Annex 3: Geological Setting Study
EGYPTIAN ELECTRICITY TRANSMISSION COMPANY

PHYSICAL AND GEOLOGICAL SETTING FOR
GEBEL EL ZEIT – WEST SAMMALUT
TRANSMISSION LINE PROJECT, EGYPT

MARCH – 2010, CAIRO
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INTRODUCTION
Electric Power Transmission Line:-

Electric power transmission or "high voltage electric transmission" is the bulk transfer of electrical energy, from generating plants to substations located near to population centers. This is distinct from the local wiring between high voltage substations and customers, which is typically referred to as electricity distribution. Transmission lines, when interconnected with each other, become high voltage transmission networks. In the US, these are typically referred to as "power grids" or sometimes simply as "the grid".

Historically, transmission and distribution lines were owned by the same company, but over the last decade or so many countries have introduced market reforms that have led to the separation of the electricity transmission business from the distribution business.

Electricity is transmitted at high voltages (110 kV or above) to reduce the energy lost in long distance transmission. Power is usually transmitted through overhead power lines. Underground power transmission has a significantly higher cost and greater operational limitations but is sometimes used in urban areas or sensitive locations.

Egypt has a tremendous potential for the use of renewable energy technologies especially wind and solar power generation. Egypt's energy market is expected to grow by 7-8 % annually until 2010. Almost all the solar, wind and biomass technologies and applications have been demonstrated and field-tested in Egypt.

The present work deals with the geomorphology, stratigraphy, litho-logical characteristics, tectonics and other environmental elements in the area stretched from Gebel El-Zeit on the Gulf of Suez to West Sammalut station. The total length of the transmission line is about 300 Km.
As far the Electric power transmission line stretches from the Gulf of Suez in the east to West Sammalut area in the west for about 300 Km., the line crossing three different regions i.e., the Gulf of Suez, the North Eastern Desert and the Nile Valley regions. Each one of these regions has its own physical and geological characteristic parameters which greatly differ from one region to another's.

1-Location:
The study area is located in the stretch between Ras Gharib (Gebel El-Zeit) in the Red Sea Coast and along the southern boundary of El-Galala El-Qibliya Plateau and west Sammalut area in the Nile Valley (Figs. 1& 2 & 3).

2 – Objectives:
The main objectives of the present study are:

- To provide the basic physical and geological information's of the environmental conditions
- To identify the natural and the man-induced hazards that may affect the operation processes
- To identify the expected environmental factors which may affects on the routing line and to propose the effective mitigative measures.

3 – Tasks:
It was necessary to carry out the following tasks:

- study the geomorphic, climatic conditions
- study the exposed rock units and the main geological structures that can affect the area.
- identify the natural hazards that may affect the project area
- Propose some mitigative measures to reduce or to minimize the impact of the expected hazards.
4 – *Accessibility*:

It easily to drive along the high way from El-Minia (Sammalut) in the Nile Valley in the west through El-Sheikh Fadl - Wadi Tarfa to Ras Gharib in the Red Sea Coast via Wadi Abu-Had.

5- *Scope of Work*:

The present study, the physical and the geological of each region will be presented in the following three parts:-

PART – I: Gebel El-Zeit – Wadi Abu-Had Region,
PART – II, El-Galala El-Qibliya (Wadi Tarfa) Region and
PART – III, El-Minia – Sammalut (Nile Valley) Region
Fig. 1- Topographic Map of the Northern Part of the Eastern Desert
Fig. 2- Satellite Image for the study area
PART – I

GEBEL EL-ZEIT – WADI ABU HAD REGION

I – CLIMATIC CONDITIONS

Generally, the climate of the Red Sea coastal belt is characterized by aridity typified by very low rainfall, high evaporation rate, high summer temperature
and vigorous winds with average 16.5 Km/h. The presence of the meteorological data is very important in planning national projects in the desert areas.

The following meteorological features can be summarized.

I-1- Air – Temperature:

The temperature generally diminishes from October to January, and then raises continuously, the maximum being in April and the minimum in the last week of December and beginning of January. The average recorded temperature is 21.2°C as a minimum and 23.1°C as a maximum (Table 1) during the summer. The minimum is -1.3°C in St. Antony Monastery.

Table 1:- Annual average & minimum and maximum temperature

<table>
<thead>
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<th>Annu. average</th>
<th>Maximum</th>
<th>Minimum</th>
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<td>42.5</td>
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<tr>
<td>Hurghada</td>
<td>23.1</td>
<td>43.0</td>
<td>3.4</td>
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</table>

I-2- Sand Temperature:

The near-surface recorded temperature is 7°C as a minimum and 30°C as a maximum during December, 6°C as a minimum and 43°C as a maximum during March, and 17°C as a minimum and 58°C as a maximum during August.

I-3- Ground Radiation:

The minimum ground radiation recorded (temperature in vacuo) is 5°C during December and 6°C during March.

I-4- Relative Humidity:
The relative humidity, in general, is 42 – 44% during summer and 46 – 50% during winter (Table 2).

Table 2:- Relative Humidity

<table>
<thead>
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<tr>
<td>St. Antony</td>
<td>44</td>
</tr>
<tr>
<td>Hurghada</td>
<td>-----</td>
</tr>
</tbody>
</table>

I-5- Frost and Snow:

Frost and snow were recorded far in the higher altitudes near the watershed. In the Red Sea Hills, such an occurrence is almost seldom, but water-bags are occasionally frozen on the mountain tops at night. In the district of Gabel El-Shayib severe cold weather and frost was experienced during the period of the last week of December and the beginning of January. It may therefore be safely stated that a marked general cooling would have been accompanied by greater snowfall and frost in the mountain regions.

I-6- Surface Wind:

Generally, the N – NW wind is prevailing. The ranges of hills arrest the south-western winds, or the eastern-trending currents of the Mediterranean air-movements. Sand-free and sand-carrying winds are prevalent, also wind storms. Cool NW winds prevail in the study area. The wind velocity (in wadis) during the month of December was recorded as 9 miles / hour for the maximum and 0.125 miles / hour for the minimum (Fig. 4).

The main points are:

1- Wind, mainly from the north-west was especially prevalent during the Months of March & April, and also towards the end of December.
2- Two recognized areas of maximum cold and wind, Ras Gharib in the north and Gabel El-Shayib.

3- Sand – storms mark the maximum of the temperature oscillations in the months of February, March and April (Khamasin Winds) and attain their greatest effect in the long valleys and plains which run in the direction of prevalent wind, viz., northwest. In the mountains, these sand-storms are commonly replaced by heavy NW – winds, without carrying sands.

4- The hot, dry, sand- laden winds called "Khamasin" usually blow for 4 – 5 days in March & April, at these times the shade temperature rises to over 45 C and the air is thick with sans and dust.

5- The sea-coast, being the edge of a comparatively narrow rift, is usually Windy, the sea-plains being especially liable to sand –storms and Whirlwinds.

On the other hand, according to Yehia et al 2002, showing the mean monthly wind roses recorded at the stations surrounding the Gulf of Suez area, namely; Suez (No. 450) Sudr (No. 455), El-Tor (No. 459) and Hurghada (No. 463). (After the Egyptian Meteorological Authority, 1996). The wind roses represent the percentage ratio of the frequencies of occurrence of wind (the length of the column) blowing from certain direction. The different parts (with different colors and widths) of the column represent the wind speed range in knots. The number in the circle represents the percentage ratio of calm wind frequency multiplied by 10.

I-7- Rainfall:

The rain is naturally an important factor in all cases. The rainfall, winds and storms are connected with movements of the great exceptional atmospheric depressions from the Mediterranean area, which affect the area
under the consideration during the most of the year. The depressions or the storms are accompanied by southerly winds and warm weather in front of the trough and colder weather, northerly winds and rain is rear. According to Craig, 1910, there is a traverse track from WSW to ENE passing over the Gulf of Suez area during March. Another track existed in April traversed from SSW to NNE over the Ras Gharib area whereas in May, a track traversed from West to East, to the immediate vicinity north of Hurghada (Table 3 & Fig 5). The practical interest of these cyclonic systems to the country is that all the rainfall is associated with them; their study makes "Khamasin" prediction and storm prediction possible.

Accurate rainfall isohyetal map are not available, but it can be said that precipitation on the high mountains which rise to a height of some 1000 m., is of the order of 25 mm /annually. This figure decrease eastward to the coast and westward to the Nile Valley.

Other observations have been recorded and are summarized as in the following points:-
- The area is to a large extent rainless
- Heavy clouds accumulation over the highlands especially from January to March

<table>
<thead>
<tr>
<th>Station</th>
<th>Rainfall</th>
</tr>
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<td>Annu. Average</td>
</tr>
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<td>St. Antony</td>
<td>10.4</td>
</tr>
<tr>
<td>Hurghada</td>
<td>4.0</td>
</tr>
</tbody>
</table>

**I-8- Dew:-**
Heavy dews fall during the night and early morning in the winter months and constitute an important factor in supporting fairly abundant vegetation.
Fig. 4: Mean monthly wind roses recorded at the stations surrounding the Gulf of Suez area, namely; Suez (No. 450) Sudr (No. 455), El-Tor (No. 459) and Hurghada (No. 463). (After the Egyptian Meteorological Authority, 1996)
Fig. 5: Isotherm map of annual means of daily maximum (A) and minimum (B) air temperature in °C, relative humidity in percent (C) and isohyetal map of annual rainfall in mm (D) (After the Egyptian Meteorological Authority 1996)

II- REGIONAL GEOMORPHIC FEATURES
Generally, the Eastern Desert is a wilderness of ranges extending in a NNW - SSW directions from Ain Sukhna region to Sudanese border, over nearly 1000 km. and rising from 1000 to over 2000 m.a.s.l. Towards the Nile Valley, the decline is more gentle and marked with tabular landscapes and low hills.

The geomorphic features in the study area depend on their geological structure, lithology and in part on the paleo-climatic conditions and the groundwater behavior.

The following is the main geomorphic features in the area under the consideration:–

**II-1- Gebel El-Zeit:**

Gabel El-Zeit area consists of a high topographic elongated range (30 Km. long and 5 Km wide) trending N 45 – N 50 W and bordering the western coast of the Gulf of Suez between Ras Dib in the north and Ranim Island in the south. Gebel Zeit itself is a 14 Km long outcrop of basement rocks with a maximum elevation of 465 m. It is bordered to the west by outcrops of ante and syn-rift sedimentary deposits forming the West Zeit Range (maximum elevation is about 350 m. These two ridges trending NW-SE, are separated by the longitudinal depression of Wadi Kabrit. To the south, the Little Zeit (maximum elevation is 250 m) is a small isolated basement outcrop (3 Km long), separated from the Gabel Zeit by a topographic saddle (maximum elevation 150 m) west of Ras El-Ush.

Gabel El-Zeit range comprise the eroded leading edge of a complexly broken, southwest- dipping tilted fault block along the west bank of the Gulf of Suez.

Phisographically, Zeit Range divided into four portions:–

1- The main granitic Gabel El-Zeit range lies along the coast in the northern portions of the area
2- Paralleling the granitic range to the southwest is the West Zeit range, formed by resistant Cretaceous rock units capped by Miocene reefs. Wadi Kabrit forms a low valley eroded in Paleozoic sandstones between the two.

3- The South Zeit range lies at the southern end of the mountains separated from the Main and West Zeit ranges.

4- An Evaporite- draped saddle lying in the central transverse graben.

Gabel Zeit and Esh Mallaha region displays three major fault scarps which originated by NW-Se normal faults bounding the Pre-Cambrian basement rocks. These scarps are close to the faults that produced them and grow with further movement along the faults. The fault scarps have been formed as a result of the tilting of the basement rocks towards the southwest.

**II- 2- Piedmont Plains:**

The study area is characterized by the gently sloping Gemsa and Mallaha plains reaching a maximum slope of 8°. The whole slope is termed piedmont and abuts against nearly vertical uplifted basement rocks. This piedmont consists of two parts, a lower part of a gradational origin called a bajada and formed of detritus derived from the uplifted blocks and an upper part which is really an eroded bedrock surface called a pediment. Minor occurrence of cobbles and pebbles derived from the sedimentary rocks has been observed.

**II-3- The Low-lying Coastal Belt:-**

The Coastal Belt forms a continuous strip of low-lands bordering the Red Sea coast. Numerous flat-bottomed wash-filled wadi runs in a direction perpendicular to the coast (Figs. 1 & 2). The sea shore form a nearly continuous coralline beach, rocky shores are exceptional.
From the eastern foot scarp of El- Galala El-Qibliya Plateau to Ras Gharib, the coastal belt overlies the large sedimentary structures of the Zeit and Esh El-Mellaha basins and forms a 20 – 30 km. wide plain marked by the extrusion of elongated granitic ridges parallel to the shore line.

**II-4-The Red Sea Hills:**

Rising above the coastal belt, is a steep escarpment, the high and rigged Red Sea Mountains present a sunset, a wild and impressive skyline. They do not form a continuous range, but rather a series of mountain groups which are more or less coherently lined up parallel to the coast. The Red Sea Hills overlook and are parallel to the Great Plain; the coastal plain separates the similarly related ridge of Esh El-Mellaha which follows the Red Sea – Gulf of Suez trends. The northern portion of the main chain of the Red Sea Hills though forming conspicuous summits is very narrow in width and for the greater part consists of very precipitous ridge terminating in highly serrated edges. The Red Sea Hills are several ranges of hills forming the most part, one mountain – chain which has a NNW-SSE direction crossed by several transverse valleys. The higher mountains generally form the watershed between the Nile and the Red Sea. The eastward drainage differs strikingly from the westward in being much steeper and more complex. This range (chain) offers no easy communication between the Nile and the Red Sea (Fig. 2). The constituted rocks belong to the Pre-Cambrian complex of chists, granites and volcanic. The uplift of this block is recent and possibly still active. Wadis run deeply in geometrically arranged narrow gorges incised along the faults and fractures showing everywhere evidence of current cutting. A shallow wash-fill occurs only in the major collectors where it consists of a coarse arenaceous sand or pebbly pavement such as Wadi Abu Had, Wadi Dib and Wadi Dara.

**II- 5- Wad's and Drainage System:**
The study area crossed by three main wadis. The central parts represent an area for surface water divide between these wadi basins. These wadis represent the Red Sea drainage system

- Wadi Abu Had (Red Sea system).
- Wadi Dib
- Wadi Dara

The main wadi in which the line passing, is Wadi Abu-Had. Wadi Abu-Had is one of the major wadis which crossing the northern part of the Red Sea Hills and flowing to the Red Sea nearby the Ras Gharib Town. The catchment area of Wadi Abu-Had basin covering an area about 1080.8 Km2

**II-6- Alluvial Fans:**

Alluvial fans exist mainly where a distinct boundary exists between the uplifted blocks and the adjacent plains. In the study area, alluvial fans are common along faulted block fronts. The bajada of the region consists of a series of coalescing alluvial fans built by streams which debauch onto the piedmont and spread their detritus radially outward from the mouth of the wads.

**II-7 - Sabkha and Wetland:**

Parallel to the coast, a topographic low elongated depression lies below sea level and covered with salt marches and sea water are located and forming a wetland area. It consists of fine muddy sands with highly saliferous with salt and gypsum.

**III- GEOLOGICAL SETTING**

**III - A - STRATIGRAPHY**
As far the project area covering a tract from Gebel Zeit / Ras - Gharib in the Red Sea region to West Sammalut in the Nile Valley, the area can be geologically classified into the following regions:

**III - A-1- The Geology of Gebel El-Zeit Area:**

Gabel El-Zeit area consists of a low elongated range (30 Km long, 5 Km wide) trending N 145 – N 150 and bordering the western coast of the Gulf of Suez between Ras – Dib to the North and the Ranim Island to the South. Zeit itself is a 14 Km long outcrop of basement rocks with a maximum elevation of 465 m. It is bordered to the West by outcrops of ante and syn-rift sedimentary deposits forming the West Zeit Range (max. elevation is about 350 m. These two ridges trending NW – SW, are separated by the longitudinal depression of Wadi Kabrit. To the South Little Gabel Zeit (max. elevation 250 m) is a small isolated basement outcrop (3 Km long) separated from the Gabel Zeit by a topographic saddle (max. elevation 150 m) west of Ras El- Ush.

**III -A-1- a- Pre-Cambrian Basement Rocks:**

The basement rock crop out in Gebel Zeit itself and in the Litte Zeit where they form the highest summits of the area. They consist mainly of old metamorphic rocks intruded by pink (orthose and biotite) or grey plagioclase granites. These granites are cut by numerous doleritic dykes. In the Little Zeit, basement is composed of more basic plutonic rocks, Diorite. Just south of the Wadi Kabrit pass, granitic rocks are overlain by volcanistic deposits of different ages.

**III-A-1-b - Sedimentary Rocks:**

The sedimentary succession in the study area starts by the Pre-Cretaceous sediments represented mainly by Nubian beds.
• **Nubin Sandstone:**

  The basement rocks are overlain by a thick unit (about 400 m) of coarse milky white to yellowish sandstones. They are mainly massive orthoquartzites with well rounded grains and gravels; oblique and cross bedding is common in the upper part. Thin layers of white kaolinifized arkose and black to reddish ferruginous lenses can also be observed. Basal strata consist of weathered arkoses overlying granite-wash. The lack of conglomerate or breccia suggests that the erosional unconformity was a smooth flat lying surface. The Nubian sandstones are generally attributed to the Paleozoic but could have an age ranging from Cambrian to Lower Cretaceous.

• **Upper Cretaceous**

  The monotonous "Nubian sandstone" is conformably overlain by a much more marine sequence. All the previous collected samples were barren of nannofauna and could not be dated. From the stratigraphic and facies analogy attributed the age to the Cenomanion - Turonian and to the Senonian.

  Cenomanian – Turonian rocks, consists of green gypsiferous shales interbedded with fine grained ferruginous sandstones and bioclastic dolomitic limestones. This unit may be correlated with the well defined yellow – orange dolomitic bar that can be followed along the western cliff of the Wadi Kabrit.

  Senonian being with variegated sandstones and shales intercalated with numerous ferruginous layers. The upper part is more argillaceous and displays phosphatic beds with massive chert (Campanian) and white chalky marls (Maestrichtian). Brown marls overlying a chalk bed at the northern tip of the West Zeit Range was dated to Upper Campanian – Lower Maestrichtian ages.

• **Eocene (Te)**
In West Zeit Range, two small isolated outcrops of chalky limestone with chert nodules have been attributed to the Eocene by facies analogy. These deposits are typical of a transgressive marine sequence on a stable continental platform. During the Cenomanian, Turonian and Early Senonian times, abundant sandy sedimentation with gypseous marls which indicating near-shore environment.

The pre-rift marine units are outcropping west of the Wadi Kabrit and in the northern part of the West Zeit Range. To the south these units are progressively truncated by Miocene deposits and wedge out.

**Tertiary Unconformity**

The Tertiary unconformity is developed as an erosional surface on the tilted pre-Miocene section. It bevels the pre-Miocene strata in the north and south of the main Gabel Zeit range. The erosion surface itself may exhibit a rolling topography, with the current high regions of the West Zeit range possibly being a higher area in pre-Miocene times. Also, the depth and location of weathered zones suggests that the soft, central Wadi Kabrit Formation sandstone formed a precursor of the current Wadi Kabrit. The erosion surface now slopes at roughly 15 to 25 to the southwest. It is reasonable to visualize the pre-Miocene topography as a muted version of the present topography, with an eastern granitic range, a sandstone floored valley, and a low line of Cretaceous – cored hills.

**Miocene:**

The Miocene sequence of the Gulf of Suez is commonly subdivided into Lower Miocene, referred to as the Gharandal Group and Middle Miocene to as the Ras Malab or Evaporite Group. Both groups are important, the lower containing the richest source rocks in combination with excellent reservoirs deposited under most favorable structural
conditions, and the upper group providing the most efficient seal for both Miocene and pre-Miocene reservoirs.

The aggregate thickness of these two groups is about twice that of the pre-Miocene formations. It indicates a fast subsidence of the graben area within a short period of time Fig. Shows the major unconformities which affected the Neogene sequence

**The Gharandal Group:** It is subdivided into three stratigraphic units which can be recognized in most of the entire graben area as follows:

- **The Nukhul Formation:** This is the lower unit at the base. It contains carbonates and high energy reefal buildups on the pre-Miocene topographic highs, and sands and shales in the lows between fault blocks and on tilted surfaces of the fault blocks.

- **The Rudeis Formation:** It overlies the Nukhul and is composed essentially of high fossiliferous shales and marls referred to as the Globigerina Marls, and sandstones. This formation is oil bearing in Belayim Land, Belayim Marine, Morgan and other oil fields. The Rudeis grades upwards into the Kareem across a laterally extended anhydritic level.

- **The Kareem Formation:** It is made up of shale with frequent intervals of sandstones. Shales of the Rudeis and the Kareem Formations are considered by many authors to be the main source rocks in the Gulf of Suez area. The interbedded sands provide excellent reservoirs with porosities ranging from 11 to 25%. The thickness of the Globigerina Marls exceeds 2200 m. in the northern part of the Gulf thinning to less than 200 m. at the Red Sea – Gulf of Suez junction.

- **Ras-Malab (Evaporate) Group** divided into the following formations:-

  - **The Belayim Formation:** It contain two distinct units, a thick lower evaporate section and a relatively thin band of clastics. The lower unit
consists of rough weathering, massive anhydrite and gypsum, relatively free from shale or limestone interbeds in the north. In the South Zeit range and on the eastern side of the ranges, limestones are found interbedded with the lower gypsum. The evaporates in these places are greatly disturbed along the eastern border fault of the horst. The upper unit is made of clay, limestone bands and occasional conglomerate from a continuous outcrop along the entire length of the ranges.

Overall, the Belayim Formation exhibits lagoonal facies with some open marine clastics; however, the limestones in the lower portions suggest a more coastal deposition. These limestones also suggest a possible correlation of the lower portion of this formation with the Gemsa Formation since a non-marine facies is exhibited. As a whole, the formation is most appropriately considered as the Belayim Formation.

- South Gharib / Zeit Formations: It consists of banded anhydrite and gypsum interbedded with thin shale's, limestones, violet rock salt, and occasional patchy, thin peaty layers. In general this unit contains more clastics than the underlying gypsum. These sediments seem to have been laid down in alternating open and closed lagoonal conditions, with some plant growth occurring intermittently.

According to Said (1962) the South Gharib and Zeit Formations are generally considered to be of Middle Miocene age.

**Pliocene Sediments:**

Pliocene section consists of rounded gravels with rolled fragments of Ostrea sp. and Pecten sp. fossils Cast beds and oolitic limestones are reported in the South Zeit range (Sadek, 1959). These rocks contain also a completely Indo-Pacific fauna, indicating the severance of the Gulf from the Mediterranean and the continuing connection of the Red Sea with the
Indian Ocean. The Pliocene gravels represent shallowing conditions in the Gulf of Suez basin and ends to the Neogene evaporate cycle.

- **Quaternary and Recent Sediments:**
  The Quaternary and recent deposits in the study area consist of:-
  - Horizontal Pleistocene reefal limestone associated with wave cut terraces with beach gravels coalescing alluvial fan deposits.
  - Sand sheet accumulation
  - Bushes, Shrubs and Phytogenic mound along the course of the wad's
  - Sabkha and salt marches

**III-A-2-The Geology of Wadi Abu-Had:**
The volcanic rocks in Esh El-Mellaha range pertain to Dokhan Volcanics which are of relatively wide distribution in the northern part of the Eastern Desert (Fig. 6). The rock units are arranged from oldest to youngest as follows:-

- Metasediments: - these units includes sericite-chlorite, siliceous schists and conglomerates, cropping out in the south eastern part of the studied area. They strike E – W and dip 30 – 60 to the north.
- Metavolcanics:- This unit represented by meta-andesite, metabasaltic andesite and their tuffs and related porphyries.
- Ultramafic rocks: - These rocks form three very small masses within the area of metavolcanics south of Wadi Dib. The rocks are partially rserpentinized and in some places they are composed of antigorite.
- Dokhan volcanic: - The Dokhan volcanic at Esh-Mellaha range represents the main rock unit. They form a belt of grayish black rocks that extends in a NW-SE direction. The succession is
represented by lava flows and pyroclastics. The lava flows are composed mainly of mafic intermediate rocks associated with less abundant felsic rocks. They are intruded by the Younger Granite and overlain unconformably by the Hammamat Sediments.

- **Hammamat Sediments**: This formation includes volcanogenic deposits represented by a series of alternating conglomerates, gritstones and sandstones intercalated by andesite, porphyrites, dacites and their tuffs.

- **Younger Granites**: These rocks are represented by ineqigranular granites, granophyric granites and porphyritic granites. They display steep intrusive contacts with surrounding rocks. Gradational contacts were observed among these varieties.
Fig. 6: Geological map of Wadi Abu Had and Gabal Gharib areas
Table 4: Generalized Stratigraphic Column Gulf of Suez and Southern Galala Plateau (after Schlumberger, 1984)
Fig. 7 A: - Simplified Geological Map of the Study area

III -B - STRUCTURE:
Generally, Gulf of Suez rift (Graben) was initiated as a structural embayment with oscillatory movement between Cratonic Basement rocks in Pre-Eocene ages and evolved as faulted swell, i.e. Graben in Post Eocene. The represented structural features in the study area are mainly faulting and folding.

III -B-1- Faulting:

The western Gulf of Suez was structurally controlled by the major western marginal fault. The faulting systems are in different trends; NW-SE, NE- SW with minor E-W trend. Generally, they are normal, gravity types with a downthrown toward the center of the Gulf and along the scarp face of the Northern Galala and Gebel Ataqa. They are not continuous with partial overlap. In addition, most of these faults are considered to be of Post Miocene and Pliocene ages.

The main fault trends (Figs. 8 &.9 & 10) are:-

- N 65 W trend: This trend is related to the Gulf of Suez. The faults here are normal, gravity and longitudinal type. The downthrown is toward the north and northeast.
- N 25-35 W trend: This is the Gulf of Suez trend (Pelusic trend). Most of faults are normal, gravity, strike and longitudinal types.
- N 15-25 E trend: This is a minor trend which is related to the Gulf of Aqaba system.

The faults have an N 30 W and extend for about 8 km length. The spring of St. Paul Monastery is situated at the intersection of two faulting system, i.e., N 30 W and N 65 W trend.
Gabel El-Zeit region consists of a single, highly faulted basement block, rotated to the southwest between major Gulf-parallel faults. The eastern edge of this block is complexly broken by cross-faulting along older trends leading to transverse graben formation. Four major structural elements lie within the larger region. The most prominent of these is the main granitic Gabel Zeit range bounded by the eastern border fault, Wadi Kabrit and a southern cross-fault. Within this range, a transverse graben has hinged Gulfward along older trends in response to arching of the range during uplift. Several Gulf-parallel, northeastward dipping normal faults of roughly 50m. displacement also break the range at this point. South of the main Gabel Zeit range, a central transverse graben is delineated by major hinge faults, the eastern border fault and a major anticlinal flexure. The northern side along the hinge fault is marked by extreme folding in the Miocene evaporates. All of these folds are directly related to faulting in the underlying basement and Paleozoic rocks in the main Gabel Zeit range. The southern portion of the graben consists of a block rotated along line, raising the southern corner roughly 75 m. over adjacent sediments. Bowing of the sediments along the northern edge of this block has formed the transverse syncline. The South Zeit range has an exposed basement core broken by Gulf-parallel faults. Gulfward movement of the central area has drawn the Miocene sediments into a curved syncline. The West Zeit range lies further from the edge of the Gulf and exhibits far less deformation. Cross faults in the basement die out into folds in this thick cover. Faulting in the region follows several trends, with gulf-parallel faulting dominant. Conjugate normal faulting caused by arching during uplift is the latest faulting effect.

Jointing is very complex, especially in the basement rocks, with substantial variation in both density and orientation. The basement is most highly faulted, with some areas appearing almost shattered. Within the sandstone sequences, great variations are apparent, with some areas containing only widely spaced joints, but others showing swarms of parallel, closely spaced joints. Several ages
of joint and fault development are apparent from an examination of cross-cutting relationships in the rocks. The oldest fracture sets are N 70 E Tethyian trend. Traces of other faint older trends can be observed at various joint stations. The E – W trend is most likely the next oldest, including a growth fault in the Cretaceous sediments. During the Early Tertiary, the Cretaceous section was tilted approximately 25 to the southwest, as indicated by the configuration of the pre-Miocene erosional surface.

Jointing and faulting along the Suez trend was initially dominant, with Gulfward step faulting involving basement becoming pronounced. There is some suggestion that the shallowest dipping Gulf-parallel faults are the oldest, indicating a continuing sequence of faulting as the horst block rotated. The final faulting and jointing involved the arching of the horst, generating conjugate normal fracturing and faulting along the Aualitic trend and rejuvenating other trends to form the complex cross-graben system.

**III -B- 2- Dips:**

The general dip ranges from 2-3 except at the area neighborhood to the fault plain.

**III -B-3- Folding**

The study area was strongly affected with asymmetric folds of the Syrian Arc Folding system which represented in both surface and in the subsurface. On the surface, it represented by Wadi Araba anticline. This heights was responsible for the disconformities between the Upper Cretaceous-Middle Eocene at the southern Galala Plateau.
IV - NATURAL RESOURCES

IV-A-Oil and Natural Gas:

Since 1886, Egyptian and foreign companies have explored the Gulf of Suez by classical mapping and geophysical techniques. During that time 13 oil and gas fields have been discovered. Average daily production currently is of the
order of 50,000 BOPD. Structurally, the western Gulf of Suez is divided into two major provinces; Ras Gharib, Ras Shukeir, Umm El-Yuser, Kheir, West Bakr and West Zeit. In the former, beds characteristically dip to the northeast; in the later, they dip to the southwest, both in surface outcrop and in subsurface. Within each province, fields are located over structural traps (Fig. 11).

As a result of drilling it is apparent that the structures resulted from major movement during the early Miocene. A major unconformity occurs at the top of the Lower Miocene Nukhul Formation, and the beds of the overlying Middle Miocene Belayim Formation transgress onto rocks as old as Precambrian.

The Nubia Sandstone, one of the best reservoirs, is a blanket deposit over the whole gulf region and ranging in thickness from 130 m to more than 660 m. The Miocene sands are more sporadic in their distribution and thickness. Three depocenters are known in West Bakr, Shukeir and Wadi Dib areas (Fig. 12). Further reservoirs of less importance are Cretaceous sands (6.5 m) to 32 m thick through the area, Eocene carbonates and Miocene reefs.

Production up to the present has been from structural traps; future expansion of production will depend upon our ability to locate stratigraphic traps. Sands sourced by the shale's have seldom given high yields. The hope is that through the generation of depositional environment models it will be possible to define prospects where the optimum sand / shale ratio of 1/4 to 1/6 can be found.

- Source Rocks:

Source rocks are generally classified according to the amount and type of organic matter, the degree of maturation and the thermal alteration. The sedimentary section of the Gulf of Suez contains six intervals which exhibit source rock characteristics. These intervals consist of fine clastics and carbonates and are present in Carboniferous formations, in Upper Cretaceous carbonates (Brown Limestone & Sudr Formations), in Paleocene – Eocene deposits (Esna Shale) and in the Lower – Middle Miocene fine clastis (
Kareem, Rudeis and Belayim Formations. Their content in organic, oil prone matter ranges between 1.04 to 1.44 % which classified as a "good content ".

The maturation level of the source rocks in the Gulf of Suez area appears to be essentially the result of age and burial.

The temperature gradient that affected the thermal alteration of the organic matter had apparently little influence on the various levels as it varies very little over the general Gulf of Suez area and averages about 2F/100 ft.

- **Reservoirs:**

Most of the Gulf of Suez oil occurs in sands of Miocene, Cretaceous and Carboniferous age. Commercial oil is also present in Miocene, Eocene and Upper Cretaceous fissured and fractured reefal and shelf limestone. Fracture and fissure porosity encountered in the limestone reservoirs is due to the intense structuring that affected the Suez graben area.
Fig. 11:- Oil potential of province 3 in which the study area is located

(After Hagras et. al., 1983)
Fig. 12: Location map of Oil and Gas fields in the Gulf of Suez region

- Traps, Seals and Oil Migration:
Accumulations of oil are encountered in reservoirs associated with fault block structures. Time equivalent and overlying shales, and especially the evaporitic sequence of the South Gharib – Zeit Formations of Middle Miocene age, provide the necessary and most efficient seals. The plasticity of these evaporitic sequences enabled them to mold to the various types and sizes of fault blocks during the differential vertical and horizontal block movements. Most of the important oil fields are found on tilted fault blocks or in reversals produced by warping of formations over fault blocks.

-Nature of Hydrocarbons:

Suez crude oil can be classified as asphaltic – paraffinic, the content of paraffins and asphaltenes ranging in all pay zones from 2.9 to 4.2 % and 2.4 to 12 % respectively. The Gulf of Suez fields are characterized by a paucity of associated gas or gas caps especially in pre-Miocene pay zones (Fig. 21). Only a few fields have high gas / oil ratios or gas caps with condensate content.

IV-B- Gypsum Deposits:

A huge thickness of evaporate (Gypsum) of Middle Miocene age is reported at the study area and along the Red Sea Coast as well in the Middle Miocene (Evaporate Group section). These deposits can be quarried for industrial and agricultural purposes (Appendices A1 & A2).

V. WATER RESOURCES

V-A- Groundwater Resources:-
The main characteristics of the groundwater known to exist in the area under consideration are only pointed out. Tow essential and distinctive types of groundwater are present, one type of purely meteoric origin and the other being formed during the different geological times, the so-called formation water. The formation is being highly saline and occurred on deep wells and mixed with minerals, sulphites.

The water of meteoric origin making its entry at the outcrops of permeable formations, percolated down faults and takes varying amounts of salts with solutions. The result is the formation of shallow and deep water accumulations. This study aims at demonstrating the viability of alternative water resources, such as alluvial aquifers recharged by flash flooding, which could complement surface waters. Ground water in the shallow alluvial aquifers of the Eastern Desert and in the karstified Eocene limestone aquifers underlying the alluvial aquifers could provide an alternative renewable water resource. In the Eastern Desert, rainfall is collected as surface runoff through networks of alluvial channels in the main valleys and as ground water in the shallow alluvial and limestone fractured aquifers flooring the main valleys.

V-B- Occurrence and Distribution of Water Resources:

The extent of water supply depends largely on the direct rainfall, as much of the water occurs in rock-Poole in the upper mountain-valleys. Water-Poole are abundant and of long standing in the central hills. The valleys draining from them will have good underground water supplies at their heads, gradually diminishing in quantity and increasing in salinity as we pass eastwards to the Gulf of Suez. Generally, in this hilly regions composed of igneous & metamorphic and sedimentary rocks, wells in the valleys are frequent. At depth from 8 to 10 m., the groundwater varying in their quality & quantity according to the nature of the season, e.g. whether rainy or rainless.
Generally, water is good in winter after the rainfall in the ranges and unpleasantly salty in the summer or during rainless period. For normal drinking purposes, fresh water of salinity up to 1000 p.p.m. can satisfactorily be used, Saline water, of salinity ranging from 1000 to 3000 p.p.m., is used for limited irrigation in a sandy soil. Very saline water has a salinity range of 3000 – 5000 p.p.m., the brackish is of 5000 – 10000 p.p.m., and that over 10000 p.p.m. is considered as sea water or brine, for instance, the average water salinity for the open Red Sea is 42000 p.p.m. while in the Mediterranean open sea is about 37000 p.p.m.

The following is a short account of all resources or supplies known to exist within the study area.

1- Ras Gharib area: Ras Gharib town was previously supplied by tankers from Suez. This has been abandoned, since the development of the Shagar well fields in 1966.

All wells of the oil-field region have evidently salty waters of different characteristics. The drilled wells near the lighthouse indicated the presence of saline water at very shallow depths of 3 to 8 m. in the Pleistocene sediments. The water has the following character (Ganoub, 1969);

- T.D.S. = 54600 P.P.m.
- Salinity (as NaCl) = 44900 P.P.m.
- Ca / Mg Ratio = 0.24

4- Bir Abu Kheleifi (Abu El efieh):- This is a spring issuing abundant supply of brackish water from a fault plane between Senonian and Cenomanian.

5-Bir Uldahal: - It is also a spring issuing abundant water from a similar fault and was reported as a best seen in this locality.
6-Shagar Wells: - This is the most important area for water supply. The Shagar wells lie at a distance of about 25 Km due south from Ras Gharib and at about 15 Km. to the west of the shore line. They comprise four wells (one was plugged and the others are productive). The production aquifer is the Gharandal sand, situated at a depth of 300 - 600 m. a.s.l. The average daily rate of production is 250 – 300 m\(^3\) / day / per well. The water from the wells is pumped through a 4 inch pipeline and is used for both domestic and technical purposes at Ras Gharib and at Ras Shukeir areas as well. The salinity ranges from (T.D.S) 2100 – 1708 p.p.m. (NaCl) 485 – 355 p.p.m.

7-Bir Kufra: - This is situated at the foot of the porphyry range north of Gebel Dokhan, being the center of water –supply for a wide region. It was reported that it is of great importance to anyone desiring to explore certain portions of the Red Sea Hills. In addition to this, it may be recalled that there are plentiful holes at the foot of Gebel Abu Harbo, some 7 km. SW Bir Kufra, which would be filled after a rainy and as these are dry, the Arabs obtains a supply from the neighbourhood of Gebel Abu Marwa some 4 km NW Bir Kufra.
Fig. 14: Hydrogeological map of the study area (after RIGW, 1988)

VI - NATURAL HAZARDS
The area usually suffered and threatens by the main natural hazards; flash flood and earthquake.

**VI- A - Flash Flood:**

The climate of the Red Sea and Gulf of Suez is characterized by aridity typified by very low rainfall, high evaporation rate and high summer temperature. Nevertheless, the region is occasionally subjected to heavy rainstorms that commonly followed up by floods. These may cause disastrous impacts on life, roads and settlements.

The system of natural drainage of the area is remarkably simple, but little rain, as is well known, falls in central and southern portions. The rain-channels are dry during the greater part of the year and vary in length according to the season.

Generally, the torrents of terrible floods were observed during November & December, 1932 and in December 1959, in the area from Safaga to Ras Banas, the discharge of rain was estimated at 500 cubic meters per second but the second torrent is least destructive action (Ganoub, 1969).

The drainage network is well-developed; variable dense and high integrated (El-Etr et al., 1990. Gradient is commonly steep particularly in the upper reaches and tends to be gentler at the foot slopes of the mountains and pediment and gentle at the coastal plain where local fans are formed. El-Shazly et al. 1991 and Yehia et al., 2002, classified the Gulf of Suez catchments area. The main basins / catchment areas in the study area are from north to south; Wadi Abu-Had, Wadi Dara, Wadi Dib and Wadi Mellaha basins. Morphometric parameters of the delineated hydrographic basins (Table- 7 ) were defined in terms of order, weighted mean bifurcation ratio, frequency, density, slope gradient, basin shape, basin length and length of overland flow in order to elucidate their bearing on runoff (flash flooding).
behavior and consequently their potential for recharge of the shallow underground aquifers.

Table 7: The Morphometric parameters of the main basins.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Basin name</th>
<th>W. Abu-Had</th>
<th>W. Dara</th>
<th>W. Dib</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area in Km²</td>
<td></td>
<td>1080.816</td>
<td>1158.0392</td>
<td>305.537</td>
</tr>
<tr>
<td>Perimeter in Km.</td>
<td></td>
<td>223.755</td>
<td>200.348</td>
<td>117.006</td>
</tr>
<tr>
<td>Difference in elevation</td>
<td></td>
<td>882</td>
<td>1228</td>
<td>1216</td>
</tr>
<tr>
<td>Basin length</td>
<td></td>
<td>75.5</td>
<td>63.5</td>
<td>16</td>
</tr>
<tr>
<td>Total segment number</td>
<td></td>
<td>1295</td>
<td>921</td>
<td>147</td>
</tr>
<tr>
<td>Weighted mean bifurcation ratio</td>
<td></td>
<td>4.636</td>
<td>4.75</td>
<td>3.759</td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td>1.1982</td>
<td>0.795</td>
<td>0.48115</td>
</tr>
<tr>
<td>Density</td>
<td></td>
<td>1.314</td>
<td>1.07</td>
<td>0.83265</td>
</tr>
<tr>
<td>Elongation ratio</td>
<td></td>
<td>0.4913</td>
<td>0.605</td>
<td>1.233</td>
</tr>
<tr>
<td>Circularity ratio</td>
<td></td>
<td>0.2713</td>
<td>0.363</td>
<td>0.2804</td>
</tr>
<tr>
<td>Total segment length</td>
<td></td>
<td>1389.612</td>
<td>1213.65</td>
<td>248.928</td>
</tr>
<tr>
<td>Mean gradient</td>
<td></td>
<td>0.7641</td>
<td>1.115</td>
<td>4.417</td>
</tr>
<tr>
<td>Overland flow</td>
<td></td>
<td>0.380517504</td>
<td>0.46728972</td>
<td>0.600492404</td>
</tr>
</tbody>
</table>

(Source, Yehia et al. 2002)

**Surface Runoff Modeling:** The model construction involved extraction of geomorphologic and lithologic information from Landsat thematic mapper (TM) scenes and digital terrain elevation data (DTED) to enable estimates to be made for initial loss, recharge rate through transmission loss, and runoff at the watershed’s outlets. We adopted the U.S. Department of Agriculture-Soil
Conservation Service method (SCS, 1985) to calculate initial losses in the sub-basins.
Gharib Landuse map showing the risk zone (NARSS, 1997)
VI- B- Earthquakes:

The oldest reported seism on the Red Sea shores occurred in 497 A.D. Numerous other important seisms, some of them destructive, have been

Fig. 19:- Landsat – MSS composite image of Ras - Gharib region
(After NARSS, 1997)
recorded in Saudi Araia (particularly in Jiddah Al Medna areas), in Eritrea, and in the Sudan. SIEBERG mentions about 15 major seisms in Egypt, among them that of August 8th, 1303 A.D. which probably reach intensity XI at Fayum. On August 7th, 1847, a tremor caused 85 deaths in the same locality and 27 in central Egypt.

The area under the consideration is located within the Craton Nubian – Arabian Shield as clearly shown on Fig. 21. It is well known that tectonic activity in Egypt is controlled by active rifting in the Gulf of Suez / Red Sea, left lateral strike slip motion along the Gulf of Aqaba and Levant (Dead Sea) transform, and the convergence between Africa and Eurasia in the eastern Mediterranean (Fig.22). Three plate boundaries border Egypt: the African–Eurasian plate margin (Hellenic and Cyprus Arcs), the Red Sea plate margin and the Levant transform fault as shown in Fig. (Abou Elenean, 1997; Sofratome Group, 1984; Ben-Avraham et al., 1987; Woodward-Clyde Consultant, 1985; Jarriage et al., 1990).

Historical seismic activity was compiled from Badawy (1996, 1999), Badawy and Horvath (1999). Historical information indicated that many earthquakes caused severe damage in the northern part of Egypt. Some of these events are related to the convergence between the African and Eurasian plates while the others are located within the plate itself. The most famous historical events are that of 18 March 1068 (Levant fault area); 20 May 1202 (Dead Sea); 8 August 1303 (south-east Crete); 18 March 1481 (South Cyprus); 13 February 1756 (Hellenic Arc); 7 August 1847 (Fayum); 11 July 1879 (Gulf of Suez) and 17 July 1887 (Hellenic arc). Epicenters of the historical activity are located in some specific areas, which are tectonically active. The majority of these events are located along the Levant transform fault. Some events are located along the Suez Gulf-Cairo trend and others along the Mediterranean Shelf.
Although the historical epicenters are suffering from location errors, they are conformable with the major active tectonic provinces and boundaries. The tectonic setting of Egypt is well understood by considering the geological history and evolution of Northeastern Africa and adjacent regions. In interpreting this history, the concept of Plate Tectonics is applied as a basis for describing the deformation of the Earth's Crust. Most active tectonic features are located along the plate boundaries and are characterized by a large deformation.

Very important information about the tectonics of Egypt can be obtained from the distribution of seismic activity. The main earthquake activity takes place along the recent active faults or the plate boundaries. The epicenters of the historical active earthquakes are located in some specific areas which are tectonically active. The majority of these events are located along the Levant – Gulf of Aqaba transform fault. Figure 22: showing the epicenter of different earthquakes; A) Epicenter distribution of varying magnitude earthquake, focal mechanism of principal earthquakes and active seismic trends. B) Enlarged view from A showing the earthquakes surrounding the Gulf of Suez and the extention of the Red Sea – Gulf of Suez – Cairo – Alexandria trend. C) Epicenters of historical and recent medium to large earthquakes. D) Epicenters of small earthquakes. E) Intensity distribution of earthquakes of March 1969. (A, B, C and D after Kebeasy 1990, and E after Maamoun and El-Khasab, 1978)

According to Mahmoud, 2003, Egypt may be divided into eight seismic zones according to its seismicity maps. One of these zones is the Red Sea / Gulf of Suez. The tectonic setting of the area causes its slight instability. In the Egyptian territory, the distribution of epicenters of moderate to large and small earthquakes and micro-earthquakes indicates that the earthquake activity tends to occurs along three main seismically active belts and trends (Fig. 23).
A catalogue of smaller to large earthquakes that affect Egypt and its surroundings has been compiled for the period from 1900 to 2000. This catalogue has the seismicity data of the area located between 22–34 N and 25–36.5 E. It represents the output of the integration and comparison between three catalogues available at NRIAG (Abou Elenean, 1997), the Egyptian Geological Survey and Mining Authority (EGSMA) and the earthquake catalogue for the Middle East Countries adopted by Riad and Meyers in (1985). Earthquake magnitude has been unified to be represented only by the body wave magnitude (Mb). According to these catalogues, Abou Elenean (1997) divided Egypt into five active seismic zones; the Gulf of Suez-Northern part of Eastern Desert zone, the Southwest Cairo zone, the Northern part of Red Sea, Gulf of Aqaba zone and the Aswan zone. Badawy, 1996, 1999; Badawy and Horvath, 1999 and Mahmoud 2003, concluded that the earthquakes along the Red Sea margin indicates a cluster of activity at the entrance of the Gulf of Suez and this extends southward for a small distance in the medial part. This cluster is attributed to the intersection of NW (Red Sea–Gulf of Suez) trend with the NE (Aqaba) trend. Besides the second seismic zone which extends from the Gulf of Suez towards north into the northern part of the Eastern Desert. This area is highly populated and has a large economic interest. Seismic activity of this zone is related to the faults trending NW–SE that parallel the trend of the Gulf and also are perpendicular to the gulf (NE–SW). Published focal mechanisms from the region show normal faults with small strike slip movement. Tension stress is more horizontal and trending NE–SW in this zone.

Further south in the Shadwan Island, Fairhead and Girdler 1970, reported an earthquake (Mb = 6) in March 1969 preceded by three foreshocks and followed by 17 aftershocks. Maamoun and El- Kashab 1978 reported 35 foreshocks during the last half of March 1969 preceding the main shock. Ben Menahem and Abodi 1971 located its epicenter to the northwest of Shadwan.
Island and found that the ruptured zone appeared to extend 30 Km. to the southwest. In this event, earth slumps and rock falls were common. Fissures and cracks in soil were found with a main direction nearly parallel to the Red Sea- Gulf of Suez trends.

Generally, the Gulf of Suez trend is characterized by the occurrences of shallow, micro, small, moderate and large earthquakes. Activities are limited within the crust. The activity along this trend is mainly attributed to the Red Sea rifting along several active faults.

On August 14th, 1846, a ship was endangered by a tidal wave following submarine seisms in the Red Sea. The risk of "Tsunamis" should not be neglected for coastal installations.

Fig. 21- Sketch map of the structural aspects of the Nubian-Arabian Shield margin in Northern Egypt and Sinai. (After Schlumber-ger, 1984)
VI-C Neotectonics

With regards to the neo-tectonics, the eastern parts of the proposed site for the project are considered unstable due to the effects of the recent earthquakes.
VII – MAN-INDUCED HAZARDS

VII- A- Land Subsidence:

Due to the neo-tectonics and recent activities of the earthquakes in addition to the oil extraction (production), may cause a land subsidence that can threat the eastern part of the study area closed to the coastal area.

VII- B- The Impact of Oil fields:

As far the selected area for the project is located nearby the Ras - Baker and Ras - Gharib Oil Fields, the impact of the heat, smoke and gas emissions especially at the eastern part of the project area, should be taken into consideration.

Shukeir Inland (Onshore) Oil Field

VII- B- The Archaeological Sites:
Gebel El-Zeit area was a source for the Galena, Lead and other minerals during the Old and Neo Kingdoms periods. The old mines and the ancient settlements at Gebel El-Zeit represent a special kind of archaeological sites.

In fact, the transmission line will not affect these sites as far as the project location will be west of these sites.

The location of the old mines in Gebel Zeit

VIII- ENVIRONMENTAL IMPACTS
OF THE PROJECT
This chapter deals with the significance evaluation of the identified potential changes that may occur within any component of the environment due to the project activities and their consequences. According to the Environmental Law No.4, Year 1994, this study present the impact of the project on the environment and the interaction between the environment and the project as in the following:-

**VIII - A- Environmental Impact on radar installations:**

The U.S. Department of Defense has released a report about the impact of wind farms on military radar installations. The report undermines previous U.S. Air Force report which stated that *the impacts were minimal*, and the new report calls more a more in-depth look at the risks. The report covers all aspects of risk, including the impact on military radar, commercial air radar and fishing and ocean navigation systems. The department would like to see radar 'red zones' implemented in order to appease national security concerns and maintain the credibility of current systems.

**VIII -B- Environmental Impact on Water Resources:**

In the project wind farm site , the sewage disposal system of the offices and in the rest-houses should be leading to the local sewage treatment plant before discharged into sewage system or be re-used for irrigation of green defense belt

**VIII -C- Impact on Wildlife, Human Activities:**

The construction of the planned wind farm project and the transmission line are not likely to change the environmental conditions. A few numbers of
migratory birds were observed around the Sabkha and Wetland area located at the eastern part of the project area. The present project may provide more job opportunities and may contribute to a better standard of living.

**VIII - E- Environmental Impact of the Earthquakes:**

The eastern part of the study area is vulnerable to earthquakes. This should be taken into consideration during the design and the foundation and the installation of the towers and the turbines.

**VIII - F- Impact due to the Flash Flood:**

According to the morphometric parameters proposed by different authors, the flash flood risk assessment in the study area will be in a medium grade due to the following facts:

1. The area is located and bounded along the southern cliffs of El-Galala El-Qibliya Plateau throughout Wadi Tarfa and Wadi Abu Had.
2. The main catchments area of Wadi Tarfa, Wadi Abu Had and the northern upstream of Wadi Qena which drains its surface water to El-Mina in the Nile Valley, Ras Gharib Town in the Red Sea Coast respectively.

As far the Transmission Line is passing through Wadi Abu Had and the northern upstream of Wadi Qena Basin, the project will be subjected to the impact of the flash flood hazards. The project area can be divided into 3 sectors (Appendices B-1, B-2 and B-3). In each sector, the risk zone
area is marked and determined in the intersection of the Transmission Line with the main drainage system and wadi tributaries.

It is highly recommended to trace the Transmission Line on the top of the Wadi Terraces above the level of the wadi course and in the downstream side of the wadi. In this case, the road will be acting as a dyke to reduce the velocity of the surface runoff and to minimize the risk of the flash flood hazards.
LIST OF APPENDICES

A – Mineral Resources Map:-

   A- 1- Non Metalic Mineral Deposits and Occurrences in Egypt

   A- 2- Metallic Mineral Deposits and Occurrences in Egypt
B- Risk Zone Maps:

3 Risk zone areas Maps for Sectors, (A-B-C-)

C: - Satellite Image showing the Drainage lines in Gabal El-Zeit
   – Esh El-Mellaha Range
Appendix B -1 : - Risk Zone area ( A)

1- N 28 10 58 20 E 32 37 11 23
2- N 28 12 35 55 E 32 38 54 87
3- N 28 14 40 17 E 32 41 25 77
4- N 28 15 15 27 E 32 41 43 09
5- N 28 16 23 71 E 32 42 39 45
Appendix B -2 : - Risk Zone area ( B )

1- N 28  08  29 80  E 32  30  57 66
2- N 28  15  05 10  E 32  41  42 29
3- N 28  16  59 04  E 32  43  08 67
Appendix B -3 : - Risk Zone area ( C )

1- N 28 12 13 03 E 32 22 18 80
2- N 28 10 39 69 E 32 24 11 16
3- N 28 09 50 50 E 32 26 11 10
4- N 28 08 29 80 E 32 30 57 66
Appendix C: - Satellite Image showing the Drainage lines in Gabal El-Zeit
-Esh El-Mellaha Range
Generally, the climate of the northern part of the Eastern Desert is characterized by aridity typified, very low rainfall, high summer temperature and vigorous winds with average 16.5 Km/h.

The following meteorological features can be summarized.
**I-1-Air – Temperature:**

The temperature generally diminishes from October to January, and then raises continuously, the maximum being in April and the minimum in the last week of December and beginning of January. The average recorded temperature is 21.2°C as a minimum and 47.5°C as a maximum (Table 1) during the summer. The maximum temperature record is 47.5 in El-Minia and the minimum is -1.3 in St. Antony Monastery.

<table>
<thead>
<tr>
<th>Station</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annu. average</td>
</tr>
<tr>
<td>Beni Suef</td>
<td>21.6</td>
</tr>
<tr>
<td>El-Minia</td>
<td>21.2</td>
</tr>
<tr>
<td>St. Antony</td>
<td>22.2</td>
</tr>
</tbody>
</table>

**I-2-Sand Temperature:**

The near-surface recorded temperature is 7°C as a minimum and 30°C as a maximum during December, 6°C as a minimum and 43°C as a maximum during March, and 17°C as a minimum and 58°C as a maximum during August.

**I-3- Ground Radiation:**

The minimum ground radiation recorded (temperature in vacuo) is 5°C during December and 6°C during March.

**I-4-Relative Humidity:**
The relative humidity, in general, is 42 – 44 % during summer and 46 – 50 % during winter (Table 2). The average relative humidity percentage recorded is 31 as a minimum and 63 as a maximum during December.

Table 2:- Relative Humidity

<table>
<thead>
<tr>
<th>Station</th>
<th>Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>06 U.T</td>
</tr>
<tr>
<td>Beni Suef</td>
<td>63</td>
</tr>
<tr>
<td>El-Minia Aver.</td>
<td>50</td>
</tr>
<tr>
<td>St. Antony</td>
<td>44</td>
</tr>
</tbody>
</table>

**I-5- Frost and Snow:**

Frost and snow were recorded far in the higher altitudes near the watershed. In the Red Sea Hills, such an occurrence is almost seldom, but water-bags are occasionally frozen on the mountain tops at night. In the district of Gabel El-Shayib severe cold weather and frost was experienced during the period of the last week of December and the beginning of January. It may therefore be safely stated that a marked general cooling would have been accompanied by greater snowfall and frost in the mountain regions.

**I-6- Surface Wind:**

Generally, the N – NW wind is prevailing. The ranges of hills arrest the south-western winds, or the eastern-trending currents of the Mediterranean air-movements. Sand-free and sand-carrying winds are prevalent, also wind storms. Cool NW winds prevail in the study area. The wind velocity (in wadis) during the month of December was recorded as 9 miles / hour for the maximum and 0.125 miles / hour for the minimum ( Fig. 4 ).
The main points are:

1- Wind, mainly from the north-west was especially prevalent during the Months of March & April, and also towards the end of December.
2- Two recognized areas of maximum cold and wind, Ras Gharib in the north and Gabel El-Shayib.
3- Sand – storms mark the maximum of the temperature oscillations in the months of February, March and April (Khamasin Winds) and attain their greatest effect in the long valleys and plains which run in the direction of prevalent wind, viz., northwest. In the mountains, these sand-storms are commonly replaced by heavy NW – winds, without carrying sands.
4- The hot, dry, sand- laden winds called "Khamasin" usually blow for 4 – 5 days in March & April , at these times the shade temperature rises to over 45 C and the air is thick with sans and dust

On the other hand, according to Yehia et al 2002, showing the mean monthly wind roses recorded at the stations surrounding the Gulf of Suez area, namely ; Suez (No. 450) Sudr (No. 455), El-Tor (No. 459) and Hurghada (No. 463), (After the Egyptian Meteorological Authority, 1996). The wind roses represent the percentage ratio of the frequencies of occurrence of wind (the length of the column) blowing from certain direction. The different parts (with different colors and widths) of the column represent the wind speed range in knots. The number in the circle represents the percentage ratio of calm wind frequency multiplied by 10.

I-7- Rainfall:

The rain is naturally an important factor in all cases. The rainfall, winds and storms are connected with movements of the great exceptional atmospheric depressions from the Mediterranean area, which affect the area
under the consideration during the most of the year. The depressions or the storms are accompanied by southerly winds and warm weather in front of the trough and colder weather, northerly winds and rain is rear. According to Craig, 1910, there is a traverse track from WSW to ENE passing over the Gulf of Suez area during March. Another track existed in April traversed from SSW to NNE over the Ras Gharib area whereas in May, a track traversed from West to East, to the immediate vicinity north of Hurghada (Table 3 & Fig 5). The practical interest of these cyclonic systems to the country is that all the rainfall is associated with them; their study makes "Khamasin" prediction and storm prediction possible.

Accurate rainfall isohythal map are not available, but it can be said that precipitation on the high mountains which rise to a height of some 1000 m., is of the order of 25 mm /annually. This figure decrease eastward to the coast and westward to the Nile Valley. The average rainfall in St. Antony is 10.4 while in El-Minia is about 5.3 mm. Other observations have been recorded and are summarized as in the following points:-

- The area is to a large extent rainless
- Heavy clouds accumulation over the highlands especially from January to March

<table>
<thead>
<tr>
<th>Station</th>
<th>Rainfall</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Annu. Average</td>
<td>Maximum 24 hours</td>
</tr>
<tr>
<td>Beni Suef</td>
<td>8.5</td>
<td>16.6</td>
</tr>
<tr>
<td>El-Minia</td>
<td>5.3</td>
<td>10.2</td>
</tr>
<tr>
<td>St. Antony</td>
<td>10.4</td>
<td>18.3</td>
</tr>
</tbody>
</table>

**I-8- Dew:-**
Heavy dews fall during the night and early morning in the winter months and constitute an important factor in supporting fairly abundant vegetation.

II- REGIONAL GEOMORPHIC FEATURES

Generally, the Eastern Desert is a wilderness of ranges extending in a NNW - SSW directions from Ain Sukhna region to Sudanese border, over nearly 1000 km. and rising from 1000 to over 2000 m.a.s.l. Towards the Nile Valley, the decline is more gentle and marked with tabular landscapes and low hills.

The geomorphic features in the study area depend on their geological structure, lithology and in part on the paleo-climatic conditions and the groundwater behavior.

The following is the main geomorphic features in the area under the consideration:-
II- 1- The Limestone Table Land (El-Galala El-Qibliya Plateau):

The two Galalas (Northern and Southern) are separated by the major E-W consequent Wadi Araba, which debouches into the Gulf of Suez, assuming 90 km in length. The wadi collects its water from both scarps on either side. On the other sides of the watershed, Wadi Sannur runs for 100 km in a westerly direction before it reaches the Nile. The Southern Galala Plateau is separated from the western cliffs bordering Wadi Qena by the major consequent Wadi Tarfa, which flows westward to the Nile Valley.

North of this wadi, the Southern Galala is triangle in shape, the apex being at Gebel Thelmet, whereas the base lies about 80 km to the southwest at Sikket El Agel. From here on, the scarp continues bordering Wadi Tarfa to the east of Maghagha at the Nile Valley. At the eastern side of the Galala, the altitude is 1200 m a.s.l., decreasing rapidly to 609 m a.s.l at Sikket El Agel to 243 m a.s.l. opposite Maghagha. The Plateau is covered by Eocene limestone with minor shale interbeds to the west. The surface on top is highly rough dissected by many faults parallel to the Gulf of Suez forming many benches and blocks showing angles of dips in different directions. The southeast scarp of the Southern Galala together with the eastern scarps of Wadi Qena form a major arch extending for almost 250 km in south direction before the scarp bends suddenly to the west at the area of Bir Aras and Wadi El Qreiya heading to the Nile.

At the eastern side of the arch and till the Gulf of Suez, a complex and rough terrain is covered by interlocking basement and sedimentary rocks. The basement makes the apex of its triangle outcrops before it starts to widen out considerably to the south forming the main mass of the Red Sea Hills. At its northern tip the basement is covered by varied thicknesses of Phanerozoic sediments, however the Paleozoic thicknesses never exceed to 600 m as by drilling in Wadi Araba. The outcropping rocks are mostly Cretaceous and
Eocene amounting to more than 1 km in thickness though in the Gulf itself more thicknesses are attained.

The undisturbed Eocene limestone plateau give rise to flat – topped plateau which boldly dominate the surrounding relief. The Southern Galala (El-Galala El-Qibliya Plateau) is one of the main massive tabular blocks of high relief (1200 m.)- (Fig. 1). It is an uplifted blocks between WSW – ENE faults of the Eocene limestone table land.

II- 2- Wad's and Drainage System:

The study area crossed by three main wad's. The central parts represent an area for surface water divide between these wadi basins. Each of these wadi represent a different system as follows:

- Wadi Tarfa (Nile Valley system).
- Wadi Qena system

In the following, a short note will be given to describe each one: -

1- Wadi Tarfa:-

This wadi is the second major wadi in the north Eastern Desert. Lt has a long history since the Oligocene uplift of the Red Sea Hills, when the reversal in slope of the main Egyptian land took place from south to north during the Cretaceous up to the late Early Eocene to east- west during the Oligocene and most of the Miocene. Before the detachment of the Western

2- Wadi Qena:-

Wadi Qena is considered as one of the biggest wades' in the eastern desert area. The surface area of Wadi Qena is estimated to be more than 15,000 km2. The wadi extends from the north east side to the south west side (nearby Qena city). For the sake of simplicity, Wadi Qena can be divided into 18 sub-catchments. Each sub-catchment consists of four types of soils
with different percentages. The flowing water of many far wades (300 km far from Wadi Qena) collect in the Wadi then go to the Saela El-Armania canal which had been made especially to avoid the runoff disaster (Saela El-Armania located at km 6 in Qena-Safaga road way). This canal was the main reason to save Qena city from great disaster as the velocity of flowage water reached about 70 km/hr.

**II-3- Alluvial Fans:**

Alluvial fans exist mainly where a distinct boundary exists between the uplifted blocks and the adjacent plains. In the study area, alluvial fans are common along faulted block fronts. The bajada of the region consists of a series of coalescing alluvial fans built by streams which debauch onto the piedmont and spread their detritus radially outward from the mouth of the wad's.

**III - GEOLOGICAL SETTING**

**III - A- STRATIGRAPHY**

**III - A- The Geology of El- Galala El-Qibliya Plateau:**

In the present study, the stratigraphy of the exposed rock units exposed in El-Galala El-Qibliya main scarp is dealt with (Table 4). In the following is a brief description of each rock units from older to younger (Fig. 7B).

- **Malh Formation:** This term was first introduced by Abdallah and Adindani (1963) to describe the Lower Cretaceous section that exposed at El-Galala massif. This unit was first mapped from Wadi Qena in the south (Nubian Sandstone). It was traced and recognized from the southern cliffs of El-Galala El-Qibliya massif to the scarps overlooking Wadi Arabe in the north. At the southern cliffs of El-Galala El-Qibliya massif, this unit is found as a nearly vertical cliff overlain by the Cenomanian marine rocks and underlain by the Paleozoic rocks or rest directly over the basement rocks. It is found in
the form of hills or dissected ridges at the foot slopes of the main scarp. This sandstone overlies the red shales of possibly Permo-Triassic or upper Paleozoic age and underlies the marine Cenomanian rocks. Lithologically, this unit is mainly consists of 80 m. of non-fossiliferous sandstone, formed of multicoloured alternating, cross-bedded sandstone, mainly white and pale pink, fine to coarse grained intercalated with shale and kaolinitic clay.

Recently, in Wadi Qena area, this sequence was divided into two units for which a Jurassic age is assigne to the lower unit and the Lower Cretaceous was assigne to the upper unit.

- **Galala Formation**: - This term was first introduced by Abdallah and Adindani (1963). This marine rock is well represented all over the area and can be easily identified lithologically and paleontologically from the underlying sandstone and the overlaying thick carbonate unit. This unit covers highly dissected parallel scarps due to intensive faulting systems in the area. In most cases, the formation beds are faulted down against the Turonian or younger beds. This unit attains a maximum thickness of 80 m. and consists of two members, a lower marly and shally member and an upper carbonate one. Generally, the formation is highly fossiliferous with different assemblage: *Exogyra sp.*, *Ostrea sp.*, *Hemiaster sp.*, *Strombus sp.*, *Flabellammina sp.*, and others

- **Wata Formation**: - This unit covers relatively low dissected and undulating escarpments or isolated hills on top of the Cenomanian (Galala Formation). The rocks attains a thickness of 60 m. and has a wide areal distribution with a relatively high clastic ratio at its base. Generally the Turonian beds have a great variation in thickness and are highly dissected by faults.

Lithologically, the Turonian rocks are mainly consists of grayish white limestone, hard dolomitic limestone alternating with marl, dark
brown sandstone and varicoloured shales. It is highly fossiliferous with *Thomasites sp.*, *Tylostoma sp.* *Llinthia sp.*

- **Matulla Formation**: - It is well distributed in the area studied forming a dissected secondary ridges or isolated hills piled above the Turonian escarpments. It is characterized by its typical cross bedded sandstone composed of dark brown and red ferruginous sandstone capped by dark quartzite, intercalated with dark grey and green shales, fossiliferous with badly preserved pelecypods and oyster fragments. Generally the exposed beds of the unit attain a thickness of 30m. and in most cases dipping with angle 25. On the other hand, by correlating these rocks with similar rocks cropping out further north at the eastern cliffs of the Northern Galala, Awad and Abdallah (1966) allocated a Coniacian age for these beds and used the term (*Taref sandstone member of Nubia Formation*) and its age was assigned to Coniacian-Santonian ages based on microfaunal contents.

- **Duwi Formation**: - The Campanian Duwi Formation is mostly found as isolated hills on top of the Santonian beds at the southern slopes of El-Galala El-Qibliya Plateau. With an average thickness of 39 m. while at the base of the plateau it has a maximum thickness of 170 m. east and west of St. Antony Monastery. Lithologically, the sequence mainly consist of yellowish marly limestone, grey tinted limestone, dark brown sandstone and clay interbeds with several phosphate layers (30 – 40 cm. thick). The phosphate is characterized by an abundance of shark teeth and bone fragments, including *Ostrea sp.*, *Pecten sp.* The most top part of the section is characterized by a chalky phosphatic bed, 150 cm. thick. This bed can be easily traced all over the area studied and along the scarp face thus makes a key horizon between the Campanian and the overlying Maastrichtian rocks.
- **Sudr Formation**: - The Maastrichtian- Lowe Paleocene rock units are found as sporadic outcrops along the southern slopes of the main Galala massif. At the southern cliffs of El-Galala El-Qibliya, the Aastrichtian – Paleocene rocks are overlain by the Esna Formation. At St. Paul Monastery area, the Esna Formation thins out gradually to a limit where the Maastrichtian – Paleocene rocks are unconformably overlain by middle Eocene limestone. Lithologically, the Maastrichtian – Paleocene rocks are mainly composed of snow whit chalky limestone and marl at top, generally poor in fossils rich in calcite veinlets, pyrite and stem like concretions of iron oxides.

- **Esna Formation**: - The Landenian – Lower Eocene Esna Formation represented at the southern cliffs of El-Galala El-Qibliya Plateau by the Esna Formation which assumes an average thickness of 20 m. Northwards, the Esna Formation wedges out till it completely disappears 20 km. south of St. Paul Monastery. Lithologically, it is composed of papery and gypseous green shales intercalated with thin chalky and marly limestone bands. The microfaunal assemblage includes *Marginulina sp.*, *Pseudoclavulina sp.* and others which assigns the age to Landenian – Lowe Eocene.

- **Lower Eocene**: - Lower Eocene crops out at the southern cliffs of El-Galala El-Qibliya Plateau and mainly consists of about 90 m. of chalky limestone at the lower part and grayish white sandy limestone with flint concretions and chert bands with badly preserved nummulites and forming a steep vertical face.

- **Mokattam / Minia Formation**: - The middle Eocene rocks are well developed at the northern scarps of El-Galala El-Qibliya. It forms the main bulk of the scarp face and the plateau surface with the maximum thickness of about 250 m. Lithologically; it is composed of thick-bedded siliceous limestone intercalated with marly limestone and gritty sandstone, fossiliferous with several nummulitic bands and
badly preserved gastropods, pelecypods and oyster fragments. The section grades upward to chalk and chalky limestone m thick-bedded containing *Nummulites gizahensis*. 
### Table 5 - Generalized Stratigraphic Column for the Southern Galala Plateau

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Limestone</td>
</tr>
<tr>
<td>2</td>
<td>Sandstone</td>
</tr>
<tr>
<td>3</td>
<td>Mudstone</td>
</tr>
<tr>
<td>4</td>
<td>Shale</td>
</tr>
<tr>
<td>5</td>
<td>Volcanic</td>
</tr>
</tbody>
</table>

*Note: This table represents the stratigraphic layers found in the Southern Galala Plateau.*
Fig. 7 B :- Geological Map of El-Galala El-Qibliya Plateau

III - B - STRUCTURE:
III-B-1- Faulting:

The western Gulf of Suez was structurally controlled by the major western marginal fault. The faulting systems are in different trends; NW-SE, NE- SW with minor E-W trend. Generally, they are normal, gravity types with a downthrown toward the center of the Gulf and along the scarp face of the Northern and Southern Galala Plateaus. They are not continuous with partial overlap. In addition, most of these faults are considered to be of Post Miocene and Pliocene ages.

- The main fault trends (Figs. 8 &.9 & 10) are:-
- N 65 W trend: This trend is related to the Gulf of Suez. The faults here are normal, gravity and longitudinal type. The downthrown is toward the north and northeast.
- N 25-35 W trend: This is the Gulf of Suez trend (Pelusic trend). Most of faults are normal, gravity, strike and longitudinal types.
- N 15-25 E trend: This is a minor trend which is related to the Gulf of Aqaba system.
- The faults have an N 30 W and extend for about 8 km length. The spring of St. Paul Monastery is situated at the intersection of two faulting system, i.e., N 30 W and N 65 W trend.
- Jointing is very complex, especially in the basement rocks, with substantial variation in both density and orientation. The basement is most highly faulted, with some areas appearing almost shattered. Within the sandstone sequences, great variations are apparent, with some areas containing only widely spaced joints, but others showing swarms of parallel, closely spaced joints. Several ages of joint and fault development are apparent from an examination of cross-cutting relationships in the rocks. The oldest fracture sets are N 70 E Tethyian trend. Traces of other faint older trends can be
observed at various joint stations. The E–W trend is most likely the next oldest, including a growth fault in the Cretaceous sediments. During the Early Tertiary, the Cretaceous section was tilted approximately 25° to the southwest, as indicated by the configuration of the pre-Miocene erosional surface.

Jointing and faulting along the Suez trend was initially dominant, with Gulf-ward step faulting involving basement becoming pronounced. There is some suggestion that the shallowest dipping Gulf-parallel faults are the oldest, indicating a continuing sequence of faulting as the horst block rotated. The final faulting and jointing involved the arching of the horst, generating conjugate normal fracturing and faulting along the Aualitic trend and rejuvenating other trends to form the complex cross-graben system.

**III-B-2- Dips:**

The general dip ranges from 20-100 except at the area neighborhood to the fault plain.

**III-B-3- Folding**

The study area was strongly affected with asymmetric folds of the Syrian Arc Folding system which represented in both surface and in the subsurface. On the surface, it represented by Wadi Araba anticline. This heights was responsible for the disconformities between the Upper Cretaceous-Middle Eocene at the southern Galala Plateau.

IV – NATURAL RESOURCES

**IV-C-Ornamental and Building Stones Materials:-**
Granite, Dolomite and building stone materials can be exploited from the exposed different rock units (Appendices A1 & A2).

V. WATER RESOURCES

V-A- Groundwater Resources:-

Ground water in the shallow alluvial aquifers of the Eastern Desert and in the karstified Eocene limestone aquifers underlying the alluvial aquifers could provide an alternative renewable water resource. In the Eastern Desert, rainfall
is collected as surface runoff through networks of alluvial channels in the main valleys and as ground water in the shallow alluvial and limestone fractured aquifers flooring the main valleys.

The subject of this study is the ground waters in the shallow (< 150 m) alluvial and limestone aquifers of Wadi El-Tarfa (Fig.13) and Wadi Qena. Here, Quaternary deposits comprise wadi and floodplain deposits. The alluvial deposits were eroded from the dissected plateau and the Red Sea hills and were deposited within the valleys. The floodplain deposits of the Nile Valley are made up of relatively thin (7 m) Holocene units of fine mud and silt deposited by repeated seasonal floods during the Last Pluvial Period (past 8,000 y). The sediments are underlain by thicker deposits of middle Pleistocene sand and gravel under the Nile Valley proper. Figure, 14 showing the hydrogeological conditions in the study area.

The Quaternary deposits rest on karstified carbonates of Eocene and Upper Cretaceous ages. The carbonates are underlain by Paleozoic-Mesozoic Nubian sandstones that host nonrenewable fossil waters under high pressure (Fig. 13). Isotopic Data from Wadi El-Tarfa Hydrogen and oxygen isotope ratios were determined by the methods of Coleman et al. (1982) and Socki et al. (1992), respectively. Hydrogen and oxygen isotope ratios are expressed as

\[ \delta = \left[ \frac{R_{\text{sample}}}{R_{\text{standard}}} - 1 \right] \times 1000, \]  

[1] where R represents the ratio of D/H or 18O/16O, respectively, in the sample and the standard.

The Wadi El-Tarfa ground waters have isotopic compositions that are quite distinct from those of the Nubian aquifer paleowaters. This result indicates that the samples could be composed mostly of evaporated rainwater, such as flash flood waters that must occasionally infiltrate the shallow alluvial aquifers and the underlying limestone aquifers in the study area. Because the water table in all investigated wells is above the Nile River level (RIGW, 1988) the modern Nile River is unlikely to be the sole source of the ground water under investigation. Tritium (3H), the radioactive isotope of hydrogen, has a half-life
of 12.43 y. Tritium was produced during the atmospheric testing of fusion bombs between 1953 and 1964 and is an excellent tracer for recharge, flow, and mixing processes of young ground waters (Plummer et al., 1993).

**V-B- Occurrence and Distribution of Water Resources:**

The extent of water supply depends largely on the direct rainfall, as much of the water occurs in rock-Poole in the upper mountain-valleys. Water-Poole are abundant and of long standing in the central hills. The valleys draining from them will have good underground water supplies at their heads, gradually diminishing in quantity and increasing in salinity as we pass eastwards to the Gulf of Suez. Generally, in this hilly regions composed of igneous & metamorphic and sedimentary rocks, wells in the valleys are frequent. At depth from 8 to 10 m., the groundwater varying in their quality & quantity according to the nature of the season, e.g. whether rainy or rainless.

Generally, water is good in winter after the rainfall in the ranges and unpleasantly salty in the summer or during rainless period. For normal drinking purposes, fresh water of salinity up to 1000 p.p.m. can satisfactorily be used, Saline water, of salinity ranging from 1000 to 3000 p.p.m. , is used for limited irrigation in a sandy soil. Very saline water has a salinity range of 3000 – 5000 p.p.m., the brackish is of 5000 – 10000 p.p.m., and that over 10000 p.p.m. is considered as sea water or brine, for instance, the average water salinity for the open Red Sea is 42000 p.p.m. while in the Mediterranean open sea is about 37000 p.p.m.

The following is a short account of all resources or supplies known to exist within the study area.

**1- Bir St. Antony Monastery:** - The water issuing along faults between Senonian – Cenomanian beds and resemble the potable water found at alignments of the Monastery. The water of this spring is markedly fresh and
drinkable by the devotees of the Monastery in the neighborhood. The spring is located within an obviously fissured and jointed Turonian limestone plateau and is surrounded by a small forest of palm trees. The supply for this spring is at a rate of 98 m³/day.

2-Bir St. Paul Monastery: - This consists of two wells and one spring of potable water located within the same Turonian limestone plateau as Bir St. Antony. Horizontal channeling, cracking and fissures making an interlacing network also occur. These assist in the continuity of the aquifer for a considerable distance, probably exceeding 22 km., i.e. over the distance between springs at both Monasteries.

3- Bir Abu Kheleifi (Abu El efieh):- This is a spring issuing abundant supply of brackish water from a fault plane between Senonian and Cenomanian.

4-Bir Uldahal: - It is also a spring issuing abundant water from a similar fault and was reported as a best seen in this locality.

5-Bir Kufra: - This is situated at the foot of the porphyry range north of Gebel Dokhan, being the center of water–supply for a wide region. It was reported that it is of great importance to anyone desiring to explore certain portions of the Red Sea Hills. In addition to this, it may be recalled that there are plentiful holes at the foot of Gebel Abu Harbo, some 7 km. SW Bir Kufra, which would be filled after a rainy and as these are dry, the Arabs obtains a supply from the neighbourhood of Gebel Abu Marwa some 4 km NW Bir Kufra.
Fig. 13: Wadi Tarfa Hydrogeological Cross-Section (after Sultan et. al., 2005)
Fig.14: Hydrogeological map of the study area (after RIGW, 1988)

VI – NATURAL HAZARDS
The area usually suffered and threatens by the main natural hazards; flash flood and earthquake.

**VI- A - Flash Flood:**

Nevertheless, the region is occasionally subjected to heavy rainstorms that commonly followed up by floods. These may cause disastrous impacts on life, roads and settlements.

The system of natural drainage of the area is remarkably simple, but little rain, as is well known, falls in central and southern portions. The rain-channels are dry during the greater part of the year and vary in length according to the season.

**Surface Runoff Modeling:**

The model construction involved extraction of geomorphologic and lithologic information from Landsat thematic mapper (TM) scenes and digital terrain elevation data (DTED) to enable estimates to be made for initial loss, recharge rate through transmission loss, and runoff at the watershed’s outlets. We adopted the U.S. Department of Agriculture-Soil Conservation Service method (SCS, 1985) to calculate initial losses in the sub-basins.

The model results were tested against field observations reported for El-Tarfa watershed during the 1994 event (Maim, 1995) and then applied to the Qena watersheds. These watersheds collect a large proportion of the precipitation in the study area. The frequency of rain storms, the size of the 1994 event was then estimated from archival precipitation data to constrain average annual ground water recharge. Hydrologic and floodplain studies were conducted by using the HEC-1 flood hydrograph package (USACE, 1991).
During the 1994 storm event, the major highway (which runs north-south) east of the River Nile at the outlet of Wadi El-Tarfa acted as a dam behind which water collected. The absence of a drainage system under the highway at the time caused a lake to develop. On the basis of the field observations and those made by the Egyptian Geological Survey (Naim, 1995), the area of the lake was estimated to be 3.6 km². Its average depth was 0.5 m, as indicated by watermarks left by the 1994 flood event on a building within the lake. The volume of water in the lake was estimated at 1.8 × 10⁶ m³. Sultan et al., 2005, model predicted runoff at the outlet of Wadi El-Tarfa at 1.9 × 10⁶ m³ (Table 8).

Results for Sultan, et. al, 2005, four major watersheds in the northern part of the Eastern Desert are tabulated in Table 6. The lithology and topography of a watershed’s (Fig. 15) surface area greatly affect the partitioning of water between the estimated initial losses, transmission losses, and downstream runoff. Using Wadi El-Tarfa as an example. Sultan, computed the initial losses, transmission losses, and downstream runoff at Although the sub-basins draining into location A constitute only 9% of the total area of the Wadi El-Tarfa watershed (Fig. 15), the rainfall over this area encompasses approximately 15% of total precipitation over the entire watershed, demonstrating the preferential precipitation over the mountains compared to the downstream areas. The highest initial losses are encountered upstream, in areas largely covered by rocks of high infiltration capacity (Nubian sandstone). In these areas, initial losses amount to approximately 90% of the total precipitation over the sub-basins. Because the downstream and central sub-basins are largely composed of Tertiary outcrops with low infiltration capacity, the initial losses are relatively small (76-78% of precipitation). Transmission losses are relatively large over downstream sub-basins and in the central parts of the watershed, amounting to 16-20% of the total precipitation compared to 3.6% in the upstream area. This pattern reflects the relatively large runoff volumes and the wider and denser mesh of alluvial channels in the downstream and central areas. Conservative
estimates of average annual recharge for the examined watersheds were obtained by investigating the frequency of storms that appear comparable to or even more intense than the 1994 event. We identified 16 such events between 1929 and 1983 by assuming that reported monthly precipitation represents a single rain event. We estimate average annual recharge for the Tarfa, Qena, and alluvial aquifers at 4.7 × 10^6 m³, 14.7 × 10^6 m³, respectively, with the assumption that a large storm event of the magnitude of the 1994 event occurs once every 40 months. In addition, heavy to extreme rain storms selectively concentrated on the mountains could have gone undetected, given the absence of rain gauges over the mountains.

<table>
<thead>
<tr>
<th>Precipitation (x 10^5 m³)</th>
<th>El-Tarfa</th>
<th>Asyuti</th>
<th>Qena</th>
<th>Hammamat</th>
</tr>
</thead>
<tbody>
<tr>
<td>76.1</td>
<td>75.3</td>
<td>245</td>
<td>190.7</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial losses x 10^6 m³ (% of total precipitation)</th>
<th>El-Tarfa</th>
<th>Asyuti</th>
<th>Qena</th>
<th>Hammamat</th>
</tr>
</thead>
<tbody>
<tr>
<td>58.4 (76.7)</td>
<td>50.3 (66.8)</td>
<td>187 (76.3)</td>
<td>124.3 (65.2)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transmission losses x 10^5 m³ (% of total precipitation)</th>
<th>El-Tarfa</th>
<th>Asyuti</th>
<th>Qena</th>
<th>Hammamat</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.8 (20.8)</td>
<td>20 (26.4)</td>
<td>49 (20)</td>
<td>59 (30.9)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Downstream runoff (% of total precipitation)</th>
<th>El-Tarfa</th>
<th>Asyuti</th>
<th>Qena</th>
<th>Hammamat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.9 (2.5)</td>
<td>5 (6.8)</td>
<td>9 (3.7)</td>
<td>7.4 (3.9)</td>
<td></td>
</tr>
</tbody>
</table>

Table 8:- Results of Sultan Hydrology model for Wadi Tarfa, Assyuiti, Qena and Hammamat
Fig. 15: The main basins and the type of the surface rock units (after Sultan et. al., 2005)
Fig. 16: Wadi Tarfa Downstream
Fig. 17:- Wadi Tarfa network and some hydraulic parameters
(after Sultan et. al., 2005)

Fig. 20:- The drainage network of Wadi Qena basins.
This chapter deals with the significance evaluation of the identified potential changes that may occur within any component of the environment due to the project activities and their consequences. According to the Environmental Law No.4, Year 1994, this study presents the impact of the project on the environment and the interaction between the environment and the project as in the following:

**VII - A- Environmental Impact on radar installations:**

The U.S. Department of Defense has released a report about the impact of wind farms on military radar installations. The report undermines previous U.S. Air Force report which stated that *the impacts were minimal*, and the new report calls for a more in-depth look at the risks. The report covers all aspects of risk, including the impact on military radar, commercial air radar and fishing and ocean navigation systems. The department would like to see radar 'red zones' implemented in order to appease national security concerns and maintain the credibility of current systems.

**VII - B- Environmental Impact on Water Resources:**

In the project wind farm site, the sewage disposal system of the offices and in the rest-houses should be leading to the local sewage treatment plant before discharged into sewage system or be re-used for irrigation of green defense belt.
VII -C- Impact on Wildlife, Human Activities:

The construction of the planned wind farm project and the transmission line are not likely to change the environmental conditions. A few numbers of migratory birds were observed around the Sabkha and Wetland area located at the eastern part of the project area. The present project may provide more job opportunities and may contribute to a better standard of living.

VII - D- Impact on Archeological Sites:

Archaeological survey carried out during 1992 in the Wadi Abu Had in the Eastern Desert. Its main objective was to discover a secondary route in the less well-known areas of the Eastern Desert that could provide a link between Egypt and the Near East. The topographical layout of the region was examined and evidence sought on inhabitants, either itinerant or semi-nomadic, who might have occupied this area at various stages of prehistoric and historic Egypt. Large scatters of flint and knapping sites were discovered, dating from the Lower Palaeolithic to the Holocene. Additionally, stone structures varying from desert hearths, road markers, and small cairns to rock shelters were sighted, together with Bedouin remains and shard scatters.

The religious temple, Speos Artemidos, is a rock cut shrine 3km from Beni Hasan in a small wadi. The shrine probably dates to the Middle Kingdom, but it is most commonly associated with the new Kingdom and the New Kingdom. It was dedicated to the lion goddess Pakhet, who was an aspect of Hathor. The facade of the shrine consists of four pillars cut into the rock with a central doorway. The entrance opens into a hall with four pillars decorated with hieroglyphs and damaged reliefs. The most important inscription was left during the reign of Hatshepsut, and describes the
stabilizing effect of the reign of Hatshepsut following the chaos of the Hyksos rulers

**St. Paul Monastery:** - The Monastery of St. Paul probably dates to the fifth century and was founded in memory of one of Egypt's greatest saints and anchorites, who is said to have lived in a cave over which it was built for a period of some eighty years. We mostly know of his life from the writings of St. Jerome and his work, *Vita Pauli* (Life of Paul), which was written between 375 and 380 AD. St. Jerome tell us that, while it may have been St. Anthony who founded the monastic way of life by inspiring others, Amathas and Macarius, who were disciples of Anthony, affirm that Paul of Thebes was actually the originator of the practice.

![St. Paul Monastery in the south eastern cliff of El-Galala El-Qibliya Plateau.](image)

**VII - E- Environmental Impact of the Earthquakes:**
The eastern part of the study area is vulnerable to earthquakes. This should be taken into consideration during the design and the foundation and the installation of the towers and the turbines.

**VII - F- Impact due to the Flash Flood:**

According to the morphometric parameters proposed by different authors, the flash flood risk assessment in the study area will be in a medium grade due to the following facts:

1. The area is located and bounded along the southern cliffs of El-Galala El-Qibliya Plateau throughout Wadi Tarfa and Wadi Abu Had.
2. The main catchments area of Wadi Tarfa, Wadi Abu Had and the northern upstream of Wadi Qena which drains its surface water to El-Mina in the Nile Valley, Ras Gharib Town in the Red Sea Coast respectively.

*As far the Transmission Line is passing through Wadi Tarfa, Wadi Abu Had and the northern upstream of Wadi Qena Basins, the project will be subjected to the impact of the flash flood hazards. The project area can be divided into 6 sectors (Appendices B: -D-E-F-G-H-I-). In each sector, the risk zone area is marked and determined in the intersection of the Transmission Line with the main drainage system and wadi tributaries.*

*It is highly recommended to trace the Transmission Line on the top of the Wadi Terraces above the level of the wadi course and in the downstream side of the wadi. In this case, the road*
will be acting as a dyke to reduce the velocity of the surface runoff and to minimize the risk of the flash flood hazards.
APPENDICES

LIST OF APPENDICES

B- Risk Zone Maps:-

6 Risk zone Maps for Sectors, (D-E-F-G-H-I-)
C: - Satellite Image showing the Drainage lines in Gabal El-Zeit – Esh El-Mellaha Range
Appendix B-4 : Risk Zone area ( D )

1- N 28 17 10 85 E 32 14 57 42

Appendix B-5 : Risk Zone area ( E )

1- N 28 17 29 53 E 32 01 22 03
2- N 28 17 44 64 E 32 02 20 03
3- N 28 17 38 65 E 32 01 46 78
Appendix B -6: - Risk Zone area ( F )

1- N 28 15 29 71 E 31 51 25 50
2- N 28 16 25 43 E 31 53 51 65
3- N 28 16 51 93 E 31 56 22 46
4- N 28 17 10 53 E 32 oo 01 04
5- N 28 17 38 44 E 32 02 23 66
Appendix B -7 : - Risk Zone area ( G )

1- N 28 13 29 11 E 31 39 22 95
2- N 28 13 02 72 E 31 43 49 18
3- N 28 14 31 10 E 31 48 37 69
4- N 28 16 32 43 E 31 54 17 99
Appendix B -8 : - Risk Zone area ( H )

1- N 28 14 21 89 E 31 33 22 22
2- N 28 14 03 97 E 31 34 43 13
3- N 28 13 10 98 E 31 41 15 49
4- N 28 13 18 08 E 31 54 30 17
5- N 28 13 12 47 E 31 41 10 54
Appendix B -9: - Risk Zone for Sector ( I )

1- N 28 19 21 25 E 31 19 40 03
2- N 28 17 58 95 E 31 22 51 57
The following meteorological features can be summarized.

I-1--Air – Temperature:
The temperature generally diminishes from October to January, and then raises continuously, the maximum being in April and the minimum in the last week of December and beginning of January. The average recorded temperature is 21.2°C as a minimum and 45.7°C as a maximum (Table 1) during the summer. The maximum temperature record is 47.5°C in El-Minia and the minimum is -4.0°C in El-Minia.

Table 1:- Annual average & minimum and maximum temperature

<table>
<thead>
<tr>
<th>Station</th>
<th>Temperature (°C)</th>
<th>Annu. average</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beni Suef</td>
<td></td>
<td>21.6</td>
<td>45.7</td>
<td>-3.3</td>
</tr>
<tr>
<td>El-Minia</td>
<td></td>
<td>21.2</td>
<td>47.5</td>
<td>-4.0</td>
</tr>
</tbody>
</table>

**I-2-Sand Temperature:**

The near-surface recorded temperature is 7°C as a minimum and 30°C as a maximum during December, 6°C as a minimum and 43°C as a maximum during March, and 17°C as a minimum and 58°C as a maximum during August.

**I-3- Ground Radiation:**

The minimum ground radiation recorded (temperature in vacuo) is 5°C during December and 6°C during March.

**I-4-Relative Humidity:**

The relative humidity, in general, is 42 – 44% during summer and 46 – 50% during winter (Table 2). The average relative humidity percentage
recorded is 20 as a minimum and 80 as a maximum during December, 29 as a minimum and 75 as a maximum during March, and 43 as a minimum and 31 as a maximum during August.

<table>
<thead>
<tr>
<th>Station</th>
<th>Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>06 U.T</td>
</tr>
<tr>
<td>Beni Suef</td>
<td>63</td>
</tr>
<tr>
<td>El-Minia</td>
<td>Aver.</td>
</tr>
</tbody>
</table>

**I-5- Frost and Snow:**

Frost and snow were recorded far in the higher altitudes near the watershed. In the Red Sea Hills, such an occurrence is almost seldom, but water-bags are occasionally frozen on the mountain tops at night. In the district of Gabel El-Shayib severe cold weather and frost was experienced during the period of the last week of December and the beginning of January. It may therefore be safely stated that a marked general cooling would have been accompanied by greater snowfall and frost in the mountain regions.

**I-6- Surface Wind:**

Generally, the N – NW wind is prevailing. The ranges of hills arrest the south-western winds, or the eastern-trending currents of the Mediterranean air-movements. Sand-free and sand-carrying winds are prevalent, also wind storms. Cool NW winds prevail in the study area. The wind velocity (in wadis) during the month of December was recorded as 9 miles / hour for the maximum and 0.125 miles / hour for the minimum ( Fig. 4 ).

The main points are:
5- Wind, mainly from the north-west was especially prevalent during the Months of March & April, and also towards the end of December.

6- Sand – storms mark the maximum of the temperature oscillations in the months of February, March and April (Khamasin Winds) and attain their greatest effect in the long valleys and plains which run in the direction of prevalent wind, viz., northwest. In the mountains, these sand-storms are commonly replaced by heavy NW – winds, without carrying sands.

7- The hot, dry, sand- laden winds called "Khamasin" usually blow for 4 – 5 days in March & April, at these times the shade temperature rises to over 45 C and the air is thick with sans and dust

The wind roses represent the percentage ratio of the frequencies of occurrence of wind (the length of the column) blowing from certain direction. The different parts (with different colors and widths) of the column represent the wind speed range in knots. The number in the circle represents the percentage ratio of calm wind frequency multiplied by 10.

I-7- Rainfall:

The rain is naturally an important factor in all cases. The rainfall, winds and storms are connected with movements of the great exceptional atmospheric depressions from the Mediterranean area, which affect the area under the consideration during the most of the year.

Accurate rainfall isohythes map are not available, but it can be said that precipitation on the high mountains which rise to a height of some 1000 m., is of the order of 25 mm /annually. This figure decrease eastward to the coast and westward to the Nile Valley as recorded at El-Minia and Beni Suef Stations ( Table 3 )

Other observations have been recorded and are summarized as in the following points:-
- The area is to a large extent rainless
- Heavy clouds accumulation over the highlands especially from January to March

| Station      | Rainfall | Rainfall | Maximum  
|--------------|----------|----------|----------
|              | Annu. Average | 24 hours |          |
| Beni Suef    | 8.5      | 16.6     |          |
| El-Minia     | 5.3      | 10.2     |          |

### Table 3:- Rainfall Precipitation

I-8- *Dew*:-

Heavy dews fall during the night and early morning in the winter months and constitute an important factor in supporting fairly abundant vegetation.

II- **REGIONAL GEOMORPHIC FEATURES**

The geomorphic features in the Nile Valley Region area depend on their geological structure, lithology and in part on the paleo-climatic conditions and the groundwater behavior.

The following is the main geomorphic features in the area under the consideration:

**II-1-Dissected Plateau:**

The plateau overlooking the Nile assuming a relief ranges from 300 m in the eastern plateau to 200 m. in the western one. The plateau is very irregular in outline and shrinking generally in a north – south trend with several embayments and their corresponding promontories. The plateau is highly dissected with a group of faults which have a northwest-southeast direction.

**II-2- Pediments:**

There are two main rock-cut pediments are distinguished in the area namely, the Upper and the Lower pediments.

- The Upper Pediments: It stretches parallel to the scarp face bounding the plateau

  The pediments surface is a barren white limestone with clay intercalations stretching 3 to 10 km. east till it abuts against the scarp face of the dissected plateau. Over the surface of the Upper pediment, several limestone mesas and butts are encountered. This represents remnants of the surface of a limestone pediment (Retreated Scarp).

  Several east-west wadis dissect this surface. The most important of these are

  Wadi Tarfa and Wadi Sannur. These wadis incise their channels deeply in the limestone surface and in places the incision may reach up to 30 m.

- The Lower Pediment: It runs nearly parallel to the upper to the upper pediment and overlooks the Nile terraces to the west. In a few places along its stretches, the pediment forms a scarp of 44m. high above the Nile terraces . The surface of the pediment is covered by limestone beds which make a flat surface extending towards the Nile. The western side of the pediment is smooth in outline, only where fan-glomerates are present, the outline is irregular.
II-3- The Nile Terraces:

These make a thin strip along the Nile, 0.5 to 1 km. wide. Most parts of these terraces are now cultivated and only very limited rocky places are desert. Nile mud and silt of variable thickness are recorded.

II-4- Alluvial Fans:

Alluvial fans exist mainly where a distinct boundary exists between the uplifted blocks and the adjacent plains. In the study area, alluvial fans are common along faulted block fronts. The bajada of the region consists of a series of coalescing alluvial fans built by streams which debauch onto the piedmont and spread their detritus radially outward from the mouth of the wad's.

III-4- Sand Dunes:

It extends in a longitudinal shape from the central part of Wadi El-Rayen Depression to the western margins of the Nile Valley flood plain opposite the Dayrut town in the south for a distance of about 185 km. This field is composed of several parallel compound and complex dune belts extending in a SSE direction. It can be divided according to Embabi, 2004, into tow sections; the northern Wadi El-Rayen is dominated by linear dunes while the southern is barchans and barchanoid. Due to the impact of the northwesterly prevailing wind, it is expected that the sand move preferably down slop toward the Nile flood plain. In the stretch between El-Minia and Sammalut, this dune field of the extreme eastern belt are reclaimed and cultivated during the last three decades. However, dune movement and sand encroachment on the cultivated fields along the margins of the Nile flood plain represents a permanent threat to soil productivity and agricultural production in the west Nile Valley area (Kishk, 1990).
III- GEOLOGICAL SETTING

III- A- STRATIGRAPHY

**III- A - The Geology of Nile Valley Area:**

The exposed rock fall into the following stratigraphic rock units from base to top (Table 6):

1. **Moqattam Formation:** This term was first introduced by Zittel (1883) to describe the limestone and clastic beds at Gebel Moqattam east of Cairo. In the study area, the Moqattam Formation covers the two pediments at the foot slope of the main plateau. It consists of about 40m. of thick limestone
with thin shale and clay intercalation. The limestone is quarried in many places for building purposes.

Said (1971) stated that the Middle Eocene can be described in a four units, the Minia Formation, the Sammalut Formation, the Moqattam Formation and the Guishi Formation.

The Middle Eocene, Moqattam Formation is highly fossiliferous with *Nummulites gizehensis, Lucina pharaonis Ball, Fish teeth, Operculina sp.*, and others.

2- **The Qurn Formation**: The formation makes the slope of the eastern scarp and some patchy hillocks scattered over the pediment surface. It consists of about 95 m.

3- **Abu-Zabaal Formation**: It consists of basalt flow in the form of basalt dyke west of El-Bahnasa –Ahnasia area and trending in a North-West direction which parallel to the faulting system in the study area. The age was assigned to the Oligocene time.

4- **Kom El-Sheloul Formation (Umm Raqaba Formation)**: The Pliocene sediments are known from many small and patch outcrops in different parts of the Nile Valley. This term was first introduced by Sandford and Arkell (1939) to describe the marine Pliocene exposure around Abu Sir and Giza Plateau on the western bank of the Nile Valley. To the east at Gebel Umm Raqaba, similar exposures are located and described by Zaghloul, 1979 under the term Umm Raqaba Formation overlying the Eocene limestone bed rocks. It is consists of about 30 m. of clay and sandy clay.

5- **Idfu Formation**: The Idfu Formation (Gravels) represents the early fluviatile deposits during the Protonile phase. The formation mainly consists of gravels and coarse sands. It has a wide extension on the surface and limited on the subsurface. The age was assigned to the Early Pleistocene (Said, 1981).

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7- **The Qena-Dandara Complex**: - It is the most extensive and important unit for the groundwater aquifer in the Nile Valley and Delta. It consists of fluviatile sands. The maximum thickness exceeds 250 m. The Qena- Dandara complex was attributed to the Middle Pleistocene.

8- **Abbassia Gravel**: - It has a wide extension on the surface and limited extension in the subsurface. It represents the last pluvial period and arid conditions in which the older sediments were eroded by wind. It consists of about 15 m. of thick gravel section. The age was assigned to the Middle Pleistocene.

9- **The Debira-Arkin Formation**: - This is the youngest unit which represents the flood plain deposits of the famous fertile alluvial land of the modern River Nile. It is consists of silt, clay and silty clay, sandy silt at the base. The maximum thickness is about 12m. while it is reduced towards the outer portions. It rests over the eroded surface of the underlying units with marked unconformity surface. The age was assigned to late Pleistocene to Holocene.

10- **El-Khafoug Formation**: - The dune field of Wadi El-Rayan represents the third cycle of dune movement in west Minia region in which the Aeolian sand dune remains known as El-Khafoug Formation of Said, 1981, inter-finger both the Prenile deposits of the Middle Pleistocene ( ending 200,000 BP) and the Neonile sediments of Late Pleistocene estimated to be 12.000- 20.000 BP.

11- **Sand Dunes**: - It extends in a longitudinal shape from the central part of Wadi El-Rayan Depression to the western margins of the Nile Valley flood plain opposite the Dayrut town in the south for a distance of about 185 km. This field is composed of several parallel compound and complex dune belts extending in a SSE direction. It can be divided according to Embabi, 2004, into tow sections; the northern Wadi El-Rayan is dominated by linear dunes while the southern is barchans and barchanoid. Due to the impact of the
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encroachment on the cultivated fields along the margins of the Nile flood plain
represents a permanent threat to soil productivity and agricultural production in
the west Nile Valley area (Kishk, 1990).
Table 6:- Generalized Stratigraphic Column of the Nile Valley

Fig. 8:- Geological Map of the Nile Valley area
LEGEND

Recent
- Wadi Deposits.

- Sand Dune.

Holocene
- Cultivated Land.

- Alluvial Conglomerates.

Late Pleistocene
- Elkhefoug Formation (Neonile).

- Debeira Arkin Formation (Neonile).

Middle Pleistocene
- Abbasia Gravels (Neonile/Prenile).

Qena Dandara Formation (Prenile).

Early Pleistocene

Idfu Formation (Protonile).

Pliocene

Kom El Shelul Formation (Paleonile).

Oligocene

Abu-Za‘abal Basalt.

Miocene

Eocene Limestone.

Fault Line.

III-B - STRUCTURE:
**III-B-1- Faulting:**

The western part of the Nile Valley Plateau was structurally controlled by a group of faults. The general structural outlook of the area is one of the flat surface with very gentle dips (1 – 2) at the variable directions.

Youssef, 1968, recorded a major fault along the Nile at this area which he assumed to have the Gulf of Aqaba trend, i.e. N 15 E. and Gulf of Suez i.e. N 45W. Zaghloul, 1978, reported that the Upper Eocene at the eastern cliff of the Nile has a relative elevation of 327 m. in comparison with 237 m. at the western cliff. Most probably a group of faults are located near the present Nile channel culminating in the upthrown of the western side. Youssef, 1968, indicated that the stresses leading to this faulting movement are parallel to N 10 W and S 10 E.

The effect of these stresses on the area under consideration lies in change of the general northerly direction of dip to a southern component. The downthrown block was dragged down hence the change in the direction of dip.

The main faults are:

- **Gebel Umm Raqaba Fault:** - This fault runs in an N 65 W direction for a distance of about 6 Km. The fault plane swings few degrees to the north as well as to the south. The fault affects both the Upper Eocene and Pliocene sections. The thrown is to the north.

- **Wadi Sannur Fault:** - This fault runs along the southern bank of Wadi Sannur and has a N 48 W direction for a distance of about 8 Km. The thrown of the fault is to the north with an estimated amount of 10 m.

**IV – NATURAL RESOURCES**
The natural resources on the Nile Valley region can be summarized in the following:

1- The fertile agricultural soil
2- The Groundwater Resources
3- Limestone; Dolomite, Basalt and clay which quarried and used as
   a building stone materials, commercial marble, road pavements
   and Cement Factories (Appendices A1 & A2).

V. WATER RESOURCES

V-A- Groundwater Resources:

Due to the continuity of the water bearing formation, there is an east-west and west-east groundwater flow from the reclaimed area (high in elevation) to the flood plain aquifer. Little of this flow is intercepted by the drains, so the flood plain aquifer is continuously recharged. This causes upward leakage and water-logging of the original Nile Valley lands.
The Wadi El-Tarfa ground waters have isotopic compositions that are quite distinct from those of the Nubian aquifer paleowaters. This result indicates that the samples could be composed mostly of evaporated rainwater, such as flash flood waters that must occasionally infiltrate the shallow alluvial aquifers and the underlying limestone aquifers in the study area. Because the water table in all investigated wells is above the Nile River level (RIGW, 1988) the modern Nile River is unlikely to be the sole source of the ground water under investigation. Tritium (3H), the radioactive isotope of hydrogen, has a half-life of 12.43 y. Tritium was produced during the atmospheric testing of fusion bombs between 1953 and 1964 and is an excellent tracer for recharge, flow, and mixing processes of young ground waters (Plummer et al., 1993).

V-B- Groundwater Bearing Formations:-

In the vicinity of the flood plain, the main aquifer consists of sand and gravel of the Qena Formation capped with the recent Holocene silt and clay of the Debira-Arkin Formation. The sand and gravel extends to the desert fringes. The aquifer connects with the faulted Eocene limestone and underlain by the Pliocene clay. The maximum thickness is about 200 m. in the valley flood plain reducing to about 50 m. at the eastern and western fringes,
Fig. 13: Wadi Tarfa Hydrogeological Cross-Section (after Sultan et. al., 2005)

**V-c- Groundwater Level:**

The groundwater level ranges from 20 – 50 m. below the level of the ground surface.
V-d- Groundwater Quality:-

The groundwater quality within the reclaimed areas along the fringes of the Nile Valley differs considerably from one place to another, but is more or less constant and fresher in the old lands. It is brackish in the reclaimed area and adjacent desert (TDS ranging from 1000 and 3500 ppm) and is of the Na-Cl type. On the other hand, the groundwater in the flood plain is strongly related to the infiltrated surface water, being of the Ca-HCO3 type, with a TDS ranging between 400 and 800 ppm. (Attia, 1991).

VI - NATURAL HAZARDS

The area usually suffered and threatens by the main natural hazards; flash flood and earthquake.
VI- A - Flash Flood:

The climate of the Nile Valley is characterized by aridity typified by very low rainfall, high evaporation rate and high summer temperature. Nevertheless, the region is occasionally subjected to heavy rainstorms that commonly followed up by floods. These may cause disastrous impacts on life, roads and settlements.

The system of natural drainage of the area is remarkably simple, but little rain, as is well known, falls in central and southern portions. The rain-channels are dry during the greater part of the year and vary in length according to the season.

Surface Runoff Modeling: - The model construction involved extraction of geomorphologic and lithologic information from Landsat Thematic Mapper (TM) scenes and digital terrain elevation data (DTED) to enable estimates to be made for initial loss, recharge rate through transmission loss, and runoff at the watershed’s outlets. We adopted the U.S. Department of Agriculture-Soil Conservation Service method (SCS, 1985) to calculate initial losses in the sub-basins.

The model results were tested against field observations reported for El-Tarfa watershed during the 1994 event (Maim, 1995) and then applied to the Qena watersheds. These watersheds collect a large proportion of the precipitation in the study area. The frequency of rain storms, the size of the 1994 event was then estimated from archival precipitation data to constrain average annual ground water recharge. Hydrologic and floodplain studies were conducted by using the HEC-1 flood hydrograph package (USACE, 1991).

Results for Sultan, et. al, 2005, four major watersheds in the northern part of the Eastern Desert are tabulated in Table 6. The lithology and topography of a watershed’s (Fig. 15) surface area greatly affect the partitioning of water between the estimated initial losses, transmission losses, and downstream
runoff. Using Wadi El-Tarfa as an example. Sultan, computed the initial losses, transmission losses, and downstream runoff at Although the sub-basins draining into location A constitute only 9% of the total area of the Wadi El-Tarfa watershed (Fig. 15), the rainfall over this area encompasses approximately 15% of total precipitation over the entire watershed, demonstrating the preferential precipitation over the mountains compared to the downstream areas. The highest initial losses are encountered upstream, in areas largely covered by rocks of high infiltration capacity (Nubian sandstone). In these areas, initial losses amount to approximately 90% of the total precipitation over the sub-basins. Because the downstream and central sub-basins are largely composed of Tertiary outcrops with low infiltration capacity, the initial losses are relatively small (76-78% of precipitation). Transmission losses are relatively large over downstream sub-basins and in the central parts of the watershed, amounting to 16-20% of the total precipitation compared to 3.6% in the upstream area. This pattern reflects the relatively large runoff volumes and the wider and denser mesh of alluvial channels in the downstream and central areas. Conservative estimates of average annual recharge for the examined watersheds were obtained by investigating the frequency of storms that appear comparable to or even more intense than the 1994 event. We identified 16 such events between 1929 and 1983 by assuming that reported monthly precipitation represents a single rain event. We estimate average annual recharge for the Tarfa, Qena, and alluvial aquifers at $4.7 \times 10^6$ m$^3$, $14.7 \times 10^6$ m$^3$, respectively, with the assumption that a large storm event of the magnitude of the 1994 event occurs once every 40 months. In addition, heavy to extreme rain storms selectively concentrated on the mountains could have gone undetected, given the absence of rain gauges over the mountains.
Table 8:- Results of Sultan Hydrology model for Wadi Tarfa, Assyuiti, Qena and Hammamat

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<td>Precipitation ($\times 10^6$ m$^3$)</td>
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<td>Initial losses $\times 10^6$ m$^3$ (% of total precipitation)</td>
<td>58.4 (76.7)</td>
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<td>Transmission losses $\times 10^6$ m$^3$ (% of total precipitation)</td>
<td>15.8 (20.8)</td>
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<tr>
<td>Downstream runoff (% of total precipitation)</td>
<td>1.9 (2.5)</td>
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Flood water accumulation east of Beni Suef – El-Minia eastern Highway after the November 1994 flash flood.
Fig. 16: Wadi Tarfa Downstream
Fig. 17:- Wadi Tarfa network and some hydraulic parameters (after Sultan et al., 2005)

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<th>C</th>
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<td>0.7</td>
<td>3.4</td>
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The area under the consideration is located within the Craton Nubian – Arabian Shield as clearly shown on (Fig. 21). It is well known that tectonic activity in Egypt is controlled by active rifting in the Gulf of Suez / Red Sea, left lateral strike slip motion along the Gulf of Aqaba and Levant (Dead Sea) transform, and the convergence between Africa and Eurasia in the eastern Mediterranean (Fig. 22).

Historical seismic activity was compiled from Badawy (1996, 1999), Badawy and Horvath (1999). Historical information indicated that many earthquakes caused severe damage in the northern part of Egypt. Some of these events are related to the convergence between the African and Eurasian plates while the others are located within the plate itself. The most famous historical events are that of 18 March 1068 (Levant fault area); 20 May 1202 (Dead Sea); 8 August 1303 (south-east Crete); 18 March 1481 (South Cyprus); 13 February 1756 (Hellenic Arc); 7 August 1847 (Fayum); 11 July 1879 (Gulf of Suez) and 17 July 1887 (Hellenic arc). Epicenters of the historical activity are located in some specific areas, which are tectonically active. The majority of these events are located along the Levant transform fault. Some events are located along the Suez Gulf-Cairo trend and others along the Mediterranean Shelf.

Very important information about the tectonics of Egypt can be obtained from the distribution of seismic activity. The main earthquake activity takes place along the recent active faults or the plate boundaries. The epicenters of the historical active earthquakes are located in some specific areas which are tectonically active. The majority of these events are located along the Levant – Gulf of Aqaba transform fault. Figure 22: showing the epicenter of different earthquakes; A) Epicenter distribution of varying magnitude earthquake, focal mechanism of principal earthquakes and active seismic trends. B) Enlarged view from A showing the earthquakes surrounding the Gulf of Suez and the extent of the Red Sea – Gulf of Suez – Cairo – Alexandria trend. C)

According to Mahmoud, 2003, Egypt may be divided into eight seismic zones according to its seismicity maps. One of these zones is the Red Sea / Gulf of Suez. The tectonic setting of the area causes its slight instability. In the Egyptian territory, the distribution of epicenters of moderate to large and small earthquakes and micro-earthquakes indicates that the earthquake activity tends to occurs along three main seismically active belts and trends (Fig. 23). A catalogue of smaller to large earthquakes that affect Egypt and its surroundings has been compiled for the period from 1900 to 2000. This catalogue has the seismicity data of the area located between 22–34 N and 25–36.5 E. It represents the output of the integration and comparison between three catalogues available at NRIAG (Abou Elenean, 1997), the Egyptian Geological Survey and Mining Authority (EGSMA) and the earthquake catalogue for the Middle East Countries adopted by Riad and Meyers in (1985). Earthquake magnitude has been unified to be represented only by the body wave magnitude (Mb). According to these catalogues, Abou Elenean (1997) divided Egypt into five active seismic zones; the Gulf of Suez-Northern part of Eastern Desert zone, the Southwest Cairo zone, the Northern part of Red Sea, Gulf of Aqaba zone and the Aswan zone. Badawy, 1996, 1999; Badawy and Horvath, 1999; and Mahmoud 2003, concluded that the earthquakes along the Red Sea margin indicates a cluster of activity at the entrance of the Gulf of Suez and this extends southward for a small distance in the medial part. This cluster is attributed to the intersection of NW (Red Sea–Gulf of Suez) trend with the NE (Aqaba) trend. Besides the second seismic zone which extends from the Gulf of Suez towards north into the northern part of the Eastern Desert. This area is highly populated and has a large economic

- 136 -
interest. Seismic activity of this zone is related to the faults trending NW–SE that parallel the trend of the Gulf and also are perpendicular to the gulf (NE–SW). Published focal mechanisms from the region show normal faults with small strike slip movement. Tension stress is more horizontal and trending NE–SW in this zone.

Further south in the Shadwan Island, Fairhead and Girdler 1970, reported an earthquake (Mb = 6) in March 1969 preceded by three foreshocks and followed by 17 aftershocks. Maamoun and El- Kashab 1978 reported 35 foreshocks during the last half of March 1969 preceding the main shock. Ben Menahem and Abodi 1971 located its epicenter to the northwest of Shadwan Island and found that the ruptured zone appeared to extend 30 Km. to the southwest. In this event, earth slumps and rock falls were common. Fissures and cracks in soil were found with a main direction nearly parallel to the Red Sea- Gulf of Suez trends

Generally, the Gulf of Suez trend is characterized by the occurrences of shallow, micro, small, moderate and large earthquakes. Activities are limited within the crust. The activity along this trend is mainly attributed to the Red Sea rifting along several active faults.
Fig. 22:- Epicenter distribution of varying magnitude earthquake, focal mechanism of principal earthquakes and active seismic trends.


VII-C- Neotectonics:
With regards to the neo-tectonics, the eastern parts of the proposed site for the project are considered unstable due to the effects of the recent earthquakes.

**VII-D- Sand Dune Encroachment:-**

In the stretch between El-Minia and Sammalut, this dune field of the extreme eastern belt of Wadi El-Rayan Dune field, are reclaimed and cultivated during the last three decades. However, dune movement and sand encroachment on the cultivated fields along the margins of the Nile flood plain represents a permanent threat to soil productivity and agricultural production in the west Nile Valley area (Kishk, 1990).

![Fig. 23. Sand dune encroachment in the West Sammalut area](image-url)
IX- ENVIRONMENTAL IMPACTS OF THE PROJECT

This chapter deals with the significance evaluation of the identified potential changes that may occur within any component of the environment due to the project activities and their consequences. According to the Environmental Law No.4, Year 1994, this study present the impact of the project on the environment and the interaction between the environment and the project as in the following:-

IX- A- Environmental Impact on radar installations:

The U.S. Department of Defense has released a report about the impact of wind farms on military radar installations. The report undermines previous U.S. Air Force report which stated that the impacts were minimal, and the new report calls more a more in-depth look at the risks. The report covers all aspects of risk, including the impact on military radar, commercial air radar and fishing and ocean navigation systems. The department would like to see radar 'red zones' implemented in order to appease national security concerns and maintain the credibility of current systems.
IX-B- Environmental Impact on Water Resources:

In the project wind farm site, the sewage disposal system of the offices and in the rest-houses should be leading to the local sewage treatment plant before discharged into sewage system or be re-used for irrigation of green defense belt.

IX- D- Impact on Archeological Sites:

Gebel El-Zeit seems to have been the main source of galena during the Middle Kingdom, and may have been used before but were exploited intensively at this time, and were exhausted by the reign of Ramesses II in the New Kingdom (Bomann and Young 1994, p.29). Bomann and Young say that it is “noteworthy that Gebel el-Zeit, near the Strait of Geble and Wadi Abu Had, lies nearly opposite Minya (Menat Khufu) the seat of the sixteenth Upper Egyptian Nome (1994, p.30). Artifacts discovered at the galena mines included Tell el-Yahudiyeh ware, Pan grave shreds, and Syro-Palestinian cylinders suggesting either the presence of foreigners or contact with them.

Another religious temple is the Speos Artemidos, a rock cut shrine 3km from Beni Hasan in a small wadi. The shrine probably dates to the Middle Kingdom, but it is most commonly associated with the new Kingdom and the New Kingdom. It was dedicated to the lion goddess Pakhet, who was an aspect of Hathor. The facade of the shrine consists of four pillars cut into the rock with a central doorway. The entrance opens into a hall with four pillars decorated with hieroglyphs and damaged reliefs. The most important inscription was left during the reign of Hatshepsut, and describes the stabilizing effect of the reign of Hatshepsut following the chaos of the Hyksos rulers.
Tihna El-Gebel (El-Minia) Archaological Sites:

The modern village of Tihna el-Gebel is on the east bank of the Nile, around 20km north of El-Minya City. It is perhaps best known for its Old Kingdom rock-cut tombs, the ‘Fraser Tombs’, but in the Graeco-Roman Period the site was an important town named Akoris.

South of Tihna el-Gebel (along the east banks of the Nile, then over a narrow canal and through fields) is a low ridge (20-25m) containing Egyptian rock tomb which was reused in the Greek period. Here, too, is a temple of the Roman Imperial period, half hewn from the rock and half in masonry, with limestone columns; and on the river side of the hill is a chapel with a relief of a bald headed man in Roman dress before Egyptian gods. To the north, towards the village, are the remains of brick buildings belonging to the ancient town of Tenis oracoris, in the Hermopolitan name. Half an hour's walk south, buried under fallen rock, are three rock tombs of the Old Kingdom with interesting inscriptions (testaments).

The Old Kingdom tombs are about 2km away to the east of the town, in the gebel which borders the desert. They include the tomb of Nikaankh, a ‘Priest of Hathor’ during the reign of Userkaf of Dynasty V. The town itself was in Pharaonic times known as Dehenet, which is attested from the Old Kingdom, at which time there was a Temple of Hathor here. Another temple, built during the reigns of Rameses II and Merenptah has four chambers cut into the rock and originally had a pronaos or portico with four columns at either side of the entrance. The temple is poorly preserved, but damaged remains of Hathor-
headed columns may still be seen in the dark interior. In front of the Temple of Hathor there are wide plain columns still standing and nearby there is Roman and Coptic inscriptions in ink on scattered blocks. A ramp was added during the Roman Period by the Emperor Nero.

Two more small Roman temples have only single chambers with statue niches at the rear. The temples are very high up in the rock above the town site and make this a dramatic site to visit, though a potentially dangerous one with deep shafts which seem to open up everywhere.

The town of Dehenet was enlarged during the Greek and Roman eras and given the name of Akoris. Remains of many high mudbrick structures can still be seen sprawling over the vast mounds which constitutes the domestic site today. The Graeco-Roman necropolis consists of tombs cut high into the rocks above the area of the temples, around the side of the cliff to the right. These seem to be a mixture of both Egyptian and Greek styles and very elaborately decorated on their façades, some with life-sized reliefs of the tomb-owners. Several corn-mummies (funerary objects connected to Osiris) dating to the Late or Graeco-Roman Periods have been found in burials at Tihna el-Gebel. There is also evidence here that one of the tomb chapels was later re-used as an early Christian hermitage, as it has a cross cut into the statue niche in the rear of the tomb.

IX- E- Environmental Impact of the Earthquakes:
The eastern part of the study area is vulnerable to earthquakes. This should be taken into consideration during the design and the foundation and the installation of the towers and the turbines.

**IX-F- Impact due to the Flash Flood:**

According to the morphometric parameters proposed by different authors, the flash flood risk assessment in the study area will be in a medium grade due to the following facts:

1. The area is located and bounded along the cliffs of Wadi Tarfa.
2. The main catchments area of Wadi Tarfa drains its surface water to El-Mina in the Nile Valley.

- **As far the Transmission Line is passing through Wadi Tarfa, the project will be subjected to the impact of the flash flood hazards at the down stream of the wadis Tarfa, Sannur.**
- **It is highly recommended to trace the Transmission Line on the top of the Wadi Terraces above the level of the wadi course and in the downstream side of the wadi.**
- **The location of West Sammalut Station will partially subjected to the threat of the sand dunes encroachments. Sand fixation and stabilization process should be taken on the consideration**
- **The transmission line on the strip east of the River Nile from Sammalout to El-Minia will pass closed to many**
Archaeological and Historical Sites, such as: Tihna El-Gebel and Tell El-Amarna

APPENDIX (D)

INDICATIVE GEOGRAPHIC CO-ORDINATES
LIST OF CONTENTS

TABLE:-- THE GEOGRAPHIC CO-ORDINATES AND THE TYPE
       OF HAZARDS FOR EACH POINT

FIG. 25:-- SATELLITE IMAGE SHOWING THE LOCATION OF
       THE
       ROUTE
FIG. 26:– TOPOGRAPHIC MAP SHOWING THE LOCATION OF THE ROUTE

Landsat Image ETM at 2000

Indicative Geographic Coordinates
- All other values
- 1
- 20
- 40
- 60
- 78

Img Source : Topographic Map
Projection: UTM
Datum: WGS 84
Spheroid: WGS 84
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- 149 -
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The geographic co-ordinates and the type of hazards for each point.
Fig. 26; Topographic map showing the location of the route
Fig. 26: - Topographic map showing the location of the route
Abdel Ghany, M. S. and E. A. Zaghoul, 1973, Geological studies on the Quaternary deposits in the Nile Valley, Internal report, GEGSM, Egypt


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