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SOIL SURVEY REPORT FOR ABU RAYA AREA, KAFR EL-SHEIKH GOVERNORATE

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EGYPT WATER USE AND MANAGEMENT PROJECT

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ABSTRACT

A soil characterization survey of Abu Raya was conducted with a sampling density of 1 profile per 20 *feddans*. The survey shows the soil to be mostly in the Vertisols order with some soils in the Vertic subgroup of the Entisols order. The difference between them was primarily the presence or absence of slickensides. Three soil series were identified, two of which were subdivided into saline, sodic and gypsiferous phases depending on the sodium adsorption ratio and the presence of gypsum in lower horizons. The soils as a whole show substantial salinity and sodicity, both tending to increase with depth.

The text includes maps of soil showing salinity and SAR, plus tables of chemical and physical properties.

56 Pages, 4 Tables, 6 Figures

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مستخلـــــــــص

تم القيام بحصر لخواص الأرض فى منطقة أبو رية بمحافظة كفر الشيخ وذلك بأخذ قطاع ممثل لكل ٢٠ فدانا . وقد اظهر الحصر أن الأرض عامـــــة تنتمى الى رتبة الفيرتيسولز مع وجود بعض أراضى فى تحت مجموعة الفيرتيك فى رتبة الأنتيسولز . كان الخلاف بين هذة الاراضى هو أساسا وجود أو غيـاب الجوانب المنزلقة . تم تعريف ثلاثة سلاسل اثنان منهما تم تقسيمهما الـى حالات ملحية وصودية وجبسية بناء على نسبة الصوديوم المدمص ووجود الجبس فى الآفاق السفلى . أظهرت الأراضى ملوحة وصودية جوهرية تميلان للزيـادة بالعمـــــق .

يحتوى التقرير على خرائط للأرض توضح الملوحة ونسبة الصوديوم المدمص بالاضافة الى جداول التحليلات الطبيعية والكيماوية .

٥٦ صفـــة ، ٤ جداول ، ٦ أشكال

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I. Introduction

The Abu Raya pilot area is one of the three areas selected for conducting the Water Use and Management studies in the Nile Valley and Delta. It lies in the north central part of the Nile Delta in Kafr El-Sheikh Governorate and consists of about 2000 *feddans*. The soils are typical of the Lower Delta soils.

The area was surveyed in detail at a scale of 1:2500. The morphological features of the profile were carefully described using the system outlined in the USDA Soil Survey Manual (1951). Because of the fine texture and the high content of montmorillonite in the clay, most of the soils are classified as Vertisols and the remainder as Entisols.

II. Physiographic Features of the Area

1. Location

The study area covers about 2000 *feddans* lying between the Hamoul-Riyadh road on the north and Helal canal on the south and between Drain No. 7 on the east and El-Raghama Drain on the west. The Dakalt canal crosses the area from south to north, dividing the area into two nearly equal parts. The Abu Raya village lies in the middle of the eastern half.

2. Topography

The land surface is flat and very gently sloping toward the north, and the area in general lies at the 2 m contour above sea level.

3. Geomorphology

Soils of the Abu Raya area were formed from Holocene alluvial deposits. These deposits consist essentially of dark greyish brown suspended matter consisting of biotite and other micaceous minerals. The alluvium is of considerable thickness as a consequence of the river overflowing its banks and depositing its load over thousands of years. The thickness of the deposits varies according to locality as well as to the irregularities of the surface on which they were originally laid down, and also to changes over time in the path of the river. The thickness of the Nile deposits ranges from 6 to 7 meters in Aswan-Qena to about 11 meters in the northern Delta. The average thickness in the Delta is about 10 meters.

The mineralogical composition of the Nile deposits throughout its entire thickness is comparable to the materials currently carried in suspension by the river, the deeper layers may contain slightly larger amounts of ferric oxide, alumina and calcium carbonate but smaller amounts of magnesium carbonate and organic matter (Ball, 1952).

III. Materials and Methods

1. Field Survey

The soil survey of Abu Raya was carried out using a cadastral map of scale 1:2500. A total of 101 soil profiles (pits) were examined in the area, averaging one profile per 20 *feddans* or 12 profiles per one square kilometer.

The profile characteristics were described in accordance with the USDA Soil Survey Manual (1951). These characteristics included: soil depth, sequence and thickness of horizons or layers, color, texture, structure, consistency, porosity, lime and/or gypsum accumulations, nodules or concretions, root distribution, effervescence with HCl, water table depth, etc. Water table depths are those observed at the time of the survey and they vary throughout the year as irrigation management practices change from crop to crop. The land surface features, namely topography, relief, crops and salinity or alkalinity symptoms were also described.

Soil samples were collected, from each profile, in layers till the depth of the groundwater table. A total of 287 soil samples and 9 representative groundwater table samples were collected for laboratory analysis.

The soil boundaries were drawn using both the morphological differences observed during the soil profile examination and subsequent laboratory analyses.

2. Soil Analyses

The soil samples were air-dried, crushed and passed through a 2-mm screen for analysis.

Electrical conductivity, soluble cations (Ca, Mg, Na, and K) and anions (HCO_3 and Cl) were determined in the saturation extract, using the analytical procedures mentioned in the USDA Handbook (1954).

Particle size distribution, calcium carbonate content, cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) were determined on selected samples representing different identified soils in the area using procedures outlined in USDA Handbook No. 60 (1954).

The pH, electrical conductivity, and soluble cations (Ca, Mg, Na, and K) and anions (HCO_3 and Cl) were determined in the saturation extract and in the groundwater samples. Sulphate contents in groundwater samples were estimated by subtracting the sum of the anions (HCO_3 and Cl) from the sum of the cations (Ca, Mg, Na, and K). The total soluble salts in the groundwater was calculated by summing the equivalent weights of the cations and anions.

The soil and water analyses are given in Tables A-1, A-2, and A-3.

3. Criteria for Soil Classification

The soils of the study area were classified according to the USDA Soil Taxonomy System (1975). Members of only two orders were identified in the area. These are Entisols and Vertisols.

The following is a key to the higher category classification of the orders identified in the area.

a) Order: Vertisols

Vertisols derive their name from the Latin word Verto which means "to turn" or "to invert". These soils are characterized by the tendency to show deep vertical cracking in which soil particles fall in the cracks and cause substantial soil movement, i.e. inverting. Vertisols are defined as soils that have 35 percent or more clay in all horizons to a depth of 50 cm or more. They are also characterized by having, at certain periods of the year, cracks that are open to the surface or to the base of a plow layer or surface crust; these cracks are at least 1 cm wide at a depth of 50 cm unless the soil is irrigated. One or more of the following might be presented:

- Gilgai;
- Slickensides at some depth between 25 cm and 1 m that are close enough to intersect or;
- Wedge shaped structural aggregates at some depth between

25 cm and 1 m, whose long axes are tilted 10° to 60° from the horizontal.

Suborder: Torrerts: It includes Vertisols that, unless irrigated, have in most years cracks that either remain open throughout the year or are closed for less than 60 consecutive days at a period when the soil temperature at a depth of 50 cm is continuously higher than 8°C;

Subgroup: Typic Torrerts: These are Torrerts that:

i. Have a moist color value of 4 or more in the surface horizon in more than half of each pedon, or if the upper horizon that has a color value (moist) less than 4, is less than 30 cm thick, and
ii. Do not have prismatic or blocky structure accompanied by clay skin on ped faces. These faces have a color value lower than that in the matrix within 1 m of the soil surface.

b) Order: Entisols

This includes soils that do not have any diagnostic horizons other than ochric or an anthropic epipedon and do not have any of the following:

- A mollic epipedon;
- A salic horizon whose upper boundary is within 75 cm of the surface; or
- A calcic or petrocalcic, a gypsic or petrogypsic or duripan if the upper boundary of any of them is within 1 m of the surface, unless it is a buried horizon;

Suborder: Fluvents: It comprises Entisols that do not have a lithic or paralithic contact within 25 cm of the soil surface and that have an organic carbon content that decreases irregularly with depth or remains above a level of 0.2% to a depth of 1.25 m and decreases regularly if texture is homogeneous;

Great Group: Torrifluvents: Fluvents that have a torric moisture regime unless irrigated and are alkaline or calcareous and salty in some places;

Subgroup: Vertic Torrifluvents: These are Torrifluvents that have cracks at certain periods in most years that are 1 cm or wider at a depth of 50 cm, that are at least 30 cm long in some parts, and that extend upward to the soil surface or to the base of an A_p horizon. Unless the soils are irrigated, the cracks remain open in most years for more than 240 days cumulative, and are not closed for as many as 60 consecutive days at any season of the year.

c) Lower Category Classification:

Family Level: The basic factors of soil classification at the family level are soil texture of the control section, mineralogy, soil depth and temperature regime. Since the soils of the area are generally similar in these characteristics, only three families were identified under the two orders.

Series level: The subsoil texture was used as criteria of soil classification at the series level. Two series were identified under the Typic Torrerts subgroups of order Vertisols; namely Abu Raya clay and Sadek clay. On the other hand, only one series was identified under the Vertic Torrifluvents, namely, Hammad clay.

Phase Level: The soil series were differentiated into phases according to the following criteria:

i) Saline phase:- Including soils that have an electrical conductivity of the saturation extract of more than 8.0 mmhos/cm with or without one or more of the following: (a) an ESP value higher than 15%, (b) gypsum accumulation in the subsoil, (c) water table within 1.0 m of the surface.

ii) Sodic phase:- Including soils that have an ESP of more than 15 with or without one or both of the following: (a) gypsum accumulation in the subsoil, (b) water table within 1.0 m of the surface.

iii) Gypsiferous phase:- Including soils that have gypsum accumulation of more than 1% in the subsoil with or without a water table within 1.0 m from the surface.

iv) Higher water table phase:- Including soils in which the water table exists within 1.0 m from the surface.

IV. Classification of Soils in Abu Raya Area

The soils of the area are in the Nile Delta and are of recent alluvial origin. Therefore, they do not show appreciable development of diagnostic horizons. Howe~~ver, b~~ecause of its location near the lower end of the Delta, alluvium in Abu Raya area has more clay than the upper valley soils.

The high clay content and its dominantly montmorillonitic nature cause the soils to swell upon wetting, and to develop wide, deep cracks upon drying. In many parts, the soil is characterized by the presence of the shiny, polished and grooved surfaces, known as slickensides, which are produced by the slidings of a soil mass apart as a result of the swelling and shrinkage of the soil. The soils of the area include members of only two orders, namely Vertisols and Entisols. Representative soil profiles are described in Appendix Table A-4.

1. Order: Vertisols

Soils of the Vertisols order cover the major part of the study area. Two soil series of Vertisols were mapped in the area, namely Abu Raya Clay and Sadek Clay. The descriptions of those two soil series are given below:

a) Abu Raya Clay Series

Classification

Family: Clayey, montmorillonitic, slightly calcareous, deep, level, hyperthermic

Subgroup: Typic Torrerts

Order: Vertisols

Description: This series covers the major part of the study area (Figure A-1). The normal phase of the series is dark-colored (very dark greyish brown) and heavy textured throughout the control section.

The influence of the dominantly montmorillonitic nature of the clay fraction on the soil characteristics is quite evident.

The soil is very hard when dry, very sticky when wet and very plastic when moist.

The soil water holding capacity is very high and its permeability is low. The soil swells upon wetting and develops deep wide cracks upon drying. There are no distinctive horizons in the soil profile other than the presence of the slickensides in the subsoil. The presence of wide deep cracks and slickensides is characteristic of Vertisols.

The soil salinity of the surface soil was generally low as characterized by the conductivity of the saturation extract. It rarely exceeded 4 mmhos/cm and was well below 8 mmhos/cm in all samples. The lime content was less than 3% and the pH of the saturation extract generally between 7.8 and 8.4. The exchangeable sodium percentage (ESP) was well below 15 in the surface soil.

The high cation exchange capacities are typical of Vertisols which are characteristically high in montmorillonite clay.

The gypsiferous phase of the series covers a much smaller area than the normal phase and differs from it only in having crystalline gypsum accumulation in the subsoil. The gypsum content of the subsoil varies from less than 1% to slightly more than 2.5%.

The high water table phase: This phase covers the area represented by profiles 27, 31, 62 and 71. It differs from the normal phase only in that it had a water table at a depth of less than 1 m at the time of sampling and by the presence of gypsum accumulation in the subsoil within the zone of water table fluctuation.

The sodic phase: This phase covers only a small part of the study area and is represented by profiles 13, 18, 19, 20 and 51. It differs from the normal phase of Abu Raya Series in having an ESP in the surface higher than 15.

b) Sadek Clay Series

Classification

Family: Fine loamy, mixed, slightly calcareous, deep, level, hyperthermic.

Subgroup: Typic Torrerts

Order: Vertisols

Description: The Sadek clay series covers only a small part of the study area (Figure A-1). It is represented by profiles 32, 33, 38, 43 and 44.

The major difference that distinguishes the Sadek series from the Abu Raya one is the presence of a fine loamy layer immediately below the clay-textured surface horizon or the plow layer. Thus, the soil does not develop the wide and deep cracks characteristic of the Abu Raya Series. However, the deeper part of the control section has a clay texture similar to, or heavier than, that of the surface layer.

The soil is dark-colored (dark to very dark grey) and has a sticky consistency when wet, plastic when moist and hard when dry. Permeability to water is low.

2. Order: Entisols

Soils of the Entisols order cover only a small part of the survey area. Only one soil series of Entisols was mapped in the area, namely Hammad clay. The following is a description of that soil series:

a) Hammad Clay Series

Classification:

Family: Clayey, montmorillonitic, slightly calcareous, deep, level, hyperthermic

Subgroup: Vertic Torrifluvents

Order: Entisols

Description: The Hammad clay series is the second most dominant soil in the area. It differs from Abu Raya series only in the absence of slickensides. The normal phase of this soil series has a deep, uniform profile with no clear diagnostic horizons other than occasional stratification.

It is dark-colored (dark brown to very dark greyish brown) and has a clay to heavy clay texture (clay content ranges from 42% to 72%), blocky structure, and a low to very low permeability.

The soil salinity of the normal phase is low, the conductivity of the saturation extract being less than 4 mmhos/cm in most samples and slightly more than 7 mmhos/cm in only one sample. The soil salinity in general increases slightly at the lower depths of the soil profile.

The Gypsiferous Phase: The gypsiferous phase of the Hammad series covers only an area represented by profiles 63 and 82. It differs from the normal phase only in the presence of gypsum accumulation in the subsoil.

The Saline Phase: The area is typically represented by profiles 35 and 66 and has surface soil salinity greater than 8 mmhos/cm. It is, for this reason, separated from the normal phase of the Hammad series and classified as a saline phase of this series.

A barren part of the Abu Raya area, represented by profile 85, is characterized by the presence of a salic horizon. The electrical conductivity of the saturation extract is 86.5 mmhos/cm at the surface soil and decreases to 51.0 mmhos/cm at the lower depths. This soil is classified as typic salorthids (order Aridisols), but because of its small areal extent, it is mapped in association with the saline phase of Hammad clay soil series.

SUMMARY

Three soil series in the study area were described. They tend to be generally similar in major characteristics such as soil depth, texture, color, calcium carbonate content, cation exchange capacity and water holding capacity. Differences within series (phases) were based on salinity, sodicity, water table depth and the presence of gypsum accumulations in the subsoil.

The extent, location and distribution of the soils identified are shown in Figure A-1. This map was reproduced from the base soil survey map - scale 1:10,000. Interpretive maps of selected soils and soil related characteristics for salinity, sodium adsorption ratio and depth to water table are shown in Figures A-2 through A-6.

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APPENDIX

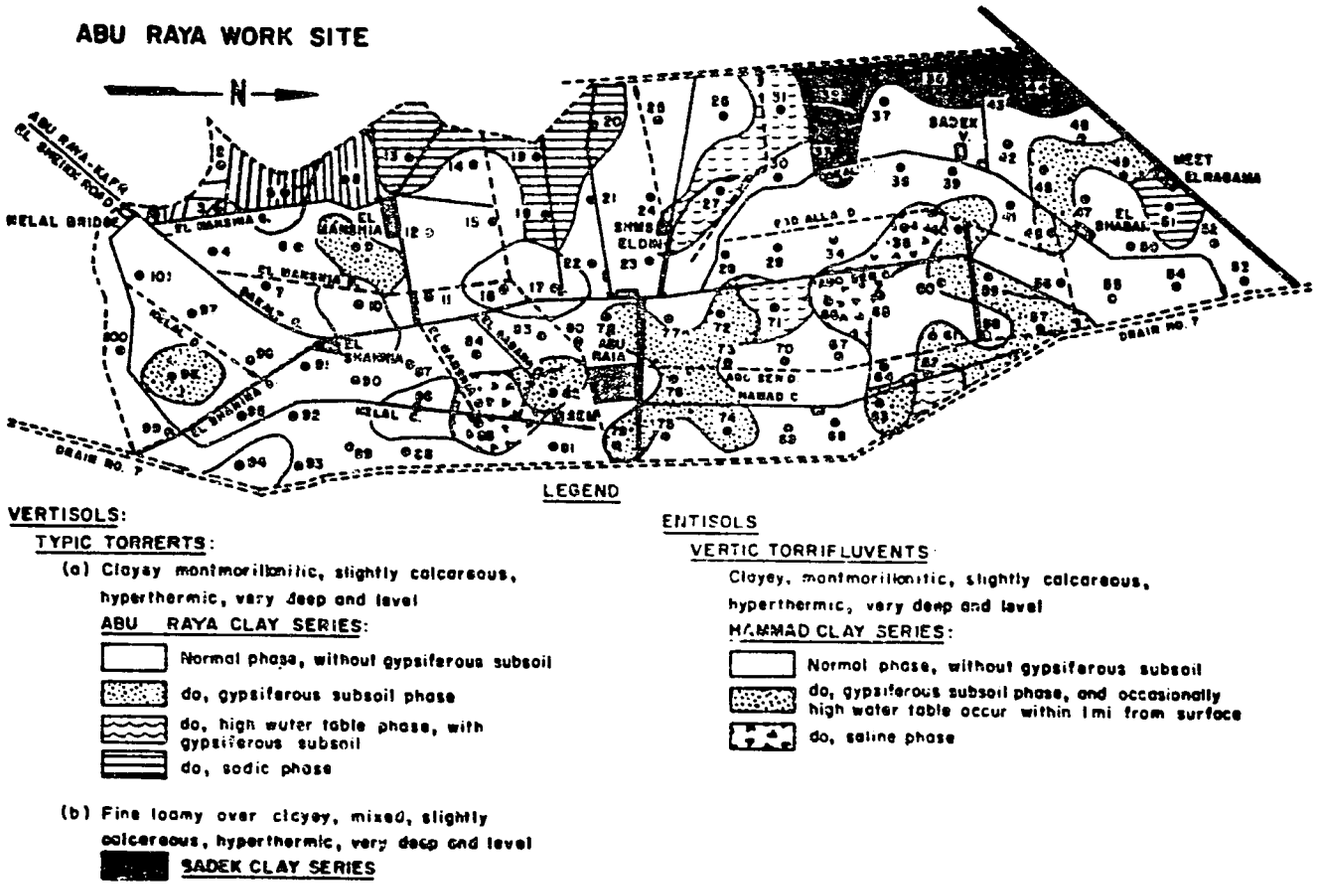

Figure A-1. Soil Map and Profile Locations for Abu Raya, Kafr El-Sheikh, Egypt.

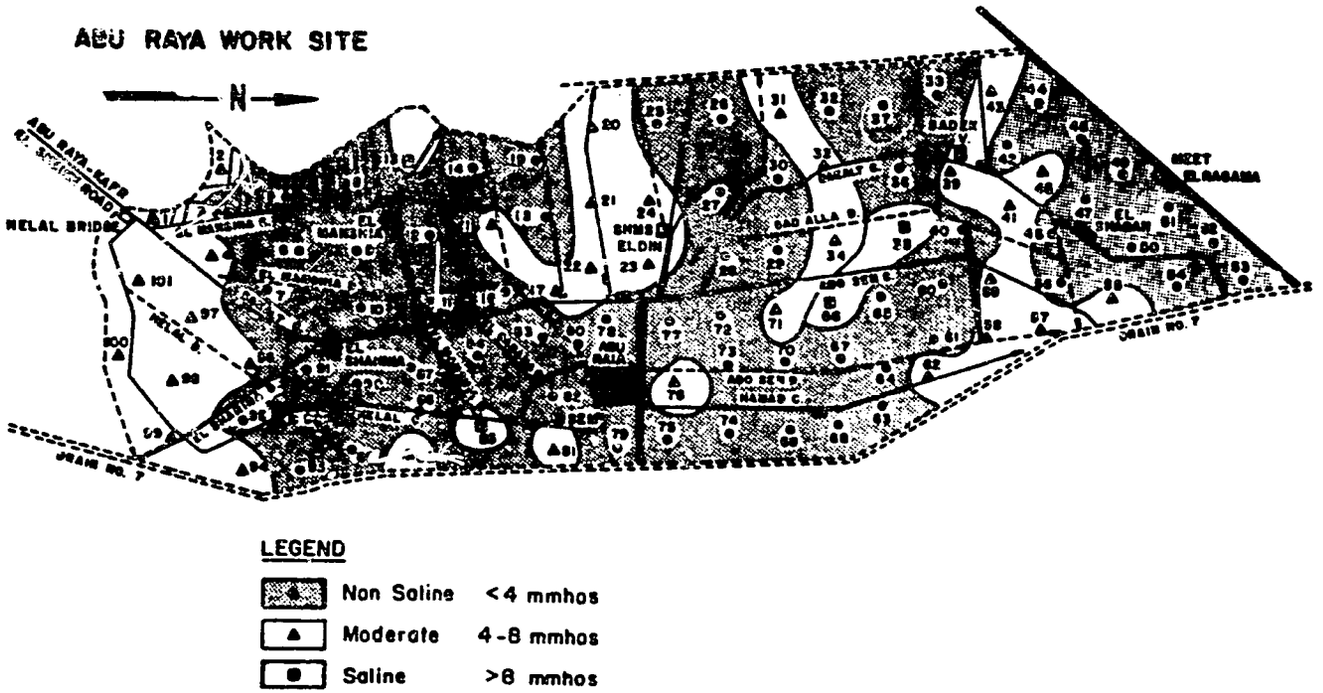

Figure A-2. Soil Salinity (EC) Map of 0-25 cm Depth of Abu Raya, Kafr El Sheikh, Egypt.

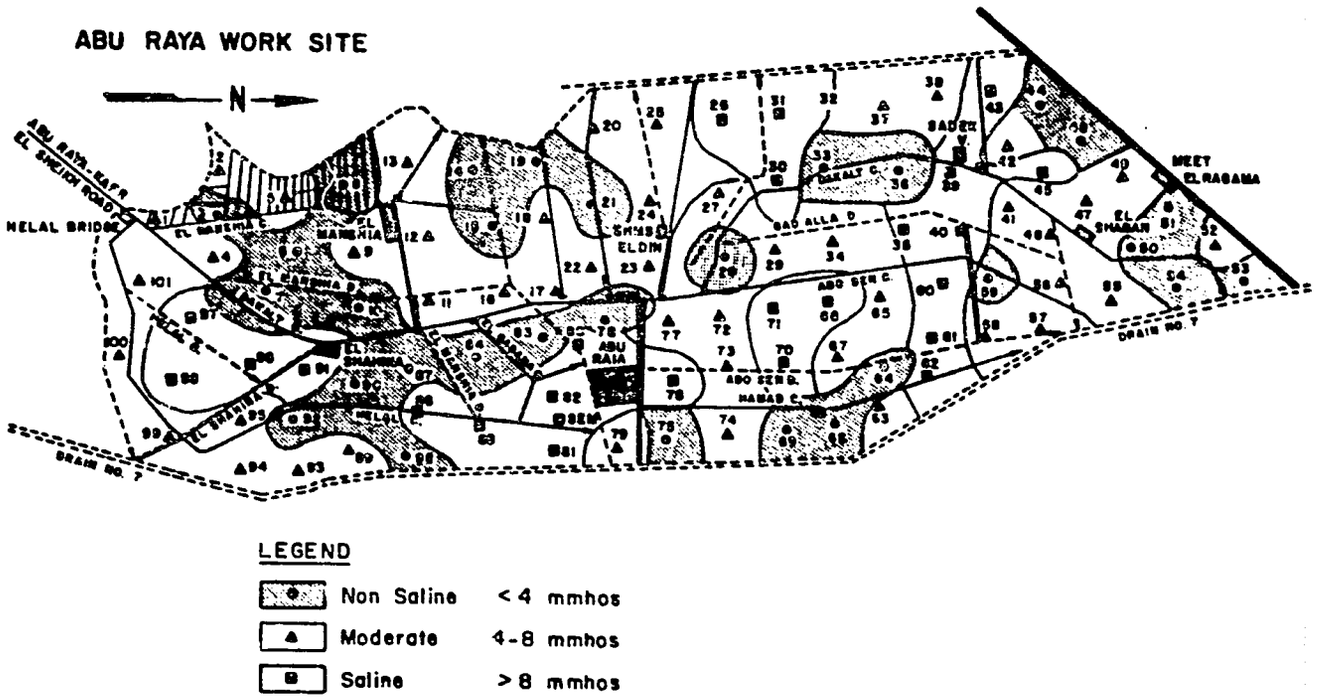

Figure A-3. Soil Salinity (EC) Map for Greater than 25 cm Depth of Abu Raya, Kafr El Sheikh, Egypt.

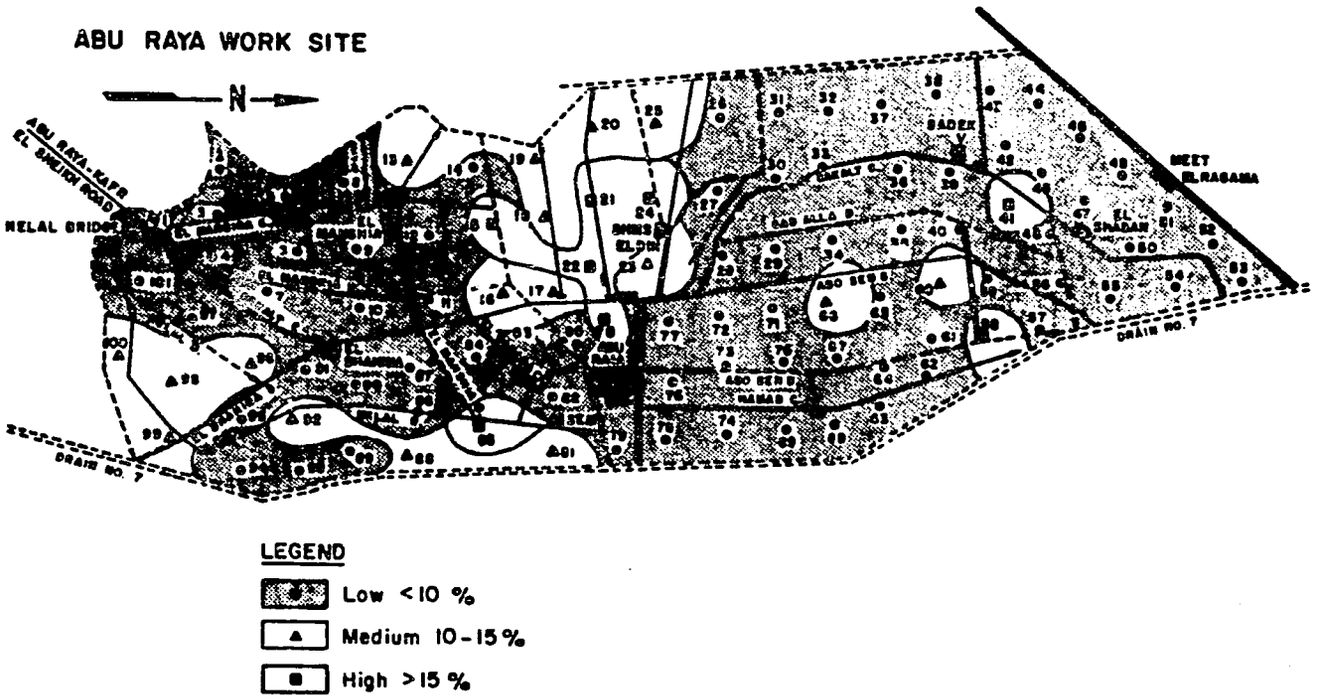

Figure A-4. Sodium Absorption Ratio (SAR) for 0-25 cm Depth of Abu Raya, Kafr El Sheikh, Egypt.

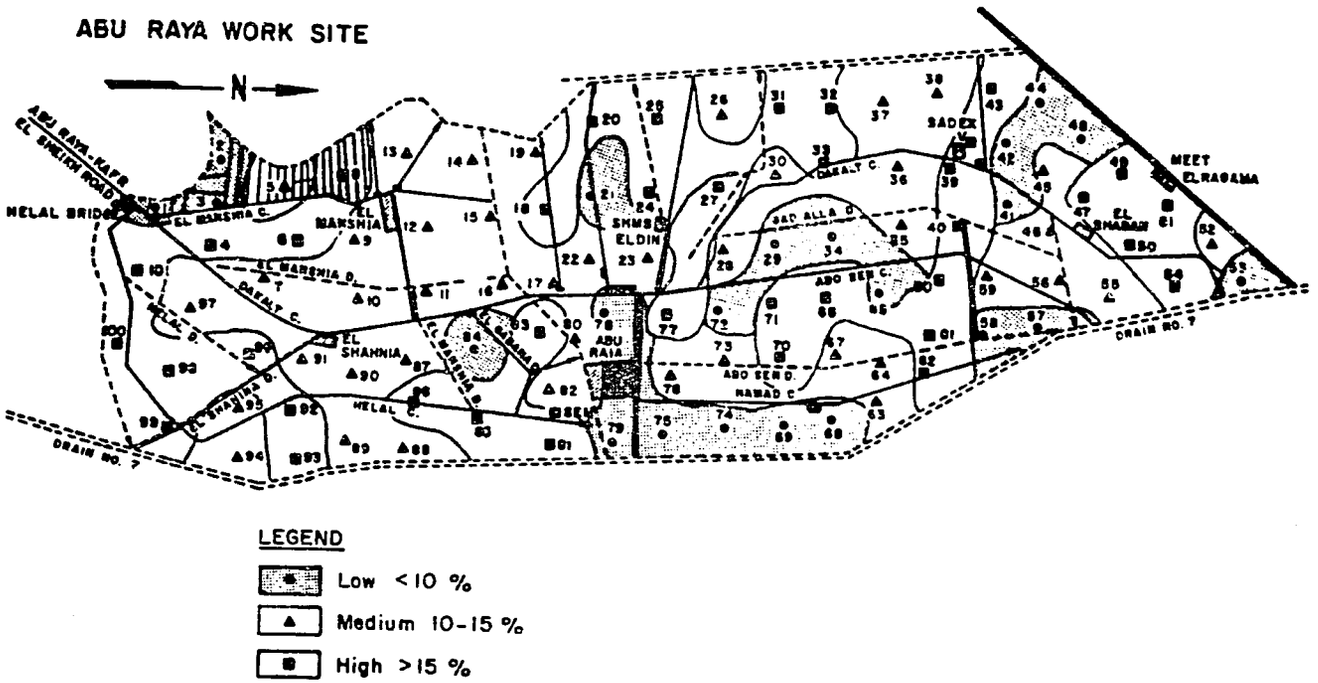

Figure A-5. Sodium Absorption Ratio (SAR) for Greater than 25 cm Depth of Abu Raya, Kafr El Sheikh, Egypt.

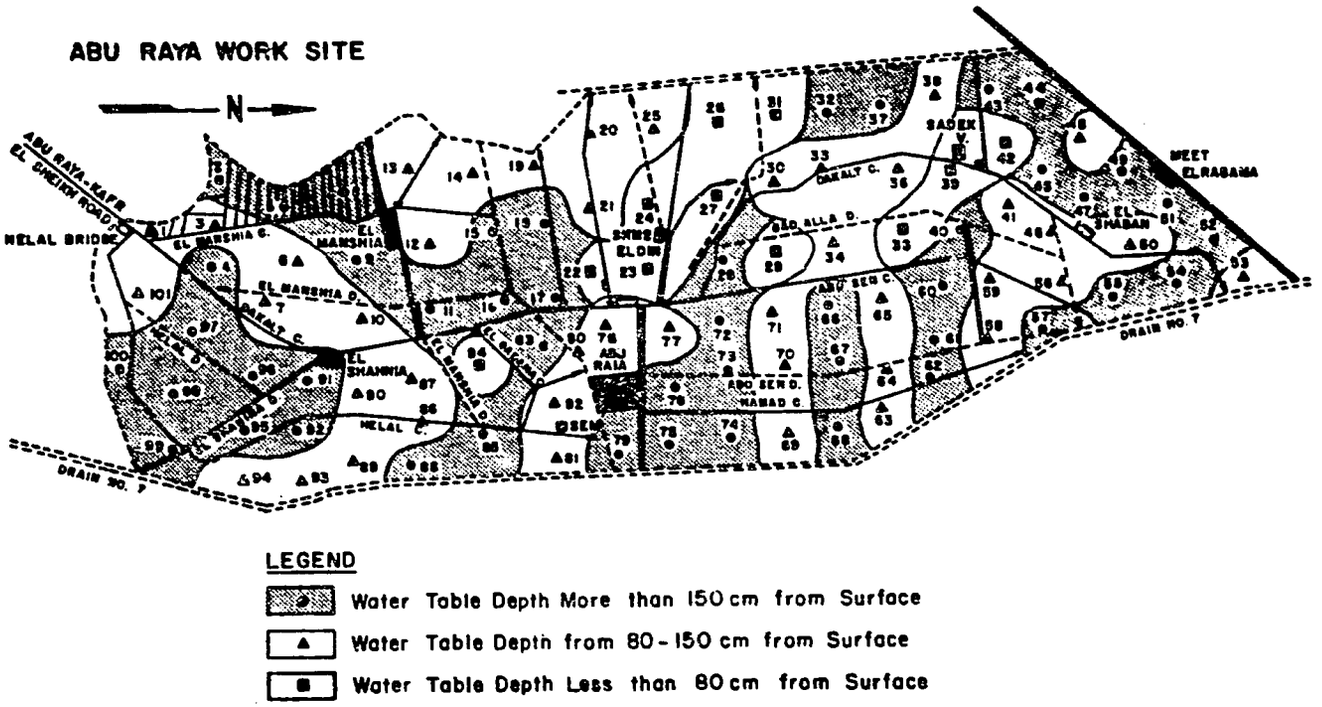

Figure A-6. Water Table Depth at Time of Sampling for Abu Raya, Kafr El Sheikh, Egypt.

Profile No.	Depth cm	Clay %	Silt %	F Sand* %	C Sand* %	TSS %	$CaCO_3$ %
1	0-25	45.0	32.0	20.5	0.5	0.3	1.8
	25-60	56.7	22.8	18.7	0.2	0.2	1.2
	60-100	59.9	25.6	13.1	0.13	0.5	1.2
2	0-20	69.1	15.5	14.4	0.2	0.3	0.7
	20-50	63.1	17.2	17.4	0.5	0.4	1.8
	50-150	72.0	18.0	7.3	1.1	0.9	0.7
4	0-20	56.5	20.4	20.9	0.5	0.2	1.4
	20-70	64.7	15.0	18.7	0.6	0.5	1.6
	70-150	60.0	14.5	22.8	0.5	0.3	1.9
8	0-20	60.5	16.5	20.4	0.5	0.2	1.9
	20-70	61.3	13.9	21.5	0.3	0.2	1.9
	70-150	40.6	10.4	47.8	0.2	0.3	0.8
9	0-20	66.4	11.7	18.7	0.5	0.1	2.4
	20-60	66.6	9.3	22.0	0.4	0.4	1.4
	60-150	48.6	11.6	37.0	0.4	0.3	1.3
10	0-25	56.7	16.1	26.4	0.2	0.1	0.6
	25-80	50.1	20.1	28.5	0.6	0.2	0.5
	80-100	33.2	25.4	37.3	0.8	0.2	3.1
20	0-30	60.0	8.6	27.8	0.4	0.2	1.9
	30-80	47.6	24.3	26.7	0.3	0.3	0.7
30	0-50	61.2	13.6	22.0	0.3	0.2	2.6
	80-100	53.1	19.8	24.5	0.3	0.5	2.3
33	0-30	47.5	32.5	27.4	0.1	0.2	2.1
	30-80	27.0	33.7	38.4	0.1	0.2	0.5
	80-140	49.0	21.8	28.2	0.2	0.3	0.4
35	0-25	58.0	12.0	27.1	0.7	0.5	1.3
	25-55	35.4	15.4	45.3	0.1	0.5	0.9
	55-80	44.5	30.5	20.5	0.9	0.9	1.0

* F sand - fine sand; C sand - coarse sand, TSS - total soluble solids

Table A-1. Particle Size Distribution of Selected Soil Profiles, Abu Raya Area

Profile No.	Depth cm	Clay %	Silt %	F Sand %	C Sand %	TSS %	$CaCO_3$ %
37	0-15	45.9	18.8	31.6	0.4	0.3	3.0
	15-50	42.7	25.6	28.3	0.3	0.3	2.8
	50-150	46.8	19.2	32.8	0.2	0.6	0.4
40	0-20	47.7	17.4	31.9	0.3	0.3	2.4
	20-70	40.0	29.5	26.3	0.2	0.5	1.1
	70-150	40.0	49.5	5.4	1.14	1.4	0.3
43	0-20	44.1	21.5	32.6	0.5	0.4	0.9
	20-60	34.9	24.3	40.2	0.2	0.5	0.1
	60-150	50.5	26.1	21.8	0.5	0.9	0.3
44	0-20	41.3	19.9	18.2	0.3	0.3	0.9
	20-70	34.4	20.7	43.2	0.1	0.2	1.5
	70-150	47.4	33.1	16.8	0.2	0.4	1.3
51	0-25	52.5	21.0	22.7	0.7	0.3	2.8
	25-60	40.8	27.8	29.3	1.1	0.3	0.5
	60-150	41.5	31.4	21.9	0.2	0.4	1.2
54	0-20	45.8	19.5	32.7	0.1	0.4	1.6
	20-65	44.6	29.3	24.1	0.5	0.3	1.3
	65-150	49.2	22.7	27.1	0.1	0.4	0.5
58	0-25	53.4	7.1	37.7	0.1	0.5	1.5
	25-65	42.4	21.8	35.3	0.1	0.3	0.3
	65-100	40.4	20.9	36.6	0.7	0.4	1.2
72	0-30	51.0	27.1	20.7	1.0	4.0	0.2
	30-65	51.6	24.7	22.9	1.5	3.5	0.3
	65-150	51.7	23.9	22.4	1.9	3.1	0.1
75	0-30	54.9	20.0	24.1	1.0	4.4	0.1
	70-150	52.2	21.1	24.5	2.1	4.2	0.2
77	0-30	51.5	24.6	22.3	1.5	4.5	0.2
	30-80	55.8	22.9	20.2	0.9	3.8	0.3
	80-150	49.6	28.7	20.5	0.8	2.7	0.5

Table A-1 Continued

Profile No.	Depth cm	Clay %	Silt %	F Sand %	C Sand %	TSS %	$CaCO_3$ %
82	0-20	54.9	15.6	28.3	1.3	4.0	0.1
	20-60	47.1	20.0	22.2	0.1	4.5	0.1
	60-110	20.7	12.7	66.5	0.1	0.3	0.1
	110-125	29.5	19.8	50.4	0.2	1.9	0.1
	125-150	48.6	27.4	22.2	1.8	3.4	0.1
84	0-20	54.5	29.1	24.9	1.3	4.5	0.2
	20-100	60.5	21.3	16.2	0.5	3.4	0.5
	100-150	60.9	18.7	18.8	1.1	3.9	0.6
87	0-30	50.1	20.7	28.5	0.6	4.0	0.1
	30-90	42.7	25.4	31.3	0.5	3.1	0.1

Table A-1. Continued

Profile No.	Depth cm	pH*	SP**	EC† mmhos/cm	Composition of the Saturation Extract meq/l						SAR†	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
1	0-25	7.8	75.5	5.6	21.9	21.8	26.0	0.5	3.6	20.0	5.6	44.5	9.5	
	25-60	7.8	84.0	3.8	7.3	7.4	23.0	0.3	3.0	29.0	8.5	49.5	12.9	
	60-100	7.9	97.5	5.3	8.3	16.9	34.0	0.5	2.2	54.0	9.8	51.0	15.4	
2	0-20	7.7	62.0	5.9	22.9	20.8	16.0	0.3	1.5	56.0	3.4	48.0	9.1	
	20-50	7.8	75	6.3	17.7	21.1	35.0	0.3	1.5	63.0	7.9	48.0	13.7	
	50-150	7.7	74	11.7	46.8	36.6	61.0	0.3	1.5	129.0	9.4	50.0	17.4	0.6
3	0-20	8.0	81.5	1.9	5.2	3.5	10.0	0.2	2.5	13.0	4.8			0.0
	20-60	7.9	90	3.5	5.7	5.0	25.0	0.1	2.5	30.0	5.2			
	60-130	8.0	102	2.4	3.6	2.2	17.5	0.1	2.5	12.0	10.3			
4	0-20	7.7	77.5	4.1	10.4	14.8	19.0	0.3	3.0	30.0	5.4	45.0	12.2	
	20-70	7.6	98	7.8	6.8	15.4	63.0	0.3	1.5	86.0	18.9	59.0	28.4	
	70-150	8.1	90	5.7	12.0	13.3	44.5	0.3	1.5	42.0	12.5	44.5	22.4	
5	0-20	7.8	75.5	2.5	7.3	5.3	13.0	0.3	3.0	15.0	5.2			
	20-70	7.8	84	3.0	9.9	8.6	13.0	0.3	2.5	24.0	4.3			
	70-150	7.8	98	6.9	11.5	12.8	56.0	0.3	2.0	64.0	16.1			

* pH of the saturation paste
** Saturation percentage
† Of the saturation extract

Table A-2. Chemical Characteristics of Soil Profiles Sampled in Abu Raya Area.

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
7	0-20	7.8	89	1.7	3.1	3.2	10	0.2	3.7	5.0	5.6			
	20-60	8.2	86	1.6	1.0	0.9	14	0.1	3.6	4.0	8.1			
	60-120	8.0	102	1.9	1.6	0.9	15	0.1	3.7	6.0	12.8			
8	0-20	7.9	90	2.0	2.6	2.3	15	0.2	3.4	7.0	9.6	43.0	11.6	
	20-70	8.0	107	2.6	1.6	1.4	25	0.2	3.1	13.0	20.8	51.0	22.1	
	70-150	7.8	114	3.8	2.1	1.8	34	0.2	2.4	25.0	24.3	54.5	33.2	
9	0-20	8.2	113	1.4	4.2	3.6	6.3	0.3	2.2	5.0	3.2	56.0	6.6	
	20-60	8.3	98	5.9	19.7	16.2	33	0.3	2.5	11.0	7.8	41.0	15.6	1.9
	60-150	8.2	114	4.8	6.2	7.3	44	0.3	1.8	32.0	16.9	45.0	17.6	
10	0-25	8.4	98	2.8	6.2	3.4	17.5	0.4	1.6	22.0	7.6	44.0	9.2	
	25-80	7.8	114	2.1	3.6	5.5	13.2	0.2	2.0	14.0	6.2	52.0	13.2	
	80-100	8.4	53	3.3	3.1	2.7	27.8	0.2	3.0	24.0	16.2	48.0	26.0	
11	0-20	8.1	88	2.5	8.3	8.2	16.0	0.3	3.0	10.0	3.5			
	20-70	8.4	90	1.7	3.1	2.7	14.5	0.2	3.0	11.0	8.5			
	70-150	8.1	100	7.8	12.5	10.8	56.5	0.3	2.0	70.0	16.6			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/L Ca	Mg	Na	K	HCO_3	Cl	SAR	CEC	ESP	Gypsum %
12	0-15	8.2	91	3.5	10.4	5.6	19.0	0.4	2.0	22.0	6.7			
	15-70	8.2	96	3.7	7.3	11.2	18.5	0.2	1.5	36.0	6.1			
	70-130	8.0	70	8.8	9.4	13.9	68.5	0.3	2.0	86.0	20.1			
13	0-30	8.0	90	9.9	13.5	36.9	60.0	0.5	3.5	100.0	11.9		24.0	4.0
	30-65	8.1	97	7.9	9.4	20.2	52.5	0.4	2.5	80.0	13.6			
14	0-20	8.3	102	2.5	7.3	8.2	11.0	0.3	3.0	17.0	4.0			
	20-60	8.1	106	4.1	7.3	4.9	32.0	0.3	2.5	24.0	10.3			
15	0-30	8.2	95	5.2	6.3	2.0	47.5	0.2	2.5	46.0	23.3		6.0	
	30-70	8.3	92	4.8	4.2	6.0	40.0	0.2	2.0	37.0	17.7			
	70-150	8.1	96	2.8	9.4	5.7	16.0	0.3	2.5	18.0	5.8			
16	0-30	7.7	109	3.4	3.1	6.5	28.0	0.2	3.2	15.0	12.7		10.0	
	30-80	7.6	108	8.2	20.8	19.0	60.0	0.3	2.1	46.0	13.5			
	80-150	7.8	109	3.2	7.3	6.8	19.0	0.2	2.4	23.0	7.2			0.6

Table A-2. Continued

Profile No.	Depth cm	pH	SP	EC mmhos cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
17	0-20	7.8	88	4.7	7.3	6.3	36.0	0.2	1.5	44.0	13.8		7.3	
	20-70	8.2	102	8.1	12.5	16.6	60.0	0.2	1.5	78.0	15.7			
	70-150	8.2	106	2.3	5.7	4.0	16.0	0.3	4.0	13.0	7.3			0.4
18	0-30	8.1	104	3.4	5.2	2.6	29.0	0.2	3.0	28.0	14.7		18.0	
	30-80	8.1	112	7.2	11.5	8.9	56.0	0.2	2.0	67.0	17.5			
19	0-20	8.0	112	1.9	2.1	1.8	17.0	0.1	3.8	10.0	12.2		27.0	4.0
	20-70	7.9	115	1.7	5.2	2.6	10.0	0.2	3.6	8.4	5.1			
	70-150	7.9	112	3.1	3.1	1.3	30.0	0.2	3.4	20.0	14.3			
20	0-30	8.0	116	4.1	5.3	5.4	45.0	0.2	3.5	34.0	13.4	52.0	19.6	4.5
	30-80	7.8	126	5.3	4.7	4.1	45.0	0.2	2.4	50.0	21.6	44.0	27.6	
	80-100	7.8	114	7.2	4.6	7.3	67.0	0.4	4.0	58.0	27.5			
21	0-30	7.4	106	6.0	5.2	7.4	47.0	0.4	2.3	47.0	18.7		7.2	
	30-70	7.6	115	3.4	6.8	7.2	17.0	0.3	2.7	16.0	5.9			

Table A-2. Continued

Profile No.	Depth cm	pH	SP	EC µmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
22	0-20	7.8	117	4.6	6.2	5.4	38.0	0.4	2.2	35.0	15.7		9.0	
	20-70	8.0	106	7.1	22.9	20.8	48.0	0.6	2.7	53.0	10.3			0.3
23	0-20	7.7	104	4.5	8.3	7.2	33.0	0.3	2.4	24.0	11.9		8.0	
	20-80	7.5	103	5.5	14.6	8.7	35.0	0.5	2.2	31.0	10.3			
24	0-20	8.2	108	6.6	6.6	9.4	57.0	0.4	2.5	42.0	20.1		14.0	
	20-50	8.0	115	4.3	6.2	5.4	38.0	0.3	2.7	34.0	15.7			
25	0-30	7.9	102	3.6	8.4	5.2	30.0	0.3	3.6	25.0	11.5			
	30-60	7.9	112	5.4	6.2	4.5	46.0	0.2	3.0	43.0	19.9			
	60-120	7.7	103	5.7	6.3	2.1	54.0	0.2	3.5	49.0	26.5			
26	0-20	7.8	100	3.2	13.5	9.8	14.0	0.3	3.2	16.0	4.1			
	20-70	8.3	98	8.1	30.6	21.9	52.0	0.4	2.0	34.0	10.2			
27	0-20	7.6	92	3.4	8.9	14.5	16.0	0.3	3.0	18.0	4.7			
	20-50	7.5	105	7.5	26.0	16.7	54.0	0.4	2.4	42.0	11.7			1.5
	50-80	7.7	115	6.7	6.8	10.7	56.0	0.3	1.8	58.0	18.9			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
28	0-15	8.0	104	2.2	5.3	8.3	8.0	0.4	2.6	9.0	3.1			
	15-80	8.3	114	1.9	4.7	2.1	12.0	0.2	3.2	5.0	6.5			
	70-150	8.4	111	1.9	1.0	1.4	17.5	0.1	2.0	11.0	16.0			
29	0-25	7.7	91	3.5	7.6	13.1	18.0	0.6	2.5	12.0	5.6			
	25-80	7.8	107	4.8	9.4	17.6	28.3	0.5	1.0	14.0	7.7			
30	0-50	7.4	99	2.4	3.7	4.1	16.0	0.2	3.5	18.0	8.1	48.0	13.4	
	80-100	7.4	84	8.1	26.0	26.5	52.0	0.4	1.6	43.0	10.3	45.5	19.5	
31	0-20	7.8	86	4.7	14.6	13.6	28.0	0.6	1.5	30.0	7.5			
	20-45	7.8	86	4.1	8.3	13.0	22.3	0.2	2.0	29.0	6.8			
	45-80	7.8	82	9.0	9.4	16.4	75.7	0.3	1.0	90.0	21.1			1.6
33	0-30	7.9	73	4.0	9.9	11.5	22.0	0.4	2.0	36.0	6.7	41.0	14.1	
	30-80	8.0	55	3.6	2.6	4.2	31.8	0.1	1.0	26.0	17.2	33.0	21.5	
	80-140	8.3	112	2.7	1.0	0.9	26.8	0.1	1.0	18.0	27.2	43.5	39.0	

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
34	0-20	7.8	86	7.0	20.8	31.6	36.0	0.5	1.5	28.0	7.0			
	20-50	7.9	100	7.1	19.8	39.9	37.3	0.6	1.5	30.0	6.8			
	50-90	7.9	100	8.0	18.7	37.6	58.5	0.6	1.0	48.0	11.0			
35	0-25	7.6	89	9.3	29.8	36.0	41.5	1.2	2.2	52.0	7.2	42.5	14.0	
	25-55	7.7	92	8.4	24.9	34.2	52.2	0.7	1.5	50.0	9.6	40.0	19.5	
	55-80	7.6	94	9.4	28.1	31.1	69.5	0.8	1.4	75.0	12.8	41.0	25.0	1.5
36	0-20	8.0	100	1.2	2.1	2.8	7.0	0.3	2.0	5.0	4.5			
	20-60	8.4	107	1.9	1.1	1.9	16.0	0.2	1.2	9.0	13.3			
	60-100	8.5	81	1.1	1.1	0.9	9.5	0.1	2.0	3.0	9.7			
37	0-15	7.9	85	2.9	5.2	10.3	16.0	0.3	1.5	15.0	5.7	41.0	12.1	
	15-50	8.0	89	4.6	6.2	16.6	33.8	0.4	1.0	23.0	10.0	38.0	17.3	
	50-150	7.8	78	8.1	16.7	17.8	53.0	0.5	2.8	35.0	12.8	41.0	26.1	
38	0-30	8.1	88	3.6	12.5	7.9	15.5	0.4	3.0	21.0	4.9			
	30-50	8.1	55	4.9	6.3	15.1	30.0	0.2	2.9	27.0	9.2			
	50-150	8.2	85	4.4	4.2	8.5	32.0	0.2	2.5	25.0	12.7			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
39	0-25	7.9	88	7.7	20.1	18.6	35.0	0.5	1.6	33.0	8.0			
	25-80	8.2	107	8.4	12.3	15.0	59.0	0.4	1.5	61.0	15.8			0.4
40	0-20	8.1	100	3.4	10.4	10.5	18.5	0.3	1.7	20.0	5.7	44.5	8.9	
	20-70	8.0	92	8.7	27.1	32.1	55.5	0.8	2.1	45.0	10.2	41.0	18.2	2.5
	70-150	7.9	84	19.2	33.3	50.2	150.0	0.6	1.5	157.0	23.2	39.5	22.2	1.1
41	0-20	8.2	125	5.8	5.2	5.5	50.0	0.2	1.6	49.0	21.6			
	20-60	7.8	96	4.9	15.6	24.5	20.0	0.8	2.6	16.0	4.5			0.25
	60-120	7.9	93	8.1	18.7	35.4	52.0	0.7	2.0	25.0	10.0			
42	0-20	7.9	94	2.5	8.3	6.3	11.0	0.4	2.8	7.0	4.1			
	20-70	8.0	93	6.3	18.7	30.8	31.0	0.4	2.6	21.0	6.2			
43	0-20	7.7	67.0	6.0	17.7	16.3	29.0	0.4	2.6	55.0	7.0	34.0	15.0	
	20-60	7.7	55.0	7.8	15.6	19.4	54.0	0.3	2.0	85.0	12.9	29.5	20.3	
	60-150	7.9	93.5	10.2	7.3	14.1	94.0	0.4	1.8	101.0	28.7	46.0	26.7	

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l Ca	Mg	Na	K	HCO_3	Cl	SAR	CEC	ESP	Gypsum %
44	0-20	7.7	81.0	2.2	4.2	6.4	10.0	0.4	3.0	9.0	4.3	46.0	10.0	
	20-70	8.0	50	1.9	5.7	1.1	12.0	0.2	2.8	10.0	6.5	42.5	14.3	
	70-150	7.8	82	5.2	18.7	15.2	31.0	0.5	2.2	6.0	7.5	46.0	13.2	0.5
45	0-20	7.9	95.0	6.6	12.5	13.4	36.0	0.5	3.0	47.0	8.5			
	20-50	7.9	86.5	12.0	24.9	41.9	92.0	0.9	2.0	64.0	15.6			
	50-150	7.8	95.0	7.5	14.6	18.4	55.0	0.6	2.0	51.0	13.5			2.7
46	0-20	7.6	94	2.1	5.2	7.4	9.5	0.4	3.4	7.0	3.8			
	20-60	7.6	85	6.9	30.3	25.0	36.0	0.7	3.2	21.0	10.7			2.2
	60-90	7.7	85.9	8.4	16.7	23.5	58.0	0.7	2.0	36.0	13.0			
47	0-20	8.0	90	3.0	6.2	7.3	18.0	0.5	3.4	14.0	6.9			
	20-60	8.1	100	4.0	5.7	15.6	24.0	0.4	2.6	15.0	7.4			
	60-110	7.9	81	6.3	7.3	8.3	55.0	0.6	2.6	38.0	19.8			0.2
	110-150	8.0	60	5.5	6.2	10.3	47.0	0.5	2.2	40.1	16.4			
48	0-25	7.9	90	1.6	6.3	4.4	7.0	0.2	1.6	5.0	3.0			
	25-60	8.0	100	2.0	4.2	7.5	10.5	0.2	1.6	3.0	4.3			
	60-120	7.8	85	4.6	12.5	13.7	25.0	0.5	1.8	8.0	7.7			0.5

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
49	0-30	8.0	100	2.9	4.2	10.4	17.0	0.2	1.9	10.0	6.3			
	30-70	7.5	80	9.0	22.9	20.8	60.0	0.4	1.4	20.0	12.8			1.8
	70-150	7.8	123	3.7	1.3	2.6	32.0	0.2	2.4	10.0	22.9			
50	0-20	7.8	98.0	1.0	2.1	2.8	4.5	0.3	3.2	20.0	2.9			
	65-120	7.8	98.5	2.6	2.1	3.7	20.0	0.4	2.6	13.0	11.7			
	120-150	7.9	80.0	4.9	3.1	4.6	44.0	0.4	2.4	37.0	22.3			
51	0-25	8.0	125	1.9	1.6	3.3	13.5	0.3	3.5	14.0	8.6	48.0	22.0	
	25-60	8.1	116	3.2	1.5	1.9	29.0	0.4	3.4	15.0	22.2	50.0	21.6	
	60-150	8.2	119	4.3	1.7	2.7	39.0	0.4	2.6	28.0	26.3			
52	0-20	7.6	103.5	2.4	3.1	11.0	10.0	0.4	3.6	9.0	3.8			
	20-65	7.8	114.0	4.3	4.7	10.9	29.0	0.6	2.6	21.0	10.4			
	65-150	7.8	92.0	6.3	7.3	9.7	50.0	0.6	2.0	39.0	17.2			
53	0-25	7.8	119.5	1.9	2.6	6.1	11.0	0.3	2.8	5.0	5.3		2.5	
	25-75	8.0	125.0	1.5	1.6	1.8	11.0	0.3	3.6	6.0	8.4			
	75-120	7.9	100.0	1.8	1.0	2.8	13.0	0.3	2.6	9.0	9.3			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
55	0-25	7.6	88.5	4.8	21.9	29.6	12.0	0.8	1.8	4.0	2.4			0.7
	25-80	7.7	81.5	5.7	21.9	31.5	17.0	1.2	1.6	6.0	3.3			
	80-150	8.0	104.5	2.9	2.1	2.0	28.2	0.4	3.0	4.0	19.7			
56	0-20	7.7	96.0	3.4	6.8	12.2	15.0	0.6	3.4	11.0	4.9			
	20-60	7.7	90.0	7.1	21.9	35.4	36.0	1.1	1.6	17.0	6.7			
	60-120	8.0	112.5	5.2	2.1	7.1	44.0	0.5	2.2	39.0	20.5			
57	0-20	7.6	81	4.4	21.9	22.8	16.0	0.7	2.8	7.0	3.4			2.3
	20-70	7.6	105	2.5	6.3	6.4	13.0	1.7	3.0	14.0	5.2			
	70-150	7.9	132	7.5	26.0	27.4	34.0	1.4	1.3	28.0	6.6			
58	0-25	7.9	110	7.8	7.3	14.1	58.0	1.4	1.6	53.0	17.7	44.5	12.5	
	25-65	8.1	115	4.1	8.3	12.1	21.0	1.7	2.1	19.0	6.6	37.5	16.5	
	65-100	8.0	108	5.6	8.3	14.0	33.0	1.9	1.9	29.0	9.9	39.0	23.0	
59	0-25	7.7	106	6.6	20.8	19.9	40.0	1.1	1.5	8.0	8.9			
	25-70	7.6	100	4.5	3.1	3.7	40.0	0.3	2.7	13.0	21.7			
	70-120	7.8	93	1.5	2.1	3.7	8.5	0.3	2.7	5.0	5.0			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
60	0-15	7.8	104	2.2	2.1	3.7	16.0	0.6	2.5	11.0	9.4		15.0	
	15-40	7.7	113	2.5	3.1	1.8	20.4	0.6	3.0	14.0	13.0			
	40-110	7.8	86	15.0	27.1	44.8	85.5	3.0	1.5	92.0	14.3			1.0
	110-150	7.9	95	16.8	12.5	34.1	121.0	3.0	1.7	146.0	25.0			
61	0-25	7.7	105	2.3	4.2	5.5	11.0	0.6	2.1	10.0	5.0			
	25-80	7.7	102	4.3	5.7	8.8	29.0	0.8	2.0	24.4	10.7			
	80-150	7.4	87	15.6	26.0	36.1	119.0	2.0	1.6	100.0	21.4			1.0
62	0-30	7.6	89	5.3	19.2	33.8	19.0	1.0	1.5	17.5	3.7			
	90-150	7.4	86	12.2	26.6	31.2	98.0	1.5	2.4	80.0	18.2			1.3
63	0-30	7.7	90	3.2	8.1	13.3	13.0	0.6	3.5	10.0	4.0			
	30-90	7.7	91	6.9	25.0	32.3	37.0	0.5	2.4	15.5	6.9			2.7
	90-140	7.7	83	7.9	19.2	25.6	53.1	1.0	2.0	15.0	11.2			
64	0-35	8.1	94	1.5	4.2	3.6	7.0	0.3	2.0	8.0	3.6			
	35-65	8.0	104	1.7	2.1	3.7	10.0	0.3	2.1	9.0	5.9			
	65-100	8.3	106	2.9	2.1	3.3	20.8	0.4	1.5	20.0	12.8			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
65	0-20	[illegible]	90	1.8	5.2	5.5	7.6	0.3	2.2	11.0	3.2			
	20-60	8.0	101	4.1	10.4	15.8	17.0	0.5	1.5	28.0	4.7			
	60-90	7.9	105	5.8	15.6	15.4	37.0	1.0	1.5	47.0	9.4			
66	0-35	7.8	86	11.2	26.0	43.9	74.0	0.6	1.2	84.0	12.5			
	35-100	8.0	86	10.9	26.0	34.1	85.0	1.2	1.2	70.0	15.5			1.5
	100-150	7.8	83	12.9	27.1	28.3	125.0	1.7	1.5	83.0	23.8			
67	0-20	7.8	89	2.9	5.2	4.5	10.5	0.3	2.8	11.0	4.8			
	20-80	7.8	105	4.1	6.8	9.7	30.0	0.4	1.8	35.0	10.5			
	80-150	7.7	99	10.8	28.0	25.2	83.0	0.6	1.6	84.0	15.8			
68	0-35	7.8	73	3.4	7.8	8.7	18.0	0.3	3.0	20.0	6.3			
	35-90	8.0	96	1.4	3.6	4.1	7.0	0.2	2.0	4.0	3.5			
	90-150	7.8	95	4.3	18.7	9.4	24.0	0.4	1.8	6.0	6.4			
69	0-25	7.9	104	3.7	5.2	9.5	23.0	0.3	1.6	15.0	8.5	46.0	11.3	
	25-60	8.1	102	2.5	4.2	7.5	15.0	0.2	1.8	10.0	6.2	48.0	19.7	
	60-100	7.9	105	3.7	6.8	7.8	24.5	0.6	1.8	16.0	9.1	46.9	20.0	

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
70	0-30	7.9	89	3.1	8.3	6.3	20.5	0.6	3.0	15.0	7.6			
	30-70	7.8	98	8.8	27.6	26.3	74.5	0.8	2.5	37.0	14.3			
	70-120	7.9	88	11.0	26.6	30.7	109.0	0.6	2.5	55.0	20.4			0.5
71	0-20	7.9	90	5.4	17.7	11.4	35.5	0.6	3.0	42.0	9.3			
	20-45	7.9	101	8.4	33.3	26.9	63.0	0.6	2.0	53.0	11.5			
	45-150	7.8	103	12.5	37.5	25.6	113.0	1.3	1.5	95.0	20.1			1.8
72	0-20	7.6	90	2.2	8.3	5.3	11.9	0.3	3.0	6.0	4.6			
	20-60	8.0	104	5.8	24.0	10.0	36.8	0.7	2.0	6.0	8.9			
	60-150	7.9	81	6.7	22.9	23.7	50.8	0.5	2.0	6.0	10.5			1.9
73	0-35	8.0	101	1.7	5.2	4.0	10.4	0.4	3.0	5.0	4.8	52.5	8.9	
	35-90	8.0	107	4.0	10.4	5.2	30.5	0.5	2.5	16.0	10.9	52.5	13.5	
	90-150	7.9	90	5.9	20.8	15.1	53.0	0.6	2.0	10.0	12.5	52.5	17.5	
74	0-20	7.9	97	1.8	4.7	4.5	11.4	0.3	3.0	4.0	5.3			
	20-60	8.2	100	5.2	24.0	11.9	30.5	0.4	2.0	6.0	7.2			
	60-150	8.0	85	6.8	26.0	15.7	50.8	0.5	2.0	4.0	11.1			1.4

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
75	0-30	7.9	97	1.8	6.3	3.4	9.4	0.3	3.0	8.0	4.3	50.0	7.1	
	30-100	8.0	88	2.2	5.2	4.5	14.6	0.2	3.0	7.0	6.6	42.0	15.8	
	100-150	8.1	55	2.1	4.7	3.6	13.8	0.7	3.0	5.0	6.8	27.0	32.5	
76	0-25	8.3	86	4.0	10.4	9.0	22.0	0.6	3.0	22.0	7.1			
	25-60	8.1	80	9.0	26.0	16.7	71.5	0.4	2.0	22.0	15.5			
	60-150	8.0	91	6.3	26.0	12.8	35.8	0.7	2.0	14.0	8.1			1.1
77	0-25	7.9	94	3.2	10.4	6.1	18.8	0.3	3.0	18.0	6.5			
	25-65	8.1	105	5.1	8.9	7.6	41.5	0.3	2.5	35.0	14.5			
	65-110	8.1	99	5.7	7.8	5.8	50.0	0.3	3.0	4.0	19.2			
78	0-30	8.1	95	3.3	8.9	5.7	21.3	0.4	2.5	20.0	17.9			
	30-70	7.9	95	6.0	14.5	0.6	40.8	0.4	2.0	3.0	11.5			
	70-110	8.0	85	1.8	6.3	4.4	7.3	0.3	3.0	5.0	3.2			1.1
79	0-25	8.0	89	3.0	8.9	5.7	17.7	0.6	3.5	13.0	6.6			
	25-70	7.9	87	5.1	28.1	5.8	25.0	0.8	2.5	12.0	6.1			1.0
	70-150	7.9	93	4.9	18.3	9.8	27.5	0.9	2.0	16.0	7.2			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
80	0-30	8.1	78	2.1	5.2	4.5	13.5	0.3	3.0	8.0	6.1			
	30-70	8.0	98	5.0	15.6	11.1	30.3	0.3	2.5	17.0	8.3			
	70-100	7.9	78	8.3	29.2	12.1	54.0	0.4	2.0	38.0	11.9			
	100-150	7.8	63	10.5	24.5	14.3	87.0	0.2	1.5	83.0	19.7			
81	0-30	7.9	104	5.5	11.5	7.9	43.0	0.8	3.0	40.0	13.8	44.5	13.5	
	30-90	7.9	98	8.0	13.0	11.3	66.5	1.7	2.0	64.0	19.1	46.0	16.3	
	90-150	7.7	103	25.7	66.7	57.6	207.5	4.7	1.5	263.0	26.3	46.0	30.0	
82	0-25	8.0	94	3.9	12.5	8.9	22.0	0.3	3.0	22.0	6.7	48.0	10.2	
	25-70	8.0	88	5.5	15.6	10.6	37.3	0.6	2.0	32.0	10.3	39.0	15.0	
	70-90	7.7	64	9.0	36.9	24.3	59.5	0.4	2.0	58.0	10.8	—	—	2.1
83	0-35	8.0	95	2.2	5.6	5.4	12.4	0.2	3.5	10	5.3			
	35-120	8.1	113	3.8	5.1	3.1	31.5	0.2	3.0	30	15.6			
	120-150	7.9	102	11.3	20.7	12.2	97.5	1.2	1.5	80	24.0			
84	0-20	7.9	102	2.5	6.1	10.3	12.5	0.4	3.0	10	4.4			
	20-70	8.1	103	2.4	4.0	12.4	12.6	0.1	3.0	6	4.4			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
85	0-25	7.4	73	86.5	254.8	377.9	765.0	2.0	1.5	1238	43.0	39.0	19.0	0.6
	25-60	7.6	86	44.0	93.0	144.4	315.0	0.2	1.0	510	28.9	41.0	20.0	
	60-150	7.5	86	51.0	122.3	164.3	372.5	0.2	1.0	622	31.1	41.0	20.0	
86	0-40	8.0	89	3.7	7.1	8.9	22.0	0.2	2.5	22	7.8			
	40-150	7.9	89	12.9	32.9	26.1	106.0	0.4	1.0	82	19.7			
87	0-35	8.2	91	2.7	5.1	7.3	15.4	0.4	3.0	10	6.2			
	35-80	8.2	110	3.7	2.5	9.9	25.0	0.1	2.5	10	10.0			
	80-130	8.3	50	3.2	5.1	3.6	24.5	0.1	2.0	12	11.8			
88	0-30	7.9	78	4.8	4.6	13.7	32.9	0.5	3.0	30	10.9			
	30-75	8.0	82	3.3	11.1	3.5	21.8	0.5	2.5	18	8.1			
	75-150	8.1	90	4.0	6.1	4.9	34.3	0.3	2.5	22	14.6			
89	0-20	8.2	100	1.8	5.1	4.0	11.0	0.6	2.5	8.0	5.2			
	20-90	8.1	110	3.3	6.1	4.9	24.4	0.4	1.0	20.0	10.4			
	90-130	8.2	50	4.7	8.1	4.7	35.3	0.7	1.5	30.0	14.0			

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
90	0-25	8.2	88	3.3	9.1	6.4	20.1	0.3	2.0	14.0	7.2			
	25-30	8.4	110	2.9	4.6	3.2	23.4	0.2	2.0	9.0	11.8			
	80-130	8.4	100	2.6	2.5	2.1	23.4	0.2	2.0	10.0	15.4			
91	0-30	8.2	94	2.9	5.6	6.4	15.8	0.3	3.0	10.0	5.6			
	30-120	8.3	96	5.7	11.1	9.0	40.3	1.9	2.0	17.0	12.7			
	120-150	8.1	85	10.8	27.8	17.9	87.0	0.4	1.5	45.0	18.2			
92	0-25	8.4	100	2.3	2.5	1.6	15.1	0.1	3.5*	15.0	13.3			
	25-70	8.6	116	3.5	2.0	1.7	34.3	0.1	2.0**	9.0	26.0			
	70-150	8.9	190	2.3	2.0	1.7	20.8	0.1	4.0**	5.0	15.3			
93	0-20	8.4	96	2.3	2.5	4.8	17.0	0.1	3.5*	6.0	8.9	50.0	11.0	
	20-100	8.5	109	2.8	2.5	2.2	25.0	0.2	3.0*	14.0	16.3	51.0	17.8	
	100-130	8.6	46	5.2	5.1	1.3	47.8	0.2	3.0*	28.0	26.7	26.0	20.0	
94	0-35	8.1	88	6.8	7.1	28.4	39.0	0.4	2.5	34.0	9.1	42.0	7.5	
	35-100	8.2	85	6.5	11.6	14.9	45.0	0.2	2.0	30.0	12.4	41.5	11.0	

* Traces of CO_3
** 1.0 meq/l CO_3

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l Ca	Mg	Na	K	HCO_3	Cl	SAR	CEC	ESP	Gypsum %
95	0-25	8.3	80	2.2	4.6	5.4	13.0	0.2	3.0	10.0	5.8			
	25-80	8.2	80	4.9	5.1	15.0	33.0	0.2	2.0	32.0	10.4			
	80-150	8.1	86	6.8	8.1	10.2	50.0	0.6	1.5	50.0	16.5			
96	30-80	8.1	75	7.1	13.6	18.4	51.0	0.3	2.0	42.0	12.8			
	80-150	8.0	81	10.4	17.2	16.2	76.3	0.3	2.0	78.0	18.7			
97	0-25	8.0	75	7.9	25.3	17.6	44.0	0.4	2.5	47.0	9.5			
	25-70	7.8	86	12.7	24.3	25.9	106.0	0.4	1.5	104.0	21.2			
	70-150	8.0	84	9.3	19.2	16.4	65.0	0.2	1.0	72.0	3.9			
98	0-20	8.0	87	8.0	20.2	25.5	47.8	0.5	3.0	54.0	10.0			
	20-80	8.0	82	12.5	30.3	28.6	93.5	0.4	3.0	85.0	17.2			
	80-150	7.8	77	14.7	40.4	38.6	100.0	0.4	2.0	104.0	15.9			1.4
99	0-25	8.1	76	6.9	16.2	13.0	52.0	0.4	1.5	42.0	13.6	39.0	13.0	
	25-90	8.1	77	6.9	15.2	13.1	52.0	0.2	1.0	51.0	13.8	39.0	15.0	
	90-150	8.0	78	8.9	17.2	15.7	76.5	0.2	1.0	68.0	18.9	38.0	19.0	

Table A-2 Continued

Profile No.	Depth cm	pH	SP	EC mmhos/cm	Composition of the Saturation Extract meq/l						SAR	CEC	ESP	Gypsum %
					Ca	Mg	Na	K	HCO_3	Cl				
100	0-30	8.2	81	4.6	8.1	10.2	30.8	0.2	3.0	28.0	10.2			
	30-75	8.3	100	4.8	7.1	4.3	41.5	0.5	2.5	35.0	17.4			
	75-100	8.4	104	5.7	6.1	4.4	51.0	0.2	2.5	42.0	22.3			
101	0-20	8.3	78	4.0	10.6	9.9	22.0	0.1	2.0	22.0	6.9			
	20-80	8.2	74	5.0	12.1	9.4	31.5	0.1	2.0	34.0	9.6			
	80-130	8.0	87	10.0	14.2	13.2	93.5	0.2	1.5	91.0	25.3			

Table A-2 Continued

Profile No.	Water-table Depth, cm	pH	TSS ppm	EC mmhos km at 25°	Composition meq/l							SAR
					Anions			Cations				
					HCO_3^-	Cl^-	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{++}	K^+	
7	120	7.4	2330	2.2	7.0	16.0	12.6	2.8	6.2	26.5	0.1	12.5
19	110	7.5	1470	1.4	5.0	10.0	7.4	3.7	5.3	13.3	0.1	6.3
26	70	7.7	7000	6.3	4.5	42.0	63.0	18.5	23.9	66.7	0.4	14.5
35	80	7.3	16200	15.9	5.0	169.0	95.8	46.3	71.4	151.3	0.8	19.7
38	100	7.6	11500	10.8	13.0	89.0	81.5	20.4	37.4	125.0	0.8	23.3
77	110	7.7	11900	11.8	10.0	138.0	48.9	16.2	42.4	137.5	0.8	25.4
82	100	7.6	16600	15.4	9.5	182.0	87.1	57.4	65.4	155.0	0.8	19.8
87	120	7.8	7620	7.2	14.0	54.0	48.7	7.0	14.5	95.0	0.3	29.0
94	100	7.2	8280	8.3	8.5	80.0	45.6	13.9	28.9	91.0	0.3	19.7

Table A-3. Analysis of the Groundwater in the Abu Raya Area.

Table A-4. Morphological Descriptions and Associated Site Characteristics of Selected Soil Profiles Representative of the Major Soil Series Which Occur.

Profile No.: 10	Date: 6/11/78	Parent material: Alluvium
Series: Hammad clay - normal phase		
Location: Abu Raya		Salts: —
Land form: Floodplain		Water table: 100 cm
Slope: Level		Vegetation: Maize

Depth cm:	DESCRIPTION
0-25	Very dark greyish brown (10 YR 3/2) moist, clay, moderate medium subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine roots, weak effervescence, diffuse boundary.
25-80	Dark grey (10 YR 4/1) moist, few diffuse dark greenish grey (5 GY 4/1) mottles, clay, moderate medium subangular blocky, many fine and medium pores, common fine roots, weak effervescence, diffuse boundary.
80-100	Dark brown (10 YR 3/3) moist, clay loam, moderate fine granular, many fine and medium pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 20	Date: 8/11/78	Parent material: Alluvium
Series: Abu Raya clay - sodic phase		
Location: Abu Raya		Salts: Few salt efflorescence
Land form: Floodplain		Water table: 110 cm
Slope: Level		Vegetation: Fallow after cotton

Depth cm:	DESCRIPTION
	Cracks of 3-5 cm wide and 20-50 cm deep
0-30	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine roots, weak effervescence, diffuse boundary.
30-80	Very dark greyish brown (10 YR 3/2) moist, clay, moderate medium angular blocky, slickensides, friable, sticky, plastic, many fine and medium pores, few fine roots, weak effervescence, diffuse boundary.
80-110	Very dark greyish (10 YR 3/2) moist, few clear dark greenish grey (5 GY 4/1) mottles, clay, strong angular blocky, friable, sticky, plastic, many fine pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 40	Date: 21/11/78	Parent material: Alluvium
Series: Abu Raya clay - gypsiferous phase		
Location: Abu Raya		Salts: Some salt efflorescence
Land form: Floodplain		Water table: Below 150 cm
Slope: Level		Vegetation: Fallow after rice

Depth cm:	DESCRIPTION
0-20	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine roots, weak effervescence, diffuse boundary.
20-70	Dark brown (10 YR 3/3) moist, clay, moderate medium subangular blocky, firm, sticky, plastic, many gypsum concretions and crystals, few fine roots, weak effervescence, diffuse boundary.
70-150	Very dark greyish brown (10 YR 3/2) moist, clay, strong fine angular blocky, slickensides, friable, sticky, plastic, many gypsum concretions and veins, weak effervescence.

Table A-4 (Cont.)

Profile No.: 44	Date: 10/11/78	Parent material: Alluvium
Series: Sadek clay		
Location: Abu Raya		Salts: —
Land form: Old river levees		Water table: Below 150 cm
Slope: Level		Vegetation: Wheat

Depth cm:	DESCRIPTION
0-20	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine and medium roots, weak effervescence, diffuse boundary.
20-70	Very dark greyish brown (10 YR 3/2) moist, clay loam, moderate medium subangular blocky, friable, common fine pores, common lime concretions, few fine roots, weak effervescence, diffuse boundary.
70-150	Very dark greyish brown (10 YR 3/2) moist, clay, strong fine angular blocky, slickensides, friable, sticky, plastic, common fine pores, many gypsum veins, weak effervescence.

Table A-4 (Cont.)

Profile No.: 58	Date: 11/1/79	Parent material: Alluvium
Series: Hammad clay - normal phase		
Location: Abu Raya		Salts: Some salt efflorescence
Land form: Floodplain		Water table: 110 cm
Slope: Level		Vegetation: Berseem

Depth cm:	DESCRIPTION
0-20	Very dark greyish brown (10 YR 3/2) moist, clay, massive, firm, sticky, plastic, many fine and medium pores, many fine and medium roots, weak effervescence, clear boundary.
20-65	Brown (10 YR 4/3) moist, common diffuse dark bluish grey (5 B 4/1) mottles, clay, many medium subangular blocky, firm, sticky, plastic, common fine pores, few fine roots, weak effervescence, diffuse boundary.
65-110	Dark brown (10 YR 4/3) moist, clay strong fine angular blocky, firm, sticky, plastic, many fine pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 63	Date: 21/11/78	Parent material: Alluvium
Series: Hammad clay - gypsiferous phase		
Location: Abu Raya		Salts: Few salt efflorescence
Land form: Floodplain		Water table: 140 cm
Slope: Level		Vegetation: Fallow after rice

Depth cm:	DESCRIPTION
0-30	Brown (10 YR 4/3) moist, common diffuse dark greenish grey (5 BG 4/1) mottles, clay, weak subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine roots, weak effervescence, diffuse boundary.
30-90	Dark greyish brown (10 YR 4/2) moist, clay, moderate medium subangular blocky, firm, sticky, plastic, common fine and medium pores, many gypsum crystals and veins, few fine roots, weak effervescence, diffuse boundary.
90-140	Dark greyish brown (10 YR 4/2) moist, clay, moderate medium subangular blocky, friable, sticky, plastic, common fine pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 71	Date: 22/11/78	Parent material: Alluvium
Series: Abu Raya clay - high water table, gypsiferous phase		
Location: Abu Raya		Salts: Few salt efflorescence
Land form: Floodplain		Water table: 85 cm
Slope: Level		Vegetation: Fallow after cotton

Depth cm:	DESCRIPTION
0-20	Very dark grey (10 YR 3/1) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine roots, weak effervescence, diffuse boundary.
20-45	Very dark greyish brown (10 YR 3/2) moist, clay, moderate fine and medium angular blocky, weak slickensides, friable, sticky, plastic, common fine and medium pores, few fine roots, weak effervescence, diffuse boundary.
45-85	Brown (10 YR 4/3) moist, few diffuse dark bluish grey (5 B 4/1) mottles, clay, moderate medium angular blocky, friable, sticky, plastic, common fine and medium pores, many gypsum crystals and veins, weak effervescence.

Table A-4 (Cont.)

Profile No.: 81	Date: 23/11/78	Parent material: Alluvium
Series: Abu Raya clay - normal phase		
Location: Abu Raya		Salts: Some salt efflorescence
Land form: Floodplain		Water table: 100 cm
Slope: Level		Vegetation: Fallow after rice

Depth cm:	DESCRIPTION
0-30	Very dark grey (10 YR 3/1) moist, clay, weak subangular blocky, firm, sticky, plastic, common fine and medium pores, few soft lime concretions, many fine and medium roots, weak effervescence, diffuse boundary.
30-90	Very dark greyish brown (10 YR 3/2) moist, clay, strong angular blocky, slickensides, friable, sticky, plastic, many fine pores, few fine roots, weak effervescence, diffuse boundary.
90-100	Very dark greyish (10 YR 3/2) moist, clay, strong fine angular blocky, friable, slickensides, sticky, plastic, many fine pores, common gypsum veins and concretions, weak effervescence.

Table A-4 (Cont.)

Profile No.: 82	Date: 23/11/78	Parent material: Alluvium
Series: Abu Raya clay - normal phase		
Location: Abu Raya		Salts: Few salt efflorescence
Land form: Floodplain		Water table: 110 cm
Slope: Level		Vegetation: Fallow after rice

Depth cm:	DESCRIPTION
0-25	Very dark grey (10 YR 3/1) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine pores, few soft lime concretions, many fine and medium roots, moderate effervescence, diffuse boundary.
25-70	Very dark greyish brown (10 YR 3/2) moist, clay, moderate medium subangular blocky, firm, sticky, plastic, common fine pores, few soft lime concretions, few fine roots, weak effervescence, diffuse boundary.
70-90	Dark brown (10 YR 3/3) moist, clay, strong, fine angular blocky, friable, sticky, plastic, common fine pores, many gypsum veins and crystals, weak effervescence, diffuse boundary.
90-110	Brown (10 YR 4/3) moist, loam massive, friable, many fine pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 85	Date: 23/11/78	Parent material: Alluvium
Series: Hammad clay - saline phase		
Location: Abu Raya		Salts: Brown salt crust
Land form: Floodplain		Water table: Below 150 cm
Slope: Level		Vegetation: Barren land

Depth cm:	DESCRIPTION
0-25	Very dark greyish brown (10 YR 3/2) moist, clay, structureless massive, firm, sticky, plastic, common fine pores, weak effervescence, diffuse boundary.
25-60	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, firm, sticky, plastic, common fine pores, common gypsum veins, weak effervescence, diffuse boundary.
60-150	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, friable, sticky, plastic, common fine pores, weak effervescence.

Table A-4 (Cont.)

Profile No.: 99	Date: 25/11/78	Parent material: Alluvium
Series: Abu Raya clay - normal phase		
Location: Abu Raya		Salts: Few salt efflorescence
Land form: Floodplain		Water table: Below 150 cm
Slope: Flat		Vegetation: Maize

Depth cm:	DESCRIPTION
0-25	Very dark greyish brown (10 YR 3/2) moist, clay, weak subangular blocky, firm, sticky, plastic, many fine and medium pores, many fine and medium roots, weak effervescence, diffuse boundary.
25-90	Very dark greyish brown (10 YR 3/2) moist, clay, moderate medium angular blocky, slickensides, firm, sticky, plastic, many fine pores, few fine roots, weak effervescence, diffuse boundary.
90-150	Very dark greyish brown (10 YR 3/2) moist, clay, strong fine angular blocky, friable, sticky, plastic, common fine pores, weak effervescence.

AMERICAN EQUIVALENTS OF EGYPTIAN ARABIC TERMS AND MEASURES COMMONLY USED IN IRRIGATION WORK

LAND AREA	IN SQ METERS	IN ACRES	IN FEDDANS	IN HECTARES
1 acre	4,046.856	1.000	0.963	0.405
1 feddan	4,200.833	1.038	1.000	0.420
1 hectare (ha)	10,000.000	2.471	2.380	1.000
1 sq. kilometer	100×10^3	247.105	238.048	100.000
1 sq. mile	259×10^6	640.000	616.400	259.000

WATER MEASUREMENTS	FEDDAN-CM	ACRE-FEET	ACRE-INCHES
1 billion m^3	23,809,000.000	810,710.000	
1,000 m^3	23.809	0.811	9.728
1,000 m^3 /Feddan (= 238 mm rainfall)	23.809	0.781	9.372
420 m^3 /Feddan (= 100 mm rainfall)	10.00	0.328	3.936

OTHER CONVERSION		METRIC	U.S.
1 ardab	=	198 liters	5.62 bushels
1 ardab/feddan	=		5.41 bushels/acre
1 kg/feddan	=		2.12 lb/acre
1 donkey load	=	100 kg	
1 camel load	=	250 kg	
1 donkey load of manure	=	0.1 m^3	
1 camel load of manure	=	0.25 m^3	

EGYPTIAN UNITS OF FIELD CROPS

CROP	EG. UNIT	IN KG	IN LBS	IN BUSHELS
Lentils	ardeb	160.0	352.42	5.87
Clover	ardeb	157.0	345.81	5.76
Broadbeans	ardeb	155.0	341.41	6.10
Wheat	ardeb	150.0	330.40	5.51
Maize, Sorghum	ardeb	140.0	308.37	5.51
Barley	ardeb	120.0	264.32	5.51
Cottonseed	ardeb	120.0	264.32	8.26
Sesame	ardeb	120.0	264.32	
Groundnut	ardeb	75.0	165.20	7.51
Rice	dariba	945.0	2081.50	46.26
Chick-peas	ardeb	150.0	330.40	
Lupine	ardeb	150.0	330.40	
Linseed	ardeb	122.0	268.72	
Fenugreek	ardeb	155.0	341.41	
Cotton (unginned)	metric qintar	157.5	346.92	
Cotton (lint or ginned)	metric qintar	50.0	110.13	

EGYPTIAN FARMING AND IRRIGATION TERMS

fara = branch
marwa = small distributer, irrigation ditch
masraf = field drain
mesqa = small canal feeding from 10 to 40 farms
qirat = cf. English "karat", A land measure of 1/24 feddan, 175.03 m^2
qarla = village
sahm = 1/24th of a qirat, 7.29 m^2
saqia = animal powered water wheel
sarf = drain (vb.), or drainage. See also masraf, (n.)

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