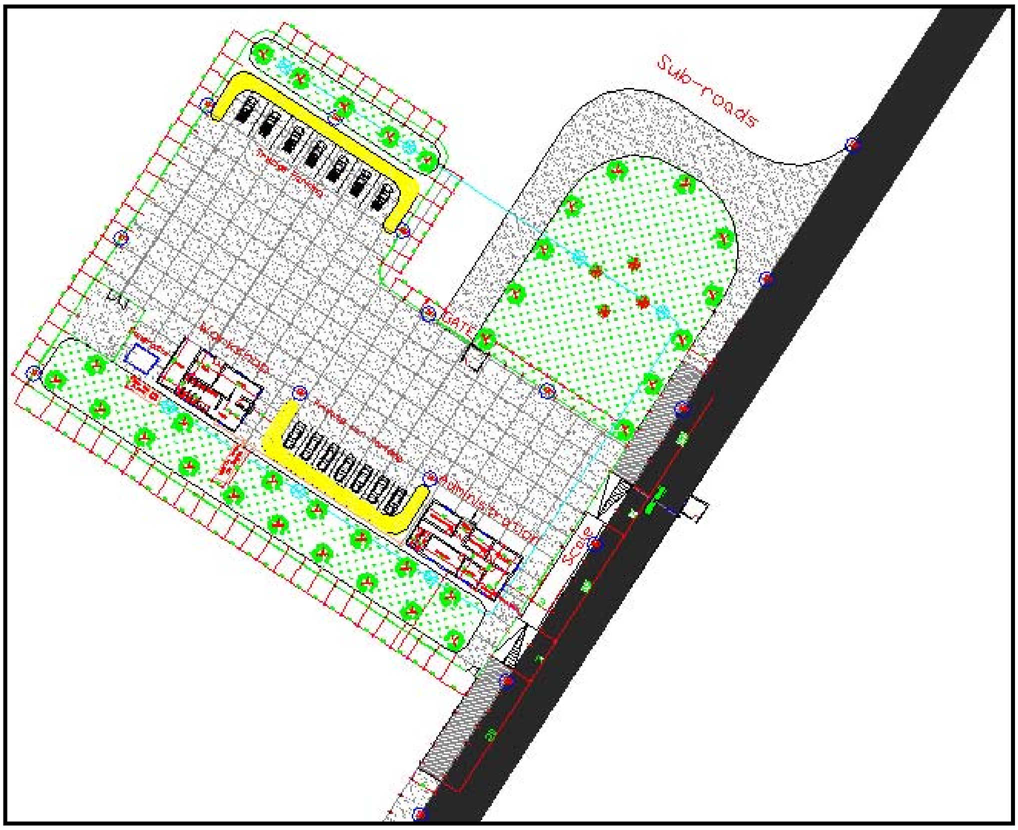


Figure 3.2. Al- Hammam Landfill Administrative Area

3.3 SIZE AND LIFETIME OF THE LANDFILL

The total area of the landfill is 1.19 km^2 (1700*700 m). The topography of the site is almost flat. Onyx's design criteria include an excavation plan to a depth of a maximum 11.5 m to maximize the potential capacity of the landfill. The excavation depth differ from one cell to another, depending on the cell design and dimensions. The landfills cells will be constructed in phases where only one cell is constructed per phase. As previously mentioned, cell number 1 is already closed while cell number 2 is in the operation phase. Excavation work for cell number 3 has already started. The excavated soil from this cell will be stored in a specific area to be used as cover material. The sequence is then repeated for the other new cells.

Currently, Alexandria Governorate produces approximately 3,000 ton/day of waste. Aproximately 80% of this amount is disposed of in either Borg El-Arab or Al-Hammam landfills. Al- Hammam landfill receives a daily amount of 1,800 to 2,600 t/day of waste during summer period.

The lifetime of the landfill has been estimated by comparing the volume available for landfilling at the site to the volume of waste received annually. The following assumptions have been used in estimating the lifetime of the landfill:

- Area of site = 1700*700 m
- Quantity of daily waste transferred to the site: 2,600 t/day

- Average depth of cells: 11 m
- Average density of waste: collected 0.3 ton/m^3 compacted 0.9 ton/m^3
- Total volume of soil cover: 10%
- Population growth rate: 2%
- The landfill will be used for 5 months from May 1st to September 30th
- Composting factories will work with the same production capacity

The volume available for landfilling is estimated as follows:

Volume = 1700*700*11 = 13.09 M m^3

This number is decreased by 10% to accommodate for volume of soil used as cover and another 10% to accommodate for dikes. Therefore the actual volume available for waste is:

Actual volume = 13.09*0.8 = 10.47 M m^3.

The actual volume of waste received is estimated as follows:

The average annual quantity of received waste will be assumed to be $2,600*1.02^{10}$ (10 years from now). Therefore, the actual annual average volume received before compaction is:

Volume = 2,600 (t/d) * 30 (d/month) * 5 (month/yr) / 0.3 (t/m^3) = 1.3 M m^3

The volume after compaction to be reduced to one third of the original volume is:

Volume after compaction = 1.3 * 0.33 = 0.43 M m3

Therefore the lifetime of the landfill is:

Lifetime = 13.09 / 0.43 = 30 years

3.4 LANDFILL DESIGN, CONSTRUCTION, OPERATION AND CLOSURE PHASES

Al- Hammam landfill is designed according to the international standards. The sanitary landfill consists of the following components:

- Administration buildings
- Gatehouse
- Fence

- Weighing scale
- Leachate collection and treatment system
- Gas collection and treatment system

An illustrative layout of the proposed landfill and its associated facilities is shown in Figure 1.

3.4.1 Design Specifications

3.4.1.1 Base Sealing

The base sealing of sanitary landfill is one of the most important methods of preventing leachate and gas migration from the cells. The main components of a base sealing for landfills are an impermeable layer, HDPE liner, protection layer, drainage layer and filter layer. The World Bank guidelines recommends a composite liner system. In a composite liner system, a layer of compacted clay of 1 m height with low permeability followed by high density poly ethylene layer are used. The purpose of compacted soil clay is to minimize the ability of the soil to seep leachate to the groundwater through decreasing the permeability coefficient to $1*10^{-7}$ cm/sec. In Al-Hammam landfill, the soil permeability coefficient is less than ($1*10^{-7}$ cm/sec). Therefore, existing soil at the site will be used as the primary lining layer. The following additional layers will be used on top of the primary lining layer:

Geotextile 400 gm: a layer of thick geotextile liner is proposed to be used as the base for the impermeable liner.

Plastic liner (HDPE): in order to achieve a combined sealing system, a high density polyethylene (HDPE) liner of 2 mm thickness will be used on the impermeable layer. This liner will be resistant against the corrosive effect of leachate and gas produced from the waste.

Geotextile 600 gm (Protection Layer): a Geotextile layer is used to minimize pressure of the waste on the HDPE liner.

Gravel layer: a drainage layer, consisting of 30 cm of gravel will be laid to assist drainage of leachate. Gravel will be of uniform sizes and washed to ensure a high permeability. Perforated HDPE leachate collection pipes will be embedded in the drainage layer to further assist leachate collection.

Geoltextile 180 gm: a filter layer (Geotextile) will be used to avoid clogging of the drainage layer. The following figure shows the details of the base sealing materials for a typical cell.

Figure 3.3, shown below, depicts base sealing layers for a typical cell.

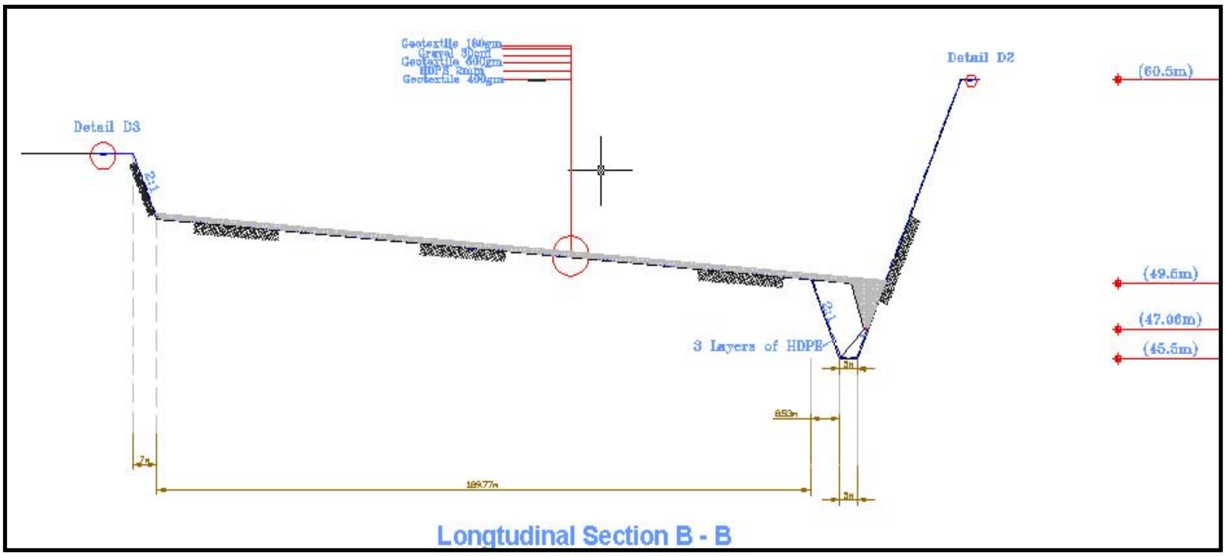


Figure 3.3 Cross-Section for The Base Sealing for a Typical Cell Leachate Collection and Treatment Systems

For collection of leachate within Al- Hammam landfill, sloped bottoms are constructed. A 30 cm gravel layer is placed over the cell bottom to allow for easy movement of leachate until reaching the trench. The leachate is collected in a trench through gravitational movement. A perforated concrete pipe is used as a casing for the pipe that collects the leachate from the trench via a pump. The perforated concrete pipe is of diameter 800 mm. Figure 3.4, shown below, depicts the connection of the perforated concrete pipe with the trench. The trench has a concrete base with dimensions of 3*3*0.5 m while the soil under the trench base is protected by a 400 gm geotextile layer, 3 layers of 2 mm HDPE and 3 layers of 600 gm geotextile.

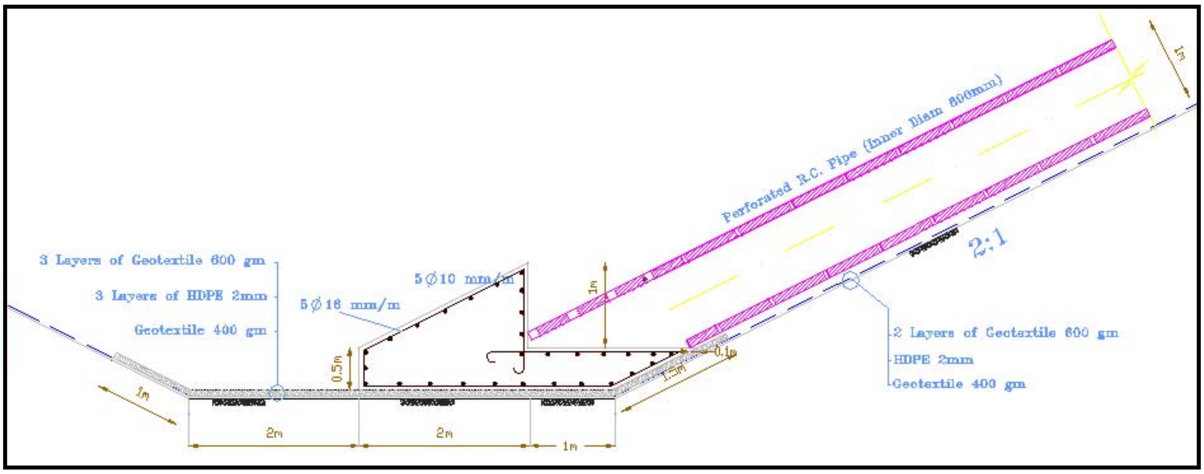


Figure 3.4. Connection of Leahcate Collection Pipe with the Trench for a Typical Cell

The collected leachate will be pumped out of the collection trench and directed to the leachate collection ponds. The leachate is treated in the ponds by mechanical aerators and natural evaporation. The purpose of the mechanical aerator is to enhance the evaporation process and to defuse fresh air which enhances the decomposition of the organic content of the leachate.

The site has 3 leachate treatment ponds where the dimensions of each is 52*52*2.5 m. Figure 3.5 shows the details of the protection layers of the leachate ponds. The protection layers consist of 300 gm geotextile layer, 2 mm HDPE layer, 300 g geotextile layer, 30 cm clay layer (protection layer), 25 cm base coarse layer, and 6 cm asphalt layer. The design capacity for each leachate pond is 6,760 m^3.

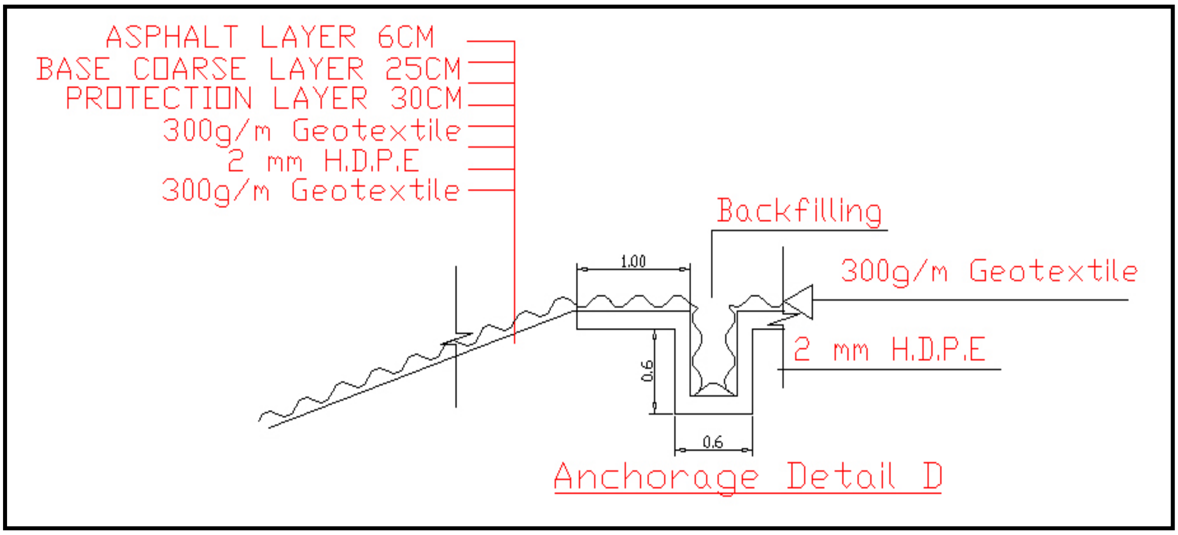


Figure 3.5. Cross Section of the Base Sealing for the Leachate Ponds

3.4.1.2 Gas Collection System

The gas collection system at Al Hammam landfill is composed of vertical landfill gas wells. For a typical cell, approximately 14 landfill gas wells are used. The landfill gas wells are constructed of perforated concrete pipes of 1 m diameter. A perforated 0.2 m perforated high density polyethylene (HDPE) pipe is placed inside the concreter pipe and the space between the 2 pipes is filled with filter gravel. The cap of the well is composed of a 0.25 m HDPE pipe which extends above the final cover level of the cell. A flare is connected to each well head where the collected landfill gas is combusted. Figure 3.7, shown below, illustrates the detail of the well head and the flare.

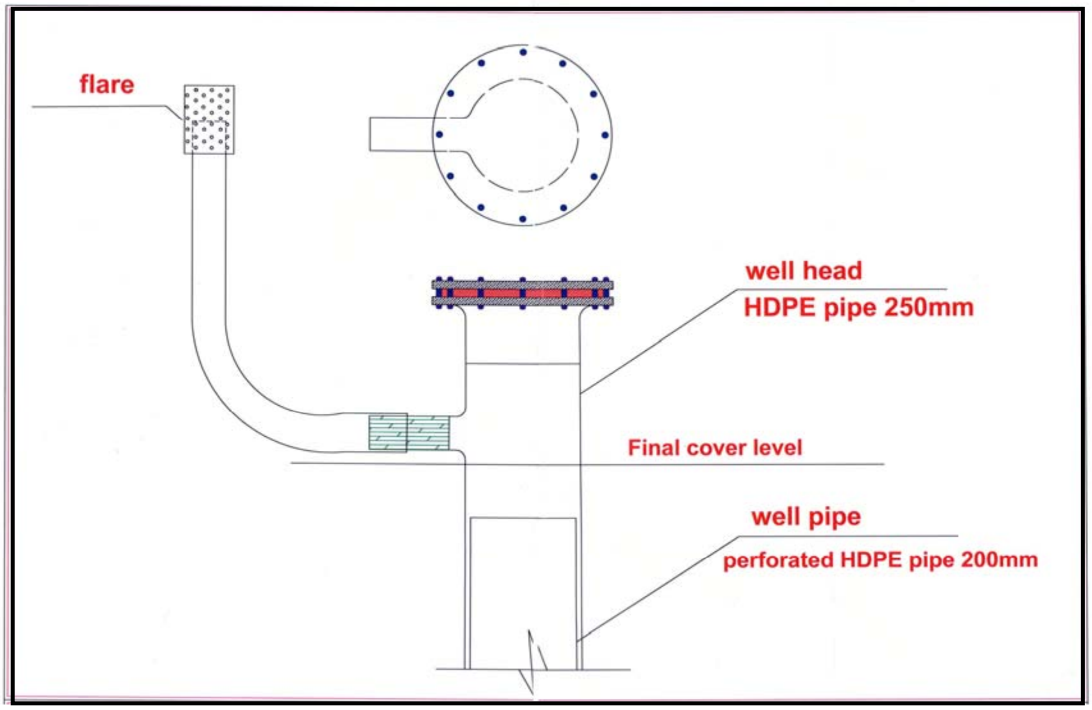


Figure 3.7. Typical Well Head and Flare

3.4.1.3 Auxiliary Services

Al- Hammam landfill site is neither connected to the city water supply nor to the sewer network. Moreover, the site is not connected to the local electricity grid. Drinking water is being brought to the site by water tanks. The administration building is connected to a trench for wastewater collection. Diesel generators are being used to supply the site with the requested power to operate the scale, workshop and the administration building.

3.4.1.4 Landfill Equipment

Landfill equipment consists, in addition to those mentioned above, of the following:

- Compacting machine;
- Crawler;
- Two Trucks; and
- Unloading hoppers.

3.4.2 Construction Phase

The landfill has been working for the last two years. The administration area, weighing scale, workshop and cells 1 and 2 has been already built. As previously mentioned, the scope of this EIA study focuses on the establishment of the new 13 cells within Al-Hammam landfill site. Each cell will be prepared by removal of the vegetation layer and excavated to the required depth as per the design criteria. The excavated soil will be stored in a designated area to be used again as daily cover material and for cell closure. The excavation works is conducted using 2 bulldozers, and the excavated soil is transferred to the storage area via 2 heavy trucks of capacity 15 m^3 each.

The cell total surface area will be waterproofed, including cell bottom and side slopes. Waterproofing of the cells will be carried out by means of artificial barriers and its construction will be done gradually. A 400 gm geotextile layer followed by a 2 mm high density polyethylene sheet protectively covered by another layer of 600 gm geotextile will be laid. A 30 cm gravel layer will be laid on top in order to protect the sheets and to allow for leachate drainage. A 180 g geotextile layer will be placed on top of the gravel layer to prevent clogging.

For leachate collection in Al- Hammam landfill, a network of collection pipes and trench will be used in each cell. The cell excavation work will create slope in the base of each cell to facilitate gravitational movement of the leachate toward the evacuation sump. The slope of the base will be constructed according to the cell design specifications. The trench will be constructed at the lowest point in the cell of reinforced concrete material. The trench will be waterproofed by means of 3 HDPE layers, which prevent the seeping of leachate to the underground water. Specification of sump is depicted in Figure 3.

The Construction of landfill gas wells will follow the design specifications for each cell. A reinforced concrete base (2*2*0.3 m) will be constructed on the bottom of the cell. A perforated concrete pipe with an external diameter of 1 m and 3 m length will be placed over the concrete base. Another pipe will be placed on top when the waste reaches the height of the existing pipe. This process continues till the waste reaches the maximum cell design level. The top most pipe is not perforated. Another 0.2 m perforated pipe made of Poly Ethylene will be fitted inside the concrete pipe and the space between both pipes will be filled with filter gravel.

Construction of leachate collection and treatment ponds will follow the same procedures as for the cell construction. Excavation work will be done to the depth stated in the design specifications, followed by waterproofing works. Al- Hammam landfill has 3 operating leachate ponds, each of dimensions 52*52*2.5 m.

3.4.3 Operation Phase

3.4.3.1 Operational Management

Al-Hammam landfill will be operated in conformance with an operational and environmental management plan. The site manager will be responsible for the overall environmental performance of the landfill. The operations manager will be available on a full-time basis at the site. His responsibilities include reporting the operational and environmental performance to the site manager on a daily basis. Moreover, he will be responsible for handling any complaints by the local authorities about the environmental performance of the landfill. Also, he will supervise the implementation of day-to-day control duties at the facility, including environmental monitoring activities.

3.4.3.2 Site Operations

Waste Acceptance and Weighing

Types and quantity of all incoming waste should be recorded to provide data for a continuous assessment of waste inputs and cover requirements. In addition, information on rates of filling should be recorded. Once the truck arrive the site, it is directed to the weighing scale before entering the site to unload the waste in the designated cell.

Filling and Covering

It is planned that filling of the site will be carried out using the cell method approach. The filling will be carried out in layers. The height of the daily tipping will be approximately 50-80 cm after which the wastes will be compacted by bull dozers and compactors. The equipments will make 3-5 passes along the inclination direction. Waste compaction enables a high density of waste to be achieved and hence maximizes the landfill capacity and lifetime.

At the end of the day, daily cover of approximately 15-30 cm soil will be placed on top of the waste layer. The daily cover has the advantages of minimizing risk of fire, reduction of landfill odors, and reduction of windblown garbage. In case the new waste layer will be placed over the compacted waste layer within less than one month, a sheet of poly ethylene is used as a covering material.

De-Covering of the Waste

Covering the waste with sand consume a significant amount of the cell capacity. Also, these layers of soil decrease the velocity of leachate movement within the cell and hence may cause localized leachate trapping within the cell. Therefore, a de-covering activity takes place in the daily operation of the cells. In this activity, the soil covering layer is removed with bull dozers, leaving a small depth of sand on top of the existing waste. The new waste is then placed above this layer of soil. The removed sand (clean sand) will be stored in designated area to be used again for covering activities. The waste covering and de-covering activities take place every day till the cell is totally filled.

3.4.3.3 Site Management

A range of standard procedures to reduce environmental impact will be adhered to during operation. These procedures include:

- Strict control over entry and exit to the site;
- Control of vermin, insects and birds by compaction of deposited waste, use of daily cover and adoption of cellular filling practices;
- No open burning of waste will be done in accordance with law 4/1994 which prohibits such activities;
- Use of protective clothing by personnel;
- Provision of first aid facilities.

3.4.3.4 Environmental Monitoring

During the operation of Al-Hammam landfill, one of the most important activities is environmental monitoring. Monitoring will be carried-out in accordance with an environmental monitoring plan. The monitoring plan, which stipulates the criteria in the contract between Onyx and Alexandria Governorate, has been revised and approved by the Environmental Management Unit at the Governorate. Assessment studies for the different environmental parameters are planned to be conducted in cooperation with Alexandria University. Detailed monitoring plan is included in section 8. Data gathered through these studies will warn against any anticipated pollution risks from the site and indicate a need for any remedial or corrective actions. Onyx management has established a database for wastes entering the landfill. The database contains different information such as waste quantities, density, and composition. Such information is used in optimizing the management of the landfill.

3.4.3.5 Estimation of Leachate and landfill gas Quantities

Leachate Quantities

Leachate includes a significant concentration of inorganic and organic compounds, which are harmful to the environment. The leachate is formed mainly due to waste moisture released by compaction and a part of precipitation where infiltration through the surface layer of the landfill dissolves organic, inorganic, and biological material. Quantities and characteristics of the leachate depend on many factors including: type of waste, type and thickness of the cover, age of landfill, and meteorological characteristics of the area. Meteorological characteristics include intensity, duration and frequency of precipitation, evaporation rate. According to the World Bank guideline, the most widely used approach for estimating the quantities of leachate is the classic "water balance calculation" expressed as:

$$L = P - ET - R - AS$$

Where

L is the leachate volume

P is the volume of precipitation i.e. rainfall

ET is the volume lost through evapotranspiration (i.e., evaporation from the ground surface and transpiration from vegetation)

R is the volume of surface runoff

AS is the volume of moisture storage available in soils and waste

The two factors; precipitation (P) and evapotranspiration (ET) are the main factors, which affect the water balance calculations. The two remaining factors, R and AS, have a smaller influence and are more difficult to estimate.

Actual measurements at Borg Al-Arab landfill showed that the quantity of leachate produced per month is approximately 6,000 m^3 / month. Although the rainfall rate during summer months (where Al-Hammam landfill is used) is lower than that for winter months, the same monthly leachate production rate will be used for Al-Hammam which is a conservative assumption. Moreover, an excess safety margin of 15% will be assumed. Table 3.1, shown below, presents the estimated quantity of leachate during the period 2004 to 2016.

Table 3.1. Estimated Quantity of Leachate At Al- Hammam Landfill

Year	Expected Quantity of Leachate (m^3)
2004	34,500
2005	35,000
2006	35,700
2007	36,400
2008	37,140
2009	37,800
2010	38,600
2011	39,400
2012	40,200
2013	41,000
2014	41,800
2015	42,600
2016	43,500

Methane Gas Estimation

The process of organic degradation does not occur instantly. The establishment of the adequate microbiologic regime needs time, which varies from several months to several years. The process of degradation and decaying has few phases: aerobic, anaerobic sour phase, phase of accelerated forming of methane, and the phase of decelerated forming of methane. Methane is the final product of the organic decay of the solid communal waste. It is a colorless and odorless gas which is very flammable.

The first order decay model presented in the Intergovernmental panel for Climate Change (IPCC) was used to estimate methane emissions from the landfill. The model is as follows:

$$CH4_{Projected,\ y} = k * L_o * \sum_{t=0,y} WASTE_{contract,\ t} * e^{-k(t-y)}$$

Where:

$CH4_{projected,y}$ is the quantity of methane estimated to be generated (m^3)

k is the methane generation rate constant (1/yr)

L_o is the methane generation potential (m^3 CH4 / t Waste)

$Waste_{contract,t}$ is the waste input at year y

t is the year where methane is calculated

y is the year where the waste was input to the landfill

Assumption of k

According to IPCC guidelines, the value of the methane generation rate constant may range from 0.005 to 0.4 per year. The estimation of methane generated form the landfill is highly sensitive to the assumption of the value of k. K value depend on the moisture content in the landfill, temperature in the anaerobic zone, pH , and nutrient availability. A value of k was assumed at a value of 0.05 for a half lifetime of 15 years.

Estimation of Methane Generation Potential (L_o)

According to IPCC guidelines, methane generation potential is estimated from the following equation:

$Lo = MCF*DOC*DOC_f*F*(16/12)$

Where:

Lo is the methane generation potential of the waste (t CH4 / t Waste)

MCF is the methane correction factor

DOC is the degradable organic carbon in the waste (fraction)

DOCf is the fraction of organic carbon dissimilated (fraction)

F is the fraction of CH_4 in the landfill gas (fraction)

Estimating MCF

MCF was assumed to have a value of 1 since the landfill is a well managed landfill.

Estimating DOC

Degradable organic fraction is based on the composition of the waste. DOC is estimated from a weighted average of the carbon content of various components of the waste stream. IPCC guidelines gives default values for the carbon content for various waste types. These values are presented in Table 3.2, shown below.

Table 3.2. Degradable Organic Carbon For Major Waste Streams

Waste Stream	Percent DOC by Weight
A. Paper and textiles	40%
B. Garden and park waste, and other (non-food) organic putrescibles	17%
C. Food wastes	15%
D. Wood and straw waste	30%

If the composition of the percentage of each type of waste is known , the weighted average of the degradable organic carbon can be estimated as follows:

% DOC (by weight) = 0.4(A) + 0.17(B) + 0.15(C) + 0.30(D)

Where:

A is the percent paper and textiles in the waste

B is the percent garden and park waste, and other non-food organics

C is the percent food waste

D is the percent wood and straw waste

Table 3.3, shown below, presents the composition of waste in Egypt. This composition was used to estimate the degradable organic fraction of the Egyptian waste.

Table 3.3. Composition of Egyptian Waste

Waste Type	Percentage
Food	50-60%
Paper	10-25%
Plastics	3-12%
Glass	1-5%

Metals	1.5-7%
Textiles	1.2-7%
Others	11-30%

An average value was assumed for each waste stream. Yard waste was assumed at 5% of the total waste while wooden waste was assumed at 2%. The weighted average for the degradable organic carbon was estimated as follows:

% DOC = 0.4(0.22) + 0.17(0.05) + 0.15(0.55) + 0.3(0.02) = 0.19

The default value given in the IPCC guidelines for wastes in Egypt is 0.21 which shows that the estimated value for DOC is a conservative assumption.

Estimating DOC_f

Fraction dissimilated DOC is the portion of the degradable organic carbon that is converted to landfill gas. IPCC guidelines presents the following equation to estimate DOC_f:

$DOC_f = 0.014T + 0.28$

Where:

DOCf is the fraction dissimilated degradable organic carbon

T is the temperature in the anaerobic zone

The temperature in the anaerobic zone was assumed at 35 ^oC. Therefore, the DOCf was estimated as follows:

$DOC_f = 0.014(35) + 0.28 = 0.77$

Estimating F

The default value for the fraction of methane in landfill gas is 0.5 as given by IPCC.

Estimating L_o

Based on the estimation of different parameters needed, methane generation potential was estimated as follows:

$Lo = MCF*DOC*DOC_f*F*(16/12)$

Lo = 1*0.19*0.77*0.5*(16/12) = 0.098 Mg CH4 / Mg Waste = 137 m^3 CH4 / t Waste

IPCC guidelines states that the value of Lo may range from less than 100 to over 200 m^3 CH4 / t Waste. This shows that the estimated value are within acceptable range.

Estimation of Waste Quantities

As previously mentioned, Al Hammam landfill receives waste generated during the period of May to September. Projected waste starting from 2004 was estimated based on those received in the previous year with an assumed increase of 2%. Tables 3.4 present the amount of solid waste that is projected to be disposed of during the project lifetime at Al Hammam landfill.

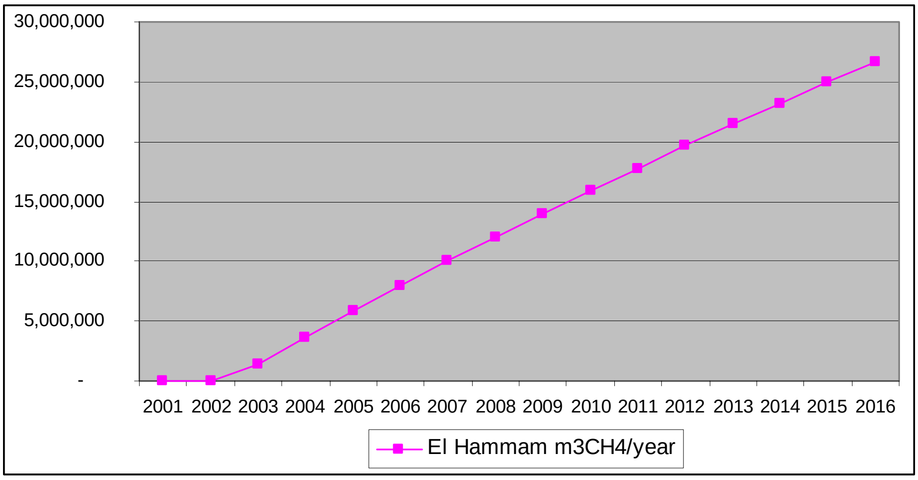
Table 3.4. Projected Municipal Solid Waste Disposed in Al Hammam Landfill During Project Lifetime

Year	Waste Quantity (Tons)	El Hammam m3CH4/year
2001	-	-
2002	-	-
2003	200 000	1,360,000
2004	340 356	3,608,093
2005	347 163	5,792,833
2006	354 106	7,918,237
2007	361 189	9,988,142
2008	368 412	12,006,218
2009	375 781	13,975,975
2010	383 296	15,900,773
2011	390 962	17,783,825
2012	398 781	19,628,210
2013	406 757	21,436,878
2014	414 892	23,212,655
2015	423 190	24,958,252
2016	431 654	26,676,269

Total Quantity of Methane Generated

Applying the IPCC model using the estimated parameters, the total quantity of methane generated from the landfill can be estimated. Figures 3.8, shown below, presents the total quantities of methane that are expected to be generated from the landfill.

Figure 3.8. Methane Generation from Al Hammam Landfill



3.4.4 Closure and Post Closure Phase

Once the waste reaches the ground level, a perimeter soil berm is built along the cell with a width of 8 meters. When the waste height reaches the berm level, the berm will be extended upwards with the same shape and dimension till reaching the final design level of the cell. Upon reaching the final design level of the cell, a 30 cm layer of sand , followed by two layers of clay of low permeability ($1*10^{-7}$ cm/sec) will be laid. Each clay layer is 50 cm thick where both layers will be compacted to reach a final thickness of 75 cm. These layers prevent the waste from absorbing rainwater. Finally, a 30 cm layer of plantation soil will be spread.

For appropriate management and environmental protection, cells which have been completed will be restored. This will reduce the amount of leachate, and greatly improve the appearance of the site. Al- Hammam Landfill site will be restored using vegetative treatment where sowing grass and trees will be planted.

4.1 GEOLOGY

Egypt is a part of the north African craton. The northern part of Egypt including, the north Western Desert, the Nile Delta and north Sinai lie in the unstable shelf area (Schlumberger, 1984). The Onyx landfill site is located about 10 km south of El-Hammam city, Matrouh Governorate in the northwestern Mediterranean coastal zone of Egypt (Figure 4.1).

4.1.1 Surficial Geology of the Project Site and the Surrounding Areas

The exposed rocks in the northwestern Mediterranean coastal zone are entirely of sedimentary origin ranging in age from Early Miocene to Holocene with a maximum thickness of about 200 m (Atwa, 1979) (Figure 9). Good Miocene outcrops are recorded at Salum and the Qattara and Siwa escarpments. On the other hand, a thick sedimentary succession; about 4,000 m is encountered by deep drilling in Burg El Arab (lat. 300 55/ 20// N, long. 290 31/ 20// E) as well as in other deep wells drilled in search for oil.

The sedimentary rocks which form several types of water-bearing formations and are of interest belong to Neogene and Quaternary. The exposed sediments and rocks at the landfill site belong to the Holocene and Pliocene-Pleistocene.

4.1.2 Regional Geomorphology

The northwestern Mediterranean coastal zone which extends between Alexandria and Salum occupies the northern extremity of the great Marmarican Homoclinal plateau that covers much of the Western Desert between the Qattara Depression and the Mediterranean Sea (Shata, 1957). This zone displays geomorphological features which reflect the effect of both arid and wet climatic conditions. The present day landforms have a great effect on the groundwater conditions where watershed areas, water collectors, drainage basins and discharge areas are developed. The northwestern Mediterranean coastal zone could be differentiated into the following geomorphologic units (Figure 4.1):

4.1.2.1 The Northern Coastal Plain

The northern coastal plain occupies the peripheral zone parallel to the present Mediterranean shoreline. It extends in an east-west direction for about 500 km. The average width of this plain varies at different localities as controlled by the situation of the southern tableland. This plain slopes generally towards north and exhibits elevations ranging from 60 m above sea level to about the mean sea level or slightly below.

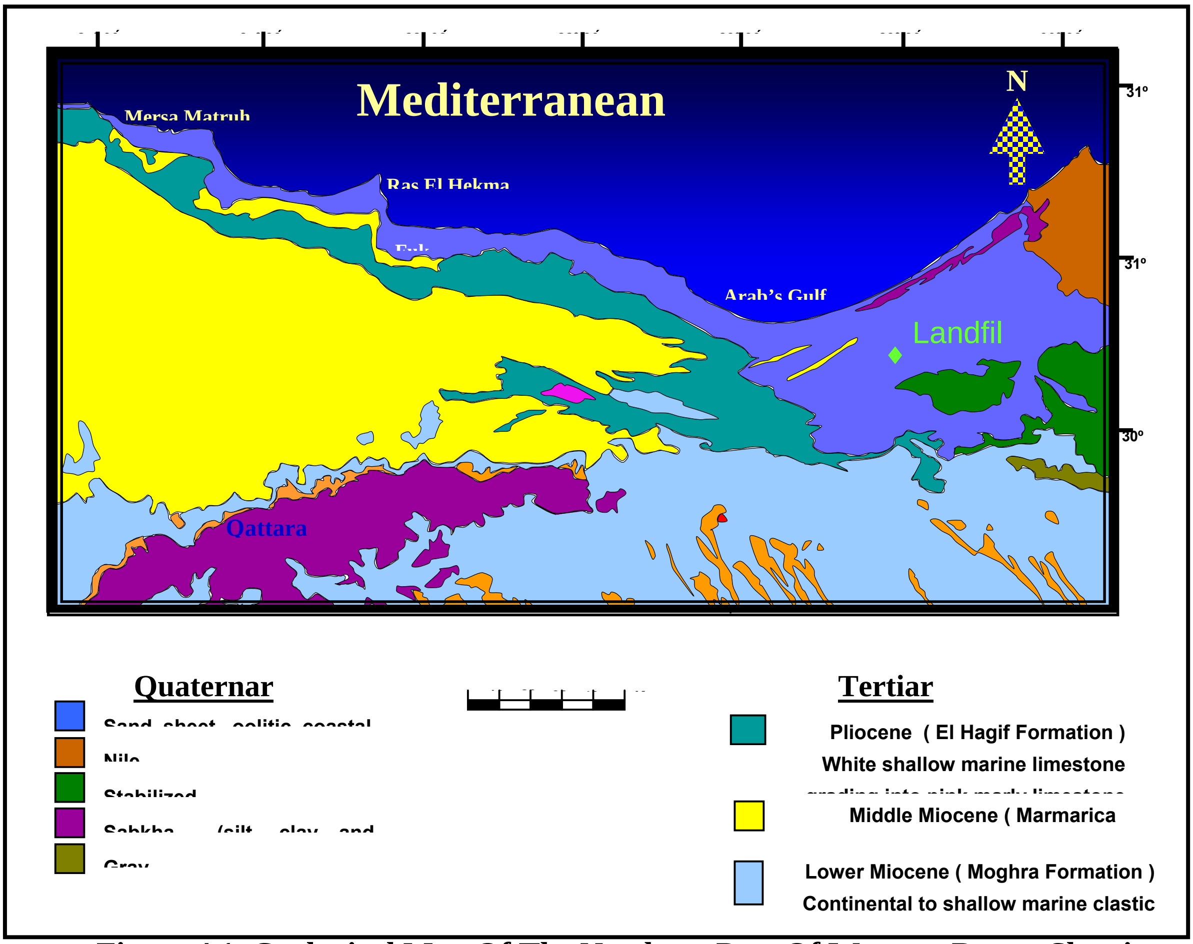


Figure 4.1. Geological Map Of The Northern Part Of Western Desert Showing Location of the Landfill

The northern coastal plain exhibits the following landforms:

The Beaches

Occupying a narrow zone lying between the low and high tidal zones. They are covered with loose carbonate sands. These beaches are well developed to the east of El Alamein and to the east of the protruded head lands (Ras El Dabaa, Ras El Hekma, Bagush, Ras Alam El Rum, Ras Umm El Rakham, El Negeila and Salum).

Sand Dune Accumulations

These dunes constitute an outstanding land feature at several localities of the coastal plain (Burg El Arab, El Dabaa, Fuka, Bagush, El Qasr, etc). They cover portions of the near-shore ridge which runs parallel to the Mediterranean Sea. These dunes are composed of loose oolitic carbonate sands derived from the low lying beaches by the on-shore winds. The foreshore dunes act as water bearing in local areas where their base is low relative to the level of the prevailing water table (e.g. Bagush and El Qasr).

The Coastal Ridges

The coastal plain is characterized by the occurrence of a series of elongated ridges running parallel to the present shoreline, rising sometimes to more than +50 m, and attaining lower attitudes towards the shoreline.

These ridges represent ancient shorelines of the Mediterranean Sea during the Pleistocene time, from the Sicilian to the late Monasterian, and exhibiting different heights. The coastal ridges are missing or deformed at several localities due to the effect of local structures as well as due to erosion. These are well developed to the east of El Alamein and exhibit some abnormalities in elevation and direction to the west of the same locality.

The coastal ridges are generally composed of oolitic limestone of different degrees of hardness. They act as water divide areas during rainy season and as natural barriers for soils and water conservation. The coastal ridges are distinguished according to their hydrologic response into two groups:

Group A

The northern foreshore ridge; composed essentially of white friable weakly cemented oolitic limestone which is locally interbedded by loose carbonate sand lenses of estimated porosity of about 45% . This ridge and overlying dune sands act as collecting areas where most of the rain water infiltrates directly downwards contributing to the fresh-water body prevailing underneath this ridge. This ridge is of relative higher capacity as an aquifer compared with the other inland ridges, which exhibit advanced diagenetic stage.

Group B

The southern inland ridges; composed of moderately hard to hard ooltic limestone of dark color. The outer portion of these ridges is developed into a very hard siliceous crust which minimizes, to a great extent, the infiltration of surface rain water within the ridges. Consequently, these ridges act as water divides where the surface water seeps along the slopes towards the bounding low depressions.

The Elongated Depressions

The coastal ridges are separated by elongated shallow topographic depressions. The surface of these depressions is almost flat to gently undulated with a gentle slope to the north. The elevation of these depressions ranging between +30 m above sea level to about the mean sea level.

Generally, they act as collecting basins for the surface water runoff. Towards the shoreline, the ground elevation of the depressions is generally near to sea level. Therefore, these depressions become inundated with sea water and are consequently developed into shallow salt lakes or converted into salt marshes where salt tolerant plants are widely distributed. In the inland depressions, a thick layer of brown alluvium exists and favours the growth of natural vegetation and is also suitable for cultivation.

4.1.2.2 The Frontal Plain

This plain occupies the area lying between the coastal plain and the southern tableland and is separated from the latter by a conspicuous low lying cliff running in a NE-SW direction. Al-Hammam landfill is located in this plain. To the east of Al-Hammam, the plain attains maximum width and become the lowest topographically. The frontal plain slopes in a northward at the rate of 5m/km. During the rainy season, the frontal plain receives much of the surface runoff of both the tableland and the most inland ridge (Gebel Maryut ridge). The surface of this plain is mainly occupied by scattered, disconnected and irregularly oriented low lying limestone ridges. The low land surrounding these ridges are filled with a stony and pebbly calcareous soil which appears suitable for cultivation of barley (Shata 1958)

4.1.2.3 The Piedmont Plain

The piedmont plain represents an extended sloppy surface separating the tableland to the south from the frontal and coastal plains to the north. It is well developed where the tableland escarpments are well pronounced (Burg El Arab, El Alamein, Fuka, Ras El Hekma, Ras Alam El Rum, Mersa Matruh and Salum). The surface of the piedmont plain is either covered with thin layer of alluvial and sand deposits (aggradational) or degraded and appears as rocky surface.

4.1.2.4 The Southern Tableland

The southern tableland constitutes a prominent geomorphologic unit bounding the coastal plain from the south. It occupies the northern extremity of the great Marmarican Homoclinal plateau and extends to the Qattara Depression. The tableland extends generally in an E-W direction with ground elevation which reaches 100 m above sea level and slopes regionally in the northward direction. The tableland is composed mainly of fissured and jointed limestone whose top portion is highly weathered and is developed into a hard pink crust.

The southern tableland area displays complex geomorphological features where both arid and wet climatic conditions are manifested. At some localities, the northern edge of the tableland area is characterized by the occurrence of a well developed escarpment facing north and separating the southern tableland from the northern coastal plain (west of Ras El Hekma). On the other hand, the northern portion of the tableland area is dissected by a number of short and deep consequent valleys acting during rainy seasons as active drainage arteries. The bottom of the drainage lines dissecting the tableland is occupied by thick alluvial deposits composed of gravel, cobbles intermixed with sand, silt and finer material and constitute a subsidiary aquifer of very limited potentialities. This aquifer is recharged from the surface water runoff running along the courses of the drainage lines. Generally, the initial phase in the development of the hydrographic lines took place at least during Late Miocene when the climatic conditions were wetter compared to the present day aridity.

The southern tableland represents the main watershed area in the northwestern Mediterranean coastal zone. The northward slope of the surface and the development of hard crust on the top of the weathered surface favors the surface water runoff to be directed either to the inland depressions of the coastal plain where it forms small ephemeral lakes and ponds, or to the peripheral lakes and lagoons. In some localities (Salum) the drainage water goes directly to the Mediterranean Sea.

4.1.3 Stratigraphy of the Project Site

The different stratigraphic units in the surface and subsurface in the area of the landfill and surroundings are described from younger to older as follows:

4.1.3.1 Quaternary

Holocene Deposits

Alluvial deposits; are developed in the shallow elongated depressions and along the channels of the drainage lines in the form of Wadi terraces and Wadi fillings. These deposits are loamy deposits composed of quartz sand, silt and clay with abundant carbonate grains in the north while pebbles and gravels are abundant to the south. In the lower elevations of the elongated depressions, sabkhas and salt marshes are recorded where evaporites are developed.

Pleistocene Sediments

The Pleistocene sediments are also widely distributed along the northwestern Mediterranean coastal zone and are mainly represented by:

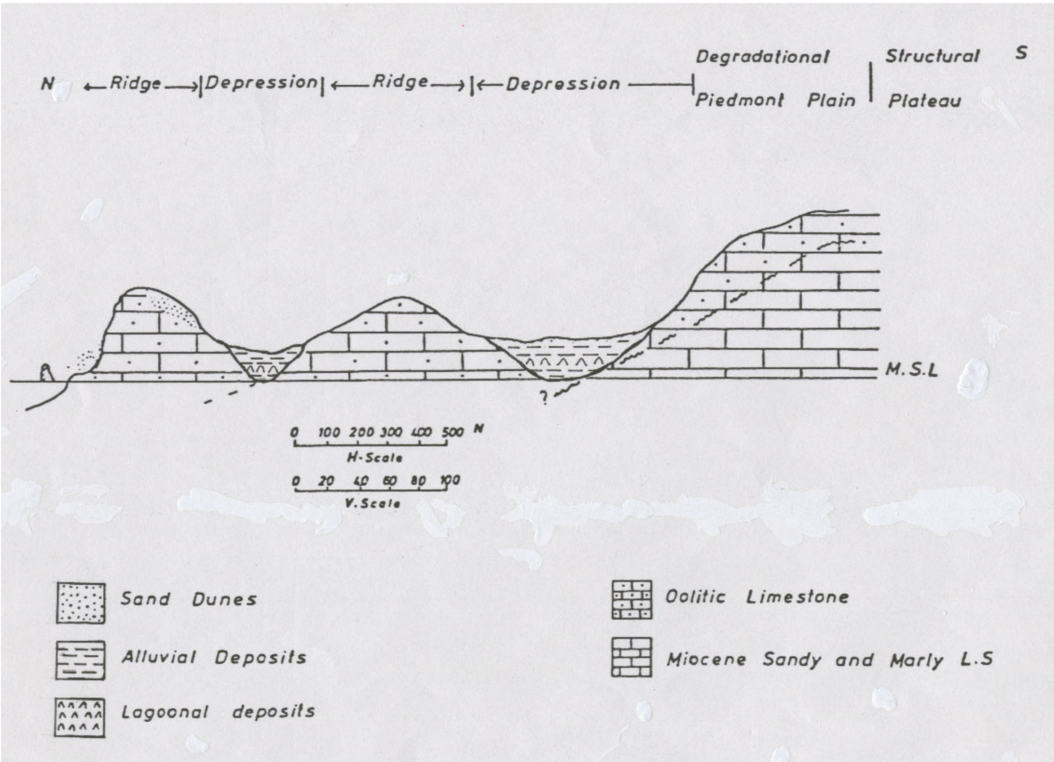


Figure 4.2. A North-South Diagrammatical Section Showing Different Geomorphologic Units of the Northwestern Coastal Zone

- White oolitic limestone, which constitutes the main bulk of the Pleistocene sediments. These cover the greater part of the coastal zone. It is almost developed in the form of elongate ridges running parallel to the present coast. The ridges are cross-bedded and composed of snow white oolitic sand grains which are weakly cemented and displaying yellow to grayish yellow color on weathering. The oolitic limestone has variable petrophysical properties which reflect the degree of compaction and the extent of post-depositional changes. However, it is characterized by high degree of primary porosity (total porosity ranges from 25.1 to 54%, Abd El Latif, 1973).

- Cardium limestone; composed of whitish grey oolitic limestone, chalky in appearance and rich with Cardium edula. It is exposed locally at different localities, e.g. Burg El Arab, El Dabaa, Ras El Hekma, Mersa Matruh,...etc., where it has a thickness not exceeding 1 m.

- Pink limestone; occupies the topmost part of the escarpment along some of the drainage lines which dissect the tableland, e.g. Wadi El Kharruba, Wadi El Asida, Wadi El Raml and Wadi Agiba. This limestone series overlies unconformably the Middle Miocene strata which constitute the main bulk of the southern tableland. It is composed of hard fragmentary sandy limestone which is developed into a very hard pink crust at its upper part. The pink limestone varies in thickness between two meters and seven meters and its surface is marked by terrestrial gastropodal molds. It is attributed to the Plio-Pleistocene (Taha, 1973).

4.1.3.2 Neogene

The Neogene deposits are exposed throughout the area of study and constitute the major part of the tableland.

Pliocene Sediments

Pliocene sediments have limited exposures along the northwestern coastal zone and have been encountered in the subsurface where they are concealed beneath younger deposits. Local Pliocene deposits are known at some localities, e.g. to the south of Ras El Hekma, El Dabaa, and Mersa Matruh. In Burg El Arab, the Pliocene is mostly developed into a shale or clay facies, about 50 m thick (Ouda,1967).

Miocene Sediments

The Miocene sediments in the Western Desert are distinguished into two main rock units (Said, 1962), these units are as follows from younger to older:

A Marmarica limestone Formation; covers the larger part of the northern plateau of the Western Desert, which is of Middle Miocene age. This formation is built up of cavernous limestone intercalated with clay and marl interbeds. Good exposures occur on the cliffs facing the Mediterranean Sea between Salum and El Dabaa, e.g. Salum, Ras Umm El Rakham, Ras Alam El Rum, Ras El Hekma and El Sira (El Dabaa). In the subsurface, it is widely distributed under younger sediments as beneath the landfill site.

B Moghra Formation: It represents the Lower Miocene clastic sediments. In the coastal area, surface exposures of this formation are very rare. It is only exposed at Salum where it constitutes the basal 15 m at the Salum cliff (Selim, 1969). It is also forming the northern cliffs of the Qattara Depression and occupies most of its floor extending to the east and dipping beneath younger formations to the north. Moghra Formation is made up of sands, sandstone and shale interbeds with occasional subordinate limestone beds. Both surface and subsurface boundaries of the Moghra Formation are well known because of oil exploration in northwestern Egypt and are described by Joint-Venture Qattara (1981) as follows:

- To the north, the Moghra Formation grades sharply into a less permeable clayey facies especially along the Mediterranean Sea coast, and is overlain by cavernous limestone of the Middle Miocene Marmarica Formation.
- To the south and southwest, it is limited by the progressively higher top of the Oligocene shale of Dabaa Formation. Oligocene basalt flows and a fault escarpment associated with the Bahariya-Abu Roash uplift form the southeastern boundary of the Moghra Formation.
- To the east, the thickness of the Moghra Formation decreases gradually and its clastic nature changes into a less permeable clayey facies.
- To the west, the Moghra Formation interfingers with a less permeable limestone and shale sequence. The top of the underlying shale of Dabaa Formation is higher westward, delineating the western boundary of the Moghra Formation.
- The top of the Moghra Formation is mostly exposed except in the area to the north of Qattara Depression, where it is overlain by the Middle Miocene limestone of the Marmarica Formation.
- The base of the Moghra Formation is marked by Oligocene shale of Dabaa Formation. The thickness of the Moghra Formation varies according to the buried structure on which it was deposited.

4.1.4 Pre-Neogene Rocks

The subsurface Pre-Miocene succession has been differentiated from top to bottom into:

Upper Eocene-Oligocene (Dabaa Formation)

The Dabaa Formation consists of shale with thin beds of limestone. The maximum thickness of Dabaa Formation in the coastal area is about 650 m. It is overlain conformably by the Moghra Formation whereas it generally overlies unconformably the underlying Appollonia Formation of Paleocene-Eocene age.

Paleocene-Eocene (Appollonia Formation)

The Appollonia Formation ranges in age from Paleocene to late Eocene. It consists of an open marine sequence of limestone and some shales. The thickest Appollonia section is about 1760 m. The Appollonia Formation is overlain unconformably by the Dabaa Formation, where the top part of the Appollonia is missing. It mostly overlies unconformably the Khoman Formation (Cretaceous) where the Paleocene and Lower Eocene are missing.

Cretaceous

The Upper Cretaceous is divided into three rock units, namely; Bahariya, Abu Roash and Khoman Formations which are mainly of shallow marine to open marine environment. The base of Upper Cretaceous is mainly sandstone, shale and limestone while the topmost part (Khoman Formation) is mainly chalky limestone.

The Lower Cretaceous is also divided into three main rock units, namely; Alam El Bueib, Alamein and Kharita Formations which are mainly of continental and shallow marine environments (sandstones, shales and carbonates).

Jurassic

The Lower Jurassic, present in the northwestern corner of the Western Desert (Wadi Natrun Formation) consists of lagoonal deposits that is alternating dense limestone, green shales and dolomite with subordinate interbeds of sandstone and anhydrite.

The Middle to late Jurassic is represented by the Khatatba Formation composed of thick carbonaceous shale sequence with interbedded sandstone, coal seams and limestone streaks. It grades into the time equivalent Masajid Formation made up of oolitic, reefal and dolomitic limestones with cherty intervals. Jurassic is apparently overlain unconformably by the lower part of the Lower Cretaceous.

Paleozoic

The Paleozoic sediments nonconformably overlie the basement rocks and is overlain unconformably by the Jurassic or younger sediments. It is dominated by sandstones and siltstones with an abundance of limestone and shales in the upper part of the section.

4.2 TOPOGRAPHY AND GEOLOGIC STRUCTURES OF THE PROJECT SITE

4.2.1 Topography

The landfill site is located in a topographically low area with no distinct relief. The land surface of the frontal plain slopes is in a northward direction. The slope of the land surface is about 5 m/km which is considered as very gentle slope. This gentle slope does not accelerate surface runoff where the area has an indistinct drainage pattern. The surface runoff is captured by low lying depression where most of this surface storage evaporates.

4.2.2 Geologic structures

The regional structure of the northern portion of the Western Desert is a great homoclinal structure located to the north of the Qattara Depression and tilted very gently northward. This feature is associated with epeirogenic rising that took place during late Tertiary times and continued even throughout the Quaternary (Shata, 1953 & 1955 and Abdallah, 1966).

The north Western Desert and the Nile Delta are greatly affected by the Late Miocene tectonics which caused the development of the down warped zone bounding the southern part of the Nile Delta and the northwestern coast (Shata and El Fayoumy, 1970) (Figure 11). Shata (1957) indicated the possibility of presence of three normal faults belonging to the Late Miocene tectonics that have affected the tableland producing the structural plateau. The regional structural setting of the northern part of the Western Desert is a series of structurally positive areas trending NNW-SSE which affect the coast at Maryut, Ras El Hekma, Matruh, Salum and probably El Dabaa (Shata, 1955) as shown in Figure 4.3.

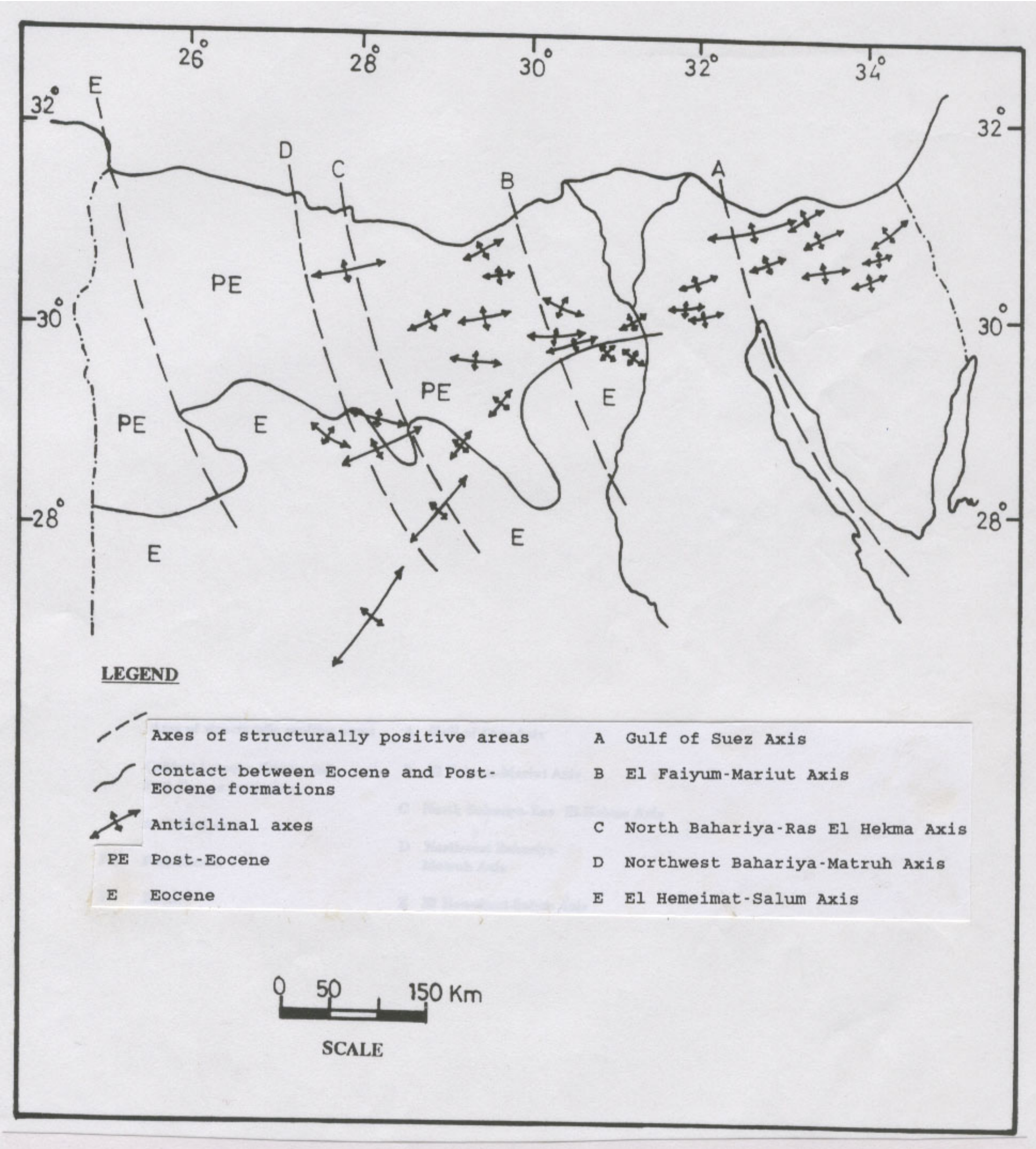


Figure 4.3. General Structural Setting Of Northern Egypt

A series of local monoclinal structures were developed that account for the formation of headlands protruding into the sea and recorded at Salum, Sidi Barrani, Mersa Gargub, Mersa El Asi, Ras Abu Laho, Ras Umm El Rakham, Ras Alm El Rum, Ras El Hekma and Ras El Dabaa. The successive monoclinal structures are alternated with synclinal basins or embayments having the same trend, e.g. Arab Gulf Synclinal Basin, Fuka, Bagush, Mersa Matruh, El Negeila and east Salum Gulf.

Jointing systems are well pronounced to the west of El Alamein and are responsible for the development of drainage lines (E-W and NE trends). Referring to the geological map of Egypt, the landfill site is located in the frontal plain where no fractures occur. On the southern plateau soils are deeper, stonier and sandier than in the other areas, deeper soils being found in sink holes. Soil texture varies from sandy to sandy loam, with evidence for the sandy and loamy sand textures being associated to aeolian contributions. Most soils observed on the southern plateau are not saline. It is very likely that the success of cultivation in these land systems is more linked to the presence of water-catching depressions and geographical positions than to soil characters.

Soils are characterized by their bright yellowish brown or orange colors, sandy and loamy sand textures. Generally, the chemical analysis of these soils indicates that they are characterized by low salt content. Organic matter and total nitrogen contents are relatively higher in the cultivated (olives and figs) soils than in unmanipulated areas such as the area of the landfill, calcium carbonate is generally very high in the coastal areas.

4.2.3 Soil profile

At the project site two boreholes were drilled for a total depth of 20 m in order to investigate the soil and subsoil profile, soil texture, and soil hydraulic characteristics (permeability). The soil and subsoil profiles of the two boreholes are shown in Figures 4.4 and 4.5. The percentage of fine materials in soil ranged from 52 to 64% at a depth from 9 to 10 m. The soil profile at the project site consists of the following main layers:

1) Silty caly extends from the ground surface to a depth of 8 m. It has a coefficient of permeability of $1.62*10^{-7}$ cm/s. This layer contains traces of fine sands and shows some fissures in clays which may slightly increase its permeability. It is better to depend on a permeability coefficient of about $1.0*10^{-6}$ cm/s which is also suitable for use as a bottom liner of the landfill. It is recommended when using this local soil in lining of the landfill cells and leachate evaporating ponds and in closure of the landfill to get rid of coarse materials through screening to ensure very low coefficient of permeability. The use of pure silty clay besides a 2 mm HDPE liner will ensure prevention of leachate leakage from the landfill during the working time and also prevent infiltration of rain water in the post-closure period.

2) Sandy silt of calcareous nature with some clay and limestone fragments, extends from depth of about 8 to 12 m. It contains silty clay lenses. This is cemented and has a moderate value of permeability.

3) Silty clay and limestone layer resembles the topsoil layer and found at a depth of 12 m where it is interbedded with limestone lenses.

4) Limestone of whitish grey color encountered at a depth of about 17 m to the bottom of the boreholes (20 m). It is considered as the bedrock from which the overlying layers originated by weathering in addition to the transported soils by wind and water actions.

The relatively high contents of medium to fine particles (silt fraction) in the soils of the landfill site is the main cause of their noticeably high water holding capacity. This characteristic may be the reason, at least in part, for the high percentage of seed germination of annual species following the rainy season. Moreover, it may be the reason for the high species richness of the vegetation.

The soil of landfill site is xeric carbonated calcimagnesic soil. These evolved soils exhibit a type of evolution which is strongly dominated by high content of calcium and magnesium. They are calcareous at the surface, and contain a strong lime accumulation in depth in the form of hard nodules, incrustation and even caliche or slab. The geotechnical investigation report is attached in Annex III.

BORHOLE NO. (1)

PROJECT:	El Hamam Landfill project - Cell (2) Alexandria Governorate	DATE :	April,2004
		G. L. :	Non
CLIENT:	Eamic Engineering International	G. W. D. :	Non

Depth (m)	SOIL DESCRIPTION	q_p (kg/cm²)	W_n (%)	W_L (%)	W_P (%)	γ_b (t/m³)	SPT-Depth (10 20 30 40 50)	Recovery (%)	R.Q.D.(%)
1	SILTY CLAY, dark brown,medium, fissured								
2	SILTY CLAY, light brown, medium to stiff,expansive								
3			4	68	29	1.88			-
4									
5	SILTY CLAY, brown,medium to stiff,traces of sand								
6									
7	SILTY CLAY, light brown , medium		5	71	28				
8									
9	CLAYEY SILT, gray, cemented , higly calcarous, some limestone fragments,traces of sand								
10									
11									
12	SILTY CLAY, gray,some lenses of cemented silt, calcarous								
13									
14	SILTY CLAY and LIMESTONE, gray cakcarous silty clay and some lenses of limestone							44	14
15								39	0
16								48	12
17								51	17
18	LIMESTONE, whitsh gray, fossiliferous, hard							64	27
19								71	24
20									

CONFIDENTIAL

Notes: ■ > 50

Remarks: borehole excuted by mechanical drilling method (rotary)

Engineering Consulting Office
Dr. Mohey Aboutaha
Tel & Fax : 4031425
File:Hamam-BH1

Figure 4.4. Lithologic Log of Borehole No. 1

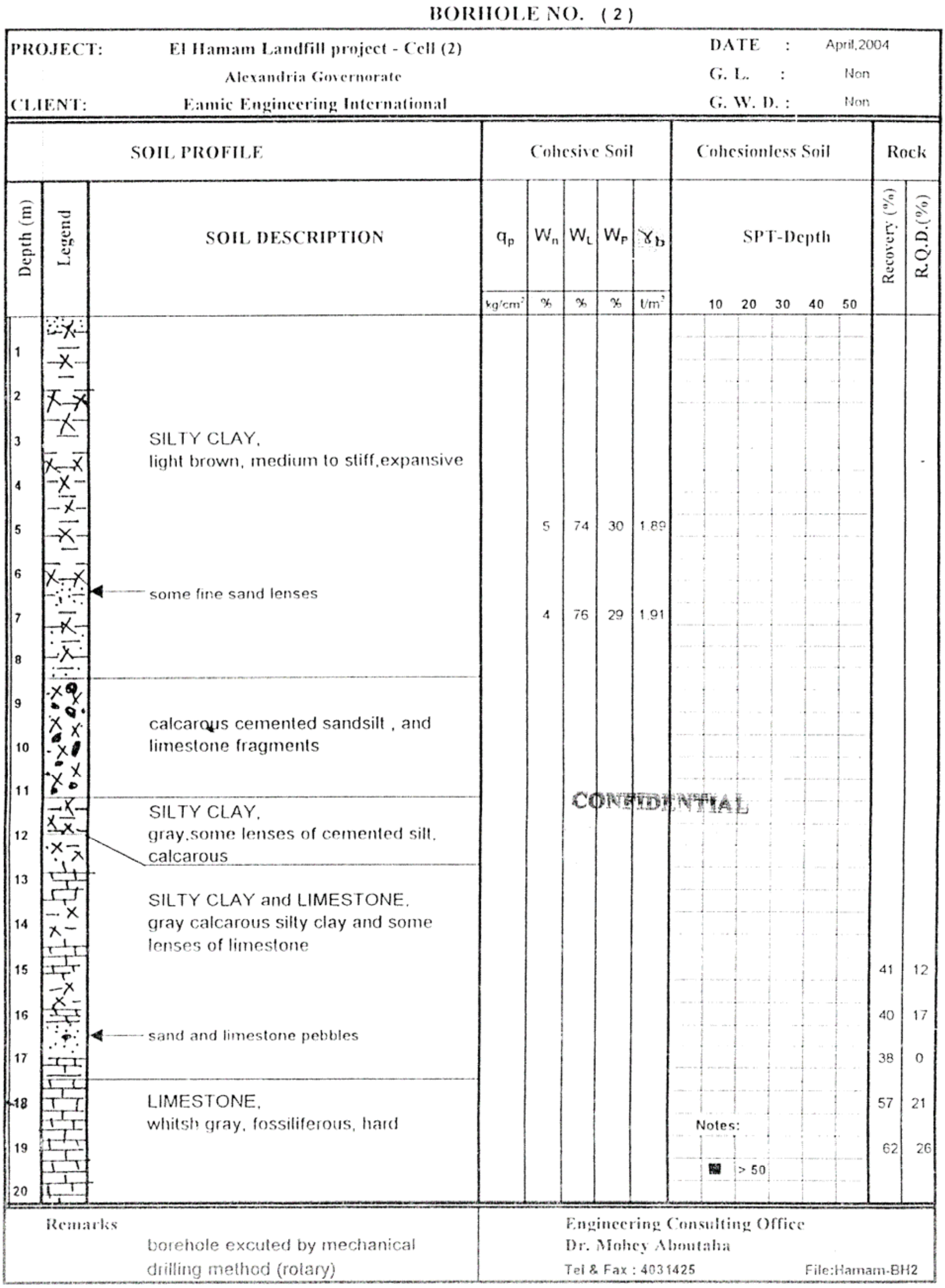


Figure 4.5. Lithologic Log of Borehole No. 2

4.3 GEOLOGICAL HAZARDS AND SEISMIC ACTVITY

At a regional scale of the northern part of the Western Desert, geological hazards such as landslides are not common. Suitable conditions of landslide occurrence are not encountered because most of the rocks forming steep slopes are competent. These conditions are the availability of rain water, steep or slightly steep slopes, and most important the occurrence of alternating inclined clay or shale layers and other hard layers on the slopes. Most slopes in the north of the Western Desert are stable. At the landfill site, the area is peneplained with no steep slopes. As a result the hazard of landslides is not considered. On the other hand, earthquakes with a Richter magnitude of 4 probably would not generate landslides (Keefer 1984). A discussion of the African tectonic plate is given in the following sub-section.

4.3.1 The African Tectonic Plate

The Plate is the stage on which the geological history of Egypt and Faiyum has been played out. Under the Faiyum and Western Desert it is immensely stable, but it has active edges in the east, along the Red Sea, and in the South at Gebel Uwaynat and Gilf Kebir. The active margins of the plate have been the engines driving the geomorphology of Egypt.

Egypt is situated on the north east portion of the African Plate. In Egypt, the "basement level" of the Plate, below which no sediments occur, is buried deeply below marine sediments. This is a result of successive transgressions, at paces 9 km deep (Hantar 1990). In the north of the Western Desert, these deep sediments are covered by a thin layer of marine, fluvio marine or aeolian deposits. To the north of the Plate is a continental shelf 15 to 50 km wide, bounded by a tectonically active fault line. Figure 4.6, shown below, illustrates a sketch of the Egyptian Tectonics.

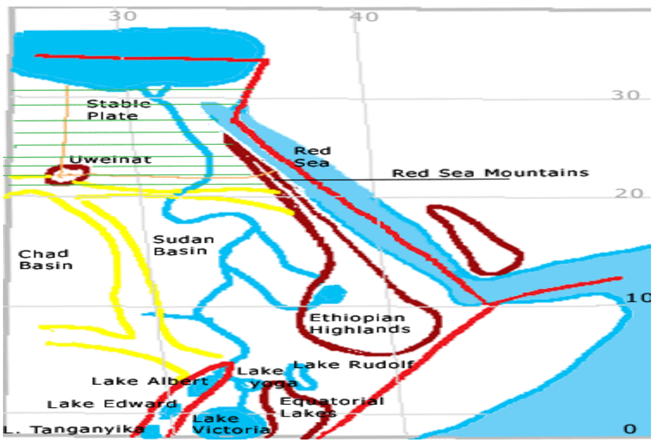


Figure 4.6. Sketch Map of Egyptian Tectonics

Under the Western Desert, the Plate has not been subject to the rigorous mountain building and folding found to the north in Europe. It has not experienced the tectonic upheavals which have produced the Great Rift Valley and the Equatorial Lakes. The movement at the margins has produced many smaller faults, mainly in a band running westwards between the coast and Beni Suef which result in minor seismic activity. They are the origin of the sill which caps Gebel Qatrani in the Fayum. There are few lines of major faults and the few folds noted are minor rolls with gentle dips and large amplitude.

4.3.2 African-Eurasian Plate Margin

The African and Eurasian plates are converging across a wide zone in the northern Mediterranean Sea. The zone is characterized by folding within the Mediterranean Sea floor and subduction of the northeastern African plate to the north beneath Cyprus and Crete. To the north of the margin, there is a complex zone of convergence (folding and reverse faulting) and strike-slip faulting. The effects of the plate interaction are mainly north of and remote from the Egyptian coastal margin. Some secondary deformation appears to be occurring along the northern Egyptian coast, as represented by earthquake activity.

Earthquakes with magnitude of up to 7.3 have occurred in Egypt causing casualties and significant damage to property both in historical and recent times. The most recent earthquakes are those whihc occurred on October 1992 (Cairo), November 1995 (Aqaba), October 1996 (Cyprus). According to the Geodynamic Institute, National Observatory of Athens (NOAGI), a M L 6.1 earthquake shook a large part of the East Mediterranean Sea on 22 January, 2002. Felt areas were extended, by hundreds of kilometers, into remote places like Egypt, Cyprus and Israel.

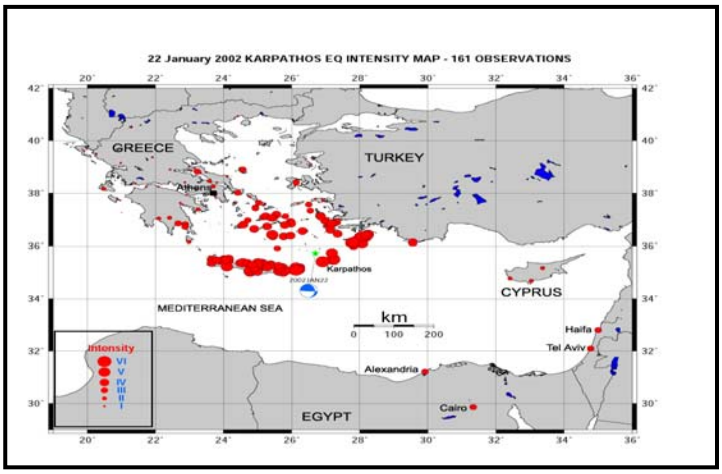


Figure 4.7. Epicenter Of the Karpathos Earthquake of 22 January 2002 And its Focal Mechanism According to USGS (Circles Indicate Macroseismic Intensities)

The main, large- scale geodynamic feature that controls the seismicity in the Hellenic arc and trench system is the active subduction of the Mediterranean lithosphere beneath the South Aegean Sea. Seismic intensities of degree III or even higher in 12-point intensity scales were typically reported as far as South Italy, Malta, Cyrenaica, Egypt, Cyprus, Israel and Palestine at epicentral distances up to 800 km and more. According to the determinations of NOAGI , another 2 earthquakes were observed on 21 May 2002 and 6 June 2002 of magnitudes M L 5.1 and M L 5.2, respectively.

The seismicity maps of earthquakes in Egypt show the presence of three regions, of high activity. The first region is concentrated around the entrance of the Gulf of Suez. The second region is along the Gulf of Aqaba while the third is located at the southwestern part of Cairo at Dahshour region. The epicentral distribution of micro earthquakes shows that the activity is aligned conformable with the major tectonic trends of the Suez rift, Aqaba rift with their connection with the Red Sea rift and Gulf of Suez-Cairo-Alexandria trend.

There should not be any significant seismic risk within the region of the landfill which could cause destruction of drains, or other civil works, or require unnecessarily costly engineering measures. There is also no fault line or significantly fractured geological structure that would allow unpredictable movement of gas or leachate within 0.5 km of the perimeter of the proposed landfill development.

4.4 HYDROLOGY AND WATER RESOURCES

Freshwater resources are an essential component of the earth's hydrosphere and an indispensable part of all terrestrial ecosystems. The freshwater environment is characterized by the hydrological cycle, including floods, and droughts, which in some regions such as marginal drylands have become more extreme and dramatic in their consequences. Global climatic change and atmospheric pollution could also have an impact on freshwater resources and their availability. Water is a vital source of life especially for Drinking water (human, animals), input for crop, forage, and fodder growth, Input for artisan and industrial activities.

Groundwater and surface water are fundamentally interconnected. In fact, it is often difficult to separate the two because they "feed" each other. This is why one can contaminate the other. The source of groundwater (recharge) is through precipitation or surface water that percolates downward. Approximately 5-50% (depending on climate, land use, soil type, geology and many other factors) of annual precipitation results in groundwater recharge.

4.4.1 Surface Hydrology of the Project Site and Surroundings

The water resources in the northern part of the western desert are mainly derived from atmospheric precipitation. Surface runoff is collected by means of stony dams built across wadis and their tributaries and man-made underground storage cisterns or galleries. On the other hand, groundwater is essentially discharged from wells (shallow, deep, hand-dug wells and boreholes) and shallow open trenches. At the landfill site, a well developed drainage pattern is absent, but instead, surface runoff is collected in depression areas as surface storage and finally evaporates.

Surface watersheds are defined by a simple process of identifying the highest elevations in land that drains to the surface water body (i.e. lake, pond, river, estuary, etc.). Watersheds are all shapes and sizes where many smaller watersheds are "nested" inside a larger watershed. The southern tableland is considered as the watershed area of the northern part of the western desert, whereas the frontal and coastal plains are working as water collectors.

Evaporation and Evapotranspiration

Evaporation is the process by which water is transferred from liquid state to gaseous state. It includes evaporation from ground surface and evaporation from open water surface. Evaporation intensity is generally affected by air temperature, air humidity, wind speed and solar radiation. The measured values of evaporation in the meteorological stations are actually pitche evaporation. The mean total annual evaporation increases towards south where desert conditions prevail.

Swidan (1969) noticed that the values of free surface evaporation and potential evapotranspiration increases towards west along the northwestern Mediterranean coast. On the other hand, these values increase towards south as the temperature becomes higher and the wind speed becomes lesser than in the coastal areas. The maximum average monthly evaporation is 147.3 mm/month recorded at El-Omayed meteorological station in July 2001. This high rate of evaporation will help in evaporating leachates from the evaporation ponds at the landfill site with the aid of wind reflectors.

Surface Runoff

Ward (1975) defined runoff as "the process which comprises the gravity movement of water in channels which may vary in size from those containing the smallest ill-defined trickles to those containing the large rivers". This water represents the excess of rainfall over evapotranspiration, when allowance is made for storage on and under the ground surface.

In the northwestern Mediterranean coastal zone, surface runoff is generally poor due to the low average precipitation. However, some ephemeral streams may occasionally flow through channels of dry wadis already engraved in the tableland during the Pleistocene Pluvial time. Ezzat (1976) considered that the infilteration in the northwestern coastal zone is as follows: a coefficient of 20% in the wadi runoff zone; a coefficient of 30% in the plane zone; and a coefficient of 50% in absorbed water reaching the lower strata as groundwater

4.4.2 Subsurface Hydrology of the Project Site and Surroundings: Ground watershed and Groundwater Table

Groundwater is an important resource which must be wisely managed and protected against pollution. Landfills, especially those without lining and leachate collection systems, are among the most sources of groundwater pollution. According to the published hydrogeological map of Egypt (RIGW 1988) the landfill site is located above local and moderately productive aquifers where insignificant surface recharge and limited subsurface recharge are common. The depth to groundwater of the Quaternary aquifer exceeds 50 m. This groundwater depth decreases its vulnerability to pollution by leachate from the landfill which is lined by local low permeability silty clay soil, geotextile 400g/m^2, 2 mm HDPE, and geotextile 600 g/m^2. This lining prevent leachate leakage where a leachate collection system is available.

4.4.3 Water Resources and Uses in the Watershed

The surface water divide is located at the southern tableland at a distance of about 30 km to the south of the landfill site. Watershed area is located to the north of this divide where rare surface runoff goes toward north. This watershed area is only used locally for grazing and barley cultivation by rainwater. The southern tableland is cut by the new Wadi El Natrun-El Alamein desert road.

4.4.4 Hydrometeorology and Hydrophysiography

4.4.4.1 Hydrometeorology

The northwestern Mediterranean coastal zone occupies a portion of the semi-arid belt south of the Mediterranean Sea (Figure 4.8). The climate of this region is characterized by a rainy unstable winter and a stable warm and dry summer. The other two seasons are also characterized by unstable climatic conditions, e.g. Khamasien storms during spring and occasional sudden heavy rain fall during autumn. The landfill is located in the arid zone to the south of the Mediterranean Sea.

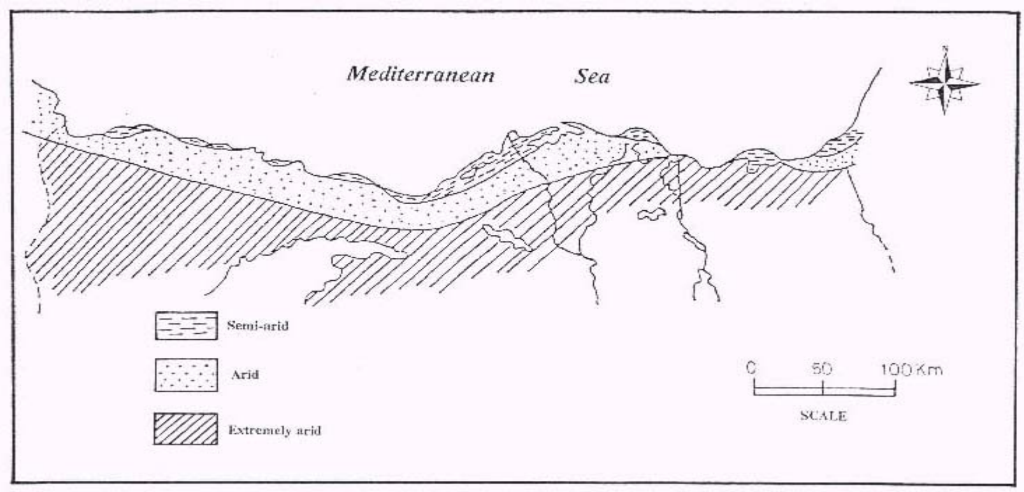


Figure 4.8. Aridity Map of Northwestern Egypt

4.4.4.2 Hydrophysiography and Drainage Pattern

The Northwestern Mediterranean coastal zone can be differentiated into two main physiographic provinces. These are the elevated tableland in the south and the coastal zone to the north. A great number of drainage lines dissect the elevated tableland, which acts as a major watershed area. Rain water flows to the north following the regional slope of the tableland surface either towards the low coastal plain and/or towards the sea. The rest of rain water infiltrates through joints to feed the lower limestone aquifers. However, the presence of a thin hard crust accelerates surface runoff to the north.

The frontal and low coastal plains act as collecting basins for the rainfall and runoff water from the southern tableland. The coastal ridges lead to the conservation of soil and surface water. Meanwhile, the elongate depressions act as collecting basins for the runoff water from both the ridges and the tableland.

The hydrographic pattern of the area was mainly developed during the Pluvial periods prevailing in the Quaternary Era (Taha, 1973). The drainage lines dissecting the elevated tableland are structurally controlled. They are well developed in areas where lines of weakness are common (E-W trend at wadi Agiba and wadi Mohquine). Taha (1973) differentiated the northern edge of the homoclinal plateau on the basis of the nature of the drainage lines into three sectors.

1) An eastern sector; characterized by few, short and shallow drainage lines.

2) A central sector; characterized by dense, long and deep drainage lines.

3) A western sector; characterized by few, short and shallow drainage lines.

The landfill site is located in the central sector.

4.4.5 Groundwater Aquifers

The important groundwater aquifers in the coastal zone are classified into the following categories; the dune sand accumulations (Holocene); the oolitic limestone (Pleistocene); and the fissured limestone (Middle Miocene).

4.4.5.1 The Dune Sand Accumulations (Holocene)

This hydrogeologic unit consists of unconsolidated calcareous sand of high porosity. Such accumulations act as good local reservoirs for the directly precipitated rainfall at the coast. Such formations are tapped by a number of wells to yield water of low salinity (ultra-fresh water).

4.4.5.2 The Oolitic Limestone (Pleistocene)

The oolitic limestone forms the most important aquifer throughout the region to the west of Alexandria. It covers the whole coastal plain forming elongated ridges. The oolitic limestone extends southward from the coast line to about 10 km in average. The foreshore oolitic limestone ridge is characterized by less cementing materials compared with the inland ridges and hence it has more porosity. The flanks of the foreshore ridge are covered by loose foreshore sand accumulations which permit direct infiltration and percolation of rainwater.

The source of groundwater found in the oolitic limestone ridges comes either from direct infiltration and percolation of annual rainfall on the ridges or from the rain water falling on the tableland located to the south. Most of the groundwater of the oolitic limestone ridges is abstracted by large diameter wells especially in the first and second ridges. The groundwater of this aquifer ranges from fresh to brackish.

4.4.5.3 The Fissured Limestone (Middle Miocene)

The Miocene formations, which form the underlying rocks of the whole area, are composed of limestone with few clay intercalations. Such limestone may be dolomitic, marly, clayey or chalky limestones according to the local environment of sedimentation. A small scale homoclinal and synclinal folding and fissuring appear to be the most common structural features along the coastal zone. Such structural conditions have their effect on the groundwater occurrences in this area. Consequently, groundwater occurs in the form of separated sheets accumulated above the contact with the impervious clays alternating with the porous limestone. Miocene formations have no importance as an aquifer eastward from El Alamein.

The recent geological history of the area indicates more favourable conditions for ground-water accumulation, principally due to the fact that this area was subjected to past wet climatic conditions. Unfortunately, such groundwater has been influenced by the rise of the Mediterranean Sea level which took place in Sibilian times (Ball, 1939). This rise of sea level allowed the rise of the saline water body that resulted in the deterioration of the fresh water accumulated during the past wet periods (Taha, 1973).

4.4.5.4 The Moghra Aquifer

Moghra is a small unihabited oasis situated on the north eastern edge of Qattara Depression and bordered by brachish water lake. The Moghra Formation was named by Said (1962) represents the Lower Miocene clastic sediments forming the northern cliffs of the Qattara Depression. The Moghra Formation also occupies most of the floor of the Qattara Depression. It is made up of sandy and clayey layers of the Lower Miocene. The maximum thickness of the Moghra aquifer is about 930 meters in the northeastern part. Along the Mediterranean Sea, the aquifer's thickness decreases sharply to zero where it grades into an impervious clayey facies.

The Moghra aquifer is recharged from five different sources: (1) direct rainfall on the aquifer's outcrops, (2) groundwater seepage from the overlying Marmarica limestone aquifer, (3) the Mediterranean Sea, (4) the Nile Delta aquifer, and (5) upward leakage from the Nubian artesian aquifer (Rizk and Davis 1991). Natural discharge from the Moghra aquifer occurs through evapotranspiration from the Qattara Depression in the west. Most of the groundwater that evaporates in the depression comes from the Moghra Aquifer system. The water-table elevation map (Figure 4.9) shows that ground water in the Moghra aquifer flows to the Qattara Depression from the north, east, and south (Rizk and Davis 1991).

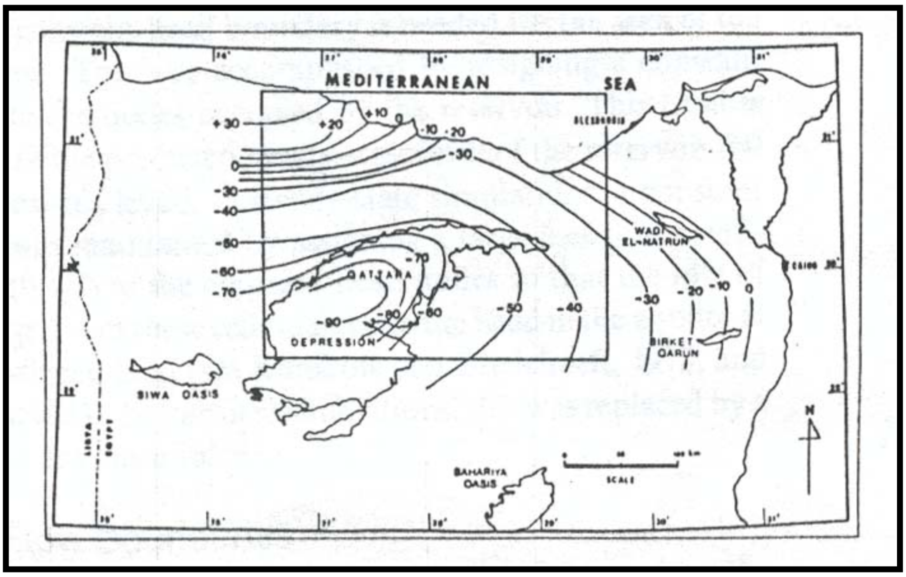


Figure 4.9. Water Table Contour Map Of The Moghra Aquifer

This map shows that the depth of groundwater of the Moghra aquifer under the landfill site ranges between 76 to 86 m.

4.4.5.5 Groundwater Conditions

Groundwater in the northern part of the Western Desert and beneath the landfill site occurs mainly under water table condition. The source of water supporting the main water table is only the localized rainfall directly precipitated on the coastal plain and the southern tableland. The main fresh-water table forms a thin fresh water layer floating on the main saline water. The hydrologic relation between these two water tables is controlled by the well known principle of the salt-water intrusion into coastal aquifers.

4.5 ECOLOGY (FLORA AND FAUNA)

4.5.1 Project Hinterland

The project is located in the Mediterranean Coastal Desert, which is the northern part of the wider Western Desert eco-region. This coastal belt stretches from Alexandria to Salloum, bounded by the shoreline on the north and the Qattara Depression to the south. It is less arid than the rest of the western desert and its distinctive feature is the relatively high, and more consistent, rainfall (about 150-180 mm/year) and low temperature compared to the rest of Egypt. However, the rainfall decreases very rapidly inland from the coast, giving this zone a maximum width of 50 km along its 600 km length (Hoath, 2004; EEAA/UNEP, 1993).

The region may, on geomorphologic grounds, be divided into two parts: an eastern province between Alexandria and Ras El-Hekma, including El-Hammam area, and a western province between Ras El-Hekma and Salloum (Selim, 1969 in EEAA/UNEP, 1993). In general, the coastal belt comprises a coastal plain and a tableland. In the eastern province, the coastal plain is wide and characterized by a series of long ridges (bars) alternating with long depression all running parallel to the coast. In certain parts, nine limestone ridges may be noted; they represent a Pleistocene sequence of shoreline bars (EEAA/UNEP, 1993).

Habitat types and plant growth relate to physiographic conditions. In the eastern province, the shoreline is fringed by bodies of coastal sand followed by a series of ridges alternating with furrow-like depression. The first (northeast) depression is partly occupied by the westward extension of Lake Mariut. It is a saline depression while inland depressions are not saline. Further inland is the limestone plateau. The coastal dunes and associated near-shore ridges provide room for fig and olive orchards; the non-saline depressions provide room for barley cultivations in year of good rain, while the rest are rangelands for herds of sheep and goat (EEAA/UNEP, 1993).

Rain-fed agriculture is practiced in the area in addition to livestock grazing. With the introduction of irrigation water via canals, the area has rapidly changed. Several desert areas have been reclaimed and new agricultural settlements have appeared in the last years. Except for the small reserve of El-Omayed, which is also threatened by agricultural land reclamation and grazing activities, the natural vegetation and wildlife are in highly degraded conditions. Haphazard tourism expansion, land reclamation, industrial development and urbanization have resulted in the destruction of natural habitats, particularly from Alexandria to Matruh.

In fact, the area near the coast, west of Alexandria, is actually characterized by intensive strip development. In a continuous band for 120 km, the coast has been totally transformed into intensive summer-home apartment housing developments, surrounded by continuous fencing which block public access to the beach, and interactions between the sea and the coastal lands. In addition, the coastal ridges have been quarried for building materials, destroying the habitat of rocky-land species. Accordingly, the coastal dunes, together with their species and the ecological interactions between the sea and the inland areas, have been almost completely lost.

Despite the human impact, the distinctive geography of the Mediterranean Coastal Desert allows it to host Egypt's most prolific flora, both in terms of absolute numbers and of species diversity. Unsurprisingly, this rich flora supports a wide range of animal life.

4.5.2 Data Analysis

4.5.2.1 Types of Habitats

Based on literature review and on the spatial extent of the study area, previously delineated through topographic maps and later on through field reconnaissance, the types of habitats encompassing the project area were determined.

4.5.2.2 Biodiversity

Data gathered through literature review and field survey were used to list the floral and faunal species of the study area. Personal experience in similar, nearby, settings was also exploited to identify prevailing species diversity.

The developed lists of wildlife species include the main habitats encompassed by the study area. They include not only species recorded through field reconnaissance, but also species indicated by references as present in the area, or that could be present.

4.5.2.3 Species Identification

Previous experience was exploited to identify prevalent faunal and floral components. Some floral specimens were also collected and identified at the Botany Department of the Faculty of Science, Alexandria University. Besides, specialized field guides were used during the survey. Encountered species were also photographed and reference verification was undertaken. Other characteristics such as behavior, distinguishing features and range were also considered to determine faunal communities of the area.

4.5.2.4 Threatened and Endangered Species

It was important to highlight receptors needing special conservation attention occurring in the project area. Therefore, lists concerning locally and internationally endangered species were prepared.

The CITES1 appendices and IUCN2 Red List were used to determine the international status of species. To determine the local status, it was referred to the available literature and information tools, particularly Hoath (2004) for mammals, Bruun and Baha El Din (2002) and Tharwat (1997) for birds and Saleh (1997) for reptiles. Birds protected by the Egyptian Law and mentioned in the Minister of Agriculture Decree No. 28 of 1967 were also indicated.

[1] Convention on International Trade of Endangered Species of Fauna and Flora, Washington D.C., 1973
[2] International Union for the Conservation of Nature

4.5.3 Flora

Of the 2000 species of plants in Egypt, 1000 occur within 30 km of the Mediterranean coast (IUCN, 2003a). However, a large number of Egypt's plants have become locally rare or extinct, due to habitat destruction, overgrazing, and over-harvesting.

The eastern province may be ecologically organized into five main groups, representing a sequence of zones lying on a north-south axes starting from the shoreline. These zones as well as their principal floral characteristics are herein presented (EEAA/UNEP, 1993).

4.5.3.1 Coastal Dunes

Ammophilia arenaria is found on active baby dunes at the shoreline, while the plant is associated with Euphorbia paralias and Lotus polyphyllos on partly stabilized sand dunes near the shoreline. Stabilized sand dunes support Pancratium maritimum and Thymelaea hirsuta while Pituranthos turtuosus and Echiochilon fruticosum are present on coastal limestone ridge.

Inland Dunes

In inland dunes, plant life is dominated by Urgina maritima and Thymelaea hirsuta.

Inland Ridges

In inland ridges, the following sub-divisions are recognized:

- Summits of ridges (rocky sites) with chasmophytes and lythophytes including Thymus capitatus, Globularia arabica and Helianthemum lippii;
- Intermediate slopes with Gymnocarpos decandrum and Reaumeria vermiculata;
- Lower slopes with Plantago albicans, Asphodelus microcarpus and Salvia lanigera.

Saline Depression

This is a habitat of a variety of salt marshes communities; habitat types vary in relation to depth of the saltwater level and often show zoned pattern that seem to depend on ground level and surface accumulation of deposits (e.g. phytogenic mounds). Most common dominant species include Arthrocnemum macrostachyum, Halocnemum strobilaceum, Sarcocornia fruticosa, Suaeda vermiculata and Limoniastrum monopetalum. Sites with surface salt crusts are usually sterile.

Non-Saline Depressions

Plant communities seem to differ in relation to the nature (such as texture, depth and chemistry) of the surface deposits. Accordingly, the following plant communities are dominant:

- Anabasis articulata and Echiochilon fruticosum on sandy soils;

- Plantago albicans and Noaea mucronata on calcareous (often saline) soils;
- Asphodelus microcarpus, Thymelaea hirsuta and Artemisia monosperma on soft (fine textured) soils;
- Stipagrostis ciliata and Hammada scoparia in the more arid (inland) areas.

The area is also important for medicinal and aromatic plants, which are either wild or cultivated. Matrouh Governorate and surroundings count for more than 50% of the wild medicinal and aromatic plants existing in Egypt, i.e. more than 1000 wild species (ESDF, 2002). This floral wealth is currently misused and over-harvested by residents who use them for folk medicine, human nurturing and animal grazing, thus subjecting the plants to the risk of extinction. The conservation of medicinal plants is a component of Egypt's National Biodiversity Strategy and Action Plan.

On the other hand, virtually all trees seen in semi-urban environments are exotic, and, in rural areas, the ubiquitous Eucalyptus spp. is an import from Australia. Casuarina trees are widely used as wind-breakers and to border fields while Ficus sp. is commonly used as ornamental plant.

4.5.4 Fauna

The Western Mediterranean Coastal Desert possesses one of the richest herpetofauna in Egypt. A total of 32 species of reptiles and two species of amphibians have been recorded from this area. One reptile, the Mediterranean Hooded Snake Macroprotodon cucullatus, has been recorded only from this habitat in Egypt (EEAA/UNEP, 1993). Saleh (1997) collected several specimens of this reptile at El-Hammam, Dabha and Sidi Kreir. Characteristic species of this habitat type include (Flower, 1933; Marx 1968; Saleh and Saber, 1992 in EEAA/UNEP, 1993; Saleh, 1997):

- The Moorish Gecko Tarentola mauritanica and the Starred Agama Laudakia stellio in rocky areas
- The Changeable Agama Trapelus mutabilis
- Nidua Lizard Acanthodactylus scutellatus
- Javelin Sand Boa Eryx jaculus
- The Lesser Cerastes Viper Cerastes vipera and the Egyptian Tortoise Testudo kleinmanni in sandy areas
- Bosc's Lizard Acanthodactylus boskianus
- The Gold Skink Eumeces schneiderii
- Montpelier Snake Malpolon monspessulana
- Schokari Sand Snake Psammophis schokari

- Clifford’s Snake Spalerosophis diadema and the European Chameleon Chamaeleo chamaeleon in mixed rocky and sandy habitats

The Egyptian Tortoise, once very common, has been mostly eradicated from the region due to commercial over-exploitation and habitat destruction (Saleh, 1997). In an attempt to verify its status in the North Coast, Baha El Din and Baha El Din (1994) undertook an exhaustive survey of the region that included El-Hammam area, but no animals were found, nor was there any evidence of their existence (scats, tracks or dead animals) in any of the surveyed areas.

Concerning birds, at least 38 species are known to breed in the Mediterranean Coastal Desert. One resident species, the Raven Corvus corax is known only from this habitat in Egypt. Characteristic resident bird species include: the Cream-colored Courser Cursorius cursor, the Bar-tailed Desert Lark Ammomanes cincturus, the Hoopoe Lark Alaemon alaudipes, the Crested Lark Galerida cristata and the Goldfinch Carduelis carduelis (EEAA/UNEP, 1993; Tharwat, 1997; Baha El Din and Atta, 2002; Bruun and Baha El Din, 2002). It should be noted that the resident population of the Houbara Bustard Clamydotis undulata has been subjected to a very severe hunting pressure, which has driven the species near to extinction. Besides, several birds of prey such as the Common Kestrel (Falco tinnunculus) and the Barn Owl (Tyto alba) are regularly seen in the area and its hinterland.

During the autumn and spring migrations, Western Mediterranean Coastal Desert receives vast numbers of palearctic migrants. The region provides the first available resting and feeding area for huge numbers of individuals of many species after their Mediterranean crossing. Most famous of these are the Quail, Coturnix coturnix and the Golden Oriole, Oriolus oriolus. The presence of buildings along the coast affects landing of birds. Quails were observed to direct to the west away from concrete constructions and their inhabitants; some birds have been observed dashing into buildings and being unable to fly again (Batanouni, 2001). Besides, quails are decimated by locals, which use nets to capture them.

Up to the early 1970s, the Western Mediterranean Coastal Desert supported very large populations of the Dorcas Gazelle Gazella dorcas, possibly the largest in Egypt. Very few, gazelles, if any, are now found in the area as a result of uncontrolled hunting and habitat destruction (EEAA/UNEP, 1993).

Thirty-eight species of mammals have been recorded from this eco-region. Three species of rodents, namely the Lesser Molerat Spalax ehrenbergi, the Four-toed Jerboa Allactaga tetradactyla and the Lesser Short-tailed Gerbil Dipodillus simoni are restricted to this habitat type, with the latter two found only in littoral salt marshes (EEAA/UNEP, 1993). Characteristic mammals also include the following:

- Long-eared Hedgehog Hemiechinus auritus
- the Ethiopian Hedgehog Paraechinus (aethiopicus) deserti
- the Cape Hare Lepus capensis

- Anderson’s Gerbil Gerbillus andersoni
- the Large North African Dipodil Gerbillus (Dipodillus) campestris
- Shaw’s Jird Meriones shawi
- The Fat Sand Rat Psammomys obesus and the Greater Egyptian Jerboa Jaculus orientalis

The Swamp Cat Felis chaus is found in areas with thick cover such as farmlands, marshes and reed beds, while the Wild Cat F. silvestris inhabits dryer areas with cover. The Jackal Canis aureus and, particularly, the Red Fox Vulpes vulpes occupy a variety of habitats though they are not true desert species, while the Striped Weasel Poecilictis libyca is found in sandy but vegetated desert and semi-desert (Hoath, 2004; EEAA/UNEP, 1993).

4.5.4.1 Project Site

The site covers an area of 1.19 km2 and is located approximately 35 km south of the coastal road and about 13 km south of El-Hammam town (30°45'22.5"N, 29°25'16.0"E). The site may be divided into two parts: a disturbed area devoid of vegetation occupying the eastern section where landfilling activities take place, and a vegetated area in the western part where landfill extension will occur. This currently undisturbed zone is a flat strip of silty clay soil with fairly rich shrubby vegetation (Figure 4.10).

Figure 4.10. Shrub By Vegetation Of The Study Area

Floral specimens were collected from the site and identified. The vegetation cover is dominated by woody shrubs, particularly Thymelaea hirsuta, in addition to Anabasis articulata, Noaea mucronata, and Asphodelus microcarpus.

Numerous signs of animal life were also detected in the project site. Rodent burrows, probably belongi [illegible] (Figure 4.11).

Figure 4.11. Rodent Burrows

Besides, several individuals of Desert Snail, Eremina desertorum, where noticed on the branches of the shrub Thymelaea hirsuta (Figure 4.12). Also, large numbers of House Sparrows, (Passer domesticus) were observed at the operational cell, definitely attracted by the great quantity of organic waste. Waste is also expected to attract several other opportunistic species such as the Black Rat (Rattus rattus) and the House Mouse (Mus musculus). Larger mammals, such as the Red Fox and the Jackal probably visit the site in search of food during the night or at dusk. Moreover, sheep feces were noticed, indicating that the site is used for grazing activities.

Figure 4.12. Desert Snail

4.6 BIODIVERSITY VALUE

4.6.1 Flora

There is only one rare endemic species in this region, Helianthemum sphaerocalyx (Cistaceae), found in coastal dunes (Salem, 2003).

However, natural vegetation finds commercial and practical applications contributing to locals' livelihood. In fact, livestock grazing is a widespread activity in the area and several ligneous plants, such as Thymelaea hirsuta and Anabasis articulata, are collected as fuel wood (Batanouni, 2001). Besides, Bedouins, with a strong traditional culture, have a real interest in medicinal plants as they collect and use them. Although most Egyptians rely on modern medicines, there is a big demand for medicinal plants in Egypt, but most of these are for export to the USA and Europe.

Moreover, vegetation has also other important ecological functions that benefit man such as natural water purification, soil stabilization, nitrogen fixation (e.g. Casuarina sp.) and in providing food and shelter for local wildlife.

4.6.2 Fauna

Some reptiles are subjected to a severe human pressure, which has driven the population of some species to a rapid decline. The Mediterranean Hooded Snake has been recorded only from this habitat in Egypt and is locally vulnerable due to commercial over-exploitation (Saleh, 1997), while the Egyptian Tortoise is locally near to extinction and internationally ranked “critically endangered” (CR) according to the IUCN status categories and included in CITES Appendix I.

Concerning birds, all birds of prey are protected species and included in CITES Appendix II. Besides, they have a high societal importance in controlling the number of rodents. The Cream-colored Courser, the Bar-tailed Desert Lark and the Hoopoe Lark are protected in Egypt as useful to agriculture, according to the Minister of Agriculture decree No. 28/1967. The Houbara Bustard is close to extinction in Egypt and is included in CITES and CMS3 Appendix I. Besides, the migrating Quail and Golden Oriole populations have drastically declined due to habitat destruction, coastal development and capture by locals who fence several parts of the coast with nets during the migrating period. Although not threatened, sub-species Galerida cristata nigricans is endemic to Egypt.

Threatened mammals include the Wild Cat and the Jungle Cat which are included in CITES Appendix II and in the IUCN lists. The Four-toed Jerboa is threatened by tourist development along the coast and habitat destruction (Hoath, 2004). The Dorcas Gazelle is listed as “vulnerable” (VU) by the IUCN, but the animal has completely disappeared from the study area. Few populations probably still survive in remote inland areas of the Western Desert.

Besides, predators function as natural biological controls for agricultural pests. Birds of prey, snakes and many mammals, such as the Red Fox Vulpes vulpes, feed on rodents and insects that may spread diseases and cause damages to crops. Moreover, scavengers such as the regionally limited Corvus corax and the widespread Hooded Crow (Corvus corone) are highly ecologically important as they eliminate carrions and organic waste.

[3] Convention of Migratory Species of Wild Animals, Bonn, 1983

4.6.3 Nature Conservation

4.6.3.1 Medicinal Plants Conservation

The IUCN has been engaged since 1996 in a program aiming at promoting the conservation of biodiversity in North Africa, a network of institutions from the region in support of this objective, and the role of women in biodiversity conservation.

The overall objectives of Phase III of the IUCN North Africa Biodiversity Program were to:

- Promote the conservation of endangered and economically useful plants in North Africa, with special reference to medicinal and economically useful plants;
- Promote indigenous knowledge and the equitable participation of people in the management and conservation of endangered and economically useful plants in North Africa.

Accordingly, the Center and Garden for Conservation of Endangered Plants (CGCEP) has been established at Al-Hammam. It includes rare and medicinal plants, such as Hyoscyamus albus and Artemisia herba-alba. The latter is used for nervous troubles, parasites, hemorrhagic wounds, burns, abscesses, etc. It is also used as a plant insecticide, and a veterinary parasiticide. Besides, Colchicum ritchii, a rare endemic species from the dune ecosystem is fruiting in the Garden. This plant is used for arthritis, rheumatism, gout and abdominal colics (IUCN, 2003a).

A number of Bedouins at Al-Hammam are also involved in the conservation of medicinal plants and are the main CGCEP's source for wild Artemisia and Teucrium. The center is essentially based on ex situ conservation of medicinal plants. It includes a building and a garden where threatened and endangered plants are grown. Four Bedouin micro-nurseries produce hard-to-find plants for the garden, and the traditional knowledge of the Bedouin is being gathered and documented. The project is also supporting phytochemical research, investigations on the status of medicinal plants in the project area.

4.6.3.2 El-Omayed Biosphere Reserve

Biosphere reserves are areas of terrestrial and coastal/marine ecosystems that are internationally recognized under UNESCO's Man and the Biosphere (MAB) Program. They are designed to promote and demonstrate a balanced relationship between people and nature. The reserves are nominated by national governments and remain under the sovereign jurisdiction of the States where they are situated (Chape et al., 2003). The following description of El-Omayed Biosphere Reserve is based on that of the UNEP/WCMC (1988). The Omayed protected area is situated in the northwestern Mediterranean Coastal Desert, 7 km south of Omayed village and 80 km west of Alexandria (30°45'N, 29°12'E). The protectorate southern boundaries are located approximately 10-15 km from the landfill site. It has an area of 1000 ha (100 ha core area) and an altitude ranging from sea level to 110 m.

El-Omayed has been accepted by Unesco as a Biosphere reserve in October 1981 after having been protected since 1974. The Governor of Matrouh recognized and designated the site at the same time as the Biosphere designation. Official national recognition of the site was made under Law 102 of 1983 and was instituted by Prime Ministerial decree in July 1986 (Ghabbour, 1986).

Physical Features

The site is situated on the Mediterranean Sahara coast, extending inland along the Gebel Mariut – Khashm El-Eish Depression of the western desert. Geological formations are essentially Quaternary and Tertiary in origin. The coast consists of Holocene beach deposits and sand dune accumulations. The pink oolitic limestones are of Pliocene-Pleistocene origin. The topographic relief is characterised by Pleistocene fossil rich white limestones forming successive undulations running more or less parallel to the coast. These undulations are in the form of calcareous rocky ridges (ancient dunes) alternating with depressions and varying in height from 10 to 60m. Five main habitat types exist at Omayed and these include: a) coastal calcareous dunes; b) inland ridges with relict soils; c) saline marsh depressions; d) non-saline depressions; and also e) inland plateaux (Ayyad and Ghabbour, 1986). The soils are generally sandy with a high percentage of calcium carbonate (Abdel-Razik et al., 1984).

Climate

It is a Mediterranean arid sub-saharan bioclimate with typical low annual rainfall figures of 150-200mm. Temperatures vary from 10 °C in January to 26 °C in August. The area is included in Emberger's Mediterranean isoclimatic zones and is arid with mild winters and warm summers. There is some humidity influence from the nearby Mediterranean sea (Le Houérou, 1981).

Flora

The flora is characterised by xerophytic steppic vegetation of the Saharan Mediterranean region (Quezel, 1978, quoted by Ayyad and Ghabbour, 1986). The typical associations consist of Thymelaea hirsutae with Noaea mucronata (wet variant dominated by Asphodelus microcarpus and dry variant by Achillea santolina) or Anabisis articulata with Suaeda pruionosa (El Ghonemy and Tadros, 1970; Ayyad and Ghabbour, 1986). Dune vegetation consists of Ammophila arenaria, Euphorbia paralias, Pancratium maritimum, Elymus fancrus, Crucianella maritima, Echinops spinosissimus and Thymelaea hursuta on young dunes, whilst there are communities of Crucianella maritima and Ononis vaginalis on the older dunes (Ayyad and Ghabbour, 1986). The inland siliceous sands are dominated by communities of Urginea maritima, Plantago albicans and P. squarrosa. The shallow soiled inland ridges are more often characterised by either Thymelaea spp. and Gymnocarpos decadrum communities or by associations of Plantago albicans and Asphodelus microcarpa. In these communities local variations result from humidity differences: a) low moisture rocky ecosystems- Thymus capitatus, Globularia arabica and Dactylis glomerata; b) deep soil ecosystems - Asphodelus microcarpus, Hernaria hemistemon, Plantago albicans and Salvia lanigera; c) intermediate habitats - Gymnocarpos decandrum, Anabasis articulata, Helianthemum lippii and Pituranthos tortuosus (Ayyad and Ghabbour, 1986). The halophilous vegetation, typical of saline and marsh habitats, is dominated by Salicornia fruticosa, Cressa cretica, Atriplex halimus, Juncus rigidus, Arthrocnemum glaucum and Limonium echioides. In relatively deep water and under higher salinity conditions are also Suaeda monoica, Zygophyllum album, Limoniastrum monopetalum, Aeluropus lagopoides, Salsola tetrandra and Frankenia revoluta. In areas with deep water and low salinity are communities of Atriplex halimus, Hammada scoparia and Anabasis articulata (Ayyad and Ghabbour, 1986). The inland plateau vegetation includes Artemisia monosperma and Hammmada elegans associations (calcareous soils), Anabasis articulata and Hammada scoparia (shallow degraded soils) and Suaeda pruinosa and Salsola tetrandra communities (saline soils) (Ayyad and Ghabbour, 1986; El Ghonemy and Tadros, 1970).

Fauna

The mammals at Omayed include Dorcas Gazelle Gazella dorcas, a number of gerbils Gerbillus spp., the east Mediterranean endemic Mole Rat Spalax leucodon, the Fennec Vulpes zerda, Red Fox Vulpes vulpes, Cape Hare Lepus capensis and the North African endemic Fat Sand Rat Psammomys obesus. There are 50-70 bird species including Common Kestrel Falco tinnunculus and Quail Coturnix coturnix and between 7-13 reptile and amphibian species such as Horned Viper Cerastes cerastes and also the Greek Tortoise Testudo graeca. Common insects are represented by the families Terrebrionidae, Scarabaeidae and Carabidae. There are also records of sand roach Heterogamia syriaca, harvester ants Messor spp. and a localised protozoa Acanthamoeba (Ayyad and Ghabbour, 1986).

Local Population

Rains fed fig farms are present in the reserve. There are some scattered settlements and semi-nomad communities which have traditional land-use and grazing rights over the area (Ayyad and Ghabbour, 1986).

Scientific Research and Facilities

Projects include studies on soil, climate, flora and fauna. There are also monitoring projects specializing in meteorology, soil physics and behavior of grazing animals. Controlled experiments are carried out on grazing densities and pressures in 75 ha of land (varying from 25 to 50% grazing concentrations). The facilities at Omayed include a research station along with climatic station and accommodation for scientists (Ayyad and Ghabbour, 1986).

Conservation Management

The site has been designated because of its important assemblages of desert fauna and flora and for its research potential. The fenced core area of 100 ha has been completely protected from grazing since 1974, and shows signs of regeneration.

Three other fenced areas totaling 75 ha have a controlled maximum level of 50 per cent grazing by domestic livestock. A major proportion of the remaining area is under traditional pasture land-use. A detailed management plan has recently been drawn up to include the whole protected area (Ayyad and Ghabbour, 1986).

In addition, specific legislation prohibits “any action that would endanger living species or destroy landscapes within the protected area”.

Management Problems

The main problem encountered in Omayed is the conflict in land-use especially since the area has long been used for grazing and agriculture. Tourist villages are currently being built on the adjacent coast and so may cause additional pressure. Other threats to the fauna include quail hunting by local people (Ayyad and Ghabbour, 1986).

4.7 METROLOGICAL CHARACTERISTICS OF THE SITE

A brief description of the different meteorological elements is presented in the following sub-sections.

4.7.1 Air Temperature

The mean monthly values for temperature are more or less in the same range all over the area which reflects regional identity. The maximum and minimum values of temperature are generally recorded in August and January being 26 ^oC and 10^oC, respectively. The monthly mean temperatures during the whole year are presented in table 4.1.

Table 4.1. Monthly Mean Values of Temperature

Month	**Mean Temperature ^oC**
January	10
February	10
March	15
April	17.5
May	22
June	25
July	26
August	26
September	25
October	20
November	15
December	11

4.7.2 Relative humidity

The relative humidity plays an important role in the amount of evaporation and evapotranspiration. The mean monthly values of relative humidity are relatively high in summer months. The maximum and the minimum values of relative humidity are recorded in August and April, being 70% and 63%, respectively. The monthly mean values of relative humidity during the whole year are presented in table 4.2.

Table 4.2. Monthly Mean Values of Relative Humidity

Month	Relative Humidity (%)
January	64
February	65
March	65
April	63
May	65
June	67
July	70
August	70
September	69
October	68
November	66
December	68

4.7.3 Precipitation

The Mediterranean coastal zone of Egypt receives noticeable amounts of rainfall, especially in winter. The rainy months are October, November, December, January and Febrauary. In summer, no rain is recorded, while in Autumn, occasional heavy rain may occur. The rainfall shows a general steady decrease from north to south ranging from 168.9 mm/year at the coast to 16.2 mm/year at Siwa Oasis to the south. Precipitation is considered as the main source of recharge of groundwater aquifers in the northwestern Mediterranean coastal zone and affects greatly the amount of water stored in such aquifers. Al-hammam landfill site receives most of the rainfall in winter. The average yearly rain fall rate on the site range from 100- 150 mm/y.

4.7.4 Wind

The direction of prevailing wind is from the northwest direction. However, variable wind directions were recorded in the different seasons. For example, during spring the area is subjected to the southeast Kamasien winds which results in severe sand storms. The monthly wind roses are depicted in Figures 4.13 through 4.24.

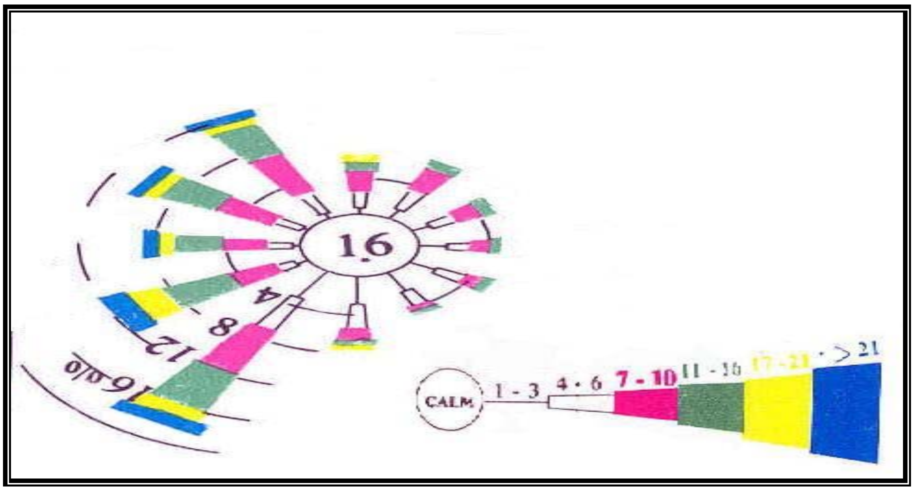


Figure 4.13. Wind Rose For January At Al- Hammam City

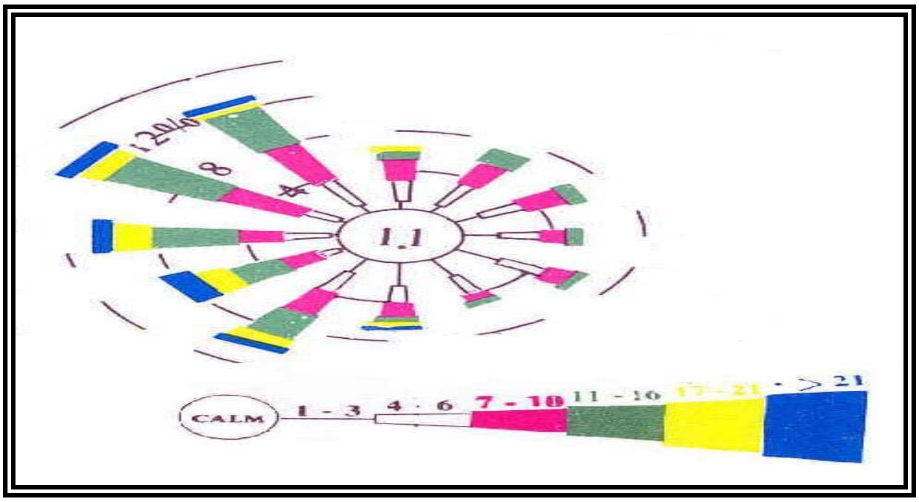


Figure 4.14 Wind Rose For February At Al- Hammam City

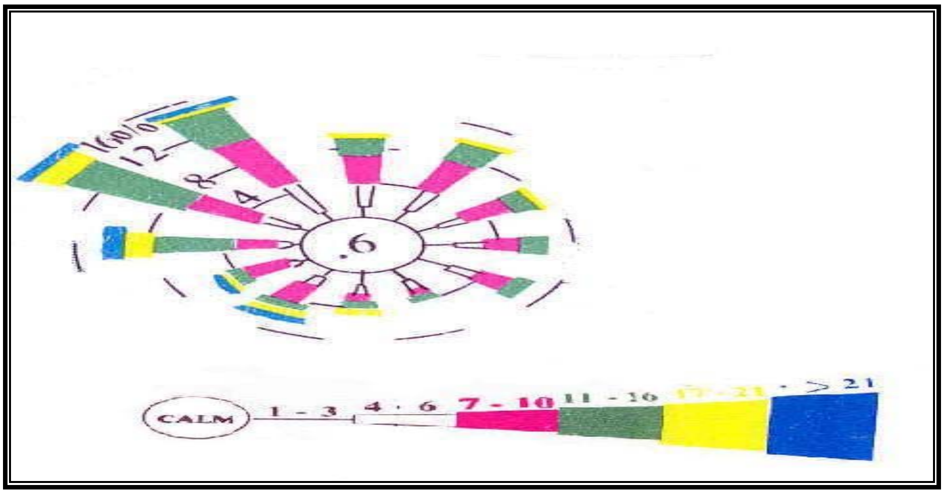


Figure 4.15 Wind Rose For March At Al- Hammam City

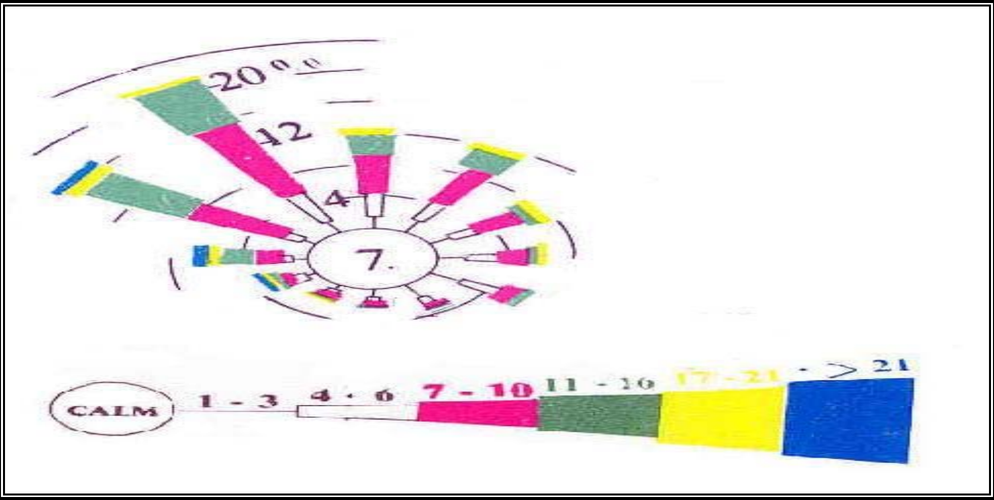


Figure 4.16 Wind Rose For April At Al- Hammam City

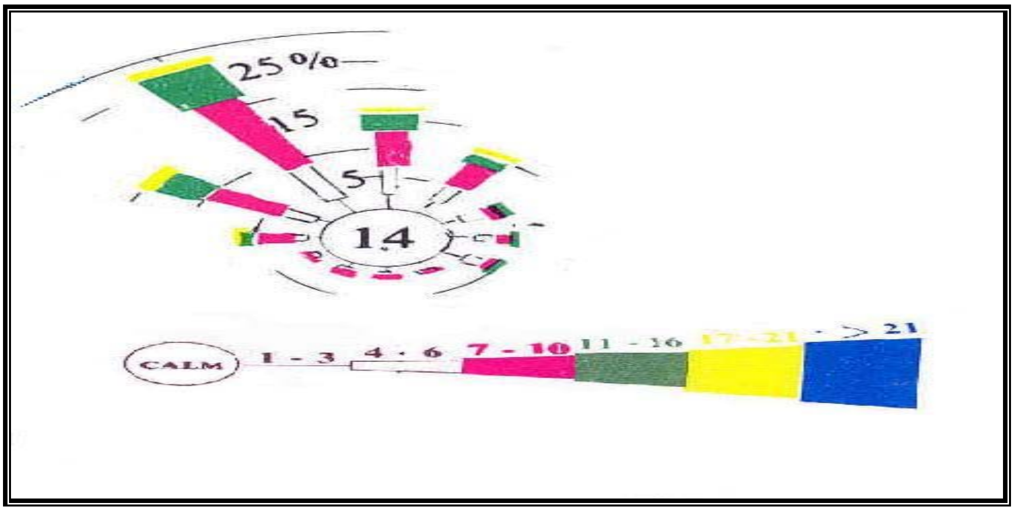


Figure 4.17 Wind Rose For May At Al- Hammam City

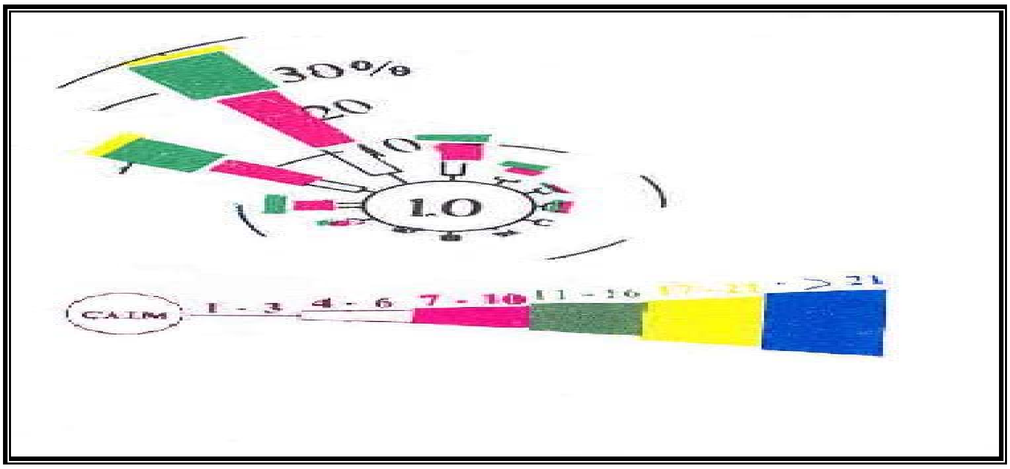


Figure 4.18 Wind Rose For June At Al- Hammam City

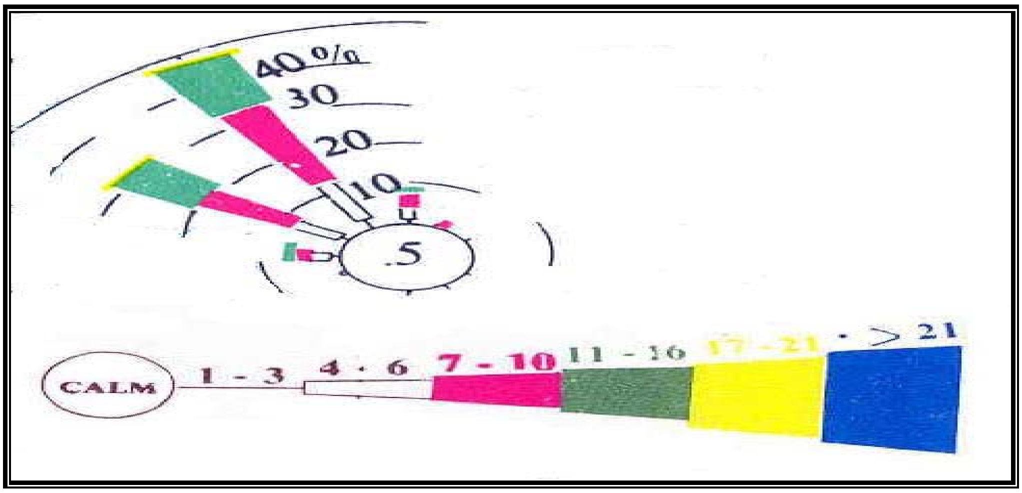


Figure 4.19 Wind Rose For July At Al- Hammam City

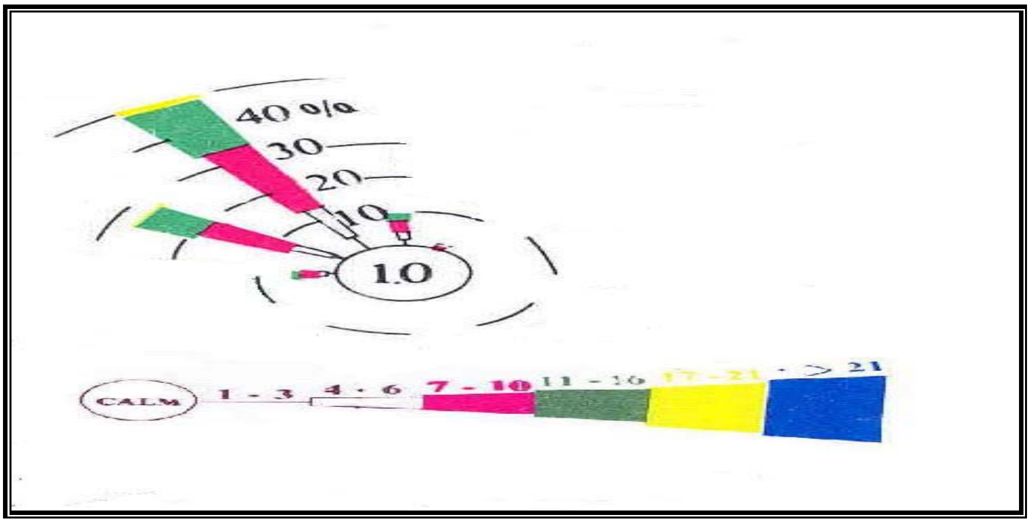


Figure 4.20 Wind Rose For August At Al- Hammam City

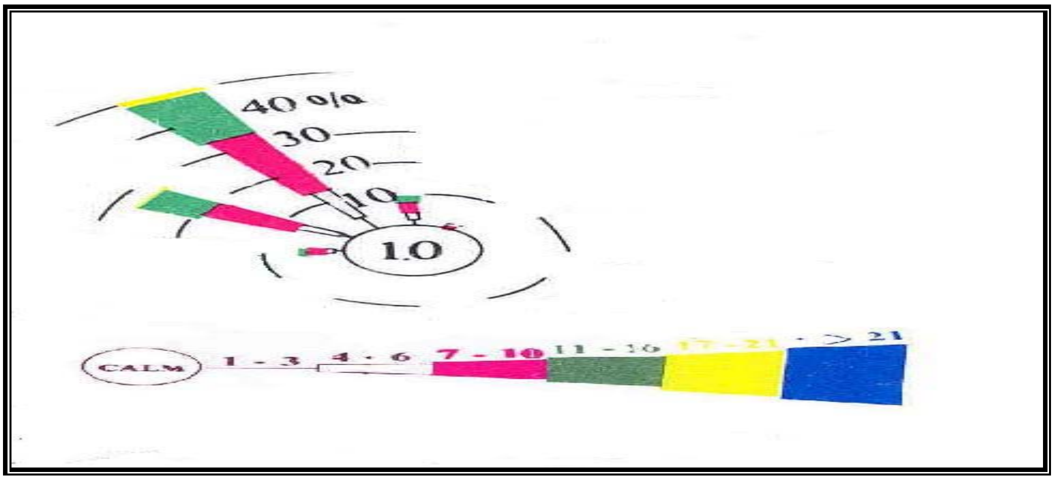


Figure 4.21 Wind Rose For September At Al- Hammam City

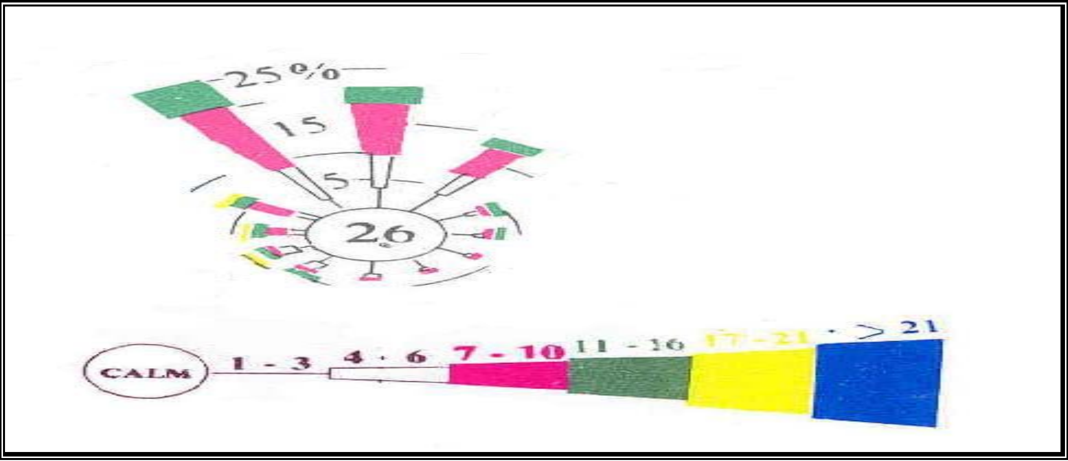


Figure 4.22 Wind Rose For October At Al- Hammam City

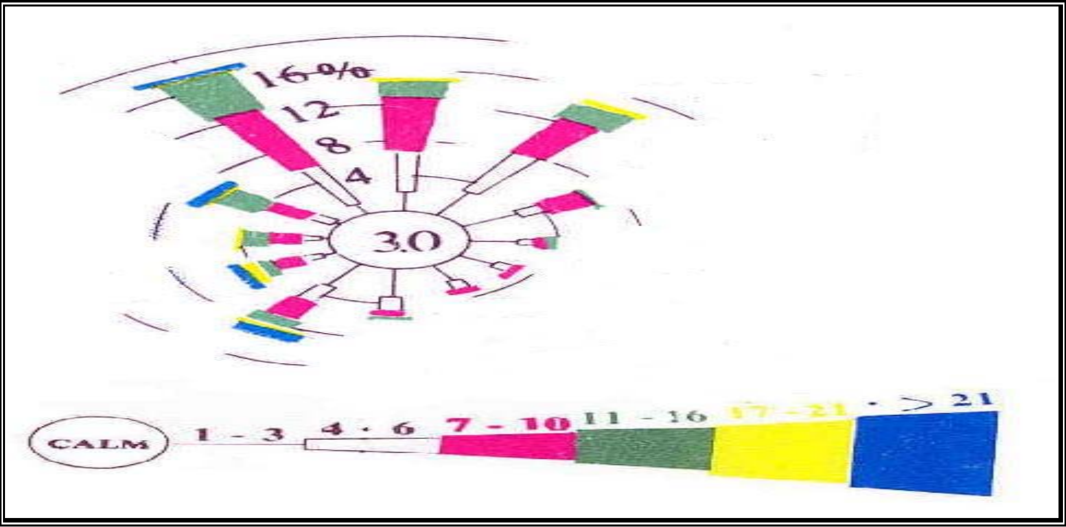


Figure 4.23 Wind Rose For November At Al- Hammam City

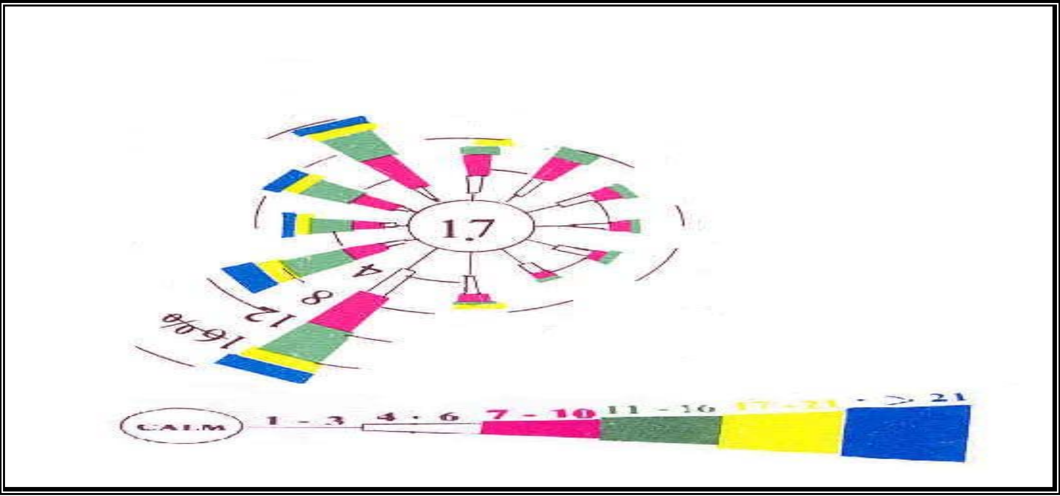


Figure 4.24 Wind Rose for December at Al- Hammam City

This section of the study reviews the solid waste management laws and regulations that are currently in effect in Egypt. This includes national laws and regulations as well as decrees issued by the Governor of Alexandria. The Egyptian legislation addressed the solid waste issue in a series of laws and decrees. The principal law governing solid waste management in Egypt is Law Number 38 for the year 1967 on General Public Cleaning and its executive regulations issued by Minister of Housing. The Environment Law number 4 for the year 1994 and its executive regulations issued by the Prime Minister's decree number 338/1995 also contain some articles governing general solid waste management.

Several other laws also address specific solid waste issues. For example, law number 48/1982 on the protection of the Nile and its canals prohibits dumping solid waste in the Nile River and its canals. Law number 140/1956 regarding the occupation of public ways and law number 84/1968 concerning public ways prohibit dumping solid waste on roads or in public areas.

5.1 LAW NUMBER 38/1967

5.1.1 General Public Cleaning

Law number 38/1967 on General Public Cleaning is the primary law governing the management of solid waste in Egypt. It came into force in 1967 and replaced all previous laws dealing with solid waste, including law 97/1956 on organization of solid waste collection and transfer, law 159/1953 on cleaning public squares, streets and highways and law 151/1947 on cleaning fences and unused areas. Since 1967, law 38/1967 has been amended four times. In 1968, the Minister of Housing issued the executive regulations for the law. Although the law and its executive regulations deal primarily with solid waste, they also address wastewater and fencing of open areas.

5.1.2 Solid Waste Management Provisions

Law 38/1967 and its executive regulations prohibit placing solid waste anywhere except in areas designated by the local council. This prohibition applies to treatment and disposal of solid waste as well as to temporary placement in an undesignated container. Article 1 of Ministry of Housing 134/1968 defines solid waste as refuse generated by individuals, residential units, non-residential buildings such as commercial establishments, camps, animal pens, slaughterhouses, markets, public areas, amusement parks, and means of transportation.

The law and its regulations require the local governmental authority responsible for general cleaning or a contractor licensed by the local authority to collect, transfer, and dispose solid waste. These operations must be in accordance with the specifications in the executive regulations as well as those of the local council. Specifications of dump sites as contained in the regulations area as follows:

- The site must be located in an easily accessible area opposite to the dominant wind direction. The distance between the site and residential areas should not be less than 250 m. An adequate dump area to accommodate the expected incoming quantities of wastes should be available at the site.

- A fence made of an appropriate material with a minimum height of 1.8 meters must surround the site. The fence must be provided with a gate of adequate size that permits entry of waste carrying vehicles and trucks.

- The site must have an appropriate water source to sprinkle wastes with water.

- The site must include an adequate number of toilets and showers for the cleanliness of workers.

- The waste must be placed in appropriate piles with side slopes of 1:2 or in special trenches. Moreover, the waste should be compressed and covered by soil at a minimum thickness of 15 cm. Then, it should be well-compacted and sprinkled with water.

- In case the waste will be transformed to compost, a proper place must be located for sorting different materials such as glass, tin, rubber, etc.

- In case of using incineration as the treatment method, the site must be equipped with one incinerator or more with an adequate capacity suitable for the received quantities of wastes. The waste must be fully incinerated and volatile materials should be controlled to prevent air pollution.

Law 38/1967 authorizes the local council to impose a fee of not more than two percent of the rent to fund solid waste management. This fee, along with all fines collected for violation of law requirements, must be placed in a general cleaning fund established by the local council. The fund must be used for general cleaning. These funds can be augmented by funds from the general budget to insure adequate funding for solid waste management. Law 38/1967 also requires owners of open land to remove accumulated waste and keep the land clean. The executive regulations authorize the local authority to remove solid waste from open land at the owner's expense in case the owner refrains within 15 days after notification.

5.1.3 Local Enforcement Authority

Article 11 of law 38/1967 authorizes implementation of the law by competent employees in local government, as identified by decree from the Minister of Justice. In 1976, the Minister of Justice issued decree number 3137, which identified the following local government employees as having authority to enforce law 38/1967:

- Governorate housing administrators

- Governorate health department administrators

- Engineering division administrators at town and district councils

- Municipal organization administrators and engineers

- Governorate or local unit general manager for urban environmental protection

- Governorate health affairs representatives working in environmental protection

- Physicians at health offices and units in towns, districts, and village units
- Environmental protection inspectors in local units
- Heads of village units in rural areas
- Technical personnel supervising cleaning services in local units
- Cleaning and draining inspectors and supervisors

Article 1 in presidential decree number 272 for the year 1982 transferred jurisdiction for general cleaning from the Ministry of Housing to the local administrative units. The Governor of Alexandria has issued the following decrees regarding the enforcement of law 38/1967.

- Governor's Decree Number 40 for the year 1994 prohibits the use of animal carts to haul waste and authorizes the traffic authority and utilities police to enforce this prohibition.
- Governor's Decree Number 163 for the year 1996 concerning the system of incentives for workers in the Central Administration for the Cleanliness and Beautification of Alexandria (CACBA) identifies enforcement responsibilities for various provisions of law 38/1967 for cleanliness inspectors, utilities police, and the traffic authority.
- Governor's Decree Number 1065 for the year 1998 authorizes the CACBA and all police agencies to enforce the waste hauling and dumping provisions of law 38/1967 within the boundaries of Alexandria Governorate.

In 2001, the Governorate established the Solid Waste Inspection and Environmental Monitoring Administration (SWIEMA). Governor's decree number 1143 of 2001 delegated the authority to SWIEMA to enforce law 38/1967 instead of CACBA.

5.1.4 Penalties

Article 9 of law 38/1967 specifies penalties for violating the law. It establishes a fine up to LE 100 for violating the terms of the law, although fines can be higher if authorized by other laws. If wastes are deposited in an undesignated area, Article 9 authorizes local authorities to require the violating party to either remove the wastes or pay for the costs of their removal. A violator can resolve a claim made against him or her for violation of Articles 1 or 4 by removing the violation and paying an LE 10 fine within 24 hours of notification.

In 1998, the Governor of Alexandria issued decree 1065 for the year 1998 elaborating on the penalty for illegal hauling and dumping of waste. Article 1 in the decree authorizes seizure and retention of vehicles illegally hauling or dumping waste in public streets or at the entrances of the city. The vehicles can be retained for up to six months or until the violator pays a fine of LE 1,000. The seizure and fine are additional to those specified in law 38/1967.

5.2 ENVIRONMENT LAW NUMBER 4/1994

Law Number 4 for the year 1994 on the Environment is the first comprehensive environmental law to be issue in Egypt. One article in law 4/1994 addresses general solid waste management while another article addresses management of construction and demolition debris. In addition, two articles deal with solid waste management on ships and offshore platforms. Moreover, five articles address hazardous waste management.

Prime Minister's decree number 338 for the year 1995 issued the executive regulations for law 4/1994. The executive regulations contain two articles addressing general solid waste management and one article addressing the management of construction and demolition debris. Law 4/1994 and its executive regulations also contain provisions requiring establishments to conduct environmental impact assessment studies. Also, articles for establishments to control air and noise pollution, and address worker safety are present in the executive regulations. These provisions apply to solid waste management facilities such as recycling and composting plants, medical waste treatment facilities, and sanitary landfills.

5.2.1 Solid Waste Management Provisions

Similar to law 38/1967, law 4/1994 and its executive regulations prohibit the disposal or treatment of solid waste except in areas designated by the local authorities. Article 38 promulgates some specifications for solid waste treatment and disposal sites. The article states that it is prohibited to dump, treat or burn solid waste except in special sites, designated for such purpose. The site must be far from inhabited, industrial or agricultural areas as well as from waterways. The site must satisfy the following specifications, conditions and minimum permissible distances:

- It is strictly forbidden to burn any waste (other than the infectious waste referred to in paragraph one of this Article) in residential or industrial areas. Such waste shall be incinerated in special incinerators having the following specifications:

    - They shall be downwind in the populated areas.

    - They shall be at a distance of at least 1500 meters from the nearest residential area.

    - The capacity of the incinerator or incinerators shall be adequate to burn the waste transported thereto within 24 hours.

    - The incinerator shall be sited in a place with an adequate space to receive the expected waste according to the nature of activities in the urban area and the number of its inhabitants.

- In case of extreme necessity, and within a transition period not exceeding three years from the date of publication of the executive regulations, waste shall be allowed to be burned uncovered, subject to the following conditions:

- With a prior permit from the EEAA and the Civil Defense Department. Incineration shall be carried out under the supervision of both the municipal authority units and the Civil Defense Department.

- The place where the waste is incinerated stands at a minimum distance of 1.5 kilometers from populated, industrial and downwind areas.

- The municipal authorities shall allocate a site to receive the waste after carrying out an integrated study on the topography and nature of the area, and the quantity of waste required to be disposed of every 24 hours. The site shall be:

    - At a lower contour level than the surrounding area.

    - Of an area adequate for storing the garbage intended to be transported and for carrying out other operations normally effected on the site, such as sorting and any other related operations.

    - Supplied with a water source for emergency cases and other necessary uses.

    - Supplied with the necessary equipment for storing, sifting and disposing of ashes by burying them so that they will not be dispersed in the air or leak into the underground water.

- Infectious waste from hospitals and health centers shall be burned on site in incinerators especially designed for that purpose and capable of absorbing the collected quantities without congestion or storage near the incinerator. In case of necessity, and with the approval of the competent municipal authorities and EEAA, the waste of such units may be transported to the nearest hospital equipped with one or more incinerators, provided they can absorb the waste transported thereto. Such waste is transported in sealed containers which do not allow the dispersal of their contents in the air and the containers are incinerated together with their contents.

- In all cases, the incinerators shall be fitted with adequate technical methods to prevent the dispersal of ashes or the emission of gases except within the permissible limits as prescribed in Annex 6 of the executive regulations of law 4/94.

- Municipal authorities shall, in agreement with the EEAA, allocate sites where solid waste shall be dumped, treated or incinerated according to the provisions of this Article.

Article 39 of the executive regulations for law 4/1994 promulgates some specifications for solid waste containers and collection vehicles. Both the law and its executive regulations address the management and disposal of construction and demolition debris. They require all persons involved in exploration, excavation, construction and demolition to take necessary actions to safely store, transport, and dispose of wastes generated by those activities. Article 41 of the executive regulations contains these specifications and requires local authorities to incorporate them into permits for exploration, excavation, construction and demolition.

5.2.2 Local Enforcement Authority

Local authorities are empowered to enforce Law 4/1994 and its executive regulations. The articles in Law 4/1994 and its executive regulations that address general solid waste management specify responsibilities of local or municipal authorities as follows:

- Designating sites for treatment, burning and disposal of solid waste (after consultation with EEAA)
- Granting permits (after consultation with EEAA) for transporting infectious medical waste to hospitals for incineration
- Implementing specifications for solid waste containers and collection vehicles
- Incorporating construction and demolition debris requirements into permits for exploration, excavation, construction and demolition and designating sites for disposal of those wastes.

Article 104 of Law 4/1994 states that inspectors of administrative authorities who have the capacity of judicial officers in matters relating to the environment shall be authorized to enforce the provisions of law and its executive regulations. In 1996, the Minister of Justice issued decree number 1353 authorizing several local government authorities to enforce Law 4/1994 and its executive regulations. This included governor's deputies, town mayors, district and village heads, and the managers of environment offices in the Governorates.

Article 103 of Law 4/1994 gives every citizen and organization concerned with the protection of the environment the right to report violations of the law to competent authorities. Article 65 of the executive regulations reiterates this right and further requires the Ministry of Interior to form a police force specialized in environmental protection. This force is mandated to enforce the provisions of the law.

5.2.3 Penalties

The penalties for the solid waste management provisions of Law 4/1994 are found in Articles 86 and 87. The penalty for disposing, treating, or burning solid waste in an undesignated area is a fine ranging LE 1,000 to LE 20,000. In case of recidivism, the penalty is the fine plus imprisonment. These penalties are higher than those specified in Law 38/1967. Provisions of law 4 takes precedence over all other laws dealing with the same violations. Article 9 of Law 38/1967 also states that higher fines can be imposed if authorized by other laws.

The penalty for violating the provisions for management of construction and demolition debris is a fine ranging from LE 500 to LE 1,000. The court is given authority to suspend a violator's license and, in the case of recidivism, to revoke the license. The penalties for violation of Law 4/1994 can be more severe if so prescribed by other law. However, solid waste management fines in Law 4/1994 are higher than those specified in any other law.

5.3 LAW FOR THE PROTECTION OF THE NILE AND ITS CANALS NUMBER 48/1982

Law number 48 for the year 1982 addresses protection of the Nile and its canals. The executive regulations for law were issued by the Minister of Irrigation's decree number 8 for the year 1983. The law and its executive regulations primarily focus on wastewater discharges to the Nile and its canals, but also contain articles that address solid waste.

5.3.1 Solid Waste Management Provisions

Both law 48/1982 and its executive regulations prohibit the disposal of solid waste in the Nile and its canals without permission of the Ministry of Irrigation. The executive regulations extend this prohibition to the temporary or permanent placement of solid wastes on the banks of the Nile and its canals. The executive regulations define solid wastes as solid materials (including refuse, garbage, sweeping materials, dry rubbish, fractured stones, construction and demolition debris, and workshop scraps) generated by individuals, residential units, non-residential units (governmental, commercial, industrial, tourist), and means of transportation.

5.3.2 Local Enforcement Authority

Article 19 of law 48/1982 authorizes irrigation engineers in the Ministry of Irrigation to enforce the law within their jurisdictions. Article 13 assigns the surface water police of the Ministry of Interior with the responsibility to assist the implementing authorities in identifying violations of law 48/1982. Moreover, the law assigns the same division to notify violators and remove the causes of violations. Article 89 of law 4/1994 increased the penalties for violation of Article 2 of law 48/1982.

5.3.3 Penalties

Article 16 of law 48/1982 establishes a penalty for violating Article 2 of up to one year in prison and a fine ranging from LE 500 to LE 2,000. In addition to payment of the penalty, violators must remove or rectify the violation within a period determined by the Ministry of Irrigation. If a violator fails to remove the violation within the allotted time, the ministry is authorized to remove it at the violator's expense. Article 89 in law 4/1994 reduced the lower limit of the fine for violation of Article 2 of Law 48/1982 to LE 200, but increased the upper limit to LE 20,000. The article contains the same language as found in article 16 of Law 48/1982 which authorizes the Ministry of Water Resources and Irrigation to require removal or rectification of the violation or remove it on its own at the expense of the violator. The article does not state that it is an amendment to the penalties in Law 48/1982, but Article 3 of the presidential decree issuing Law 4/1994 repeals all provisions of other laws running counter to the provisions of Law 4/1994.

5.4 LAWS CONCERNING PUBLIC WAYS

Two laws concerning public ways (highways, streets, and squares) contain restrictions on solid waste management and disposal. These are occupation of public ways law number 140 for the year 1956, and law number 84 for the year 1968. Although law number 106 for the year 1976 on building construction amended by law number 101 for the year 1996 does not contain specifications for the management of construction wastes, it does contain a funding mechanism that can be used by local authorities to enforce laws 140/1956 and 84/1968.

5.4.1 Solid Waste Management Provisions

Law 84/1968 prohibits placing solid wastes on public ways. Law 140/1956 and its executive regulations, issued by Minister of Municipal and Rural Affairs decree number 395 for the year 1956 deal primarily with obtaining licenses for occupation of public ways within the borders of areas with local councils. One of the activities that require a license is placement of construction and demolition debris in a public way. The executive regulations for the law contain specifications for the management of construction and demolition debris. The law also allows the competent administrative authority to charge a fee for occupation of public ways.

5.4.2 Local Enforcement Authority

Article 21 of Law 140/1956 authorizes the Minister of Municipal and Rural Affairs and the Minister of Justice to enforce the law. Article 16 of that law authorizes the Minister of Municipal and Rural Affairs to specify the competent authorities for enforcement of the law’s provisions. Article 1 in PD 272/1982 transferred jurisdiction for enforcement of Law 140/1956 and Law 84/1968 to local administrative units.

5.4.3 Penalties

Violation of Law 140/1956 and its executive regulations specifies a fine that ranges from LE 100 to LE 300. Violators are required to pay five times the occupation fee, two times of the court fees, and the cost to remove the debris. If the violator does not remove the debris, the local authority is authorized to do so at the expense of the violator. In addition, the governor can suspend the violator’s construction and demolition license until the violation is removed. The violator can be imprisoned for up to one month and his fines can be increased to from LE 300 to LE 1,000 if the penalties are not paid.

Law 106/1976 is the general law concerning construction activities. Article 6 of the law requires individuals who receive a construction permit to pay a non-refundable fee. This fee amounts to one percent of the value of the construction and is deemed to cover expenses incurred by the Governorate during or after construction. Article 4 of the executive regulations for the law, issued by Minister of Housing and Public Utilities decree 268 for the year 1996 allows the Governorate to keep the revenues collected from the one percent fee in a special fund. This special fund is used to finance several activities, including removal of construction and demolition debris left by violators of the law. Thus, Law 106/1976 and its executive regulations do not have specifications for the management of construction and demolition debris, but rather create a financial mechanism for allowing enforcement of the provisions of laws 140/1956 and 84/1968.

5.5 OTHER LAWS AND REGULATIONS

5.5.1 Labour Law Number 137/1981

Law number 137 for the year 1981 requires employers to inform employees of the hazards associated with handling solid waste. Moreover, the same law requires employers to provide safety equipment and training to employees handling solid waste.

5.5.2 Traffic Law Number 155/1999

Article 72 of the traffic law 155 for the year 1999 states prohibits vehicle drivers from disposing refuse, waste, or any other item that pollutes public ways. The violator shall be fined not less than LE 50 or more than LE 500. In addition, the driver’s license can be suspended for 30 to 60 days. Enforcement authority for this law is the traffic police in the Ministry of Interior.

5.5.3 General Egyptian Penal Law

In addition to the specific laws referenced above, the General Egyptian Penal Law contains two articles prohibiting throwing wastes. Article 377 provides for a fine up to LE 100 for throwing wastes in public roads. Article 378 provides for a fine up to LE 50 for throwing wastes on vehicles, buildings, gardens, and fenced land. Moreover, the same law prohibits disposing objects into the Nile or its canals that will obstruct navigation. Enforcement authority for the Penal Law lies with the Ministry of Justice and the Egyptian Courts.

The safe and reliable long-term disposal of solid waste residues is an important component of integrated waste management. Historically, landfills have been the most common, environmentally and economically acceptable method of disposal of solid waste. Even with the implementation of waste reduction, recycling, and transformation technologies, disposal of solid waste in landfills remains a significant component of an integrated waste management strategy. This section provides an assessment of the potential positive and adverse impacts resulting from the establishment of the 13 new cells and continued operation of the Al-Hammam landfill. The issues/impacts which are addressed in this section are as follows:

- Social, socio-economic and cultural and heritage;
- Hydrogeology, hydrology and water quality;
- Air quality;
- Ecology (flora and fauna);
- Health and safety;
- Noise ; and
- Off-site traffic.

6.1 SOCIAL, SOCIO- ECONOMIC AND CULTURAL IMPACTS

The land of Al- Hammam landfill is a public property and is not used for any commercial purpose. It is already utilized for landfilling waste and there are no houses or permanent residential camps located within the site boundaries. Also, no inhabitants are present in informal dwellings on-site. Therefore, the project will not involve displacement of population. There is no need to establish new roads or off sites roads. Therefore, the project will not disrupt the productivity of the surrounding lands.

The project will have positive impacts on the employment of population living close to the site. The site is located 13 km far from Al- Hammam town in neither a touristic nor a recreational area. The site is located in an unoccupied area. No sites of cultural and heritage importance lie close the landfill site. Therefore, the project have no negative cultural impacts

A summary of the significance of the potential impacts on population from the establishment of the new cells within Al- Hammam landfill is presented in table 6.1, shown below.

Table 6.1. Significance of Potential Impacts On Population (Social, Socio- Economic And Cultural Impacts)

Potential Impact	Type	Potential Significance
Resettlement of Population Displaced	Negative	No significance
Loss of land	Negative	No significance
Creation of local employment opportunities	Positive	Moderate
Loss of recreational and religion areas	Negative	No significance
Property value	Negative	Minimal

6.1.1 Mitigation Measures

The project activities will not involve establishment of new roads, population displacement, or loss of productive land. Moreover, the project activities will not affect recreational, religious, archeological or toursitic areas. Therefore, no specific mitigation measures are required. However, it is advisable that restoration be developed and in accordance to the best practices and standards. Also, increasing public and media attention to the environmental performance of the landfill is important. This would improve the public image about the landfill operation and would help decrease the effect on the land value around the site.

6.2 GEOLOGICAL AND HYDROLOGICAL IMPACTS

This section describes the range of potential geological, hydrological, and water quality impacts associated with the establishment of the new 13 cells and continued operation of Al- Hammam Landfill. The potential significance of the impacts and proposed or recommended mitigation measures are also presented.

6.2.1 Soil Erosion and Sedimentation

The formation and persistence of soil cover in the landfill site are strongly influenced by the arid climate. The scarcity of water for reactions within the soil and for the leaching of soluble components restricts the extent of soil formation processes. All soils in the area are considered to be very young and immature, and are highly influenced by the geological and geomorphological conditions of their formation. Soil texture is controlled by geological and geomorphological factors as well. At the proposed site, soils are deep, not too sandy in texture, and generally free from salinity/sodicity problems, except in limited areas coastwards. Soil texture varies from sandy to sandy loam, with evidence for the sandy and loamy sand textures being associated to Aeolian contributions.

One of the typical environmental stresses in the landfill site is the soil degradation due to pollution, landscape alteration and waste dumping. For example, soil degradation occur due to reduction in vegetation cover. This happens during site excavation and in the surrounding areas due to the effect of nylon bags, which escape from the site and are caught by natural vegetation. This is usually accompanied by soil erosion, sedimentation of lower slopes and increased surface runoff.

An eroded soil will almost always have less organic matter (biological soil degradation), increased bulk density (physical soil degradation) and other problems such as water logging. Salinity and sodicity commonly occur along with other aspects of soil degradation. The significant potential agents of soil degradation that could play a role in the landfill site during and following site clearing and leveling include:

- ***Soil Erosion by Wind and Sedimentation (Soil Burial).*** Soil erosion by wind and burial by wind blown sediments are clearly a serious issue. The effects of wind sedimentation may be harmful or good, according to the mode of such sedimentation. The formation of huge deposits of wind-mobile material is clearly very harmful. Areas of diffuse wind sedimentation, that when not distributed by cropping, often take the shape of hummocky lands; generally increase biological productivity, increasing soil thickness and fertility. This in noticed in surrounding area of the landfill site.

- ***Loss of Vegetation Cover.*** Vegetation is important since protects the soil from erosion by wind. Plants' roots help to maintain soil structure and facilitate water infiltration.

6.2.1.1 Mitigation Measures

Soil erosions and land degradation are the main agronomic but limited negative impacts of Al- Hammam landfill. The impacts are expected to be moderate to minimal. However, it is highly recommended to establish no more than one cell a time. This will decrease the loss of vegetation cover. Also, a restoration and plantation program should be implemented for the closed cell to increase the vegetation cover. The company has to establishing a fence of height of at least 1.8 m. Moreover, trucks should be covered during the process of transferring the waste. To protect the soil from erosion, shelter-belts planted perpendiculars to the prevailing wind direction (wind breaks) are recommended, which reduces wind speed at the soil surface. Shelterbelt species must be of a specie that is not palatable or must be protected from grazing activities.

6.2.2 Changes in Drainage Patterns

The site area is comprised of flat land and few small hills. The main town of Al-Hammam is located about 13 km to the northeast. The topography is mostly flat with minor undulating hills. The altitude in the area is generally the same with average height being 56 meters above sea level.

The proposed site of the landfill occupies an area with indistinct drainage pattern in the frontal plain to the north of the southern tableland. Thus, the site has no impact on changing the natural drainage pattern which in turn has no effect on the surface water resources and distribution of the wildlife habitat. Even during operation and after closure, the increase of height of the site will lead to diversion of the rarely occurred surface runoff toward depression areas.

6.2.2.1 Mitigation Measures

No specific mitigation measures to protect the surface water and water resources are required.

6.2.3 Likelihood of Flooding and Landslides

The landfill is located in a peneplained area that is not prone to flooding where surface runoff is rare and where no distinct drainage pattern exist. The proposed landfill is located in area that is not subject to landslides, mudslides, or sinkholes. The likelihood of landslides due to changes in geomorphology will be minimized following site leveling operations and closure and post closure activities. Also, it important to note the land filling waste with high organic content will lead to a slight land subsidence in the cells. Therefore, the project will have no negative impact on the surface run off, and will have minimal impact on the geopmorphology of the area.

6.2.3.1 Mitigation Measures

As the project site is located in an area that not prone to flooding, specific mitigation measures are not required. However, it is recommended that the landfill cells should be designed to withstand flooding and prevent the waste from washing out. Also, it is recommended that site leveling operation and post closure care activity should be included in the project in line with the best practice standards.

6.2.4 Impact on Groundwater

Leachate is produced directly from liquid waste and refuse moisture content and indirectly from precipitation which percolates through the waste pile. Raw municipal waste leachate typically contains high levels of chlorides, nutrients, ammonium, and organic compounds, which create very high biological and chemical oxygen demands. Leachate may also contain metals and various inorganic compounds. In some cases, the leachate may contain toxins, depending on the types of wastes disposed.

The landfill cells are designed to prevent entrance of moisture to minimize leachate formation and to prevent leakage of leachate to the underlying groundwater. Moisture is prevented from entering the cells through the utilization of landfill cover while leakage is prevented by using the liner layers and the associated leachate collection and removal system. The landfill is also sited at a location where the landfill area is not hydraulically connected to groundwater. Since the depth of the water table in the landfill area exceeds 50 m and due to the use of lining and leachate collection systems to prevent, the possibility of groundwater pollution is not considered.

6.2.4.1 Mitigation Measures

Although the site water table depth exceeds more than 50 m (which is far below the cells excavation depth of 11 m) and the use of the liner and collection system system, there will be always some risk of leachate leakage. Therefore, it is recommend to conduct a water quality monitoring program to ensure the identification of any possible contamination and immediately address the problem. Groundwater wells should be constructed and used to monitor the water quality during the lifetime of the site. Also, post-closure care will be done, which include:

- Maintaining the landfill cover to ensure little or no water will enter the landfill;
- Removing leachate from the liner system.

Table 6.2 Summary of Potential Geological And Hydrogeological Impacts

Potential Impact	Type	Potential Significance
Contamination of underground water from leachate	Negative	Minimal
Reduction in flood storage capacity	Negative	None
Soil erosion and land degradation	Negative	Minimal
Changes in site geomorphology	Negative	Minimal

6.3 AIR QUALITY IMPACTS

This section discusses potential air quality impacts associated with the Al- Hammam landfill and the mitigation measures to address these impacts.

6.3.1 Odour Impacts

Odors at landfill sites are generated from transferring, placement and decomposition of waste. The main method of reducing the generation of odors from the site is to implement the site operational management best practice procedures. The emission of odor depends also on the collection and transporting efficiency. Waste which is collected after long time will be in the degradation phase upon arrival to the landfill, and therefore possibility of odor is higher. Odor impacts are expected to be moderate from the proposed project and will be contained within the site boundaries since management procedures and polices are implemented. The nearest residential area is located down wind, 10 km far from the site. Therefore, odor impact will not affect the closest residential to the site.

6.3.1.1 Mitigation Measures

The key mitigation measure is to ensure the implementation of best practices with special focus on prohibiting waste burning. The proposed mitigation measures include landfilling the waste using the cell phase approach, daily covering of the incoming wastes with sand, capping the cell following completion.

6.3.2 Dust Impacts

Dust is generated during landfill construction and operation phases. Main sources of dust are excavation work, bulldozers and trucks movements over unpaved roads and waste cover, and cell closure activities. The highest impact are occur during construction phase and will be associated with the movement of large construction dozers/ trucks into and out of the site. This impact is classified to be short-term, reversible and limited as it will only occur during excavation activities. Also, these impacts are expected to be contained within the site boundaries.

6.3.2.1 Mitigation Measures

Dust from construction activities will be minimized by adopting cell approach. The purpose of adopting such practice is to minimize the environmental impact of the construction and operation of the landfill. Confining the working area to a small part of the site facilitates management of the construction activities on site to meet the environmental standards. During operation phase, dust impacts can be minimized through good site practices, as follows:

- Filling the landfill in small cells;
- Use of waste compaction and daily cover;
- Construction of paved site roads throughout the site and;
- Ensuring that wheels of all vehicles are washed before departure form the site.

6.3.3 Vehicle Exhaust Emissions

Few traffic movement and air pollution sources exist near the landfill site. Vehicles transporting waste to the site are likely to cause significant portion of total emissions in the area. However, since baseline levels of pollutants are low, emissions from these vehicles are unlikely to raise the level of air pollutants to hazardous levels. Therefore, the potential impacts of vehicle emissions resulting from vehicles are likely to be minimal and contained within the site boundaries.

6.3.3.1 Mitigation Measures

As the air quality of the site is very good and the impacts from the vehicles emissions are likely to be minimal, no specific measures are required. However, it is highly recommended that maintenance of vehicles be done on regular basis and according to a preset maintenance plan. Also, it is recommended that vehicles emissions testing to be performed on yearly basis.

6.3.4 Landfill gas Emissions

Landfill gas is generated as a result of decomposition of municipal waste under anaerobic conditions. landfill gas is mainly composed of carbon dioxide and methane. Carbon dioxide and methane are greenhouse gases, which do not cause harmful effects to the local environment, but rather affects global warming. A very small percentage of volatile organic compounds are found in the landfill gas. Emissions of volatile organic compounds are photochemically reactive, which results in the formation of tropospheric ozone. Tropospheric ozone causes adverse effects to the respiratory system such as breathing difficulty and aggravated Asthma. Moreover, tropospheric ozone can cause damage to crops and plants. Volatile organic compounds are also known for their carcinogenic effect from chronic exposure. Since volatile organic compounds comprise very small percentage of the landfill gas, impact on air quality is expected to be minimal.

6.3.4.1 Mitigation Measures

A landfill gas wells and passive flaring system will be used in the site. The main purpose of the collection system is to minimize explosion risk from methane emissions. The use of such system also destroys volatile organic compounds emissions.

The following table summarizes the potential air quality impacts of Al-Hammam landfill.

Table 6.3 Summary of Potential Air Quality Impacts

Potential Impact	Positive/ Negative	Potential Significance
Odour impacts from site activities	Negative	Moderate
Dust generated from on-site vehicle movement	Negative	Minimal
Vehicle exhaust emissions	Negative	Minimal
Landfill gas Emissions	Negative	Minimal

6.4 ECOLOGY (FLORA AND FAUNA) IMPACTS

Landfilling operations can have substantial impacts on terrestrial wildlife, ranging from temporary noise disturbances to destruction of food resources and breeding habitat. Unless closure and reclamation return the land essentially to its pre-landfill state, certain impacts to some individuals or species will be permanent.

Noise during the construction phase or during operations, for example, may displace local wildlife populations from otherwise undisturbed areas surrounding the site. Some individuals or species may rapidly acclimate to such disturbances and return while others may return during less disruptive operational activities. Still other individuals may be displaced for the life of the project.

Other wildlife impacts include habitat loss, degradation, or alteration. Wildlife may be displaced into poorer quality habitat and therefore may experience a decrease in productivity or other adverse impact. Habitat loss may be temporary (e.g. construction-related impacts), long-term (e.g. over the life of a landfill), or essentially permanent (e.g. the replacement of vegetated areas with permanent structures).

The construction activities will be limited in nature and duration and are confined to the landfill site. Field visit revealed the absence of valuable biodiversity within the site boundaries. Therefore, impacts during this phase are expected to be moderate. However, a list of potential impacts arising from the construction activities are presented in the following sub-sections.

6.4.1 Direct Impacts on Vegetation

The most obvious impact to biodiversity from the landfill preparation is the removal of vegetation, which in turn alters the availability of food and shelter for wildlife. Loss of flora may result due to vegetation clearing activities for construction purposes and site preparation of the project components. However areas will be revegetated following closure.

6.4.1.1 Mitigation Measures

The vegetation cover at the site was composed of very common species which are abundant in the project hinterland. However, due to the stated importance of vegetation for livelihood activities, the hinterland should be preserved from damaging activities useless for the project implementation such as clearance for trucks’ circulation or cut-off for charcoal or other uses. Besides, trucks’ circulation should use the designated roads and tracks and drivers should avoid driving off road.

6.4.2 Loss of Habitat

It is a direct result of the project due to construction activities that will replace the natural habitat with a man-made environment.

6.4.2.1 Mitigation Measures

Construction activities should be localized to the project components and carried out within the site boundaries. Construction waste should not be disposed haphazardly but according to a waste management plan.

6.4.3 Displacement of Fauna during the construction phase

Rodents and other burrowing animals will migrate to other locations. Dust, noise, vibration, artificial lights and emissions resulting from construction activities will lead to the migration of fauna from the project site and its adjacent areas.

6.4.3.1 Mitigation Measures

Environmental standards concerning noise and dust levels should be strictly applied to minimize impacts’ amplitude and magnitude. Dust elimination technologies such as water sprinklers should be used to reduce dust created during excavation and transport. Monitoring for compliance to environmental standards should be implemented on a regular basis.

6.4.4 Displacement of Fauna During the Operation Phase

Noise, vibrations, artificial lights and emissions resulting from the project activities will lead to additional migration of fauna from the project’s neighboring areas. Although some wildlife may become accustomed to noise, others will move from the area, potentially reducing the population of those species in the immediate proximity of the site.

6.4.4.1 Mitigation Measures

Faunal disturbance should be minimized from sunset to sunrise, as during this interval fauna is more active in performing its natural necessities. Most operations should not be carried out during this period of time. Self-monitoring activities should be carried out to reduce disturbance.

6.4.5 Increase of Pest Species

Vermin may increase as a result of the waste presence in the area. In addition, landfills can attract a large variety and number of animals such as feral dogs and cats, rodents, birds, and insects. These animals, especially particularly pests, are of concern because of their potential to spread disease and to adversely affect the aesthetic quality of the properties near the landfill. Besides, toxic substances tend to bioaccumulate in living organisms and may be transmitted to valuable species such as raptors through the food chain.

6.4.5.1 Mitigation Measures

A fence should be constructed around the site to limit the entrance of larger animals. Besides, Waste should be compacted and covered daily to prevent the procreation of vermin and attraction of birds and other opportunistic species to the site.

6.4.6 Impacts of Leachate Ponds on Biodiversity

The presence of leachate ponds may enhance the growth of marginal vegetation and the establishment of fly and mosquito populations that are sources of nuisance and public health threat.

Due to the nature of the desert and the scarcity of water, mammals and migrating birds are likely to be attracted by the ponds. Accordingly, these animals may be exposed to the risk of toxic substances, which might lead to their death.

6.4.6.1 Mitigation Measures

It should be noted that no signs of wildlife were recorded near the operational leachate ponds. However, it is recommended to fence the perimeter of the leachate ponds to prevent access to large animals. Moreover, the fence should have nettings to keep out small animals. Biocides which are safe to man and environment may be added to the leachate ponds to control mosquitoes and flies. Moreover, marginal vegetation, if any, should be regularly removed.

6.4.7 Creation of New Habitats

Clearance of vegetation and the formation of a man-made habitat due to the presence of water, anthropogenic waste, as well as introduced plants and animals may result in the creation of a new habitat. This may attract new species to the area resulting in the increase of number of rodents and other undesirable species. This may lead to changes in the behavior of local wildlife, thus affecting the ecological balance of the area.

6.4.7.1 Mitigation Measures

An awareness program aiming at providing landfill workers with basic knowledge on local natural resources is suggested to avoid unnecessary disturbing activities to neighboring areas.

6.4.8 Closure Phase Activities / Residual Impacts

Closure of the landfill will allow ecological resilience of the area. On the other hand, some impacts may arise if exotic species of plants are used for re-vegetation. Selection of plant species for reclamation is based on suitability for future uses and tolerance of site conditions and erosion protection. In addition, non-edible plants should be used to re-vegetate the waste cells. Plant species that fit these selection criteria may be non-native species. Therefore, reclamation procedures may increase distribution of alien species.

The best practice for re-vegetation and re-grading phases of the landfill cells would be based on reintroducing native species of plants, non-palatable to both humans and animals, but this may result unpractical. Nevertheless, Batanouni (2001) noticed the increase of cover and growth of non-palatable species, and particularly of non-ligneous plants such as Zygophyllum album, in disturbed areas of the western Mediterranean coastal desert. It should be added that native species such as Artemisia herba-alba (Arabic name: Shih) might be used as ornamental plants within the site, in areas not affected by landfilling activities.

It is also suggested to allow alternative uses of the land after the end of the operation period. Therefore, a study addressing sustainable future uses of the site is recommended before landfill closure.

6.4.8.1 Residual Impacts

Introducing a vegetated area to the natural desert landscape of the area during the post-closure phase is likely to change the ecology of the area and may lead to the introduction of new species. However, it is hard to predict whether this change will have a positive or negative impact on the surrounding environment. Careful monitoring of the site during the post-closure is therefore necessary to indicate the type and extent of this impact.

6.5 HEALTH AND SAFETY IMPACTS

This section discusses the range of potential health and safety impacts associated with the project activity. It is known that modern landfills pose minor health risk problems to workers within the site and residents living near the landfill site. These risks include, but not limited to, transmission of infectious diseases, methane gas explosion and safety of the workers. Diseases can be transferred from the landfill site to the local community through animal vectors, water, and air. There is a risk of exposure of workers and residents of areas close to the landfill to explosion of methane gases. The risk will be high higher if gases are allowed accumulate within the cells.

6.5.1 Mitigation Measures for Health Impacts

Vectors which may transfer diseases from the landfill site to local communities include vermin, insects, birds and humans. Therefore, in order to minimize health impacts, operational practices already include the following:

- Control of entry and exit to the site;
- Control of vermin, insects and birds by compaction of waste and use of daily cover;
- Control of birds through use of bird scaring methods and fences around the leachate collection ponds;

- Prohibit manual handling of the waste and use of mechanical equipment;
- Providing protective clothing to personnel working on site;
- Providing first aid facilities; and
- Regular health checks for personnel.

It is also recommended that a health monitoring program to be developed to warn in the presence of any infection disease. Sticking to the operational management will make the risk of diseases transmission to be low. Therefore the impacts are defined to be minimal significance.

6.5.2 Mitigation Measures for Methane Gas Explosion Risk

In order to minimize the risks to human health from landfill gas, a gas collection and flaring system will be used at the site. Also, gas monitoring activities on a continuous basis to determine alarming levels of methane gases.

Table 6.4 Summary of Potential Health and Safety Impacts

Potential Impact	Positive/ Negative	Potential Significance
Health impacts	Negative	Minimal
Risk of gas explosion	Negative	Moderate

6.6 NOISE IMPACTS

As mentioned above the landfill is located in an uninhabited area and no sensitive receivers such as hospitals, mosques, churches, schools, or residential areas exist in the vicinity of the project site. Therefore, no detailed noise survey nor noise modeling is needed. Construction, operational and post closure activities will have no noise impacts on the neighborhood. However, noise impact may only occur be due to vehicles movement on access roads, which crosses Al- Hammam town. The most significant period of construction noise generation will be during the initial site infrastructure works, which has been completed. Construction activities will extend throughout the lifetime of the project, as new cells and phases of the site will be established. Sources of operational noise from the landfill site include vehicles, leveling and compaction of waste, and daily cover placement activities. Operational noise is expected to be less than that of generated at construction phase.

As the site is located some 10 km away from the nearest residential area and 10 km away from the main access road, noise impacts are expected to be contained within the site boundaries with minimal significance.

6.6.1 Mitigation Measures

No specific mitigation measures are required. However, it is recommended to plant a green belt of beautification trees around the site to act as a noise shelter.

6.7 OFF SITE TRAFFIC IMPACTS

This section discusses the range of potential off-site traffic impacts associated with Al-Hammam landfill and their potential significance. The lifetime of Al- Hammam landfill has been estimated to allow the landfill to continue to accept waste for a period of 30 years. The site is connected to Al- Hammam town and Alexandria through Al- Hammam main road. This road is the only access to the site which provides the main way to the Al-Hammam city and the adjacent villages. The condition of the road is very good with a width of 6-8 meters. This width is sufficient enough to allow two way flow of landfill-related traffic. Traffic flow on the street comprises a mixture of personal and commercial vehicles.

The most probable impacted area from the increase of vehicle movement is the main entrance of Al- Hammam city where crowded traffic flow exists. However, during a site visit no congestion were observed at Al –Hammam town entrance. Also it is worthy to note that the landfill operates only during summer time during May to October. Therefore, the increased traffic over Al- Hammam main road is defined to be of moderate significance. The vehicles emission impacts on the air quality of Al- Hammam town is expected to be minimal.

6.7.1 Mitigation Measures

As the impacts are with minimal significance, no specific mitigation measures are required. However, it is the recommended to follow good maintenance practices and conduct annual emissions testing for the fleet to ensure low emission levels from vehicles.

Section 7 PROJECT ALTERNATIVES

According to the Egyptian Environmental Impact Assessment Guidelines, analysis of project alternatives forms an integral part of the EIA. This analysis aims at evaluating whether there are viable alternatives to a proposed development which can fulfill the same function with reduced overall environmental impact.

This section discusses the following alternatives:

- No action alternative
- Alternative sites;
- Alternatives to waste disposal by landfilling; and
- Landfill technology alternatives.

7.1 NO ACTION ALTERNATIVE

Currently Borg El-Arab landfill which is located on the north coast close to a touristic villages area is utilized for accepting the waste from Alexandria Governorate. The estimated lifetime of Borg El Arab landfill is 12 years. Al-Hammam landfill is proposed to receive Alexandria's waste for 5 – 6 months a year. This will result in the duplication of the lifetime of Borg Al- Arab landfill lifetime.

7.2 ALTERNATIVE SITES

The Egyptian Environmental Affairs Agency with the support of a European funded project carried out an extensive site search exercise to identify and select landfill sites in different parts of the country. Borg El-Arab city was the only location identified to serve Alexandria Governorate. Subsequently, the Prime Minister decided to open a second site to accept waste during summer months.

Another site search was conducted by the Ministry of Housing and Alexandria Governorate to identify other locations. Al –Hammam city site was chosen based on the hydrological studies of the area which showed that the groundwater table is very deep and the soil permeability is very low.

The lifetime of Borg El-Arab landfill was estimated to be 12- 13 years only. This estimation was based on the assumption that the landfill will be utilized 365 days per year. Other unofficial dumpsites are being utilized by the private sector and Zabaleen. Also, waste burning activities are carried out in some of these dumpsites. These dumpsites are illegally operated and pose environmental and health problems. In conclusion, Al-Hammam landfill site has the potential to provide significant benefits compared to finding and/or developing another alternative site for the following reasons:

- The continued operation of the site rather than seasonal closure will allow currently employed personnel to keep their jobs
- Developing an alternative site has the potential of significant environmental impacts, facing public resistance, and/or will require with additional costs

- Utilization of Al- Hammam landfill in addition to Borg El–Arab site will increase the lifetime of Borg Al-Arab landfill

7.3 ALTERNATIVE TO WASTE DISPOSAL BY LANDFILLING

Landfilling is the most environmentally favorable choice. It should be noted that even in countries with the most active and successful waste reduction programs, there is always a need for some landfilling capacity. Quantity of landfilled waste is mainly influenced by introduction of policies, technologies and awareness programs. According to the solid waste sound management hierarchy, waste minimization is the first step to avoid generation of waste. The next step is to reuse or recycle this waste as much as possible. Waste treatment will follow the previous steps aiming at minimizing the quantity of waste that requires final disposal.

Although Alexandria Governorate has implemented public awareness programs for waste minimization, the quantity of waste generated is still increasing. Also, Alexandria Governorates has established three composting plants. The total capacity of these plants only covers 10 % of the total generated waste. Therefore, a practical choice for disposing waste in Alexandria Governorate is landfilling.

7.4 TECHNOLOGY ALTERNATIVES

7.4.1 Leachate Treatment

Due to the low precipitation rate in Al- Hammam landfill and due the high annual average temperature, evaporation of leachate is the proposed treatment method. Other treatment methods and technologies were investigated, according to the contract between Alexandria Governorate and Onyx Alexandria. These treatment methods include recirculation of leachate to the landfilled waste to accelerate the waste decomposition process. This treatment method needs skilled labor and controlled management. Therefore, Alexandria Governorate requested Onyx Alexandria to change this treatment method to leachate evaporation supported by mechanical aerators to enhance the decomposition of the organic content. Also, EEAA guideline for construction and operating sanitary landfills does not recommend the application of leachate recirculation as a treatment practice. Therefore, leachate evaporation is the most viable option at Al-Hammam landfill.

7.4.2 Gas Treatment

The contract between Onyx Alexandria and the Governorate states that Onyx must collect and treat the generated landfill gas without specifying a level. Gas treatment options include either flaring or use for energy production. Energy production from collected landfill gas is not a feasible option in Egypt due to the very low price of electricity exported to the grid. Onyx Alexandria will use the flaring option for the treatment of landfill gas. The suggested system is presented in section 3.

Site operations should comply at all times with law 4 and its executive regulations. Several sources of pollution exist in the landfill site which require some monitoring activities to be undertaken on regular basis. Also, EEAA guidelines requires the development of a monitoring plan as an integral part of any EIA report. This monitoring plan should provide mechanisms for:

- Assessing the overall environmental impacts of site development;
- Identify, at an early stage, pollution emanating from the site;
- Identifying any deviations from acceptable standards of site operation; and
- Formulating proposals for site remediation measures, as necessary.

The purpose of environmental monitoring is not just to meet standards, but to provide information which allows for improved operational management on site. Onyx Alexandria has developed self monitoring activities and undertakes these activities on regular basis. The monitoring activities include air quality monitoring, leachate detection and leachate analysis. It is recommend that leachate should be monitored throughout the lifetime of the site while air quality should be monitored on quarterly basis. Leachate detection tests should be performed twice a year or whenever needed.

The contract between Onyx Alexandria and the Governorate states that ground water monitoring wells should be used. Due to the low permeability of the soil and the deep distance of the ground water table which is at a distance of 50 m, monitoring wells has not been used. Nevertheless, leak detection will be used on a regular basis.

8.1 LEACHATE DETECTION

Onyx Alexandria regularly performs a geo-electrical leak detection program, as part of the monitoring activities, to ensure the integrity of the geo-membrane surface of the leachate ponds. Annex II contains the last report of leak detection performed in November 2004. A specialized consultant performed the test where the dipole electrical method was used. This method complies with ASTM D6746 guide for the selection of techniques for electrical detection of potential leak paths in geo-membranes.

8.2 LEACHATE MONITORING

The cells receiving the waste has been designed to minimize leakage of leachate and to provide a high level of containment of leachate. Leachate should be monitored throughout the lifetime of the site on a bi-monthly basis. Parameters which should be monitored are as follow:

- Leachate levels in on-site monitoring wells
- pH
- Chloride

- Conductivity
- COD
- BOD
- Total organic carbon
- Full range of compositional characteristics (organic, salts and heavy metal compounds)

Onyx has contracted the Environmental Health Research and Studies Unit at the University of Alexandria to perform leachate monitoring and analysis for the landfills at Borg Al- Arab and Al- Hammam. A series of onsite and off site monitoring wells should be established. The depth of these wells must vary and cover wide range from 1 meter below the cells depth and up to 30 m.

8.3 GAS MONITORING

The most significant risks associated with landfill gas result from the potential for formation of flammable mixtures of methane in air. This occurs when methane is present within certain concentrations in air. At the boundary of the landfill, such relatively high levels of gas should not occur because of the effects of dilution and dispersion. Gas concentration should be monitored to control gas migration from the site. In order to minimize the risks of landfill gases, Onyx Alexandria will monitor concentration of methane after flaring to ensure efficiency of combustion on a yearly basis.

Section 9 Conclusion

In order to evaluate the environmental impacts of Al- Hammam landfill on the surrounding environment, Onyx Alexandria contracted Integral consult to conduct an environmental impact assessment study. Different impacts on the environment of the proposed extension of the landfill and mitigation measures to reduce these impacts were identified. A multidisciplinary team of environmental experts including: EIA manager, geology and hydrology expert, air pollution expert, ecology expert, solid waste specialist carried out the EIA of the site and its associated infrastructure and technology. An extensive environmental assessment for the site has been carried out, evaluating methods of construction, operation, and draws a conclusion regarding environmental protection of the surrounding environment. The work included a site visit to identify the baseline environmental conditions, interviews with Onyx Alexandria staff, identifying the impacts and evaluating the proposed mitigation measures.

The site is connected to Al- Hammam town and Alexandria through Al- Hammam main road. According to the hydrogeological map of Egypt and the hydrogeological studies of the site, the landfill site is located above local and moderately productive aquifers. The depth to groundwater of the aquifer exceeds 50 m, and the site will have minimal impacts on the ground water quality.

According to The site ecology (flora and fauna) analysis, the project is not expected to have significant impacts on local wildlife. The project site has floral and faunal communities that are widespread in the Mediterranean Coastal Desert and no wildlife of special importance were found in the project facility. The baseline levels of air pollutants are low and the air quality standards for the site are very high. The site is located in an undeveloped area, and no residential areas are settled close to the site. The nearest residential area is 13 km far from the site. Impact analysis indicated that social, socio-economic, cultural and heritage, hydrogeology, hydrology and water quality, air quality, ecology, health and safety, noise, off-site traffic impacts are with minimal significance. The proposed mitigation measures are enough to either eliminate or minimize these impacts.

In conclusion, the site location is appropriate for establishing a landfill. The proposed mitigation measures and treatment technologies are very suitable for pollution control. It is highly recommended that Onyx Alexandria implement all the stipulated mitigation measures, monitoring plan and the recommendations mentioned in this report.

APPENDIX I

APPENDIX II

APPENDIX III