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LAND CLASSIFICATION AND CAPABILITY IN SINAI

SINAI DEVELOPMENT STUDY - PHASE I

PERFORMED FOR THE ADVISORY COMMITTEE FOR RECONSTRUCTION

OF THE MINISTRY OF DEVELOPMENT

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(in association with Industrial Development Programmes SA)

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GLOSSARY OF SELECTED TERMS

ALLUVIAL -- Relating to or composed of clay, silt, sand, or gravel, or similar material desposited by running water.

ALLUVIUM -- Stream deposits of comparatively recent time.

DENDRITIC -- Characterized by irregular branching in all directions (e.g., dendritic drainage pattern: tributaries joining the main stream at all angles).

DENUDATION -- The process of washing away of the covering of strata.

DETRITUS -- Material which is produced by the disintegration and weathering of rock and which has been moved from its point of origin.

ELUVIAL -- Relating to or composed of rock debris produced by the weathering and disintegration of rock; or fine soil or sand deposited by wind.

EOLIAN -- Applied to the erosive action of the wind, and to deposits which are due to the transporting action of the wind.

EPHEMERAL -- A plant that grows, flowers, and dies in a few days.

ERG -- A vast region covered deeply with pure sand and occupied by dunes.

ESCARPMENT -- A steep face frequently presented by the abrupt termination of stratified rocks.

GLEIZATION (GLEY) -- A soil horizon in which the material is bluish-gray or blue-gray, more or less sticky, compact, and often structureless, developed under the influence of excessive moisture.

INSELBERG -- Steep-sided residual hills and mountains rising abruptly from plains.

LACUSTRINE -- Produced by or belonging to lakes.

LOCAL RELIEF -- The vertical difference in elevation between the highest and lowest points on a land surface within a specified horizontal distance or in a limiting area.

LOW ENERGY ENVIRONMENT -- Environment characterized by general lack of wave or current action; very fine grained sediment is permitted to settle.

MASS WASTING -- The slow downslope movement of rock debris.

OROGRAPHIC RAIN -- Derived from rising air currents adjacent to mountains.

OUTLIER -- Portions of any stratified group which lie detached, or out from the main body, the intervening or connecting portion having been removed by denudation.

PEDIMENT -- Gently inclined planate erosion surfaces carved in bedrock and generally veneered wit fluvial gravels.

SLOPE -- The inclined surface of a hill, mountain, plateau, plain, or any part of the surface of the earth; the angle at which such surfaces deviate from the horizontal.

TALUS -- A collection of fallen disintegrated material which has formed a slope at the foot of a steeper declivity.

TRANSHUMANCE -- The seasonal movement of livestock, especially sheep, between mountain and lowland pastures either under care of herders or owners.

EXECUTIVE SUMMARY

This paper presents an analysis of land capability in terms of present land use patterns in Sinai as related to agriculture, tourism, industry, mining, and urban settlements. Based on an assessment of resource potentials and project possibilities, the areas most suitable for various land uses are identified.

Sinai's five physiographic regions (see Figure 4-1) are evaluated in terms of potential land use. A summary of their development capability is given below:

- Southern Mountains Province
  - Rough relief, generally inaccessible
  - Lack of water and poor soil
  - Tourism as primary land use.
- Stable Platform Province
  - Low relief, limited engineering difficulties
  - Scarce water supply, reclamation dependent on locating a large quantity of good quality groundwater
  - Very limited land use, possibly range improvement.
- Mobile Platform Province
  - High plains relief, variety of land use environments
  - Reclamation dependent on locating a large quantity of good quality groundwater
  - Limited land use except for mining and some agriculture.
- Mediterranean Foreshore Province
  - Active sand deposits, engineering and construction difficulties
  - Comparatively high potential to support rainfed agriculture
  - Tourism, industry, and agriculture as primary land uses.
- Suez Rift Province
  - Diverse relief, considerable areas for land use development
  - Lack of water
  - Industry and tourism as primary land uses.

The spatial distribution of Sinai development projects is currently concentrated along three axes--along the north coast, including El Arish, Bir El Abd, and the Lake Bardawil area; along the Suez Canal, from El Qantara to Ras Sudr; and between Abu Zenima and Abu Rudeis.

Fifteen map plates accompany this paper. They show the spatial distribution of development projects, topographic contours, relief, slope, landforms, environmental geology, land resources suitability, engineering suitability, groundwater potential, mineral potential, construction materials potential, population distribution, social services and infrastructure, accessibility, and tourism points of interest.

Knowing the primary goal of Sinai development--maximum population absorption based on sound economic growth, environmental conservation, and social justice--an assessment of available resources and the potential of different resource combinations is of primary importance in strategic physical planning. The Draft Final Report for the Sinai Development Study, Phase I, will discuss how much development growth can take place on a sustained basis, given the existing resource base, and what combination of development projects best uses these resources and provides for comprehensive development.

LAND CLASSIFICATION AND CAPABILITY IN SINAI

1.0 INTRODUCTION

1.1 SCOPE OF WORK

The objectives of this paper are to describe Sinai's physical and cultural resources and to incorporate anticipated land use categories into a reconnaissance level assessment of land capability. In the Draft Final Report for Phase I, this analysis of land capability will be linked to potential socioeconomic land use as part of the iterative and interactive process of planning.

This paper is submitted in fulfillment of one component of Task 11, Preliminary Development Strategy and Investment Study, of the Sinai Development Study, Phase I. It documents much of the land capability assessment which has been onging throughout the project. Land classification and capability are analyzed in terms of:

- Potential land use (primarily agriculture, tourism, industry, mining, and human settlement)
- Opportunities and constraints with regard to land resources
- How the physical resource base can support development
- The strategic approach to physical planning.

Land quality in Sinai, as elsewhere, is an important criterion on which to build a set of development scenarios. The following factors are an integral part of this analysis because of Sinai's combination of physical terrain features and cultural resources:

- Water availability and water quality, now and in the future, as perhaps the single most important constraint to human activity
- Potentially different patterns of development in agriculture, tourism, industry, mining, and human settlement
- Accessibility as an important constraining factor for most types of near-term development
- Different mixes of development alternatives.

This paper is divided into the following sections:

- Section 2.0, Summary and Conclusions
- Section 3.0, Evaluation of Physical Terrain Characteristics
- Section 4.0, Description of Physical Terrain Features

- Section 5.0, Land Resources
- Section 6.0, Engineering Suitability
- Section 7.0, Cultural Resources
- Section 8.0, Land Use Suitability.

A reference list follows Section 8.0. Selected portions of this paper were drawn from various other working papers submitted as part of the Phase I work. The working papers are cited in text, as appropriate, and a complete list is included with the references.

1.2 APPROACH

The importance of planning is that is provides a rational course of action for the attainment of a desired end. Effective planning selects the input combination most likely to yield the desired output at the lowest cost. Planning is, therefore, based on three factors--knowledge of the desired end, the resources available, and the potential of different resource combinations. The goal of Sinai development is maximum population absorption based on sound economic growth, environmental conservation, and social justice. Knowing this, the second and third planning factors--available resources and the potential of resource combinations--become the focus of this paper and provide a linkage to potential socioeconomic land use, to be discussed in the Draft Final Report.

This paper uses a land evaluation system developed by the U.N. Food and Agriculture Organization (FAO) in 1976, and modified to fit the strategic planning needs of the Sinai Development Study, Phase I. Figure 1-1 presents Dames & Moore's approach to this land capability assessment, based on the FAO model. The FAO system was designed primarily for agricultural purposes; the land classification system for Sinai must be applicable for a variety of land uses and must have the flexibility to accommodate the quite sharply differentiated potential between adjacent land units.

Land evaluation is generally concerned with present land use and with degrees of optimal potential use under different management conditions. The primary strategy for Sinai focuses on potential use, since one of the overall objectives of development is to absorb a significant amount of Egypt's rapidly growing population.

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SINAI LAND CAPABILITY ASSESSMENT (ADAPTED FROM FAO APPROACH)

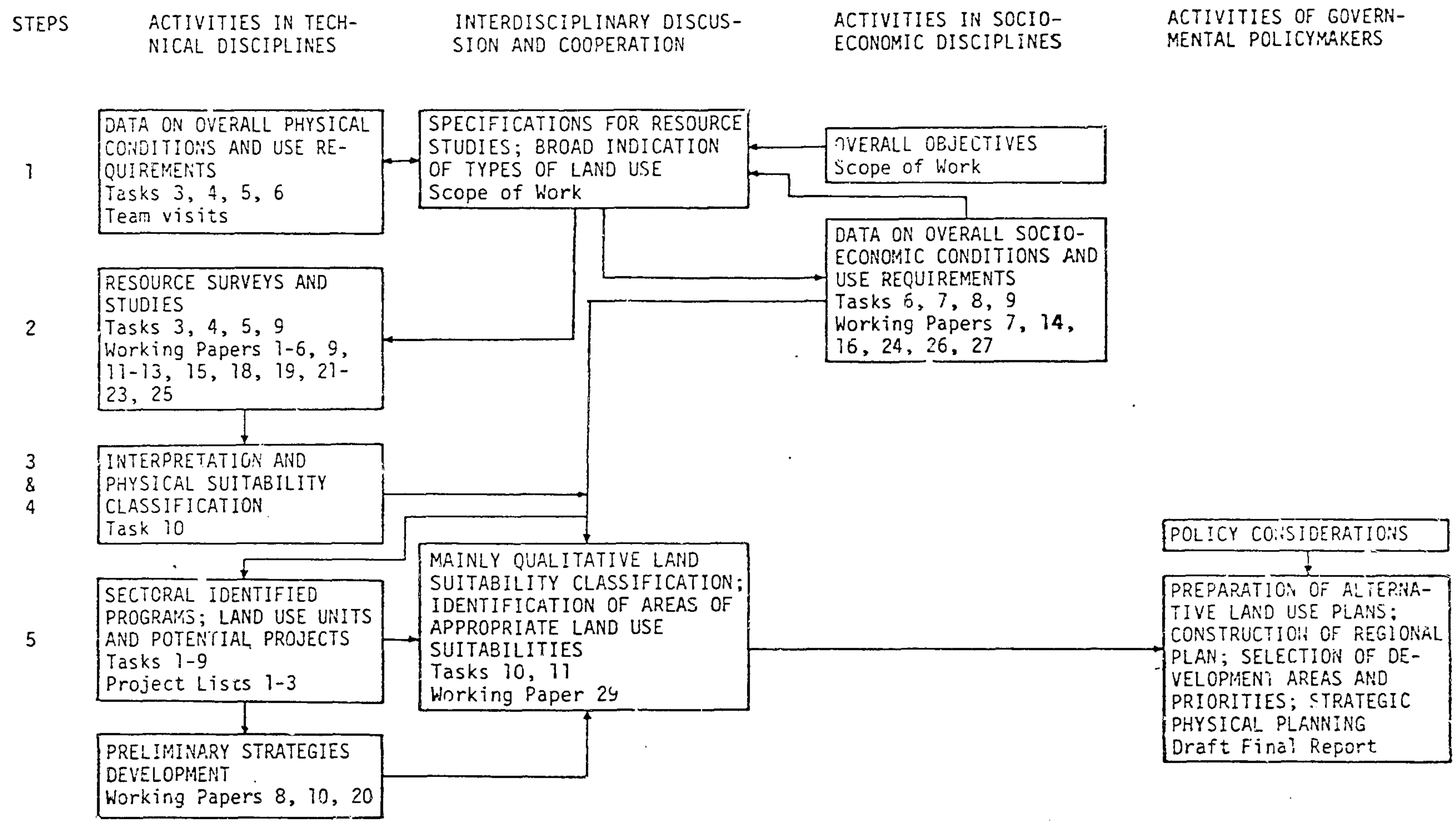


FIGURE 1-1

At this stage of land capability assessment, emphasis has been placed on finding answers to the following questions:

- <u>Natural factors</u>
  - What are the natural exploitable resources?
  - Where are these resources present?
  - What are the major variations of these resources?
  - What are the land characteristics?
  - What constraints do the natural resources and land characteristics place on development?
  - What is the spatial configuration of these resources, land characteristics, and constraints?
- <u>Cultural factors</u>
  - What are the existing cultural resources of Sinai?
  - What are its existing cultural resource patterns and flows?
  - What demands do the current cultural resources place on the natural resource base?
- <u>Sector plans</u>
  - What early action projects are suggested?
  - What are their spatial relationships?
  - What development projects are suggested?
  - What are their spatial relationships?

Questions related to strategic physical planning, such as the following, will be addressed in the Draft Final Report:

- Given the existing resource base of Sinai, how much development growth can take place on a sustained basis? Where?
- What mix of development projects best uses these resources and provides for accretionary development?

2.0 SUMMARY AND CONCLUSIONS

2.1 RESOURCES

This working paper presents a small-scale reconnaissance level assessment of Sinai's physical and cultural resources. It incorporates five anticipated land use categories which were identified in the original Terms of Reference for Phase I of the Sinai Development Study:

- Agriculture
- Tourism
- Industry
- Mining
- Urban settlements.

As the study progressed, each of these categories was subdivided into more specific units, such as rainfed, irrigated, and drip-irrigation agriculture, based on Sinai's overall capacity to support specific land uses.

The major natural resource limitation in Sinai is water, which has only marginal capacity for expansion. Increasing the water resource in Sinai by transporting water from the Nile is expensive and competes with other possibly more productive uses in the Valley and Delta. Expansion by desalinization is also quite expensive, the cost of which can only be borne by select tourism, industrial, and domestic uses. The scarcity of water is and will continue to be the major constraint to development.

Other available natural resources, such as developable agricultural land, land for settlements and industry, range potential, minerals, and energy supply, are expandable to some extent or--in the case of minerals--unknown, but are expected to have minor impact on Sinai's overall socioeconomic development. Thus, unlike traditional urban planning or even regional planning in resource-rich areas, land use conflicts are generally not a problem in Sinai. In planning urban expansion in primary development areas, such as El Arish, El Qantara, and El Tor, care will have to be taken to allocate the best agricultural land to agriculture and to preserve local tourism attractions. This, however, is a local problem and not a major regionwide planning concern at this time.

The evolution of Sinai's cultural resources has kept pace with its level of progress toward development. Thus, while the cultural resource base may, at present, be limited, it can be predicted that as development activity intensifies, this base will correspondingly expand.

Major development activity in Sinai may take one or a combination of forms, such as petrochemical and fertilizer complexes, tourism beach resorts, and agricultural land reclamation. Examples of more modest development projects are agricultural development near El Arish and on the El Qaa Plain; clothing manufacturing, fish processing,or olive oil production; tourism routes from beach areas at El Arish to central Sinai, linking other tourism points of interest such as Qal'at El Gindi, Serabit El Khadim, and Wadi Mukattab with the south coast beaches or Saint Catherine's; and small mining operations for kaolin, gypsum, and construction materials. A third level of development, and one that may eventually have a measurable impact on Sinai's overall rate of growth, is represented by small projects in remote areas and projects aimed at improving basic living standards. Such projects could include the installation of water pumps at Nakhl; the provision of wind-powered generators for Bedouin homes, and windmill pumps and spreader dams for livestock watering holes and domestic gardens; and the promotion of handicraft cooperatives. Each of these three levels of development activity can potentially be supported by Sinai's resources.

The land use and development potential of Sinai's five physiographic regions can be summarized as follows:

- Southern Mountains Province--This province is very sparsely inhabited. Agriculture is possible only in small areas near oases. Fruits such as dates, pears, and nuts are grown along with subsistence-level vegetable crops. Very poor grazing range is available in this province.

  The potential land use in the Southern Mountains Province will almost totally be limited to tourism. The magnificently colored and eroded mountains, combined with a relatively cool climate and historic monuments, represent a strong touristic attraction. Large agricultural efforts will be excluded because of the lack of soil and water; urbanization will not be very viable because of the rough relief and inaccessibility of the area.

- Stable Platform Province--This province is sparsely inhabited by Bedouins. Transhumant livestock and agricultural practices are the norm. Crop agriculture is possible only in the wadi beds, in small patches, and is very irregular.

  The potential for agricultural growth in the Stable Platform Province is low, primarily because of a scarce water supply. There is a very limited opportunity for tourism. Urban development also appears unlikely because of considerable distance from markets and shipping points. The area has some potential for rangeland improvement, but this will require rigid controls on livestock numbers and traditional grazing practices.

- Mobile Platform Province--This province is also sparsely inhabited. Agriculture is restricted to rainfed patches in the wadi beds.

  The potential for agricultural reclamation is low and will depend on finding a moderate-to-large quantity of good quality groundwater. Agriculture will continue to be restricted to the wadi plains. Other than the Maghara coal resources, there is little inducement for urbanization in the region. Based on existing roads and cultural resources, it appears that Gifgafa is more likely to be the settlement base for exploitation of Maghara coal than a new settlement that might develop near the mine site. The feasibility of developing the Maghara coal is still not proven. There are very few points of interest for tourism in this province.

- Mediterranean Foreshore Province--Sand dunes and sand sheets cover most of northern Sinai. Present agriculture in this province includes date palms in the depressions between sand dunes and near the coast; scattered rainfed agriculture consisting primarily of watermelon, various vegetables, and some barley; and a limited amount of drip-irrigated crops near El Arish. Fishing is a major form of livelihood along the coast. Population density in this province is the highest in Sinai.

  Future agricultural development depends largely on the introduction of large amounts of irrigation water. Tourism may also become a major source of income to this area since the wide sandy beaches are almost ideal for beach tourism. Accommodations for tourists will have to be improved or developed. Industrial growth may develop along the western border, taking advantage of existing skilled labor pools and nearby potentially available good water resources.

- Suez Rift Province--This province is moderately well populated, with several small settlements along its western coastline. Agriculture here is minimal; what little exists is limited to the wadi alluvial fans and consists of vegetable patches and date palms. This province contains several mineral resources which are being exploited on a limited basis.

  The potential for agricultural development is low because of the lack of a proven source of good water. Industrial potential is good, based on the potentially available mineral and petroleum resources. This province also has a fair potential for tourism development.

2.2 DEVELOPMENT

Many development projects have been identified and summarized by the sector investigators during the Sinai Development Study, Phase I. Plate 2-1 shows the spatial distribution of these projects.

Projects were divided into the following developmental categories:

- Early action
  - Administrative action (no infrastructure required)
  - Infrastructure required
- Long-term development
  - Administrative action (no infrastructure required)
  - Infrastructure required.

From this plate, it appears that the majority of the projects identified during the sector investigations can best be accommodated by the resource conditions around El Arish, El Qantara, East Suez, El Tor, Abu Rudeis, New Mit Abul Kom, Ras Sudr, Abu Zenima, and Saint Catherine's. Numerous other projects are scattered around Sinai.

Three axes of concentrated development are also apparent from Plate 2-1:

- An east-west axis along the north coast highway--El Arish forms the principal node of this axis, with Lake Bardawil and Bir El

Abd forming secondary activity nodes. After final withdrawal in April 1982, settlements such as Sheikh Zuwayid and possibly Rafah could become part of this development axis. Tourism, industry, and agricultural development will be concentrated in these areas.

- A north-south axis along the Suez Canal--El Qantara forms the primary node of this axis, with New Mit Abul Kom, East Suez/El Shatt, and Ras Sudr forming the secondary nodes. Improved access across the Suez Canal as a result of the completion of the El Hamdi tunnel and improved ferry service are likely to give impetus to growth along this axis during the next few years. This axis is formed principally by industrial activity, with agriculture as a secondary development. At New Mit Abul Kom, however, agriculture is dominant.
- A third axis links Abu Zenima and Abu Rudeis--This axis is based primarily on mining and industrial activities.

Additional axes of development may emerge following the release of eastern Sinai in April 1982, as roads and other infrastructure link that section of the peninsula with the areas now under intensive analysis in Phase I.

3.0 EVALUATION OF PHYSICAL TERRAIN CHARACTERISTICS

A major purpose of Task 11.1, Land Capability Maps, is to provide data on the natural features of Sinai to be used in assessing the overall planning and development potential of the region. Physical characteristics examined include those pertaining to relief, slope, landforms, and environmental geology. These factors were evaluated, individually and in combination, to determine the suitability of terrain for resources and engineering development. As a result, it was possible to identify an area's suitability for certain development activities and any physical and environmental constraints on development.

The results of this task are synthesized on a series of six thematic overlays registered to the 1:250,000-scale base map of Sinai. These overlays provide a summary of the physical characteristics and development potential of the region in terms of focusing on specific areas, or zones, where detailed spatial and alternative development strategies may be required.

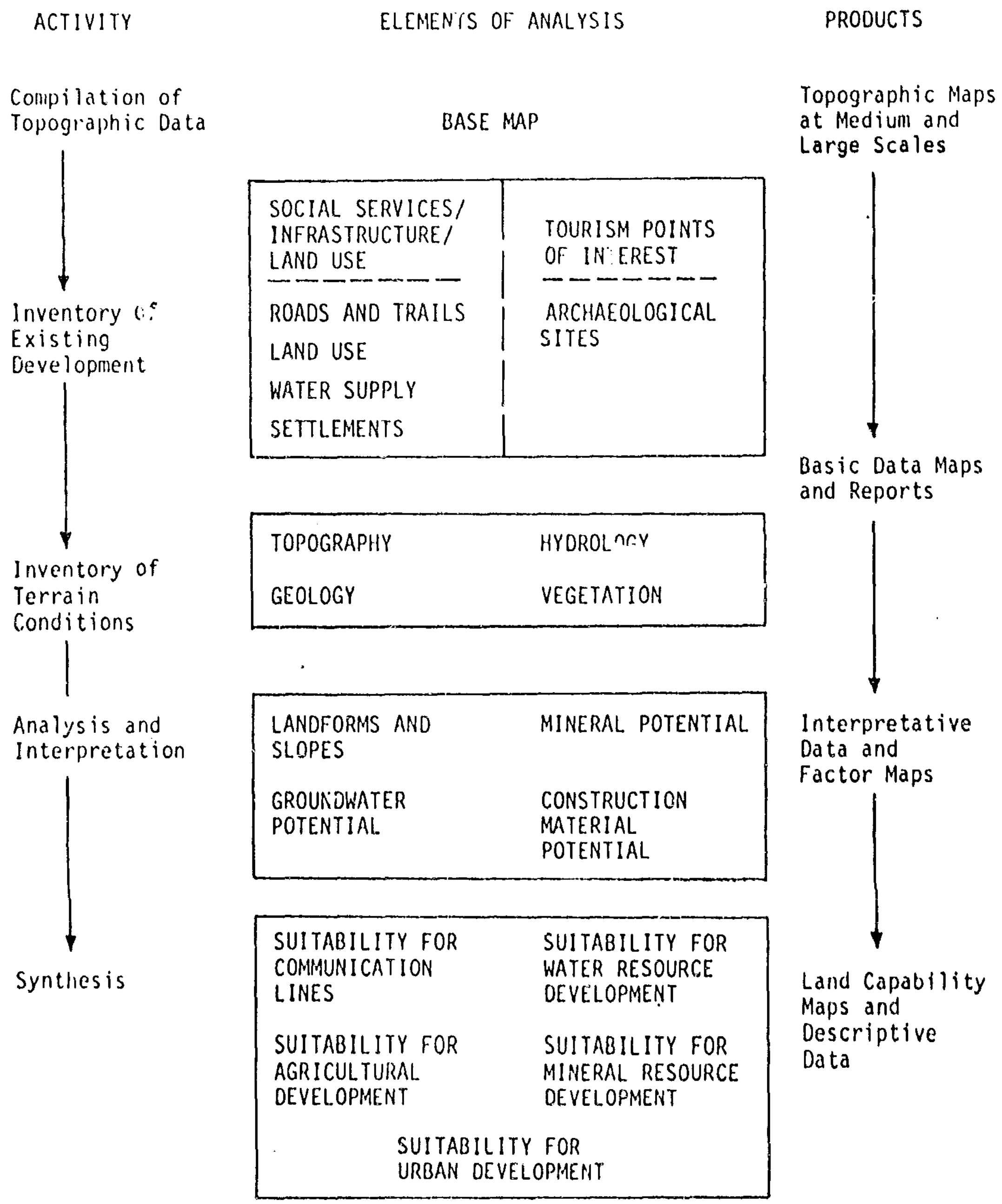
It must be noted that this particular task was an iterative process, taking into consideration the data and recommendations furnished by the other principal investigators over the past 14 months. Figure 3-1 shows the elements and general flow of the physical terrain analysis.

3.1 STUDY AREA

The land capability analysis addresses all of Sinai, a triangular land mass of approximately 61,500 square kilometers. This large area is covered by two 1:250,000-scale base map sheets--a north sheet extending from the Mediterranean coast southward to latitude 29°40' N., and a south sheet extending below the tip of the peninsula at Ras Mohammad. The base map sheet configuration used for the land capability analysis is shown in Figure 3-2.

3.2 METHODS OF STUDY AND ANALYSIS

The evaluation of physical terrain characteristics encompassed five major tasks--the collection of terrain data from published and unpublished sources, including personal communication with scientists, engineers, and other task specialists (Section 3.2.1); the review,



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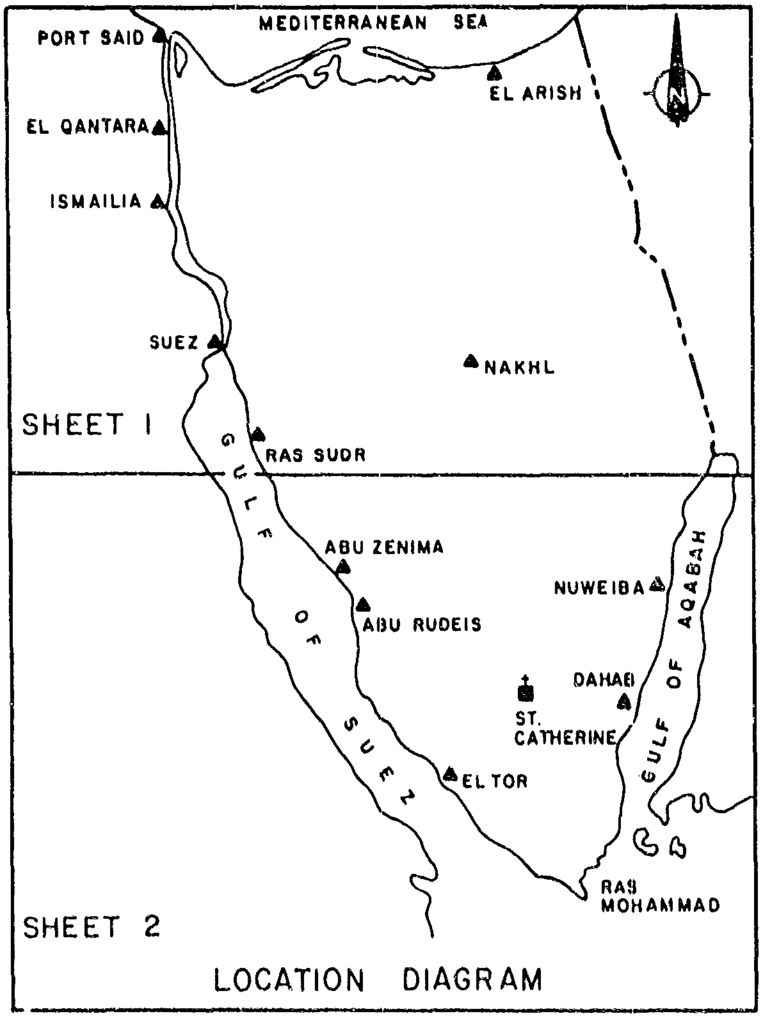
FLOW CHART SHOWING USE OF TERRAIN ANALYSIS TO SUPPORT SINAI DEVEVELOPMENT STUDY

FIGURE 3-1



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BASE MAP INDEX FOR LAND CAPABILITY ANALYSIS

FIGURE 3-2

interpretation, and analysis of the collected data (Section 3.2.2); the synthesis and compilation of data into a format compatible with the requirements of 1:250,000-scale mapping (Section 3.2.3); the preparation of interpretive data base graphics (factor maps, Section 3.2.4); and the preparation of constraint maps (land capability maps, Section 3.2.5) for resources and engineering development.

The base map series used in this study is the 1:250,000-scale Sinai North and Sinai South sheets, commonly referred to as the "Camp David Maps." These special-purpose maps are composites from a series of eleven 1:250,000-scale topographic map sheets published by the U.S. Defense Mapping Agency at a contour interval of 100 meters.

3.2.1 Data Collection

This task involved the collection of available information on topography, bedrock geology, surficial geology/soils, and hydrology. Typical information sources collected include reports, maps, LANDSAT imagery, and aerial photographs, supplemented by selected site visits and discussions with scientists and engineers from the Desert Institute and the Remote Sensing Center. Relevant data compiled by the other task specialists, particularly on water resources, mineral resources, tourism, and agriculture, were also included. A complete listing of all information sources appears in the reference list.

Two major information sources were the early drafts and data collected by the Desert Institute and selected data from the General Company for Research and Groundwater (REGWA). As this report neared completion, the final reports from both of these sources became available. It was professionally rewarding to note that many of the conclusions drawn from the very early Phase I resource evaluations and upon which the team members have based their project and development decisions were verified by the findings of these two reports. Additional information, such as detailed soils data, will be incorporated into the land capability assessment section of the Draft Final Report.

The basic data for terrain mapping were collected primarily from existing sources, including discussions with key individuals familiar with the terrain conditions and physical characteristics of Sinai. Several extensive field trips were also made by Sinai Development Study, Phase I, team members. Particular emphasis was placed on acquiring representative descriptive information pertaining to the following terrain characteristics:

- Topography (contours, escarpments, relief, slope)
- Geomorphology (landforms, erosion, deposition)
- Surface drainage (wadis, catchment areas, flood plains, wet areas)
- Groundwater (aquifers, recharge areas, discharge areas, high water table)
- Surficial geology/soils (occurrence, associations, textures)
- Bedrock geology (lithology, structure, weathering)
- Special conditions (extensive gullying, collapse, dune sand movement and accumulation, desertification).

In addition to the collection of reports and maps, selected scenes of LANDSAT Multispectral Scanner (MSS) and Return Beam Vidicon (RBV) imagery were also used. Specifically, this included the acquisition of LANDSAT MSS color composite imagery at a 1:250,000 scale and selected frames of RBV black and white imagery at a 1:500,000 scale. Representative frames of aerial photography over specific areas of Sinai were also acquired. This photography, purchased from the Egyptian Military Survey Department, consisted of 1:40,000-scale stereo pairs over Abu Zenima and El Tor, and 1:30,000-scale photos over the Maghara-Wadi El Arish Basin. A complete set of 1:50,000-scale uncontrolled black and white mosaics of Sinai, developed from aerial photographs taken in 1955 and 1956, was also used.

The original plan to evaluate LANDSAT MSS data over several years to determine time-variant phenomena--such as soil moisture and eolian transport--could not be implemented during this investigation because of insufficient seasonal coverage and because of the poor spectral and spatial signature resolution.

3.2.2 Data Review and Analysis

This task involved review and analysis of the various information sources gathered in the data collection task. Primary emphasis was placed on making maximum use of information developed by other authorities. All information bases were evaluated and used in accordance with their reliability. The final data matrix report (July 1981) provides information on the accuracy of most of the available map data bases.

For major portions of Sinai, however, information on land characteristics and soils was limited. In these particular areas, the interpretation and analysis of basic data sources was required to define key attributes related to landform, rock, and soil characteristics. Interpretations were based largely on the anticipated behavior of each unit, as determined by the analysis of LANDSAT imagery and selected frames of large-scale aerial photography, field observations, and comparisons with analogous units in similar geologic environments. The resulting inferences, with respect to the basic engineering and environmental characteristics of key units, provided the basis for subsequent synthesis and compilation of thematic overlays for landforms and environmental geology.

3.2.3 Data Synthesis and Compilation

The information developed as a result of the data review and analysis task was compiled onto a series of thematic overlays or data maps, registered to the 1:250,000-scale Sinai base maps. These overlays consist of interpretive working maps (factor maps) that show the extent and distribution of key physical terrain characteristics. Specific factor maps developed for the land capability analysis include relief, slope, landforms, and environmental geology.

During the map compilation task, major emphasis was placed on presenting information that was accurate, useful, and applicable to overall land capability planning. Because the base map scale was relatively small (1:250,000), the amount of information shown on each overlay was carefully considered to prevent excessive detail and confusion. The resulting factor map overlays depict key terrain conditions using area and linear features, supplemented by various alphanumeric designators, symbols, and patterns. This method was found to provide the most uncluttered, readable, and understandable presentation, compatible with the requirements of the Phase I land capability analysis.

Information on the key physical characteristics of terrain was compiled by using a variety of transfer techniques. Since most maps depicting a particular terrain subject rarely had the same scale as the special-purpose regional compilation base, it was necessary either to enlarge or to reduce this information to meet the specific scale requirements of the base. The representative map compilation techniques used during this study included the Bausch and Lomb Zoom Transfer Scope for scale enlargements; the Map-O-Graph for reductions and enlargements; proportional dividers and related grid transfer systems for area and linear scale rectification; and purely photographic techniques for enlargements or reductions of map information on stable base materials.

3.2.4 Factor Maps

The individual factor maps depict specific physical attributes related to topography (relief, slope), landforms, and rock/soil characteristics. These attributes are considered to be the most important natural controls in terms of assessing the resources and engineering development potential of the region.

Topography is a product of tectonic forces and gradational processes, including physical and chemical weathering. Plate 3-1 (Sheets 1 and 2) is a topographic contour map. The characteristics of a landform are dependent on the agents that produced it, the rocks and earth structures of which it is composed, and the climate in which it was developed. Most landforms are erosional and are produced by atmospheric agents--water and wind--acting on the materials of the earth's surface. The forces of tectonism and the agents of gradation work on various types of rock--some weak and some resistant; some massive, others layered in beds of various thicknesses and attitudes; some horizontal, others inclined or vertical; some undistrubed, and some fractured, crushed, or folded at different intensities. The highly variable terrain of Sinai is clearly the result of these diverse forces and gradational processes.

3.2.4.1 Relief Map. This map identifies the general distribution of landform units as determined by selected ranges of local relief. Although the kinds (or degrees) of roughness or disection are used to describe and distinguish the major classes of landforms, the distinction between the units is based on local relief.

The 1:250,000-scale topographic maps of Sinai provided the primary data source for compiling the relief overlay. Computation of local relief for the land surface of Sinai was accomplished by subdividing the 10,000-meter UTM grid squares on the base map into four equal

5,000-meter squares; thus, the greatest horizontal distance used was the length of the hypotenuse, or 7,000 meters.

The relief overlay (Plate 3-2, Sheets 1 and 2) incorporates the following classification units:

Unit	Local Relief (meters)	Classification
1	0-50	Low plains
2	50-150	High plains
3	150-300	Plateau
4	300-600	Hilly upland
5	Over 600	Mountains

Table 3-1 shows the limitations of various development activities in terms of local relief characteristics.

3.2.4.2 Slope Map. The slope map, Plate 3-3 (Sheets 1 and 2), shows the degree of surface inclination over the Sinai Peninsula. This attribute is helpful in evaluating the suitability of land for various uses.

Slope is a natural environmental control; as such, its severity could create practical limitations with regard to development suitability. For Sinai, land slopes were classified and delineated in accordance with three regional slope classes--0 to 8 percent, 8 to 25 percent, and greater than 25 percent.* These were selected as the ranges that could best be differentiated, considering scale factors and contour limitations, and that would still assist in identifying factors which limit various anticipated land uses. Slopes in the 0 to 8 percent class are defined as nearly level to undulating; 8 to 25 percent slopes are generally moderately-to-strongly rolling; slopes exceeding 25 percent are hilly, steep, or very steep, depending on degree of surface inclination. Slopes in excess of 25 percent generally preclude the use of land for most agricultural and urban/industrial purposes and increase the risk of landslides. Table 3-2 shows some of the practical limitations of land development in terms of regional slope classes.

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*The original plan to map slopes in the 0 to 5, 5 to 15, 15 to 30, and greater than 30 percent categories could not be implemented because the 100-meter contour interval of the 1:250,000-scale maps would not enable resolution and differentiation of these detailed slope classes. The slope classes used are compatible with FAO guidelines.

TABLE 3-1

Limitations Based on Local Relief Characteristics[a]

Unit	Local Relief (meters)	Classification	Agriculture	Infrastructure	Urban/Industry
1	0-50	Low plain	E	E	E
2	50-150	High plain	F-G	E	G-F
3	150-300	Plateau	P	G-F	F-P
4	300-600	Hilly upland	P	F-P	P
5	Over 600	Mountains	P	P	P

[a]E=excellent, G=good, F=fair, P=poor.

TABLE 3-2

Ranges of Slopes for Various Regional Uses/Activities

Use or Activity	Regional Percent Slope		
	0-8 [a]	8-25	>25
General recreational/tourism	X	X	X
Wildlife/environmental reserves	X	X	X
Engineered structures [b]	X	X	X
General urban uses	X	to 15%	
All-weather urban roads	X		
Rural roads	X	to 15%	
Commercial centers/industry	X		
Airports	X		
Railroads	X		
Tracked vehicle operations	X	X	X
Agriculture	X	(c)	
Grazing	X	X	X

[a] Meets FAO slope limitation standards for areas considered to have no impediment to mechanized agriculture (i.e., the most stringent category).

[b] Dams, bridges, tunnels, pipelines, transmission lines, etc.

[c] Agriculture using drip irrigation can take place at slopes of 8 to 25 percent or greater, provided that there is sufficient soil and proper management.

SOURCE: Mayberry (1972).

Slopes were determined by plotting contour densities corresponding to the various slope class limits on a small transparent template, and moving this template over the surface of the 1:250,000-scale topographic maps so as to compare contour densities at frequent intervals. This enabled the analyst to outline areas of similar densities for each of the slope classes, resulting in compilation of the regional slope map of Sinai.

3.2.4.3 Landform Map. The review of available geologic reports and maps, supplemented by the interpretation of LANDSAT imagery and topographic maps, provided the primary means for delineating the regional and subregional landform units of Sinai. Major emphasis was placed on identifying key landform features that were considered critical to land planning and development. Plate 3-4, Sheets 1 and 2, show the landform units of Sinai.

Sinai is characterized by highly diverse physiographic types. Distinctive landforms have developed in each type, in large part reflecting differences in topography, rock and soil types, and structure. These differences cause distinctive engineering problems in terms of development.

The regional landform units of Sinai comprise three major types--plains, plateaus, and mountains. The plains regions are characterized by comparatively flat, smooth, level, or gently rolling-to-undulating land, with few or no prominent surface irregularities, but sometimes with a considerable slope. Plains regions usually occupy low elevations with reference to the surrounding areas; local relief is up to 150 meters.

Plateau landform units in Sinai generally occupy upland areas that are limited on at least one side by an abrupt descent. The uplands are characterized by surfaces which range from flat tablelands to extremely rough, narrow, and steeply gullied terrain (badlands). Relief generally varies from 150 to 300 meters and can approach 600 meters in local instances where intensely dissected terrain predominates.

Mountain landforms in Sinai occupy an elevated surface characterized by a restricted summit area, generally with steep slopes and considerable bare rock surfaces. Relief is generally greater than 300 meters, often exceeding 600 meters.

Table 3-3 shows the representative physiographic units delineated on the landform map.

3.2.4.4 Environmental Geology Map. The environmental geology map was compiled to show information on the broad range of conditions regarding the engineering and environmental characteristics of rocks and soils in Sinai. The "Sinai Geological Map" (1980), prepared by the Geological Survey of Israel--supplemented by Rushdi Said's "The Geology of Egypt" (1962), and the "Soil and Land Classification Maps" published by the Enterprise for Applied Geophysics, Zagreb, Yugoslavia (1963)--provided the basic information sources. These sources were supplemented by the interpretation of LANDSAT color composite imagery and aerial photographs to qualitatively infer the engineering characteristics of individual lithologic units or groups of similar units. The remote sensing imagery provided valuable insights with regard to determining the extent and distribution of rock outcrop, weathering patterns, resistance to erosion, degree of fracturing, gullying, and overall soil textural classes.

Table 3-4 summarizes the regional engineering and environmental characteristics of the key rock and surficial geology units of Sinai. In this study, a total of 15 environmental geologic map units have been identified, 10 of which are rock units, and five of which are unconsolidated surficial units. Specific engineering and environmental characteristics evaluated for each unit include:

- Engineering
  - Ease of excavation (easy, moderate, difficult)
  - Ease of drilling (easy, moderate, difficult)
  - Foundation stability (good, fair, poor)
  - Susceptibility to mass wasting (high, moderate, low)
  - Cut-slope stability (good, fair, poor)
  - Depth to bedrock (exposed, shallow, moderate, deep)
  - Stony surface (high, moderate, low)
- Environmental
  - Susceptibility to erosion (high, moderate, low)
  - Susceptibility to gullying (high, moderate, low)
  - Degree of fracturing (high, moderate, low)
  - Recharge potential (good, fair, poor)

TABLE 3-3

Landform Units for Sinai Land Capability Analysis

Regional Landform	Map Unit	Subregional Landform	Map Unit	Key Feature	Map Unit
Plain	P	Coastal	C	Wetland/marsh	we
				Beach	be
		Interior	I	Erg (dunes)	du
				Hammada (rocky)	ha
				Badlands	ba
		Alluvial	A	Undifferentiated	un
				Wadi	wa
				Alluvial fan	af
				Bolson plain	bo
		Colluvial	CO	Colluvial slopes	cs
Plateau	PL	Upland	U	Badlands	ba
				Tableland	ta
				Hammada	ha
				Escarpment	
				Colluvial slope	cs
Mountain	M	Block	B	Linear ridges	lr
		Dome	D	Hogback	ho
				Breached core	bc
	E	Complex	C	Undifferentiated crystalline	uc

TABLE 3-4

Environmental Geology Units

MAP UNIT*	ROCK/SURFICIAL MATERIALS	ENGINEERING**							ENVIRONMENTAL			
		EASE OF EXCAVATION	EASE OF DRILLING	FOUNDATION STABILITY	SUSCEPTIBILITY TO MASS WASTING	STABILITY OF CUT SLOPES	DEPTH TO BEDROCK	STONY SURFACE	SUSCEPTIBILITY TO EROSION	SUSCEPTIBILITY TO GULLYING	DEGREE OF FRACTURING (PERMEABILITY)	RECHARGE POTENTIAL
R_1	Clay, sandstone, marl, gypsum, conglomerate, and limestone of Oligocene-Miocene age	D	M	F	M	P	M	H	H	H	M	F
R_2	Dikes, sills, flows, and related intrusives	D	D	G	M	G	EX	M	M	M	H	P
R_3	Chalk, lime, and chert of Eocene age	D	D	F	M	F	EX	H	L	L	H	F
R_4	Chalk, marl, clay, chert, and limestone of late Cretaceous-Paleocene age	M	E	F	H	F	S	H	H	H	M	P
R_5	Limestone, dolomite, sandstone, and marl of early-middle Cretaceous age	D	D	G	M	F	EX	H	M	M	H	G
R_6	Limestone, dolomite, marl, and sandstone of Jurassic age	D	D	G	M	G	EX	H	L	M	H	F
R_7	Sandstone, clay, and dolomite of Cambrian Cretaceous age	D	D	G	M	F	S	H	M	M	H	F
R_8	Granite and calc-alkaline complex and related igneous rocks	D	D	G	M	G	EX	H	L	H	H	G
R_9	Undifferentiated metamorphic rocks (gneisses, migmatites, basic, and ultra-basic rocks	D	D	G	M	G	EX	H	L	H	H	G
R_{10}	Undifferentiated metasedimentary, metavolcanic, and volcanic rocks.	D	D	G	M	G	EX	H	H	H	H	F
S_1	Undifferentiated alluvial sand, silt, and gravel	E	E	G	L	P	DE	M	H	H	L	G
S_2	Sand dunes, various types	E	E	P	L	P	DE	L	H	L	L	G
S_3	Coastal deposits of clay, conglomerate, and reefs	E	E	P	L	P	DE	L	H	H	L	P
S_4	Lake deposits of marl, clay, sand, and conglomerate	E	E	F	L	P	M	M	H	H	L	P
S_5	Colluvial talus, slope wash, and slump deposits	M	M	P	H	P	M	H	H	H	L	F
S_6	Wadi deposits of sand, silt, and clay	E	E	P	L	P	DE	M	H	H	L	G

*Map rock units designated by "R" indicate that over 50% of the unit could have rock at the surface. map units designated by "sR" indicate that 20-50% of the unit could have rock exposed at the surface.

**KEY

E-EASY	DE-DEEP	G-GOOD	L-LOW
M-MODERATE	S-SHALLOW	F-FAIR	H-HIGH
D-DIFFICULT	EX-EXPOSED	P-POOR	

The environmental geology map (Plate 3-5, Sheets 1 and 2) shows the major rock and surficial geology units in the region. These units are classified by means of a series of symbols that signify their pertinent characteristics and interrelationships. The evaluation of these characteristics, in combination with relief and slope factors, greatly assisted in the identification of areas that are best and least suited for certain development activities.

3.2.5 Constraint Maps (Derivative Maps)

Two constraint overlays were developed to show the generalized land capability potential of the study region. The overlays include a resource map that shows the suitability of the region for agricultural and mineral development and an engineering map that highlights regional suitability for urban, industrial, and infrastructure development, including communication systems.

Each of the constraint maps was compiled by analyzing the overlays for relief, slope, landforms, and environmental geology in composite fashion and by assessing the interrelationships between key terrain attributes and impacts to proposed development. Information provided by the other task investigators was of primary importance in this analysis. As a result, it was possible to evaluate variations within given locations and to determine those areas which are best and least suited to certain development activities.

The constraint maps assist the planning team in assessing development strategies for all of Sinai and in identifying high priority areas where more detailed planning studies should be conducted.

3.2.5.1 Land Resources Map. The land resources map (Plate 3-6, Sheets 1 and 2) places primary emphasis on identifying areas of agricultural suitability. Also shown on these overlays are areas of known mineral potential.

In terms of agricultural suitability, major limitations to the development of an area include such constraints as local relief in excess of 150 meters, slopes in excess of 8 percent, shallow rock and thin soils, stony residuum, sand dune movement, saline soils, and severe erosion and gullying. These constraints, either individually or in combination, could be potential limiting factors in determining a particular area's suitability for agricultural development. The land resources map identifies areas according to geomorphic constraints. This assessment of suitable agricultural lands must be combined with an evaluation of water availability (Section 5.0).

3.2.5.2 Engineering Map. The primary purpose of the engineering constraint map (Plate 3-7, Sheets 1 and 2) is to provide information on the kinds of rocks and soils and the general range of conditions in the region. This map identifies the potential capabilities and limitations inherent in the development of Sinai from the standpoint of urban, industrial, and infrastructure planning.

Some potential limiting factors to urban and industrial development include local relief in excess of 150 meters, slopes greater than 15 percent, and poor engineering conditions with regard to adverse soils, workability (excavation), and foundation stability. From the standpoint of infrastructure development, additional limiting factors include constraints such as cut-slope stability and drifting sand dunes and other geologic hazards such as landslides and flooding.

3.2.5.3 Groundwater Potential Map. The groundwater potential map (Plate 3-8, Sheets 1 and 2) identifies aquifer areas, the estimated sustainable withdrawal rate from the area, and the total dissolved solids (TDS) of the water. Also shown is an estimated cost per cubic meter for extracting the water, and the estimated current usage at selected settlements.

The availability of water is generally the most limiting factor to consider when planning development in Sinai. Areas with the most potential for development will be identified by matching the quantity, quality, and cost data shown on the groundwater potential map with the land resources map and current groundwater usage data.

Based on the primary goal of maximum population growth on a sound economic basis, these results can then be matched with the estimated water and land resource needs of the development projects in all sectors and balanced with the remaining available resources.

4.0 DESCRIPTION OF PHYSICAL TERRAIN FEATURES

4.1 REGIONAL OVERVIEW

Sinai is comprised of five physiographic/geomorphic provinces - Southern Mountains Province, Stable Platform Province, Mobile Platform Province, Mediterranean Foreshore Province, and Suez Rift Province (Figure 4-1).

Distinctive landforms have developed in each province, in large part depending on the type of underlying rocks. The landforms reflect the various periods of mountain building and crustal warping, and the effects of different erosional forces. The present landscape reflects the total geologic environment, past and present.

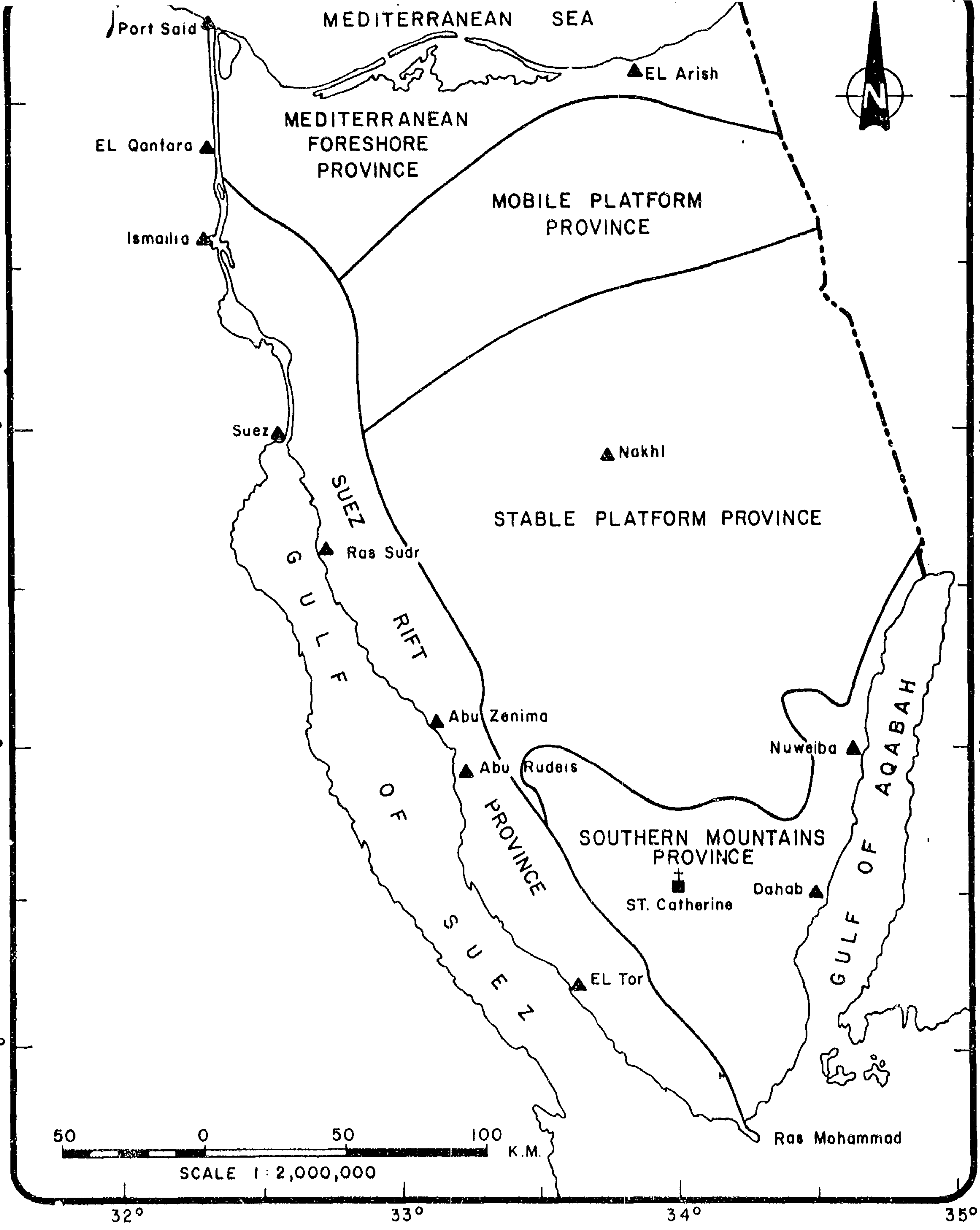
The Southern Mountains Province is composed of the Afro-Arabian shield basement rocks and represents the structural core of the peninsula. This province is characterized by steep, rugged slopes and high relief terrain.

North of the Southern Mountains is the Stable Platform Province. A gently dipping uplands area, developed on limestones and sandstones, this province occupies the major portion of the peninsula.

The Mobile Platform Province bounds the Stable Platform Province on the north. This province is a narrow northeast-southwest trending strip of the Syrian arch, with elongate hills and low-lying plains. Prominent landforms are the Gebel Maghara, Gebel Yelleq, and Gebel El Halal anticlines.

The Mediterranean Foreshore Province, an area of low relief terrain, extends along the entire northern coast of Sinai, inland to the mountains of the Mobile Platform Province. The landforms are predominantly sand dunes, sand sheets, and coastal depressions.

The Suez Rift Province parallels the Gulf of Suez and extends inland from the coast to the western limits of the Southern Mountains, Stable Platform, and Mobile Platform Provinces. The terrain in this province is highly variable. Most features are aligned in a north-northwest to south-southwest direction. Inland the province is marked by steep slopes and high relief, and along the coast moderate-to-gentle slopes and flat or slightly undulating relief are typical.



Sinai Development Study Phase I

Ministry of Development

Dames & Moore

SINAI PHYSIOGRAPHIC/GEOMORPHIC PROVINCES

FIGURE 4-1

The physiography and environmental geology of each province are described in detail in Sections 4.2 through 4.6. Each of these sections begins with a brief summary of the terrain suitability in terms of resources and engineering development.

4.2 SOUTHERN MOUNTAINS PROVINCE

As explained in Sections 4.2.1 and 4.2.2, the combined high relief, steep slopes, and very limited soil material of the Southern Mountains Province will be major deterrents to its development for any terrain-dependent, macroscale land uses. Plates 3-6 and 3-7, Sheet 2, identify the terrain suitability of this province in terms of resources and engineering development. Since the South Sinai mountains are dramatically beautiful and important to religious tradition, they could become the site of major tourist developments, but are unlikely to attract a large population of permanent settlers.

4.2.1 Physiography

4.2.1.1 Relief. The Southern Mountains Province is characterized by an extremely rugged, steeply sloping, high relief upland underlain by a variety of metamorphic, igneous, and metavolcanic rocks. Average relief within this province is on the order of 550 meters (1,800 feet), though local relief may exceed 1,370 meters.

The highest point in the Southern Mountains Province is Gebel Katherina, with an elevation of 2,642 meters above mean sea level. Numerous other peaks achieve or exceed the 2,000-meter elevation.

The relief map (Plate 3-2, Sheet 2) clearly shows that local relief in the core area of this province exceeds 600 meters. Along the western side of the central core, there is a gradation from mountains to hilly uplands (300 to 600 meters local relief) to plateau (150 to 300 meters local relief) terrain. The zone of plateau-like terrain marks a distinct boundary between this province and the Suez Rift Province. The hilly uplands to the south of the El Tih Escarpment form the northern boundary of the Province.

4.2.1.2 Slope. As shown on the slope map (Plate 3-3, Sheet 2), the Southern Mountains Province is characterized by predominantly steep slopes exceeding 25 percent (class 3). Only the lower reaches of the major wadis -- Feiran, Isla, Qenai, El Beida, Kid, and Nasb, for example -- are sufficiently level to be in the 0 to 8 percent category (class 1). The 8 to 25 percent (class 2) slope category contains areas with surface or near surface rocks that are relict remnants (inselbergs) of old mountains. These inselbergs are surrounded by detrital material, alluvial fill, and in some local areas lacustrine or eolian deposits. Other geomorphic features are areas of mass wasting, including talus slopes, debris slides, and rock falls. The majority of the class 1 and 2 slopes are in the north, north-central, and northeastern sections of this province.

4.2.1.3 Landforms. The Southern Mountains Province is a rugged, maturely dissected complex mountain mass consisting of crystalline rocks -- namely granite, gneisses, and schists -- with local occurrences of strongly disturbed metasedimentary (quartzites) and metavolcanic (metabasalt) rocks (Plate 3-4, Sheet 2). The rocks are highly fractured and are intruded by numerous dikes of variable relative resistance. Depending on their resistance, these dikes form either elongate ridges or narrow valleys and gorges.

The terrain is strongly controlled by rocks and structures. Landforms vary from bold, massive, domelike hills in granite areas to parallel, sharp-ridged hills and valleys in gneiss and schist areas. Soil cover is generally thin except in the valley areas, where the topography is controlled by differential weathering and structure. The drainage pattern is typically medium to fine-textured dendritic and rectangular dendritic. Curvilinear drainage alignments are common in the dome-like granitic area; rectangular drainage patterns reflecting structural control are prominent in gneiss and schist areas. Most of the wadis and gorges are characterized by steep side slopes; the channel gradients are also steep. Only some of the major wadis -- such as Feiran, Zelega, Marra, and Kid -- are of sufficiently gentle gradient and broad enough to provide a normally reliable transportation route. During the winter season, when maximum precipitation falls, transportation through these wadis is severely hindered due to flash flooding and road washouts.

4.2.2 Environmental Geology

The characteristics of the crystalline rocks in the Southern Mountains Province contrast sharply in engineering/environmental aspects with those of the sedimentary rocks to the north and west in the plateau and fold belt (Plate 3-5, Sheet 2). The three major rock complexes--Precambrian granites, metasediments, and metavolcanics--are all very hard, requiring blasting for excavation; extremely resistant to erosion; have excellent foundation stability factors; and retain a cut slope. Environmentally, they do not exhibit high water tables, are not flood prone (except in wadi channels), are not subject to dune transgression, and may be fair local aquifer recharge units. The rock complexes are also all highly dissected, fractured, and subject to mass wasting along the steep slopes. The alluvial and lacustrine deposits in the wadis range from very shallow to moderately shallow and are subject to flash flooding. Residual soils on the slopes of the mountains are very sparse, thin, and subject to severe erosion.

Except in the wadis and plains, the surface material in this province is bedrock. The granites, gneisses, and schists that dominate the province decompose into orthoclase, quartz, and plagioclase, with a variable quantity and content of other minerals. Physically, they weather out into coarse-grained sands with a limited amount of clay development. The extent of clay development is a function of the age of the alluvial material, its position in the wadi channel profile, and the amount of in situ (eluvial) weathering to which it has been exposed.

The depth of alluvial fill in wadis is highly variable. The soils of the wadis have little to no soil profile structural development and cannot be considered true soils. According to the American Soil Taxonomy (1975), most wadi soils in this province can be classified into two soil groups -- Torriorthents (dominant) and Torripsamments (subdominant). The eluvial materials, those which have developed in situ, tend to exhibit a slightly stratified sequence of loams, fine gravels, and coarse gravels. Depending on the age of the material and its position in the channel profile, it may exhibit varying amounts of carbonate deposits.

The soils of the Feiran Oasis are anomalous. They have developed around springs and have abnormally (for Sinai) high amounts of humic material. Stones, typical of wadi alluvial materials, have been removed by the farmers. Near Feiran Oasis, a series of pleistocene-lacustrine deposits form steep cliff banks to the wadi. The farmers of Feiran Oasis mine the loamy materials of these lacustrine deposits as a soil additive for their vegetable plots. However, soil analyses of the deposits indicate a salinity level on the order of 20 to 25 mmhos and higher; thus, the addition of these lacustrine deposits could be more detrimental than beneficial.

4.3 STABLE PLATFORM PROVINCE

As described in Sections 4.3.1 and 4.3.2, predominantly low relief combined with gentle-to-moderate slopes make much of the Stable Platform Province good-to-excellent for most terrain-dependent land uses. General recreation/tourism, engineered structures, general urban development, commercial and industrial centers, airports, railroads, and roads will encounter limited problems, most of which will be of a local nature. Agriculture will be restricted to the low-lying, low-energy alluvial plains. Plates 3-6 and 3-7, Sheets 1 and 2, identify the terrain suitability of this province in terms of resources and engineering development. This area has many resources which could support a significant number of new settlers on fair-to-good land with limited engineering difficulty. However, unless additional new sources of water are found, the lack of sizable quantities of usable water will preclude realization of this potential.

4.3.1 Physiography

4.3.1.1 Relief. As shown on Plate 3-2, Sheets 1 and 2, the Stable Platform Province is generally one of low relief. The predominant relief category is high plains. The second most predominant category is low plains. Lesser areas of plateau and hilly upland units are also found.

The highest point in this province is Ras El Geneina(1,626 meters above mean sea level)of the El Igma Plateau. The El Igma Plateau rises an average of 260 meters above the El Tih Plateau. On the west, the El Tih Plateau rises about 588 meters above the plains of Hosh El Bagar and Ramlet Himeiyir to the south; on the eastern side, it rises about 428 meters.

The regional dip of the Stable Platform Province is very gentle to the north, a drop of about 1,200 meters over 152 kilometers. Combined with this gentle northward dip, which is a stratigraphic dip, the province also has a gentle topographic slope toward its north-south axis. The effect of this basin can be seen by the central position and direction of Wadi El Arish and its main tributaries.

Relief in the Stable Platform Province is attributed mainly to differential erosion of the underlying strata. Only around the eastern, southern, and western perimeters is the relief directly influenced by tectonics. Because of the compound regional dip of this province, low plains -- the most gentle relief -- are found along its central areas, which are dissected by broad, low-lying wadis.

A broad expanse of high plains is located in a roughly crescentic pattern outward from the low plains. The high plains of this province have developed primarily on the Eocene limestones. To the south, below the El Tih Escarpment, the Hosh El Bagar and Ramlet Himeiyir areas are also classified as high plains.

Some of the more high relief areas -- still in a roughly crescentic pattern -- are found around the western, southern, and eastern perimeters of the province. Extending outward from the high plains is a narrow strip of plateau terrain. This unit includes the upper reaches of the El Igma Plateau and the Middle Cretaceous limestones of the El Tih Plateau. Beyond this area is another crescentic strip of hilly upland -- found on the more erodible, Lower Cretaceous sandstones and limestones of the outer edges of the El Tih Plateau and the upper reaches of the Umm Bugma area Other outliers of this category also exist on a more local basis in the higher elevations along the eastern and western borders.

4.3.1.2 Slope. The Stable Platform Province is characterized by slopes that are predominantly in the 0 to 8 percent category (Plate 3-3, Sheets 1 and 2). As with relief, the steeper slopes are located around the perimeters of the province. Slopes in excess of 25 percent are found along the extreme outer edges of the province along the El Tih, El Igma, and Umm Bugma Plateaus. A few small outliers of this class 3 slope category occur in the vicinity of Gebel Bodhiya, Gebel Magmar, and Ugret El Niseir. Slopes greater than 25 percent generally form the cliff face of escarpments, mountains, and other upland areas.

Class 2 slopes, those with 8 to 25 percent gradients, appear as small outliers, sparsely scattered throughout the central areas of the province. The largest areal extent of the class 2 slopes is along the inland sloping edges of the El Tih and El Igma Plateaus; these slopes represent areas of youthful erosional processes occurring on the steeper inclined strata. Class 1 slopes, 0 to 8 percent gradients, are by far the most predominant in the province and occupy virtually all of the low plains areas and much of the high plains areas.

4.3.1.3 Landforms. The major portion of the surface in the Stable Platform Province is low-lying, with rounded landforms predominating, as shown on Plate 3-4, Sheets 1 and 2. This is particularly evident inland, away from the tectonically affected perimeters. The landforms here reflect the low-energy state of the central part of the plateau. Few escarpments or structural barriers are found. Wadis and their tributaries often demonstrate a confused drainage pattern, where there is no clearly defined main channel. Along the uplifted boundary areas, however, a completely different landform development phase is present. Here the headwaters of the Wadi El Arish and its tributaries have cut deep and narrow gorges into the Cretaceous and Eocene limestones and sandstones. In the southern and southeastern region of the Stable Platform Province, the terrain is typified by "knife-blade" badland topography with numerous slope reversals. Extensive escarpments, intense dissection, and high relief make this region virtually impenetrable to all types of movement.

4.3.2 Environmental Geology

The bedrock of the Stable Platform Province is predominantly composed of horizontally bedded Middle and Lower Cretaceous sandstones and limestones and Eocene limestones. In general, the Cretaceous strata on the periphery of the province form a horseshoe pattern around the Eocene limestones. The Middle and Lower Cretaceous sandstones form a somewhat less resistant strata than the Eocene limestones. The Umm Bugma region to the south and southwest of the El Tih Plateau has developed on Cambrian to Carboniferous sandstones (Plate 3-5, Sheets 1 and 2).

The rock types that make up the province are quite varied in engineering and environmental qualities. The Eocene limestones of the El Igma Plateau are rather hard, possibly requiring blasting for excavation; they present good foundation stability, but are locally subject to mass wasting along some of the steeper slopes. Depending on their topographic and geographic position, they may be subject to flooding, periodic high water tables, and sand dune encroachment. These rocks are fairly resistant to erosion.

The Upper Cretaceous sandstones, limestones,and slates are fairly easy to excavate with power equipment. This unit displays good foundation stability, but may be susceptible to moderate degrees of mass wasting; environmentally, it appears to be highly susceptible to erosion and gullying. Depending on the topographic and geographic position, this unit could be locally subject to flooding, periodic high water tables, and dune encroachment.

Middle to Lower Cretaceous sandstones and limestones make up the El Tih Plateau. These rock units are moderately resistant to erosion, exhibit excellent foundation stability characteristics, and are only locally affected by mass wasting and cut-slope degradation. Environmentally, they do not appear to be overly prone to erosion and gullying. Such conditions could occur, however, in the more densely fractured areas. These stratigraphic groups form one of the best aquifer recharge units in Sinai.

South and soutwest of the El Tih Plateau are the Cambrian to Carboniferous sandstones which make up the Umm Bugma region. These rock units are quite variable from site to site and range from hard to moderately hard. However, they all appear to have good foundation stability and low mass-wasting characteristics. Environmentally,the units are somewhat susceptible to erosion and gullying and are highly fractured.

Rock, near surface rock, colluvium, alluvium, and a small amount of eolian sand deposits make up the surficial geology of this province. The rock and near surface rock areas are by far the predominant units. Colluvium is found along some of the lower reaches of the high plains relief areas. The colluvial deposits are made up of gravity, fluvial, or otherwise rapidly disintegrated materials. They exhibit poor sorting and are composed chiefly of stones and boulders. They have little-to-no cementation factor. Slope stability in these colluvial materials is usually very poor.

Alluvium has been deposited along the wadis and low-lying areas. These materials range from medium to fine-textured deep soils to soils with a flint capping. Limestones and sandstones were the parent material of most of these soils; thus, they are very calcareous.

4.4 MOBILE PLATFORM PROVINCE

The Mobile Platform Province presents a varied mixture of land use environments, as described in Sections 4.4.1 and 4.4.2. Its broad near-surface rock areas on the high plains relief unit may be compatible with all but agricultural land use. Agriculture here, as well as in most areas of Sinai, will be restricted to the low-lying, low-energy areas of the synclinal plains and alluvial valleys. Plates 3-6 and 3-7, Sheet 1, summarize the suitability of this province in terms of resources and engineering development. The Maghara coal resources may provide a stimulus for settlement in this province; the mountains will form an aesthetically pleasing setting for settlement development. Active sand dunes in this area are a hindrance to transportation and, as elsewhere in Sinai, water is a major constraint.

4.4.1 Physiography

4.4.1.1 Relief. The Mobile Platform Province is characterized by a series of northeast-southwest trending anticlinal dome structures that extend across the northern portion of Sinai. Gebel Maghara, Gebel Yelleq, and Gebel El Halal are some of the more prominent topographic features. Gebel Maghara rises to a height of 775 meters and has an average local relief of 262 meters. Gebel Yelleq achieves a maximum height of 1,075 meters at Ras Abu Qurun, the highest point in the province, and has an average relief of 300 meters. Gebel El Halal attains a maximum height of 890 meters and has an average relief of 338 meters. Some of the smaller peaks include Gebels Libni, Kherim, and El Thamila.

Four relief categories characterize the province (Plate 3-2, Sheet 1). Hilly uplands (300- to 600-meter local relief) occur along the crests of each of the major anticlines, where the underlying strata have been uplifted and exposed to erosive forces. Plateaus generally occur along the perimeter of the hilly uplands. Minor plateau features also occur in the inland areas within the more gentle and widespread high plains unit. The high plains relief unit occupies intervening lowland areas between the uplifts and consists of bajada surfaces, hogbacks, low-lying hills, and talus slopes; this area progressively grades into the lower relief low plains unit.

4.4.1.2 Slope. Slopes in this province are predominantly in the 0 to 8 percent category, as shown on Plate 3-3, Sheet 1. Virtually all of the low plains and most of the high plains relief units are within this slope class. In the central core area of Gebel Maghara and a small area in Gebel El Halal, where detritus and alluvium have infilled canyons, 0 to 8 percent slopes are also found.

As with the Southern Mountains Province, the class 2 slopes (8 to 25 percent) consist chiefly of hogback features, talus slopes, and landslide areas. They represent a transitional sequence from the gentle slopes of the lowlands and plains to the steep slopes of the hilly uplands and plateaus. Areas with greater than 25 percent slopes coincide roughly with the hilly upland and the plateau relief units. They occur along the crests of anticlinal structures, and thus represent the fracturing and rupturing which most of these anticlines were subjected to as they were uplifted.

4.4.1.3 Landforms. The Mobile Platform Province landforms include sand dunes and sand sheets, mountains, and plains (Plate 3-4, Sheet 1). The erg deposits of the sand dunes and sand sheets cover the western quarter of the province and the northern side. Gebels Maghara, Yelleq, and Halal are domed mountains developed on the northeast-southwest trending anticlines, which are an extension of the Syrian arch. Gebels Maghara and Halal have eroded breached cores in which small alluvial plains have formed. Hogbacks and escarpments are common throughout the mountains.

Alluvial and hammada plains surround Gebels Yelleq and Halal. They also surround Gebel Maghara except on the northwest and western sides, where they have been covered by sand. These plains areas are the most potentially useful landforms of the province.

4.4.2 Environmental Geology

Seven major rock types are found in the Mobile Platform Province (Plate 3-5, Sheet 1). The strata that form the anticlines -- with the exception of the northwestern half of Gebel Maghara -- are predominantly Cretaceous limestones, dolomites, marls, and sandstones. Gebel Maghara's northwestern half is comprised of Jurassic limestones and sandstones. Small intrusive basalt dikes also occur along the eastern flanks of Gebels Maghara and Yelleq. Outliers of Eocene chalk and limestone occur in the synclinal lowlands between the anticlines or along their flanks.

The Middle and Lower Cretaceous limestones and sandstones form the uplifted areas of the anticlines, are resistant to erosion, have excellent foundation stability characteristics, and form stable cut slopes. Because these units are the ridge formers in this province, they are not susceptible to dune encroachment, flooding, or high water table problems. The areas where these units crop out may act as local aquifer recharge areas. Because of their hardness, the units are difficult to excavate and are usually exposed at the surface or are very near the surface.

The Jurassic limestones and standstones that make up the northwestern half of Gebel Maghara share most of these same characteristics except that they are not a significant aquifer recharge unit.

The other rock units in this province, except the alluvial and sand dune surficial deposits, generally exhibit fair engineering qualities. Although the basalt intrusives have many of the same characteristics as described for the Middle and Lower Cretaceous units, their areal extent is so small and narrow that their qualities are severely diminished.

Alluvial deposits and sand dunes occur in major portions of this province. The alluvial deposits occur mainly between the anticlinal uplifts; they exhibit good engineering qualities with respect to ease of excavation and drilling, have generally good foundation stability factors, and are usually deep. Their primary environmental quality is that they act as an aquifer recharge unit. Depending on their proximity to moving sand dunes, they may or may not be susceptible to dunal encroachments; they are, however, quite floodprone and may exhibit a high water table on occasion. They are also usually heavily dissected by drainage channels. The sand dunes in this province are dynamic features and should not be considered for any type of development. However, sand dunes often form local "dune specific" aquifiers and may provide irregular supplies of water.

The high relief areas, hilly uplands, and plateaus are chiefly exposed rock. Extending outward from these areas into the high plains relief unit, surficial materials are largely detritus, colluvium, or other unconsolidated deposits covering near-surface rock. These areas cover an extensive region of the province.

Wide, flat, alluvial valleys occur between these upland areas and areas of near-surface rock. The alluvial deposits in these areas are currently used on a local basis for agriculture. These deposits vary from sandy-clay loams to coarsely graded gravelly soils. Many of them display calcareous horizons or hard-pans.

Eolian deposits in this province are either moving or currently stabilized. The moving or active dunes are predominantly on the northwest and northern sides of the province, while the partially stable dunes are on the northeastern side. Where eolian deposits and alluvial deposits have become mixed, the soils are usually fairly deep, finer textured, and do not exhibit the calcareous deposits typical of alluvial soils.

4.5 MEDITERRANEAN FORESHORE PROVINCE

The active nature of the western sand deposits in the Mediterranean Foreshore Province (Sections 4.5.1 and 4.5.2) poses serious operational and maintenance problems for transportation routes. Furthermore, the unconsolidated nature of the surficial material will require additional engineering and construction efforts to plan, build, and maintain road foundations. Many of the same engineering problems will be encountered when constructing multi-story or single-story structures. Agriculture will be limited to the stabilized dune areas and to dune-free areas. The poor nature of the soils in the western three-quarters of this province will make any large-scale land reclamation effort marginal at best. Plates 3-6 and 3-7, Sheet 1, identify the terrain suitability of this province in terms of resources and engineering development.

Of all the provinces, the Mediterranean Foreshore Province has the most potential to support rainfed agriculture. Additional natural resources beneficial to development include excellent beaches and the wildlife habitat around Lake Bardawil.

The agricultural land capability of this province has been studied on a larger scale, though still at a reconnaissance level, by the General Company for Research and Ground Water (REGWA). The REGWA report provides additional detail on landforms, soils, vegetation, and soil unit capabilities. The REGWA report and this report, though undertaken separately, share the same general conclusion that there is some potentially arable land in this province.

4.5.1 Physiography

4.5.1.1 Relief. The Mediterranean Foreshore Province is characterized by sand dunes, sand sheets, sabkhas, and low-lying plains (Plate 3-2, Sheet 1). The average relief is approximately 56 meters. The highest point in the province is 229 meters above sea level. The lowest points are in the El Tina Plain and at the eastern edge of Lake Bardawil, where the elevation is slightly below sea level.

Relief in this province is divided into the high and low plains. The high plains area coincides roughly with the extent of currently active dunes. The low plains area runs along the coast and includes the El Tina Plain, the sand bars of Lake Bardawil, and the partially stabilized dunes of the El Arish and eastern areas.

4.5.1.2 Slope. Except for a few scattered and very small areas, the Mediterranean Foreshore Province has a 0 to 8 percent slope class, as shown on Plate 3-3, Sheet 1. Areas with an 8 to 25 percent class designation are associated with major sand dunes.

4.5.1.3 Landforms. The Mediterranean Foreshore Province is an area of eolian landforms (Plate 3-4, Sheet 1). There are two classes of sand dunes here -- partially stabilized and active. Sand sheets and sand dunes are both present.

The stabilized dunes occur on the eastern side of the province. One reason for this may be the higher amount of precipitation in north-eastern Sinai, thus affording a better climate for vegetation to become established and for calcitic cementation of sand particles.

The active sand dunes can be divided into two geomorphic types -- Barchan and Seif dunes. Wherever the direction of the predominating winds is mixed, the sand dunes take on a crescent form, with the tails of the dune leading to the lee side; the windward side of the dune is usually more gently sloped. Seif dunes, or longitudinal dunes, form long ridges in the direction of the wind.

Other features in the province include coastal wetlands and marshes (in the El Tina Plain area), sand bars and extensive beaches along the Mediterranean Sea coast, sabkhas such as Lake Bardawil and Lake Malaha, and numerous smaller playas along the inland areas of these sabkhas. All features show extensive wind erosion and deposition.

4.5.2 Environmental Geology (Plate 3-5, Sheet 1)

This province is characterized by massive dunal deposits, with no bedrock exposed. The erg deposits are all easy to excavate. Except for the alluvial deposits and consolidated materials along the coast, they have poor foundation stability characteristics and are all very susceptible to mass wasting and cut-slope degradation. Environmentally, these materials are all easily eroded and, except for small very localized aquifers, cannot be considered good groundwater recharge areas. Along the coast the erg materials may be subject to a high water table.

Four types of surficial material are found in the Mediterranean Foreshore Province--current sand dune deposits, stabilized sand dune deposits, coastal deposits, and alluvial deposits -- all with widely varying soils. The soils in the El Tina Plain area have a high salt and clay content; those in the stabilized dune areas show high amounts of calcareous deposits. Soils developed on the alluvial materials of Wadi El Arish show the influence of both fluvial and eolian deposition; they tend to be lighter than purely alluvial soils and are somewhat more finely textured. The active sand dune areas have no soil horizon development and are unconsolidated sand piles.

4.6 SUEZ RIFT PROVINCE

The Suez Rift Province has considerable area for land use development, as explained in Sections 4.6.1 and 4.6.2. Only the central section of the province poses any major engineering or environmental geology problems to terrain-dependent land uses. Based on slope and surficial geology, this province -- especially its southern section -- appears to be suitable for agricultural development. Plates 3-6 and 3-7, Sheets 1 and 2, identify the terrain suitability in terms of resources and engineering development. A lack of water resources in this province will hinder its agricultural development, but the beautiful beaches, corals, and hot springs will stimulate increased tourism activity.

4.6.1 Physiography

4.6.1.1 Relief. The Suez Rift Province represents the intensely faulted eastern side of the Gulf of Suez rift. The strata have been subject to complex block faulting and associated folding along with depositional and erosional processes (Plate 3-2, Sheets 1 and 2).

The northern section of the province extends from the Bitter Lakes area south to near Abu Zenima, where it terminates into the alluvial fan deposits of Wadi Ba'ba and Wadi Sidri and the Cambrian to Carboniferous sandstones of the Umm Bugma Plateau. The southern section extends from Abu Zenima south to Ras Mohammad, at the extreme southern tip of Sinai.

The northern section displays the most rugged relief. Here, the Oligiocene and Miocene sedimentary units abut the Middle Cretaceous sediments of the Stable Platform Province. Along this contact they rise to over 400 meters. This contact area is a complex zone of intermixed hilly upland and plateau relief units. Outward from these higher relief areas, a broad belt of high plains runs the length of the section. In its southern reaches, plateau relief units are interspersed. The caprock nature of the Eocene limestones is displayed here also. Along the gulf coast is a belt of low plains relief that widens wherever it intercepts a wadi, thus reflecting the alluvial fan deposits. Around Abu Zenima several small hilly upland units also appear.

In the southern section of the Suez Rift Province, all five relief units are found. Gebel Abu Huswa of the Gebel Araba Ridge attains an elevation of 677 meters. North of El Tor several mountain ranges rise abruptly from the El Qaa Plain. These ranges are classified as hilly uplands with subunits of plateau relief. High plains are found interspersed between these ranges.

On the eastern side of the southern section, and abutting the crystalline rocks of the Southern Mountains Province, a narrow strip of plateau relief runs the length of this section, except on the extreme north where it is terminated by the hilly uplands of Gebel Abu Treifia. The predominate relief category of the southern section is high plains, which extend in a broad belt the entire length of the section and are continuous with the same belt of the northern section. At Abu Zenima, however, the high plains converge into a very narrow strip along the coast. The only low plains area found in this section is near the center of the high plains unit, north of El Tor, in the El Mashash mudflat area.

4.6.1.2 Slope. This province is characterized by the 0 to 8 percent slope class (Plate 3-3, Sheets 1 and 2). A broad belt of this class 1 slope extends the entire length of the province. At Abu Zenima the strip is very narrow and restricted to the beach. The steeper slopes form a complex area along the coast and central part of the province from the El Nikheilat Oasis, north of Hammam Fara'un, to Hammam Saidna Musa at El Tor. The class 3 slopes are along the ridges of the hills and mountains such as Gebel Qabeliat, Gebel Araba, Gebel Abu Treifia, and Hammam Fara'un. The more gentle class 2 slopes are formed on the detrital material along the toe of these ridges.

4.6.1.3 Landforms. The Suez Rift Province is a series of fault block mountains, plateaus, and flat plains, as shown on Plate 3-4, Sheets 1 and 2. The fault block mountains are best illustrated by Gebel Withr and Gebel Hammam Fara'un. The plateau areas are geomorphically a western extension of the Umm Bugma Plateau area of the Stable Shelf Province.

Two major plains areas are found in this province. The El Qaa Plain in the south is predominately an alluvial, or bolson surface, with extensive stone and gravel terraces cut by numerous disappearing wadi courses. North of El Tor this plain has considerable alluvial build up and has a finer texture than the southern portion. Although there are some eolian deposits they are of low relief, are generally local in nature, and are restricted to the southern half.

The northern plains are almost a reversal of the El Qaa Plain. They have extensive dunes and sand sheets in the north and central region and a small area of pediment surface in the south. Much of the coastal belt of this area is built up from wadi alluvial fans.

The central section of the Suez Rift Province, around Abu Zenima, is a series of flat-topped mesas, hogbacks, cuestas, and deeply incised arroyo channels.

4.6.2 Environmental Geology

The bedrock units of this province range from the recent alluvium through the Miocene, Eocene, and Cretaceous sediments to the Precambrian crystalline granites, schists, and gneisses. This broad stratigraphic spectrum and a complex structural history make the environmental geology of this province quite variable (Plate 3-5, Sheets 1 and 2).

Other than the recent alluvial material, the most predominant stratigraphic unit in the province is the Oligiocene-Miocene sediments -- generally clays, sandstones, marls, gypsum, conglomerate, and limestones, all of which are moderately hard. Second to this unit are the Eocene limestone units; here, as in the El Igma Plateau, they are the caprock formers. The other stratigraphic units are of a much smaller areal extent and are intensely faulted and interspersed.

The Oligiocene-Miocene units are not characterized by good engineering qualities. They may be difficult to excavate, in some areas requiring blasting or heavy equipment; additionally, they generally have fair foundation stability factors, are moderately susceptible to mass wasting, and have a poor retention of cut slopes. Environmentally, they are very susceptible to erosion and gullying. In this region, the units are moderately fractured and are considered to have only fair local aquifer recharge characteristics.

The Eocene units are generally caprock units, which are difficult to excavate and require blasting. Their foundation stability factors are fair. Although these units are moderately susceptible to mass wasting, they usually retain cut slopes. Environmentally, they are considered to be only slighly susceptible to erosion and gullying. The Eocene units in the Suez Rift Province are highly fractured and may be a fair local groundwater aquifer recharge unit.

The other bedrock units of this province are all highly fractured and faulted, and occur in small, usually upturned sections. Because of these structural stresses, their engineering qualities cannot be considered normal or necessarily comparable to the same stratigraphic units that occur elsewhere in Sinai. Any deployment of terrain-dependent land uses will require extensive geologic and engineering analysis.

The material of Quaternary age is of three major types -- undifferentiated wadi alluvium, eolian deposits, and coastal deposits. All three of these units are easily excavated. With the exception of the wadi alluviums, which have good foundation stability properties, they provide a poor medium on which to build. All of these units are very susceptible to erosion. Sand dunes are affected by wind erosion, and the wadi and coastal deposits are affected by gullying. The sand dunes and the wadi alluvium both provide for fair-to-good local aquifer recharge.

The wadi alluvium and coastal sediments are subject to flooding. The coastal sediments are often affected by high water table conditions.

Because of the diverse nature of the local stratigraphy and the fact that almost all the wadis of this province have their headwaters in the neighboring stratigraphic units of the upland provinces, the alluvial deposits and resulting soils are variable. In general, the steeper class 2 and 3 slope areas, and the higher relief areas -- mountains, hilly uplands, and plateaus -- have exposed bedrock at the surface. Thus, the unconsolidated surficial material is restricted to the high and low plains areas and to the wadis.

As mentioned previously, the northern portion of the Suez Rift Province is affected by active sand dunes. Coastal sediments are located to the southwest and west of these dunal areas, along the coast near Suez. These deposits are highly saline, have clay and sandy/loam horizons, and reflect a gleization soil development process.

The alluvial deposits of this section of the province and those of the southern portion of the south section both exhibit a stony-to-coarse gravelly surface, with varying textures and depths of gravel beneath the surface. Calcification of varying degrees may be present.

Along the low-lying mudflats area of El Mashash, in the south, a somewhat different soil development has taken place. Soils here may have gley markings and are generally of a sandy clay/loam texture. The source of the salts in these soils is the gypsums of the Oligiocene-Miocene strata south of Abu Rudeis. The amount and texture of the gravels in these soils is variable. The alluvial deposits of the El Qaa Plain and portions of the northern plains area are quite deep.

5.0 LAND RESOURCES

This section describes various land resources in Sinai, including water, agriculture, domestic livestock, vegetation and grazing land, the environment, minerals, and energy. Section 5.3 explains a system for the classification of land according to agricultural suitability.

5.1 WATER

5.1.1 Precipitation

Almost all of the precipitation in Sinai occurs during the winter months. Rainfall and occasional hail are the major precipitation forms in North Sinai, while rain, hail, and snow are common in the southern mountains.

Annual precipitation varies from 100 to 300 millimeters along the northeast coast to 20 millimeters in the plateau and lowlands region of central, western, and southern Sinai. The amount of precipitation increases generally from west to east--with an annual average of 79 millimeters at Port Said and 304 millimeters at Rafah. The orographic effects of the El Igma-El Tih Plateau and of the mountain area around Saint Catherine's cause slightly higher precipitation to occur in these areas.

5.1.2 Surface Runoff

Seven drainage basins are found in Sinai (Table 5-1), three of which are considered major in that they carry significant amounts of runoff to the sea--the Mediterranean Basin, the Gulf of Aqabah and Dead Sea Basin, and the Gulf of Suez Basin. Table 5-2 presents data on the availability of water for possible groundwater recharge and for the proper deployment of spreader and catchment basin dams.

Numerous historical attempts have been made by Bedouins to harness surface runoff in several of the Sinai wadis--usually by the use of low earthen dams behind which the flow of water is trapped to flood olive orchards and agricultural fields. The use of these spreader dams does not appear to be as common today as it was prior to 1967. Areas in which agriculture took place during 1955 and 1956 are shown on the land resources map (Plate 3-6, Sheets 1 and 2).

Several attempts were also made to construct masonry dams across the main channel of Wadi El Arish and a few of its major tributaries. The El Rawafaa dam, about 50 kilometers south of El Arish, originally had a 3-million-cubic-meter capacity. This dam is reported to now be almost

TABLE 5-1

Drainage Basins and Subbasins in Sinai

Basin/Subbasin	Drainage Area	Estimated Catchment Area (square kilometers)
NORTHERN OR MEDITERRANEAN BASIN		
Wadi El Arish		20,850
• Wadi El Aqabah	Southeast El Tih Plateau	
• Wadi El Ruaq	Southern El Tih-El Igma Plateaus	
• Wadi El Bruk	Western El Tih-El Raha Plateaus	
• Wadi Geraia	Eastern Sinai and a portion of southern Negev	
• Wadi El Hasana	North-central Sinai	
• Wadi Hareidin	Southern Negev and north-eastern Sinai	
GULF OF AQABAH BASIN		
Wadi Watir	South Sinai to Gulf of Aqabah at Nuweiba	3,513
Wadi Nasb	South Sinai to Gulf of Aqabah at Dahab	2,025
Wadi Kid	Southern portion of South Sinai to Sharm El Sheikh	1,025
Wadi Umm Adawi	Southern portion of South Sinai to Sharm El Sheikh	350
GULF OF SUEZ BASIN		
Wadi El Hagg	El Raha Plateau to Gulf of Suez at Ayun Musa	512
Wadi El Raha	El Raha Plateau to Gulf of Suez at Ayun Musa	725
Wadi Lahata	El Raha Plateau to Gulf of Suez at Ayun Musa	580
Wadi Sudr	Gulf of Suez north of Abu Zenima	625
Wadi Wardan	Gulf of Suez north of Abu Zenima	1,288
Wadi Gharandal	Gulf of Suez north of Abu Zenima	800

TABLE 5-1 (cont'd)

Basin/Subbasin	Drainage Area	Estimated Catchment Area (square kilometers)
Wadi Tayiba	Gulf of Suez north of Abu Zenima	425
Wadi Ba'ba	Southwestern Sinai to south of Abu Zenima	713
Wadi Sidri	Southwestern Sinai to south of Abu Zenima	1,025
Wadi Feiran	Southwestern Sinai to south of Abu Zenima	1,675
Wadi El Aawag	Southwestern Sinai to south of Abu Zenima	1,463
LOWLAND AREA EAST OF BITTER LAKES		
Wadi El Giddi	Umm Khisheib Plateau and adjacent folded areas	325
Wadi Umm Khisheib	Umm Khisheib Plateau and adjacent folded areas	350
LOWLAND AREA SOUTH OF LAKE BARDAWIL		
Wadi El Hegayib	Folded complex of El Maghara, Umm Mafruth, and Risan Aneiza	912
LOWLAND AREA EAST OF EL QANTARA (no defined drainage lines)		
WADI GERAFI AND TRIBUTARIES	Eastern portion of El Tih Plateau to southern Negev and Dead Sea	2,350

SOURCE: Dr A. Shata, unpublished notes.

TABLE 5-2

Estimated Rainfall and Runoff Data for Sinai Drainage Basins

Drainage Basin	Catchment Area (wadis)	Area (square kilometers)	Mean Maximum Rain in One Day (millimeters)	Potential Runoff in One Day (10^6 cubic meters)
Mediterranean	El Arish	20,850	35.0	31.3-461
Gulf of Aqabah	Watir	3,513	47.4	5.3-164
	Nasb	2,025	57.8	3-76
	Kid	1,025	51.7	1.5-34
	Umm Adawi	350	40.0	0.5-8.4
	El Aawag	1,463	55.1	2.2-52
Gulf of Suez	Feiran	1,675	58.6	2.5-64
	Sidri	1,025	50.0	3-32
	Ba'ba	713	40.0	1.1-17
	Tayiba	425	38.0	0.6-9.6
	Gharandal	800	37.0	1.2-17
	Wardan	1,288	39.0	1.9-30
	Sudr	625	40.0	0.9-15
	Lahata	580	45.0	0.8-16
	El Raha	725	45.0	1.6-20
	El Hagg	512	40.0	0.8-12
Bitter Lakes	El Giddi	325	37.0	0.5-7.1
	Umm Khisheib	350	33.0	0.5-6
El Bardawil	Hegayib	912	33.0	1.4-17
Dead Sea	El Gerafi	2,350	30.9	3.5-40

SOURCE: Dr. A. Shata, unpublished notes.

totally silted up. A somewhat smaller dam was built by the Turks during World War I, across Wadi Guedeirat, but it is also silted up.

Several potential catchment dam sites can be identified on the basis of physical terrain data alone. Two of these are located at the upper and lower ends of the El Daiqa Gorge, where Wadi El Arish cuts through Gebel El Halal. A third location is the El Mitmetni Gorge, between Gebel Tabaqet-El Mitmetni and Gebel Taliat El Bedan. Further upstream, west of Gebel Kherim, the Wadi El Arish channel narrows. This, too, may be a potential site for a catchment or spreader dam. Numerous other potentially good sites for small earthen dikes can be identified in each major drainage basin.

Water from spreader and catchment dams will be available only on an intermittent basis and cannot be relied upon. Therefore, it cannot be considered as a dependable resource for planning purposes. In the future, as better meteorological and flow data become available, water availability from this source may be more predictable, at which time it can be used as valid input to the development planning process; until then, its capture and use can only be suggested. Another factor that must be considered is the impact which any catchment dam placed across a major channel will have on downstream groundwater aquifers. Typically these impacts can be negative--reducing downstream groundwater recharge, and/or positive--increasing local groundwater recharge. Careful, detailed geohydrologic and geologic analysis will be critical to the proper siting of such structures.

5.1.3 Groundwater Recharge and Potential

There are several significant groundwater aquifer and recharge units in Sinai--Pleistocene coastal, Quaternary alluvium, Middle Cretaceous, Eocene, Miocene sandstone, crystalline, Lower Cretaceous sandstone, and nubian sandstone. Several smaller, less significant aquifers and recharge areas are comprised of sand dunes, wadi channel alluvium, and alluvial deposits. These smaller aquifers generally form only local and highly variable water supplies

Table 5-3 presents generalized information on the average well depth, discharge rate per well, estimated sustainable daily yield, total dissolved solids, estimated cost of extraction, and data confidence level for 46 areas within the major aquifers. The estimates of water that can be withdrawn from aquifers refers to the estimated total

TABLE 5-3

Estimated Groundwater Availability in Sinai

Area[a]		Aquifer	Well Depth (m)	Discharge Rate Per Well (l/sec)	Estimated Long-term Groundwater Withdrawal Possible From Area (m^3/day)	TDS of Water (mg/l)	Cost of Groundwater (LE/m^3)	Average Confidence Level of Information[b]
1.	Rafah	Pleistocene coastal aquifer	40-90	9-17	25,000	1,000-3,000	0.02-0.07	2.4
2.	El Arish	Pleistocene coastal aquifer	40-60	3-28	25,000	1,000-6,000	0.01-0.06	1.2
3.	North coastal strip	Sand dunes	5-8+	~2[d]	6,000	2,000-5,000	0.07	2.2
4.	Rabaa	Pleistocene aquifer	70-110	11-23	10,000	5,000-7,000	0.02-0.05	2.8
5.	Masagid Basin	Quaternary aquifer	30-50	1-9	3,000	1,000-3,000	0.05-0.21	3.8
6.	East side of Gebel Maghara	Middle Cretaceous aquifer	50-250	2-14	5,000	2,000-5,000	0.02-0.42	3.4
7.	Gebel El Halal	Middle Cretaceous aquifer	45-250	2-14	5,000	1,500-4,000	0.02-0.39	3.4

[a] Refer to Plate 3-8, Sheets 1 and 2, for location of areas.

[b] Estimated long-term groundwater withdrawal possible.

[c] The number "1" indicates the highest level of confidence; the number "4" indicates the lowest level.

[d] Trenches about 15 meters long are assumed to be the primary means of groundwater development.

TABLE 5-3 (cont'd)

	Area	Aquifer	Well Depth (m)	Discharge Rate Per Well (l/sec)	Estimated Long-Term Groundwater Withdrawal Possible From Area (m^3/day)	TDS of Water (mg/l)	Cost of Groundwater (LE/m^3)	Average Confidence Level of Information
8.	Gebels Yelleq and Fallig	Middle Cretaceous aquifer	50-250	2-14	7,000	1,500-3,000	0.02-0.40	3.4
9.	Gebels Hamra and Giddi	Middle Cretaceous aquifer	50-250	2-14	2,000	2,000-6,000	0.02-0.41	3.6
10.	Gebel Kherim	Middle Cretaceous aquifer	50-250	2-14	800	2,000-4,000	0.02-0.38	3.6
11.	Gebels Burga and Taliat El Bedan	Middle Cretaceous aquifer	50-250	2-14	2,000	2,000-4,000	0.02-0.38	3.4
12.	Central Sinai	Middle Cretaceous aquifer	250-450	2-14	7,000	1,500-4,000	0.05-0.65	3.6
13.	El Quseima	Eocene aquifer	25-75	3-17	3,000	500-3,000	0.01-0.14	3.0
14.	Great Bitter Lake to Ras Misalla	Miocene sandstone	150-550	6-23	10,000	1,000-8,000	0.02-0.31	2.4
15.	Wadi El Arish upstream Gebel Halal	Wadi alluvium	30-40	2-17	3,000	1,500-4,000	0.02-0.19	3.0
16.	Wadi El Gayifa	Wadi alluvium	30-40	2-9	3,000	1,000-2,500	0.03-0.17	3.0

TABLE 5-3 (cont'd)

	Area	Aquifer	Well Depth (m)	Discharge Rate Per Well (l/sec)	Estimated Long-term Groundwater Withdrawal Possible From Area (m^3/day)	TDS of Water (mg/l)	Cost of Ground-water (LE/m^3)	Average Confidence Level of Information[b]
17.	Wadi El Gerafi	Wadi alluvium	30-50	2-12	7,000	1,000-3,000	0.02-0.19	3.0
18.	Wadi Gerala	Wadi alluvium	20-40	2-9	500	1,500-2,500	0.03-0.17	2.8
19.	Wadi El Aqabah	Wadi alluvium	25-45	2-9	1,500	1,500-4,000	0.03-0.18	3.0
20.	Wadis El Bruk and El Arish	Wadi alluvium	25-45	2-9	2,500	2,500-6,000	0.03-0.18	2.8
21.	Wadi Sudr Delta	Wadi alluvium	20-30	3-14	1,200	2,500-3,000	0.02-0.11	2.2
22.	Wadi Wardan Delta	Wadi alluvium	20-30	3-14	1,200	2,000-3,000	0.02-0.11	2.2
23.	South Central Sinai	Middle Cretaceous aquifer	150-250	2-14	10,000	1,500-4,000	0.03-0.41	3.6
24.	Gebel Somar to Gebel Igma	Middle Cretaceous aquifer	50-150	3-23	12,000	1,000-2,000	0.01-0.21	3.0
25.	El Themed to Ras El Geneima	Middle Cretaceous aquifer	50-150	1-9	6,000	2,000-4,000	0.03-0.66	3.2

TABLE 5-3 (cont'd)

	Area	Aquifer	Well Depth (m)	Discharge Rate Per Well (l/sec)	Estimated Long-Term Groundwater Withdrawal Possible From Area (m^3/day)	TDS of Water (mg/l)	Cost of Ground-water (LE/m^3)	Average Confidence Level of Inform-ation
26.	Wadi Gharandal	Wadi alluvium	15-35	0.5-2	600	2,000-5,000	0.10-0.53	2.8
27.	Southern Mountains	Crystalline aquifers	40-120	1-7	30,000	200-2,000	0.03-0.47	3.0
28.	Wadi Ba'ba, El Markha Plain	Wadi alluvium	50-200	2-14	1,200	2,000-4,000	0.02-0.33	2.8
29.	Wadi Sidri and Delta	Wadi alluvium	40-80	1-9	900	1,000-3,000	0.03-0.44	2.6
30.	Abu Rudeis to El Qaa Plain	Miocene sandstone	30-80	2-17	2,000	4,000-6,000	0.01-0.20	2.8
31.	Wadi Feiran and Wadi El Sheikh	Wadi alluvium and lake deposits	10-55	0.5-6	5,000	400-800	0.03-0.69	1.6
32.	Gebel Katherina area	Wadi alluvium	30-60	0.5-4	1,400	200-800	0.10-0.62	2.4
33.	El Qaa Plain	Wadi alluvium	80-150	12-35	24,000	600-2,500	0.01-0.10	1.6
34.	Sharm El Sheikh	Miocene sandstone	20-30	0.5-2	600	2,000-6,000	0.07-0.41	3.0
35.	Sharm El Sheikh	Wadi alluvium	40-100	2-12	1,000	1,500-4,000	0.02-0.21	3.6
36.	Wadis Kid and Umm Adawi; Nebq	Wadi alluvium	40-100	2-12	1,500	600-3,500	0.02-0.21	3.4
37.	Wadi Nasb	Wadi alluvium	25-40	0.5-7	3,000	300-1,500	0.03-0.59	3.2

TABLE 5-3 (cont'd)

	Area	Aquifer	Well Depth (m)	Discharge Rate Per Well (l/sec)	Estimated Long-term Groundwater Withdrawal Possible From Area (m^3/day)	TDS of Water (mg/l)	Cost of Groundwater (LE/m^3)	Average Confidence Level of Information
38.	Wadi El Ghaib and Dahab area	Wadi alluvium	15- 40	1-9	1,600	2,000-4,000	0.02-0.31	3.0
39.	Wadi Watir and Nuweiba area	Wadi alluvium	15- 40	1-9	1,200	1,000-3,500	0.02-0.31	3.2
40.	Gebel Maghara area	Lower Cretaceous sandstone	50-250	2-23	8,000	2,000-7,000	0.01-0.48	2.6
41.	Risan Aneiza area	Lower Cretaceous sandstone	60-450	2-23	2,400	2,000-7,000	0.01-0.71	2.6
42.	Gebel El Halal	Lower Cretaceous sandstone	50-250	0.3-9	1,000	1,000-3,000	0.03-0.80	2.4
43.	Gebel Kherim	Lower Cretaceous sandstone	100-450	3-17	400	1,500-2,500	0.03-0.45	3.0
44.	Central Sinai	Lower Cretaceous sandstone	450-950	2-14	10,000	1,500-2,500	0.09-1.50	2.6
45.	South Central Sinai	Lower Cretaceous sandstone	350-450	2-14	10,000	1,500-2,500	0.06-1.00	3.0
46.	Southern Sinai	Nubian aquifer	100-450	2-14	7,000	1,500-3,000	0.03-1.00	3.2

groundwater available and includes both groundwater currently being withdrawn and any additional amount that can be safely withdrawn in the future. Table 5-4 estimates current water use in Sinai. Plate 3-8, Sheets 1 and 2, provides a summary map of the estimated quantity, quality, and cost of water for each aquifer.

5.2 AGRICULTURE

Optional Working Paper No. 18, Crop Production in Sinai (August 1981), presented an overview of the current agricultural practices and productivity in Sinai. Optional Working Paper No. 11, Livestock Production in Sinai (June 1981), described livestock practices and the importance of the livestock sector. Additional information on agricultural and animal husbandry practices was obtained during field investigations by the Desert Institute.

The largest concentration of crop production in Sinai is near El Arish, where irrigated farming has been practiced for several decades. There is also some rainfed crop farming in the area, particularly east of El Arish toward Rafah.

East of Bitter Lakes, a second fairly large area of intensive crop production, using Nile water for irrigation, is in the early stages of development. Total production here during 1981 is less than near El Arish but potential production within 5 years could be significantly greater.

Aside from these two concentrated areas, there are many small, almost garden-like plots scattered throughout Sinai which, in total, may produce as much as the area near El Arish. Table 5-5 shows the estimated crop production in North Sinai in 1981.

5.3 AGRICULTURAL LAND SUITABILITY CLASSIFICATION

Plate 3-6, Sheets 1 and 2, show the overall land resources suitability of Sinai in terms of agricultural development and known mineral resources potential.

Four general land classes of agricultural suitability were defined from the qualitative evaluation of key physical attributes related to slope, relief, landforms, and soil characteristics, including surface texture, depth, erosion, and gullying. Thus, the classification is primarily a geomorphic one, refined wherever possible by chemical analysis data. This approach suits Sinai particularly well due to its

TABLE 5-4

Estimated Current Water Use in Sinai

Area or Community	WATER SOURCE: LOCAL GROUNDWATER: Total Groundwater Withdrawal (m^3/day)	Aquifer and Location	Wells or Springs	Uses: Public supply (m^3/day)	Uses: Irrigation (m^3/day)	Uses: Exported to other areas: Amount (m^3/day)	Uses: Exported to other areas: Destination	NILE WATER (for irrigation): Amount (m^3/day)	NILE WATER: Origin	PIPED WATER (for domestic supply): Amount (m^3/day)	PIPED WATER: Origin	BY TRUCK (for domestic supply): Amount (m^3/day)	BY TRUCK: Origin	BY TANKER (for domestic supply): Amount (m^3/day)	BY TANKER: Origin
El Arish	24,100	Pleistocene coastal aquifer	Wells	8,100	13,100	2,500	Gifgafa and Umm Khisheib, also Quseima	0	-	0	-	0	-	0	-
Rafah - Sheikh Zowaid	~12,000	Pleistocene coastal aquifer	Wells	~3,500	~8,500	0	-	0	-	0	-	0	-	0	-
Abu Aweigila	~150	Wadi alluvium	Wells	~50	~100	0	-	0	-	600	El Arish groundwater	0	-	0	-
Quseima	~400	Eocene or Cretaceous limestone	Well and springs	~100	~300	0	-	0	-	600	El Arish groundwater	0	-	0	-
Bir El Abd	~250	Sand dune aquifer	Wells	~250	0	0	-	0	-	0	-	16	Nile water at Qantara	0	-
Negila	~30	Sand dune aquifer	Well	~30	0	0	-	0	-	0	-	28	Nile water at Qantara	0	-
Rabaa	~200	Sand dune aquifer	Wells and trench	~20	~180	0	-	0	-	0	-	16	Nile water at Qantara	0	-
Romana	~40	Sand dune aquifer	Wells	~40	0	0		0	-	0	-	16	Nile water at Qantara	0	-
Baloza	0	-	-	0	0	0	-	0	-	0	-	25	Nile water at Qantara	0	-
Gilbana	~100	Sand dunes or Pleistocene aquifer	Wells	~100	0	0	-	0	-	0	-	30(?)	Nile water at Qantara	0	-
El Qantara East	0	-	-	0	0	0	-	0	-	1,000	Nile water, from across Suez Canal	0	-	0	-

TABLE 5-4 (cont'd)

Area or Community	WATER SOURCE: LOCAL GROUNDWATER							NILE WATER (for irrigation)		PIPED WATER (for domestic supply)		BY TRUCK (for domestic supply)		BY TANKER (for domestic supply)	
	Total Groundwater Withdrawal	Aquifer and Location	Wells or Springs	Uses: Public Supply	Uses: Irrigation	Uses: Exported to Other Areas									
	(m^3/day)			(m^3/day)	(m^3/day)	Amount (m^3/day)	Destination	Amount (m^3/day)	Origin	Amount (m^3/day)	Origin	Amount (m^3/day)	Origin	Amount (m^3/day)	Origin
New Mit Abul Kom, Hero Village and Youth Farms	0	-	-	0	0	0	-	55,000	Nile water, via Suez irrigation canal and siphons south of Ismailia	0	-	0	-	0	-
Gifgafa	~10	Lower Cretaceous aquifer(?)	Military well	~10	0	0	-	0	-	100	El Arish groundwater	0	-	0	-
"Early Warning Station" at Umm Khisheib	0	-	-	0	0	0	-	0	-	1,100[a]	El Arish groundwater	0	-	0	-
El Hamma (Baghdad)	0	-	-	0	0	0	-	0	-	300	El Arish groundwater	0	-	0	-
El Hasana	~150	Wadi alluvium, Paleocene, and basalt dykes	Wells	~150	0	0	-	0	-	0	-	24	Nile water at Qantara	0	-
Bir El Thamada	~15	Wadi alluvium	Wells	~15	0	0	-	0	-	0	-	10(?)	Nile water at Qantara	0	-
Nakhl	~20	Wadi alluvium and lower Cretaceous	Wells	~20	0	0	-	0	-	0	-	4	Nile water at Qantara	0	-
El Shatt	0	-	-	0	0	0	-	0	-	0	-	2	Nile water from Qantara	0	-
El Kuntilla	~100	Wadi alluvium	Wells	~100	0	0	-	0	-	0	-	0	-	0	-
El Themed	~125	Wadi alluvium and Middle Cretaceous	Wells	~125	0	0	-	0	-	0	-	0	-	0	-

[a] Some of this flow is reportedly used for agriculture at the Umm Khisheib Station.

TABLE 5-4 (cont'd)

Area or Community	LOCAL GROUNDWATER: Total Ground-water With-drawal (m³/day)	Aquifer and Location	Wells or Springs	Uses: Public Supply (m³/day)	Uses: Irri-gation (m³/day)	Uses: Exported to Other Areas: Amount (m³/day)	Uses: Exported to Other Areas: Destin-ation	NILE WATER (for irriga-tion): Amount (m³/day)	NILE WATER: Origin	PIPED WATER (for domestic supply): Amount (m³/day)	PIPED WATER: Origin	BY TRUCK (for domestic supply): Amount (m³/day)	BY TRUCK: Origin	BY TANKER (for domestic supply): Amount (m³/day)	BY TANKER: Origin
Ayun Musa	~500-1,000[b]	Miocene and Lower Cretaceous	Flowing wells and springs	0	0	0	-	0	-	0	-	1	Nile water from Qantara	0	-
Ras Misalla	150	Basal Miocene and Cretaceous	Two wells	0	0	~150	Ras Sudr	0	-	0	-	0	-	0	-
Ras Sudr (and Abu Suweira)	~500	Quaternary	Wells	0	~500	0	-	0	-	~150	Two wells at Ras Misalla	40	Nile water from Qantara	(d)	-
Wadi Gharandal	~100	Quaternary	Wells	2	~100	0	-	0	-	0	-	0	-	0	-
Abu Zenima	0	-	-	0	0	0	-	0	-	0	-	4	Nile water from Qantara	0	-
Abu Rudeis	~900	Quaternary	Wells 8 km away, in Wadi Sidri	~100											
		Quaternary	Nearby wells	~800[c]	0	0	-	0	-	0	-	8	Nile water from Qantara	(e)	Suez
Feiran and Belayim	0	-	-	0						~1,300[c]	Wells in Wadi Feiran located 10-12 km from sea	0	-	(e)	Suez

[b] Estimated free flow from springs and flowing wells at Ayun Musa. The water is apparently not put to use; TDS reported to range from 2,500 to 13,000 ppm.

[c] Estimated use for oil fields.

[d] Some water may be received at Ras Sudr by tanker.

[e] These communities receive freshwater by tanker for domestic purposes, but the amount is not known.

TABLE 5-4 (cont'd)

Area or Community	WATER SOURCE: LOCAL GROUNDWATER: Total Groundwater Withdrawal (m³/day)	Aquifer and Location	Wells or Springs	Uses: Public supply (m³/day)	Uses: Irrigation (m³/day)	Uses: Exported to Other Areas: Amount (m³/day)	Uses: Exported to Other Areas: Destination	NILE WATER (for irrigation): Amount (m³/day)	NILE WATER: Origin	PIPED WATER (for domestic supply): Amount (m³/day)	PIPED WATER: Origin	BY TRUCK (for domestic supply): Amount (m³/day)	BY TRUCK: Origin	BY TANKER (for domestic supply): Amount (m³/day)	BY TANKER: Origin
Wadi El Sheikh between Feiran Oasis and Watia Pass)	~210	Wadi alluvium	Wells	~10	~200	0	-	0	-	0	-	0	-	0	-
Saint Catherine's	~100	Quaternary and crystalline units	Wells and Springs	50	~50	0	-	0	-	0	-	0	-	0	-
El Tor	~2,800	Wadi alluvium	Wells	700	~100	~2,000	Sharm El Sheikh	0	-	0	-	4	Nile water	0	-
Wadi Feiran (10-12 km from Gulf of Suez)	~1,300	Miocene sandstone and possibly Quaternary	Three wells	0	0	1,300	Feiran and Belayim oil fields	0	-	0	-	0	-	0	-
Oasis of Feiran	~2,550	Wadi alluvium	Wells	50	2,000	0	-	0	-	0	-	0	-	0	-
Sharm El Sheikh	~10	Miocene sandstone	Wells	~10	0	0	-	0	-	~2,000	El Tor wells	0	-	0	-
Nebq	~10	Quaternary	Wells	~10	0	0	-	0	-	~200	Eilat; wells in Gerafi Basin	0	-	0	-
Dahab	~100	Quaternary	Wells	~100	0	0	-	0	-	~200	Eilat; wells in Gerafi Basin	0	-	0	-
Nuweiba/Wasit	~100	Quaternary	Wells	~100	0	0	-	0	-	~400	Eilat; wells in Gerafi Basin	0	-	0	-

TABLE 5-5

Estimated Crop Production in North Sinai, 1981

Crop	Number of Trees or Plants	Estimated Area (feddans)	Yield per Feddan (tons)	Total (tons)
IRRIGATED				
Olives	69,783	700	--	2,500
Grapes	2,072	--	--	2.5
Pomegranates	1,512	--	--	1.5
Almonds	468	4	--	0.3
Oranges-lemons	3,395	30	--	6
Guavas	973	--	--	3
Figs	1,198	--	--	0.75
Vegetables				
Tomatoes	--	180	15	--
Cucumbers	--	80	6	--
Squash	--	80	8	--
Peppers	--	50	3	--
Eggplant	--	40	5	--
Potatoes	--	7	8	--
Watermelon	--	3	15	--
Okra	--	3	5	--
Hot chili (green peppers)	--	3	7	--
NONIRRIGATED				
Small grains	--	2,052	--	--
El Arish				
Beans	--	300	--	--
Watermelon	--	200	--	--
North Coast				
Beans	--	180	--	--
Watermelon	--	1,600	--	--
Palm trees (dates)	347,425	--	--	10,400

SOURCE: Officials of North Sinai Governorate, the Ministry of Agriculture, and the Green Revolution Society.

aridity and lack of a general soil or vegetative cover. The four agricultural suitability classes used in this study are:

- Good: 50 percent or more of the area is cultivable.
- Fair: 20 to 49 percent of the area is cultivable.
- Poor: 5 to 19 percent of the area is cultivable.
- Unsuitable: Less than 5 percent of the area is cultivable.

These land classes are roughly equivalent to the U.S. Soil Conservation Service (SCS) land suitability classes 3, 4, 5, and unsuitable, respectively. There are no SCS prime, I, or II agricultural lands in Sinai. Appendix A describes the standard SCS land suitability classes.

In terms of agricultural suitability, areas in Sinai that appear to have the best development potential from the standpoint of topographic and soil characteristics are those which allow the most cultivation and require the least in special management and treatment practices. Conversely, lands classified as "poor" are most restricted in use and require costly management and treatment techniques for partial reclamation; generally, these lands are suitable only for drip irrigation. Lands classified as "unsuitable" are areas with severe physical or chemical soil deficiencies, and they should not be considered for agricultural development.

Historically, land capability assessments have been based on rainfed, flood-, or sprinkler-irrigated agricultural practices, in which considerable attention must be placed on soil chemistry/water quality combinations. In an area such as Sinai, however, with water of low quantity and poor quality, the more generally appropriate agricultural system is drip irrigation. This land capability assessment, therefore, accepts drip-irrigation agriculture as a significant land use. However, because drip irrigation is less dependent on geomorphic and soil constraints than are mechanized agricultural practices, the more rigid requirements of these latter systems have been used as land capability delineators for Sinai. Thus, lands identified as having "good," "fair," and "poor" agricultural capability meet the stringent requirements for slope and soil texture of the mechanized agricultural systems and can accommodate drip irrigation even better.

5.3.1 "Good" Land

All of the good agricultural lands--those having 0 to 8 percent slopes, 0 to 50 meters of local relief, and a deep soil cover--are located in northern and central Sinai. These lands are roughly equivalent to the poorer components of the SCS class II and III soils.

North of the El Tih Plateau, the good agricultural land is located along the wadi channels. The main areas are along Wadi El Bruk, extending from Gebel El Kaib north to Bir El Thamada, and then east to the confluence of Wadi El Arish near Gebel Kherim.

The Wadi El Arish main channel and its tributary, Wadi El Aqabah, also form a good agricultural area, but a smaller and narrower one than the Wadi El Bruk area. The Wadi El Arish agricultural area extends from the confluence of Wadi Abu Gidil north to Wadi El Bruk. The Wadi El Aqabah branch extends south along the wadi channel to the confluence with Wadi El Misheiti.

There is also good agricultural land from the confluence of Wadi El Bruk north to the El Mitmetni Gorge. Feeding into this area from the east is a large area formed by the flood plain of Wadi Geraia. This area and the Wadi El Bruk area both show signs of previous agricultural use and still contain patches of agriculture. From the El Mitmetni Gorge, a narrow belt of good agricultural land runs north along Wadi El Arish to the confluence of Wadi Gayifa. This narrow strip of good land also runs eastward up Wadi Gayifa to near Ain Qadeis.

The other major region of good agricultural land in North Sinai includes the El Guarir area east of Gebel Maghara and Wadi El Hamma, which drains the lowlands between Gebel Maghara and Gebel Yelleq. It is restricted on its eastern side by Gebel Libni. An additional area of good agricultural land runs along Wadi El Arish, from the town of El Arish south to El Mitmetni Gorge.

5.3.2 "Fair" Land

Fair agricultural areas are usually more dissected than good areas and have a slightly stonier surface. They are considered to have 20 to 49 percent cultivable land within their boundaries. The areas designated as fair tend to extend upstream along the wadi channels from the good areas. They may also form narrow belts along the outwash plains of mountains. These lands are similar to the SCS class IV soils.

There are several significant areas of fair agricultural land in North and South Sinai. On the western and northern and southern sides of Wadi El Bruk, between the wadi and the mountains, there is an irregular, narrow band of fair agricultural land. This band broadens and becomes quite extensive in the Harabet Es Saheimi area.

A large area of fair agricultural land lies around the base of Gebel Libni. It occupies most of the area between Gebel Libni and the El Sirr and El Kafaf areas. It also extends on the west over much of the Wadi El Hamma flood plain.

Along the northeastern coast between the town of El Arish and the border, and extending inland about 10 kilometers, is a small strip of fair agricultural land. This strip coincides roughly with the Mediterranean coastal aquifer. On the eastern side of Sinai, a narrow strip of fair agricultural land lies along the flood plains of Wadis Gerafi and Khadakhio near El Kuntilla.

Another large area of fair agricultural land in North Sinai is a 5- to 20-kilometer strip that trends north-south along the Great Bitter Lakes area.

In South Sinai, the largest area of fair agricultural land lies in the El Qaa Plain. This area runs north-south, encompassing most of the central stretch of the El Qaa Plain. Its broadest point is around El Tor, where it widens to about 10 to 15 kilometers.

Two other areas of fair agricultural land are found at Abu Rudeis and El Belayim. These areas occupy alluvial fans developed by Wadis Ba'ba and Feiran, respectively. Long narrow strips of fair agricultural land are located in most of the major wide wadis of South Sinai.

5.3.3 "Poor" Land

There are several extensive areas of poor agricultural land in Sinai. These areas generally occupy the talus and colluvial deposits upslope from the fair agricultural land. Poor agricultural land includes the SCS class V and VI soil areas. One of the most extensive areas of this class practically surrounds Gebel Yelleq, except on the east where it is bounded by the flood plains and good agricultural land of Wadi El Arish. This area covers the El Nehaidein area between Gebels Maghara and Yelleq, extends westward to Bir Gifgafa, then south along Wadi El Hegayib to Bir El Thamada.

It occupies a narrow east-west strip on the upper alluvial slopes of Gebel Yelleq.

Another large and extensive area of poor agricultural land has formed in the headwater drainage basin of Wadi Geraia. This area occupies the entire region between Gebels Araif El Naga, El Sha'ira, and El Gunna, and the confluence of Wadi El Baluhi and Wadi Geraia.

A slim, 5-kilometer wide, 40-kilometer long strip of poor agricultural land is located along the Little Bitter Lake and the Gulf of Suez to about Ras Misalla.

In South Sinai, the eastern flank of the El Qaa Plain is occupied by a strip of poor agricultural land that broadens in the extreme south, pinching out the fair agricultural land near Ras El Millan. Other areas of poor agricultural land in South Sinai are along the alluvial fans bordering the Gulf of Aqabah.

5.3.4 "Unsuitable" Land

These areas generally match SCS class VII and VIII soils. By far the vast majority of Sinai's terrain is categorized as unsuitable for agricultural purposes. This land has been evaluated as being unable to support any agriculture on an economic basis. Much of the land classified as unsuitable contains either no soil or a very thin veneer of soil. In other areas where soil does exist, the structure or chemistry of the soil is such that even under the most intensive management and with better water quality than is likely to be available, any significant level of agriculture could not be maintained on a cost-effective basis.

5.4 DOMESTIC LIVESTOCK

The most prevalent species of domestic livestock in Sinai are goats, sheep, and camels; there are fewer numbers of cattle, horses and donkeys. There is no accurate count of poultry, but several chicken barns are operating at Bir El Abd and El Arish. Additionally, turkeys, rabbits, ducks, and geese are found in small numbers. Pigeons are also occasionally raised in pigeon towers.

Table 5-6 presents data collected by the Desert Institute on the number of livestock in Sinai.

TABLE 5-6

Estimated Number of Livestock in Sinai from 1950 to 1981

Type	1950[a]	1967[b]	1978[c]	1981[d]
Sheep	7,500	9,500	25,400	38,000
Goats	9,000	15,600	66,200	120,600
Camels	5,000	8,500	9,050	20,050
Cattle	800	1,250	160	100
Horses	100	250	250	300
Donkeys	3,250	1,300	unreported	6,300

[a]Ministry of Agriculture.

[b]General Desert Development Organization.

[c]The Israeli Occupied Territories Authorities.

[d]Desert Institute field survey, 1981.

Table 5-7 estimates the number of livestock in Sinai by region. The distribution of animal types by location indicates that goats are the preferred animal in mountainous terrain. Sheep, on the other hand, tend to be more prevalent in the broader wadis and flatland country.

The Bedouins still follow traditional practices of livestock management. According to season, the livestock are generally moved between mountain and lowland pastures (transhumance). Routes and tracks through the mountainous areas are traditionally used. In the plains and wadies, however, flocks and herds tend to meander over the whole area.

The movement of flocks to the range starts at sunrise, and they return at dusk. Lamb and kids usually graze separately, closer to the settlement. All flocks are constantly herded--the flocks by the children and sometimes women, and camels by young men. Some Bedouin settlements hire a shepherd for LE 2 per day.

Animal watering holes, wells, and outlets along pipelines are few and scattered over wide areas. During the wetter seasons (winter and spring), sheep, goats, and camels are often not watered. They survive on the moisture in the plants they eat, or they may obtain an occasional drink in low areas where runoff has collected. During the dry summer season, they are usually kept within 50 kilometers of a watering point and watered every 2 to 3 days.

During spring, sheep and goats are shorn. Fleece weight is about 1 kilogram. The wool is spun and woven into floor coverings and handicrafts. Weaving is done at home on hand looms. A typical floor covering measures approximately 4 x 0.75 meters, requires about eight fleeces, and sells for about LE 30.

Although camel wool is a valuable product, it appears that little effort is presently made to exploit it. Some is used by the Bedouins themselves, but little is sold. Apparently, hides are bartered and sold if not required for a family's own use.

5.5 VEGETATION AND GRAZING LAND

5.5.1 Summary

In general, perennial vegetation in Sinai is limited to the wadis and catchments of drainage systems. These areas cannot maintain a continuous

TABLE 5-7

Estimated Animal Population in Sinai by Region, 1981

Location	Sheep	Goats	Camels	Donkeys	Horses
NORTH SINAI					
El Arish	6,052	21,227	539	157	-
Bir El Abd	11,114	35,924	1,654	107	-
Al Hasana and Nakhl	7,993	18,562	1,573	966	-
SUBTOTAL	25,159	75,713	3,766	1,230	-
SOUTH SINAI					
Ras Sudr	1,611	3,595	239	70	11
Abu Suweira	1,636	4,116	223	95	-
Gharandal	604	1,230	864	183	3
El Bagha	140	670	147	240	2
Abu Gaada	289	594	751	267	7
Wadi El Ranya	134	237	357	480	3
Wadi El Yanis	51	504	481	363	17
El Ramla and Wadi El Beda	110	153	620	400	9
Bir El Nassib	131	1,093	1,375	178	6
Ain Sudr	384	1,665	140	380	6
Abu Rudeis	1,372	3,155	1,980	274	9
Wadi Hylfia	420	740	240	335	4
Wadi Feiran	1,421	5,967	3,720	298	57
Wadi El Tor	379	4,175	1,480	197	12
El Tor	2,127	6,249	590	86	-
El Nehayat	620	2,292	631	238	19
Wadi El Dalal	467	2,513	700	482	72
El Malha	240	1,830	960	375	51
Saint Catherine's	562	4,139	784	151	14
SUBTOTAL	12,698	44,917	16,282	5,092	302
TOTAL	37,857	120,630	20,048	6,322	302

SOURCE: Ministry of Agriculture, 1981.

vegetative cover, either spatially or temporally, because of the lack of water. The plateaus and mountain slopes have the least vegetation because of their exposure to wind, sun, evaporation, and soil erosion. Wadis, on the other hand, are exposed to lower wind velocities and collect runoff water and soil and therefore present a somewhat more favorable environment for vegetation. An occasional rain during winter and spring will give rise to annuals, but sporadic rainfall limits the vegetative species and cover density. The transhumant form of livestock management is promoted by variable and uncertain water and range conditions.

The natural range vegetation of northern Sinai can best be described as an open shrub cover with sparse stands of dwarfed shrubs. Various species of ephemerals are also found; their presence and density vary greatly from year to year, depending on the amount and distribution of rainfall during the winter and spring. Production of forage by the palatable species is low.

In central and southern Sinai, range vegetation is extremely poor, largely due to a lack of soil cover and extreme aridity. As in North Sinai, palatable range plants are generally confined to the wadis and alluvial fans. Good vegetative cover can be found near springs; however, the limited rangeland causes these areas to be severely overgrazed. This overgrazing may in time turn even these areas into unproductive forage units.

Salt marsh vegetation occurs in saline depressions throughout Sinai. These areas are most abundant along the north coast around Lake Bardawil and the El Tina Plain. Another extensive area occurs along the Bitter Lakes and Suez region and may be considered to occur intermittently along the entire Gulf of Suez coast. There are other salt marsh vegetation areas near Ras Sudr and south of El Tor.

Several range areas were sampled by the Desert Institute during 1981 to identify the various range plants used by the flocks and herds. Rangeland suitability is closely tied to agricultural land suitability. Natural range plants tend to select the finer soils, lower energy geomorphic areas, and therefore the areas which receive the most runoff. Thus, areas for rangeland improvement will generally coincide with the "good," "fair," and "poor" areas defined for agricultural suitability.

Of the most common range plants in Sinai, Artemisia monosperma has the greatest range, followed closely by Artemisia judaica, Farsetia judaica, Farsetia aegyptia, Plantago albicans, Zilla spinosa, Zygophyllum sp., Pituranthos tortuosus, Nitraria retusa, Ephedra alata, and Achillea fragrantissima.*

According to species diversity, selected locations can be ranked in the following manner:

- Ras Sudr--25 species
- Wadi El Bruk--24 species
- Nakhl--17 species
- Gebels Giddi and Yelleq--14 species
- Gifgafa/Maliss--13 species
- Gifgafa/Maghara--13 species
- El Arish--13 species
- Lake Bardawil Flats--12 species
- El Qaa Plain--12 species
- Wadi Feiran--8 species

Table 5-8 shows the chemical analyses and nutritive value of various range plants. Table 5-9 provides a ranking of some of the more widespread and important plant species according to nutritive (based on dry matter digestibility) and crude protein values.

5.5.2 El Arish

This area includes the northern extent of Wadi El Arish, the alluvial deposits along the wadi plain, and the adjacent sand dunes. Even with the significant amount of precipitation in this area (as compared with the rest of Sinai), the vegetation is predominantly perennials. Forage cover includes about 14 species.

Acacia saligna, Euphorbia katherina, Tamarix articulata, and Tamarix aphylla were found to be growing vigorously in the sand dunes. Zygophyllum sp. appeared in saline depressions and scattered along the coastal plains. Other herbs and grasses such as Anabasis articulata, Artemisia monosperma, Launaea capitata, Moltkea callosa, and Thymelaea hirsuta were found in the sand sheets. Panicum turgidum and Panicum sp. are also dominant in the investigated area.

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* Most Latin names are found in Tackholm, Students' Flora of Egypt, 1974.

TABLE 5-8

Chemical Analysis and Nutritive Value of Range Plants in Sinai

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%)						
				D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
NORTH SINAI										
Wadi El Arish-Lahfan	*Tamarix mannifera*	Dominant	All animals	40.09	8.19	3.57	11.55	24.92	51.77	59.60
	Tamarix aphylla	Dominant	Camel, goats	34.91	12.88	3.99	13.65	20.11	49.37	49.74
	Acacia saligna	Sparse	Goats, sheep	46.07	11.93	2.77	16.91	9.8	58.59	50.58
	Artemisia monosperma	Dominant	Sheep, goats	39.47	14.25	5.70	17.31	17.29	45.45	71.29
	Nitraria retusa	Medium	Sheep, goats	25.00	17.66	4.29	7.26	24.54	46.25	84.85
	Anabasis articulata	Dominant	Sheep, goats	48.99	7.32	1.18	16.46	19.75	19.75	66.71
	Zygophyllum album	Dominant	Sheep, goats	24.70	7.76	2.46	11.21	34.16	44.41	76.26
	Hyoscyamus muticus	Sparse	Goats, sheep	12.39	13.5	3.87	12.26	31.10	39.27	--
	Thymelaea hirsuta	Dominant	Goats	43.88	7.56	4.91	28.56	8.26	50.71	46.55
	Heliotropium luteum	Medium	All animals	33.65	21.76	4.98	11.28	18.77	43.21	80.83
	Moltkea callosa	Medium	All animals	30.12	9.27	3.22	14.51	31.54	41.46	44.97
	Salvia lanigera	Sparse	All animals	39.9	10.75	6.51	29.54	11.48	41.72	61.57
	Ammophila sp.	Sparse	All animals	68.97	6.01	4.27	31.14	16.71	41.97	40.38
	Echinops spinosossimus	Medium	All animals	36.29	11.52	6.31	24.78	17.52	39.34	64.34
	Silene sp.	Sparse	All animals	31.47	12.55	4.94	26.82	15.32	41.37	62.38

NOTE : Where results not shown, samples were not enough to support analysis

D.M. : Dry matter
N.F.E. : Nitrogen-free extract
C.P. : Crude protein
E.E. : Ether extract
C.F. : Crude fiber
D.M.D. : Dry matter digestibility

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
South El Bardawil	Nitraria retusa	Sparse	Sheep, goats	22.48	15.44	3.70	12.82	30.33	37.71	82.21
	Halocnemon strobilaceum	Dominant	Camel	29.74	4.69	2.22	7.04	40.34	45.60	63.0
	Arthrocnemon glaucum	Dominant	Camel	22.94	3.38	1.26	12.14	51.93	31.29	77.44
	Zygophyllum album	Dominant	All animals	17.16	8.66	2.36	11.36	35.99	41.63	-
	Thymelaea hirsuta	Dominant	Goats	40.61	9.00	3.00	24.90	7.11	55.99	44.64
	Panicum turgidum	Medium	All animals	51.72	2.38	2.34	23.15	21.95	50.18	28.56
	Artemisia monosperma	Dominant	Sheep, goats	27.95	7.06	3.57	10.02	10.23	69.12	58.78
	Moltkea callosa	Sparse	Sheep, goats	30.49	13.03	1.33	17.98	29.35	38.31	65.58
	Calligonum comosum	Sparse	Camel, sheep	23.15	9.31	1.95	15.12	15.44	58.18	35.80
	Juncus sp.	Sparse	(tips) All animals	37.04	7.88	2.03	29.02	7.98	23.09	44.65
	Zygophyllum album	Dominant	All animals	10.5	5.55	3.38	9.60	24.93	56.54	81.15
	Calligonum comosum	Sparse	Sheep, goats	28.36	9.00	1.91	16.87	9.19	63.03	33.58
	Cornulata monocantha	Sparse	Camels, sheep	34.43	9.50	1.68	22.01	13.14	53.67	31.93
	Acacia salegna	Sparse	Goat, sheep	35.48	12.33	4.39	17.02	10.69	55.57	52.01

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Wadi Fatih El Maghara	Acacia raddiana	Dominant	Goats	31.15	20.27	3.01	12.50	6.41	57.81	50.27
	Thymelaea hirsuta	Dominant	Goats	45.10	9.44	3.61	25.03	9.00	52.92	37.82
	Retama raetam	Dominant	Goats	47.71	10.08	3.80	20.79	4.88	60.45	58.59
	Anabasis articulata	Dominant	All animals	48.27	7.22	1.43	16.47	18.47	56.41	65.67
	Farsetia aegyptiaca	Sparse	All animals	68 48	7.08	2.11	40.36	8.81	41.64	35.07
	Zygophyllum decumbens	Medium	Camel	37.73	9.37	1.80	24.09	26.90	37.84	49.64
Wadi El Bruk	Plantago albicans	Dominant	All animals	23.58	14.29	1.79	11.89	34.35	32.68	74.36
	Asphodelus viscidulus	Dominant	Sheep, goats	10.90	15.14	4.43	16.51	24.12	39.80	73.37
	Ephedra alata	Dominant	All animals	34.21	17.25	2.96	21.82	10.14	52.17	83.45
	Diplotaxis acris	Dominant	All animals	10.91	10.56	2.38	11.64	31.39	44.03	83.07
	Reaumuria hirtella	Sparse		24.27	11.64	3.03	7.40	41.22	36.71	80.18
	Salicornia fruticosa	Medium	All animals	43.59	13.77	1.64	17.39	16.58	50.62	66.36
	Trigonella stellata	Dominant	All animals	28.41	16.30	1.60	12.61	35.99	33.50	67.87
	Anthemis melampodina		Sheep, goats	27.27	10.79	3.32	15.19	27.99	42.71	77.36
	Zilla spinosa	Medium	All animals	13.46	9.91	5.02	11.55	29.11	44.41	83.95
	Zygophyllum coccineum	Medium	All animals	19.02	8.41	2.88	9.89	35.30	43.52	--
	Zygophyllum album	Medium	All animals	25.54	8.88	3.33	9.08	28.41	50.30	--
	Amaranthus sp.	Sparse	All animals	22.52	13.54	2.58	8.84	41.48	33.56	69.46

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Wadi Umm Khisheib	*Atriplex halimus*	Sparse	Sheep, goats	17.06	15.5	2.60	9.81	35.75	36.34	87.39
	Francoeuria crispa	Medium	Sheep, goats, camel	34.16	8.56	2.22	26.65	20.36	42.20	66.89
	Zygophyllum decumbens	Sparse	Camel	54.19	13.20	2.78	16.85	32.95	34.22	66.95
	Moricandia nitens	Medium	All animals	33.94	9.74	3.09	24.66	23.19	34.32	56.14
Wadi El Giddi	*Zygophyllum decumbens*	Dominant	Camel, goats	57.46	13.88	2.68	17.22	30.19	36.03	64.27
	Francoeuria crispa	Medium	Goat, sheep, camel	36.02	8.77	2.45	24.91	20.60	43.21	67.87
	Retama raetam	Dominant	Sheep, goats	39.78	10.48	3.22	19.72	5.11	61.27	57.85
	Artemisia monosperma	Medium	All animals	23.56	7.66	3.66	9.75	10.00	68.93	78.82
Wadi El Hegayib	*Retama raetam*	Dominant	Sheep, goats	34.62	11.19	3.00	18.25	3.66	63.90	65.42
	Farsetia aegyptiaca	Sparse	All animals	72.53	10.32	2.89	42.23	7.98	36.58	35.43
	Anabasis articulata	Dominant	All animals	45.17	7.33	1.99	16.91	17.11	56.66	63.34
	Artemisia judaica	Medium	All animals	38.72	12.01	6.66	26.14	11.47	43.72	66.40
	Thymelaea hirsuta	Dominant	Goats	44.50	9.63	3.31	24.78	8.81	53.47	37.82
Wadi El Meleiz	*Artemisia monosperma*	Dominant	All animals	25.82	7.29	3.44	10.16	10.04	69.07	78.35
	Hyoscyamus desertorum	Medium	Sheep, goats	16.22	14.96	3.88	6.90	50.03	24.23	78.46
	Salicornia fruticosa	Dominant	Camels	37.60	13.53	1.89	18.88	14.30	51.39	70.46
	Fagonia arabica	Sparse	All animals	41.37	8.61	2.77	16.10	42.50	30.02	54.51
	Lycium europaeum	Medium	All animals	37.38	15.28	2.55	24.17	11.30	46.70	74.58

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%)						
				D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Wadi El Natila	*Retama raetam*	Dominant	Sheep, goats	23.49	21.76	2.15	21.80	6.17	48.12	73.36
	Reaumuria hirtella		All animals	25.97	13.82	2.69	7.65	40.88	34.96	80.32
	Ephedra alata	Dominant	All animals	45.83	11.47	2.58	18.83	14.11	53.01	70.58
	Artemisia judaica	Dominant	All animals	33.95	13.14	7.03	25.16	10.64	44.03	61.48
Wadi Thammada	*Anabasis articulata*	Dominant	All animals	45.08	7.28	2.14	17.21	18.55	54.82	64.44
	Salicornia fruticosa	Dominant	All animals	43.41	12.19	1.77	19.43	14.99	51.62	68.46
Wadi El Ghadra	*Francoeuria cripa*	Dominant	All animals	17.63	9.11	2.88	20.11	18.97	48.93	66.68
	Asteriscus graveolens	Medium	All animals	29.90	10.62	3.29	23.14	20.75	42.15	56.02
Wadi El Saheimi	*Artemisia judaica*	Dominant	All animals	22.83	14.16	7.22	23.12	10.18	45.32	65.19
	Salicornia fruticosa	Dominant	Camel, sheep, goats	35.85	13.14	1.89	19.44	13.92	51.61	68.46
	Plantago albicans	Medium	All animals	27.94	8.47	3.28	15.87	39.35	33.03	52.37
Wadi El Bruk	*Artemisia judaica*	Dominant	All animals	33.49	13.44	6.89	25.18	11.00	43.69	61.88
	Artemisia monosperma	Dominant	All animals	27.33	7.64	3.72	10.27	9.84	68.53	75.38
	Farsetia aegyptia	Medium	All animals	37.31	11.12	2.49	58.16	8.44	39.79	31.87
	Ephedra alata	Medium	All animals	37.54	12.45	2.20	27.42	11.70	45.23	52.19

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Wadi El Hamth	Zygophyllum decumbens	Dominant	Camel	18.58	14.45	2.88	15.21	28.19	39.27	69.62
	Salicornia fruticosa	Dominant	Camel, sheep, goats	44.87	11.98	2.41	14.88	15.43	50.30	67.92
	Artemisia judaica	Dominant	All animals	43.37	14.11	2.44	26.25	11.08	41.12	62.61
Wadi El Arish	Atriplex leucoclada	Dominant	Sheep, goats	25.59	15.11	2.69	10.82	33.57	37.81	85.70
SOUTH SINAI										
El Ramla	Haloxylon salicornicum	Dominant	Donkeys, Sometimes camels	46.67	13.00	4.66	26.25	16.72	38.38	53.71
Abu Zenima	Haloxylon salicornicum	Dominant	Donkeys	42.42	14.81	5.11	24.11	15.84	40.13	46.46
	Zygophyllum album	Medium	Sheep	32.08	8.21	3.53	13.44	27.03	47.79	65.05
Wadi Gharandal	Tamarix aphyla	Dominant	Camels & donkeys	52.67	10.89	4.31	17.64	22.43	44.73	60.28
	Juncus subulatus	Sparse	Sheep, goats	40.00	6.86	2.41	30.25	11.18	49.30	34.40
	Alhage maurorum	Sparse	Sheep, goats	29.91	7.19	3.54	28.89	24.99	35.39	34.24
	Zygophyllum album	Medium	Sheep, goats, camels, donkeys	32.00	7.04	2.17	11.27	30.11	49.41	67.15
	Haloxylon salicornicum	Dominant	Donkeys	44.60	12.16	5.94	25.52	16.00	40.38	50.35

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Wadi El Nassib	*Acacia*	Dominant	Camels on leaves	28.18	10.43	3.52	20.33	13.01	52.71	45.07
	Zygophyllum simplex	Dominant	Goats on pods	28.13	9.55	2.25	16.10	18.26	53.84	60.76
	Fagonia arabica	Dominant	Sheep, goats	45.55	13.17	4.12	25.45	16.24	41.02	49.78
Wadi Karieh	*Panicum turgidum*	Sparse	Sheep, goats	50.0	9.94	4.72	32.35	12.10	40.89	21.75
	Ochradenus baccatus	Sparse	Sheep, goats	38.89	10.13	4.59	33.34	15.19	36.75	32.36
Wadi El Tayiba	*Nitraria retusa*	Sparse	Sheep, goats	32.20	11.08	2.42	30.49	37.24	18.77	63.39
Abu Suweira	*Nitraria retusa*	Dominant	Sheep, goats	37.57	10.19	2.46	32.57	32.98	21.80	61.84
	Tamarix mannifera	Medium	Camels	42.86	11.64	4.88	16.29	21.95	45.24	70.83
	Salsola tetrandra	Medium	Camels	30.00	7.80	2.25	34.18	32.16	23.61	77.64
	Halocnemon strobilaceum	Medium	Camels	27.91	6.29	3.51	16.58	26.35	47.27	60.72
	Zygophyllum album	Sparse	Sheep, goats	21.37	7.89	2.58	12.11	31.36	46.06	80.20
Ras Sudr	*Atriplex nummularia*	Dominant	Sheep, goats	28.21	14.42	4.21	19.61	33.87	27.89	74.89
	Zygophyllum album	Dominant	Sheep, goats	19.61	8.90	2.33	10.13	32.15	46.49	73.92
	Salsola tetrandra	Dominant	Sheep, goats	37.14	6.32	2.37	36.12	35.87	18.82	68.02
	Suaeda fruticose	Medium	Sheep, goats	25.00	10.0	5.00	33.23	16.13	35.64	70.39
	Nitraria retusa	Dominant	Sheep, goats	34.78	10.64	2.34	31.62	35.28	20.12	59.61

TABLE 5-8 (cont'd)

Location	Plant	Distribution	Animal Fed	Proximate Analysis (%) D.M.	C.P.	E.E.	C.F.	Ash	N.F.E.	D.M.D.
Ayun Musa	*Alhagi maurorum*	Medium	Sheep, goats	43.76	9.45	4.42	29.46	25.92	30.75	36.37
El Gebeil	*Juncus acutus*	Dominant	Sheep, goats, camels	35.00	7.11	2.35	28.31	12.33	49.90	34.39
	Zygophyllum album	Dominant	Sheep, goats	33.87	6.39	2.11	14.22	33.31	43.47	71.32
El Tor	*Alhagi maurorum*	Sparse, in patches	Sheep, goats, camels	38.73	7.12	5.35	30.19	16.66	40.68	36.74
Wadi Feiran	*Artemisia judaica*	Medium	Sheep, goats	59.73	12.08	6.11	39.84	14.11	27.86	52.61
Saint Catherine's	*Artemisia judaica*	Dominant	Sheep, goats	55.36	12.50	9.21	33.96	10.94	33.39	49.48

TABLE 5-9

Nutritive Ranking of Selected

Widespread Range Plants

Plant Species	Crude Protein (%)	Dry Matter Digestibility (%)
Zilla spinosa	9.91	83.95
Artemisia monosperma	8.78	72.52
Zygophyllum album	7.96	72.31
Nitraria retusa	13.33	70.75
Ephedra alata	13.72	68.74
Retama raetam	13.37	66.30
Anabasis articulata	7.28	65.04
Plantago albicans	11.38	63.36
Zygophyllum decumbens	12.72	62.62
Zygophyllum sp.	9.55	60.76
Artemisia judaica	13.06	59.94

5.5.3 Lake Bardawil

This area is typified by saline soils; thus, salt-tolerant plants, such as Arthrocnemon glaucum, Halocnemon strobilaceum, Juncus arabicus, and Zygophyllum sp. are the main vegetative cover. Other subdominant shrubs and forbs include Acacia saligna, Lycium europeum, Nitraria retusa, Artemisia monosperma, Cornulaca monacantha, Lolus sp., Mcltkea callosa, Panicum sp., and Thymelaea hirsuta. Halocnemon, Arthrocnemon, Zygophyllum, and a cultivated shrub, Galligonum comosum, are all highly palatable and used for range forage.

5.5.4 Gifgafa-Maghara

The natural plant cover in this area is characterized by ephemerals, shrubs, and perennials. The dominant shrub species are Acacia raddiana, Nitraria retusa, Retama raetam, and Zilla spinosa. Perennials, the most permanent and abundant component of the vegetative cover, include Anabasis articulata, Artemisia monosperma, Cornulata monacantha, Fagonia arabica, Farsetia aegyptia, and Verginea maritima.

Trigonella stellata is the dominant ephemeral species found in this region. This ephemeral has a very short phenological calendar, requiring only a few months or even weeks for completion of its life cycle.

5.5.5 Gifgafa-Maliss

About 13 vegetative species are found in this area. Predominant are the forbs Achillea fragrantissima, Anabasis articulata, Artemisia monosperma, Diplotaxis acris, Lygos raetam, Pituranthos tortuosus, and Salicornia fruticosa. Plantago albicans, one of the more palatable of the forage plants, is found in limited quantities. Zygophyllum sp. can be found in the saltflats. Zilla spinosa and Alkanna sp. are the two most common shrubs.

5.5.6 Gebels Giddi and Yelleq

The natural forage plant species in this area are predominantly forbs--Anabasis articulata, Achillea fragrantissima, Artemisia monosperma, Astragalus spinosa, Echinops sp., Fagonia arabica, Farsetia aegyptia, Lygos raetam, Peganum harmala, and Plantago albicans. Plantago albicans is considered to be the best of these forbs for forage. Shrubs in this area include Nitraria retusa, Ephedra alata, Lycium europeum, and Zilla spinosa. Zygophyllum sp. is found in saltflats.

5.5.7 Nakhl

About 18 plant species exist within the wadis and flatlands around Nakhl. The forb species in this area include Anabasis articulata, Archillea fragrantissima, Artemisia judica, Artemisia monosperma, Fagonia arabica, Farsetia aegyptia, Filago spitholata, Gymnocarpos decandrum, Lygos raetam, Menosonia senegalensis, Peganum harmala, Pituranthos tortuosus, and Plantago albicans. Atriplex sp. shrubs, a major forage plant for sheep, also inhabit these wadis. Tamarix articulata, Ephedra alata, Tamarix aphylla, and Zygophyllum sp. form a subdominate community.

5.5.8 Wadi El Bruk

Wadi El Bruk represents one of the most promising areas in Sinai for range development. Within the wadi flood channel, the dominant species is Diplotaxis harra; Diplotaxis acris, Trigonella stellata, Achillea fragrantissima, Plantago albicans, Asphodelus viscidulus, Ifloga spicata, Filago spathiolata, Euphorbia retusa, Centaurea aegyptia, and Senecio aegyptius are the subdominant species. Sand hummocks form around the Haloxylon salicornicum, Anabasis articulata, and Zilla spinosa shrubs.

On the elevated outwash plains of Wadi El Bruk, several other shrubs and forbs are found. Included in this habitat are Salicornia fruticosa, Farsetia aegyptia, Withania somnifera, Farsetia longisiliqua, Fagonia arabica, Anabasis articulata, Zilla spinosa, Haloxylon salicornicum, Erodium hirtum, Anthemis pseudocotula, Blepharis edulis, Euphorbia retusa, Fagonia mollis, Artemisia monosperma, Heliotropium luteum, Diplotaxis acris, Savignya parviflora, and Centaurea pallescens. Higher up the alluvial slopes are Artemisia judaica, Anastatica hierochuntica, Pituranthos tortuosus, and Salicornia fruticosa.

5.5.9 Ras Sudr

The Ras Sudr area contains about 23 species of grasses, shrubs, and forbs. Acacia saligna, Nitraria retusa, Atriplex sp., and Lycium europeum are scattered on the flat areas and among the dunes. Acacia raddiana is found only in the bottom of the valleys and lower slopes of the hills. Artemisia monosperma, Diplotaxis acris, Farsetia aegyptia, Haloxylon salicornicum, Heliostropium luteum, Noaea mucronata, Saliva sp., and Verginea maritima generally inhabit the flat areas and hill slopes.

Panicum coloratum, Panicum turgidum, Plantago albicans, Trigonella stellata, and Lolium sp. are the most palatable species in this area and are generally widely distributed. Juncus arabicus is found in saline soils.

5.5.10 El Qaa

About 12 plant species are located in the El Qaa Plain. Zilla spinosa, Nitraria retusa, and Ephedra alata are the dominant shrub species. Panicum turgidum, Phlaris minor, Plantago albicans, and Trigonella stellata are the most grazed species. Pituranthos tortuosus, Noaea mucronata, Gymnocarpos decandrum, Farsetia aegyptia,and Cornulata monacantha form a secondary forage supply. The flocks and herds use these plant species only when feeding conditions are poor and the less hardy preferred forage plants are not available.

5.5.11 Wadi Feiran

Wadi Feiran is surrounded by rugged mountains and is fed by tributary wadis. Vegetation along this wadi has adapted to growing in the cracks of the surrounding granite slopes and to the rocky wadi fill materials. Typical shrub species here include Acacia raddiana, Gymnocarpos decandrum, Lycium europeum, and Zilla spinosa. Typical grasses and forbs are Panicum coloratum, Pituranthos tortuosus, and Farsetia aegyptia.

5.6 ENVIRONMENT

5.6.1 Sensitive Plants

The floristic diversity of Sinai is represented by approximately 270 plant species that are "special" to Sinai and are not known in other parts of Egypt (L. Boulos, personal communication, 1981). Thirty-nine taxa (31 species and eight varieties) are endemic to Sinai; that is, these species are found in nature only in Sinai--they grow nowhere else in the world. Of these, eight are endangered and four are threatened plant species. (An "endangered" species is one that is on the verge of extinction, and a "threatened" species is one that is likely to become endangered.)

The greatest threats to vegetation in Sinai are from overgrazing, the uprooting of shrubs for firewood, and the cutting of trees. The northwest Sinai ecosystem, for example,has for many generations been under grazing pressure by herds maintained by the Bedouins. Due to military activities during the Israeli occupation of Sinai, from 1967 to 1978, the plant communities enjoyed gradual rehabilitation from overgrazing.

5.6.2 Sensitive Wildlife

5.6.2.1 Birds. A variety of birds pass through Sinai in route to Africa in autumn and return to the north again in the spring. Lake Bardawil, for example, is of international importance as a resting, feeding, and nesting area for many species of migrating water and land birds. Thousands of eagles and other birds of prey are also funneled across northern Sinai on their passage between Africa and Eurasia. These raptors are thought to fly along this route to avoid crossing open coastal water.

The greatest threat to birds in Sinai is man. In northern Sinai, for example, the annual harvest of quail along the Mediterranean coast is tremendous. As the exhausted quail arrive in Sinai after completing the long flight across the Mediterranean, they are met by a series of mist nets 5 meters high that extend along the beach for a distance of some 25 to 30 kilometers. A governmental decree regulates the netting of quail, but like other laws intended to protect wildlife, they are infrequently observed and rarely enforced, and as a result only a few quail make it past the nets.

5.6.2.2 Mammals. The abundance of certain mammals in Sinai has declined over the years, and some species are on the verge of extinction. The following species merit special protection (I. Helmy, personal communication, 1981):

- Ibex (*Capra ibex nubiana*)
- Hare (*Lepus capensis sinaiticus*)
- Sinai leopard (*Panthera pardus jarvisi*)
- Wildcat (*Felis sylvestris tristrami*)
- Ruppell's sand fox (*Vulpes ruppelli ruppelli*)
- Dorcas gazelle (*Gazella dorcas saudiya*)
- Fennec fox (*Fennecus zerda*)
- Striped hyena (*Hyaena hyaena dubbah*)
- Hyrax (*Procavia capensis syriaca*)
- Caracal (*Caracal caracal schmitzi*)
- Desert hedgehog (*Paraechinus dorsalis dorsalis*)
- Dugong (*Dugong dugong*).

Three of these species, the Sinai leopard, Dorcas gazelle, and dugong, are listed as endangered.

The military and market hunters have been particularly hard on wildlife in Egypt (I. Helmy, personal communication, 1981). Military abuses have resulted in the slaughter of wildlife--personnel have been known to machine gun a herd of gazelle, killing or maiming seven or eight regardless of sex or age. Commercial hunters from Europe are also a threat to wildlife. They come with coolers and orders for wild game and make a business of supplying meat to eager buyers. Hunting by Bedouins to provide food and eliminate predators can also be a problem. The extent of Bedouin hunting is difficult to assess; during the Israeli occupation of Sinai, it was apparently controlled.

5.6.2.3 Reptiles. Of the reptiles in Sinai, two species of sea turtle deserve special protection because they are listed as endangered:

- Leatherback sea turtle (*Dermochelys coriacea*)
- Green sea turtle (*Chelonia mydas*).

There is evidence that these sea turtles are using Tiran Island, 6 kilometers southeast of the southern tip of Sinai, but they may also use the sand beaches along Ras Mohammad.

5.6.2.4 Fish. A number of very colorful and beautiful fish need to be protected; these fish are found primarily along the Aqabah coast.

5.6.3 Coral

The coral along the Aqabah coast from Ras Mohammad to Eilat provides a rich variety of color and form--these reefs are among the most beautiful in the world. In recent years, "bomb" fishing has resulted in serious loss of coral. It takes many, many years for coral reefs to develop.

5.6.4 Environmental Preservation

The environment resources of Sinai--in particular areas with flora and fauna known to be endangered, threatened, or otherwise sensitive to development--were described in Working Paper No. 5, A Plan for the Preservation, Enhancement, and Management of the Sensitive Natural Resources of Sinai (April 1981). The working paper also presented recommendations for preservation, protection, and management of the sensitive natural resources of Sinai. Included are descriptions of flora and fauna; the types of environmental impacts anticipated from the development of infrastructure, mining and industry, agriculture, tourism, and population centers; and selected areas proposed for dedication.

Among the sensitive natural resources in Sinai, five areas were recommended for dedication. If adopted, this plan will result in wildlife preservation and management for approximately 20 percent of Sinai.

The largest single area recommended for dedication is the colorful and mountainous area of southern Sinai. The proposed Sinai National Park would encompass the rugged mountainous terrain which makes up much of the lower peninsula. The proposed park would include the monastery of Saint Catherine's, Gebel Serbal, Gebel Musa (Moses), Ras Mohammad, and much of the habitat of a number of the rare, threatened, and endangered endemic plant species, as well as the endangered Sinai leopard and Dorcas gazelle and other rare wildlife species.

Lake Bardawil, an internationally recognized resting, feeding, and breeding habitat for wintering and migratory shore and land birds; Lake Malaha, a smaller but comparable avian habitat; and the mountainous region of Maghara are also proposed as wildlife preserves because they provide habitat for rare endemic and other wildlife species.

The spectacular coral reefs along the Aqabah coast from Eilat to Sharm El Sheikh, which are said to be second only to those in Australia, shelter a variety of fish and offer a delightful paradise to the underwater diver. A coastal preserve is recommended to protect these reefs.

5.7 MINERALS

Optional Working Paper No. 4, Sinai Mineral Resource Exploration and Development Plan (April 1981), presented a thorough review of Sinai's potential mineral resources. The findings of this working paper are summarized herein and supplemented where possible with new information.

Plate 3-6, Sheets 1 and 2, identifies areas of known mineral potential. These sites have either been mined previously or mineral deposits have been reported to occur there. Plate 5-1 shows areas in which the geologic environment appears to be favorable for the occurrence of minerals.

Plate 5-2, Sheets 1 and 2, identifies areas suitable for exploration for sand and gravel, limestone, dolomite, aggregate, and gypsum construction materials. Sinai is rich in local building stone, with durable rock types readily available in all areas. The crystalline rock units of South Sinai form a particularly beautiful building material.

Mineral deposits of potential economic significance are discussed in Sections 5.7.1 through 5.7.17. Based on these data and the further results described in Optional Working Paper No. 4, Sinai Mineral Resource Exploration and Development Plan (April 1981), the following points can be made:

- At this time, none of the potential resources or exploration targets are sufficiently fixed, either geographically or from the standpoint of infrastructure needs, to define specific linkages to other development sectors.
- Mining projects are generally isolated, self-sufficient operating units with little impact on regional infrastructure.
- Mines must be developed where the mineral deposits occur, and the grade of the ore, market, distance to shipping points, and in-place infrastructure determine the placement of support mills and plants. To attempt to make any linkage to other development site infrastructure prior to the identification and evaluation of ore deposits would be highly theoretical and premature.
- Without further detailed exploration and analysis, it cannot be determined which (if any) of the potential mineral commodities in Sinai might have production potential. Therefore, it is premature to make firm market assessments or development predictions.

Optional Working Paper No. 4 outlined a plan for the exploration and development of the potential mineral occurrences in Sinai. This plan emphasizes exploration for minerals that bear a high probability of economic occurrence; may substitute for current imports; have immediate development opportunities based on existing knowledge and production history; and may be competitive in international markets. Thus, the program is focused on minerals that could help meet national targets for economic growth.

5.7.1 Construction Aggregate and Sand

Materials suitable for production of mortars, cement sand, cement gravel, and base rock occur widely as pediment cover and wadi alluvium throughout Sinai. The primary sources of gypsum are the Oligiocene-Miocene sediments along the Gulf of Suez around Ras Sudr, Gebel Hamman Fara'un, and Abu Zenima. The primary exploration areas for sand and gravel are the broad wadi alluvial deposits in Wadi El Arish, Wadi El Bruk, Wadi Geraia, Wadi Aqabah, and Wadi El Gayita in North Sinai. The wadi alluvial fans developed by Wadis Wardan, Ba'ba, and Feiran, along the Gulf of Suez, form major primary sand and gravel exploration areas.

High quality sources of construction aggregate also occur in nearly every wadi throughout South Sinai. In this region, production sites can be conveniently located near each construction project, thereby minimizing transport expense.

In general, high quality limestone, dolomite, and aggregate sources can be found in all of the major mountain areas of North Sinai. Secondary sand and gravel and limestone, dolomite, and aggregate exploration areas are found throughout northern Sinai. These areas are formed along the colluvial deposits and pediment surfaces of the region. The exploration and use of these construction material sources will depend primarily on other siting and resource criteria, such as proximity to development areas.

5.7.2 Coal

Coal deposits have been explored to varying degrees at Gebel Maghara, Ayun Musa, and Wadi Thora near Abu Zenima. Of the known coal occurrences, only those at Maghara are currently regarded as having economic potential.

The Maghara coal is black, half dull, hard, resinous, subbituminous A in rank, and occurs in two major seams ranging from 20 to 190 centimeters in thickness. It is a low-ash, high-sulphur coal and appears to have limited coking potential.

5.7.3 Manganese

Manganese-iron deposits occur as lens-shaped, concordant bodies and fissure fillings in the Carboniferous Umm Bugma Formation east of Abu Zenima and Abu Rudeis. The ore lenses average 2 meters in thickness, but locally achieve a thickness of 4 meters. The host rock consists of red and yellow crystalline dolomite, variegated shale, and sandy clay. An average lens might contain 10,000 tons of ore above a cutoff of 20 percent manganese.

Ore specimens with up to 60 percent manganese occur in the deposits; historically mined, hand-sorted, high-grade material from the Umm Bugma district averages up to 40 percent manganese. Remaining explored deposits of significant tonnage average between 20 and 30 percent manganese.

5.7.4 Iron

Iron associated with manganese east of Abu Zenima has potential economic significance as a byproduct of manganese extraction and could account for the difference between profit and loss.

Ferruginous horizons with oolitic hematite in Cretaceous sandstones have been reported; however, no plotted locations, measured sections, or sample analyses for such occurrences could be found in the available literature, nor were the Egyptian geologists contacted by Dames & Moore able to provide information regarding exposed mineralization. The sedimentary horizon that contains oolitic iron ore at Aswan does cross Sinai and therefore warrants at least reconnaissance exploration.

Micaceous hematite is known to occur in quartz veins in eastern Sinai, in granite at Gebel Abu Mesud. Comparable host granites appear in western Sinai. While known occurrences of iron mineralization of this type in Sinai are not economic, they sustain major mines elsewhere in the world. The potential presence of slightly concealed, higher grade, larger iron-bearing quartz veins in the crystalline rocks of South Sinai warrants reconnaissance investigation.

5.7.5 Phosphate

Phosphatic limestone is interbedded with sandstone, shale, and clay of formations whose outcrops ring the Stable Platform Province of Sinai. Phosphate-bearing sediments have been recorded in this horizon along the eastern Suez coast, in Gebel Qabeliat, Gebel Safariat, and Wadi Sudr,and south of both the El Tih and El Igma Plateaus. Records for only one measured and sampled section are available--in Gebel Safariat--where a 0.3-meter thick bed of phosphorite was found to contain 24.6 percent P_2O_5. This section does not compare favorably with deposits presently being mined in the eastern and western deserts of Egypt. Along the Nile, commercial phosphate beds range up to 4 meters in thickness and contain as much as 25 percent P_2O_5; the economic minimum thickness is roughly 0.5 meters, averaging 23 percent P_2O_5. However, the phosphate horizon in Sinai has not been systematically explored or even mapped. Thorough exploration, particularly toward eastern Sinai, may locate exploitable deposits. The phosphatic horizon that extends across Egypt is largely absent from central Sinai. Exploration potential here appears to be limited.

5.7.6 Kaolin

Known occurrences of kaolin appear in the Carboniferous formation and a clayey and sandy horizon in the Cretaceous sandstone formation. All reported deposits are located in the Suez Rift Province, east of Abu Zenima and Abu Rudeis. The best known of these, where some development and production have occurred, is at Budra, near the Umm Bugma manganese mine.

At the Budra site, four kaolinite beds with an aggregate thickness of 36 meters occur in a 95-meter-thick sequence of Cretaceous sandstone. The kaolin horizons are lensoidal-pinching and swelling, with variations in quality. The beds dip to the southwest at angles between 20 and 40 degrees and are offset by faults with throws of up to 100 meters.

The kaolin horizons are pure or slightly silty and sandy, and range in color from light grey through violet to dark grey. The clay is chemically pure or slightly ferruginous, and consists principally of kaolinite with small admixtures of dickite and hydromica. Its quality is suitable for the production of fine ceramics.

Based on available reports, the kaolin deposits at Budra and comparable deposits that may be discovered in the region offer the best quality and most economically available source of clay in Egypt. The kaolin may also be competitive in the export market. Its exploration and development merit serious consideration.

5.7.7 High Silica Glass Sand

Quartzitic sand, which is optimum for the production of clear glass, should be uniformly distributed in size between 200 and 600 micrometers, have an iron content of less than 0.07 percent, and have minimum contaminating sodium, calcium, and potassium. Available reports suggest that the best source of glass sand in Egypt occurs in a quartz sandstone horizon of Carboniferous sedimentary rocks east of Abu Zenima and Abu Rudeis.

The quartz sand horizon at the best known location, near Wadi El Khabouba, northeast of Abu Zenima, is approximately 30 meters thick. Further south near Wadi Budra, where the same horizon was examined during Dames & Moore's field reconnaissance, the quartz sand horizon was approximately 15 meters thick. Sinai Manganese Company engineers reported it to be nearly equal in quality to that at El Khabouba. This physically and chemically persistent horizon represents a good source of high quality silica for glass manufacturing, which may have export potential. Exploration and testing are required before considering its development for economic production and marketing.

5.7.8 Copper

Precambrian crystalline rocks at a number of locations in South Sinai bear thin quartz veins of short length which contain copper carbonate, probably an oxidation product of sparse chalcopyrite. These types of deposits have no practical exploration potential.

Historically, copper has been produced from copper oxide-bearing sandstones of the Cambrian Serabit El Khadim Formation or from overlying lower Carboniferous strata. Extensive beds of cupriferous sandstone in these units are reported to have been mined in ancient times near Wadi Maghara in west-central Sinai. Ores are described as containing up to 18 percent copper in carbonates and silicates. Numerous other locations with cupriferous sandstone outcrops have been described by Egyptian geologists who have worked in the region.

While there has been no thorough evaluation of a copper sandstone deposit in Sinai, comparable deposits elsewhere have supported economic mining operations. The deposits are sometimes associated with sandstone-bearing uranium and silver. Moreover, recent technological developments allow these ores to be treated at very low cost, making them attractive exploration targets. Their potential for economic occurrences and exploitation in Sinai appears to be well worth pursuing.

5.7.9 Turquoise

Turquoise has been mined at Serabit El Khadim, near Umm Bugma, for an extended period. Engineers of the Sinai Manganese Company stated that numerous additional small turquoise mines occur in the region. Hume also reported turquoise occurrences at Gebel Maghara.

Turquoise mining is typically a small, labor-intensive industry. Deposits generally occur as thin seams along fractures or small pockets of pebbly stone in a sandstone matrix. Owing to this distribution and the fragile nature of the material, mass mining techniques are not applicable and blasting must be minimized. However, despite the labor-intensive nature of turquoise mining, it can be a lucrative enterprise. Top-quality turquoise brings up to LE 200 per kilogram on the European wholesale market. Although limited as a major industrial growth resource, turquoise exploitation potential in South Sinai merits investigation. If sufficiently rich deposits are found, market development, minor financial aid, and technical assistance could launch a cottage industry with long-term income potential for numerous small mines.

5.7.10 Lead and Zinc

Economic deposits of lead and zinc carbonates, the near-surface expression of deeper lead-zinc sulfide ores, occur in Middle Miocene brecciated limstones and calcareous sandstones along the western

Red Sea coast. While these deposits appear concentrated in an area substantially south of Sinai and its geologic counterparts on the west side of the Gulf of Suez, their appearance in the Suez Rift Province cannot be excluded from consideration. Lead, associated with barite, was reportedly encountered in an exploration boring in the Asl oil field in the Gulf of Suez off Sinai.

If located in Sinai, lead and zinc deposits would have long-term development potential. Presently proven world reserves are reportedly sufficient to meet world demand for the next 100 years. Nonetheless, domestic resources would be a valuable asset which could contribute to national development.

5.7.11 Uranium

Trace amounts of uranium are known to be associated with carbonaceous Jurassic sedimentary rocks in the Maghara area of the Mobile Platform Province and with manganese ore deposits east of Abu Zenima and Abu Rudeis. Due to its classified nature, information regarding uranium mineralization elsewhere in Sinai and in Egypt's Eastern and Western Deserts could not be obtained. Consequently, an assessment of favorable host environments in Sinai must be relied upon to evaluate the potential for economic uranium occurrences.

A review of literature for the post-Carboniferous sandstone deposits of North Sinai did not indicate the potential presence of pronounced oxidation/reduction fronts, which serve as the concentrating mechanism for roll-front uranium mineralization (such as that which occurs in the western United States). Furthermore, extensive sequences of acid extrusive volcanic tuffs or detritus from acid instrusive rocks--indicative of trace amounts of uranium--are not present; therefore, it must be assumed that the potential for large uraniferous sandstone deposits in Sinai is limited.

While sedimentary rocks of the Stable Platform Province do not hold promise, the Precambrian crystalline rocks of South Sinai warrant some exploration. Veins up to 2 meters in width and containing pitchblende have been discovered in Precambrian rocks of the Eastern Desert. Comparable geologic environments elsewhere in the world contain highly economic uranium deposits, notably in the Precambrian shield area of Canada. It can be concluded, therefore, that uranium exploration opportunities in South Sinai warrant further consideration.

5.7.12 Heavy Mineral Bearing Sands

Beach sands with concentrated heavy mineral suites derived from Nile River outwash are known to occur along the Mediterranean coast from the Nile Delta to El Arish. The sands at some locations contain up to 3 percent ilmenite, monazite, zircon, garnet, hematite, rutile, and pyrite. Ilmenite constitutes roughly 60 percent of the heavy mineral suite. These materials were drilled and tested by the Egyptian Black Sand Company at several locations along the North Sinai coast before 1967.

Mediterranean beach sand deposits with the concentrations of heavy minerals identified to date do not appear to be economically promising. The cost of mining, processing, and distributing the potential products of the beach sands far exceeds their estimated market value. Additionally, heavy mineral bearing sands that may occur along the Gulf of Suez are not promising.

5.7.13 Sulfur

Elemental sulfur has been reported at Abu Durba, 40 kilometers south of Abu Rudeis along the Gulf of Suez coast, and in the stable Platform Province near Gebel Bedabaa and the Agama Mound. No details are known regarding the occurrences in the Stable Platform Province.

Near Abu Durba, sulfur is rumored to occur in fractures in shale and sandstone of the Upper Ras Malaab Formation. If true, the sulfur occurrence is comparable to that in Miocene evaporite sediments along the west coast of the Red Sea. At these locations, sulfur is directly and genetically related to gypsum-anhydrite deposits. Comparable deposits have no practical potential as sources of raw elemental sulfur. Economically, the production of sulfur by acid processing of gypsum-anhydrite holds greater opportunities.

Other potential sources of sulfur, such as sulfur cappings over petroleum and gas reservoirs in the Gulf of Suez, were not evaluated during this investigation.

5.7.14 Talc and Asbestos

Occurrences of talc and asbestos are typically associated with Precambrian ultramafic instrusive rocks. Ultramafics of this type host talc and asbestos deposits in the Eastern Desert of Egypt.

Currently available geologic maps of the Southern Mountains Province of Sinai do not show areas underlain by ultramafic rocks, nor have they been mentioned in most published geologic reports. Nonetheless, an Israeli Geological Survey report prepared in 1976 describes an ultramafic serpentinite mass in the Dahab area of eastern Sinai.

Additional outcrops of ultramafic rocks, introducing the possibility of economic talc and asbestos deposits, may occur in the Southern Mountains Province, but could have been overlooked during previous mapping because of limited areal extent or appearance in weathered exposures. Economic occurrences of copper-nickel sulfides, also associated with ultramafic intrusives in the Eastern Desert, are additional exploration targets.

5.7.15 Gold

No deposits of gold are known to occur in Sinai. However, an axiom with some merit in the exploration industry is that "gold is where you find it."

Numerous gold deposits are known to exist and have been historically mined in the Eastern Desert of Egypt, where host rock and geologic structural conditions are nearly identical to those in South Sinai. Four types of gold deposits, resulting from four separate cycles of gold mineralization, are found in the Eastern Desert. At least three of the four intrusive and metamorphic events associated with these cycles are also manifested in the Southern Mountains Province.

The failure of ancient miners to locate and extract gold in Sinai does not rule out the possible occurrence of economic gold ore deposits. Historic prospecting relied on the appearance of visible gold in surface outcrops to guide the tunneling effort toward valuable buried deposits.

Even today at the ancient gold mines of Egypt, gold cannot be found in surface outcrops, but can be located at some depth underground in the old tunnels. Tunnels resulting from such historic prospecting of quartz veins in the Southern Mountains Province of Sinai are not mentioned in published literature, so tunnel prospecting does not appear to have been undertaken. Gold may be present in Sinai; however, exploration should be given a low priority or be linked to the exploration for other more likely minerals.

5.7.16 Tin, Tungsten, and Rare Metals

Tin, tungsten, and rare metals such as tantalum and niobium occur in quartz veinlets, stockworks, and the contact zones of silica-rich, small granite instrusives of Gattarian and post-Gattarian age in the Eastern Desert of Egypt. These instrusives are believed to be genetically or spatially related to the pink granites that occur in both the Eastern Desert and South Sinai. One such metal deposit, at Abu Dabbab in the Eastern Desert, is sufficiently rich to warrant immediate development.

Areas of pink Gattarian granite are shown on existing maps to cover large portions of the Southern Mountains Province of South Sinai. However, ground geologic mapping has not yet been completed in sufficient detail to outline areas of silicic apogranite that might carry tin-tungsten-tantalum-niobium mineralization. Short of extensive detailed mapping, exploration for such deposits can be achieved most rapidly by stream sediment geochemical surveys. This exploration method should find early application in Sinai regional mineral resource development.

5.7.17 Potash

A few geophysical logs from oil and gas exploration borings in the Gulf of Suez revealed the presence of geophysical indicators that may represent zones of potash 700 to 1,800 meters below the floor of the gulf. Such zones at extreme depths beneath the gulf floor do not, of themselves, bear economic interest, but do serve as exploration guides.

Sedimentary horizons that carry potash beds beneath the gulf may extend eastward beneath the Suez Rift Province at shallower depths. Since formation of the rift post-dates the deposition of the potash in evaporite basins, there is no reason to suspect thinning of the valuable potash shoreward. In fact, folding which slightly predated northwest faulting in the province may have served to further concentrate potash deposits. Potash salts become extremely mobile under the forces of folding and faulting. Related tectonic pressures serve to concentrate and thicken potash beds on the crests of anticlinal folds. Broad post-Eocene folds along the central and northern Suez Rift Province might prove interesting in this respect and warrant further investigation.

5.8 ENERGY

Sinai is endowed with energy resources far exceeding its anticipated energy needs, and thus could be able to export energy to mainland Egypt for the next several decades.

Currently all electrical power is produced by local generators. There is no regional electricity distribution grid in Sinai, though a 2,200-kilovolt load capacity trunk line is planned for the Hamdi tunnel near Suez. Additionally, an 11-kilovolt power supply is planned for the east bank tunnel facilities.

Sinai's in situ potential energy resources include petroleum, natural gas, coal, geothermal, wind, and solar. Nuclear energy is not considered herein, though uranium is potentially present in South Sinai. The processing of uranium into yellow-cake and the development of nuclear power stations are independent of the uranium source.

Sinai's primary exploitable energy resources are petroleum, natural gas, and coal. Petroleum is currently being used as a major energy source. The use of petroleum for electrical generation could be replaced by natural gas and coal, releasing petroleum for use as an export commodity.

The exploitation of geothermal energy and major solar energy systems may have to await further development of Sinai and a greater demand for energy and energy resources. Solar and wind energy may find application as small energy contributors in remote areas or on an individualized basis. Both systems have proven low technology applications (e.g., domestic solar hot-water heaters, small household wind-powered electrical generators, and windmills for shallow aquifer water extraction).

5.8.1 Petroleum

Petroleum is currently the only Sinai energy resource being exploited on a large-scale basis. Present oil production is limited to onshore and marine fields in the Gulf of Suez. Several leases have been let in the Gulf of Aqabah and Mediterranean. Onshore exploratory drilling is taking place along the northern coast.

At a crude oil production rate of 114,000 barrels per day (1980), the production-to-consumption ratio is estimated to be 225. Thus, the current demand for petroleum products in Sinai is less than one-half of 1 percent of production.

Petroleum production is one of the dominant factors in Egyptian economic growth, accounting for about 15 percent of the gross domestic product (GDP) in 1979. During 1980, 1 billion barrels of proven recoverable resources were added to Egypt's inventory. Sinai's marine Belayim field and other marine fields contributed about 64 percent of this increase. In 1981, several new discoveries have been reported; however, due to industrial secrecy, it has not been possible to obtain confirmation data. Based on the history of petroleum exploration in Sinai and the current exploration levels, it is safe to assume that Sinai can expect to continue to play a major, perhaps increasing, role in Egypt's petroleum energy industry.

5.8.2 Natural Gas

A major energy resource which is presently being wasted in Sinai is the roughly 1.4 million m^3/day of natural gas associated with petroleum production. This flared gas, with an energy content equivalent to 3 million barrels of oil per year, is 17 times the present energy demand for Sinai. Present projections are that this level of production will be maintained through 1985, drop to one-half by 1990, and to one-third by 1995.

Some exploratory work has been undertaken to determine the availability of natural gas not associated with oil. There are indications that some Sinai gas fields may have commercial value. Production from newly discovered fields could add to the present proven natural gas reserves, as could exploratory drilling in North Sinai and the Mediterranean.

The current energy content of the natural gas associated with oil production in the eastern Gulf of Suez area is approximately 5×10^{10} Btu/day. Converted to electricity with efficient generators, this energy could produce 240 megawatts of power, with an annual value of LE 32 million, based on 1.6 piasters per kilowatt-hour. This application could also facilitate the displacement of about 6 million barrels of oil per year used in thermal power plants, providing a savings of $150 to $200 million per year.

5.8.3 Coal (see also Section 5.7.2)

The Maghara mine in north-central Sinai is believed to have 35.6 million metric tonnes of proven recoverable coal reserves. Several other lower quality and currently uneconomic coal deposits have been identified along the Gulf of Suez, near Ayun Musa and Wadi Thora. Additional exploration in these and other areas may identify greater and better quality reserves. Until such time, the Maghara coal is the only potentially exploitable deposit and is the only one used for input into the total assessment of Sinai's energy resource capability.

Several options for use of the Maghara coal have been proposed, including coking and as fuel for a power plant. The feasibility of these options, however, should be carefully reviewed following a thorough resource evaluation of Maghara coal; such an evaluation will have to determine total reserves, grades, mine plan, and the economics of exploitation.

5.8.4 Geothermal

There has been very limited systematic evaluation of possible sources of geothermal energy in Egypt. Of the known hot springs, two are in Sinai, at Hammam Fara'un and Hammam Saidna Musa. According to Ramly, using 1969 data, Ain Hamman Fara'un has a temperature of about 75^{o}C and a flow rate of 880 m^3/day, and Ain Hammam Saidna Musa has a temperature of about 34^{o}C (no flow data are given).

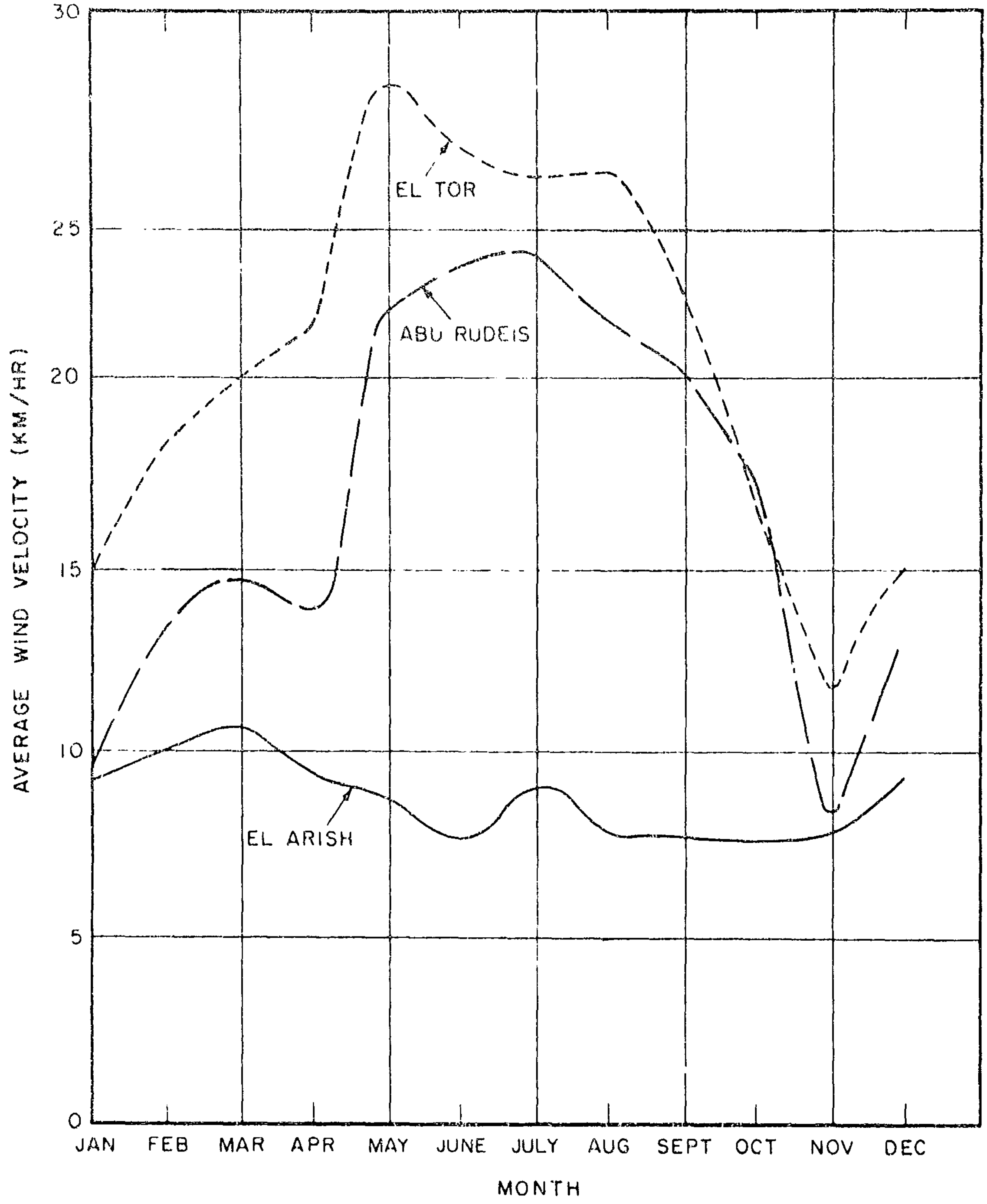
Both of these springs are currently used by locals for medicinal and religious bathing. Ain Hammam Musa has been ponded into a developed swimming pool. The development of the geothermal sources of these springs as an energy resource will require extensive study and could disrupt their use as tourist attractions.

Dry rock geothermal possibilities are also said to be promising in Sinai, but economic technology for exploiting this resource is still being developed (personal communication, Los Alamos Scientific Laboratories, 1981). Due to the high costs of development, lack of proven technology, time required to evaluate regional potential, and low number of applications in the immediate future, Sinai's potential geothermal energy resources cannot be considered a viable energy alternative between now and the year 2000. However, it may be worthwhile at this time to undertake a thorough study of existing drilling logs and well data, to map the most probable areas for geothermal exploitation, and to assess the energy potential and quality of these areas.

5.8.5 Wind

High wind velocities are common in several areas in Sinai, particularly along the coast of the Gulf of Suez. Although detailed data are not available for most locations in Sinai, some information exists for El Arish, El Tor, and Abu Rudeis. Average wind speeds of 20 km/hr in El Tor and 17 km/hr in Abu Rudeis indicate considerable potential for wind energy use, and the seasonal variations in wind velocity indicated in Figure 5-1 suggest that periods of peak supply may be well matched to periods of peak demand for irrigation or other applications. Average wind speeds for El Arish are 9 km/hr. The relatively constant velocities year-round and the lack of significant periods of high wind velocity suggest that El Arish is not well suited for major development of large wind systems.

As shown in Figure 5-2, however, virtually all areas in Sinai are capable of supporting small wind-powered systems, such as wind mills for shallow aquifer water and windchargers for remote household electrical generation. Table 5-10 gives the mean wind speed for Port Said, Ismailia, Suez, El Arish, Abu Rudeis, and El Tor. From this figure and table, it is apparent that there is sufficient surface



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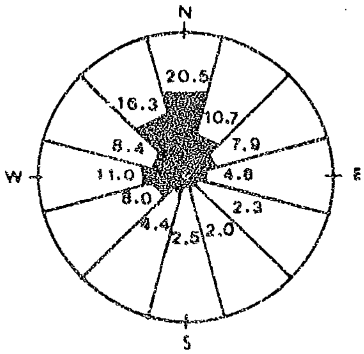
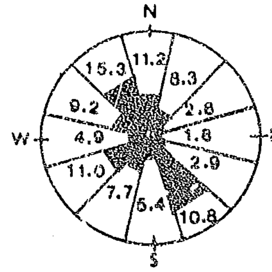
ESTIMATED SEASONAL WIND VELOCITY VARIATIONS

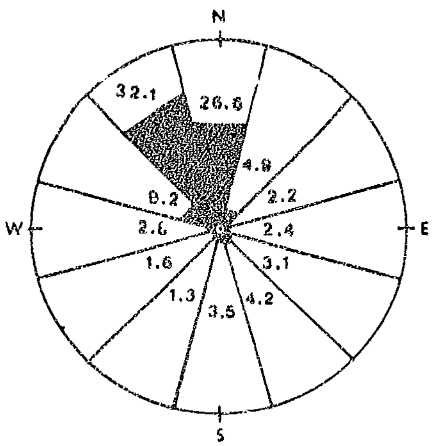
FIGURE 5-1



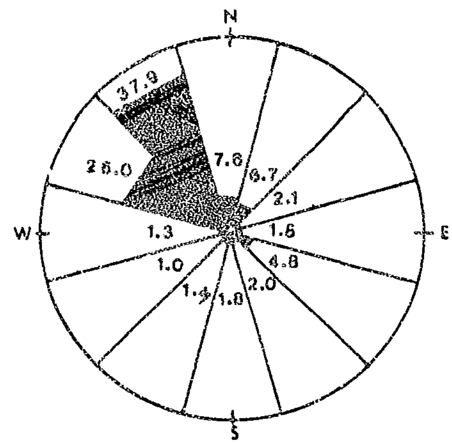
PORT SAID



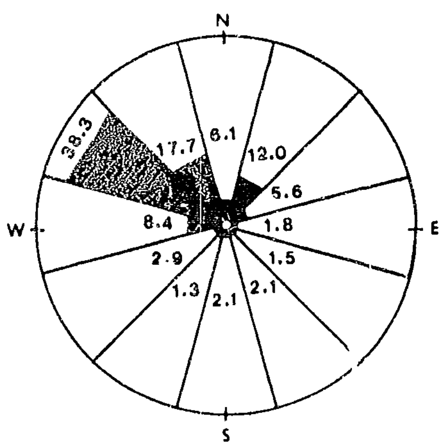
EL ARISH



SUEZ



ABU RUDEIS



EL TOR

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SURFACE WIND DIRECTIONS

FIGURE 5-2

TABLE 5-10

Mean Surface Wind Speed
(knots)

Month	Port Said 1952-1970	Ismailia 1965-1969	Suez 1965-1972	El Arish 1959-1967	Abu Rudeis 1966	El Tor 1965-1968
January	9.3	5.7	5.9	4.8	5.3	7.9
February	10.0	5.1	6.8	5.7	7.5	6.8
March	11.3	7.2	8.4	5.8	8.4	7.8
April	10.4	6.9	9.1	4.9	7.8	8.4
May	9.4	6.5	9.4	4.7	12.5	9.2
June	9.0	6.5	9.3	4.6	13.1	11.0
July	8.4	6.8	10.5	4.4	13.3	9.9
August	7.4	5.5	9.4	4.1	12.4	9.8
September	7.4	5.5	10.4	4.2	11.4	10.0
October	8.0	4.4	8.8	3.9	9.4	6.3
November	8.3	4.2	7.4	4.0	4.4	5.4
December	8.4	5.1	6.2	4.7	7.2	5.9
Annual Mean	9.0	5.8	8.5	4.6	9.4	8.2

SOURCE: Egyptian Meteorological Authority.

wind in Sinai to power these small wind-powered systems. In areas having sustained high wind veolocities and a high frequency of such winds, high technology, wind-powered electrical generation stations may be applicable.

5.8.6 Solar

Due to its favorable location and lack of any significant cloud cover throughout most of the year, Sinai has an abundant solar energy resource. Peak solar insolation rates are around 1,000 W/m^2 impinging on a horizontal surface. Factors that reduce insolation levels include sand, dust storms, fog, and clouds. In Sinai, these factors probably account for less than a 5 percent reduction in total radiation levels. Sand and dust are also the major environmental deterrents to the efficient operation of solar energy recovery units.

Several applications for solar energy exist or may develop in Sinai. Solar-powered domestic hot-water heaters were used extensively in and around El Arish during the Israeli occupation. A small solar hot-water heater fabrication factory is still in operation. Solar-powered water distillation and desalination systems may find application on a small and localized basis in Sinai. Solar-powered salt ponds have proven to be technically feasible and operable in the Dead Sea area. It is possible that such a system could be economically operated at Lake Bardawil.

Based on the lack of proven technology for applications-oriented solar recovery units (even in high technology areas as the U.S. Sunbelt), the high cost of such systems, and the lack of in-place marketing and maintenance infrastructure, it does not appear likely that the use of solar energy as a major energy source will occur in the near future. Use of this energy source is and will probably remain an individualized application. Because of the low technology level required, it can be expected that the use of domestic solar hot-water heaters will increase. Moreover, as solar tehcnology advances worldwide, substantial new opportunities may open up for exploiting solar energy in Sinai.

6.0 ENGINEERING SUITABILITY

Five areal land classification units of engineering suitability were established for urban development, industry, and infrastructure. These classes are based on a composite of slope, relief, environmental geology, and landforms, as shown in Table 6-1. The general characteristics of each of these map units are shown in the table. Plate 3-7, Sheets 1 and 2, shows these land classification areas.

In terms of engineering suitability, the areas of Sinai which appear to have the best development potential are those which would present the least impacts with regard to physical, environmental, and economic limitations. In Sinai, the best land is where slopes are gentle, relief is low, and the soil and rock characteristics present minimal impacts to development. These areas are considered to be relatively free of limitations or have limitations which can be easily overcome.

The most predominant engineering suitability class in the interior of Sinai is class 3, followed closely by class 5. The class 3 areas cover virtually all of central Sinai south of Wadi El Bruk, with the exception of the wadi channels. This broad expanse continues to the south, including the El Igma-El Tih Plateau and the high plains areas to the south. The southernmost extension of the continuous class 3 area is at Bir Infukh, just north of Gebel Umm Alawi and Saint Catherine's. Scattered intermittently throughout this expansive class 3 area are small areas of classes 5 and 2.

The class 5 area is the second most predominant engineering suitability category in the Sinai interior. The largest class 5 area is found in the southern mountains. This area extends from just north of Ras Mohammad to near Gebel Banat, then northwest to include the Umm Bugma region. Smaller areas of class 5 suitability are found in the Gebel Qabeliat-Gebel Araba areas near El Tor; the Gebel Raha range northeast of Ras Sudr; and the Gebels Yelleq, El Halal, and Maghara areas of North Sinai. Class 5 also forms much of the eastern perimeter of Sinai along the Gulf of Aqabah. The badlands of the El Hazim area in southeastern Sinai are also class 5 units.

Engineering Suitability Matrix

Map/Class Unit	Dominant Components: Slope (percent)	Relief (meters)	Surficial Geology	Landform
1[a]	0-8	0-50	Alluvial deposits	Wadis
2[b]	8-25	50-150	Colluvial Alluvial deposits	Interior plains Hammada sheets Sand
3[c]	8-25+	150-300	Rock Near-surface rock Boulders	Hammada High plains Plateaus Dome mountains with breached core
4[d]	0-25	0-150	Sand dunes Marine deposits Coastal plains	Wetlands Marsh Erg
5[e]	25+	300	Rock Near-surface rock	Badlands Hilly uplands Block mountains Complex mountains Dome mountains
[f]	100	-	Rock	Escarpment

[a]Suitable for multistructure emplacements; long straight road alignments available; foundation stability fair to good; susceptible to flash flooding; may provide only access to many areas of South Sinai.

[b]Suitable for multistructure emplacements; road alignments achieved with good planning, local briding may be required; foundation stability fair; may be locally susceptible to flash flooding; highly variable surface material composed of sand, gravel, stones, and boulders.

[c]Generally suitable for multistructure emplacements; road alignments achieved with good planning, detailed engineering and bridging required locally; foundation stability good-to-excellent; excavation and construction in some areas difficult due to resistant rock, steep slopes,and locally high relief terrain.

[d]Unsuited for multistructure emplacements; road alignments easily achieved but operation and maintenance difficult due to shifting sand or locally high water table; foundation stability poor-to-fair; requires stabilization to protect from erosion.

[e]Unsuited for multistructure emplacements; road alignments difficult due to steep rocky slopes and numerous slope reversals (badlands), generally requires substantial cut-and-fill; blasting required for most excavations; foundation stability generally excellent for single engineered structures; high relief terrain and hard rock present in much of the unit.

[f]Escarpment-hachures point downslope; slopes exceed 100 percent; present severe obstacles to development of infrastructure, particularly roads, pipelines, and transmission lines.

The third most common engineering suitability category in Sinai is class 4. The class 4 designation is made up of erg, marine deposits, and coastal plains. This class is found primarily in the northern and northwestern regions of Sinai, including virtually the entire coastal plain from the Mediterranean Sea inland to Gebels Maghara and El Thamila. It also covers the entire northwestern corner of Sinai, from the El Tina Plain inland to Gebels Gedeira and Umm Margam. It extends south to the Little Bitter Lakes area, where it is restricted by class 2 and 3 units to a very narrow coastal strip. This strip then extends from the Little Bitter Lakes south to the tip of Ras Mohammad, and is broken only occasionally by small coastal extensions of the other suitability classes.

Class 2 areas are restricted to the alluvial fans of major wadis such as Sudr and Wardan, to hammada plains (such as that of El Qaa), and to the colluvial outwash plains such as those formed by Wadis El Hamma and El Hegayib around Gebel Yelleq. Class 2 areas are generally small in extent. The largest class 2 areas in Sinai are the El Qaa Plain in the south and the outwash plains around Gebel Yelleq in the north. Another area of moderate size is formed by the Wadi El Hagg alluvial plain, near Mitla Pass.

Class 1 areas are, by definition, restricted to the wadi channels and flood plains. Thus, major units of this suitability category are found along Wadis El Bruk, El Arish, El Aqabah, and Geraia. In South Sinai, class 1 areas tend to be very narrow; typical wadis containing class 1 engineering suitability land are Feiran, Agir, El Akhdar, Solaf, Mir, Sharai, Letih, and Kid.

7.0 CULTURAL RESOURCES

In assessing the resources of any region as an input to planning, either for modernization or settlement, the cultural, educational, and technological background of the existing population and of the incoming migrants should receive primary attention.

7.1 POPULATION

The total area of Sinai covers about 61,500 square kilometers. The current population is estimated to be 180,000 (50,000 in occupied territory, 130,000 in the west); thus, the average population density is 2.9 persons per square kilometer. Compared to the national average of about 41 persons per square kilometer, this is extremely sparse.

Based on population estimates for 29 settlements in Sinai, it appears that the population is distributed as follows:

- 50 percent along the north coast (or use settlements here as their primary point for commerce)
- 5 percent in the northwest corner
- 7 percent in the liberated north-central interior
- 7 percent along the west-central coast
- 2 percent in the liberated south-central interior
- 1 percent along the southwest coast
- 4 percent along the occupied southeast coast
- 3 percent in the occupied east-central region
- 21 percent in the occupied northeast corner.

Table 7-1 lists the 29 settlements, their regional affiliation, and estimated population.

From a societal point of view, settlements within Sinai can be classified into the following major types:

- Existing urbanized settlements--El Arish
- Existing semi-urbanized settlements--Bir El Abd, El Tor
- New small, rural settlements or resettlements--New Mit Abul Kom
- Existing small Bedouin settlements--Nakhl, Bir Nasib.

Scattered enclaves of seminomadic and nomadic Bedouin tribes make up another element in the Sinai population and settlement resource base. Plate 7-1 shows the proportional populations of the 29 settlements for which population estimates are available. This map clearly shows that the majority of Sinai's population resides along its northern east-west trade route.

TABLE 7-1

Current Sinai Population Estimates, 1981

Community	Population	Region
El Arish	70,000	North
Bir El Abd	13,000	North
Negila	1,800	North
Rabaa	1,200	North
Romana	1,800	North
Baloza	2,100	North
Gilbana	5,000	Northwest
El Qantara East	5,000	Northwest
Gifgafa	4,000	North-central
El Hasana	6,500	North-central
Bir El Thamada	600	North-central
Nakhl	1,500	West-central
El Shatt	500	West-central
Ayun Musa	500	West-central
Ras Sudr	5,000	West-central
Abu Zenima	2,300	West-central
Abu Rudeis	3,500	West-central
Oasis of Feiran	1,500	South-central
Saint Catherine's	2,000	South-central
El Tor	2,200	Southwest
Sharm El Sheikh	2,500	Occupied southeast
Nebq	2,000	Occupied southeast
Nuweiba	1,500	Occupied southeast
Dahab	1,500	Occupied southeast
El Quseima	1,000	Occupied east-central
El Kuntilla	2,000	Occupied east-central
Bir El Themed	2,500	Occupied east-central
Abu Aweigila	2,000	Occupied northeast
Sheikh Zuwayid	35,000	Occupied northeast
TOTAL	180,000	

SOURCE: Dames & Moore field surveys.

7.1.1 Labor Base

North Sinai Bedouins, particularly those along the northern coast and the east-west trade route, have had considerably more exposure to outsiders and foreigners than those in South Sinai and in the interior. This exposure may account for their increased level of involvement in trade. The North Sinai Bedouin tribes generally have a mercantile orientation and seem willing to invest in businesses and work cooperatively to make economic endeavors successful.

The Bedouins in some southern areas such as Saint Catherine's also display various entrepreneurial skills, despite their relative isolation, and some have started small-scale businesses either independently or cooperatively with their families. New tourism routes, such as may develop from North Sinai to Saint Catherine's Monastery, may stimulate additional entrepreneurial endeavors by local people.

With respect to traditional Bedouin customs, a great many people appear to be quite superstitious, practice folk medicine and astrology, and live by traditional tribal customs. Women assume responsibilities for childrearing, agriculture, and animal herding. Women in the south tend to be more introverted than those in the north, probably as a result of their isolation from foreigners. Unveiled women are not uncommon in the north, while in the south they are rarely seen.

In the traditional Bedouin culture, nomads usually have no respect for manual labor. In Sinai, experience brought on by the Israeli occupation, however, has trained many of the younger generation in manual skills. Younger men are involved in construction, transportation, and mining. In El Arish, women have recently begun to use their needlework skills to make products for markets both in Sinai and in Cairo.

Few estimates are available with respect to the number of individuals involved in various skilled and unskilled endeavors. Dames & Moore's brief social survey conducted in June 1981, however, did identify the several types of labor activity by sex and wage, as shown in Table 7-2. Appendix B provides summary data for establishments in selected communities. From these data and other field observations, it appears that Sinai's current labor force emphasizes construction activities, transport services, fishing, and general supply and maintenance services. According to the North Sinai Governorate tax assessment records for 1981, there are 1,032 licensed establishments in El Arish. Table 7-3 provides a listing of these establishments.

TABLE 7-2

Labor Base Data for Unskilled and Skilled Workers

Settlement	Unskilled	Sex Male	Sex Female	Wage (LE/day)	Skilled	Sex Male	Sex Female	Wage (LE/day)
Abu Zenima	Mine laborers	X			Mechanic	X		2.00
	Construction				Electrician	X		2.00
	laborers	X			Miner	X		2.00
Bir El Abd	Carrier	X			Truck driver	X		3.00
	Handicrafts		X		Concrete finisher	X		
					Carpenter	X		
					Plumber	X		
					Electrician	X		
					Warehouse manager	X		
					Veterinarian	X		
					Poultry farm manager	X		
					Painter	X		
El Tor					Fisherman	X		
					Poultry farm manager	X		
Oasis of Feiran	Laborer	X			Rock mason	X		
					Truck driver	X		
					Carpenter	X		10.00
					Painter	X		10.00
					Concrete finisher	X		7.00
El Arish	Carrier	X		1.00	Fisherman	X		
	Salesman	X			Mechanic	X		
	Farm helper	X		2.00	Shop manager	X		
	Harvester	X	X	1.50	Machine operator	X		3.00
	Laborer	X			Farm manager	X		3.00
	Assistant cloth				Truck driver	X		3.00
	cutter		X	1.00	Brick maker	X		3.50
	Dishwasher			0.50	Tile maker	X		3.00
	Waiter	X		1.00	Tailor shop manager	X		4.00
					Tailor	X		3.25
					Clothes salesman	X		3.00
					Seamstress		X	2.00
					Restaurant manager	X		2.50
					Chief cook	X		1.25
					Assistant restaurant			
					manager	X		1.25
					Carpenter	X		5.00
Saint Catherine's	Waiter	X			Cook	X		2.50
	Driver	X			Bus mechanic	X		5.00
	Tour Guide	X			Hotel manager	X		6.25
	Grocer	X						
Ras Sudr	Driver	X			Welder	X		3.00
	Laborer	X			Mechanic	X		2.50
					Plumber	X		1.25
					Fisherman			

SOURCE: Dames & Moore field surveys.

TABLE 7-3

Licensed Establishments in El Arish

Type	Number	Market
Grocery supplies	390	retail
Dry goods	44	retail
Cloth vendors	120	retail
Butchers	15	retail
Fruits and vegetables	15	retail
Fresh fish	18	retail
Bookstores	7	retail
Cold drinks and cigarettes	9	retail
Ready-made clothes	16	retail
Sweets	6	retail
Shoes, sales/repairs	3	retail
Flour	10	wholesale/retail
Household supplies	9	retail
Carbonated water vendors	3	retail
Bakeries	7	wholesale/retail
Government-subsidized food shops	4	retail
Animal feed	1	wholesale
Watches	4	retail
Furniture and carpentry	6	construction
Bathroom fixtures	2	wholesale/retail
Bricks and cement	8	wholesale
Wood	7	wholesale
Tile workshop	2	manufacturing
Charcoal	1	manufacturing
Chickens and eggs	3	retail
General contractors	90	construction
Building contractors	8	construction
Building supplies	95	wholesale/construction
General wholesale	6	wholesale
Cotton (tailor)	3	manufacturing
Appliances	3	retail

TABLE 7-3 (co··· d)

Type	Number	Market
Auto (batteries and tires)	3	retail
Grain roaster	1	manufacturing
Fishing supplies	1	wholesale
Pharmacy	3	retail
Olives and oils	1	retail
Autos/bicycles (sales and parts)	12	wholesale/retail
Motorcycle parts	2	wholesale/retail
Metalworking factories	3	manufacturing
Cafes and cafeterias	10	service
Restaurants	18	service
Hotels	3	service
Electrical supplies	17	wholesale/retail
Export-import	3	wholesale
Glass and mirrors	4	retail
Gas-oil stations	5	retail
Travel agencies	2	retail
Office supplies	5	wholesale/retail
Photocopying	1	retail
Bottled gas	1	retail
Jewelry	8	retail
Grains	12	wholesale/retail
Photography	2	retail

SOURCE: North Sinai Governorate tax assessment records.

7.1.2 Educational Base

In traditional Bedouin culture, informal education transmitted from the elders to children is much more important than formal education. Formal education, however, is spreading among the settled and semi-settled Bedouin groups, and schooling is available in all large settlements. Before 1967, Sinai had the following schools:

- 55 primary schools
- Nine preparatory schools
- Four secondary schools
- One technical commercial school
- One technical industrial school
- One teacher training institute for women
- One teacher training institute for men.

As a result of the 1967 war, many families from Sinai were relocated to the Nile Delta and Nile Valley. A 1976-1977 survey by the Ministry of Social Affairs of 53,192 relocated Sinai individuals indicated that about 42 percent of the males and 73 percent of the females were illiterate. Of the literate individuals, about 8 percent had obtained primary school certificates, 7 percent had preparatory school certificates, and 1 percent had university degrees. No data are available regarding the educational profiles and facilities within Sinai during the occupation years.

Dames & Moore's infrastructure survey in May-June 1981 provided public education data for 20 Sinai communities. The North Sinai settlements of Bir El Thamada, Nakhl, and El Shatt reported no schools in operation. All other settlements have at least one public school. Seven communities provide preparatory schools, while only three have secondary schools. There are 43 primary schools, 11 preparatory schools, and five secondary schools in Sinai. Table 7-4 lists the public education data for the surveyed communities.

7.2 INFRASTRUCTURE

Optional Working Paper No. 14, Settlement Survey of Social and Economic Activity in Sinai (August 1981), and Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981), provide additional details on schools and other social services.

TABLE 7-4

Educational Data for Sinai Public Schools, 1981

Community	Primary Schools[a]					
	No. of Schools (and Rooms)		No. of Students		No. of Teachers	Others Employed[b]
			Girls	Boys		
NORTH SINAI						
El Arish	16	(195)	4,495	4,029	207	224
Bir El Abd	1	(8)	112	272	11	5
Negila	1	(8)	60	220	11	--
Rabaa	1	(9)	85	260	12	6
Romana	1	(6)	30	120	12	4
Baloza	1	(6)	40	155	17	--
Gilbana	1	(2)	5	25	1	3
El Qantara East	2	(15)	256	297	24	14
Gifgafa	1	(5)	28	145	8	2
El Hasana	1	(2)	7	36	3	--
SUBTOTAL	26	(256)	5,118	5,559	306	258
SOUTH SINAI						
Ayun Musa	1	1	4	11	1	2
Ras Sudr	3	17	78	167	30	6
Abu Zenima	1	3	25	20	3	--
Abu Rudeis	1	4	1	15	3	2
Wadi Feiran	6	23	29	183	20	9
Saint Catherine's	3	12	17	145	11	6
El Tor	2	12	85	159	15	6
SUBTOTAL	17	(72)	239	700	83	31
TOTAL	43	(328)	5,357	6,259	389	289

[a] Bir El Thamada, Nakhl, and El Shatt (North Sinai) have no primary schools in operation.

[b] Includes administrative, clerical, and custodial personnel.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-4 (cont'd)

Community	No. of Schools (and Rooms)		No. of Students: Girls	No. of Students: Boys	No. of Teachers	Others Employed[b]
Preparatory Schools[a]						
NORTH SINAI						
El Arish	5	(69)	1,285	1,616	101	36
Bir El Abd	1	(5)	21	145	8	3
Rabaa	1	(13)	70	260	15	7
Romana	1	(4)	25	100	11	4
El Qantara East	1	(6)	77	118	12	12
SUBTOTAL	9	(97)	1,478	2,239	147	62
SOUTH SINAI						
Ras Sudr	1	(3)	12	48	15	5
El Tor	1	(2)	12	18	14	3
SUBTOTAL	2	(5)	24	66	29	8
TOTAL	11	(102)	1,502	2,305	176	70
Secondary Schools[c]						
NORTH SINAI						
El Arish	3	(46)	499	900	96	20
Rabaa	1	(14)	54	240	20	6
SUBTOTAL	4	(60)	553	1,140	116	26
SOUTH SINAI						
Ras Sudr	1	(3)	12	48	15	5
SUBTOTAL	1	(3)	12	48	15	5
TOTAL	5	(63)	(565)	1,188	131	31

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[a] Negila, Baloza, Gilbana, Gifgafa, El Hasana, Bir El Thamada, Nakhl, and El Shatt (North Sinai) and Ayun Musa, Abu Zenima, Abu Rudeis, Wadi Feiran, and Saint Catherine's (South Sinai) have no preparatory schools.

[b] Includes administrative, clerical and custodial personnel.

[c] Bir El Abd, Negila, Romana, Baloza, Gilbana, El Qantara East, Gifgafa, El Hasana, Bir El Thamada, Nakhl, and El Shatt (North Sinai) and Ayun Musa, Abu Zenima, Abu Rudeis, Wadi Feiran, Saint Catherine's, and El Tor (South Sinai) have no secondary schools.

7.2.1 Social Services

Plate 7-2 shows the spatial distribution of social services in Sinai. The general existing land use is also included, such as agriculture, grazing, mining, and fishing.

Although the quality of services varies greatly from place to place and even daily (depending on which mechanic, nurse, doctor, etc., is on duty), general repairs and assistance can normally be obtained in the communities indicated. Tables 7-5 through 7-11 provide data on community water supply, electrical power generation, medical facilities, medical personnel, telecommunications, religious buildings and public meeting places, and benzene stations and garages, respectively. Table 7-4, presented earlier, provides basic data on educational facilities.

In addition to the social services facilities shown in the tables for El Arish, the community now has an outdoor cinema.

7.2.2 Transportation

The transport of goods and people in Sinai is dependent mainly on roads. Airfields are controlled by military authorities, and general public use is currently restricted. There is no longer a railroad operating in Sinai. The few existing anchorages are small and accommodate only fishing boats; harbor facilities are underdeveloped. There are no canals or pipelines to transport bulk commodities, except for the El Qantara-Bir El Abd water pipeline which is presently under construction.

During August 1981, a field survey was conducted to ascertain the existing conditions of Sinai roads. Survey findings indicate that about 165 kilometers of road are in good condition and require no immediate repair. Minor road repair is needed for 1,102 kilometers currently in fair condition. Major maintenace or complete reconstruction is required for 712 kilometers of road in poor condition. These numbers reflect general road conditions for all of Sinai; priority of repair and upgrading of the transportation network should be accomplished according to the primary linkages described below.

Roads are occasionally obstructed by sand or flooding. Sand obstructions can be expected in North Sinai between Ismailia and El Arish, particularly during the spring when the most severe winds below. Flooding is common during the winter season. All secondary roads leading inland

TABLE 7-5
Community Water Supply

	Domestic Water Sources					
	No. of Wells in Use					
Community	Sweet	Brackish	No. of Public Faucets	Quantity Delivered by Tank Truck (m^3/day)	Average Daily Consumption (m^3/day)	Total Storage Capacity (m^3)
NORTH SINAI						
El Arish	12	2	1	--	7,000	500
Bir El Abd	--	1	--	16	16	--
Negila	--	10	--	28	28	--
Rabaa	3	3	--	15	16	--
Romana	--	4	--	16	16	--
Baloza	--	--	4	25	25	--
Gilbana	--	21	1	(c)	24	--
El Qantara East	--	--	4	--	1,000	10
Gifgafa	--	--	2	--	96	--
El Hasana	--	--	1	24	24	12
Bir El Thamada	--	1	--	(c)	24	--
Nakhl	2	2	--	4	4	32
El Shatt	--	--	--	--	2	--
SUBTOTAL	17	44	13	129	8,275	554
SOUTH SINAI						
Ayun Musa	3	--	--	1	1	--
Ras Sudr	(b)	(b)	--	40	40	--
Abu Zenima	--	--	--	4	4	60
Abu Rudeis[a]	--	--	--	8	8	--
Wadi Feiran	4	--	14	--	250	25
Saint Catherine's	2	--	6	--	50	250
El Tor	3	13	5	4	700	500
SUBTOTAL	12[b]	13[b]	25	57	1,053	835
TOTAL	29	57	38	186	9,328	1,389

[a]Abu Rudeis also receives potable water by ship.

[b]Ras Sudr has 46 wells--32 for agriculture and 14 for domestic use.

[c]Unknown.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-6

Electrical Power Generation

Community [a]	No. of Generators	Rated Capacity (kW)	Average Daily Consumption (kWh)
NORTH SINAI			
El Arish	7	8,305	35,000
Bir El Abd	1	145	85
Negila	1	58	180
Rabaa	1	90	200
Romana	3	210	690
Baloza	2	149	390
El Qantara East	2	750	2,480
El Hasana	1	50	150
Nakhl	1	50	300
SUBTOTAL	19	9,807	39,475
SOUTH SINAI			
Ras Sudr	4	1,000	1,180
Wadi Feiran	1	30	180
Saint Catherine's	4	300	1,440
El Tor [b]	5	495	450
SUBTOTAL	14	1,825	3,250
TOTAL	33	11,632	42,725

[a] Gilbana, Gifgafa, Bir El Thamada, and El Shatt (North Sinai) and Ayun Musa, Abu Zenima, and Abu Rudeis (South Sinai) provide no public electrical service.

[b] According to the Canal Electricity Distribution Company, El Tor has two additional generators (rated capacity, 515 kilowatts) that are not used.

SOURCE: Working Paper No. 15, Energy Resources Assessment and Evaluation of Energy Requirements (September 1981).

TABLE 7-7

Medical Facilities

Community	No. of Hospitals	Total Beds	No. of Health Centers[b]	No. of Health Units[c]
NORTH SINAI				
El Arish	2	64	4[d]	(e)
Bir El Abd	--	--	--	1
Negila	--	--	--	1
Rabaa	--	--	--	1
Romana	--	--	--	1
Baloza	--	--	--	1
El Qantara East	1	16	--	1
El Hasana	--	--	--	1
Nakhl	--	--	--	1
Gifgafa	--	--	--	1
SUBTOTAL	3	80	4	9
SOUTH SINAI				
Ras Sudr	1	12	--	1
Wadi Feiran	--	--	--	1
Saint Catherine's	1	11	--	1
El Tor	1	6	--	1
Ayun Musa	--	--	--	(c)
Abu Rudeis	1	4	--	--
SUBTOTAL	4	33	0	4
TOTAL	7	113	4	13

[a] Gilbana, Bir El Thamada, and El Shatt (North Sinai) and Abu Zenima (South Sinai) provide no medical facilities.

[b] Serves small villages, provides only outpatient services.

[c] Serves urban centers, provides basic outpatient services.

[d] In addition to four public health centers, El Arish has 19 private clinics.

[e] Ambulance center.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-8

Number of Medical Personnel

Community [a]	Physicians/ Surgeons	Dentists	Nurses
NORTH SINAI			
El Arish	58[b]	7	78
Bir El Abd	3	1	2
Negila	1	1	3
Rabaa	2	1	2
Romana	1	-	3
Baloza	1	-	3
El Qantara East	3	2	4
Gifgafa	2	--	--
El Hasana	2	--	--
Nakhl	2	--	3
SUBTOTAL	75	12	98
SOUTH SINAI			
Ras Sudr	6	6	3
Wadi Feiran	2	-	-
Saint Catherine's	2	1	-
El Tor	6	1	-
Abu Rudeis	3	2	-
SUBTOTAL	19	10	3
TOTAL	94	22	101

[a]Gilbana, Bir El Thamada, and El Shatt (North Sinai) and Ayun Musa and Abu Zenima (South Sinai) have no medical personnel.

[b]Includes 15 doctors in general practice and 43 specialists.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-9

Operational Telecommunications

Community[a]	No. of Telephones
NORTH SINAI	
El Arish	700
El Qantara East	108
SUBTOTAL	808
SOUTH SINAI	
Ras Sudr	70
El Tor	5[b]
Abu Rudeis	(c)
SUBTOTAL	75
TOTAL	883

[a]The number of telephones in Bir El Abd, Gilbana, Gifgafa, Bir El Thamada, Baloza, El Hasana, Nakhl, and El Shatt (north Sinai) and Wadi Feiran, Saint Catherine's, Ayun Musa, and Abu Rudeis (South Sinai) is unknown or not reported.

[b]Only Government telephone service.

[c]No public telephone service; only a direct line to the oil company.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-10

Religious Buildings and Public Meeting Places

Community	No. of Mosques	No. of Churches	No. of Meeting Halls
NORTH SINAI			
El Arish	15	1	4
Bir El Abd	2	-	3
Negila	1	-	-
Rabaa	1	-	-
Romana	2	-	-
Baloza	1	-	-
El Qantara East	4	1	2
El Hasana	1	-	2
Nakhl	1	-	2
Gilbana	2	-	-
SUBTOTAL	30	2	13
SOUTH SINAI			
Ras Sudr	1	-	-
Wadi Feiran	3	1	-
Saint Catherine's	1	1	1
El Tor	4	1	1
Abu Zenima	1	-	1
Abu Rudeis	1	-	-
SUBTOTAL	11	3	3
TOTAL	41	5	16

[a]Gifgafa, Bir El Thamada, and El Shatt (North Sinai) and Ayun Musa (South Sinai) have no religious buildings or public meeting places.

SOURCE: Working Paper No. 16, Recommended Physical Planning Standards for Development of Major Sinai Settlements (September 1981).

TABLE 7-11

Benzene Stations and Vehicle Maintenance Garages

Community [a]	No. of Benzene Stations	No. of Garages
NORTH SINAI		
El Arish	5	16[b]
Bir El Abd	1	-
Negila	-	1
Romana	1	1
El Qantara East	1	2
SUBTOTAL	8	20
SOUTH SINAI		
Ras Sudr	1	2[c]
Wadi Feiran	-	1
Saint Catherine's	1	1
El Tor	1	1
Abu Rudeis	1	-
SUBTOTAL	4	5
TOTAL	12	25

[a] Rabaa, Baloza, El Hasana, Nakhl, Gilbana, Gifqafa, Bir El Thamada, and El Shatt (north Sinai) and Ayun Musa and Abu Zenima (South Sinai) have no benzene stations or vehicle maintenance garages.

[b] Includes nine garages, six tire and parts shops, and one car wash.

[c] Includes one garage and one tire and parts shop.

SOURCE: Dames & Moore field visits.

from the main perimeter road are subject to obstruction by blowing sand, particularly the roads between Bir El Abd and Gifgafa and from Ismailia to Gifgafa.

The coastal road leading south from Ismailia to Ras Mohammad is also subject to spot flooding. In the area between Ismailia and Ras Misalla, standing water may be present wherever the road crosses the numerous small playa depressions. During 1981, much of this road has been rebuilt on a raised roadbed. This may partially alleviate the flooding problem. However, in most places no flood culverts have been installed, and washouts are likely to occur during periods of heavy rainfall. Farther south, between Ras Misalla and Ras Mohammad, road washouts during the winter rain season are common at wadi crossings.

The primary road network in Sinai is basically a perimeter road, running from El Arish in the northeast along the Mediterranean coast to El Qantara and then south to El Tor and Ras Mohammad. When the remaining occupied territory is returned to Egypt in 1982, the primary perimeter road will extend along the Gulf of Aqabah north to Eilat. In North Sinai, the road between the Suez crossing to Mitla Pass and on to Bir El Thamada, El Hasana, and El Arish, may also be considered primary, based on use (average daily number of nonmilitary vehicles is 50 to 60) and generally good road quality. This road permits a passage to the northern interior of Sinai and to El Arish and is about 50 kilometers shorter than the perimeter road. Another primary road runs between Ismailia, Gifgafa, and El Arish; it also provides good access to Bir El Thamada and El Hasana. For the most part, access is quite good to all North Sinai communities, with the exception of Nakhl. Access to Nakhl from Suez is via the ancient Darb El Hagg trail; it is in extremely poor condition east of Gebel El Heitan. Better access is provided to Nakhl from the road running south from El Hasana. This road is gravel and graded in places but is not regularly maintained.

In South Sinai, only one good-to-fair road leads inland from the west coast. This road was paved during 1981 and runs along the bed of Wadi Feiran, through Feiran Oasis, and on to Saint Catherine's Monastery. In South Sinai, all roads or trails that provide access to the interior run along wadi beds which are subject to major washouts and poor passability due to deep wadi sands. Four-wheel drive vehicles are generally required.

Table 7-12 provides approximate kilometer distances between principal Sinai settlements.

Based on Plates 7-3 and 2-1, it appears that these currently primary roads will continue to be critical links for travel and commerce within Sinai. It is also conceivable that two other roads--between Ras Sudr and Nakhl and between Nakhl, Bir El Themed, and Nuweiba--will become primary roads as a result of increased tourism and economic activity. Future road repair, maintenance, and major upgrading efforts should be focused on these currently primary or potentially primary roads. All secondary roads should be maintained at current levels and upgraded as resources permit and usage demands.

Commercial passenger service is currently available to many Sinai communities. Buses and taxis provide the majority of the commercial passenger service, and air service is available to and from Saint Catherine's airport. Table 7-13 provides general information on the bus and taxi services. Additional information is provided in Table 7-14 (Section 7.3).

There are about 28 airfields or landing strips in Sinai. All except the one near Saint Catherine's are under military control. The El Arish airfield is currently being upgraded for civilian use. Thus, in the near future, Sinai should have very good access by air, assuming the expansion of facilities at Saint Catherine's and El Arish and the acquisition of the Sharm El Sheikh airport.

There are approximately nine anchorages around the coasts of Sinai. Currently all of these are used only by small fishing boats. The anchorages at El Arish and El Tor are being considered for upgrading into small vessel harbors.

7.3 ACCESSIBILITY

The regional flow of goods and people between Sinai communities is greatly affected by the time taken to travel between points. The cost of some commodities (such as construction materials) and the cost for shipping goods (such as furniture and supplies) vary according to the condition of the roads as perceived by the trucker. A substantial amount of internodal flow occurs within Sinai and between Sinai communities and Ismailia, Suez, and Cairo.

TABLE 7-12

Approximate Kilometer Distance Between Principal Sinai Settlements

	Abu Rudeis	Abu Zenima	Bir El Abd	Bir El Thamada	Cairo	El Arish	El Hasana	El Qantara East	El Tor	Gifgafa	Nakhl	Oasis of Feiran	Saint Catherine's	Ras Sudr	Ismailia	Suez
Abu Rudeis	0	26	346	207	287	380	254	270	95	249	228	75	120	97	224	153
Abu Zenima		0	320	181	261	354	228	244	121	223	202	101	146	71	208	127
Bir El Abd			0	211	232	78	164	76	441	197	228	421	466	249	112	193
Bir El Thamada				0	247	133	47	163	302	42	32	282	327	110	127	94
Cairo					0	310	291	156	382	205	256	362	407	190	120	134
El Arish						0	86	154	485	124	150	455	500	283	190	227
El Hasana							0	207	349	86	64	329	374	157	171	141
El Qantara East								0	365	121	195	345	390	173	36	117
El Tor									0	344	323	364	409	192	329	248
Gifgafa										0	74	324	369	152	85	136
Nakhl											0	303	348	131	203	122
Oasis of Feiran												0	389	172	309	228
Saint Catherine's													0	217	354	273
Ras Sudr														0	137	56
Ismailia															0	81
Suez																0

TABLE 7-13

Commercial Passenger Service to Sinai Communities

FROM	TO	TYPE	PRICE (LE)	TIME	REMARKS
Cairo	El Arish	Taxi	7.0	On request	Tourist - no service Friday or Saturday
Cairo	El Arish	Taxi	4.0	On request	
Cairo	El Arish	Bus	4.5	Noon	Air conditioned - tourist Except Fridays and Saturdays
Cairo	El Arish	Bus	3.25	10:00 a.m.	
Cairo	Ismailia	Taxi	1.10	On request	
Cairo	Ismailia	Bus	1.50	8:00 a.m., noon, 3:00 p.m.	Air conditioned
Cairo	Ismailia	Bus	0.90	Hourly	Ramses Bus Station
Cairo	El Qantara	Bus	1.15		
Cairo	El Qantara	Taxi	1.50	On request	

FROM	TO	TYPE	PRICE (LE)	TIME	REMARKS
Cairo	Suez	Taxi	1.25	On request	
El Shatt	Ras Sudr	Taxi	0.75	On request	
El Shatt	El Tor	Taxi	1.75	On request	
Cairo	Suez	Bus	1.50	Hourly	Air conditioned
Cairo	Saint Catherine's	Bus	--	--	Chartered

A traffic survey was conducted at the Suez Canal ferry crossings to determine the amount and type of freight and the number of travelers entering and leaving Sinai. In general, freight entering Sinai originates from Cairo or one of the major Suez Canal cities of Port Said, Ismailia, or Suez. The heaviest traffic is in building materials and petroleum. Total traffic averages about 1,900 tons/day for all ferry-crossing locations. Westbound freight (i.e. leaving Sinai) averages about 500 tons/day, is made up of finished products or perishable food, and originates in Israel, North Sinai, or Port Fauad. At the six crossing locations during a 2-week survey period in September 1981, between 4,600 people and 270 vehicles were recorded as entering or leaving Sinai each day. This represents total traffic both ways, with somewhat more people and fewer vehicles leaving than entering.

No quantitative data are available for actual commodity flows between Sinai communities. However, based on the infrastructure, traffic, and settlement surveys performed by Dames & Moore, the primary flow routes (described above) and the effect of road conditions on the flow of goods were determined. It was found that the time factor between nodes was a major input to the cost and flow of goods. Based on discussions held with shippers and Dames & Moore's field experience, it was estimated that a poor road would take twice as long to travel as a good road, and a fair road would take about 1.5 times as long. Using this approach, adjusted kilometer distances were developed for each linkage between communities. For example, the actual distance between El Arish and Nakhl is 150 kilometers; of this, 86 are considered good and 64 are poor. Thus the adjusted distance between the two communities is 214 kilometers. If a standard speed of 55 km/hr is used, the time to travel this distance is about 4 hours (which was the actual time required to travel this route on several different Dames & Moore field trips). Once the adjusted kilometer distance was determined, a standard accessibility gravity model was applied:

$$A_i = \sum_{j=1}^{N} \frac{P_j}{D_{ij}^2}$$

where: P_j = population of community "j"

D_i = time to travel from one node to another.

Based on this model, the regional accessibility for 14 Sinai communities was determined. The level of accessibility is higher (a ranking of "1" equals greatest accessibility) in proportion to the settlement's population and lower as the distance from other population centers increases.

A similar gravity model was constructed by the National Urban Policy Study in an effort to assess the relative accessibility of settlements to sources of inputs for industrial activities or markets. Table 7-14 shows the accessibility ranking of these communities and also provides data on their internal access conditions. Plate 7-3 shows the spatial relationships and proportional accessibility between these communities. The settlements along the northern coastal road and along the Suez Canal have the highest accessibility rating.

7.4 TOURISM

Working Paper No. 9, Preliminary Tourism Strategy for Sinai and Recommendations for Future Actions (June 1981), presented an analysis of the variety of tourism-related activities available in Sinai. Sinai's most important tourism resources are concentrated in three regions--North Sinai coast, South Sinai coasts, and the southern mountains.

The tourism points of interest can be classified into eight tourism sectors as follows:

- Aesthetic: Sites provide unique vistas, such as the brilliant blues and tans of Ras Mohammad, or the unexpected green of the lush vegetation in the Feiran Oasis contrasted with the surrounding pink and black granites.

TABLE 7-14

Settlement Accessibility

Settlement	Average Condition: Main Access Road	Average Condition: Main Settlement Road	Average Condition: Secondary Settlement road	Type of Transport Available to Other Settlements	Road Use	Regional Accessibility Ranking[a]
Abu Rudeis	Gp 1	Fg/s 1	Fg/s 1	B, Tx, Pr	T, Pr	11
Abu Zenima	Gp 1/2	Fg 1	F/Pg 1	B,Bt,Tx,Pr	T, Pr	10
Bir El Abd	Gp 2	Fg 1/2	Pg 1	Tx, Pr	T, Pr	5
El Arish	Gp 2	Gp 1/2	Fg 1	B,Tx,Pr	T, Pr	1
El Hasana	G/F/Pp/g 1	Pg 1	Pg/s 1	Pr	T, Pr	8
El Qantara East	G/Fp 1/2	Fp/g 1	Fg 1	Bt,Tx,Pr	T, Pr	3
El Tor	Fp 2	Pg 1/2	Pg 1	B,Tx,Pr	T, Pr	13
Gifgafa	G/Fp 1/2	F/Pg 1	F/Pg 1	Pr	T, Pr	7
Nakhl	Pg 1	Ps 1	--	Pr	Pr	9
Oasis of Feiran	Fp 1	Pg 1	Ps 1	B,Tx,Pr	Pr	12
Saint Catherine's	Fp 1	Fg 1	F/Pg 1	B,Tx,Pr	Pr	14
Ras Sudr	Gp 2	Gp/g 1	Pg 1	B,Tx,Pr	T, Pr	4

Good = G	One lane = 1	Truck = T
Fair = F	Two lanes = 2	Private = Pr
Poor = P		Bus = B
Paved = p		Boat = Bt
Gravel = g		Taxi = Tx
Sand = s		

[a]Sheikh Zuwayid and Bir El Thamada are ranked 2 and 6, respectively.

SOURCE: Dames & Moore field visits.

- Archaeological: Sites are often burial grounds or ancient settlements, as Ain El Fogeiya, the oldest known settlement in Sinai. Ancient inscriptions can be found at numerous archeological sites, such as Serabit El Khadim. It is hoped that the inclusion of these sites will stimulate the cognizant authorities to provide protective conservation measures, such as trails, signs, and fencing.

- Cultural: Sites include old cemeteries that often reflect tribal burial beliefs and practices, and Bedouin villages and markaz market places where local handicrafts can be purchased.

- Historical: Sites include ancient roads, such as the Darb El Hagg between Suez, Nakhl, and the Gulf of Aqabah; old mining villages and mines such as Umm Bugma; or old citadels such as those at El Arish, Qal'at El Gindi, or El Qaria (Gezira Fara'un). As with archaeological sites, many of these sites should be conserved and protected as part of the overall development plan for Sinai.

- Military: Sites generally reflect war remains, such as burned-out tanks near Mitla Pass and troop carriers at Nakhl. Mitla Pass and Abu Aweigila are also included because of their strategic importance in past hostilities.

- Nature: Sites have much in common with aesthetic sites. The major difference is that sites selected for the enjoyment of nature--whether focusing on geology, geomorphology, flora, or fauna--emphasize a particular feature or unique environmental niche. Hanging oases, springs, and the Forest of Pillars are typical examples. In many cases, wadis are listed for the simple reason that while traveling up the wadi an ever-changing spectra of geologic and environmental features are on display.

- Recreational: Sites emphasize either swimming, diving, or hiking. These sites have much in common with the aesthetic and nature sites. The selection of recreational sites focused on those with existing tra[illegible] exceptional scenic vistas.

- Religious: Sites include sheikh's tombs, Saint Catherine's Monastery,other old and abandoned monasteries, and ancient religious routes. Several biblical or religious sites are listed, such as Gebel Musa, Ain El Quseima, Tel El Mahmadia (or Baal-Zephon), and Ayun Musa.

Optional Working Paper No. 28, Inventory of Tourism Places of Interest in Sinai (December 1981), identified close to 300 locations of potential touristic value. These points of interest were also categorized according to level of interest, as follows:

- Special interest: Denotes sites that appeal to tourists with specialized recreational or occupational interests. Typical sites which qualify only for special interest are oases that require off-road hikes, military battlefields, and diving areas. This category represents the lowest level of usage.

- General interest: Denotes sites that appeal to the general tourist, but are not normally the focal point of their trip. These sites are usually combined with tours to primary points of interest.

- Primary interest: Denotes sites that are the focal points of a Sinai tour. These sites represent the initial stimulus that attracts tourists to the area. Saint Catherine's Monastery is a good example of a primary interest site.

The natural beauty of Sinai's landscape will be the focus of much tourism. To many people, the opportunity to hike or four-wheel drive into particular sites makes them even more attractive. Thus, no infrastructure or superstructure except for a few information signs and trails need to be developed. Other sites which lie along existing transportation routes will have a preferred advantage for increased visits--an excellent example is Qal'at El Gindi in Wadi Sudr. This ancient citadel is located near the road between Bir El Thamada and Ras Sudr, a potentially developable tour route from the beautiful beaches of El Arish to Saint Catherine's Monastery--two points of prime touristic value. Another extension to this same tour route, which would be reserved for the hardier four-wheel drive visitors, might be Qal'at El Nakhl. A third linkage to such a Sinai tour could be Serabit El Khadim, Rod El Eir, and Wadi Mokattab. Such a tour, of course, would also require overnight facilities somewhere along the route.

7.4.1 North Sinai Coast

The most important resource along the North Sinai coast is the extensive, unspoiled beach at and adjacent to El Arish. The portion of beach with the mature palm grove is one of the finest anywhere on the Mediterranean coast. This resource is well suited to serve the tremendous beach vacation market centered around the Mediterranean and other regional seacoast areas.

Complementary resources are interesting, but by no means spectacular. Lake Bardawil has some potential for water tourism development, and more probable potential as a wildlife area; the community of El Arish has a lively market and some antiquities and old buildings that could be developed to attract tourists; and the highway access corridor across the north coast offers fascinating vistas of sand dunes, oases, and Bedouin life.

Almost no tourist superstructure is presently in place along the north coast. The few hotels at El Arish are below any reasonable standard, and there are essentially no active tourist facilities.

The north coast infrastructure--in place, or with planned improvements--appears to be reasonably good. After completion of an expansion program, the airport can handle direct flights from Europe. Land access will be adequate once canal-crossing problems are solved and highway improvement is completed.

7.4.2 South Sinai Coasts

The South Sinai coasts of the Gulf of Suez and Gulf of Aqabah possess two related resources:

- Several outstanding warm water swimming beaches
- Spectacular coral reef formations that can be explored by diving, snorkeling, and glass-bottomed boat.

Complementary attractions directly along the south coasts are few, but the likely centers for development are close and accessible to the major tourist development center in the southern mountains. Several springs, towns, and citadels along the coasts could become minor tourist attractions.

While there is no tourism superstructure along the Gulf of Suez, hotels were built during the Israeli occupation in Sharm El Sheikh, Dahab, and Nuweiba (about 300 rooms), with associated restaurants, shops,and public swimming facilities. After the transfer, these facilities will be a good base on which to expand.

Some infrastructure will be adequate. The airfield at Sharm El Sheikh (or Ophir) can handle wide-body airliners, and the highway system will be adequate once canal-crossing problems are solved. Water supplies may have to be improved substantially if resort activity in these locations is to expand.

7.4.3 Southern Mountains

The southern mountains area surrounding Saint Catherine's forms a focus for cultural and sightseeing tourism. Saint Catherine's is a world-class cultural/sightseeing resource, with its famous monastery and Gebel Musa, believed by many to be Mount Sinai. The area boasts fantastic scenery, and possibly the best summer climate in all of Egypt. The proposed Interfaith Peace Monument could become another significant attraction, along with the controversial painted rocks--Le Mont Bleu.

The present airport is adequate to accommodate the projected levels of tourist traffic. Paving of the heretofore unpaved access roads is now nearing completion; this improvement will provide additional stimulus to the development of the area. Plate 7-4, Sheets 1 and 2, shows the spatial distribution of most of the tourism points of interest in Sinai. Numbers included on the map refer to site descriptions given in Working Paper No. 28, Inventory of Tourism Places of Interest in Sinai (December 1981).

8.0 LAND USE SUITABILITY

As shown in Plates 3-6, Sheets 1 and 2 (land resources suitability) and 3-7, Sheets 1 and 2 (engineering suitability), Sinai is relatively rich in undeveloped land which is suitable for development. As is always the case, individual development areas will have to be investigated in even more detail to ascertain area-specific engineering problems and potentials; this process, however, continues even to the building site and building design level.

Because there is no constraint in Sinai with regard to available land for settlement expansion or construction, other factors--such as water, accessibility, exploitable resource potential, and national development plans--must play a large role in determining the spatial distribution of the various proposed land uses.

For example, consider agriculture in the El Arish area. El Arish has good agricultural land; it has the highest accessibility index of any settlement in Sinai; and it has an estimated total available water supply of about 53,500 m^3/day. This supply is made up of:

- Groundwater 25,000 m^3/day
- Nile water 20,000 m^3/day (pipeline)
- Desalinization 8,500 m^3/day.

Of this 53,500 cubic meters, only the 25,000 cubic meters of groundwater is currently available. Current usage is already about 24,600 m^3/day--almost the total supply of groundwater. If a pipeline is laid to the Risan Aneiza area, about 20 kilometers from El Arish, an additional 2,400 m^3/day--at an estimated cost of LE 0.24 to 0.72 per cubic meter--could be obtained. Imported Nile water would cost about LE 0.44 per cubic meter, and desalinized water--up to LE 1.08.

Using an average amount of water consumption per employee--0.38 m^3/day for industry, 0.07 m^3/day for tourism, and 53.88 m^3/day for agriculture,* it is apparent that El Arish can support far more industry and tourism than agriculture. Tourism and industry will also support a larger number of employees--a plus in the overall goal to populate Sinai--and can more easily afford the more costly Nile and desalinized water. If this more expensive water is used to supplement and replace the current use of groundwater in El Arish, overall quantities of the latter could then become available for agriculture. Based on this

*Sectoral developed average requirement figures for El Arish.

scenario, some agricultural produce could be grown at El Arish and supplemented by produce from the Sheikh Zuwayid and Rafah area.

This same interative balancing of economic development potential with water supply must be performed for each settlement to determine the spatial distribution of proposed options for industry, mining, and tourism. Typical examples from the current planning effort are discussed below.

Heavy industry, such as petrochemical and nitrogen fertilizer plants, can in many ways be self-sufficient. Good accessibility or proximity to a labor force and a good water supply are basic requirements. Additionally, the plant must be located centrally to the consumed resource--petroleum and gas. Based on Ministry of Petroleum data and on the general interest and activity of the region, the western gulf coast of Sinai, the Suez Canal region, the North Sinai coastal plain, and the Mediterranean coast are potentially large producers of oil and gas. If this raw material resource is available, its use can be linked to the planned imported water supply provided by the Ismailia siphons or other trans-canal conduits under consideration (e.g., from Ismailia or El Salaam Canals). The east El Qantara area appears to be quite suitable for such activities.

Large mining activities must by nature take place where the minerals occur. Smelters and processing mills must generally be located as close as possible to the mine mouth, due to the poor economics of transporting bulk ore. Major mining activities can often be very self-sufficient--providing their own domestic water supply via desalinization, supplying worker living quarters, and developing transport and shipping systems. Small mining activities use a disproportionately smaller number of employees, thus they can adapt to local conditions relatively easily.

Abu Zenima and Abu Rudeis represent established, though somewhat dormant, settlements associated with the Umm Bugma mineral belt. With populations of 2,400 and 3,500, respectively, these settlements naturally represent a good mining-oriented labor force. Abu Zenima and Abu Rudeis may, therefore, have enough potential to stimulate further development of the region.

Tourism activities have their own special requirements--high levels of service and a generally attractive environment. As noted earlier, Sinai's tourism resource base is large; both North and South Sinai have unique resources upon which to draw--the spectacular El Arish beach and coastline, Saint Catherine's, and the gulf coast beaches. The spatial distribution of other antiquities throughout Sinai provides an opportunity to link North and South Sinai tourism resources and selected central Sinai points of interest. Much of the transportation infrastructure is currently in place, though it will have to be upgraded considerably to accept bus and private vehicle tours. Major investments will be required for improved hotel accommodations. Moreover, at present, another deterrent to tourism activity in Sinai is accessibility--across the Israeli border and across the canal--but these difficulties could be solved with relatively little expenditure.

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APPENDIX A

U.S. SOIL CONSERVATION SERVICE LAND CLASSIFICATION SYSTEM*

Class I. Soils in Class I have no, or only slight, permanent limitations or risks of damage. They are very good. They can be cultivated safely with ordinary good farming methods. The soils are deep, productive, easily worked, and nearly level. They are not subject to overflow damage. However, they are subject to fertility and puddle erosion.

Class I soils used for crops need practices to maintain soil fertility and soil structure. These practices involve use of fertilizers and lime,cover and green-manure crops, crop residues, and crop rotations.

Class II. Class II consists of soils subject to moderate limitations in use. They are subject to moderate risk of damage. They are good soils. They can be cultivated with easily applied practices.

Soils in Class II differ from soils in Class I in a number of ways. They differ mainly because they have gentle slopes, are subject to moderate erosion, are of moderate depth, are subject to occasional overflows, and are in need of drainage. Each of these factors requires special attention. These soils may require special practices such as soil-conserving rotations, water-control devices, or special tillage methods. They frequently need a combination of practices.

Class III. Soils in Class III are subject to severe limitations in use for cropland. They are subject to severe risks or damage. They are moderately good soils. They can be used regularly for crops, provided they are planted to good rotations and given the proper treatment. Soils in this class have moderately steep slopes, are subject to more severe erosion, and are inherently low in fertility.

Class III soil is more limited or subject to greater risks than Class II. These limitations often restrict the choice of crops or the timing of planting and tillage operations.

These soils require cropping systems that produce adequate plant cover. The cover is needed to protect the soil from erosion. It also helps preserve soil structure. Hay or other sod crops should be grown instead of cultivated row crops. A combination of practices is needed to farm the land safely.

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Class IV. Class IV is composed of soils that have very severe permanent limitations or hazards if used for cropland. The soils are fairly good. They may be cultivated occasionally if handled with great care. For the most part, they should be kept in permanent hay or sod.

Soils in Class IV have unfavorable characteristics. They are frequently on steep slopes and subject to severe erosion. They are restricted in their suitability for crop use. They should usually be kept in hay or pasture, although a grain crop may be grown once in 5 or 6 years. In other cases, the soils may be shallow or only moderately deep, low in fertility, and on moderate slopes. These soils should be in hay or sod crops for long periods. Only occasionally should they be planted to row crops.

Class V. Soils in Class V should be kept in permanent vegetation. They should be used for pasture or forestry. They have few or no permanent limitations and not more than slight hazards. Cultivation is not feasible, however, because of wetness, stoniness, or other limitations. The land is nearly level. It is subject to only slight erosion by wind or water if properly managed. Grazing should be regulated to keep from destroying the plant cover.

Class VI. Class VI soils should be used for grazing and forestry, and may have moderate hazards when in this use. They are subject to moderate permanent limitations, and are unsuited for cultivation. They are steep, or shallow. Grazing should not be permitted to destroy the plant cover.

Class VI land is capable of producing forage or woodland products when properly managed. If the plant cover has been destroyed, the soil's use should be restricted until cover is reestablished. As a rule, Class VI land is either steeper or more subject to wind erosion than Class IV.

Class VII. Soils in Class VII are subject to severe permanent limitations or hazards when used for grazing or forestry. They are steep, eroded, rough, shallow, droughty, or swampy. They are fair to poor for grazing or forestry, and must be handled with care.

Where rainfall is ample, Class VII land should be used for woodland. In other areas, it should be used for grazing. In the latter case, strict management should be applied.

Class VIII. Soils in Class VIII are rough even for woodland or grazing. They should be used for wildlife, recreation, or watershed uses.

Within some of the main classes, smaller subclasses are used to specify particular problems. In the American system these are applied only to Classes II, III, and IV and are shown by the addition of the following letters added after the class:

e = erosion hazard - when vulnerability of the soil is the main problem in its use.

w = wetness - when excess water is the main problem.

c = climate - when climate (e.g., temperature or lack of moisture) is the main problem.

s = soil - when limitations of the soil (e.g., salinity) are the main problem.

APPENDIX B

SUMMARY OF SINAI SETTLEMENT SURVEY ECONOMIC ACTIVITY DATA*

*Dames & Moore internal memorandum, from H. Garnett, subject: Settlement Survey Economic Data (August 11, 1981).

1. El Arish

Numbers of licensed establishments given in enclosure 1. El Arish is a regional capital and might be expected to have a high proportion of service/retail sector establishments. Its current population is thought to be 45,000.

Sector	No. establishments	proportion of total	
retail	699	0.677	
wholesale, wholesale/retail	86	0.083	
Hotels, cafes, restaurants	31	0.030	
total distribution			0.791
construction, wholesale/construction	199		0.198
manufacturing, manuf./retail	17		.016
			1.000

Eighty percent of the establishments are retail/wholesale; just over 1 percent provide a manufacturing base. Agricultural establishments have been excluded from this list. Mousa will attempt to find data on levels of activity under each heading.

Information collected from specific businesses is given below.

Mercedes Car Repair

Scope: all N. Sinai
Facility: 530 m^2
Prices: 15 per cent more than Nile Valley
Investment: LE 30,000
Sales: LE 60,000 (90% parts. 10%used cars)
Staff: 5 (all male)
Wages: all receive % profit on repairs
Origin Labor: Local and Nile Valley

Hardware store, wholesale/retail

scope: all N. Sinai
Facility: shop 40 m^2, warehouse 425 m^2
Prices; Cairo + transport (LE 15/ton)
Investment: LE 24,000
Employment: 6 full time, 3 part-time
Wages: perm - LE 40/month; temp LE 1 /day
Origin labor: local

Fishermans Coop

Scope: Bardawil + Med.
Facility: 8000 m^2 of beach
Price: various, but around LE 1/kg.
Investment: 40 big boats @ LE 15,000 - 35,000
400 small boats @ LE 7,000 - 10,000
Employment: 913 members of coop.
12 per big boat
3 per small boat
Wages: share of catch, after % goes to maintenance of boat, fuel, etc.
Origin labor: 200 from El Arish, rest else where N. Sinai.

Farm

Scope: Nakhl, Hanana, Gifgafa
Facility: 32 F olives; 47 tomatoes, cucumbers, eggplants, zuchini, green peppers. also some date palms,
Sales: 30 tons tomatoes, 12 cucumber, 10 zuchini, 15 eggplants, 10 green peppers, 10 olives.

Costs: total LE 6000 P.A.
Employees: 4 permanent, 25-30 seasonal
Wages: LE 1.25-2 per day
Origin Labor: local

Olive Oil Manufacturing

Scope: all N. Sinai and some to Port Said
Facility: 4500 m^2
Investment: LE 120,000 - machinery
Sales: 200 tons p.a.
Employment: 9 - October to Dec. only
Origin Labor: local
Wages: LE 2-3/day

Transport company

Scope: 50% local; 50% Cairo, Canal area
Investment: Mercedes truck 65,000
Sales: 3000-3500/worth ; 500 on maintenance, 500 salery, rent monthly repayments.
Prices: Cairo / El Arish 10/ton
Ismailia / El Arish 7/ton
Employment: 2
Wages: LE 60/month for assistant
Origin labor: El Arish

Tile and brick manufacturer, contractor

Scope: 75% sales to El Arish; 25% rent N. Sinai
Facility: 6760 m^2
Sales: 350 m^2 takes per day @ LE 1.5-2.5/m^2
4000 bricks per day @ LE 20/1000 bricks working at 75% capacity.
Investment: 40,000 in manufacturing.
1000,000 in contracting.
Employment: 35 full time
Wages: unskilled LE 30/month
brichmakers 100
til makers 40-100
Origin labor: ½ El Arish; rest Upper Egypt.

Clothing manufacturer

Scope: sales El Arish 25%; rest Suez, Ismailia, Cairo
Facility: 1200m^2
Investment: 50,000 p.a.
Sales: 58,000 p.a.
Prices: LE 6 parts, LE 3.5-4.5 shorts, LE 17 Suits.
Output: shorts 2500/month
pants 1500
suits 700
Employment: 29 full time, 2 part-time
Wages: assistant tailor 28-35 /month
manager 120
cotten 100
salesman 90
seamstress 40-60
Origin labor: local

Farm

Scope: all sales local, some to wholesalers
Facility: 15 feddans under cultivation, 10 not.
Investment: LE 2,500
Sales: 15 tons olives, 15 tons guava, 5 tons oranges, 15 tons tomatoes, 15 tons cucumbers, 3 tons zuchini, others 1 ton (water melon, spinach, wheat, maize
Employment: 4 full time, 10 seasonal
Wages: Skilled (ploughing) LE 8/day rest 1-5/day
Origin labor: local

El Arish Needlework Program

Scope: almost all to Cairo
Facility: $20m^2$
Investment: LE 5,000 (Menonite donation)
Sales: about 1,700 items p.a.
Prices:

tableclothes	15-70	table runners	5-10
aprons	7	handbags	6-14.50
napkin sets	25	hot mats	1
table mats	25	dresses	25

Employment: 3
Wages: 2 x 55/month
1 per piece
Origin labor: local

Iron and Cement Supplier

Scope: 90% El Arish, 10% rest N. Sinai
Facility: $400m^2$
Investment: 50,000
Sales: 125,000 p.a.: 10,000 tons cement; 3,000 tons iron bars
Prices: cement 72/ton (cost 63 ex-Cairo)
iron bars 370/ton(cost 340 ex Cairo)
Employment: 2 full, 6 part
Wages: 2 managers - profit share
6 carriers - 50 p.t./day
Origin labor: local

Door Frame Manufacturer

Scope: N. Sinai
Facility: 500 m^2 (+ 500 for new facility)
Investment: LE 87,720
Sales: LE 162,000
Prices: door frames 50, window frames 50
Employees: 8 perm, 10 temp.
Wages: 10 @ LE 2/day - installation, annually
4 @ 150/ month - machine operators
Origin labor: 4,skilled, Delta, rest local

Hotel and restaurant

Scope: El Arish, many visitors
Facility: $335m^2$
Investment: restaurants 10,000 (initial)
hotel 7,000
Sales: capacity 30 in restaurant
4-5 rooms in hotel
Prices: LE 3-4 per meal
LE 5/day 1 room.
Employment = 7
Wages: Unskilled 15-40 per month + tips
skilled 200-400/month
Origin labor: 20% local
80% Cairo

2. Bir El Abd

Bir El Abd town's population is thought to be about 14,300. But about 5 times that number including surrounding villages.

Transport company

Scope: N. Sinai, Port Said, Ismailia, Cairo
Facility: 150m^2; 1 large truck, 1 small.
prices: LE 7/m^3; or large truck 40/day, small 15/day.
sales: above x 6 days/week.
Investment: large truck 25,000; small 6,000. additional 25% costs salaries, maintenance.
Employment: 2 drivers, 1 assistant
wages: lower 100/month, assistant 50
Origin labor: local

General contractor and distributor

Scope: Bir El Abd
Facility: 400m^2
Prices: Cement LE 50/ton (permit for 30 tons), LE 3.5/ton (permit 10 tons), wood LE 190/ton (stock LE 10,000)
Sales: LE 420,000 - government projects
200 tons cement, 30 tons iron, 100m wood, 680m^2 youth center.
Investment: 25,000
Employment: full-time5 - mainly distribution
part time 25
Wages: unskilled LE 3/day
skilled 6 / day
Origin labor: 5% local, 95% upper Egypt

Food distributor (rationed food)

Scope: Bir El Abd Markaz
Sales: 5 kilos sugar, 45 grams tea, 1% kilo rice , 8 kilo maize, 2 boxes soap, 1 kilo beans: all per family
Prices: sugar 19Pt., tea 5.5 PT, rice 5 PT, Maize 6 PT, soap 3 PT, beans 10 PT
total sales LE 280.
Employment: 2 full time
Origin labor: local
Wages: LE 15/month

Farm

Scope: sales local
Facility: 10 camels, 25 sheep, 30 goats
Investment: LE 50/sheep, LE 25/goat
Sales: sold 10 sheep this year @ LE 60
Employment: family

Warehouse

Scope: local
Facility: 450m^2 (rented), 35m^2(under construction)
Sales: LE 570 p.a. a rent space - mainly for food
Prices: 4x6m - 20/month
3x6m - 15/month
20x25 - 45/month
Investment: LE 2,500 initial
Employment: 1 owner
Origin labor: local

Poultry farm
Scope: sales within 30 dm
Facility: 4160m²
Sales: chickens; LE 3,500 p.a.
Prices: LE 1.50-1.75 /kilo
Investment: LE 5,000 (4000 chickens, of which 500 died)
Employment: 3
Wages: 2 skilled @ 75/month
1 unskilled @ 30/month
Origin labor: 2 Bir El Abd, 1 El Amid

General contractor
Scope: N. Sinai, Ismailia
Facility: constructing a government building, youth center and a school
Sales: LE % million
Investment: more than LE 1 million
Employment: full time 25
part time 50
Wages: all price rates, except guards - 20/month
Origin labor: 7 local, rest Delta and Upper Egypt.

Fruit and Vegetable Merchant
Scope: Mardez
Facility: 9m²
Investment: LE 500/month (stock)
Employment: family
Origin employment: local

3. Rabaa (in Bir El Abd markaz)
population about 1,100

Wood products
Scope: all N. Sinai, except El Arish
Facility: shop 400 m², warehouse 16m²
Sales: 3,000 door and window frames p.a.
Prices: door frames LE 42 (cost LE 40)
window frames LE 37 (cost LE 35)
Investment: LE 10,000
Employment: 2 unskilled
2 skilled
Origin laborer: 3 local, 1 Delta.

4. Negileh
Population about 1,800

Handicrafts
Scope: Just starting, hope to sell to Cairo
Facility: 32 m²
Prices: canvas embroidery 3.5 /piece cost
pyjamas 4-5, childrens clothes 5,
sheets (embroidered) 7-8,tableclothes 6-7, doenes 25.
Labor: 2 full , 15 part
Origin labor: local, some from Qantara

5. Ras Sudr
population about 4,900

Farm
Scope 2 local
Facility: 30 fed, of which 6 for vegetables
Sales: LE 60 vegetables p.a. - or rest oranges, grapes, lemons, wheat, maize
Employment: 7 family

6. Oasis of Feiran
population about 600.

Farms
Scope: local - subsistence
Facility: 5 feddans: dates, olives, grapes, vegetables, turkeys, sugar cane
Employment: 4 family, 2 employees
Wages: employees get % crop.
Origin labor: local

7. St. Catherines
Population about 2,000

Hotel
Scope: 5% are tourists from Egypt, 95% from Israel (most Americans and Europeans on Holy land tours)
Facility; 1047 m^2 (hotel), 1 fed parking
Sales: LE 60,000 gross, LE 6,000 net/per month, 8000 tourists in April - record.
Costs: LE 1000 in settlement and labor and maintenance, rent 1000 per year (fr. sovernent)
Employment: 20 for hotel, 10 for bus tours
Wages: unskilled 40/mongh and lodging

2 bus mechanic	@	150/month
4 guides	@	300/month
4 drivers	@	100-200/ month
2 manager	@	200/month
1 chef	@	200/month

Origin labor: ½% local , ½ Cairo/ Alex.

General store
Scope 2 local
Facility: store 45 m^2
warehouse 36 m^2
Sales: food, clothing, crafts: LE 2,000p.a.
Employment: 3
Origin labor: local

8. El Tor
Population about 2,000

Poultry farm
Scope: all S. Sinai
Facility: 11x500 m^2
Sales: 12,000 eggs per month, 36, 000 chickens P.A. total sales LE 15,000 p.a.
Prices: 1 kg chicken 110 PT (each chicken 1.5-1.8 kg) less 6PT.
Investment: current value LE 16,000 + building
Employment: 3 full
Wages: 7-8 per month