

Overseas Development Administration

Yemen Arab Republic Montane Plains and Wadi Rima' Project: a land and water resources survey

Soil survey and irrigation suitability classification of Wadi Rima'

IP ANDERSON

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YEMEN ARAB REPUBLIC
MONTANE PLAINS AND WADI RIMA PROJECT
A LAND AND WATER RESOURCES SURVEY

SOIL SURVEY AND IRRIGATION SUITABILITY
CLASSIFICATION OF
WADI RIMA

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ABSTRACT AND KEYWORDS

ABSTRACT

The results of a soil survey and irrigation suitability study of the Wadi Rima area of the Yemen Arab Republic are reported in detail and accompanied by profile descriptions and analyses. The survey and study were part of a broader investigation of land and water resources by the Land Resources Development Centre.

Details are given of the physical and chemical properties of the mainly alluvial soils and of the classification, mapping and distribution of the soil series.

The classification of the area for irrigation purposes was based on topography and on the texture, moisture-holding characteristics, depth, nutrient status, saline/sodic conditions and drainage of the soils. More than 50% of the land surface is at the Class 2 level of suitability and after suitable development could be reclassified as Class 1.

KEYWORDS

Agricultural development, soil survey, land irrigability, alluvial soils, sandy soils, saline soils, sodic soils, soil mapping, soil physics, soil chemistry, soil water, soil depth, soil fertility, Yemen Arab Republic

PARTS 1-5

PART 1 INTRODUCTION

PREFACE

This report is the result of soil survey and irrigation suitability studies completed during 1975-6, the fieldwork extending from November 1975 to March 1976. The study was related to LRDC's investigations of land and water resources and agricultural development (LRD Project Team, 1976 and 1977). The broad results of the soil and irrigation studies have already been incorporated in these two reports.

The purpose of the report is to make the detailed results of the studies available to technical workers in the Yemen.

METHODS

Air photographs, maps and previous soil surveys

1:20 000*, 1:60 000** and 1:80 000/ scale air photography and 1972-73 ERTS imagery were used during the survey. Print laydowns, prepared from the 1972 1:20 000 photography, and topographic base maps were available at scales of 1:20 000, 1:50 000 and 1:100 000. Ministry of Defence maps (1974) cover the entire country at a scale of 1:250 000.

* DOS Contract 128, 1972

** RAF, 1973

/ DOS Contract 158, 1976

Several reports on the soils of other areas on the Tihamah and the coastal plain of South Yemen were consulted. Of particular relevance is the soil and land classification by Tesco-Viziterov-Vituki (1971) in Wadi Zabia directly to the south of Wadi Rima. Other relevant reports are those by Hunting Technical Services Ltd (1967) covering the Ahwar delta in South Yemen and by Sir William Halcrow and Partners (1972) and Ferris (1953) covering the area around Wadi Jizan in Saudi Arabia.

Photointerpretation

A preliminary interpretation of land units (physiographic units) was made using the available photography. During fieldwork and the development of a final working legend, the boundaries of these mapping units were refined progressively by API. The soil map and the irrigation suitability map were prepared after a final interpretation of the 1972 1: 20 000 and 1976 1: 80 000 air photographs and compilation of mapping units on 1: 50 000 topographic base maps.

Fieldwork

As a check on the preliminary interpretation of land units and to establish a working legend, a rapid reconnaissance was made of the survey area and soil profiles were examined by auger at 40 sites. An additional 369 sites were then selected from air photos and ground observations to establish the pattern of soil distribution. The main soil types were characterised by 42 profile pits giving a total of 451 observations. Excluding areas of deep aeolian sand deposits not surveyed in detail, observations were made at an overall density of just over 1 per km². Fieldwork was completed between November 1975 and March 1976, excluding the time subsequently spent on a complementary study of soil-water characteristics.

Profiles were examined, where possible, to a depth of 120 cm using a 'Dutch' 7 cm auger or, where penetration was difficult, a Jarret 4 in auger. Each observation included a description of site (parent material, landform, vegetation, land use), general information on the soil (drainage, depth to watertable, stoniness, erosion, human interference) and soil morphology by horizon. Soil profile pits were excavated to a depth of 160-170 cm and 22 of them were continued by auger to 280-290 cm, except where the watertable or coarse alluvial deposits were encountered at shallower depths.

Soil profile pits were sampled by horizon for analysis. All chemical and most mechanical analyses were carried out by the Tropical Soils Analysis Unit at Reading. The remainder of the mechanical analyses were undertaken by the UNDP Soil Section, Taiz. Samples were taken from approximately half the auger borings at fixed depths of 0-15 cm, 15-50 cm, 50-100 cm and 100-120 cm for pH and electrical conductivity measurements at Taiz. These measurements were also made on two samples taken from most of the deep auger borings at depths between the base of the pit and 200 cm and between 200 cm and the base of the auger boring.

From the 42 profile pits a total of 262 samples were taken for full analysis. Electrical conductivity and pH were determined for 766 augered samples and a further 120 samples were subjected to either full or limited chemical analyses. Eight samples for soluble boron and 59 samples for gypsum determinations were selected from either pit or auger sites.

Laboratory analysis

The analyses were carried out by TSAU, Reading using the methods outlined below:

Moisture and bulk density: a known volume of soil is weighed; the soil is then oven-dried to determine moisture content. The bulk density is the weight per unit volume of air dry soil

Mechanical analysis. Pretreatment with hydrogen peroxide removes organic matter. The soil is then dispersed using Calgon (sodium hexametaphosphate and sodium carbonate). Particles $<50\mu$ are determined by settling. Clay and silt fractions ($<2\mu$ and $2-50\mu$) are separated and calculated. The sand fraction $>50\mu$ is sieved into fine, $50-250\mu$, and coarse, $250-2\ 000\mu$, subfractions

Organic carbon: by Walkley and Black's method followed by colorimetric determination by auto-analyser

Total nitrogen: a Kjeldahl digestion with a selenium catalyst followed by colorimetric determination by auto-analyser

Free carbonate: effervescence with addition of hydrochloric acid:
carbonate determined on samples which react

Carbonate determination: reaction with hydrochloric acid and back
titration with sodium hydroxide

pH: measurement in water, 1M KCl and 0.01M CaCl_2 using a 1:5
dilution

Conductivity: measurement in 1:5 soil:water ratio

Soluble cations (sodium and potassium): leaching with 80% industrial
methylated spirits, determination by flame photometry

Exchangeable bases: leaching with neutral N ammonium acetate, sodium
and potassium determined by flame photometry on auto-analyser and
magnesium and calcium by atomic absorption spectroscopy

Cation exchange capacity: leaching with N potassium chloride at
pH 2.5 after removal of excess ammonium acetate; ammonia released
determined by auto-analyser

Available phosphorus: Olsen's method

Total element analysis (phosphorus, potassium and magnesium);
perchloric acid digest and determination by auto-analyser

Phosphorus: colorimetrically using ascorbic acid as reducing agent

Potassium: by flame photometry using Li as standard

Magnesium: by atomic absorption spectroscopy with Sr as releasing
agent

Trace elements (copper, manganese and zinc): by atomic absorption
spectroscopy

Gypsum: Deb's method

Boron: extracted in hot water and determined colorimetrically

PART 2 THE ENVIRONMENT

The survey area, shown on Text Map 1 and, in greater detail on Text Map 2, comprises an extensive, largely featureless sedimentary coastal plain, with an alluvial fan merging into the alluvial plain and sloping gently towards the Red Sea. Near the sea, some variation in the landscape is provided by extensive though discontinuous expanses of sand dunes, mostly barchans. Soil distribution, current land use and microrelief have been strongly influenced by the practice, over many centuries, of surface irrigation from Wadi Rima.

GEOLOGY AND GEOMORPHOLOGY

A mountain front forms the eastern boundary of the survey area and is composed of a single rock type, quartz-plagioclase porphyry, giving rise to steep scree-mantled hillslopes, often capped or interrupted by angular outcrops of polygonally jointed bare rock. Although there is only minor visible evidence of faulting it seems likely that the mountain front is fault-controlled and that rocks similar to those composing the mountains underlie the coastal alluvium at depths which increase westwards.

The main Wadi Rima valley is floored by unconsolidated bouldery and cobbly alluvium up to several tens of metres thick, flanked by a series of alluvial terraces, rising to at least 35 m above the wadi bed.

The coastal plain, consists entirely of sedimentary deposits which, away from the mountain front are at least 200 m thick. The subsurface geology is basically a continuum with two broad facies based on grain size. The eastern part, from the mountain front almost to the Judaydah-Zabid highway, is a well developed alluvial fan composed of thin beds of coarse to very coarse, unconsolidated, uncemented conglomerates with bouldery and pebbly cobble beds predominating to at least 150 m. West of the alluvial fan the deposits on the alluvial plain are finer-grained and somewhat better sorted; coarse pebbly sands, gravels and pebble beds pass westwards into medium sands with subsidiary pebbly sands, gravels, silty sands and even silty clays. Calcareous cemented nodular sandstone and siltstone horizons

are common. The deposits are rather uniform with depth and exceed 150 m. West of the main highway and particularly towards the coast superficial sand-dune deposits are prominent, stabilised in part by sparse vegetation. Grey lagoonal clays, probably of marine origin and overlain by a discontinuous veneer of aeolian fine sand, form a low raised beach in the level coastal area to the south of Wadi Rima.

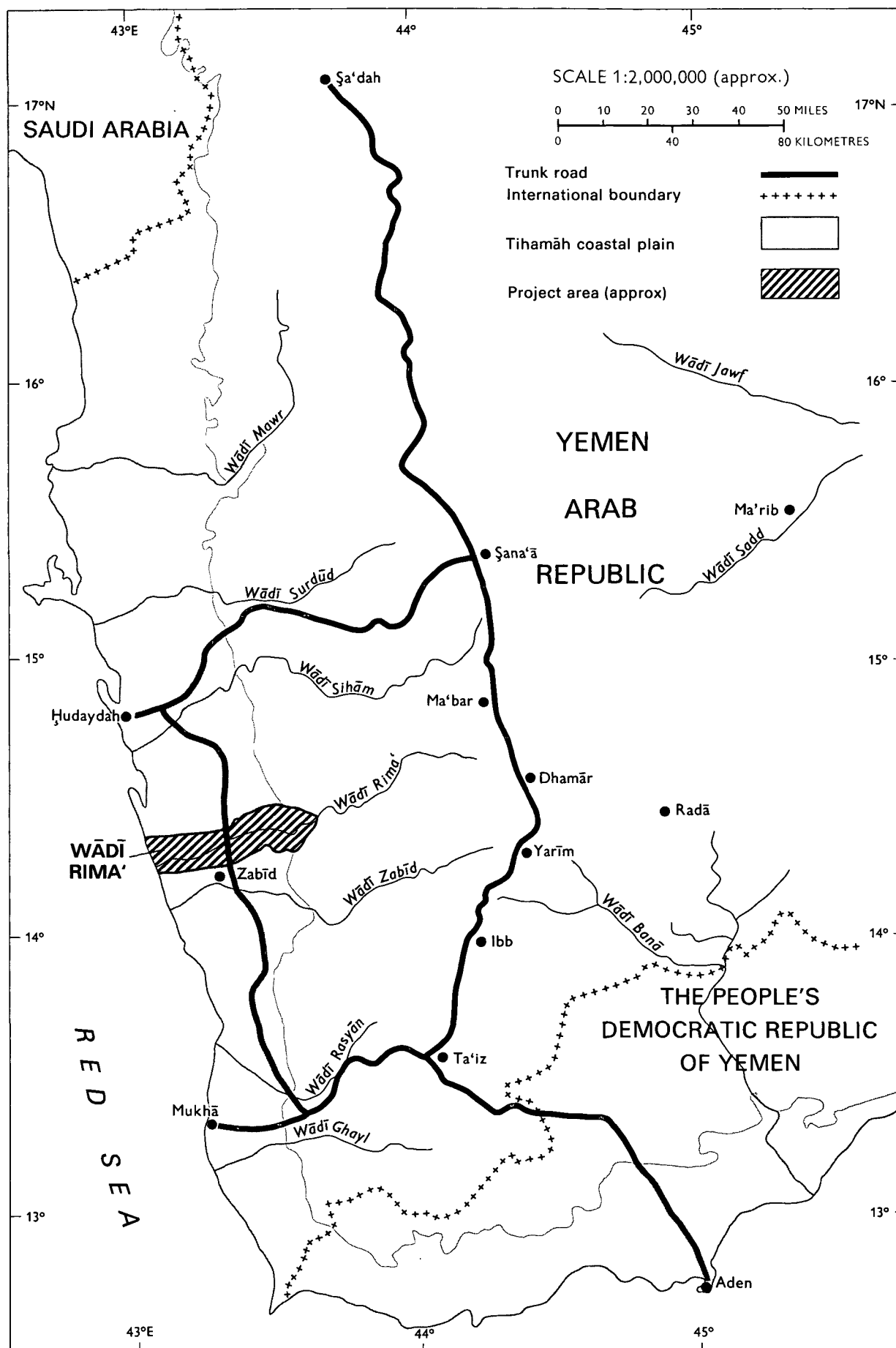
Structural developments within the sedimentary sequence of the coastal plain are limited to a series of uplifts, as evidenced by the terraces near the mountain front, the rejuvenation and incision of Wadi Rima and Wadi Jahr and the emergence of the alluvio-marine platform: a total vertical movement of perhaps 30 m.

Land units (physiographic units)

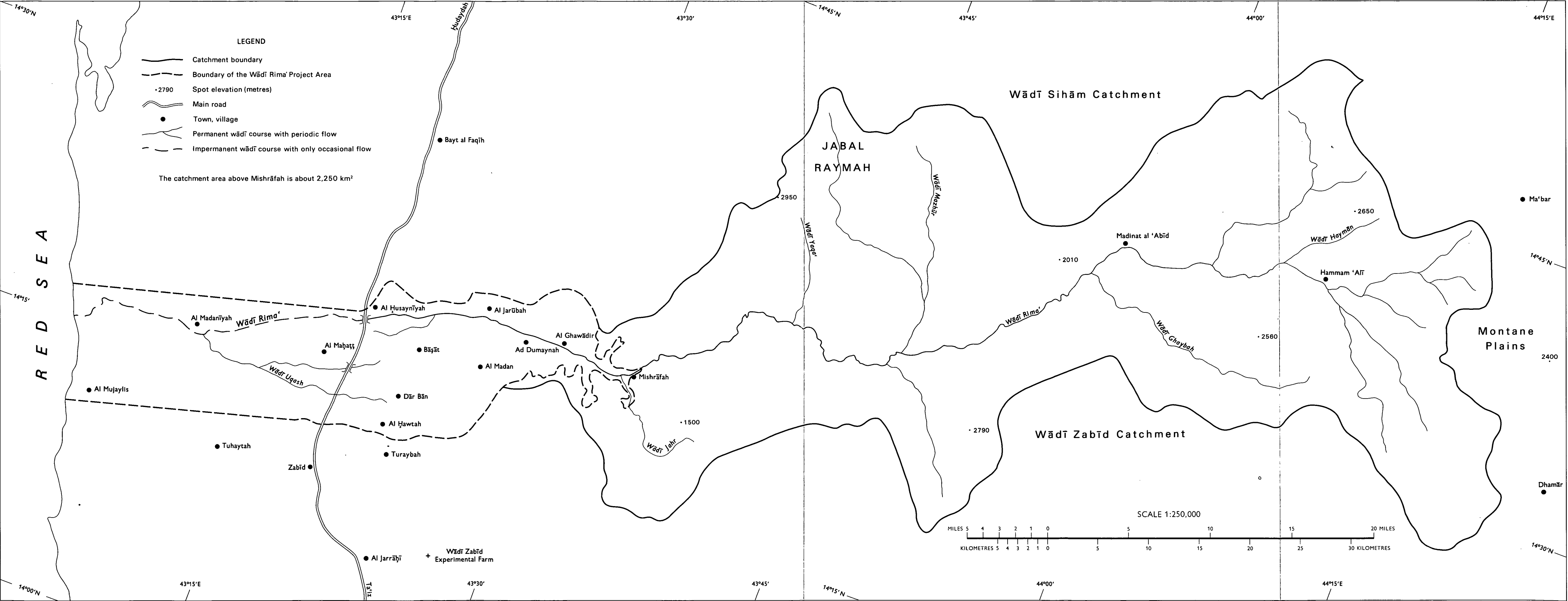
Five main physiographic units have been recognised and a small scale generalised soilmap (Text Map 3) illustrates the relationship between these units and soil distribution.

The Mountain Footslopes constitute part of the catchment area for Wadi Rima and include three major valleys of agricultural importance, Jaht, Irsimah, and Samhhah. Gently to moderately sloping terraced land borders the valley tributaries only Wadi Jahr provides a significant contribution to flow in Wadi Rima.

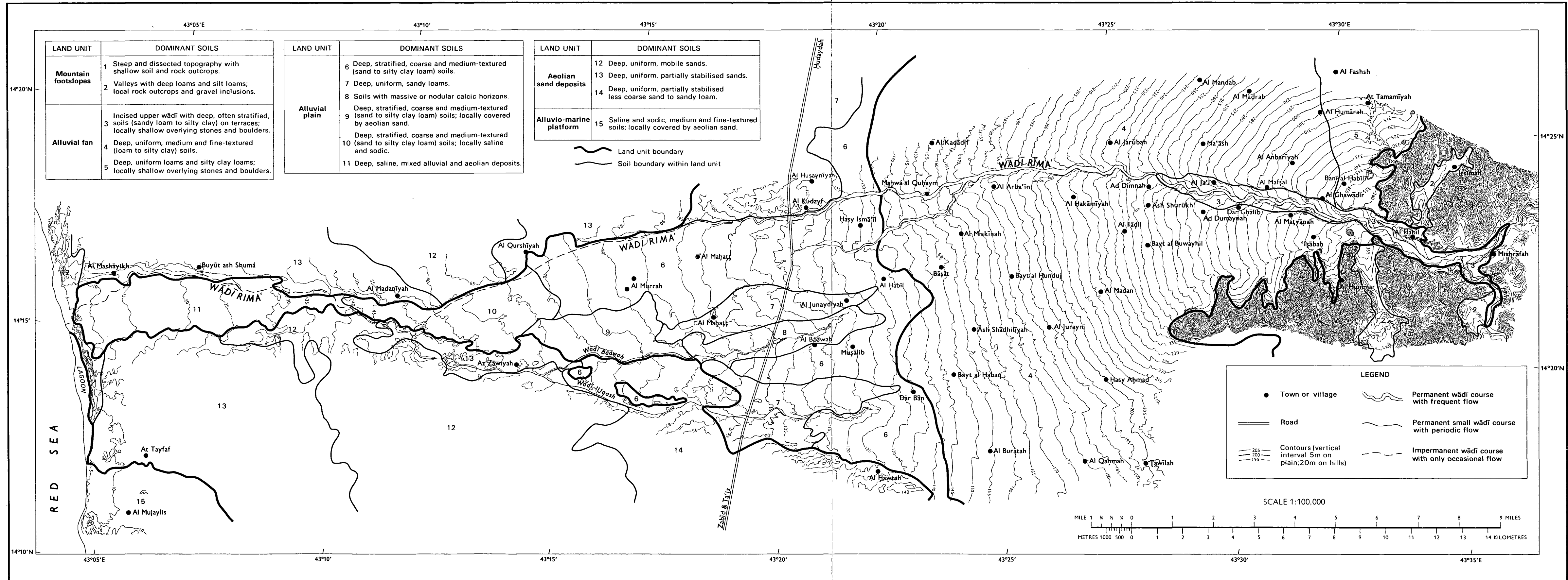
The Alluvial Fan is conical in plan extending westwards from its apex for about 20 km with a surface gradient of about 1:75 decreasing to 1:125. To the southwest alluvial deposits, associated with drainage systems to the south of Wadi Rima, coalesce with the fan. The original radial drainage of the fan is evident in the uncultivated land to the north and west of Al Jarubah State Farm. Elsewhere, the land surface is bunded to form irrigation basins. These bunds assume their greatest height on regularly spate-irrigated land close to the Wadi, forming a very distinct micro-relief. As far west as Ad Dimnah, a series of terraces border the course of Wadi Rima. The lowest terrace level is usually less than 4 m above the Wadi bed and is subject locally to flooding. Scarp slopes of very coarse alluvium separate the terrace levels, the highest of which adjoins a subdued level.



TEXT MAP 1 Location of project area



TEXT MAP 2 Wādī Rima' catchment



TEXT MAP 3 Land units and soils

The Alluvial Plain lies to the west of the alluvial fan, the transition being marked by a slight decrease in slope, more pronounced surface dissection, and the increasing influence of aeolian erosion and deposition. To the north the plain is bordered for most of its length by the main (northern) Wadi Rima channel and also receives and disperses flow in the southern channel amid a complex irrigation network now mostly pump irrigated but apparently subject to more regular spate irrigation in the past. Further south, drainage is controlled by Wadi Uqash and its tributaries which receive most of the surface runoff of the fan plus a major contribution arising outside the survey area. Well defined, continuous drainage channels of Wadi Uqash and its two main tributaries are evident only west of the 120 m contour line. The western limits of cultivation are contained within the prior and present day floodplains of Wadi Rima and Wadi Uqash. Changes in the course of the wadis still occur as demonstrated in April 1976 by Wadi Rima in its lower reaches near Al Madaniyah. Aeolian erosion and deposition affect the entire area and are locally severe. Acacia is replaced to the west by Salvadora which stabilises a microrelief of aeolian hummocks and flanks former wadi channels. In its lowest reaches, the wadi has developed a braided channel through hummocky aeolian deposits stabilised by Salvadora and halophytic grasses. The aeolian sands appear to be underlain by alluvio-marine deposits.

Aeolian Sand Deposits occupy much of the land to the north and south of Wadi Rima between the highway and the coast. Although mostly bare of vegetation, the lower dunes are partially stabilised by a sparse ground cover, or more locally, by Salvadora bushes. The dune area is both a depository and source of wind-blown sand.

The Alluvio-Marine Platform is the level coastal area to the south of Wadi Rima where medium and fine textured sediments are overlain by a discontinuous cover of aeolian sand derived from shoreline deposits. The area probably originated as a coastal sabkha.

CLIMATE

Through the combination of latitude and low elevation, the climate of the Wadi Rima area, like that throughout the Tihamah, is arid and tropical, prolonged periods of stable, dry and cloudless weather being occasionally

interrupted by instability resulting from localised low-level convergence. The degree of instability is more marked close to and east of the mountain front where orographic uplift can lead to the development of high-intensity, localised tropical storms. Though the Red Sea has a profoundly moderating influence on the climate, giving more equable temperatures and relatively high humidity, the presence of the sea and its associated corridor of dry subsident air ensures that, within 15-20 km of the coast, precipitation in any form is a rare event indeed.

Table 1 provides a summary of climatic data for Al Jarubah and represents conditions in the wadi-irrigated eastern half of the survey area.

TABLE 1 Climatic data from Al Jarubah 1975-7

Characteristics	Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual mean	Annual total
Rainfall, mm/month Jarubah	1975	0	10	0	42	9	17	47	305	122	52	24	0	-	628
	1976	20	1	12	43	76	28	47	59	57	50	18	0	-	411
	1977	6	60	9	65	59	62	4	208	80	167	0	20	-	740
	1970-7 mean	4	2	6	23	31	6	32	84	111	33	3	1	-	336
Evaporation, mm/month Penman E _o	1975	172	161	210	236	270	255	237	209	202	206	175	168	-	2501
	1976	158	177	206	234	241	243	246	249	221	208	179	158	-	2520
	1977	165	153	201	237	246	237	274	221	213	161	170	156	-	2434
	1975-7 mean	165	164	206	236	252	245	252	227	212	192	178	161	-	2488
Temperature, °C Mean Max. Mean Min. Mean $\frac{(\text{max.} + \text{min.})}{2}$	1975-7 mean	32	32	35	37	38	40	40	37	37	35	34	33	36	-
	1975-7 mean	19	20	21	23	25	26	27	25	25	22	21	19	23	-
	1975-7 mean	25	26	28	30	31	33	34	31	31	29	27	26	29	-
	1975-7 mean	25	26	28	30	31	33	34	31	31	29	27	26	29	-
Dew point, °C	1975-7 mean	18	19	20	20	22	21	20	22	23	22	19	19	20	-
Sunshine, hr/day Recorded Possible	1975-7 mean	7.4	6.8	6.5	7.5	8.4	7.4	5.1	6.1	7.0	8.0	8.5	7.7	7.2	-
	"	11.3	11.7	12.1	12.5	12.8	13.0	13.0	12.6	12.2	11.8	11.4	11.3	-	-
Wind run, km/day	1975-7 mean	173	180	191	214	197	204	252	191	146	125	133	155	180	-

PART 3 PROFILE CHARACTERISTICS AND SOIL CLASSIFICATION

The alluvial deposits, derived principally from Wadi Rima, frequently show little indication of pedogenic development. Where profile modification is evident, it is expressed as an A horizon overlying a cambic B horizon; these soils are restricted mainly to the alluvial fan, excluding those areas which regularly accrete sediment through spate irrigation. West of the alluvial fan more recent sediments reflect, in their increasing heterogeneity and stratification, a complex depositional history influenced by past changes in the course of Wadi Rima and by the encroachment of aeolian sands.

SOIL PROPERTIES

Soil texture and stratification

The soils of the alluvial fan and the three main valleys joining Wadi Rima west of Mishrafah show relatively little variation in texture. The silt-plus-clay fraction is generally higher than 60% and the sand fraction is predominantly very fine and fine. The main soil textural classes are loam, silt loam, clay loam and silty clay loam. Typical variation in clay and silt-plus-clay content with depth is illustrated in Figure 1. Profile stratification is not a prominent feature in the majority of soils.

Irrigation practices have had a significant effect on the distribution of sediments; flood control and the diversion of irrigation waters have resulted, over many years, in the development of anthropic soils. Characteristic of regularly irrigated land, particularly towards the head of the fan east of Al Mafsal, the soils are fine textured with a silt-plus-clay content normally exceeding 90% (WR 30, WR 33). These soils are derived largely from sediments carried by base and minor spate flows. Farther downstream, the extent of the anthropic influence is less easily recognised as the irrigation alluvium derived usually from spate flow, is predominantly, medium textured and similar to the natural fan deposits (WR 44) comprising the uncultivated land north and west of Al Jarubah.

At a more detailed level, the finest textured soils are often restricted to the lowest-lying positions within individual fields. Apart from the finest sediments settling out in these deeply ponded areas, the breaching

of bunds at these low points, allowing irrigation water to pass to adjacent fields, is followed by the removal of surface soil during their repair resulting in the exposure of finer textured subsoil. Other minor textural variations are occasionally found adjacent to irrigation channels where coarse material (sand or loamy sand) has accumulated as a thin surface deposit.

East of Ad Dimanh, a series of alluvial terraces border the course of the incised wadi bed. Intermittent flooding and deposition, which at present affects only the lowest terrace level, have produced stratified soil profiles usually marked by contrasting layers of coarse and medium textures (WR 28). Similar soils, although less clearly stratified and lacking coarse textured layers, are associated with a subdued level adjoining the highest terrace level and extending as far west as Al Arbain (WR 38). Profile WR 13 is characteristic of soils confined to channel beds associated with the ill-defined natural drainage network which contributes, south of Wadi Rima, to the head waters of Wadi Uqash. These medium textured profiles are frequently interstratified with gravel layers. The beds of Wadi Rima and the main radial drainage axes of the fan are composed of subrounded gravel, stones or boulders with an increasing proportion to the west of medium and coarse sand.

The alluvial plain, bordered to the north and south by aeolian deposits of fine sand, has been subject, during historical times, to both natural and anthropic deposition. The distribution of sediments and their variability are far more complex than that of the alluvial fan and for most of the area are related to past changes in the courses of Wadi Rima and Wadi Uqash. During April, 1976, an exceptionally large spate flow in Wadi Rima flooded over 10 km² of land bordering the Wadi between Bani Jammal and Al Madaniyah depositing sediment, predominantly fine sand and silt, up to 20 cm thick and exemplifying the process of sediment accumulation characterised by the stratified soils of the alluvial plain. Figure 2 illustrates the change in the clay and silt-plus-clay fractions with depth in a stratified profile.

A small proportion of soils show a sufficient uniformity in texture to suggest an anthropic mode of origin. Their widest distribution is in the area fringing the alluvial fan east of the Taiz-Hudaydah highway (WR 1, WR 10, WR 11, WR 17) becoming less common to the west (WR 4) where they probably identify sites at one time served by regular wadi irrigation.

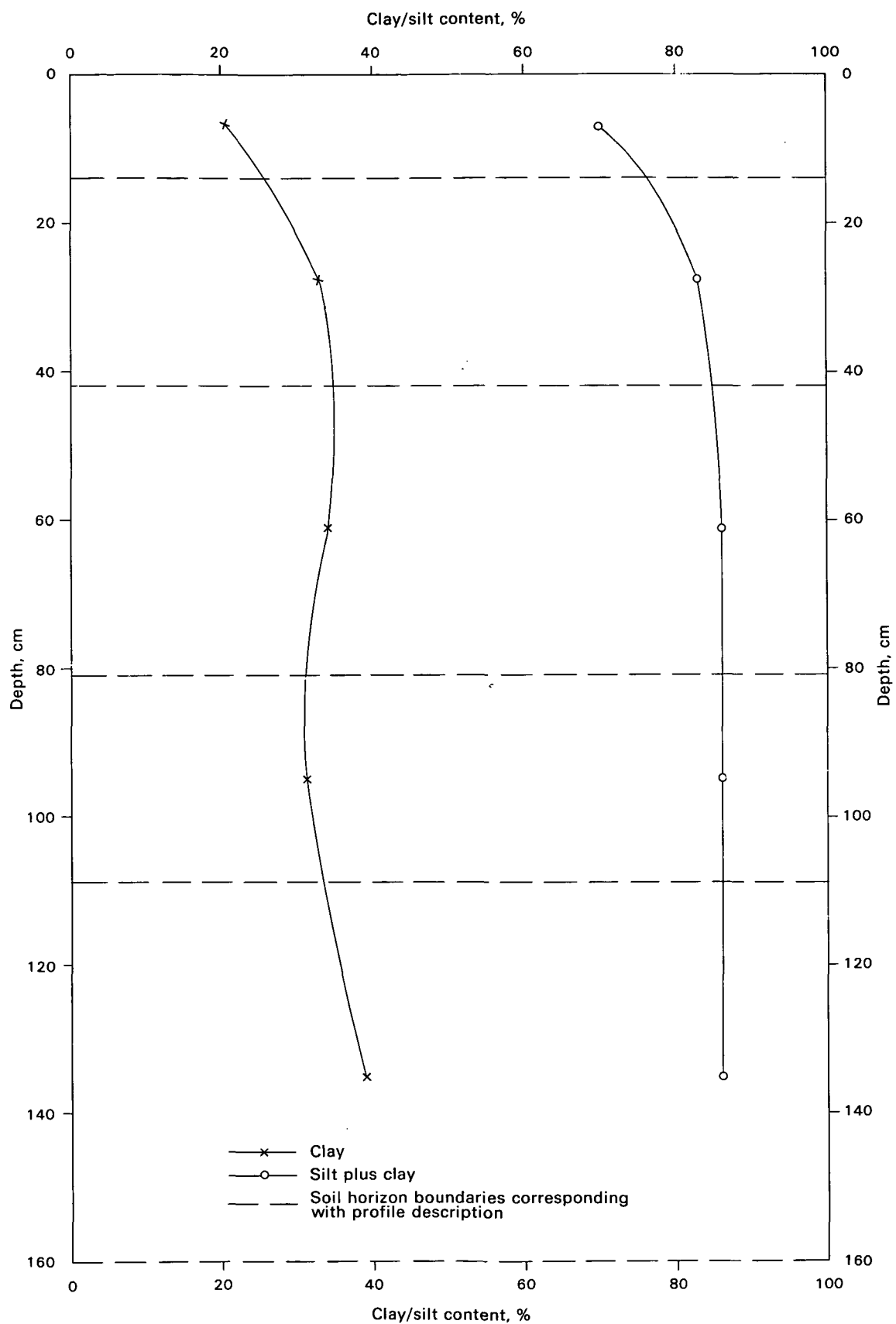


FIGURE 1 Variation in clay and silt-plus-clay contents with depth: Profile WR8, Habaq Series

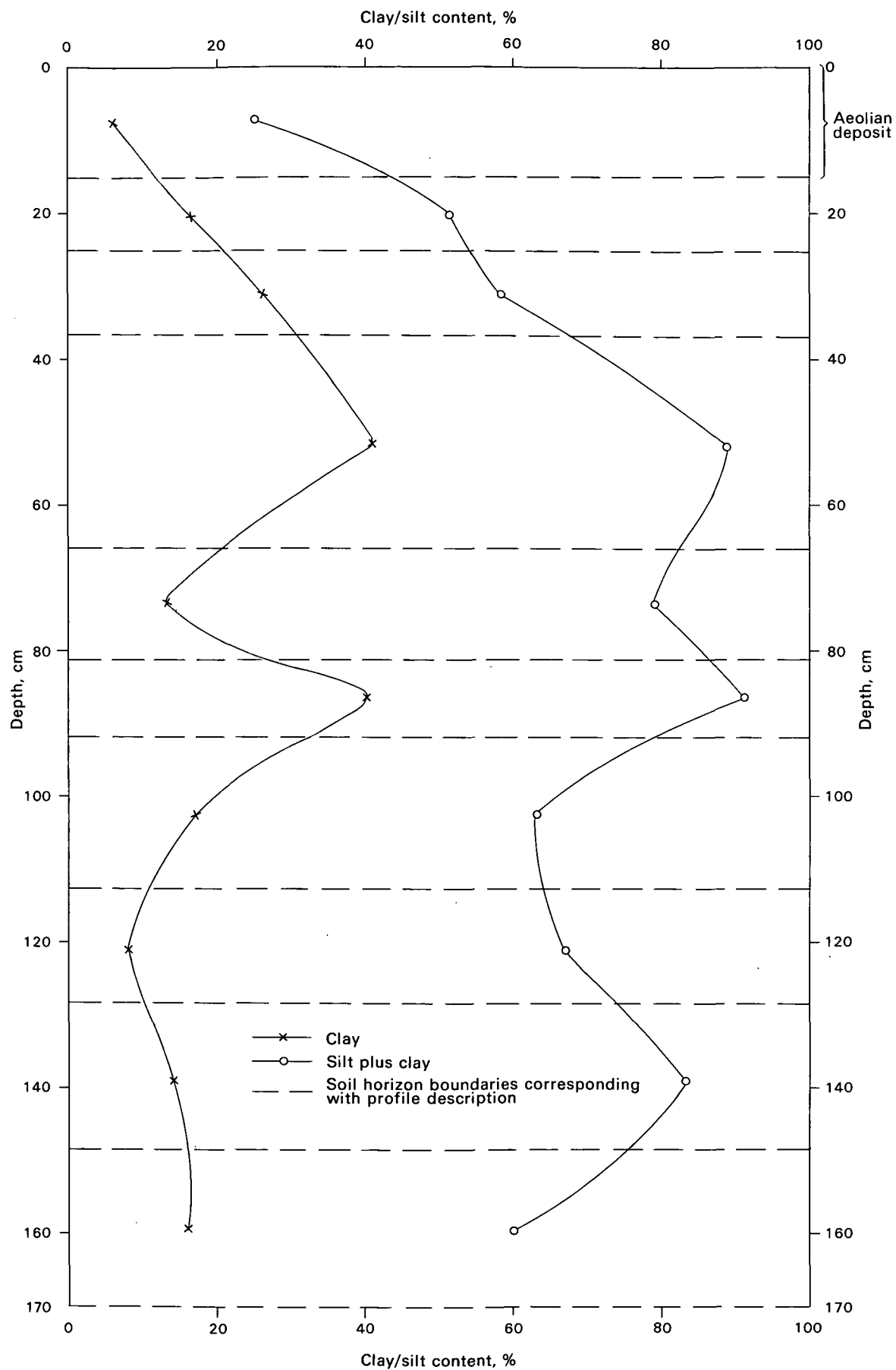


FIGURE 2 Variation in clay and silt-plus-clay contents with depth: Profile WR20, Maḥaṭṭ Series

Soils showing very weak textural contrast or stratification compared with those elsewhere on the alluvial plain occur within three areas, straddled by the main highway, west of Al Husayniyah, Al Junaydiyah and Dar Ban. The uniform fine sandy loam profiles, as represented by WR 2, WR 6, WR 15, WR 40 and WR 41, have a distinctive particle size distribution with low, <30%, silt contents. Very similar material occurs at depth in several profiles (e g WR 17) fringing the three areas and is probably the oldest alluvium exposed in Wadi Rima.

The alluvial plain is affected throughout the year by the encroachment and redistribution of aeolian sand originating from peripheral boschen dune complexes. Apart from the period between April/May and August/September when the prevailing wind is from the N-NW, the principal direction of movement is from S-SW. Overblown deposits of loose fine sand, loamy fine sand or occasionally, fine sandy loam are prevalent immediately south of Al Qurshiyah and south and south east of Al Murrah (WR 2, WR 20) but are progressively less common towards Al Madaniyah where high dunes stabilised by Salvadora fringe Wadi Uqash and Wadi Rima where they act as a natural windbreak for the leeward cultivated land. Salvadora and to the east Acacia stabilise a microrelief of aeolian hummocks scattered over the alluvial plain.

The soils around Al Mujaylis have developed within alluvio-marine sediments, probably originally deposited in a coastal sabkha. Textures are predominantly medium and fine, (WR 23, WR 24), although an extensive area has been modified by sand encroachment from shoreline deposits resulting in a superficial and cover of variable thickness partially stabilised, particularly to the east, by Odyssea

Soil depth

The effective depth of most soils exceeds 280-290 cm as indicated by deep auger borings. Very shallow soils, associated with rock outcrops, occur on the mountain footslopes but within the surevey area, these are restricted to small rock outliers, wadi beds and areas of gravel or coarser alluvium fringing terraces adjacent to Wadi Rima. Deposits of gravel or stones

probably underlie most of the alluvial fan, frequently occurring within 2 metres of the surface east of Al Humarah (WR 35). Farther west, coarse alluvium within this depth is uncommon and from the few shallow profiles described and exposures observed in deep gullies north of Al Jarubah, these deposits appear to thin gradually and form discontinuous lenses.

The majority of soils fringing the upper reaches of Wadi Badwah have a nodular or massive carbonate horizon, often cemented, within 1 metre of the surface (WR 9). Erosion along the banks of the wadi has exposed a petrocalcic horizon, quarried, at several localities, for conversion to quicklime. Nodular carbonate concretions occur at depth in other soils, usually with a uniform, fine sandy loam profile (WR 6, WR 15, WR 40) located north and south of Wadi Badwah.

Bordering the coast, particularly around Al Tayfaf and Al Mujaylis, effective soil depth is limited by depth to the watertable ranging from 0.5 m to 3.5 m and frequently at less than 1 m depth (WR 23).

Soil colour

Pedogenic processes which modify soil colour are weakly expressed in Wadi Rima as a result of the arid climate and the recent deposition of much of the alluvial sediment. Colour generally reflects that of the parent material in the absence of a well developed B horizon and any significant accumulation of organic matter. Light yellowish brown, dry (Munsell notation 10YR 6/4) to dark yellowish brown, moist, (10 YR 4/4) colours are usual throughout the profile without any marked variation with change in texture.

Free carbonate is evident in most fan soils and the finer textured layers of alluvial plain soils as white pseudomycelia occurring below the surface horizon but contributes to the matrix colour of the soil only in the few cases, (e g WR 40), where it has formed a continuous impregnation of the soil mass, usually associated with nodules or weak cementation, giving a very pale brown, dry, (10 YR 7/3) to yellowish brown, moist, (10YR 5/4) colour. A dark, brown, (10YR 4/3 to 10YR 3/3, horizon is occasionally found overlying a zone of carbonate accumulation but this variation is more usually associated with weathering melanocratic gravel within soils of the alluvial fan

(WR 25, WR 26). Concentrations of iron oxides, principally magnetite derived from weathered basic igneous rocks of the catchment, probably cause the darkening of these horizons and are also found as scattered deposits of black volcanic beach sand along the coast.

Soil mottling is uncommon, restricted to occasional rusty interlamellar mottling in fine textured horizons with slightly reduced vertical permeability, in stratified soils (WR 5) and to gley and oxidation mottles in soils with a high watertable near the coast (WR 23, WR 24).

Soil structure

Sedimentary structure is the most obvious feature in soils west of the alluvial fan with stratified, relatively homogeneous layers, up to 30 cm thick, forming a sequence of flood deposits. In many profiles, the finer textured layers have a platy structure alternating abruptly with coarser, structureless layers (WR 5, WR 39). The disturbance of the surface to a depth of about 50 cm, by cultivation and root ramification has resulted in a mixing of soil layers and the inclusion of platy silt loam and silty clay loam fragments within a structureless matrix of coarser sediment (WR 19).

Following the major spate flow of April, 1976, an extensive area was covered by a surface layer of fissile, polygonally cracked silt loam resulting from dessication of the sediment left by the uncontrolled floodwater. Layers with a similar texture and cracking pattern were noted at depth in several profiles (e g WR 39) usually with the cracks infilled by material from the overlying layer.

The majority of alluvial fan soils show evidence of structural development unrelated to deposition layering, usually in the form of a cambic B horizon. Surface horizons of loam or finer are often platy transitional downwards to a weak to moderate angular blocky structure which may coarsen with depth, tending to prismatic or a loss of structure. Horizon boundaries are clear to gradational. Occasionally, disoriented platy silt loam fragments, less than 3 cm in diameter, occur within a matrix of similar texture.

Consistence, porosity and bulk density

Soil consistence varies according to texture, the majority of medium textured soils being friable when moist and slightly hard when dry. With a high silt or clay content, consistence may be firm (moist) and hard (dry) although under field conditions most soils were described as slightly moist and the latter consistence was attained only under airdry conditions. A few horizons have a hard, brittle consistence as a result of weak to strong cementation by calcium carbonate. This may be in the form of a continuous cemented horizon up to 50 cm thick (WR 9), locally exposed in an indurated form along the banks of Wadi Badwah or as partial cementation of aggregates of calcareous nodules as in WR 40.

Most of the profiles which were examined appeared to be very porous with many tubular pores of less than 1 mm diameter ($>500/\text{dm}^2$) plus a few ($<10/\text{dm}^2$), of larger diameter usually as a result of soil faunal activity. Termite and ant workings are common with associated voids up to 5 cm diameter and, in regularly irrigated areas of the fan, surface horizons may contain a high proportion of annelid fecal pellets (WR 30). A reduced porosity is apparent in some fine textured platy layers in stratified soils where voids are restricted mainly to horizontal inter-lamellar planes resulting in a reduced vertical permeability. Towards the coast, saline-sodic soils with a high watertable, have a low porosity due to clay dispersion. In a few irrigated soils on the alluvial fan, a very porous, vesicular layer about 5 cm thick was described directly underlying a slightly hard surface skin, 1-5 mm thick, of low porosity, a similar surface characteristic to that described by Evenari *et al* (1974) in comparable soils elsewhere.

Bulk density determinations for several different textural classes and soil types are shown in Table 2. Values range from 0.90 g/ml (silty clay loam) to 1.67 g/ml (fine sandy loam). Variation is principally related to texture although differences related to soil type appear to be important. High bulk densities, relative to those for similar textures elsewhere in the wadi, are evident for the uniform sandy loam soils as represented by WR 41. Similarly, for silt loam-silty clay loam samples, values are higher in the uniform soils of the alluvial fan than in the stratified deposits further west. Possibly these differences reflect an age relationship with higher densities indicative of increasing profile maturity.

Particle density was determined on 26 samples and gave a mean value of 2.73 g/ml, (range 2.69-2.77 g/ml). A bulk density of 1.37 g/ml corresponds,

therefore, to a total porosity of approximately 50%. The particle densities are unusually high, as in the case in Wadi Zabid (Tesco-Viziter-Vituki, 1971), and this appears to be due to the presence of high specific gravity primary oxides of iron, comprising up to 10% of the soil. A black beach sand sampled near the mouth of Wadi Rima proved, on petrographic analysis, to consist of magnetite and ilmenite (60%), garnet (15%), olivine and pyroxene (15%) and quartz, feldspar, carbonate (10%) with trace amounts of zircon, rutile and copper secondaries (Harding, 1977).

Soil-water relationships

Of the soil physical characteristics described in this part, texture and stratification of the soil profile have, by far, the strongest influence on soil-water behaviour. Infiltration rates were obtained using either double cylinder infiltrometers or direct measurements from flooded plots with at least three replications at each site. Changes in soil-water content were monitored with a neutron probe providing an assessment of soil-water availability from wet (field capacity) and dry (wilting point) profiles under local crops.

In general, the soils with the lowest rates of infiltration and highest levels of available water occur on the alluvial fan. Initial infiltration rates are variable, 40-100 mm/hr, depending on the condition of the soil surface and soil moisture content, decreasing to 30-60 mm/hr after one hour and subsequently remaining fairly constant at the five hour rate of 10-40 mm/hr. The available water holding capacity of these soils is within the range of 150-220 mm/m. Figure 3 shows the change in water content with depth and time during a crop water extraction cycle.

Textural variation in the soils of the alluvial plain is reflected by a broader range in moisture characteristics. The depth and the contrast in textures of individual layers within stratified soils have an important effect on infiltration rates and water holding capacities. Field capacities are usually higher than would be expected from the summation of the contributions of each layer determined by laboratory measurement. The effect of interstratified coarse and fine textured layers is clearly shown by the soil moisture profiles in Figure 4. Initial infiltration rates for most

TABLE 2 Bulk density

Location and texture		Depth, cm	Observed bulk densities, g/ml	Mean, g/ml
Nr Al Ghawadir	ZL	10-15	1.18, 1.23	1.21
	ZL	25-34	1.32, 1.23	1.27
	ZL	40-45	1.38, 1.37, 1.32	1.36
	ZCL	58-63	1.34, 1.40, 1.47	1.40
	ZCL	98-103	1.30, 1.35, 1.33	1.33
	ZCL	109-114	1.37, 1.38	1.37
WR 8	L	5-20	1.39, 1.37, 1.36, 1.37 1.39, 1.39	1.38
	ZCL	25-40	1.51, 1.52, 1.45, 1.46 1.43, 1.43	1.47
	ZC	52-67	1.47, 1.46, 1.47, 1.47 1.51, 1.52	1.48
	ZCL	80-95	1.45, 1.45, 1.45	1.45
Nr WR 39	LfS	115-138	1.47, 1.42	1.45
	ZCL	158-181	1.06, 1.01, 1.01	1.03
Nr WR 39	ZCL	146-158	0.90, 1.00	0.95
	fSL	183-213	1.32, 1.32	1.32
	ZL	213-227	1.24, 1.19	1.21
	fS	227-265	1.63, 1.62	1.63
Nr WR 41	fSL	5-20	1.48, 1.49, 1.50	1.49
	fSL	30-45	1.54, 1.61, 1.61	1.58
	fSL	50-65	1.62, 1.62, 1.61	1.62
	fSL	70-80	1.63, 1.62, 1.62	1.62
Nr WR 41	fSL	5-20	1.51, 1.46, 1.45	1.47
	fSL	30-45	1.59, 1.60, 1.61	1.60
	fSL	50-65	1.58, 1.64, 1.61	1.61
	fSL	70-85	1.61, 1.62, 1.65	1.63
Nr WR 41	fSL	0-15	1.41, 1.39, 1.44	1.41
	fSL	25-40	1.55, 1.53, 1.53	1.54
	fSL	45-60	1.64, 1.56, 1.63	1.61
	fSL	68-83	1.62, 1.62, 1.67	1.64

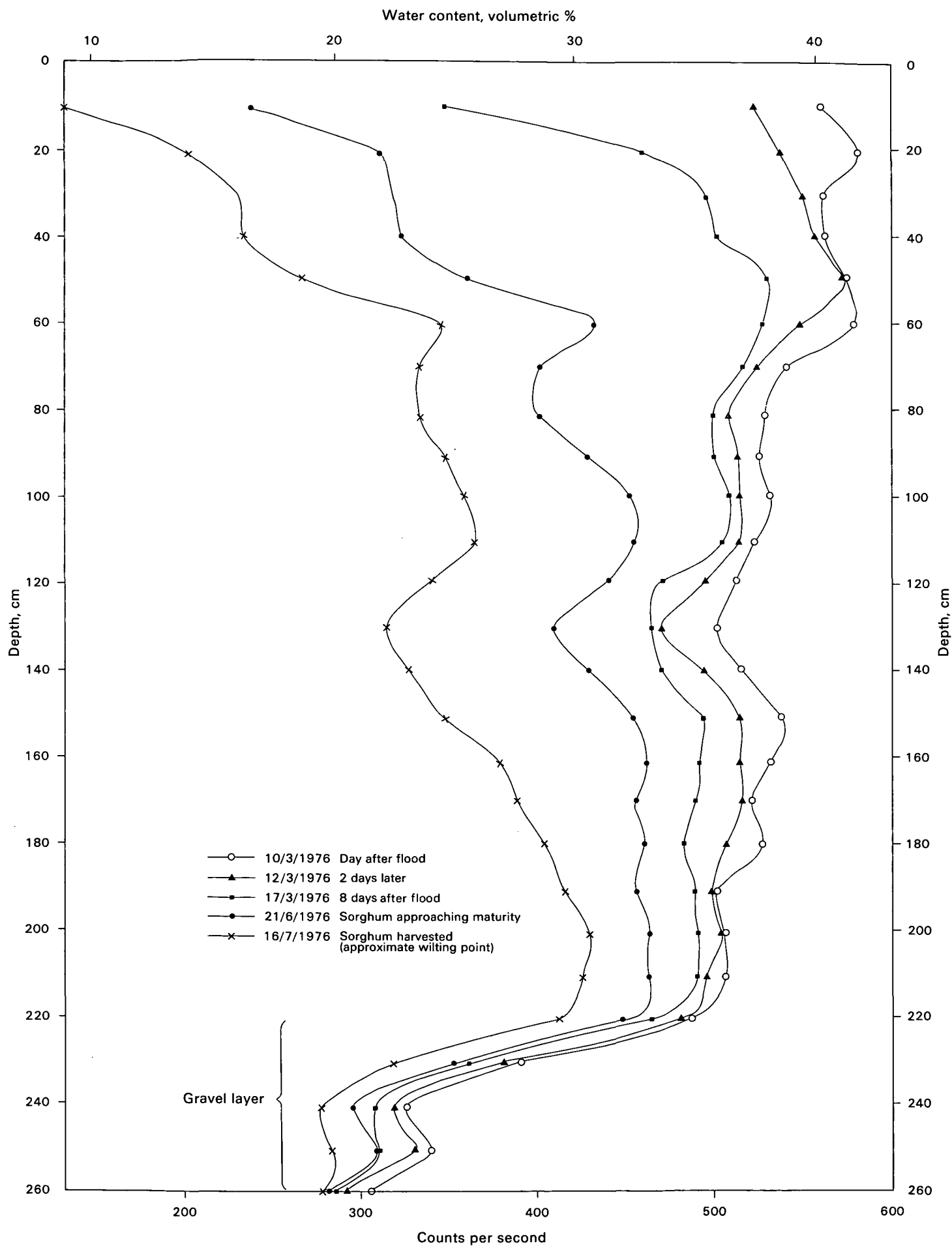


FIGURE 3 Change in soil water content with depth and time during crop growth at a site near Al Ghawādir

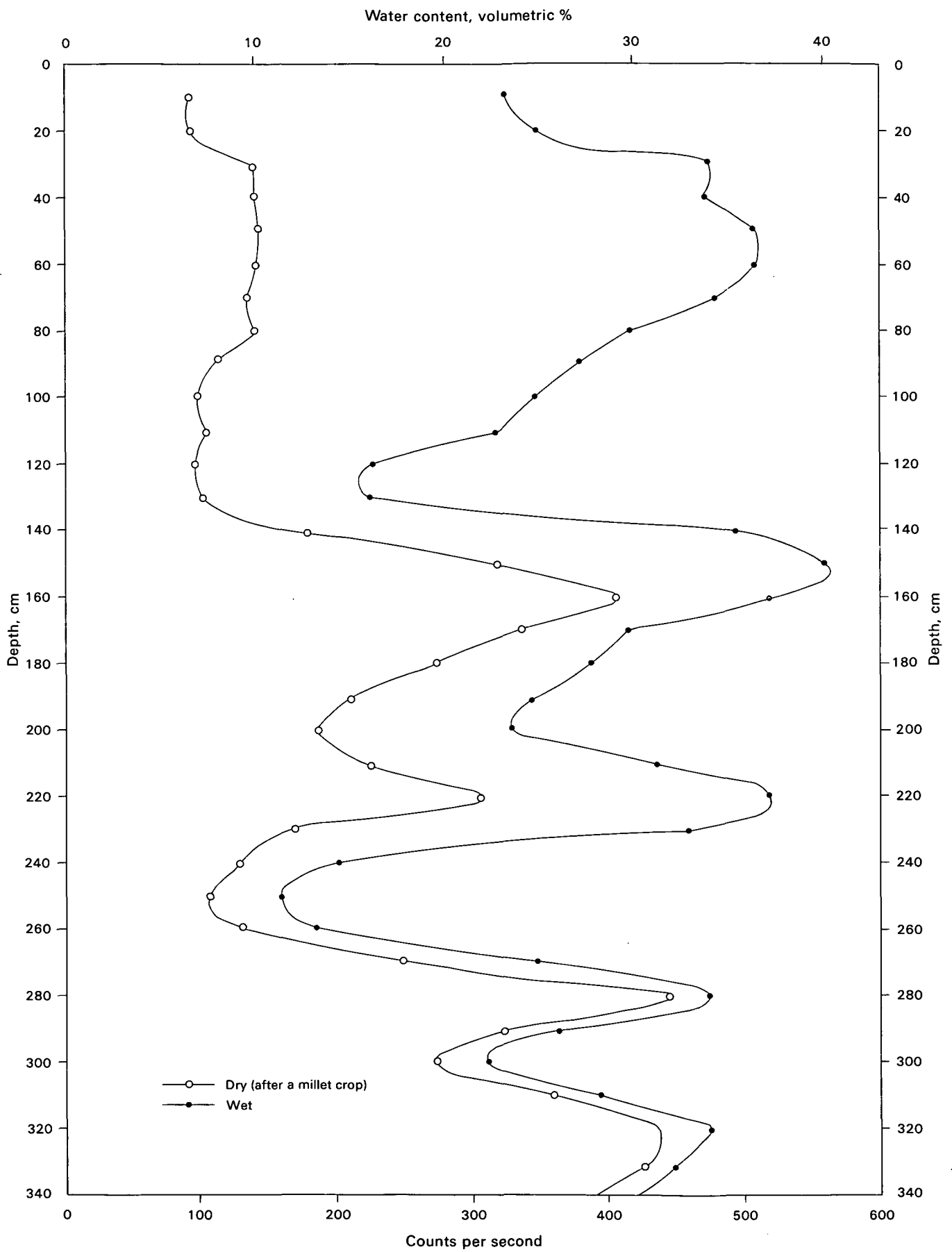


FIGURE 4 Change in soil water content with depth in a profile near WR 39 at Madaniyah

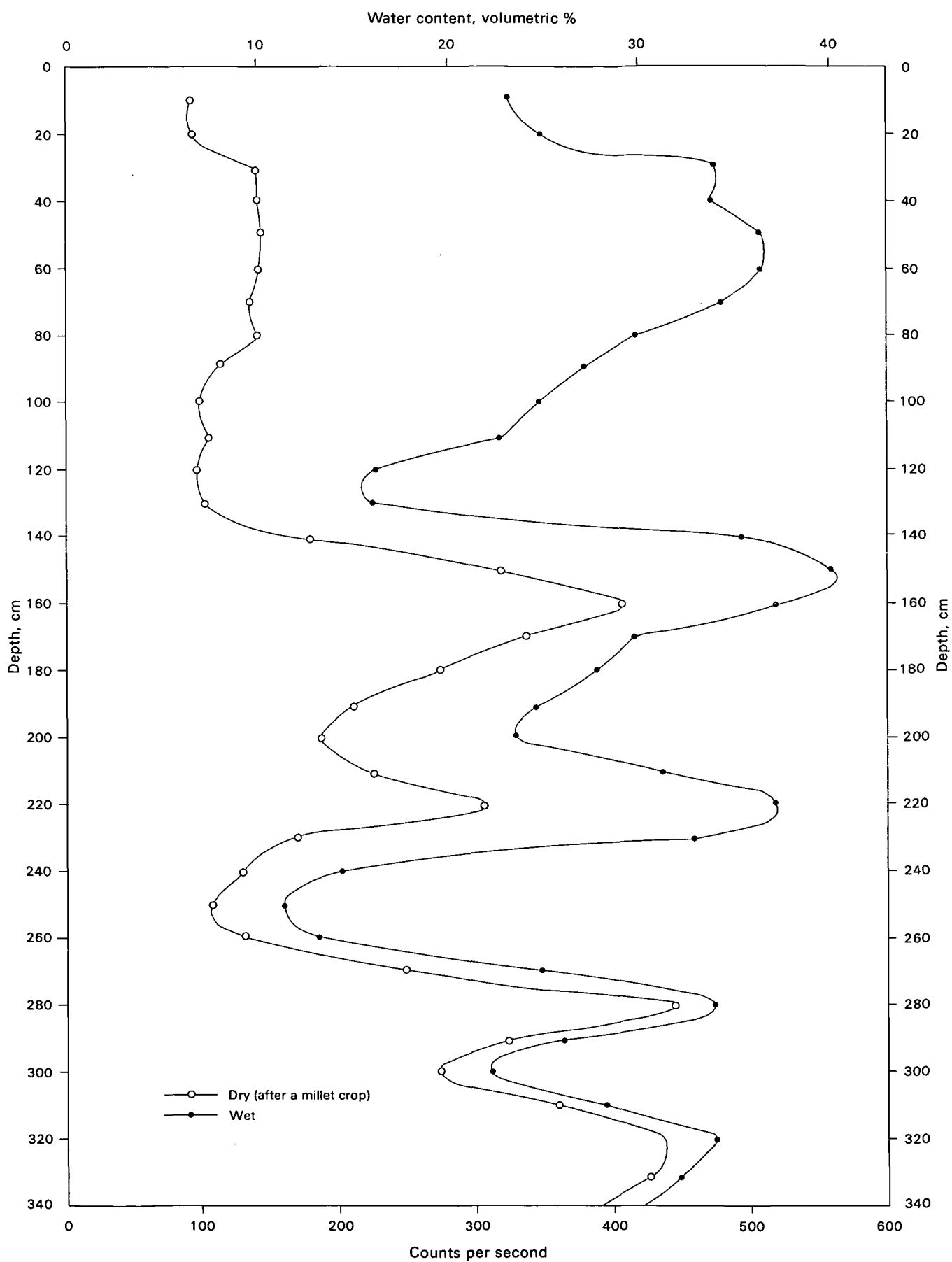


FIGURE 4 Change in soil water content with depth in a profile near WR 39 at Madaniyah

soils vary within the range of 40–200 mm/hr decreasing to a constant rate of 30–80 mm/hr after one hour. Available water capacities, between 130–200 mm/m, are characteristically variable even within individual fields reflecting lateral changes in profile texture and stratification. Coarser textured soils, with a predominance of sandy loam or coarser material within the top metre of the profile, often maintain rates exceeding 100 mm/hr after infiltration for one hour and have low levels of moisture retention, frequently less than 120 mm/m. This section provides an extract from data presently available on soil-water relationships in Wadi Rima. The results of further investigations, currently in progress, will be published as a separate report (Williams, 1979).

SOIL CHEMICAL PROPERTIES

Soil reaction (pH)

All the sampled soils have an alkaline reaction with a range in pH between 7.0 and 10.3 although the measured pH value for a particular sample may vary by as much as two units depending on the suspension medium used. For these soils, measurement in 0.01M CaCl_2 , in preference to water or 1M KCl, appears to be the best method with pH values equal to or greater than 8.0 correlating fairly well with an exchangeable sodium percentage of 15 or more.

Cation exchange characteristics

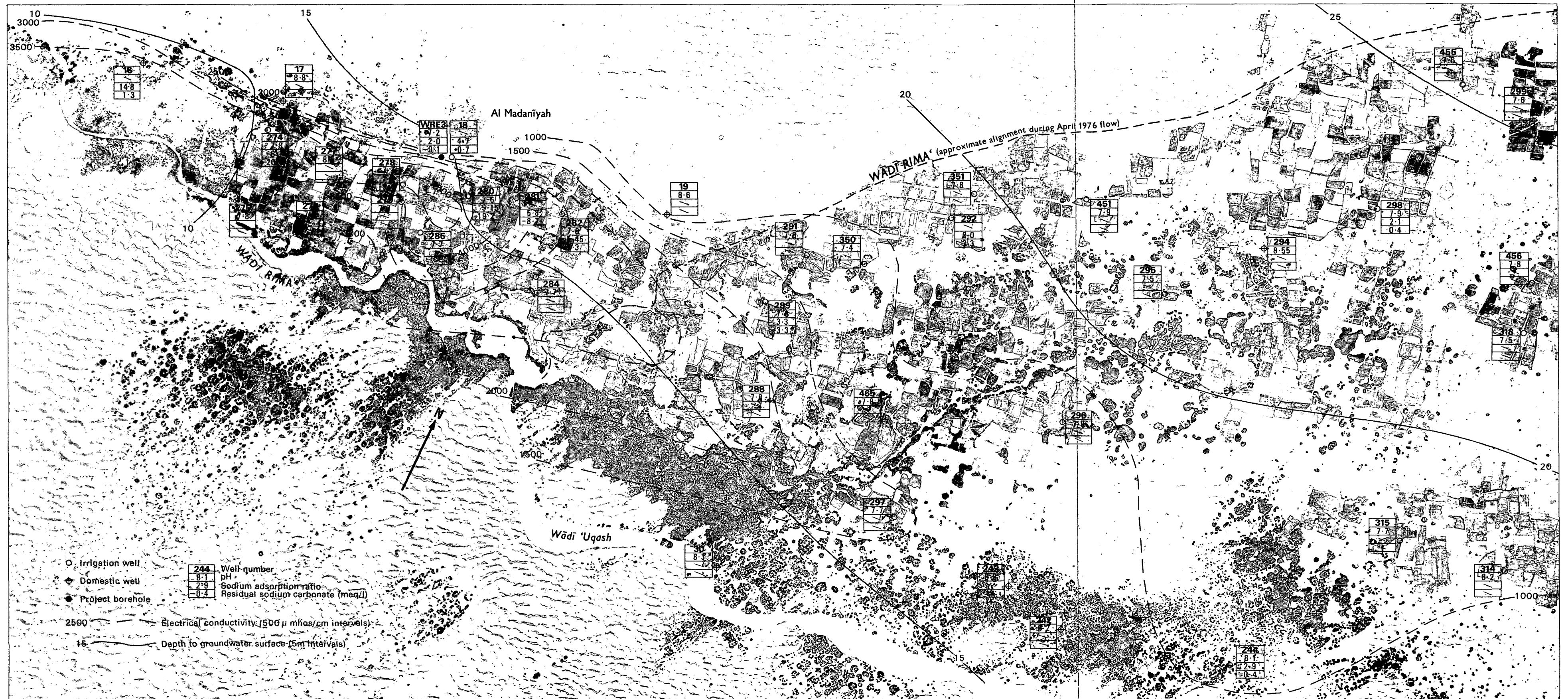
The cation exchange capacities (CEC) of most soils lie in the range 15–30 meq per 100 g of soil (meq%). In the absence of any significant accumulation of organic matter, the CEC depends principally on the fine silt and clay content of the soil. The relatively high exchange capacities suggest a mixed 2:1 layer clay mineralogy.

All soils are base saturated with an exchange complex dominated by calcium and magnesium. Due to the presence of free calcium carbonate, all measurements of exchangeable calcium are unrealistically high, incorporating a proportion of non-exchangeable calcium. Levels of exchangeable potassium are medium to high, generally exceeding 0.2 meq%. Exchangeable sodium levels

increase west of the alluvial fan, a result of irrigation with saline groundwater occasionally having a high sodium absorption ratio (Text maps 4a, 4b). The levels are usually between 1 and 2 meq% but at some sites south of Al Madaniyah may be over 3 meq% constituting more than 15% of the exchange capacity (WR 5, WR 39). Despite these high levels of sodium, the soils do not exhibit any associated deterioration of physical properties and no obvious reduction in crop yields has been observed. The maintenance of reasonable soil qualities under these conditions may be explained by the moderately low clay contents of the soils (< 30% clay), their salinity (saturation extract conductivity > 6 mmhos cm⁻¹) and the relatively short period during which pump irrigation of tolerant crops has been practiced, much of the area having only been brought under irrigation in the past decade. Comparison of the soil analysis at an uncultivated site (A351) with that of an irrigated soil nearby (A350) gives an indication of the chemical change induced by groundwater irrigation. Towards the coast, particularly around Al Mujaylis, toxic levels of exchangeable sodium are associated with areas of shallow depth to high SAR groundwater.

Soil salinity

As measured by the electrical conductivity of 1:5 soil:water suspensions, the salinity levels of the cultivated soils of the alluvial fan are low, usually less than 0.2 mmhos cm⁻¹, although at uncultivated sites where runoff is normally high (WR 44) subsurface horizons are generally saline with conductivities around 1 mmho cm⁻¹. West of the fan, the soils tend to be more saline but marked variation is found between sites (depending, if irrigated, on groundwater quality and time of sampling) and between horizons of individual profiles, salinity increasing with fineness of texture. High conductivities recorded for cultivated soils south of Al Madaniyah have developed through irrigation with very poor quality groundwater confined to this particular area (Text maps 4a, 4b). Around Al Mujaylis, where the soil surface is within the capillary zone of the watertable, high evaporation and very low rainfall have resulted in salt efflorescence and very high salinity within the surface 15 cm (WR 23, WR 24). During a dust storm at Zabid, located south of Wadi Rima but with soils similar to the Al Mahatt area (Tesco-Viziter-Vituki, 1971), a sample of windborne material was collected for analysis (WR 45) and proved chemically similar to the uncultivated, saline soils west of Al Madaniyah (A351) suggesting a movement of salts through transport by the prevailing westerly winds.



TEXT MAP 4B 1:20,000 (APPROX) Al Madaniyah groundwater: Quality, and depth to groundwater surface (May 1976)

Carbonates, gypsum and boron

All the soils are calcareous usually with less than 10% carbonate evenly distributed through the profile. In a few profiles where calcium carbonate has accumulated as a nodular or massive subsoil horizon, the proportion may exceed 15% (WR 6, WR 9, WR 40). Mechanical analysis with and without removal of the carbonate in samples from WR 8, WR 21, and WR 39 show that the carbonate particles are distributed through the fine sand, silt and clay fractions. Indications of active precipitation of calcium carbonate, suggesting a progressive increase in alkalisation, are found in soils with a high watertable around Al Mujaylis.

Low contents of gypsum, around 0.02%, are present in the alluvial plain soils and are probably lower still on the fan (WR 33). Sodium chloride and sulphate are the main salts of the coastal saline-sodic soils, with gypsum absent in the surface metre (WR 23, WR 24). The uncultivated soils west of Al Madaniyah contain about 1% gypsum (A351) contrasting with the much lower levels in adjacent irrigated soils (A349, A350).

With the exception of saline-sodic-soils which have toxic levels exceeding 6 ppm, boron is possibly deficient in the topsoils analysed (WR 2, WR 4, WR 6, WR 8) which have contents less than 1 ppm.

Available phosphorus

Available phosphorus, as measured by the method of Olsen, is low, usually less than 5 ppm, probably due to the presence of relatively insoluble tricalcium phosphate. Slightly higher values are found in profiles with a moderate accumulation of organic matter in the surface horizon (WR 30) and in sodic soils where the availability derives from the presence of more soluble sodium phosphates (WR 23, WR 24, WR 39).

Soil organic matter

Organic matter was estimated by multiplying the organic carbon percentage by a factor of 1.72. All results are extremely low, with only two exceeding 1% organic carbon. This is normal considering Wadi Rima climatic conditions

but it appears that moderate levels of soil organic matter may be maintained under a system which maximises the period of crop cover as in the case of the regularly spate irrigated areas towards the head of the alluvial fan. This relationship between cropping intensity and fertility through organic matter conservation is the opposite to that applying under more humid climates but is probably the case throughout the arid and semi-arid tropics.

The total nitrogen in the soil is related to the soil organic matter and only two profiles show levels higher than 0.1% (WR 30 WR 33).

Total contents (phosphorus, potassium and magnesium) and trace elements

Total phosphorus is at a high level exceeding 1 000 ppm in about half the profiles analysed. The levels of total potassium are moderate usually between 4 000 and 10 000 ppm, but with lower contents occurring in the coarsest textured soils. Total magnesium is very high, generally exceeding 10 000 ppm almost certainly due to the presence of a minor proportion of free magnesium carbonate.

Trace element levels are reasonable and vary very little between soils.

Copper contents are between 20 and 50 ppm, manganese between 500 and 1 500 ppm.

SOIL CLASSIFICATION AND DISTRIBUTION

The soils of Wadi Rima do not show any well developed morphological features resulting from pedogenetic processes. Series differentiation has therefore been based mainly on differences in soil texture and profile stratification, characteristics which are derived directly from the soil parent material and can be mapped with the help of an understanding of the depositional history of the wadi.

It was intended that the classification criteria should reflect differences in soil-water characteristics, particularly relevant to irrigation suitability in Wadi Rima. From the range in field capacity and wilting point determinations for four of the main soil series shown below, it is clear that texture is of primary importance.

TABLE 3 Range in field capacity and wilting point for four soil series

Soil series	Field capacity (mm/m)	Wilting point (mm/m)
Isabah	354 - 394 (8)*	145 - 195 (8)
Madan	280 - 320 (10)	115 - 155 (10)
Husayniyah	200 - 250 (8)	80 - 120 (8)
Mahatt (stratified)	280 - 324 (7)	94 - 147 (7)
* Number of observations in brackets		

Madan Series

Soils of the Madan Series have profiles to 100 cm composed of horizons of silt loam with up to 50% finer textures. Profile stratification is absent although disoriented platy fragments of sedimentary origin may be present in the same horizons. The B horizon is sufficiently altered to warrant classification as cambic. Below the surface horizon, pores and ped faces are partially coated by white carbonate pseudomycelia.

Madan Series is the principal soil of the alluvial fan and valleys of the mountain footslopes occupying extensive areas of both rainfed and irrigated land. Shallow soils overlying gravel or coarser alluvial deposits occur towards the head of the fan but are restricted to the valleys, terrace edges flanking the upper reaches of the wadi and a narrow strip extending north of Bani al Habili parallel to the mountain front. The only significant area of these soils not cultivated is around Al Kadadif where surface runoff to farmland further west has resulted in moderate to severe rill and gully erosion. A small proportion of alluvial plain soils have been classified as Madan Series at sites which appear to have been at one time regularly irrigated from Wadi Rima or Wadi Uqash and were less prone to the accumulation of sediment from uncontrolled flooding.

Habaq Series

The Habaq Series is closely associated with soils of the Madan Series differing only in being relatively finer textured with a clay loam, silty clay loam, silty clay or clay profile to 100 cm depth with up to 50% loam or silt loam textures permissible. The surface is normally loam.

Isabah Series

The textural limits for this series are as for Habaq Series although typically the proportion of loam or silt loam is likely to be less with a silt plus clay content generally exceeding 90%. Apart from a small proportion of disturbed platy fragments, profiles are very uniform with a surface texture usually silty clay loam or finer. A very weak cambic B horizon may be present but in many profiles there is no evidence of alteration. Carbonate pseudomycelia are absent, although the profiles are calcareous. Organic matter contents are high compared with the Madan and Habaq Series often averaging over 1% in the surface 50 cm of soil. Evidence of earthworm and termite activity is found throughout the profile and on the soil surface where wormcasts and fecal pellets have accumulated.

These soils are restricted to the lower wadi terraces downstream of Mishrafah and the alluvial fan around Al Ghawadir and Isabah, areas of regular spate base flow irrigation where the anthropic contribution to sedimentary deposition is most marked.

Husayinyah Series

The Husayinyah Series is a uniform fine sandy loam soil to 100 cm showing no evidence of stratification. A cambic B horizon is present together with well defined carbonate pseudomycelia which may grade into a zone of carbonate nodules in the lower subsoil.

This is a distinctive soil which has been mapped as several units adjacent to the main Zabid-Hudaydah road. Apart from a small area of pump irrigation, most of these soils are uncultivated or planted opportunistically. Mobile dunes or drifts, surface deposits of overblown sand or loamy sand and, on the north bank of Wadi Rima, severe erosion has restricted their use for arable farming.

Badwah Series

Badwah Series is a soil of variable texture, usually stratified, which includes a cemented calcic horizon at least 15 cm thick within 100 cm of the surface. Faint mottling is usually present below the calcic horizon.

The series is limited to an area around the headwaters of Wadi Badwah where the concentration of calcium carbonate appears to form a discontinuous layer exposed intermittently along the eroded banks of the wadi and in several pits where the carbonate is quarried for conversion to quicklime.

Mahatt Series

Textural variation both between and within profiles is characteristic of the Mahatt Series. Stratification is prominent with clear or abrupt boundaries to layers corresponding to successive flood deposits. Texture has been defined as loam or finer in 50% or more of the profile to a depth of 100 cm. No diagnostic horizons have developed apart from, occasionally, a weak A horizon. Carbonate pseudomycelia if present are restricted to the finer textured layers and are not usually continuous with depth.

Apart from the wadi terraces between Al Mafsal and Ad Dimnah, the Mahatt Series is restricted to and is the most widespread soil on the alluvial plain. The association with soils of the Madan and Habaq Series, in areas adjoining the alluvial fan, lessens westwards: beyond Al Mukhayrif an increasing proportion of overblown soils, dunes, drifts and stable hummocks occurs. West of Al Qurshiyah, many of the soils are naturally saline and slightly sodic.

Murrah Series

The Murrah Series is morphologically similar to the Mahatt Series differing only in the proportion of coarser textures with more than 50% of the profile to 100 cm consisting of sand, loamy sand or sandy loam.

This soil has a similar distribution to that of the Mahatt Series but also extends in association with hummocks stabilised by Salvadora parallel to the lowest reaches of Wadi Rima, almost as far as the coastline. Text Map 5 shows the detailed distribution of the Mahatt and Murrah Series along a sample strip between Wadi Badwah and Wadi Rima, just west of Al Murrah.

Mujaylis Series

Soils of the Mujaylis Series are imperfectly to poorly drained with ground-water at depths varying between 50 cm and 350 cm. Texture is variable but all the soils are sodic and saline, particularly the surface horizon.

These soils have developed from alluvio-marine sediments near the mouth of Wadi Rima and further south around Al Mukaylis

MAPPING

The soil series defined above have been mapped mostly as associations and delineated by 27 mapping units on the 1:50 000 soil map (separate Map 1). In addition to miscellaneous land types, comprising active dunes/drifts, partially stabilised dunes or stable hummocks, the map legend includes several soil phases which are defined below:

Moderately shallow: soils overlying 60% or more gravel or coarser alluvial deposits between 50 cm and 100 cm below the soil surface

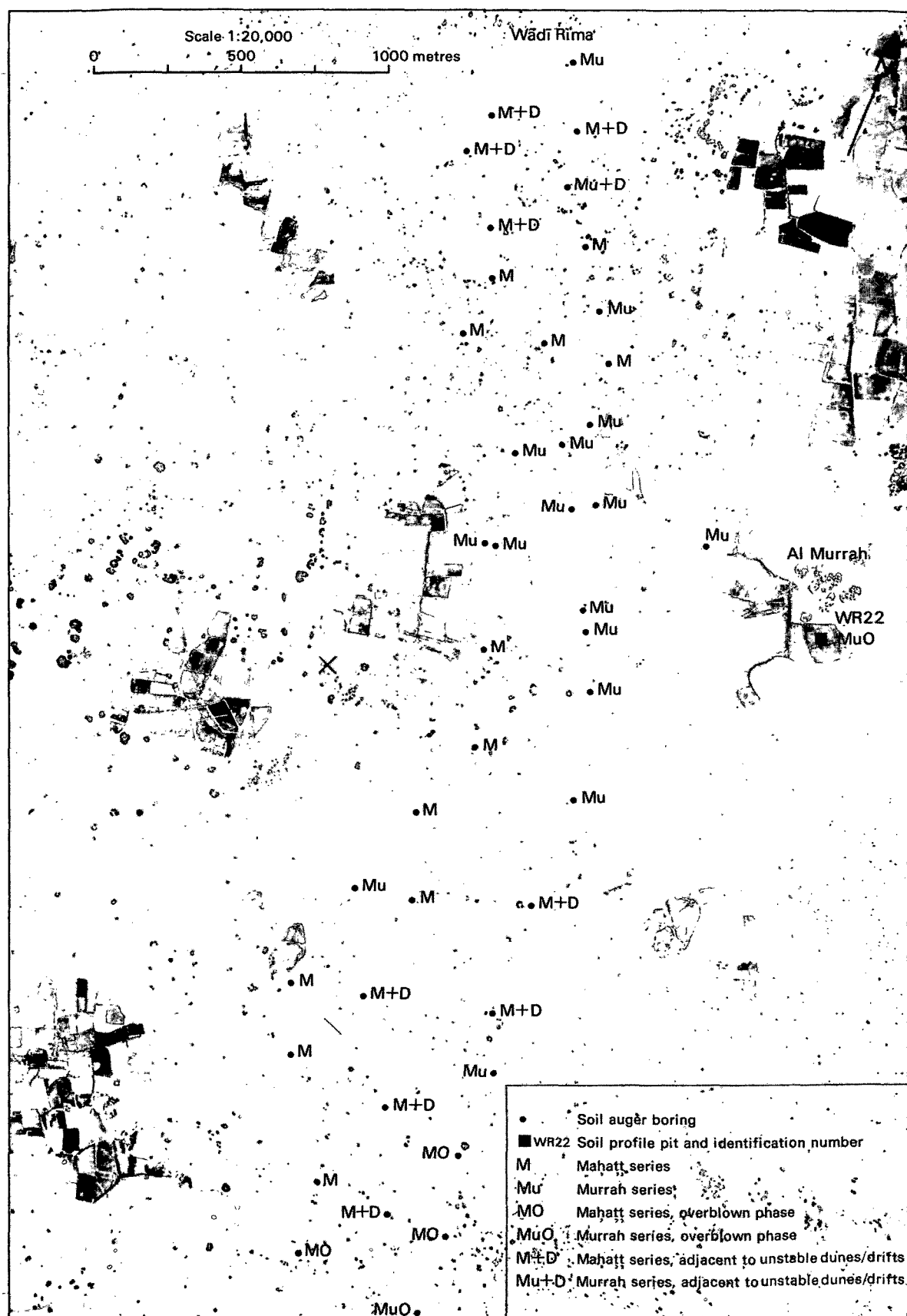
Shallow: soils overlying 60% or more gravel or coarser alluvial deposits within 50 cm of the soil surface

Overblown: stable surface wind deposits of sand, loamy sand or sandy loam thicker than 25 cm

Saline: soils which show, in some horizons within 100 cm of the surface, electrical conductivity values of the saturation extract higher than 4 mmhos/cm at 25° C. Salinity in a soil may show seasonal variations or may fluctuate as a result of irrigation practices

Sodic: soils which have more than 15% saturation with exchangeable sodium in some horizons within 100 cm of the surface

Eroded: moderate and severe erosion by water as defined in the USDA soil survey manual (1951)



TEXT MAP 5 Soil distribution between Wādī Badwah and Wādī Rima;
west of Al Murrah

SOIL CORRELATION

In Table 4, the classification of the Wadi Rima soil series is shown according to the systems currently used by the FAO and the USDA.

TABLE 4 Classification of soil series according to the FAO (1974) and USDA (1975) systems

Soil series	FAO (1974) system	USDA (1975) system
Madan	Haplic Yermosol	Fluventic Camborthid Typic Camborthid
Habaq	Haplic Yermosol	Fluventic Camborthid Typic Camborthid
Isabah	Haplic Xerosol	Intergrade between Fluventic Camborthid and Fluventic Haplustoll Typic Torrifuvent
Husayniyah	Haplic Yermosol Calcic Yermosol	Typic Camborthid Typic Calciorthid
Badwah	Calcic Yermosol	Typic Paleorthid
Mahatt	Calcaric Fluvisol	Typic Torrifuvent
Murrah	Calcaric Fluvisol	Typic Torrifuvent
Mujaylis	Gleyic Solonchak	Typic Salorthid

PART 4 LAND SUITABILITY FOR IRRIGATION

In assessing irrigation suitability, criteria related to soil characteristics, topography and drainage were selected for their relevance to conditions prevailing in Wadi Rima, and by rating their collective influence, qualitative land classes were interpreted and mapped (Separate Map 2). The main factors determining suitability for irrigated agriculture are described below.

FACTORS DETERMINING SUITABILITY

1. Soil texture The importance of texture lies in its influence on other physical and chemical soil properties, such as moisture and nutrient retention, infiltration, drainage and susceptibility to erosion. Excluding the dunelands, textural extremes, usually associated with unfavourable soil properties, are uncommon. The usual range on the alluvial fan is loam to silty clay loam, though further west the degree of profile stratification increases, incorporating coarser textures, with sandy loam, loamy sand and, rarely, sand, but retaining a predominance of finer textures. Minor areas, for the most part fringing Wadi Rima and Wadi Uqash west of the alluvial fan, are affected by a variable depth of windblown sand or loamy sand derived from adjacent dunefields. This surface deposit acts to reduce the water holding capacity of the soil and provides an unfavourable medium for crop germination and growth.

2. Available water holding capacity and infiltration rate The capacity of a soil to retain an adequate level of available water within the crop rooting zone is of prime importance, particularly under a system of irregular wadi irrigation in which heavy reliance is placed on a single application of water, which is normally applied prior to planting. With the more frequent application associated with pump irrigation, high available water holding capacities are less critical but their levels remain important in determining the required depth and frequency of irrigation. Infiltration rates are related both to soil texture and to available water holding capacity and, consequently, have not been used as separate criteria in the classification of irrigation suitability. These rates are, however, useful in estimating irrigation efficiencies and soil

drainage rates, and as a guide to irrigation planning and recommended farm management practices.

3. Effective soil depth The depth available for root exploitation exceeds 3 m in the majority of soils. Shallow soils, which occupy less than 6% of the Wadi Rima area, occur over gravel, bedrock or a weakly cemented calcic horizon within one metre of the surface. These soils have a reduced soil volume available for the retention and supply of moisture and nutrients. Bordering the coast, to the south of Wadi Rima, a high watertable (often at less than one metre depth) seriously limits the effective rooting depth. Although profile stratification can also influence root development and may even inhibit root penetration (particularly where coarse sand alternates with clay), the degree of stratification within the soils of the alluvial plain, though often well developed, generally lacks extreme textural contrast. Profile examination does not indicate any abnormal reduction in root activity with depth.

4. Nutrient status There are minor geographical variations in the level of the major plant nutrients; these are largely related to texture, but are not sufficiently important to be included in the land suitability classification.

5. Saline and sodic conditions Saline soils, in which the electrical conductivity of the saturation extract exceeds 4mmhos/cm^{-1} , though generally uncommon, occur west of Al Qurshiyah towards the coast. The level of salinisation varies (Text Map 4A) and is influenced in cultivated areas by irrigation practices and groundwater quality. Higher salinity levels, exceeding 12mmhos/cm^{-1} , are restricted to uncultivated soils west of Al Madaniyah and soils locally influenced by the high watertable in the south west around Al Mujaylis and At Tayfaf.

Sodic soils, with an exchangeable sodium percentage exceeding 15, are normally also saline. Apart from the localised development of sodic conditions around Al Madaniyah, associated with the use of groundwater having a high sodium absorption ratio, sodic soils are restricted to areas fringing the coast, particularly where the watertable approaches the soil surface and pH values exceeding 10 are not uncommon locally. Soil pH

values (in 0.01M CaCl₂) of 8 or greater were found to provide the most convenient indicator of sodic conditions however, and have been used, therefore, as criteria in the suitability classification.

6. Drainage Apart from a coastal strip approximately 5 km wide, the groundwater is sufficiently deep not to influence subsurface drainage. Moreover, current projections of the balance between recharge and extraction indicate an accelerating long-term decline in the watertable. In all areas away from the coastal strip, examination of 3 m profiles revealed no evidence for significantly impeded drainage. Bulk density values are favourable, in the range 0.9-1.6 g/cc, and exchangeable sodium levels are generally low (with the exception of the sodic soils towards the coast). Infiltration rates above 10 mm/hour were maintained even in the finer-textured soils of the alluvial fan over a 24 hour period; on the assumption that these rates approximate to a minimum intake rate, permeability levels appear to be adequate over the entire textural range. Slight drainage impedance occurs locally within certain of the soils of the alluvial plain where stratification involves alternate layers of contrasting texture having widely differing moisture holding capacities. Since, however, any layers restricting the downward movement of water characteristically show a marked lateral variation in thickness, texture and structure over very short distances, the partial and only temporary saturation of the profile following irrigation does not appear to have any adverse effect on crop production.

Surface runoff can be rapid on uncultivated land north of Al Jarubah, particularly where the natural vegetation is sparse. Locally, runoff has resulted in and is reinforced by extensive rill and gully erosion. Runoff on cultivated land is controlled by perimeter field bunds: excess water derived from local rainfall, from hill slopes or from minor wadis, drains westwards and is either diverted for irrigation or joins subsidiary wadis connecting with Wadi Rima, Wadi Uqash, or Wadi Zabid.

7. Topography With the exception of the valleys toward the head of the fan where slopes locally exceed 6%, gradients of over 1% are rare on both the alluvial fan and the plain. The pattern of microrelief is, however more complex. Topographic irregularities relating to the established field layout and irrigation network include perimeter bunds sometimes exceeding one metre in height, differences in levels between tiers of adjacent fields, and deeply incised irrigation channels lacking drop structures for erosion

control. Natural microrelief, mainly of aeolian origin, affects much of the alluvial plain. Stabilised hummocks of wind-drifted soil up to 5 m high and 50-200 m apart are widespread, increasing in density westwards to an extent that allows these features to be incorporated into the classification of irrigation suitability. Although isolated mobile dunes and drifts of sand, derived from the extensive dunefields fringing the alluvial plain and located principally to the south of Al Murrah, cover a relatively small area, their mobility is a considerable hazard to irrigated farmland. The most obvious effects of water erosion are seen in uncultivated land to the north and west of Al Jarubah, where surface runoff has resulted in moderate to severe rill and gully erosion. Elsewhere, apart from the wadi beds themselves which are highly susceptible to erosion during spate flow, damage is caused during irrigation by poor water control in a system lacking adequate canal distributaries. Much labour is expended heading up the water in incised canals to achieve command of individual fields, while the hazardous system of moving relatively large quantities of water rapidly through breached bunds and from field to field (often at significantly different elevation levels) leads to localised in-field sheet erosion and gullying, and to back-erosion wherever the flow is dropped to a lower level over earth bunds. The resulting unevenness in field levels renders any attempt to apply uniform quantities of water difficult; in general, the response is to 'over-water' to ensure that higher-lying areas absorb sufficient water for adequate cropping. The more obvious effects of unlevel fields include the occurrence of both over-watering and under-watering in the same field, unnecessary loss of water to subsurface recharge; and water standing for excessively long periods causing increased evaporation losses and an overall retarding of the rate at which water is distributed. Localised erosion and the rate of flow across fields would also contribute to farmers' reluctance to practise dry planting, i.e. pre-irrigation sowing.

SUITABILITY CLASSIFICATION

The classification of physical suitability for gravity irrigation has been adapted from United States Bureau of Reclamation land classification guidelines (US Department of the Interior, 1953). The degree of suitability of each mapping unit shown on Separate Map 2 is indicated by a land class number, followed by one or more subclasses identifying the nature of the soil and topographic or drainage limitations which determine the suitability

class. The classification diagnostic criteria are presented in Table 5, while the distribution of subclasses within each land class is shown in Table 6.

The suitability class is determined by the lowest or least favourable rating for any diagnostic criterion; moreover, a combination of two or more deficiencies may effect a downgrading in the classification of a specific area of land. In practice, therefore, when applying the criteria, it is essential to interpret and weigh carefully all the pertinent factors. As an illustration, a minimum depth of 90 cm of soil, finer than sandy loam, overlying sand or gravel has been established as a requirement for Class 1 land, but a slope of less than 2% is also necessary at sites where the minimum depth prevails. Obviously minima cannot be established for all conditions and interpretive judgement has to be exercised to maintain a balance between the varying criteria. The extensive nature of the survey and the relatively small scale of mapping prevented the application of any really detailed parameters.

Certain physical, social and economic factors, particularly those relating to the economics of crop production, have not been incorporated in the classification. These include availability of irrigation water, accessibility to markets, and land tenure. In formulating alternative development strategies for specific areas, however, these factors must of course be taken into account, along with the primary index of physical irrigation suitability based on land characteristics.

LAND CLASSES

Class 1 land This is land highly suitable for irrigation and capable of producing sustained and relatively high yields of a wide range of climatically adapted crops at reasonable cost. The diagnostic criteria are shown in Table 5. Class 1 land is level to gently sloping with only limited leveling requirements due to microrelief, and the soils are deep, well drained and of medium to fairly fine texture allowing the unhindered penetration of roots, air and water with high available moisture holding capacity. The soils are also non-sodic and without harmful accumulations of soluble salts that cannot easily be removed. No specific drainage requirements are necessary.

Minimal erosion will result from irrigation and land development can be accomplished at a relatively low cost.

Although the majority of soils currently cultivated in Wadi Rima have favourable physical and chemical characteristics in terms of irrigation suitability, no land is considered to warrant, at present, classification as Class 1 land. This is due to topographic deficiencies related to the existing system of irrigation and the established pattern of field boundaries. A general condition of uneven field levelling, caused mainly by poor water control, results in an unequal infield distribution of water with a consequent reduction in irrigation efficiency. In addition, the small size of fields (usually less than 0.5 ha) and the high field bunds restrict the application of mechanisation and impede the introduction of an improved irrigation layout. Moreover, the present system incorporates steeply sloping canals which, having high erosive velocities, are often deeply incised and fail to command adjoining fields. Because of an absence of canal distributaries, the fields themselves are used for conveyance with deleterious consequences in terms of soil erosion, uneven water distribution and overall crop production. A programme of irrigation development which incorporated the introduction of realigned canals, large levelled rectangular fields, and an improved system of water control, would however, permit a reclassification of much of the Class 2 land (47% of Wadi Rima) as Class 1 land.

Class 2 land This is land suitable for irrigated agriculture though, compared with Class 1 land, it has either a significantly lower productive capacity or is more expensive to develop for irrigation. The soils may have a lower available moisture holding capacity, as indicated by coarse texture or limited depth. They are non-sodic but may be slightly to moderately saline. Topographic limitations include uneven surface which requires significant levelling. Class 2 land is the most important single category of land in Wadi Rima, accounting for 51% of the project area, principally located between the main highway and the mountain front.
(Separate Map 2)

TABLE 5 Irrigation suitability: diagnostic criteria* for the land classification of Wadi Rima'

Land characteristics	Class 1/	Class 2	Class 3
Texture	Sandy loam to friable clay loam	Loamy sand to permeable clay	Loamy sand to permeable clay
Available water holding capacity	Exceeding 120 mm in the surface metre of soil	90-120 mm in the surface metre of soil	60-90 mm in the surface metre of soil
Depth of soil to sand, gravel or coarser alluvial deposits, or to permeable cemented carbonate horizon	At least 90 cm of fine sandy loam or finer; or 105 cm of sandy loam	60-90 cm of fine sandy loam or finer; or 75-105 cm of sandy loam to loamy sand	45-60 cm of fine sandy loam or finer; or 60-75 cm of sandy loam to loamy sand
Depth to bedrock	at least 135 cm	105-135 cm	90-105 cm
Depth of aeolian surface sand deposits over a Class 1 profile	0-10 cm of sand to loamy sand	10-25 cm of sand to loamy sand	25-50 cm of sand to loamy sand
Reaction pH in 0.01 M CaCl_2	Less than 8.0	Less than 8.0	Less than 8.0
Salinity Electrical conductivity of the saturation extract	Less than 4 mmhos/cm ⁻¹	4-12 mmhos/cm ⁻¹	4-12 mmhos/cm ⁻¹
Slope	Even slopes up to 2%; only a very limited amount of levelling required	Even slopes up to 4%; general levelling required	Even slopes up to 8%; major levelling required locally
Drainage	Good internal soil drainage; depth to watertable not less than 3 m	Good internal soil drainage; depth to watertable not less than 3 m	Good internal soil drainage; dept to watertable not less than 3 m

* Each criterion represents a minimum requirement and, unless all other criteria are near optimum, two or more interacting deficiencies may result in land being placed in a lower class

/ Note that there is no Class 1 land in Wadi Rima'

N.B. Two other classes of land occur in Wadi Rima': -

Class 5, defined as provisionally unsuitable for irrigation due to extensive gullyng

Class 6, defined as unsuitable for irrigation due to extreme soil, topographic or drainage constraints

TABLE 6 Distribution of irrigation suitability subclasses

Class	Subclass*	Area ha	% of total area
2 (suitable)	2t	30 100	
	2ct	610	
	2dt	750	
	2gt	200	
	2nt	1 070	
	2st	150	
	Total	32 880	51.1
3 (less suitable)	3et	80	
	3gt	200	
	3gv	50	
	3st	780	
	3dst	310	
	3nst	270	
	Total	1 690	2.6
5 (provisionally unsuitable)	5ev	1 120	1.8
6 (unsuitable)	6b	560	
	6ev	420	
	6gt	170	
	6gv	20	
	6rv	20	
	6st	550	
	6dsv	21 830	
	6ecv	30	
	6hmv	2 070	
	6hsv	1 160	
	6ntw	410	
	6nvw	1 110	
	lagoon	260	
	Total	28 610	44.5
Total area		64 300	100.0

*Subclass notation, indicating the nature of any soil, topographic, or drainage limitation

- b Wadi bed
- c Shallow soil, over cemented calcic horizon
- d Dunes, drifts or unstable hummocks
- e Eroded land
- g Shallow soil, over gravel or coarser material
- h Stabilised hummocks
- n Saline or sodic conditions
- r Shallow soil, over bedrock
- s Coarse-textured topsoil
- t Minor topographic limitation (poor levelling where cultivated)
- v Severe topographic limitation
- w Poor drainage and high watertable

Class 3 land This is land less suitable for irrigated agriculture, due to more severe soil or topographic limitations. These may include shallowness or excessively coarse texture resulting in low available-moisture-holding capacity. Topographic limitations may be locally serious, with either localised gullying due to water erosion, or significant slopes which require major expenditure to level. In general, the costs of irrigation development and water application are higher than on Class 2 land while the production potential is lower. Overall, Class 3 land is relatively insignificant in Wadi Rima, comprising less than 3% of the project area.

Class 4 land This designation is reserved for land shown to be irrigable following special economic or engineering studies and is not therefore relevant to Wadi Rima.

Class 5 land This is land provisionally unsuitable for irrigation due to moderate or severe water erosion, which has resulted in extensive gullying. If reclamation were to prove economically feasible, these lands would be re-designated as Class 3. As in the case of Class 3 land, the area involved, lying between Al Husayniyah and Al Jarubah, is of limited extent and accounts for only 2% of the project area.

Class 6 land Lands in this class are unsuitable for irrigation because of severe soil, topographic or drainage constraints. The soils may be shallow or very coarse-textured, drainage may be poor (associated with a high watertable and saline-sodic conditions), and the topography may be very irregular. Land designated as unsuitable for irrigation covers a significant proportion of the project area (almost 45%) but, with the exception of the wadi bed itself and the mountain front, Class 6 land lies to the west of the main highway and is principally duneland. Subsidiary areas nearer the Red Sea, in the lowest reaches of Wadi Rima and also around Al Mujaylis and At Tayfaf, are adversely influenced by the high watertable and severe soil alkalinity.

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MADAN SERIES

PROFILE WR 1 MADAN SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	4.12.75
Location	1 km north of Al Badwah petrol station on Zabid- Hudaydah highway
Elevation	115 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1 (<2%)
Vegetation/land use	Site fallow: previously pump-irrigated cotton Sorghum, cotton and sesame in adjacent fields

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Severe at field drainage outlet
Salt or alkali	None
Human influence	Terraced and banded fields, currently pump-irrigated but receiving infrequent irrigation from Wadi Rima

3. PROFILE DESCRIPTION

Depth, cm

0-28	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak coarse platy structure transitional downward to structureless; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small mica flakes; slight effervescence; clear, smooth boundary:
28-58	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, medium angular blocky structure with few, 1-2 cm, platy fragments randomly oriented; dry; slightly sticky, slightly plastic, wet; slightly hard, dry; common fine, fibrous roots; many, very fine and few, medium, tubular voids; few, small mica flakes; weak, thin, carbonate pseudomycelia; slight effervescence; diffuse, smooth boundary:
58-92	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam compound. weak. coarse, prismatic and moderate, medium, angular blocky structure with few, 1-2 cm, platy fragments randomly oriented; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small mica flakes; weak, thin, carbonate pseudomycelia; slight to strong effervescence; gradual, smooth boundary:
92-138	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, coarse, prismatic structure with few, 1-2 cm, platy fragments randomly oriented and occasional, very thin (1 mm), undisturbed sandy laminations; slightly moist; slightly sticky, slightly plastic, wet; hard, dry; few, fine, fibrous roots; common, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

PROFILE WR 1 (Continued)

Depth, cm

138-170

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; weak, coarse, prismatic structure with common, 1-2 cm, platy fragments randomly oriented; slightly moist; sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; slight effervescence:

Continuation by auger

170-210

Dark yellowish brown (10YR 4/4) moist; silty clay loam; slight effervescence:

210-250

Dark yellowish brown (10YR 4/4) moist; silt loam; few silt nodules, 1 cm diameter; slight effervescence:

250-290

Dark yellowish brown (10YR 4/4) moist; sandy clay loam; few, subrounded, igneous gravel.

ANALYSES, WR 1

Depth cm	% Moist. O ₂ d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-28	1.6	1.25	8.7	7.6	7.6	0.11	3.5			0.6	0.7	3.2	47.6	14.9
28-58	2.6	1.10	8.5	7.5	7.5	0.15	4.5			1.1	0.5	3.9	>50.0	21.5
58-92	3.3	1.04	8.3	7.5	7.6	0.22	5.0			1.4	0.5	4.7	>50.0	22.2
92-138	3.3	1.12	8.6	7.5	7.6	0.20	4.0			1.6	0.5	4.8	>50.0	20.4
138-170	3.8	1.10	8.3	7.5	7.7	0.27	3.5			1.4	0.6	5.7	>50.0	22.7

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-28	0.03	0.23	970	5700	13400	2	3	36	46	15	30	850	100			
28-58	0.05	0.35	1090	6450	15850	1	0	8	66	26	40	1210	120			
58-92	0.05	0.32	1120	6300	16200	1	0	7	66	27	40	1170	120			
92-138	0.04	0.25	1110	6100	14900	1	3	16	53	28	40	1070	120			
138-170	0.05	0.29	1160	6750	15850	3	2	15	52	31	40	1200	120			

PROFILE WR 7 MADAN SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Typic Camborthid (USDA)
Date	8.12.75
Location	½ km east of Dar Ban
Elevation	140 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Site fallow; cotton, sorghum and radishes pump-irrigated nearby

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying material characteristic of Husayniyah Series
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Slight wind erosion
Salt or alkali	None
Human influence	Terraced and banded fields with 0.5 m difference in level between fields

3. PROFILE DESCRIPTION

Depth, cm	
0-23	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, fine, platy transitional downwards to weak, very fine, subangular blocky structure; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
23-77	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; compound, moderate, coarse, prismatic and weak, medium, angular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; several insect burrows with cavities up to 80 mm diameter; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
77-105	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silt loam; weak, medium, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
105-128	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
128-170	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence:

PROFILE WR 7 (Continued)

Continuation by auger

170-190	Dark yellowish brown (10YR 4/4) moist; fine sandy loam; few, small; soft, carbonate nodules; slight effervescence:
190-230	Dark yellowish brown (10YR 4/4) moist; loam; few, small, soft, carbonate nodules; slight effervescence:
230-275	Dark brown (10YR 4/3) moist; fine sandy loam; few, small, soft, carbonate nodules; slight effervescence:
275-290	Dark brown (10YR 4/3) moist; loam; few, small, soft, carbonate nodules; slight effervescence.

ANALYSES WR 7

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-23	2.1	1.24	8.7	7.4	7.6	0.09	2.5			0.6	0.9	2.0	42.6	16.9
23-77	3.3	1.19	8.7	7.4	7.5	0.11	3.0			0.7	0.5	2.4	41.9	20.5
77-105	2.7	1.15	8.7	7.4	7.6	0.11	2.5			0.9	0.5	2.8	43.7	21.2
105-128	1.9	1.28	8.7	7.5	7.7	0.10	1.5			0.9	0.5	2.2	32.2	16.3
128-170	1.8	1.27	8.7	7.5	7.7	0.11	2.0			1.0	0.5	2.5	42.6	16.7

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-23	0.03	0.17	1050	5500	12600	3	3	39	43	15	30	810	100			
23-77	0.03	0.20	1090	6350	14400	2	3	28	45	24	30	980	110			
77-105	0.03	0.16	1230	5750	14650	2	4	32	41	23	30	980	100			
105-128	0.02	0.09	1330	4250	12250	2	7	57	24	12	30	750	90			
128-170	0.02	0.10	1270	4050	13300	2	5	56	27	12	30	770	90			

PROFILE WR 10 MADAN SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Haplic Yermosol (FAO), Typic Camborthid (USDA)
Date	4.1.76
Location	0.5 km north of Al Hawtah
Elevation	125 m a.m.s.l.
Landform	
Physiography	Alluvial plain: lower, convex slope towards minor wadi bed
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1/2 (2%)
Vegetation/land use	Site fallow; sorghum and cotton pump irrigated nearby

2. SOIL INFORMATION

Parent material	Calcareous alluvium; medium textured overlying coarse, wadi sediments
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-24	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, medium, platy transitional downwards to very weak, fine, subangular blocky structure; dry: non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; very porous with many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary:
24-38	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry: loam: weak, very fine and fine, subangular blocky structure; slightly moist: non sticky, slightly plastic, wet; slightly hard, dry: common, fine fibrous roots; many very fine, tubular voids; weak, thin, carbonate pseudomycelia: very slight effervescence: gradual, smooth boundary:
38-63	Dark yellowish brown (10YR 3/4) moist: yellowish brown (10YR 5/4) dry: horizon darkened by magnetite?; loam: weak, very fine and fine, subangular blocky structure; moist: non sticky, non plastic, wet: friable, moist: common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few gastropod shells; weak, thin, carbonate pseudomycelia: very slight effervescence; gradual, smooth boundary:
63-82	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; structureless to very weak, very fine, subangular blocky structure; moist; non sticky, non plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine, tubular voids; weak, thin, carbonate pseudomycelia; very slight effervescence; gradual, smooth boundary:

PROFILE WR 10 (Continued)

Depth, cm

82-105 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; structureless to very weak, very fine, subangular blocky structure; moist; non sticky, non plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine, tubular voids; very few, irregular, carbonate gravel; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

105-143/146 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; moist, non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; common, medium and few, large, hard irregular, carbonate nodules; slight effervescence; clear, wavy boundary:

143/146-151/156 Many (>60%), large, irregular stones of carbonate; few, fine, fibrous roots; strong effervescence; clear, wavy, boundary:

151/156-166 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) loamy fine sand; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; very few, irregular, carbonate gravel; very slight effervescence:

Continuation by auger

166-211 Dark brown (10YR 4/3) moist; sand; very few, irregular, carbonate gravel; very slight effervescence:

211-246 Dark brown (10YR 4/3) and single grain colours, moist; coarse sand transitional downwards to gritty coarse sand; common, subrounded, igneous gravel and stones; very slight effervescence:

246+ No penetration into gravel and stones

ANALYSES WR 10

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-24	1.9	1.27	9.1	7.4	8.0	0.10	3.0			0.9	0.6	2.5	43.2	18.5
24-38	3.0	1.19	8.8	7.0	7.6	0.15	1.0			1.4	0.3	2.0	31.3	22.7
38-63	3.4	1.19	8.9	7.2	7.6	0.14	1.5			1.3	0.3	2.4	39.0	23.4
63-82	2.8	1.19	8.5	7.2	7.6	0.14	2.0			0.8	0.2	2.9	42.2	21.7
82-105	2.4	1.20	8.6	7.4	7.7	0.15	6.0			0.6	0.2	3.9	>50	19.7
105-146	1.7	1.27	8.7	7.5	7.8	0.15	5.5			0.8	0.1	3.7	48.0	14.3
156-166	1.4	1.30	8.7	7.5	7.8	0.17	3.0			1.1	0.1	3.2	34.7	15.0

Depth cm	% Total H o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-24	0.03	0.25	1180	4050	15700	<1	7	39	39	15	30	850	90			
24-38	0.03	0.31	740	4350	11250	0	8	32	41	19	30	970	110			
38-63	0.04	0.29	770	3750	10500	0	6	31	47	16	30	1030	120			
63-82	0.03	0.29	750	3250	10300	0	3	31	55	11	30	1000	120			
82-105	0.03	0.17	760	2800	11050	0	3	35	50	12	20	880	100			
105-146	0.02	0.08	650	2050	10050	0	4	59	28	9	20	620	90			
156-166	0.01	0.06	770	1750	9400	0	3	68	22	7	20	520	90			

PROFILE WR 11 MADAN SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Haplic Yermosal (FAO), Fluventic Camborthid (USDA)
Date	4.1.76
Location	By Ash Shaykh Umar, 1.5 km NE of Al Hawtah
Elevation	135 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Recently harvested pump-irrigated sorghum

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm	
0-21	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, fine and medium. subangular blocky structure; dry. non sticky, slightly plastic wet; slightly hard, dry; common. fine, fibrous roots; very porous with many, very fine and few, fine, tubular voids; slightly effervescence; clear, smooth boundary:
21-46	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; moderate, fine and medium angular blocky structure; slightly moist; sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; moderate, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
46-78	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; compound, weak, coarse, prismatic and weak, coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; hard, dry; common fine, fibrous roots; many very fine and few, fine tubular and few, very fine, planar voids; common insect activity; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
78-102	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
102-117	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, gasteropod shell fragments; weak, thin, carbonate pseudomycelia; very slight effervescence; clear, smooth boundary:

PROFILE WR 1 (Continued)

Depth, cm

117-157

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; weak, coarse, prismatic transitional downwards to weak, fine, angular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence:

Continuation by auger

157-175

Dark yellowish brown (10YR 4/4) moist; silt loam; weak, thin, carbonate pseudomycelia; few, medium, carbonate nodules; slight effervescence:

175-232

Dark yellowish brown (10YR 4/4) moist; silty clay loam; weak, thin, carbonate pseudomycelia; few, medium, carbonate nodules; slight effervescence:

232-257

Dark brown (10YR 3/3) moist; silt loam; weak, thin, carbonate pseudomycelia; few, medium, carbonate nodules; very slight effervescence.

ANALYSES WR 11

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-21	2.3	1.27	8.7	7.5	7.7	0.12	2.5			0.9	1.1	3.4	42.1	19.7
21-46	3.2	1.24	9.0	7.3	7.7	0.12	1.5			1.4	0.9	3.2	43.0	24.7
46-78	2.6	1.20	8.7	7.4	7.7	0.15	4.0			1.0	0.5	3.4	>50	22.3
78-102	3.4	1.17	8.3	7.4	7.7	0.38	4.0			0.8	0.5	5.2	>50	27.3
102-117	2.2	1.22	7.8	7.4	7.7	0.41	1.0			0.8	0.4	3.7	28.1	19.5
117-157	3.7	1.12	8.0	7.2	7.7	0.36	4.0			1.0	0.5	7.0	>50	30.4

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-21	0.05	0.27	1220	5700	16450	2	0	32	49	19	40	990	100			
21-46	0.04	0.22	1240	6650	17100	<1	1	22	47	30	40	1130	110			
46-78	0.03	0.19	1170	5100	17650	<1	2	25	50	23	40	990	100			
78-102	0.04	0.21	1280	5050	20150	<1	2	23	47	28	40	1140	100			
102-117	0.02	0.11	1110	3850	15600	0	6	48	30	16	30	900	90			
117-157	0.03	0.21	1260	5700	20000	0	1	17	51	31	40	1160	100			

1. SITE INFORMATION

Map unit	7A
Higher category class	Itaphic Yermosol (FAO), Typic Camborthid (USDA)
Date	5.1.76
Location	1 km east of Ash Shaykh Umar
Elevation	140 m a.m.s.l.
Landform	
Physiography	Near edge of alluvial fan; ill defined bed of Wadi Uqash
Landform	Bottom of gently sloping concave slope
Microtopography	Pitted surface
Slope	Class 1
Vegetation/land use	Irregularly cultivated depending on rainfall and flow in Wadi Uqash; patchy sesame at present

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying gravelly and stony wadi deposits
Drainage	Well drained but subject to very occasional flooding up to 3 m depth
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Incipient gullying in thalweg together with moderate sheet and rill erosion
Salt or alkali	None
Human influence	Very little apart from occasional cultivation

3. PROFILE DESCRIPTION

Depth, cm

0-18	Dark yellowish brown (10YR 3/4) moist; yellowish brown (10YR 5/4) dry; silt loam; compound, weak, coarse, prismatic and weak, coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thick, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
18-50	Dark yellowish brown (10YR 4/4) moist; brownish yellow (10YR 6/6) dry; loam; weak, medium and coarse, angular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; very slight effervescence; clear, smooth boundary:
50-68	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, medium and coarse, angular blocky structure; moist; slightly sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few large insect burrows; weak, thin, carbonate pseudomycelia; very slight effervescence; abrupt, smooth boundary:
68-89	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; fine sandy loam; structureless; moist; non sticky non plastic, wet; friable, moist; few fine, fibrous roots; many, very fine and few, fine tubular voids; common, medium and large, hard, irregular, carbonate nodules; weak, thin, carbonate pseudomycelia; strong effervescence; abrupt, smooth boundary:
89-117	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; fine sandy loam; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, medium, hard, irregular, carbonate nodules; slight effervescence; clear, smooth boundary:

PROFILE WR 13 (continued)

Depth, cm

117-145/149

Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; common, fine, distinct brownish yellow mottles; fine sandy loam; structureless; moist; non sticky, non plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; common, medium, hard, irregular, carbonate nodules and few, subrounded, igneous gravel; strong effervescence; abrupt, wavy boundary:

145/149-160

Many (>60%), subrounded, igneous stones

58

[illegible][illegible]

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	20.2.76
Location	1.5 km east of Al Madan
Elevation	245 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Rainfed cropping of millet and sorghum, occasionally spate irrigated from Wadi Rima; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying stony wadi deposits
Drainage	Well drained
Surface stones and rock outcrops	Very few stones, no rock outcrops
Erosion	Moderate erosion of field bunds
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to P.5 m high

3. PROFILE DESCRIPTION

Depth, cm

0-16

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, very fine and fine, subangular blocky structure; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary:

16-31

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; weak, fine, subangular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; very few, subrounded, igneous gravel; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

31-52

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; sandy clay loam; very weak, very fine and fine, subangular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; few, subrounded, igneous gravel; strong, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

52-80/82

Dark brown (10YR 3/3) moist; dark brown (10YR 4/3) dry; 15% yellowish brown inclusions from overlying horizon; clay loam; weak, coarse, angular blocky structure; slightly moist; slightly sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; very few, subrounded, igneous gravel; moderate, thin, carbonate pseudomycelia; slight effervescence; abrupt, wavy boundary:

80/82-115

Many (> 60%), subrounded, igneous stones:

ANALYSES WR 25

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.			Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K		Na	K	Mg	Ca	
0-16	1.5	1.37	8.3	7.7	7.9	0.12	2.0				0.2	0.4	2.1	34.7	12.1
16-31	2.6	1.31	8.6	7.5	7.8	0.16	3.0				0.5	0.3	3.2	40.9	17.6
31-52	2.5	1.20	8.5	7.5	7.8	0.15	3.5				0.6	0.2	2.9	47.2	16.8
52-82	3.4	1.25	8.2	7.4	7.7	0.24	1.5				0.9	0.2	3.1	40.8	23.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm				Available P ppm	Mechanical analysis					Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg	2 000- 250 μm		250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn					
0-16	0.02	0.10	810	4500	12050	<1	42	46	12	30	680	80						
16-31	0.04	0.18	800	4950	12550	0	38	42	20	30	830	90						
31-52	0.04	0.27	670	4300	10200	0	44	32	24	30	880	100						
52-82	0.05	0.45	490	4600	9450	<1	44	28	28	30	860	90						

PROFILE WR 26 MADAN SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	20.2.76
Location	2 km south of Al Madan
Elevation	215 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Rainfed cropping of millet and sorghum, occasionally spate irrigated from Wadi Rima site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying gravelly and stony wadi deposits
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Moderate erosion of field bunds
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to 0.5 m high

3. PROFILE DESCRIPTION

Depth, cm

0-19

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; moderate, medium platy transitional downwards to structureless; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular and few, very fine, planar voids; few, small, mica flakes; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary:

19-40

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; compound, weak, coarse, prismatic and weak, medium, angular blocky structure; dry; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; very few, subrounded, igneous gravel; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth, boundary:

40-69

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; compound, weak, medium, prismatic and weak, medium, angular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine and medium, tabular voids; few gasteropod shells; common termite activity; very few, subrounded, igneous gravel; moderate, thick, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

69-106

Dark brown (10YR 3/3) moist; dark brown (10YR 4/3) dry; 10% yellowish brown inclusions; clay loam; very weak, medium and coarse, angular blocky structure; slightly moist; slightly sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; moderate, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

PROFILE WR 26 (Continued)

Depth, cm

106-150/154

Dark yellowish brown (10YR 4/6) moist; brownish yellow (10YR 6/6) dry; loam. very weak, medium, angular blocky transitional downwards to structureless. slightly moist: non sticky, slightly plastic, wet; slightly hard, dry; many, very fine and few, fine and medium, tubular voids; very few, subrounded, igneous gravel; weak, thin, carbonate pseudomycelia; few, medium, soft, irregular, carbonate nodules; slight effervescence; abrupt, wavy boundary:

150/154-164

Many (> 6%), subrounded, igneous gravel and stones.

4. ANALYSES WR 26

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.			Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K		Na	K	Mg	Ca	
0-19	2.1	1.35	8.3	7.5	7.8	0.12	2.0				0.2	0.4	1.8	36.6	13.9
19-40	3.2	1.23	8.6	7.2	7.6	0.13	2.0				0.5	0.3	2.1	45.0	20.4
40-69	3.3	1.22	8.3	7.2	7.6	0.16	2.0				0.8	0.3	2.3	46.8	23.4
69-106	3.7	1.24	8.4	7.1	7.6	0.24	2.0				0.9	0.2	2.4	48.2	24.7
106-154	3.3	1.26	8.5	7.1	7.6	0.21	1.0				1.1	0.2	2.0	36.8	20.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis					Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm		Cu	Mn	Zn			
0-19	0.03	0.17	820	4750	11750	2		40	48	12		30	690	80			
19-40	0.04	0.23	790	4950	11750	0		38	38	24		30	820	80			
40-69	0.05	0.30	860	5200	13100	0		36	36	28		30	880	90			
69-106	0.05	0.49	720	4800	10800	<1		36	36	28		30	830	80			
106-154	0.03	0.15	790	4450	11450	<1		38	40	22		30	790	80			

PROFILE WR 29 MADAN SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	22.2.76
Location	1.5 km west of Isabah
Elevation	315 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Irregularly spaced irrigated from Wadi Rima: site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying gravelly and stony wadi deposits
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm	
0-18	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; moderate, coarse, platy transitional downwards to weak, coarse, angular blocky structure; dry; sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, medium, tubular and few, very fine, planar voids; slight effervescence; clear, smooth boundary:
18-32	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, fine and medium, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; gradual, smooth boundary:
32-64	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, subangular blocky structure; moist; sticky, plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; moderate, thick, carbonate pseudomycelia; strong effervescence; diffuse, smooth boundary:
64-96	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; very weak, medium, subangular blocky structure; moist; sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; moderate, thick, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
96-120	Dark yellowish brown (10YR 3/4) moist; yellowish brown (10YR 5/4) dry; loam; structureless; moist; sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, angular, igneous gravel; moderate, thick, carbonate pseudomycelia; abrupt, smooth boundary:
120-153	Many (>60%), subrounded, igneous stones; few, fine, fibrous roots.

ANALYSES WR 29

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-18	3.2	1.22	8.3	7.3	7.7	0.11	2.5			0.3	0.8	4.4	43.2	22.5
18-32	2.6	1.21	8.3	7.3	7.7	0.10	2.0			0.2	0.4	3.6	44.0	18.5
32-64	3.6	1.17	8.3	7.2	7.8	0.13	6.0			0.4	0.3	3.9	> 50	24.6
64-96	3.3	1.10	8.3	7.3	7.7	0.13	3.0			0.4	0.3	3.5	> 50	22.5
96-120	3.3	1.24	8.2	7.3	7.7	0.12	1.0			0.4	0.3	3.0	38.0	21.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-18	0.07	0.46	950	6250	16150	< 1	25		55	20	30	970	100			
18-32	0.04	0.30	890	4800	14800	< 1	31		53	16	40	820	90			
32-64	0.04	0.27	900	4750	15350	0	18		53	29	40	960	100			
64-96	0.04	0.29	710	5400	14000	0	27		49	24	40	970	100			
96-120	0.04	0.36	490	4850	11150	1	41		37	22	30	860	90			

1. SITE INFORMATION

Map unit	1B
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	17.3.76
Location	Valley of Wadi Irsimah
Elevation	390 m a.m.s.l.
Landform	
Physiography	Valley
Landform	Sloping
Microtopography	Terraced
Slope	Class 3 (7%)
Vegetarian/land use	Sorghums and maize irrigation from hill-slope runoff; site recently oxen ploughed for sorghum

2. SOIL INFORMATION

Parent material	Calcareous, gravelly colluvio-alluvium
Drainage	Well drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Moderate rill and gully erosion of terrace edges
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to 2 m high with difference in field levels of 1.5 m. Recent levellings by bulldozer

3. PROFILE DESCRIPTION

Depth, cm

0-36

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; ;pa,; weak, medium and coarse, angular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, angular; igneous gravel; clear, smooth boundary:

36-62

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, medium and coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry: common, fine, fibrous roots; many, very fine and few, medium, tubular voids; prominent insect activity with common, fecal pellets; few, angular, igneous gravel and stones; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:

62-86

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, fine and medium, angular blocky structure; moist; slightly sticky, slightly plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, medium, tubular voids; prominent insect activity with common, fecal pellets; few, angular, igneous gravel and stones; weak, thin, carbonate pseudomycelia; clear smooth boundary:

86-126

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; gravelly sandy clay loam; very weak, medium subangular blocky structure: moist; slightly sticky, slightly plastic, wet: friable, moist: common, fine, fibrous roots; man, very fine and few, medium, tubular voids: common, angular, igneous gravel and few, angular, igneous stones: clear, smooth boundary:

PROFILE WR 31 (Continued)

126-163

Dark yellowish brown (10YR 4/4) moist. light yellowish brown (10YR 6/4) dry; loam structureless; moist ; slightly sticky, slightly plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine tubular voids; few angular, igneous gravel and very few, angular, igneous stones; moderate, thin, carbonate pseudomorphs.

ANALYSES WR 31

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-36	2.0	1.19	8.2	7.5	7.9	0.09	2.5			0.1	0.5	2.7	42.2	16.1
36-62	2.8	1.17	7.7	7.3	7.8	0.12	2.5			0.2	0.4	3.4	44.1	17.6
62-86	2.4	1.22	7.8	7.3	7.7	0.13	2.5			0.2	0.4	3.6	43.4	17.8
86-126	1.8	1.20	8.1	7.3	7.7	0.12	3.0			0.2	0.4	3.0	39.1	15.2
126-163	2.6	1.15	8.5	7.4	7.8	0.13	5.0			0.3	0.4	3.9	>50	17.5

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-36	0.06	0.33	1010	5800	13500	2	24		55	21	30	840	90			
36-62	0.05	0.29	1050	6000	14900	1	22		51	27	30	890	100			
62-86	0.05	0.30	990	6350	14300	2	24		51	25	30	920	100			
86-126	0.04	0.28	1210	6250	11450	2	30		43	27	30	910	110			
126-163	0.05	0.32	2030	6150	10800	5	24		51	25	30	860	120			

1. SITE INFORMATION

Map unit	1B
Higher category class	Haplic Yermoso 1 (FAO), Fluventic Camborthid (USDA)
Date	17.3.76
Location	Valley of Wadi Irsimah
Elevation	410 m a.m.s.l.
landform	
Physiography	Valley
landform	Sloping
Microtopography	Terraced
Slope	Class 3 (6%)
Vegetation/land use	Sorghum and maize irrigation from hill-slope runoff; site fallow

2. SOIL INFORMATION

Parent material	Calcareous, gravelly colluvio-alluvium
Drainage	Well drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Slight rill and gully erosion of terrace edges
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-27	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; weak, medium and coarse, angular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; prominent insect activity with common, fecal pellets; very few, angular, igneous gravel; clear, smooth boundary:
27-49	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; moderate, coarse and weak, medium, angular blocky structure; slightly moist, slightly sticky, slightly plastic wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, medium, tubular and few, very fine, planar voids; prominent insect activity with common, fecal pellets; few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:
49-63	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; weak, medium and coarse, angular blocky structure; slightly moist, slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; prominent insect activity with common, fecal pellets; few, angular, igneous gravel and stones; weak, thin, carbonate pseudomycelia; abrupt, smooth boundary:
63-73	Many (60%), angular, igneous gravel and stones; common, fine, fibrous roots; abrupt, smooth boundary:
73-106/109	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; weak, medium, angular blocky and weak, fine, subangular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, few, fine and few, medium, tubular voids; very few, angular, igneous gravel; strong, thin, carbonate pseudomycelia; abrupt, wavy boundary:

106/109-115/118

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; gravelly sand clay loam; structureless slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry: common, fine, fibrous roots; many, very fine, tubular voids; common to many, angular, igneous gravel; strong, thin, carbonate pseudomycelia; abrupt, wavy boundary:

115/118-157

Dark yellowish brown (10YR 4/6) moist; yellowish brown (10YR 5/6) dry; loam; very weak, fine and medium, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, angular, igneous gravel; moderate, thin, carbonate pseudomycelia

ANALYSES WR 32

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-27	2.1	1.21	8.0	7.5	7.7	0.12	2.0			0.2	0.6	2.7	46.5	17.0
27-49	2.6	1.10	8.4	7.3	7.7	0.11	2.0			0.2	0.3	2.7	38.2	19.9
49-63	2.4	1.13	8.1	7.4	7.7	0.14	2.5			0.2	0.2	2.6	46.4	15.8
73-109	3.3	1.12	8.2	7.3	7.8	0.13	4.0			0.3	0.3	3.7	>50	22.2
118-157	3.4	1.11	8.2	7.3	7.7	0.15	2.5			0.4	0.3	3.9	>50	20.8

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-27	0.06	0.40	910	6000	14900	2	30	49	21	30	860	90				
27-49	0.05	0.37	840	6000	14900	0	30	45	25	30	1050	110				
49-63	0.04	0.28	870	5150	12400	1	32	47	21	30	930	100				
73-109	0.07	0.39	680	5950	14650	0	26	41	33	30	970	100				
118-157	0.04	0.26	530	4900	13200	0	25	47	28	30	880	80				

PROFILE WR 34 MADAN SERIES

1. SITE INFORMATION

Map unit	1E
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	18.3.76
Location	0.25 km north of Bani al Habil
Elevation	340 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Rainfed sorghum and millet; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to 0.5 high with difference in field levels of 0.25 m

3. PROFILE DESCRIPTION

Depth, cm

0-24	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/6) dry; fine sandy loam; compound, weak, coarse, angular blocky and weak, fine, subangular blocky structure; dry; non sticky, slightly plastic wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; clear smooth boundary:
24-44	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; weak fine and medium, subangular blocky structure; dry; sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many very fine and few, fine, tubular voids; weak, thin carbonate pseudomycelia; gradual, smooth boundary:
44-65	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; moderate, fine and medium, angular blocky structure; dry; sticky plastic wet; slightly hard dry common, fine, fibrous roots; many, very fine and few, fine tubular and few, very fine, planar voids; moderate, thin, carbonate pseudomycelia: gradual, smooth boundary:
65-109	Dark Yellowish brown (10YR 3/4) wet; dark yellowish brown (10YR 4/4) dry. loam; moderate, fine and medium angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few fine, fibrous roots; many, very fine and few, fine tubular and few, very fine, planar voids; strong, thick, carbonate pseudomycelia; clear, smooth boundary:
109-131	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; fine sandy loam; very weak, coarse, angular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine fibrous roots; many, very fine and few, fine, tubular voids; very few, angular, igneous gravel; discontinuous thin gravel layer at base of horizon; moderate, thin, carbonate pseudomycelia; clear, smooth boundary:

PROFILE WR 34 (continued)

Depth, cm

131-168

Dark yellowish brown (10YR 3/4) moist; dark yellowish brown (10YR 4/4) dry; loam; structureless; slightly moist; slightly sticky, slightly plastic, wet; hard, dry; many very fine and few, fine, tubular voids; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia

73

[illegible][illegible]

PROFILE WR 37 MADAN SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	20.3.76
Location	1 km north of Al Jarubah
Elevation	220 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/landuse	Irregularly spate irrigated from Wadi Rima; site fallow with 30% grass cover

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to 0.5 m high with 0.25 m difference in field levels.

3. PROFILE DESCRIPTION

Depth, cm

0-17

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, coarse, platy transitional downwards to weak, medium, subangular blocky structure; dry; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; clear, smooth boundary:

17-38

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, fine and medium, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small mica flakes; clear, smooth boundary:

38-79

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; diffuse, smooth boundary:

79-120

Dark yellowish brown (10YR) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, angular blocky structure; moist; sticky, plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; diffuse, smooth boundary:

120-161

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, angular blocky structure; moist; sticky, plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia:

ANALYSES WR 37

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-17	3.0	1.24	8.3	7.4	7.8	0.13	4.0			0.3	0.8	4.0	>50	20.6
17-38	2.1	1.21	8.3	7.5	7.8	0.11	3.5			0.2	0.5	3.8	49.6	17.6
38-79	2.7	1.19	8.3	7.4	7.8	0.12	3.5			0.4	0.4	3.6	>50	20.9
79-120	3.5	1.07	8.7	7.4	7.8	0.11	5.0			0.6	0.3	4.3	>50	24.9
120-161	3.4	1.01	8.5	7.4	7.8	0.15	5.5			0.7	0.3	4.8	>50	25.4

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-17	0.06	0.40	1090	6100	15000	2	34		39	27	30	1070	110			
17-38	0.04	0.26	1000	6550	15100	1	22		51	27	30	970	100			
38-79	0.03	0.18	950	5850	15300	<1	28		47	25	30	1120	110			
79-120	0.04	0.24	970	6100	16250	<1	22		47	31	30	1250	120			
120-161	0.04	0.23	960	5350	17000	<1	20		49	31	40	1210	110			

PROFILE WR 38 MADAN SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	20.3.76
Location	1 km south of Al Jarubah
Elevation	230 m a.m.s.l.
Landform	
Physiography	Alluvial fan; subdued levee bordering Wad Rima
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Small date palm plantation with cereal intercropping; irregularly spate irrigated from Wadi Rima

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth (cm)	
0-28	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam to silt loam; weak, coarse, angular blocky transitional downwards to weak, medium, angular blocky structure; dry; slightly sticky, slightly pasty, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; clear, smooth boundary:
28-62	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, fine and medium, sub-angular blocky structure; moist; slightly sticky, slightly plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:
62-87	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, subangular blocky structure; moist; sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; clear, smooth, boundary:
87-121	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; moist; non-sticky, none plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; clear, smooth boundary:
121-147	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; very weak, medium, subangular blocky structure; moist; sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; clear, smooth boundary:

PROFILE WR 38 (Continued)

Depth (cm)

147-161

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; moist; non sticky, none plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia.

ANALYSES WR 38

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-28	1.9	1.15	8.6	7.5	7.8	0.12	4.0			0.4	0.5	4.9	>50	20.0
28-62	2.4	1.24	8.3	7.5	7.9	0.15	4.0			0.4	0.4	4.8	>50	19.3
62-87	3.2	1.10	8.4	7.4	7.9	0.14	6.0			0.6	0.3	4.9	>50	23.0
87-121	2.0	1.19	8.4	7.4	7.8	0.12	4.0			0.5	0.2	3.2	>50	16.1
121-147	3.7	1.15	8.4	7.3	7.8	0.13	6.0			0.7	0.3	5.0	>50	26.3
147-161	2.5	1.21	8.4	7.4	7.8	0.13	4.0			0.5	0.2	3.7	>50	19.4

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-28	0.05	0.34	910	4900	15650	<1					30	1080	110			
28-62	0.02	0.18	890	5450	14900	0					30	1050	110			
62-87	0.03	0.19	930	4900	16500	0					30	1110	110			
87-121	0.02	0.11	820	4000	13100	<1					30	910	100			
121-147	0.03	0.18	1000	4750	15300	<1					30	1130	110			
147-161	0.02	0.12	950	4050	12450	<1					30	970	100			

1. SITE INFORMATION

Map unit	1G
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	25.3.76
Location	2.5 km east of Al Husayniyah
Elevation	135 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Low hummocks, less than 1 m amplitude
Slope	Class 1
Vegetation/land use	Open <u>Acacia</u> and <u>Euphorbia</u> bushland; 2-5 m high <u>Acacia</u> 10 m or less apart; 1-2 m high <u>Euphorbia</u> 20 m or less apart; 70% bare ground

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained; rapid runoff
Surface stones and rock outcrops	None
Erosion	Moderate rill erosion; thin patches, less than 5 cm thick, of wind blown sand around base of hummocks
Salt or alkali	Subsurface horizons saline
Human influence	Runoff from this area collected on cultivated land further west

3. PROFILE DESCRIPTION

Depth, cm

0-11	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; moderate, medium, platy transitional downwards to very weak, very fine and fine, subangular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; clear, smooth boundary:
11-30	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, fine and medium, subangular blocky structure; dry; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; gradual, smooth boundary:
30-79	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, medium and coarse, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; gradual, smooth boundary:
79-119	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam to silty clay loam; moderate, fine and medium, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; very porous with many, very fine, few, fine and few, medium, tubular voids; weak, thin, carbonate pseudomycelia; clear, smooth boundary:
119-131	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; structureless; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; abrupt, smooth boundary:

PROFILE WR 44 (Continued)

Depth, cm

131-137 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, medium and coarse, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; clear, smooth boundary:

137-157 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; structureless; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; many, very fine, tubular voids; abrupt, smooth boundary:

157-166 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; many, very fine, tubular voids

Continuation by auger

166-204 Loam

204-232 Silt loam; weak, thin, carbonate pseudomycelia

232-276 Loam

276-286 Silt loam; weak, thin, carbonate pseudomycelia; few, fine, rusty mottles

ANALYSES WR 44

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-11	1.3	1.35	9.1	7.7	7.9	0.12	3.0	0.0	0.0	0.4	1.2	1.4	49.0	11.0
11-30	1.7	1.28	8.2	7.6	7.9	0.93	2.5	0.7	0.0	0.7	0.8	1.5	48.5	11.8
30-79	1.9	1.29	8.2	7.6	7.6	0.91	2.0	0.7	0.0	1.0	0.3	2.2	46.7	13.8
79-119	3.4	1.07	8.1	7.5	7.5	0.88	3.0	0.7	0.0	1.2	0.3	3.7	>50.0	23.1
119-131	2.2	1.17	8.5	7.5	7.7	0.40	4.0	0.3	0.0	1.1	0.2	3.0	>50.0	16.6
137-157	2.4	1.21	8.5	7.6	7.6	0.38	3.0	0.3	0.0	1.2	0.3	3.6	>50.0	18.8
157-166	1.7	1.28	8.6	7.6	7.6	0.28	2.0	0.2	0.0	0.8	0.2	2.2	43.7	13.6

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-11	0.02	0.16	860	5400	10700	6	4	40	45	11	20	770	90			
11-30	0.03	0.13	790	5100	10750	2	4	36	47	13	20	830	100			
30-79	0.02	0.09	840	5100	11900	1	5	37	42	16	30	860	100			
79-119	0.03	0.21	920	6850	16850	1	2	14	57	27	40	1210	120			
119-131	0.01	0.11	870	4700	14050	1	0	20	67	13	30	900	100			
137-157	0.01	0.11	980	4900	15150	1	1	21	64	14	30	940	100			
157-166	0.01	0.06	830	3750	12450	1	1	44	47	8	20	720	80			

HABAQ SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	5.12.75
Location	1 km south of Wadi Badwah on Zabid - Hudaydah highway
Elevation	100 a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Low hummocks, about 1 m amplitude
Slope	Class 1
Vegetation/land use	Open <u>Acacia</u> bushland, cut for fuel and grazed

2. SOIL INFORMATION

Parent material	Calcereous alluvium
Drainage	Well drained; rapid runoff
Surface stones and rock outcrops	None
Erosion	Slight sheet erosion and deflation
Salt or alkali	Profile saline
Human influence	None

3. PROFILE DESCRIPTION

Depth cm

0-33	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous and few, medium, woody roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
33-55	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, very fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; weak, thin carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
55-87	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; weak, fine and medium subangular blocky structure; moist; sticky, plastic, wet; friable, moist; common fine, fibrous roots; many, very fine and few, fine tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
87-105	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; weak, fine and medium, subangular blocky structure; moist; sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine tubular voids; weak, thin carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
105-143	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; very weak, fine and medium, subangular blocky structure; moist slightly sticky, slightly plastic; wet; friable, moist; few fine, fibrous roots; many, very fine and few, fine tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

PROFILE WR 3 (Continued)

Depth, cm

143-160

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; structureless; moist; slightly sticky, slightly plastic, wet; friable, moist; few, fine fibrous roots; many, very fine and few, fine, tubular voids; common gasteropod shells; weak, thin, carbonate pseudomycelia; slight effervescence

Continuation by auger

160-177

Dark brown (10YR 4/3) moist; few, fine rusty mottles associated with sedimentary layering; loam; weak, thin, carbonate pseudomycelia; few, moderately hard, carbonate nodules;; strong effervescence

177-206

Pale brown (10YR 6/3) moist; common, fine, rusty mottles; silt loam; few, medium, moderately hard, carbonate nodules; strong effervescence

206-280

Yellowish brown (10YR 5/4) moist; few, fine to coarse, rusty mottles; fine sandy loam; increasing sedimentary layering; common, medium, soft to hard, carbonate nodules; strong effervescence

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PROFILE WR 8 HABAQ SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO) Fluventic (amborthid (USDA)
Date	9.12.75
Location	Bayt al Habaq
Elevation	145 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Site fallow; previously pump irrigated cotton

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-14	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; moderate, medium, platy transitional downwards to weak, fine, subangular blocky structure; dry: non sticky, slightly plastic, wet; slightly hard, dry; common fine, fibrous roots; very porous with many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
14-42	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; moderate, fine and medium, angular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; common fine, fibrous roots; many very fine and few, fine tubular and few, very fine planar voids; weak thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
42-81	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; moderate, fine and medium, angular blocky structure; slightly moist; sticky, very plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
81-109	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; weak, fine and medium, angular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
109-160	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; compound, weak, medium, prismatic and weak, medium, angular blocky structure; slightly moist; sticky, very plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few fine tubular voids; few gasteropod shells; weak, thin, carbonate pseudomycelia; slight effervescence:

PROFILE WR 8 (continued)

Continuation by auger

160-177	Dark yellowish brown (10YR 4/4) moist; silty clay loam; few, small, soft, carbonate nodules:
177-230	Dark yellowish brown (10YR 4/4) moist; loam to clay loam; few, small, soft, carbonate nodules:
230+	No further penetration due to dryness/hardness of soil.

89

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PROFILE WR 17 HABAQ SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Haplic Yermosol (FA0). Fluventic Camborthid (ISDA)
Date	8.1.76
Location	0.5 km north of Al Junaydiyah
Elevation	125 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Flat
Microtopography	Terraced; uneven surface with 20 cm amplitude
Slope	Class 1
Vegetation/land use	Pump irrigated sorghum

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying material characteristic of Husayniyah Series
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields; small bunds and little difference in relative levels of fields

3. PROFILE DESCRIPTION

Depth, cm	
0-18	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; loam; structureless to very weak, fine, subangular blocky structure; dry; non sticky, slightly plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
18-32	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, fine and medium, subangular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; common, fine fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
32-54	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; moderate, fine and medium, angular blocky structure; slightly moist; sticky, very plastic, wet; slightly hard dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thin, carbonate, pseudomycelia; slight effervescence; diffuse, smooth boundary:
54-77	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; compound, moderate, medium, prismatic and moderate, medium, angular blocky structure; slightly moist; sticky, very plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
77-121	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; clay loam; compound, weak, coarse, prismatic and weak, medium, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

PROFILE WR 17 (Continued)

Depth, cm

121-145

Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; sandy clay loam; compound, structureless and very weak, fine, subangular blocky structure; moist; slightly sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; very slight effervescence; gradual, smooth boundary:

145-167

Dark yellowish brown (10YR 3/4) moist; dark yellowish brown (10YR 4/4) dry; fine sandy loam; structureless; moist; non sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; very slight effervescence:

Continuation by auger

167-199

Dark yellowish brown (10YR 4/4) moist; fine sandy loam to sandy clay loam; very slight effervescence:

199-267

Yellowish brown (10YR 5/4) moist; sandy clay loam; common medium and large, soft to moderately hard, carbonate nodules; strong effervescence:

267-287

Yellowish brown (10YR 5/4) moist; fine sandy loam; common, medium and large, soft to moderately, hard, carbonate nodules; slight effervescence:

ANALYSES WR 17

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-18	3.1	1.17	8.5	7.4	7.7	0.11	3.5			0.5	0.9	4.4	>50	19.2
18-32	4.3	1.07	8.8	7.4	7.7	0.10	3.0			0.6	0.6	4.3	>50	20.9
32-54	4.0	1.19	8.7	7.3	7.7	0.11	3.0			0.9	0.6	4.7	>50	24.3
54-77	4.5	1.23	8.8	7.2	7.7	0.13	2.0			1.1	0.9	5.3	49.0	26.4
77-121	4.5	1.24	8.0	7.2	7.7	0.18	1.5			0.9	0.9	5.2	43.4	26.6
121-145			8.5			0.13				0.7	0.7	4.6	37.8	22.1
145-167	3.1	1.20	8.1	7.2	7.7	0.14	1.0			0.6	0.5	4.3	37.0	21.5

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum.
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-18	0.04	0.21	1180	7250	16350	2	2	26	50	22	40	1040	120			
18-32	0.06	0.22	1180	7450	16550	0	1	21	50	28	40	1140	130			
32-54	0.04	0.20	1210	8050	16850	0	1	14	51	34	40	1140	130			
54-77	0.04	0.14	1190	7700	15850	2	1	16	46	37	40	1110	110			
77-121	0.03	0.16	1170	8100	15750	0	2	24	39	35	40	1120	120			
121-145							3	48	25	24						
145-167	0.02	0.16	670	4400	9700	0	2	54	24	20	30	770	80			

PROFILE WR 27 HABAQ SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	21.2.76
Location	1 km south west of Ad Dumaynah
Elevation	270 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Site fallow, rainfed cropland

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Irrigated from Wadi Rima prior to destruction of canal intake. Terraced and banded fields.

3. PROFILE DESCRIPTION

Depth (cm)	
0-8	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; loam; moderate, medium, platy transitional downwards to weak, medium, subangular blocky structure; dry; slightly sticky, slightly plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; slight effervescence; clear, smooth boundary:
8-23	Dark yellowish brown (10YR 4/4) moist: light yellowish brown (10YR 6/4) dry; silt loam; moderate, fine and medium, angular blocky structure; dry; sticky, plastic, wet; slightly hard, dry; common, fine and few, medium, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; few, small, mica flakes; slight effervescence; clear, smooth boundary:
23-48	Dark yellowish brown (10YR 4/4) moist: light yellowish brown (10YR 6/4) dry; silty clay loam; moderate, medium and coarse, angular blocky structure: slightly moist; very sticky, very plastic, wet: slightly hard, dry: common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids: few, small, mica flakes: slight effervescence; gradual, smooth boundary:
48-77	Dark yellowish brown (10YR 4/4) moist: light yellowish brown (10YR 6/4) dry; silty clay loam: compound, weak, coarse, prismatic and weak, medium, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
77-101	Dark yellowish brown (10YR 4/4) moist; light yellowish brown 9LOYR 6/4) dry; silt loam; very weak, medium and coarse, angular blocky structure; slightly moist; sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

PROFILE WR 27 (Continued)

Depth (cm)

101-128

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; very weak, medium and coarse, angular blocky structure; slightly moist; very sticky, very plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; moderate, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

128-160

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; structureless; slightly moist; sticky, plastic, wet; hard, dry; many, very fine and few, fine, tubular voids; few, small, mica flakes; moderate, thin, carbonate pseudomycelia; slight effervescence:

Continuation by auger

160-220

Dark yellowish brown (10YR 4/4) moist: clay loam; few, igneous gravel; few, fine, carbonate pseudomycelia; few, small, soft, carbonate nodules:

220 +

No penetration into gravel.

ANALYSES WR 27

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-8	2.8	1.12	8.7	7.2	7.6	0.10	4.0			0.4	0.6	3.1	>50	20.7
8-23	3.3	1.17	8.4	7.2	7.7	0.14	4.0			0.5	0.6	4.5	>50	23.8
23-48	3.9	1.14	8.4	7.2	7.7	0.20	4.0			0.7	0.5	6.3	>50	24.4
48-77	2.9	1.23	8.3	7.3	7.7	0.15	3.5			0.6	0.5	6.1	49.8	20.6
77-101	2.9	1.25	8.4	7.3	7.7	0.14	3.0			0.5	0.4	6.0	46.0	19.1
101-128	3.8	1.18	8.3	7.3	7.8	0.17	4.5			0.6	0.4	6.8	>50	22.3
128-160	4.0	1.20	8.3	7.3	7.8	0.17	4.0			0.7	0.3	6.7	>50	22.8

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-8	0.07	0.40	1290	6300	16160	2	19		56	25	40	1020	110			
8-23	0.08	0.43	1330	6600	17050	<1	19		50	31	40	1130	120			
23-48	0.07	0.40	1350	7150	17600	<1	17		46	37	40	1180	120			
48-77	0.05	0.22	1320	6300	16950	2	25		48	27	40	1020	110			
77-101	0.04	0.18	1180	5650	15450	0	27		46	27	30	970	100			
101-128	0.04	0.22	900	5650	16900	0	21		46	33	40	1070	110			
128-160	0.04	0.20	860	5650	16900	0	25		46	29	40	1040	100			

1. SITE INFORMATION

Map unit	1E
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	19.3.76
Location	1 km south east of Al Humarah
Elevation	315 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Irregularly spate irrigated from Wadi Rima; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium overlying stony wadi deposits
Drainage	Well drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields. bunds up to 0.5 m high with difference in field levels of 0.25 m

3. PROFILE DESCRIPTION

Depth, cm

0-20	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silt loam; very weak, fine and medium, subangular blocky structure; dry; slightly sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; clear, smooth boundary:
20-43	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; moderate, fine and medium, angular blocky structure; dry; sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, medium, tubular and few, very fine, planar voids; few, small mica flakes; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; common, gasteropod shells at top of horizon; gradual, smooth boundary:
43-64	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; weak, medium and coarse, angular blocky structure; slightly moist; slightly sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; clear, smooth boundary:
64-90/93	Dark yellowish brown (10YR 3/4) moist; dark yellowish brown (10YR 4/4) dry; clay loam; weak, medium and coarse, angular blocky structure; slightly moist; sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; very few, angular, igneous gravel; moderate, thick, carbonate pseudomycelia; clear, wavy boundary:
90/93-126	Many (>60%), angular and subrounded, weathering, igneous stones; few, fine, fibrous roots

ANALYSES WR 35

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PROFILE WR 36 HABAQ SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Haplic Yermosol (FAO), Fluventic Camborthid (USDA)
Date	19.3.76
Location	1 km east of Al Kunaydah
Elevation	275 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Rainfed cropland; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields; bunds up to 0.25 m high with little difference in field levels

3. PROFILE DESCRIPTION

Depth cm

0-18	Dark yellowish brown (10YR 4/4) moist; brownish yellow (10YR 6/6) dry; loam; moderate medium clay; transitional downwards to very weak fine, subangular blocky structure; dry non sticky, slightly plastic, wet; slightly hard dry common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few small mica flakes; very few, angular, igneous gravel; clear, smooth boundary:
18-40	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; weak, fine and medium, angular blocky structure; dry; slightly sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; clear, smooth boundary:
40-68	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; moderate, medium and coarse, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine tubular and few, very fine, planar voids; few small, mica flakes; moderate, thin, carbonate pseudomycelia; diffuse, smooth boundary:
68-96	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; clay loam; weak, medium and coarse, angular blocky structure; slightly moist, sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, medium, tubular voids; few, small, mica flakes; moderate, thin, carbonate pseudomycelia; clear, smooth boundary:
96-125	Dark yellowish brown (10YR 3/4) moist; dark yellowish brown (10YR 4/4) dry; clay loam; very weak, coarse, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; moderate, thick, carbonate pseudomycelia; clear, smooth boundary:

PROFILE WR 36 (Continued)

Depth, cm

125-168

Yellowish brown (10YR 5/6) moist; brownish yellow (10YR 6/6) dry; fine sandy loam; structureless; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids: few small. mica flakes weak. thin, carbonate pseudomycelia:

ANALYSES, WR 36

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-18	2.1	1.31	8.3	7.4	7.7	0.13	1.0			0.2	0.5	2.3	39.8	17.8
18-40	2.6	1.24	8.6	7.4	7.7	0.10	1.5			0.3	0.3	2.5	43.0	20.8
40-68	3.6	1.13	8.3	7.3	7.7	0.14	2.0			0.5	0.3	3.4	>50	26.6
68-96	3.3	1.19	8.3	7.3	7.6	0.14	1.5			0.7	0.3	3.5	47.7	26.9
96-125	3.3	1.12	8.2	7.3	7.6	0.15	2.0			0.6	0.3	3.6	48.9	26.6
125-168	3.3	1.22	8.2	7.3	7.7	0.16	1.0			0.6	0.2	2.9	35.9	20.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-18	0.04	0.28	930	5100	14250	2	31	48	21		30	860	90			
18-40	0.05	0.29	850	5150	12350	1	33	40	27		30	930	90			
40-68	0.05	0.32	800	5650	14350	0	25	38	37		30	1050	100			
68-96	0.05	0.32	660	5550	12650	<1	29	38	33		30	990	90			
96-125	0.05	0.41	570	5200	11400	<1	28	37	35		30	990	90			
125-168	0.02	0.11	660	4100	12150	<1					30	900	80			

ISABAH SERIES

PROFILE WR 30 ISABAH SERIES

1. SITE INFORMATION

Map unit	2
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	22.2.76
Location	1 km east of Isabah
Elevation	350 m a.m.s.l.
Landform	
Physiography	Alluvial fan
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Regular irrigation from Wadi Rima

2. SOIL INFORMATION

Parent material	Anthropic calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-26	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay loam; very weak, coarse, angular blocky structure; moist; sticky, plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; common, thick, silty fragments; common termite and worm activity with fecal pellets on surface; few, small, mica flakes; slight effervescence; gradual, smooth boundary:
26-56	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay loam; structureless; moist; sticky, plastic, wet; friable, moist; few fine, fibrous roots; many, very fine and few, fine, tubular voids; common, thick, silty fragments; few, small, mica flakes; slight effervescence; gradual, smooth boundary:
56-93	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay loam; structureless; moist; very sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine tubular voids; horizon includes a 10 cm thick, slightly disturbed, platy layer with very faint mottling; few small, mica flakes; slight effervescence; diffuse, smooth boundary:
93-130	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay loam; structureless; moist; very sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; slight effervescence; gradual, smooth boundary:
130-159	Dark yellowish brown (10YR 4/4) moist; brownish yellow (10YR 6/6) dry; clay loam; structureless; moist; sticky, plastic, wet; friable, moist; many very fine tubular voids; few small, mica flakes; very slight effervescence; common igneous stones at base of pit:

Continuation by auger

159-260	Dark brown (10YR 4/3) moist; clay; few fine, carbonate pseudomycelia below 200 cm:
260-279	Dark yellowish brown (10YR 4/4) moist; clay loam; few, igneous gravel

ANALYSES WR 30

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-26	4.1	1.00	8.5	7.3	7.7	0.16	5.5			0.7	0.9	7.0	>50	28.7
26-56	3.7	1.06	8.3	7.3	7.7	0.18	5.0			0.5	0.6	6.4	>50	23.4
56-93	3.7	1.06	8.4	7.3	7.7	0.15	6.0			0.6	0.7	7.7	>50	27.6
93-130	3.1	1.13	7.9	7.3	7.7	0.20	5.0			0.5	0.5	6.5	>50	23.5
130-159	2.6	1.23	8.0	7.2	7.7	0.17	3.0			0.4	0.5	5.7	40.8	22.0

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-26	0.18	1.32	1080	7150	17400	10		7	67	26	40	1220	130			
26-56	0.15	0.95	1090	6700	17050	5		9	67	24	40	1220	130			
56-93	0.13	0.81	1090	7300	17250	2		9	61	30	40	1250	120			
93-130	0.10	0.60	1020	6150	16900	1		9	67	24	40	1120	120			
130-159	0.05	0.27	970	5850	15900	1		25	53	22	40	960	100			

1. SITE INFORMATION

Map unit	2
Higher category class	Haplic Xerosol (FAO); Intergrade between Fluventic Camborthid and Fluventic Haplustoll (USDA)
Date	18.3.76
Location	0.5 km south west of Al Uqaydah
Elevation	370 m a.m.s.l.
Landform	
Physiography	Fan head trench; lower alluvial terrace bordering Wadi Rima
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Regular irrigation from Wadi Rima; recently harvested maize

2. SOIL INFORMATION

Parent material	Anthropic calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth (cm)

0-22	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay; compound, weak, coarse, prismatic and weak, coarse, angular blocky structure; moist; very sticky, very plastic, wet; firm, moist; common, fine, fibrous roots; many, very fine, tubular and few, fine, planar voids; few, small, mica flakes; gradual, smooth boundary:
22-55	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay; weak, medium and coarse, angular blocky structure; moist; very sticky, very plastic, wet; firm, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small mica flakes; clear, smooth boundary:
55-68	Dark brown (10YR 4/3) moist. pale brown (10YR 6/3) dry: silty clay loam; very weak, medium, angular blocky structure; moist: sticky, plastic, wet: friable, most: common, fine, fibrous roots; many, very fine and few, fine, tubular voids: few, small, mica flakes: clear, smooth boundary:
68-114	Dark brown (10YR 4/3) moist: pale brown (10YR 6/3) dry: silty clay; weak, medium and coarse, angular blocky structure; moist; very sticky, very plastic, wet: firm, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids: few, small, mica flakes; diffuse, smooth boundary:
114-160	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; silty clay; weak, medium and coarse, angular blocky structure; moist; very sticky, very plastic, wet; firm, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes.

ANALYSES WR 33

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-22	5.2	1.04	8.0	7.3	7.7	0.19	4.5			0.9	0.9	9.3	>50	36.1
22-55	4.3	1.11	8.1	7.2	7.7	0.18	7.0			0.9	0.4	9.0	>50	29.9
55-68	2.7	1.12	8.0	7.3	7.7	0.18	5.0			0.7	0.3	6.0	>50	21.8
68-114	4.2	1.12	8.2	7.2	7.7	0.18	7.0			0.9	0.4	9.3	>50	30.0
114-160	4.3	1.13	8.5	7.1	7.7	0.17	5.0			0.8	0.5	10.1	>50	31.1

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ²⁻ ₄ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-22	0.21	1.38	1130	8000	18500	5	5		45	50	40	1480	150		0.0	0.00
22-55	0.10	0.69	1120	6650	18300	1	9		49	42	40	1250	120		0.0	0.00
55-68	0.09	0.45	990	5650	15800	1	19		53	28	40	1050	110		0.0	0.00
68-114	0.10	0.60	1050	6850	18200	1	7		51	42	40	1340	130		0.0	0.00
114-160	0.08	0.49	1050	7300	18500	2	7		43	50	40	1400	130		0.0	0.00

HUSAYNIYAH
SERIES

PROFILE WR 2 HUSAYNIYAH SERIES OVERBLOWN PHASE

1. SITE INFORMATION

Map unit	3C
Higher category class	Haplic Yermosol (FAO), Typic Camborthid (USDA)
Date	4.12.75
Location	0.5 km south of Al Badwah petrol station on Zabid-Hudaydah highway
Elevation	110 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Hummocks with 1 m amplitude
Slope	Class 1
Vegetation/land use	Dwarf shrub grassland, uncultivated with 40-50% bare ground

2. SOIL INFORMATION

Parent material	Calcareous alluvial and aeolian material
Drainage	Somewhat excessively drained
Surface stones and rock outcrops	None
Erosion	Slight deflation between hummocks stabilised by vegetation
Salt or alkali	Deep subsoil is sodic
Human influence	None

3. PROFILE DESCRIPTION

Depth, cm

0-12	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; fine sand; structureless; dry; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; very slight effervescence; abrupt, smooth boundary:
12-30	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sand; structureless; dry; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; very slight effervescence; clear, smooth boundary:
30-66	Dark yellowish brown (10YR 3/4) moist; yellowish brown (10YR 5/4) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
66-90	Dark yellowish brown (10YR 3/4) moist; yellowish brown (10YR 5/4) dry; fine sandy loam; very weak, very fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
90-116	Dark yellowish brown (10YR 3/4) moist; yellowish brown (10YR 5/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; very slight effervescence; gradual, smooth boundary:
116-143/151	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; many, very fine, tubular voids; slight effervescence; clear, wavy boundary:
143/151-160	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; many, very fine, tubular voids; few, medium and large, hard, cylindrical carbonate nodules; strong effervescence:

PROFILE WR 2 (Continued)

Depth, cm

Continuation by auger

160-230

Dark yellowish brown (10YR 4/4) moist; fine sandy loam; few, medium, moderately hard and hard, cylindrical carbonate nodules; stony effervescence:

230-280

Dark yellowish brown (10YR 4/4) moist; loamy fine sand; very few, medium, moderately hard and hard, cylindrical carbonate nodules; slight effervescence.

ANALYSES WR 2

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 1M KCl	pH 1:5 0.01M CaCl ₂	Cond.. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-12	0.9	1.44	8.8	7.9	7.6	0.06	1.0			0.1	0.7	0.7	16.4	7.5
12-30	1.3	1.40	8.6	7.9	7.6	0.07	1.0			0.1	0.9	0.8	22.6	10.4
30-66	2.7	1.25	8.6	7.6	7.5	0.10	2.5			0.5	1.1	2.0	43.0	19.4
66-90	2.8	1.27	8.8	7.5	7.5	0.15	1.5			1.4	0.8	2.0	36.5	20.0
90-116	3.3	1.37	8.9	7.5	7.4	0.15	1.0			1.7	0.5	2.0	29.2	19.7
116-143	3.3	1.33	9.1	7.6	7.6	0.22	1.0			2.4	0.4	2.3	29.0	18.6
143-160	3.1	1.27	8.7	7.7	7.6	0.39	8.5			2.8	0.3	2.8	>50.0	16.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-12	0.01	0.07	1060	3200	8750	3	6	81	10	3	20	690	80	0.21		
12-30	0.01	0.08	930	3800	6950	1	7	72	12	9	20	720	70			
30-66	0.02	0.16	910	4900	9000	1	5	56	19	20	30	1220	80			
66-90	0.02	0.14	780	4700	10300	<1	6	58	19	17	30	960	80			
90-116	0.02	0.11	810	3950	10500	<1	5	64	18	13	30	790	80			
116-143	0.01	0.09	800	3700	11650	<1	7	60	19	14	30	760	80			
143-160	0.02	0.08	910	3450	10050	1	6	57	21	16	20	730	70			

PROFILE WR 6 HUSAYNIYAH SERIES

1. SITE INFORMATION

Map unit	3D
Higher category class	Calcic Yermosol (FAO), Typic Calciorthid (USDA)
Date	8.12.75
Location	1.25 km west of Dar Ban
Elevation	125 a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetarian/land use	Recently harvested pump irrigated sorghum

2. SOIL INFORMATION

Parent material	Calcareous alluvial and aeolian material
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields: difference in field levels of 0.5 m

3. PROFILE DESCRIPTION

Depth cm

0-28	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
28-52	Dark yellowish brown (10 YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; weak, thin carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
52-68	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; weak, fine and medium, subangular blocky structure; slightly moist, non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; moderate, thin, carbonate pseudomycelia; few, medium, moderately hard, irregular, carbonate nodules; strong effervescence; clear, smooth boundary:
68-111	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; fine sandy loam; weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, medium, hard, irregular, carbonate nodules; weak, thin carbonate pseudomycelia; strong effervescence; gradual, smooth boundary:
111-137	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; loamy fine sand; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, medium, hard, irregular, carbonate nodules; strong effervescence; clear, smooth boundary:

PROFILE WR 6 (Continued)

Depth cm

137-160

Yellowish brown (10YR 5/4) moist very pale brown (10YR 7/3) dry; stony, loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; many (60%), large, irregular and cylindrical, hard, carbonate nodules; strong effervescence:

Continuation by auger

160-230

Yellowish brown (10YR 5/4) moist; fine sandy loam; few to many, medium, hard, irregular, carbonate nodules; strong effervescence:

230+

No penetration into carbonate nodules

ANALYSES WR 6

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-28	1.9	1.29	8.7	7.8	7.7	0.11	2.5			0.6	0.4	2.6	34.8	14.2
28-52	3.6	1.19	8.4	7.2	7.6	0.14	3.0			0.9	0.3	1.6	>50.0	20.0
52-68	3.1	1.19	8.6	7.5	7.7	0.13	7.0			0.9	0.3	1.9	>50.0	18.5
68-111	2.5	1.26	8.5	7.6	7.6	0.15	16.0			0.8	0.2	2.0	>50.0	14.6
111-137	1.8	1.24	8.4	7.6	7.6	0.15	14.5			0.6	0.3	2.0	>50.0	14.5
137-160	1.6	1.25	8.3	7.1	7.5	0.17	16.0			0.5	0.3	2.4	>50.0	14.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-28	0.02	0.16	850	3700	10400	1	5	59	29	7	20	660	80	0.40		
28-52	0.02	0.12	730	3100	9800	1	3	60	14	23	30	740	70			
52-68	0.01	0.10	780	3250	10950	1	6	56	22	16	30	610	70			
68-111	0.01	0.07	690	2700	9600	1	8	53	25	14	20	540	70			
111-137	0.01	0.06	600	2500	8300	<1	9	59	21	11	20	590	70			
137-160	0.01	0.05	620	2600	8700	<1	7	60	24	9	20	520	60			

PROFILE WR 15 HUSAYNTIYAH SERIES

1. SITE INFORMATION

Map unit	3D
Higher category class	Haplic Yermosol (FAO) Typic Camborthid (USDA)
Date	6.1.76
Location	0.5 km south west of Al Habil
Elevation	125 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Rainfed crop land; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvial and aeolian material
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields; low bunds and little difference in levels between fields

3. PROFILE DESCRIPTION

Depth, cm

0-27	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; compound, structureless to very weak, very fine, subangular blocky structure; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many very fine and few, fine tubular voids; very few subrounded, igneous gravel; slight effervescence; clear. smooth boundary:
27-38/53	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak very fine and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few fine fibrous roots; many, very fine and few, fine tubular voids; slight effervescence; clear, irregular boundary:
38/53-60	Dark brown (10YR 3/3) moist; dark brown (10YR 4/3) dry; fine sandy loam; very weak very fine and fine subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many very fine tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
60-80	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; diffuse, smooth boundary:
80-118	Dark yellowish brown (10YR 4/4) moist; brownish yellow (10YR 6/6) dry; fine sandy loam; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear smooth boundary:
118-160	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; fine sandy loam; structureless; moist; non sticky, non plastic, wet; friable, moist; few, fine, fibrous roots; many very fine, tubular voids; common, medium and large, hard, irregular and cylindrical, carbonate nodules; strong effervescence:

PROFILE WR 15 (continued)

Continuation by auger

160-220

Yellowish brown (10YR 5/4) moist; fine sandy loam; common, carbonate nodules; strong effervescence:

220+

No penetration into carbonate nodules

ANALYSES WR 15

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-27	1.5	1.38	8.6	7.6	7.7	0.09	2.0			0.2	0.5	1.9	29.9	12.4
27-53	2.4	1.31	8.5	7.6	7.7	0.10	2.5			0.3	0.6	2.2	>50	16.2
53-60	2.7	1.23	8.6	7.5	7.7	0.09	2.5			0.4	0.6	2.2	>50	17.9
60-80	2.5	1.27	8.9	7.4	7.7	0.09	2.0			0.4	0.5	1.9	46.8	17.9
80-118	2.4	1.30	8.7	7.5	7.7	0.10	1.5			0.4	0.4	1.7	36.0	17.7
118-160	2.6	1.27	9.0	7.6	7.7	0.09	12.0			0.5	0.3	2.7	>50	16.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-27	0.02	0.07	1110	4000	11050	2	6	57	26	11	30	690	90			
27-53	0.03	0.12	810	4350	10000	0	4	57	23	16	30	700	80			
53-60	0.02	0.17	680	4300	10250	<1	4	58	22	17	30	710	80			
60-80	0.03	0.08	690	3400	10250	0	2	64	19	15	30	670	80			
80-118	0.01	0.05	680	3150	11700	0	2	62	23	12	30	680	80			
118-160	0.02	0.03	560	3250	11100	<1	6	52	27	15	20	650	80			

PROFILE WR 40 HUSAYNIYAH SERIES

1. SITE INFORMATION

Map unit	3A
Higher category class	Calcic Yermosol (FAO), Typic Calciorthid (USDA)
Date	22.3.76
Location	2 km north of Al Husayniyah
Elevation	125 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced, aeolian hummocks and ridges with amplitudes up to 80 cm
Slope	Class 1
Vegetation/land use	Rainfed cropland; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvial and aeolian material
Drainage	Somewhat excessively drained
Surface stones and rock outcrops	Fairly stony in patches with no rock outcrops
Erosion	Moderate wind erosion and deposition
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-12/15

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; very few, angular, igneous gravel; clear, wavy boundary:

12/15-40

Dark yellowish brown (10YR 4/4) moist: pale brown (10YR 6/3) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; gradual, smooth boundary:

40-76

Yellowish brown (10YR 5/4) moist: very pale brown (10YR 7/3) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; slightly moist: non sticky, non plastic, wet; slightly hard, dry: few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes: common, medium, moderately hard to hard, irregular, carbonate nodules; gradual, smooth boundary:

76-99

Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; fine, sandy loam; very weak, very fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; very few, medium, moderately hard, irregular, carbonate nodules; clear, smooth boundary:

99-155

Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; few, fine, fibrous roots; very porous; very few, angular, igneous gravel; many, medium and large, moderately hard to hard, irregular, carbonate nodules (>60%) weakly cemented to form agglomerations up to 5 cm diameter.

ANALYSES WR 40

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-15	1.4	1.47	8.6	7.7	8.0	0.10	1.5			0.2	0.5	1.1	28.0	10.1
15-40	2.7	1.30	8.5	7.6	7.9	0.09	6.0			0.3	0.3	1.7	>50	14.8
40-76	2.1	1.27	8.9	7.7	7.9	0.10	13.0			0.5	0.2	2.6	>50	12.3
76-99	2.0	1.25	8.7	7.7	7.8	0.14	10.0			0.6	0.2	3.5	>50	11.8
99-155	2.5	1.29	9.1	7.7	8.0	0.13	19.0			0.9	0.3	7.9	>50	11.5

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-15	0.01	0.03	760	3100	8000	4					20	550	70			
15-40	0.02	0.14	810	3550	10650	2					30	640	80			
40-76	0.02	0.06	710	3250	11500	2					20	570	70			
76-99	0.01	0.05	730	3300	12200	1					20	570	70			
99-155	0.01	0.03	550	3600	15800	1					20	460	70			

PROFILE WR 41 HUSAYNIYAH SERIES

1. SITE INFORMATION

Map unit	3D
Higher category class	Haplic Yermosol (FAO), Typic Camborthid (USDA)
Date	6.4.76
Location	1.5 km south of Wadi Uqash on Zabid-Hudaydah highway
Elevation	105 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Smooth; aeolian hummocks directly to the south
Slope	Class 1
Vegetation/land use	Pump irrigation

2. SOIL INFORMATION

Parent material	Calcareous alluvial and aeolian material
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Slight wind erosion; site protected by trees planted as windbreak
Salt or alkali	None
Human influence	Small plots 10 m x 10 m prepared for pump irrigation

3. PROFILE DESCRIPTION

Depth (cm)

0-28	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; moist; non sticky, non plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; gradual, smooth boundary:
28-49	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; gradual, smooth boundary:
49-80	Dark brown (10YR 3/3) moist; brown (10YR 5/3) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes and magnetite grains; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:
80-125	Dark brown (10YR 3/3) moist; brown (10YR 5/3) dry; fine sandy loam; very weak, fine, subangular blocky structure; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes and magnetite grains; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:
125-155	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; moderate, thin, carbonate pseudomycelia; few, small, soft, irregular, carbonate nodules; gradual, smooth boundary:

PROFILE WR 41 (Continued)

Depth (cm)

155-173

Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; few, medium, moderately hard, irregular, carbonate nodules.

ANALYSES WR 41

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-28	2.1	1.36	8.3	7.7	7.9	0.18	3.5			0.8	0.6	3.6	46.8	13.7
28-49	2.6	1.40	8.5	7.5	7.9	0.14	1.5			0.9	0.4	3.6	39.1	15.3
49-80	2.8	1.36	8.6	7.5	7.8	0.16	1.5			1.3	0.3	3.5	40.0	17.2
80-125	2.9	1.39	8.8	7.3	7.8	0.16	1.0			1.5	0.3	1.7	38.0	18.4
125-155	2.1	1.39	8.6	7.4	7.6	0.18	7.0			1.4	0.2	2.1	>50	13.7
155-173	1.8	1.44	8.6	7.6	7.7	0.18	8.0			1.1	0.2	1.9	>50	10.3

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-28	0.03	0.21	1140	4350	13350	4					30	720	90			
28-49	0.02	0.08	1120	4450	11450	2					30	770	90			
49-80	0.02	0.13	980	3850	9750	1					30	660	90			
80-125	0.02	0.11	930	3100	9250	2					30	580	90			
125-155	0.02	0.07	980	2800	9900	2					30	590	90			
155-173	0.01	0.03	1000	2450	9900	1					30	590	90			

BADWAH SERIES

PROFILE WR 9 BADWAH SERIES

1. SITE INFORMATION

Map unit	4
Higher category class	Calcic Yermosol (FAO), Typic Paleorthid (USDA)
Date	21.12.75
Location	1.5 km north east of Musalib, at small quarry
Elevation	125 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Smooth
Slope	Class 1
Vegetation/land use	Small quarry, surrounded by terraced fields

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Quarrying for carbonate for conversion to quicklime

3. PROFILE DESCRIPTION

Depth, cm

0-15	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; strong, medium, platy transitional downwards to weak, very fine, subangular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; very few, angular, igneous gravel; slight effervescence; clear, smooth boundary:
15-30	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; compound, strong, coarse, prismatic and moderate, medium, angular blocky structure; dry; sticky, plastic, wet; hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; strong effervescence; clear, smooth boundary:
30-42/48	Dark yellowish brown (10YR 4/4) moist: light yellowish brown (10YR 6/4) dry; clay loam; weak, fine and medium, angular blocky structure; dry; sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; many (10%) gasteropod shells; very few, angular, igneous gravel; weak, thin, carbonate pseudomycelia; strong effervescence; clear, irregular boundary:
42/48-57	Weakly cemented, moderately hard calcium carbonate; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; violent effervescence; gradual, smooth boundary:
57-95	Strongly cemented, hard calcium carbonate; many, very fine and few, fine, tubular voids; violent effervescence; abrupt, smooth boundary:
95/112	Yellowish brown (10YR 5/4) moist; pale brown (10YR 6/3) dry; few, small, faint, brownish yellow mottles; fine sandy loam; structureless; dry; non sticky, slightly plastic, wet; hard, dry; many, very fine and few, fine, tubular voids; very few, angular, igneous gravel; few, medium, soft, irregular, carbonate nodules and subrounded, clay nodules; strong effervescence.

ANALYSES WR 9

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-15	2.5	1.38	8.6	7.4	8.0	0.10	5.0			0.4	0.6	1.6	49.0	16.9
15-30	3.7	1.18	8.4	7.2	7.9	0.18	13.5			0.6	0.5	2.0	>50	22.9
30-42	2.9	1.16	8.6	7.3	7.9	0.21	25.5			0.6	0.4	1.9	>50	18.5
95-112	2.6	1.21	8.2	7.3	7.9	0.19	28.0			0.5	0.3	3.5	>50	18.6

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-15	0.03	0.15	1000	4800	11700	3	18	35	30	17	30	830	90			
15-30	0.03	0.20	1080	5650	14000	1	8	23	41	28	40	970	90			
30-42	0.04	0.25	910	4600	11450	2	12	22	36	30	30	830	80			
95-112	0.02	0.15	710	2900	9900	<1	7	37	34	22	20	570	50			

MAHATT SERIES

PROFILE WR 4 MAHATT SERIES

1. SITE INFORMATION

Map unit	7C
Higher category class	Calcaric Fluvisol (FAO), Typic Torrigluvent (USDA)
Date	6.12.75
Location	1.25 km south of Al Qurshiyah
Elevation	70 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Low sandy hummocks and surface rippling of sand by wind
Slope	Class 1
Vegetation/land use	Adjacent land pump irrigated; although banded site shows no evidence of recent cultivation

2. SOIL INFORMATION

Parent material	Calcareous alluvium, partly anthropic
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Moderate wind erosion and deposition
Salt or alkali	None
Human influence	Low bunds surrounding fields

3. PROFILE DESCRIPTIONS

Depth, cm 0-29	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; thin (10 cm) surface layer of windblown sand; fine sandy loam; moderate, medium platy transitional downwards to very weak, very fine, subangular blocky structure; dry; non sticky, slightly plastic; wet; slightly hard, dry; few, fine, fibrous and few, medium, woody roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
29-63	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, medium and coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet: slightly hard; dry; common, fine, fibrous roots; many, very fine, few, fine and few, medium, tubular voids; few, disoriented, platy, silt loam fragments; slight effervescence; gradual, smooth boundary:
63-78	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, medium and coarse, angular blocky structures; slightly sticky slightly plastic wet; slightly hard, dry; common, fine fibrous roots; many, very fine and few, fine, tubular voids; few disoriented, platy, silt loam fragments; slight effervescence; clear, smooth boundary:
78-104	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; very weak fine subangular blocky structure; slightly moist non sticky slightly plastic, wet; slightly hard; dry; few fine, fibrous roots; many, very fine and few, fine tubular voids; common. Silty laminations increasing to base of horizon; slight effervescence; clear smooth boundary:

PROFILE WR 4 (Continued)

Depth, cm

- 104-128 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; compound, weak, medium, prismatic and weak, medium, angular blocky structure: slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; common, hard, laminated, occasionally massive, angular silty fragments; slight effervescence; gradual, smooth, boundary:
- 128-146 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; weak, medium and coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
- 146-155 Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine, sandy loam; very weak, very fine, subangular blocky transitional to structureless; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; many, very fine and few, fine, tubular voids; slight effervescence:

Continuation by auger

- 155-245 Dark yellowish brown (10YR 4/4) moist; silt loam; slight effervescence
- 245-275 Dark brown (10YR 4/3) moist; silty clay; slight effervescence

ANALYSES WR 4

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-29	2.4	1.13	8.8	7.7	7.5	0.11	4.5			1.1	0.4	2.8	>50.0	17.2
29-63	2.2	1.11	8.6	7.6	7.7	0.20	4.5			1.5	0.6	3.5	>50.0	18.7
63-78	2.3	1.15	8.6	7.6	7.6	0.16	4.0			1.1	0.5	3.5	>50.0	17.4
78-104	2.4	1.06	8.4	7.6	7.6	0.21	4.5			1.1	0.5	3.8	>50.0	18.2
104-128	4.3	0.98	8.0	7.5	7.7	0.43	4.5			1.2	0.8	5.6	>50.0	26.4
128-146	3.4	1.13	8.0	7.6	7.5	0.30	3.5			0.9	0.7	4.5	>50.0	20.4
146-155	2.3	1.23	8.1	7.7	7.5	0.25	3.0			0.6	0.5	3.2	44.2	14.8

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-29	0.04	0.25	1040	5450	13300	1	0	24	59	17	30	920	100	0.62		
29-63	0.04	0.23	1260	6050	14700	2	1	24	51	24	30	1000	110			
63-78	0.03	0.23	1000	5500	12250	1	3	22	55	20	30	910	110			
78-104	0.03	0.21	950	5350	13300	2	0	10	72	18	30	950	110			
104-128	0.05	0.31	980	6700	14000	3	1	7	55	37	30	1220	150			
128-146	0.05	0.25	1080	6700	14000	3	2	22	48	28	40	1080	130			
146-155	0.03	0.18	800	4950	10600	2	1	39	43	17	30	850	100			

PROFILE WR 14 MAHATT SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	6.1.76
Location	0.5 km east of Al Habil
Elevation	135 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Pump irrigated sorghum and cotton; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-20/24

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand with few, platy, silty loam fragments; compound, structureless to very weak very fine, subangular blocky structure; dry, non sticky, non plastic, wet, soft, dry; common fine fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, wavy boundary:

20/24-26/28

Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; few fine, distinct brownish yellow mottles between horizontal platy lamina; silt loam moderate, coarse platy structure; dry, slightly sticky, plastic, wet; very hard, dry, common, fine, fibrous roots; few, very fine, tubular and planar voids; slight effervescence; abrupt, wavy boundary :

26/28-40

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam structureless; slightly moist; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:

40-46

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:

46-58

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; very weak, very fine and fine, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; common, slightly disturbed platy fragments; slight effervescence; clear, smooth boundary:

58-79

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, very fine, and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine tubular voids; slight effervescence; gradual, smooth boundary:

PROFILE WR 14 (continued)

Depth, cm	
79-100	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; compound, structureless to very weak, medium, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many very fine and few fine, tubular voids; very few, angular igneous gravel; slight effervescence; clear, smooth boundary:
100-121	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; weak, medium and coarse, angular blocky structure; moist; slightly sticky, plastic, wet; friable, moist; few fine, fibrous roots; many, very fine and few fine, tubular voids; weak thin carbonate pseudomycelia; slight effervescence; clear smooth boundary:
121-129	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few fine fibrous roots; many, very fine and few fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
129-160	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; loam; very weak, medium and coarse; angular blocky structure; moist; slightly sticky, slightly plastic; wet; friable moist; few, fine fibrous roots; many very fine and few fine and medium, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence
Continuation by auger	
160-204	Dark yellowish brown (10YR 4/4) moist; clay loam; slight effervescence
204-235	Dark yellowish brown (10YR 4/4) moist; fine sandy loam to loam; slight effervescence:
235-260	Dark yellowish brown (10YR 4/4) moist; silty clay, slight effervescence:
260-280	Dark yellowish brown (10YR 4/4) moist; sandy clay loam; slight effervescence:

ANALYSES WR 14

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-24	1.9	1.24	8.4	7.6	7.7	0.09	3.5			0.4	0.3	2.1	41.0	14.0
24-28	3.4	1.04	8.5	7.4	7.7	0.12	5.0			1.0	0.4	4.4	>50	23.7
28-46	1.7	1.26	9.0	7.7	7.7	0.08	3.0			0.5	0.3	2.5	37.2	11.8
46-58	3.2	1.12	8.7	7.5	7.7	0.13	5.0			0.9	0.4	4.9	>50	19.5
58-79	3.0	1.17	8.9	7.5	7.7	0.12	3.0			0.9	0.4	4.9	49.0	20.0
79-100	2.4	1.35	8.5	7.5	7.7	0.12	2.5			0.7	0.4	3.9	42.0	16.8
100-121	3.2	1.21	8.3	7.4	7.6	0.14	2.5			0.7	0.7	4.5	42.9	20.9
121-129	1.9	1.32	8.6	7.6	7.7	0.09	1.5			0.5	0.4	2.7	28.2	12.5
129-160	2.3	1.27	8.6	7.5	7.7	0.11	2.0			0.6	0.5	3.7	34.1	16.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-24	0.04	0.21	830	4050	11900	1	3	38	49	10	30	780	90			
24-28	0.08	0.49	1080	4800	16400	0	1	11	69	19	40	1160	120			
28-46	0.02	0.11	870	3950	9900	0	8	46	35	11	20	680	80			
46-58	0.05	0.24	1080	5500	15650	<1	3	18	56	23	40	1050	110			
58-79	0.04	0.19	1110	5350	15250	1	4	27	46	23	40	980	110			
79-100	0.04	0.17	1000	4750	12550	1	12	31	40	17	30	830	100			
100-121	0.04	0.18	1150	6100	15550	2	6	27	42	25	40	1010	110			
121-129	0.02	0.04	950	4300	11200	1	10	50	27	13	20	680	90			
129-160	0.03	0.07	980	4800	12450	1	7	39	38	16	30	830	90			

PROFILE WR 16 MAHATT SERIES

1. SITE INFORMATION

Map unit	1F
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	7.1.76
Location	1 km west of Basat
Elevation	140 m a.m.s.l.
Landform	
Physiography	Transition between alluvial fan and alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Pump irrigated sorghum; site probably receives irregular spate irrigation

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and bunded fields

3. PROFILE DESCRIPTION

Depth, cm

0-27

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; compound, structureless and very weak, and very fine, subangular blocky structure; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:

27-46

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, very fine and fine, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; gradual, smooth boundary:

46-63/67

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic wet; slightly hard dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, platy, silt loam fragments; slight effervescence; abrupt, wavy boundary:

63/67-89

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; compound, moderate, coarse, prismatic and weak, coarse, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; many, thick, fissile, silty fragments; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:

80-108

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay; compound, moderate, coarse, prismatic and weak, coarse, angular blocky structure; slightly moist; sticky, very plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; many, thick, fissile, silty fragments; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

PROFILE WR 16 (Continued)

Depth, cm

108-160

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; compound, very weak, coarse, prismatic and very weak, coarse, angular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence:

Continuation by auger

160-230

0
Dark yellowish brown (10YR 4/4) moist; silt loam; slight effervescence:

230-280

Dark yellowish brown (10YR 4/4) moist; silty clay; weak, thin, carbonate pseudomycelia; very slight effervescence:

ANALYSES WR 16

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-27	2.6	1.23	8.6	7.6	7.7	0.13	4.0			0.7	0.6	3.1	>50	16.5
27-46	2.9	1.20	8.7	7.5	7.7	0.12	4.5			0.9	0.5	3.7	>50	18.6
46-67	2.3	1.22	8.7	7.5	7.7	0.11	3.5			0.8	0.4	3.3	>50	16.2
67-89	4.3	1.08	8.5	7.4	7.7	0.26	5.0			1.5	0.5	5.9	>50	27.6
89-108	2.7	1.24	8.3	7.4	7.7	0.33	4.0			1.6	0.5	6.5	>50	29.3
108-160	2.7	1.23	8.4	7.4	7.7	0.19	2.5			0.9	0.4	4.3	43.2	16.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-27	0.05	0.20	1010	5250	14750	2	1	23	59	17	30	890	100			
27-46	0.04	0.20	1060	5700	15450	<1	1	17	63	19	40	1040	110			
46-67	0.03	0.15	890	5200	12450	<1	3	30	51	16	30	860	100			
67-89	0.07	0.37	1150	6850	17500	1	1	6	59	34	40	1280	140			
89-108	0.04	0.16	1050	5650	13300	2	2	6	54	38	30	880	100			
108-160	0.05	0.28	1120	6550	15350	2	5	32	44	19	40	890	110			

PROFILE WR 20 MAHATT SERIES

1. SITE INFORMATION

Map unit	5B
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	12.1.76
Location	2.5 km south of Al Murrah
Elevation	75 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced; very uneven field surface with few, low, stabilised hummocks and many, subdued, sandy, less well stabilised mounds. High, mobile dunes 100 m to the south and 300 m to the south west
Slope	Class 1
Vegetation/land use	Previously pump irrigated but well abandoned

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Moderate wind erosion and deposition
Salt or alkali	Some subsurface layers slightly saline
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm	
0-13/17	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; loamy fine sand; structureless; dry; non sticky, non plastic wet; loose, dry; common, fine, fibrous roots; many, very fine, tubular voids; very slight effervescence; clear, wavy boundary:
13/17-25	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; compound, structureless and very weak, fine subangular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
25-37	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; sandy clay loam; very weak, medium and coarse, subangular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
37-66	Dark yellowish brown (10YR 4/4) moist; yellowish brown (10YR 5/4) dry; silty clay loam; compound, moderate, medium, prismatic and moderate, very fine, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine fibrous roots; many, very fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; abrupt, smooth boundary:
66-81	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; silt loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:

PROFILE WR 20 (Continued)

Depth, cm

81-92	Dark yellowish brown (10YR 4/4) moist; brown (10YR 5/3) dry; common, fine, distinct, yellowish brown mottles; silty clay loam; moderate, very fine and fine, angular blocky; slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; abrupt, smooth boundary:
92-113	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; slightly sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; abrupt, smooth boundary:
113-129	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; dry; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:
129-149	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; dry; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, platy, silt loam fragments; slight effervescence; abrupt, smooth boundary:
149-170	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; loam; structureless; dry; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence

Continuation by auger

170-195	Dark yellowish brown (10YR 3/4) moist: fine sandy loam; strong effervescence:
195-290	Dark yellowish brown (10YR 4/4) moist: loam; strong effervescence

ANALYSES WR 20

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-17	1.6	1.31	8.9	7.7	7.9	0.08	3.0			0.4	0.7	1.6	36.8	10.1
17-25	2.4	1.32	9.1	7.6	7.9	0.17	3.5			1.6	0.8	3.3	44.6	14.7
25-37	3.4	1.23	9.4	7.4	7.9	0.21	3.0			3.1	0.7	3.0	>50	21.4
37-66	5.2	1.04	8.4	7.3	7.9	0.52	5.0	1.2	0.0	3.7	0.6	3.8	>50	33.4
66-81	2.4	1.21	8.4	7.4	7.9	0.37	4.0			1.9	0.3	2.4	>50	17.6
81-92	5.6	1.04	8.2	7.3	7.8	0.57	5.5	1.1	0.0	2.4	0.5	4.0	>50	31.9
92-113	2.8	1.24	8.4	7.4	7.9	0.28	4.5			1.2	0.3	2.6	>50	17.6
113-129	1.9	1.21	8.4	7.5	7.9	0.19	3.0			0.9	0.2	2.3	49.0	14.7
129-142	3.3	1.11	8.2	7.4	7.9	0.24	4.5			1.1	0.3	3.4	>50	20.5
149-170	2.9	1.14	8.4	7.5	7.9	0.29	6.0			1.0	0.3	3.7	>50	18.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-17	0.02	0.15	940	3900	10600	3	1	74	19	6	20	580	70			
17-25	0.03	0.16	1030	5200	12250	2	4	45	35	16	30	780	90			
25-37	0.03	0.17	1090	6100	12800	0	7	35	32	26	30	890	100			
37-66	0.06	0.33	1160	8850	19600	0	2	9	48	41	50	1340	140			
66-81	0.03	0.16	910	4200	11850	0	0	21	66	13	30	700	90			
81-92	0.05	0.31	1170	7250	17900	<1	2	7	51	40	50	1350	130			
92-113	0.02	0.14	1080	4900	12400	<1	4	33	46	17	30	900	110			
113-129	0.01	0.13	840	4050	11450	0	1	32	59	8	30	720	90			
129-142	0.02	0.23	1080	5200	14300	<1	1	16	69	14	40	930	110			
149-170	0.02	0.17	1350	4900	13600	1	2	38	44	16	30	850	100			

PROFILE WR 28 MAHATT SERIES

1. SITE INFORMATION

Map unit	5A
High category class	Calcaric Fluvisol (FAO) Typic Torrifluvent (USDA)
Date	21.2.76
Location	0 5 km north east of Ad Dumaynah
Elevation	285 m a.m.s.l.
Landform	
Physiography	Alluvial terrace of Wadi Rima
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Regular spate irrigation; sorghum intercropped with beans

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-25/27

Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry: loam; very weak, fine and medium, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard; dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, small, mica flakes; common, disoriented, platy, silty loam fragments; slight effervescence; clear, wavy boundary:

25/27-42

Yellowish brown (10YR 5/4) moist: light yellowish brown (10YR 6/4) dry: loamy fine sand; structureless: moist: non sticky, non plastic, wet; friable, moist: common, fine, fibrous roots; many, very fine tubular voids; few, small, mica flakes; very few, angular, igneous gravel; slight effervescence; clear, smooth boundary:

42-59

Dark yellowish brown (10YR 4/4) moist: light yellowish brown (10YR 6/4) dry: loam structureless: moist: non sticky, slightly plastic, wet; friable, moist: common, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; many, platy silt loam fragments in a sandy matrix: slight effervescence; clear, smooth boundary:

59-76

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; moist; non sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine tubular voids; few, small, mica flakes; very few, angular, igneous gravel; slight effervescence; abrupt, smooth boundary:

76-132

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; structureless; very moist; slightly sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, tubular voids; few, small, mica flakes; slight effervescence; gradual, smooth boundary:

PROFILE WR 28 (Continued)

Depth, cm

132-164

Dark yellowish brown(10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; structureless; very moist; sticky, plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; slight effervescence:

Continuation by auger

164-250

Dark yellowish brown (10YR 4/4) moist; uniform, micaceous silty clay loam:

250-284

Dark yellowish brown (10YR 4/4) moist. clay loam

ANALYSES WR 28

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-27	1.9	1.20	8.4	7.4	7.8	0.10	4.0			0.3	0.5	3.5	45.0	14.4
27-42	1.7	1.23	8.6	7.5	7.7	0.11	3.5			0.3	0.4	2.8	40.0	11.6
42-59	2.0	1.10	8.4	7.4	7.7	0.13	4.0			0.3	0.3	3.7	43.0	14.9
59-76	1.1	1.21	8.7	7.6	7.7	0.09	3.0			0.2	0.3	2.4	34.6	8.8
76-132	2.3	1.10	8.2	7.3	7.7	0.16	5.0			0.3	0.4	4.7	46.0	17.4
132-164	3.2	1.16	8.3	7.3	7.7	0.16	5.0			0.4	0.4	5.9	48.2	22.0

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-27	0.08	0.50	830	5050	12400	2	39	44	17	30	840	100				
27-42	0.06	0.34	750	4300	11450	2	18	68	14	20	730	90				
42-59	0.06	0.37	800	4600	12300	0	39	46	15	30	810	100				
59-76	0.03	0.22	660	3950	9650	2	63	28	9	20	670	80				
76-132	0.06	0.37	920	5650	14910	<1	25	52	23	30	950	100				
132-164	0.07	0.44	950	6250	15900	<1	44	42	14	40	1060	110				

1. SITE INFORMATION

Map unit	7C
Higher category class	Calcaric Fluvisol (FAO). Typic Torrifluvent (USDA)
Date	21.3.76
Location	By Al Madaniyah
Elevation	50 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced; few hummocks stabilised by <u>Salvadora</u>
Slope	Classll
Vegetation/land use	Site fallow, previously pump irrigated sorghum. Common halophytes. Site irrigated for about 7 years, 3 years by oxen-drawn water followed by 4 years by pumping

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	Profile saline and slightly sodic
Human influence	Plots, 10 m x 12 M, inter-connected by irrigation channels

3. PROFILE DESCRIPTION

Depth, cm

0-30	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, very fine and fine, subangular blocky structure; dry; slightly sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many very fine and few, fine, tubular voids; few, small mica flakes; clear, smooth boundary:
30-38	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, fine, subangular blocky structure; slightly moist, slightly sticky, non plastic, wet; soft dry; few, fine fibrous roots; many very fine and few fine tubular voids; small mica flakes; abrupt, smooth boundary:
38-51/53	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; silty clay loam; moderate, fine, platy structure slightly moist; very sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine tubular voids; few, small, mica flakes; weak, thin, carbonate pseudomycelia; abrupt, wavy boundary:
51/53-62/67	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; moist; slightly sticky, non plastic, wet; very friable, moist; few, fine, fibrous roots; many very fine, tubular voids; few, small mica flakes; abrupt, broken boundary:
62/67-66/69	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; clay loam; moderate, fine, platy structure; moist; sticky, plastic wet; friable, moist; few, fine fibrous roots; many, very fine, tubular voids; few, small mica flakes; weak, thin, carbonate pseudomycelia; abrupt broken boundary:

PROFILE WR 39 (continued)

Depth, cm

66/69-88/90	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, very fine, platy structure; moist; slightly sticky, slightly plastic, wet; very friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few small mica flakes; abrupt, wavy boundary:
88/90-93	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; few fine, distinct, reddish yellow mottles; clay loam; moderate, fine, platy structure; moist; sticky, plastic, wet; friable, moist; common, fine, fibrous roots; many, very fine, tubular voids; few, small mica flakes; weak, thin, carbonate pseudomycelia; abrupt, smooth boundary:
93-110	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; loamy fine sand: structureless; moist: non sticky, non plastic, wet: very friable, moist: few, fine, fibrous roots: many, very fine, tubular voids: few, small mica flakes: abrupt, smooth boundary:
110-117	Yellowish brown (10YR 5/4) moist: very pale brown (10YR 7/3) dry: common, fine, distinct, reddish yellow mottles: silt loam moderate, fine, platy structure: moist: sticky, plastic, wet: friable, moist: few, fine, fibrous roots: many very fine tubular voids: few, small mica flakes: vertical cracks filled with material from overlying layer: weak, thin, carbonate pseudomycelia; clear, smooth boundary:
117-126	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dary; fine sandy loam; structureless; moist; slightly sticky, slightly plastic, wet; friable moist; few, fine fibrous roots; many, very fine tubular voids; few, small mica flakes; clear smooth boundary:
126-140	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; moist; non sticky, non plastic, wet, very friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; abrupt, smooth boundary:
140-146	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; loam; weak, medium, platy structure; moist; slightly sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; few, small mica flakes; thixotropic; weak, thin, carbonate pseudomycelia; abrupt, smooth boundary:
146-161	Individual grain colours; fine sand; structureless; moist; non sticky, non plastic, wet; loose, moist; many very fine, tubular voids; few, small mica flakes

ANALYSES WR 39

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-30	2.3	1.12	8.6	7.9	8.1	0.74	6.5	1.6	0.0	2.6	1.0	6.7	>50	16.5
30-38	1.9	1.16	9.2	7.9	8.1	0.47	5.5			3.2	0.9	4.6	50.0	13.1
38-53	3.2	1.05	8.2	7.7	8.0	1.29	7.5	1.6	0.0	3.1	1.3	5.2	>50	19.5
53-67	1.9	1.26	8.8	8.0	8.1	0.58	5.0	0.8	0.0	1.9	1.0	3.1	>50	11.8
69-90	1.4	1.29	8.3	8.0	8.1	0.80	4.0	0.8	0.0	1.7	0.9	1.9	39.2	8.7
93-110	1.3	1.25	7.8	7.8	8.0	1.38	4.0	0.6	0.0	1.9	0.9	1.9	48.2	9.4
110-126	2.5	1.21	8.1	7.8	8.0	1.92	5.0	1.6	0.0	3.2	1.6	3.6	>50	15.3
126-140	2.9	1.13	8.0	7.7	8.0	2.17	6.0	1.0	0.0	3.4	1.8	3.3	>50	16.7
146-161	0.8	1.38	8.6	8.0	8.0	0.43	2.5			1.6	0.6	1.2	26.0	5.9

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-30	0.09	0.59	1380	6100	15500	5	0	26	55	19	30	960	110		1.8	0.06
30-38	0.03	0.20	1010	5350	12100	2	0	39	49	12	30	860	90		2.9	0.03
38-53	0.05	0.23	1200	6950	14650	6	0	17	56	27	40	1160	120		5.0	0.15
53-67	0.03	0.12	1080	5050	11850	9	1	43	45	11	30	810	90		2.8	0.06
69-90	0.01	0.02	850	3750	8650	8	1	61	31	7	20	690	90		3.2	0.10
93-110	0.02	0.06	730	4000	9050	8	0	52	41	7	20	600	80		5.7	0.18
110-126	0.03	0.14	1130	5650	12300	14	2	35	45	18	30	940	100		8.2	0.36
126-140	0.03	0.09	960	5950	14200	8	0	10	77	13	30	890	100		11.3	0.72
146-161	0.01	0.03	780	2850	7200	4	0	87	11	2	20	700	100		1.8	0.02

MURRAH SERIES

PROFILE WR 5 MURRAH SERIES SALINE AND SODIC PHASE

1. SITE INFORMATION

Map unit	7C
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	7.12.75
Location	0.5 km south of Al Madaniyah
Elevation	50 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Site fallow, previously pump irrigated cotton. Common halophytes

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	Profile saline and slightly sodic
Human influence	Terraced and banded fields adapted to pump irrigation

3. PROFILE DESCRIPTION

Depth, cm	
0-32	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; compound, structureless and very weak, very fine, subangular blocky structure; dry; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
32-47	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; common silty clay loam, platy fragments in a fine sand matrix; structureless; dry; non sticky, non plastic wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:
47-62	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; compound, weak, coarse, prismatic and weak, medium, angular blocky structure; slightly moist; sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine and medium, tubular voids; many insect burrows; slight effervescence; abrupt, smooth boundary:
62-79	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; few, silt loam, platy fragments in a fine sand matrix; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:
79-86	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, fine, subangular blocky structure; slightly moist; slightly sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:

PROFILE WR 5 (Continued)

Depth, cm

86-108/112	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; fine sandy loam; structureless; non sticky, non plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, wavy boundary:
108/112-137	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; few, fine, distinct, yellowish brown mottles; silty clay loam; moderate, fine and medium, platy structure; moist; sticky plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence. abrupt, smooth boundary:
137-163	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/4) dry; few, undisturbed laminations of silty clay loam within a loamy fine sand matrix; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence:
Continuation by auger	
163-176	Dark yellowish brown (10YR 4/4) moist; silty clay loam; slight effervescence:
176-266	Dark brown (10YR 4/3) moist; fine sand; very slight effervescence:
266-283	Dark brown (10YR 4/3) moist; fine sandy loam; very slight effervescence:

ANALYSES WR 5

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 O.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.	Exchangeable cations meq % a.d.s.	CEC meq % a.d.s.
								Na K	Na K Mg Ca	
0-32	2.4	1.16	8.1	7.9	7.8	1.95	5.5	3.6 0.0	2.2 1.1 5.5	14.9
32-47	1.8	1.23	8.6	8.0	7.8	0.55	4.5	1.5 0.0	1.8 0.9 4.4	13.0
47-62	3.3	1.17	8.3	7.9	7.7	0.93	6.0	2.1 0.0	3.2 0.7 7.4	20.2
62-79	1.2	1.24	8.7	8.1	7.7	0.60	4.0	1.6 0.0	1.8 0.3 3.5	9.9
79-86	2.6	1.08	8.3	7.9	7.7	1.20	6.5	2.7 0.0	3.4 0.6 6.0	16.3
86-108	1.8	1.06	8.6	8.00	7.9	0.66	5.0	1.6 0.0	3.2 0.4 4.6	13.4
108-137	3.1	0.99	8.3	7.8	7.8	1.55	7.0	4.3 0.0	6.8 1.0 8.2	25.9
137-163	1.5	1.12	8.7	8.0	7.9	0.83	5.0	1.7 0.0	3.5 0.5 3.7	11.7

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm	Available P ppm	Mechanical analysis	Trace elements ppm	B ppm	% SO ₄ ²⁻ meq %	% Gypsum
			P K Mg		2 000- 250 μm 50 μm 2 μm <2 μm	Cu Mn Zn			
0-32	0.08	0.44	960 5000 14200	3	1 37 47	30 800 90			
32-47	0.03	0.17	910 4300 11000	1	1 59 29	20 730 90			
47-62	0.05	0.29	1280 5500 14650	1	1 31 51	30 990 110			
62-79	0.03	0.13	850 3750 10150	1	0 55 32	20 630 80			
79-86	0.04	0.24	1200 5250 15950	1	0 27 61	30 930 110			
86-108	0.03	0.18	850 4650 12100	1	1 5 82	30 790 100			
108-137	0.05	0.35	1020 6350 14200	4	0 18 49	30 1220 150			
137-163	0.02	0.14	810 4150 10150	3	0 31 50	20 770 100			

PROFILE WR 12 MURRAH SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifuvent (USDA)
Date	5.1.76
Location	0.5 km north west of Bayt al Usayqi
Elevation	120 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Adjacent to pump irrigated land; probably rainfed

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Slight wind erosion
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-17	Yellowish brown (10YR 5/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary:
17-32	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; non sticky; non plastic, wet; soft, dry; common fine, fibrous roots; many, very fine, tubular voids; few, subrounded, igneous gravel and stones; slight effervescence; clear, smooth boundary:
32-73	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, very fine and fine, subangular blocky structure; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; very few, sub rounded, igneous gravel; slight effervescence; clear, smooth boundary:
73-97	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, very fine and fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:
97-125	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; abrupt, smooth boundary:
125-146/150	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; few, fine, faint, yellowish brown mottles; silt loam; moderate, very fine and fine, angular blocky structure; slightly moist; slightly sticky, slightly plastic; wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, wavy boundary:

PROFILE WR 12 (Continued)

Depth, cm

146/150-170

Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry: silt loam; structureless but with prominent sedimentary layering: slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine fibrous roots; many, very fine and few, fine, tubular voids; very slight effervescence:

Continuation by auger

170-253

Dark yellowish brown (10YR 4/4) moist: loam; few shell fragments; few, igneous gravel; slight effervescence:

253-290

Yellowish brown (10YR 5/4) moist; fine sandy loam; common, medium, hard, carbonate nodules; strong effervescence.

ANALYSES WR 12

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-17	1.1	1.42	8.6	7.6	7.8	0.13	3.0			0.5	0.7	1.6	34.2	12.2
17-32	1.2	1.41	8.7	7.6	7.8	0.11	2.0			0.6	0.5	1.4	32.6	12.4
32-73	2.2	1.27	8.3	7.5	7.8	0.11	4.5			0.5	0.3	2.5	>50	18.2
73-97	2.7	1.21	8.2	7.4	7.8	0.13	5.5			0.7	0.3	3.8	>50	22.7
97-125	2.1	1.16	8.0	7.4	7.8	0.17	4.5			1.0	0.3	4.2	>50	21.5
125-150	3.8	1.13	8.9	7.3	7.6	0.21	6.5			2.1	0.3	6.9	>50	31.6
150-170	3.1	1.07	8.7	7.3	7.7	0.21	4.5			2.5	0.3	6.3	>50	28.4

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-17	0.02	0.11	1120	3450	13250	1	15	48	28	9	30	670	80			
17-32	0.02	0.08	1080	3100	12350	<1	20	49	21	10	30	660	80			
32-73	0.02	0.14	1120	2950	16000	0	14	33	43	10	40	820	90			
73-97	0.02	0.15	1150	3250	18650	0	5	25	56	14	40	930	100			
97-125	0.02	0.12	1180	2850	17550	0	2	33	53	12	40	960	100			
125-150	0.03	0.18	1280	3450	21100	0	3	11	62	24	50	1130	100			
150-170	0.04	0.21	1210	3000	19300	0	2	18	66	14	40	1030	100			

1. SITE INFORMATION

Map unit	7A
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	8.1.76
Location	1.25 km north of Al Junaydiyah
Elevation	125 a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Irregular spate irrigation from Wadi Rima; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Incipient gullying near several breaches in field bunds
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm	
0-34/40	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; soft dry; common, fine, fibrous roots; many, very fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; abrupt, wavy boundary:
34/40-70	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; slightly hard, dry; few, fine fibrous roots; many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary;
70-89	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10 YR 6/4) dry; fine sandy loam; compound, structureless and very weak, fine, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
89-107	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, medium and coarse angular blocky structure; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; weak, thin, carbonate pseudomycelia; slight effervescence; gradual, smooth boundary:
107-128	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silt loam; compound, weak, medium, prismatic and weak, medium, angular blocky; slightly moist; slightly sticky, plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

PROFILE WR 18 (Continued)

Depth, cm

128-165

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry. silty clay loam. compound, weak, coarse, prismatic and weak, medium, angular blocky structure: slightly moist; sticky, plastic, wet; hard, dry; common, fine, fibrous roots: many, very fine and few fine, tubular and few. very fine planar voids; weak, thin, carbonate pseudomycelia; slight effervescence

ANALYSES WR 18

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-40	1.1	1.44	8.6	7.7	7.9	0.07	2.5			0.2	0.5	1.7	32.0	7.9
40-70	1.5	1.38	8.7	7.7	7.8	0.09	3.0			0.4	0.2	2.2	38.6	9.5
70-89	1.9	1.25	8.6	7.6	7.8	0.10	3.5			0.6	0.3	3.5	45.6	13.1
89-107	2.6	1.21	8.6	7.5	7.8	0.11	4.5			0.7	0.4	4.2	49.8	16.3
107-128	3.3	1.11	8.8	7.4	7.8	0.15	4.5			0.8	0.4	5.0	>50	20.9
128-165	4.2	1.05	8.2	7.3	7.8	0.16	4.5			1.0	0.5	6.1	>50	24.4

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-40	0.02	0.15	680	3850	7550	2	20	46	27	7	20	550	70			
40-70	0.02	0.15	670	4150	8700	0	18	38	36	8	20	620	80			
70-89	0.02	0.14	850	4800	11150	0	7	31	49	13	30	810	100			
89-107	0.03	0.17	970	5700	13800	0	3	22	57	18	40	960	110			
107-128	0.04	0.22	1030	6450	15350	<1	2	15	58	25	40	1060	120			
128-165	0.05	0.35	1060	7050	16150	0	3	14	52	31	40	1170	130			

PROFILE WR 19 MURRAH SERIES

1. SITE INFORMATION

Map unit	7A
Higher category class	Calcaric Fluvisol (FAO), Typic Torrifluvent (USDA)
Date	11.1.76
Location	1.75 km north of Al Junaydiyah
Elevation	130 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced; uneven field surface
Slope	Class 1
Vegetation/land use	Flowering cotton: irregular spate irrigation supplemented by pump irrigation

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	None
Erosion	Slight water erosion and deposition from adjacent Al Badwi canal
Salt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-20/24	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; common, thin, fissile, silty clay loam fragments in a fine sand matrix; structureless; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, wavy boundary:
20/24-32/36	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; dry; non sticky, non plastic, wet; soft, dry; common fine, fibrous roots; many very fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, wavy boundary:
32/36-44/55	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; inter-stratified fine sand and silt loam; structureless; dry; common fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, wavy boundary:
44/55-68	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; compound, structureless and very weak, fine, subangular blocky structure; slightly moist; non-sticky, non plastic, wet; slightly hard, dry, common fine, fibrous roots; many, very fine, tubular voids; very few subrounded igneous gravel; slight effervescence; clear, smooth boundary:
68-94/97	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam, compound, structureless and very weak, fine sub-angular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular voids; very few subrounded, igneous gravel; common, silt loam fragments; slight effervescence; abrupt, wavy boundary:
94/97-102/107	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few fine, fibrous roots; many very fine, tubular voids; slight effervescence; abrupt, wavy boundary:

PROFILE WR 19 (continued)

Depth. cm

102/107-109/114

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; silty clay loam; weak coarse, angular blocky structure; slightly moist. sticky. elastic wet. hard dry; few. fine. fibrous roots; many. very fine and few fine tubular and few very fine, planar voids; weak, thin. carbonate pseudomycelia; slight effervescence; clear, wavy boundary:

109/114-125

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; weak, fine and medium, subangular blocky structure; slightly moist; non sticky, slightly plastic, wet; slightly hard, dry; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; common, silt loam fragments; slight effervescence; clear smooth boundary:

125-137/141

Individual grain colours; coarse sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; very weakly cemented at base of layer; few, fine, fibrous roots; many, very fine, tubular voids; few, subrounded, igneous gravel and stones; very slight effervescence; abrupt, wavy boundary:

137/141-170

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loam; very weak, coarse, angular blocky structure; moist; slightly sticky, slightly plastic, wet; firm, moist; few, fine, fibrous roots; many, very fine and few, fine and medium, tubular voids; few, vertical cracks infilled with coarse sand from overlying layer; slight effervescence

0

ANALYSES WR 19

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-24	1.1	1.33	8.8	7.7	7.8	0.09	2.0			0.3	0.4	1.8	35.0	8.9
24-36	1.7	1.32	8.3	7.6	7.8	0.12	3.0			0.3	0.3	2.6	42.6	10.8
36-55	1.7	1.28	8.5	7.5	7.8	0.10	3.5			0.4	0.3	2.6	46.0	12.4
55-68	1.5	1.27	8.5	7.6	7.8	0.12	3.0			0.4	0.3	2.6	39.6	10.4
68-97	1.7	1.27	8.6	7.6	7.8	0.10	3.5			0.4	0.3	2.6	39.2	10.4
114-125	1.6	1.25	8.4	7.6	7.8	0.11	2.5			0.5	0.2	2.5	39.0	10.7
125-141	0.6	1.41	8.5	8.0	7.9	0.09	1.0			0.2	0.1	0.9	13.0	3.4
141-170	2.2	1.21	8.5	7.6	7.8	0.13	3.0			0.5	0.3	3.3	41.8	13.0

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-24	0.03	0.22	690	4000	8200	4	8	52	34	6	20	590	80			
24-36	0.03	0.20	740	4150	10200	<1	7	39	46	8	20	650	80			
36-55	0.03	0.23	760	4500	11500	<1	12	27	51	10	30	700	80			
55-68	0.02	0.16	690	4500	9700	<1	12	44	34	10	20	650	80			
68-97	0.03	0.18	790	4500	10550	<1	7	34	48	11	30	720	90			
114-125	0.03	0.16	670	3900	8700	1	25	27	36	12	20	720	90			
125-141	0.01	0.04	420	2350	3200	1	57	32	8	3	10	380	60			
141-170	0.02	0.11	830	5200	11250	2	11	29	45	15	30	800	100			

PROFILE WR 21 MURRAH SERIES OVERBLOWN PHASE

1. SITE INFORMATION

Map unit	5B
Higher category class	Calcaric fluvisol (FAO), Typic Torrifluvent (USDA)
Date	12.1.76
Location	1.5 km south east of Al Murrah
Elevation	80 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Common aeolian hummocks stabilised by <u>Salvadora</u> ; few sand drifts in lee of hummocks and bunds
Slope	Class 1
Vegetation/land use	Previously pump irrigated cotton; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Somewhat excessively drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Moderate wind erosion and deposition
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm

0-44

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:

44-61

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, fine and medium, subangular blocky structure; moist; non sticky, slightly plastic, wet; very friable, moist; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; common, platy, silt loam fragments; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:

61-98

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; sandy loam; compound, structureless and very weak, fine, subangular blocky structure; moist; non sticky plastic, wet; friable, moist; common, fine, fibrous roots; many very fine and few, fine, tubular voids; few, platy, silt loam fragments; weak, thin, carbonate pseudomycelia; gradual, smooth boundary:

98-117-127

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; very weak, fine and medium, subangular blocky structure; moist; non sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; common, platy, silt loam fragments; weak, thin, carbonate pseudomycelia; gradual, wavy boundary:

117/127-162/166

Individual grain colours; gravelly coarse sand; structureless; slightly moist: non sticky, non plastic, wet; loose, dry; many, very fine, tubular voids; few, medium, mica flakes and common, medium, quartz grains; common shell fragments; common, subrounded and angular, igneous gravel; slight effervescence; abrupt, wavy boundary:

PROFILE WR 21 (Continued)

Depth, cm

162/166-170/172

Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; few, fine, distinct, yellowish brown mottles; fine sandy loam; laminated depositional structure; moist; non sticky, slightly plastic, wet; friable, moist: many, very fine, tubular voids; slight effervescence; abrupt, wavy boundary:

170/172-180

Individual grain colours; fine sand; structureless; slightly moist; non sticky, non plastic, wet; loose, dry; many, very fine, tubular voids; few, small, magnetite and common, small, quartz grains; slight effervescence:

Continuation by auger

180-202

Individual grain colours: fine sand; very slight effervescence:

202-260

Dark yellowish brown (10YR 4/4) moist; loam; common, rusty mottles; slight effervescence:

260-300

Dark brown (10YR 4/3) moist; silt loam; slight effervescence:

ANALYSES WR 21

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-44	1.3	1.39	9.2	7.7	7.9	0.08	2.0			0.5	0.6	1.6	35.8	9.2
44-61	2.0	1.25	8.9	7.7	7.9	0.11	3.0			0.7	0.5	2.5	44.6	12.4
61-98	1.6	1.32	8.1	7.7	7.9	0.11	2.5			0.7	0.4	2.5	35.2	11.4
98-127	1.7	1.23	8.7	7.7	7.9	0.11	2.5			0.5	0.4	2.7	39.2	11.8

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-44	0.02	0.11	840	4350	9000	2	10	54	26	10	20	610	80			
44-61	0.02	0.17	880	4950	10750	1	4	38	47	11	30	780	100			
61-98	0.02	0.09	830	4450	8800	0	21	44	22	13	20	650	80			
98-127	0.02	0.10	870	4650	9200	<1	11	48	27	14	20	680	90			

PROFILE WR 22 MURRAH SERIES OVERBLOWN PHASE

1. SITE INFORMATION

Map	7B
Higher category class	Calcaric Fluvirol (FAO), Typic Torrifluvent (USDA)
Date	13.1.76
Location	A1 Murrah
Elevation	80 m a.m.s.l.
Landform	
Physiography	Alluvial plain
Landform	Almost flat
Microtopography	Terraced
Slope	Class 1
Vegetation/land use	Previously pump irrigated cotton; site fallow

2. SOIL INFORMATION

Parent material	Calcareous alluvium
Drainage	Well drained
Surface stones and rock outcrops	Very few stones and no rock outcrops
Erosion	Slight wind erosion and deposition
Slt or alkali	None
Human influence	Terraced and banded fields

3. PROFILE DESCRIPTION

Depth, cm	
0-16	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; loamy fine sand; structureless; dry; non sticky, non plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine and few, fine, tubular voids; very few, subrounded, igneous gravel; slight effervescence; clear, smooth boundary:
16-50	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sand; structureless; dry; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular voids; ill defined, gravel line at base of layer; very slight effervescence; abrupt, smooth boundary:
50-69	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; common, fine, distinct, light grey and yellowish brown mottles; silty clay loam: moderate, medium, platy structure; slightly moist; sticky, plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; abrupt, smooth boundary:
69-83	Dark brown (10YR 4/3) moist; light yellowish brown (10YR 6/4) dry; few, fine, distinct, yellowish brown mottles; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, platy, silt loam fragments; slight effervescence; abrupt, smooth boundary:
83-108	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; few, fine, distinct, light grey mottles; silty clay; moderate, medium, platy structure; slightly moist; very sticky, very plastic, wet; slightly hard, dry; common, fine, fibrous roots; many, very fine, tubular and few, very fine, planar voids; weak, thin, carbonate pseudomycelia; slight effervescence; clear, smooth boundary:

PROFILE WR 22 (Continued)

Depth, cm

108-118	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; common, fine, fibrous roots; many, very fine, tubular voids; few, platy, silt loam fragments; very slight effervescence; clear, smooth boundary:
118-125	Individual grain colours; fine sand; structureless; slightly moist; non sticky, non plastic, wet; loose, dry; few, fine, fibrous roots; many, very fine, tubular voids; few, small, mica flakes; very slight effervescence; clear, smooth boundary:
125-159	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; slightly moist; non sticky, non plastic, wet; soft, dry; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
159-168	Dark yellowish brown (10YR 4/4) moist; light yellowish brown (10YR 6/4) dry; common, fine, distinct, dark yellowish brown mottles; silt loam; weak, medium, platy structure; slightly moist; slightly sticky, plastic, wet; hard, dry; few, fine, fibrous roots; many, very fine, tubular and few, very fine, planar voids; slight effervescence:

Continuation by auger

168-200	Dark yellowish brown (10YR 4/4) moist. silty clay loam; slight effervescence:
200-233	Dark yellowish brown (10YR 4/4) moist; silt loam: slight effervescence:
233-271	Dark yellowish brown (10YR 4/4) moist. fine sandy loam; slight effervescence:
271-288	Individual grain colours; fine sand; very slight effervescence.

ANALYSES WR 22

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-16	1.5	1.32	8.9	7.7	7.9	0.09	3.0			0.4	0.7	2.2	40.0	10.7
16-50	0.8	1.41	9.0	7.9	7.9	0.09	1.5			0.5	0.3	1.3	27.3	6.9
50-69	3.2	1.21	9.0	7.5	7.9	0.20	3.5			1.9	0.7	3.5	>50	20.6
69-83	1.9	1.24	9.0	7.6	7.9	0.14	2.5			1.2	0.4	2.1	46.4	12.2
83-108	5.3	0.96	8.1	7.4	7.8	0.60	4.0			1.6	0.9	5.2	>50	31.4
108-118	1.2	1.19	8.4	7.6	7.9	0.32	2.0			0.7	0.3	2.1	37.2	9.2
118-125	0.9	1.36	8.6	7.7	7.9	0.26	1.5			0.4	0.3	1.5	27.0	7.0
125-159	1.6	1.24	8.4	7.5	7.8	0.27	3.0			0.5	0.4	2.4	45.0	11.2
159-168	3.9	1.02	8.5	7.4	7.8	0.22	4.0			0.8	0.8	4.9	>50	22.6

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-16	0.02	0.21	890	4400	10000	2	10	50	30	10	30	650	80			
16-50	0.01	0.08	720	3400	7300	0	17	62	16	5	20	540	70			
50-69	0.04	0.23	1010	6550	12800	1	11	20	46	23	40	1070	120			
69-83	0.02	0.10	740	4750	11350	<1	1	35	57	7	30	720	90			
83-108	0.05	0.27	1280	9300	16600	0	1	4	56	39	50	1470	140			
108-118	0.01	0.15	640	4150	7300	0	1	43	50	6	20	650	80			
118-125	0.01	0.09	580	3550	8200	0	5	73	19	3	20	550	70			
125-159	0.02	0.09	820	4200	11600	0	0	45	49	6	30	670	80			
159-168	0.04	0.16	1130	7500	15350	2	1	4	68	27	40	1130	130			

MUJAYLIS SERIES

PROFILE WR 23 MUJAYLIS SERIES

1. SITE INFORMATION

Map unit	8
Higher category class	Gleyic Solonchak (FAO), Typic Salorthid (USDA)
Date	28.1.76
Location	0.5 km east of Al Mujaylis
Elevation	10 m a.m.s.l.
Landform	
Physiography	Alluvio-marine platform
Landform	Flat
Microtopography	Few mounds
Slope	Class 1
Vegetation/land use	Date palms, many moribund, few dead. Bare ground between palms

2. SOIL INFORMATION

Parent material	Calcareous alluvio-marine sediments
Drainage	Poorly drained
Surface stones and rock outcrops	None
Erosion	None evident
Salt or alkali	Saline and sodic
Human influence	None

3. PROFILE DESCRIPTION

Z Depth, cm

0-9	Dark brown(10YR 4/3) moist; yellowish brown (10YR 5/4) dry; loam. weak, medium, platy structure: moist: sticky plastic, wet; firm, moist; many, very fine, tubular voids; thin, black layer below surface: moderate accumulation of soluble salts: slight effervescence; abrupt, smooth boundary:
9-16	Brown (10YR 5/3) moist; light grey (10YR 7/2) dry; clay; strong, medium, platy structure; moist: sticky, plastic wet; firm; moist; few, fine, fibrous roots but assumed dead as no palms within 10 m; common, very fine, planar voids; slight effervescence; clear, smooth boundary:
16-24	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; fine sandy loam; structureless; ver: moist; non sticky, slightly plastic, wet; friable, moist; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
24-39	Yellowish brown (10YR 5/4) moist; very pale brown (10YR 7/3) dry; few, fine, faint, light grey mottles; silty clay loam; very weak, medium and coarse, subangular blocky structure; very moist; sticky, plastic, wet; firm, moist; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth, boundary:
39-66	Dark yellowish brown (10YR 4/4) moist; pale brown (10YR 6/3) dry; few, fine, faint, dark yellowish brown mottles; fine, sandy loam; structureless; wet; non sticky, non plastic, wet; few, fine, fibrous roots and few, medium woody roots; many, very fine, tubular voids; weak, thin, white, soluble salt cutans in pores; very slight effervescence; clear, smooth boundary:
66-83	Yellowish brown (10 YR 5/4) moist; very pale brown (10YR 7/3) dry; loam; structureless; wet; non sticky, slightly plastic, wet; few, medium, woody roots; slight effervescence; clear, smooth boundary:

PROFILE WR 23 (Continued)

Depth, cm

83-94

Yellowish brown (10WR 5/4) moist; very pale brown (10YR 7/3) dry;
fine sandy loam; structureless; wet; few, medium, woody roots;
few, hard, irregular, carbonate nodules; slight effervescence:

94+

Groundwater (conductivity 2.5 mmhos/cm); soil sampled for
analysis between 94-115 cm

ANALYSES WR 23

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-9	1.8	1.19	10.3	9.9	10.0	4.67	10.5	45.2	0.0	33.0	1.1	3.0	48.0	14.6
9-16	3.7	0.98	9.6	8.2	9.0	0.98	15.0	2.5	0.0	22.0	1.4	14.3	45.0	26.7
16-24	1.6	1.18	9.3	8.1	8.5	0.56	8.5	1.2	0.0	9.2	0.7	9.9	43.0	14.9
24-39	2.9	1.13	9.3	7.8	8.4	0.45	12.0			8.6	0.7	14.8	>50	22.2
39-66	1.6	1.24	9.3	7.7	8.1	0.30	5.0			3.6	0.2	10.6	42.0	15.6
66-83	1.8	1.21	9.0	7.8	8.0	0.28	7.5			3.2	0.2	9.7	44.8	13.9
83-94	2.5	1.16	9.2	7.8	8.0	0.32	14.5			3.7	0.2	11.1	>50	14.9
94-115	1.8	1.21	9.0	7.8	8.0	0.32	15.5			3.8	0.2	11.2	50.0	14.3

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-9	0.02	0.40	1080	5200	24850	33	2	26	53	19	30	660	70		7.2	0.00
9-16	0.03	0.39	1140	5650	25750	2	7	6	57	30	40	900	80		0.1	0.00
16-24	0.02	0.33	970	3300	48050	0	8	45	36	11	30	600	70		0.1	0.00
24-39	0.02	0.25	1040	4450	21700	0	1	24	61	14	40	740	80		0.2	0.00
39-66	0.01	0.20	980	3150	17350	0	0	51	46	3	30	700	70		0.1	0.00
66-83	0.02	0.13	870	3250	18200	0	5	47	40	8	30	600	70		0.0	0.00
83-94	0.02	0.20	740	2700	24000	0	7	44	40	9	30	530	60		0.1	0.00
94-115	0.01	0.11	770	2650	22750	0	6	45	37	12	30	530	60		0.1	0.00

PROFILE WR 24 MUJAYLIS SERIES

1. SITE INFORMATION

Map unit	8
Higher category class	Gleyic Solonchak (FAO), Typic Salorthid (USDA)
Date	28.1.76
Location	Al Mujaylis
Elevation	10 m a.m.s.l.
Landform	
Physiography	Alluvio-marine platform
landform	Almost flat
Microtopography	Few mounds; near edge of SW - NE trending self dune
Slope	Class 1
Vegetation/land use	Date palm plantation in reasonable condition; ground bare between palms

2. SOIL INFORMATION

Parent material	Calcareous alluvio-marine sediments
Drainage	Imperfectly drained
Surface stones and rock outcrops	None
Erosion	Moderate wind erosion
Salt of alkali	Saline and sodic
Human influence	None

3. PROFILE DESCRIPTION

Depth, cm

0-6	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; loamy sand; moderate, coarse, platy structure; slightly moist; non sticky, non plastic, wet; hard, dry; weakly cemented saline crust; many, very fine, tubular and few, very fine, planar voids; slight effervescence; clear, smooth boundary:
6-15	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; loamy sand; structureless: moist: unsticky, non plastic, wet: friable, moist; many, very fine, tubular voids: slight effervescence; gradual. smooth boundary:
15-23	Dark brown (10YR 4/3) moist; pale brown (10YR 6/3) dry; fine sandy loam; structureless; moist; non sticky, slightly plastic, wet; firm, moist; many, very fine, tubular voids: slight effervescence; clear, smooth boundary:
23-54	Dark brown (10YR 4/3) moist; silt loam; very weak, very fine and fine, subangular blocky structure; moist; slightly sticky, plastic, wet; firm, moist; few, medium, fibrous roots; many, very fine, tubular voids; few, hard, irregular, carbonate nodules; slight effervescence; gradual, smooth boundary:
54-92	Dark brown (10YR 4/3) moist; loam; structureless; very moist; non sticky, slightly plastic, wet; firm, moist; few, fine and medium, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence; clear, smooth boundary:
92-107	Dark yellowish brown (10YR 4/4) moist; few, fine, distinct, light grey mottles; clay; structureless; very moist; very sticky, plastic, wet; very firm, moist; few, fine, fibrous roots; many, very fine, tubular voids; slight effervescence; clear, smooth boundary:
107-119	Dark brown (10YR 4/3) moist; few, fine, distinct, yellowish brown mottles; clay; structureless; very moist; very sticky, plastic, wet; very firm, moist; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; few, hard, irregular, carbonate nodules; slight effervescence; gradual, smooth boundary:

119-130

Brown (10YR 5/3) moist: common, fine, distinct, light grey mottles; clay: structureless: wet; sticky, plastic, wet; few, fine, fibrous roots; many, very fine and few, fine, tubular voids; slight effervescence: gradual, smooth boundary:

130-150

Brown (10YR 5/3) moist: loam; structureless: wet; slightly sticky, slightly plastic wet; few, fine and medium, fibrous roots; many, very fine and few, fine, tubular voids; few, small and medium, moderately hard, irregular, carbonate nodules: slight effervescence

ANALYSES, WR 24

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-6	0.8	1.24	9.5	9.4	9.4	4.16	6.5	172.0	0.2	80.0	0.7	1.9	36.8	10.4
6-15	0.6	1.37	9.7	9.2	9.2	4.99	7.5	26.2	0.0	14.8	0.5	2.4	36.2	8.6
15-23	1.3	1.34	9.8	8.7	9.1	3.44	7.0	14.8	0.0	17.0	0.6	2.8	38.2	13.6
23-54	3.0	1.16	9.7	8.2	9.2	1.90	7.5	7.1	0.0	26.4	0.9	5.9	42.0	27.7
54-92	2.3	1.13	9.5	8.0	8.9	1.12	8.0	3.3	0.0	16.2	0.4	10.0	44.2	20.6
92-107	3.4	0.94	9.3	7.8	8.6	1.06	9.5	2.9	0.0	18.2	0.4	16.5	47.2	30.2
107-119	2.9	1.08	9.4	7.7	8.5	0.96	6.0	2.7	0.0	14.8	0.3	14.5	46.4	26.8
119-130	3.0	0.90	9.1	7.8	8.2	0.83	24.5	2.4	0.0	11.6	0.3	17.5	>50	21.0
130-150	1.9	1.06	9.0	7.8	8.1	0.75	18.0	1.7	0.0	6.9	0.2	11.5	49.8	15.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-6	0.02	0.62	680	3750	12050	21	3	47	40	10	30	580	70		58.5	0.00
6-15	0.01	0.16	1010	2950	13550	13	8	60	26	6	20	550	70		4.6	0.00
15-23	0.01	0.15	1020	3350	16450	3	7	46	37	10	30	620	80		1.7	0.00
23-54	0.02	0.17	1110	4500	20700	<1	0	9	71	20	40	840	90		0.9	0.00
54-92	0.02	0.14	990	3750	19600	<1	1	13	75	11	30	710	80		0.7	0.00
92-107	0.02	0.20	1260	6550	29650	0	1	6	60	33	40	1020	90		1.0	0.01
107-119	0.02	0.20	1300	4800	25550	0	1	8	71	20	40	950	90		1.1	0.01
119-130	0.02	0.23	800	4450	42400	0	3	10	71	16	40	630	70		1.1	0.01
130-150	0.02	0.17	830	3700	24000	0	1	16	76	7	30	560	70		1.0	0.02

WIND BORNE MATERIAL

ANALYSES WR45 WINDBORNE MATERIAL

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 1MKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
	1.2	1.22	8.1	7.9	8.0	3.90	4.0	5.5	0.2	1.8	5.5	2.2	>50.0	13.2

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
	0.12	0.68	1670	6500	15450	46	0	43	49	8	30	700	110			

ANALYSES OF AUGURED SAMPLES

(REFERENCE TEXT MAP 4A,
AL MADANIYAH SOILS)

ANALYSES OF AUGERED SAMPLES A345-A351 (SEE TEXT MAP 4A, Al Madaniyah Soils)

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-15	1.4	1.21	8.8	7.6	7.5	0.12	4.0			0.4	0.9	3.2	38.6	13.4
15-50	2.4	1.22	8.9	7.6	7.7	0.11	5.0			0.7	0.3	3.5	41.5	16.4
50-100	1.9	1.22	9.0	7.6	7.6	0.16	4.0			1.1	0.6	3.4	40.8	15.5
100-120	2.3	1.20	9.2	7.6	7.6	0.17	4.0			1.5	0.8	3.2	42.5	16.3
0-15	1.6	1.18	9.0	7.8	7.8	0.17	4.5	0.2	0.0	0.8	1.3	3.6	47.5	14.1
15-50	2.9	1.15	8.9	7.7	7.7	0.20	5.0	0.2	0.0	1.0	1.2	3.8	50	18.3
50-100	2.6	1.20	9.0	7.7	7.7	0.25	4.5	0.3	0.0	1.5	0.5	4.2	49.4	17.3
100-120	1.7	1.11	8.7	7.7	7.7	0.50	5.0	0.5	0.0	1.9	0.4	3.3	46.7	14.5

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ²⁻ ₄ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-15	0.04	0.24	870	4750	10450	4					30	720	100		0.5	0.02
15-50	0.04	0.23	950	5050	12850	2					30	940	110		0.4	0.01
50-100	0.03	0.14	1030	5250	10650	2					30	860	110		0.5	0.01
100-120	0.02	0.20	1030	5500	10050	3					30	810	100		0.6	0.00
0-15	0.05	0.34	1000	5550	10050	4					30	810	100		0.6	0.01
15-50	0.04	0.18	1030	6150	13900	2					30	1040	120		0.6	0.01
50-100	0.02	0.12	1080	5550	13150	2					30	920	110		0.8	0.01
100-120	0.02	0.11	910	5200	10900	2					30	890	110		1.7	0.03

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ANALYSES

A350

Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
								Na	K	Na	K	Mg	Ca	
0-15	2.3	1.21	8.6	7.9	7.7	0.82	6.0	1.4	0.0	2.0	0.9	8.1	>50	16.9
15-50	3.0	1.13	8.8	7.7	7.8	0.51	7.0	0.9	0.0	1.9	1.0	8.8	>50	20.9
50-100	2.0	1.12	8.7	7.9	7.8	0.63	5.5	1.1	0.0	1.3	0.5	4.5	37.0	14.7
100-120	1.2	1.22	9.1	8.0	7.8	0.31	5.5	0.6	0.0	1.1	0.6	3.1	33.0	9.7
0-15	2.2	1.16	8.1	7.7	7.6	2.35	5.5	0.5	0.0	0.7	2.7	3.0	>50	16.4
15-50	3.5	1.10	8.1	7.7	7.7	3.05	6.0	0.8	0.1	0.7	5.7	4.8	>50	21.6
50-100	2.4	1.14	8.1	7.8	7.8	3.30	5.5	1.7	0.1	0.9	3.5	4.0	>50	13.5
100-120	1.1	1.30	8.2	7.8	7.8	2.00	4.5	1.5	0.0	0.7	1.3	2.4	31.5	9.0

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Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
0-15	0.06	0.40	1190	5100	14950	3					30	850	100		1.6	0.03
15-50	0.05	0.30	1380	6300	15500	2					40	1050	110		0.9	0.01
50-100	0.03	0.21	920	5400	12100	2					30	960	110		0.9	0.03
100-120	0.02	0.11	760	3700	10250	1					20	670	90		0.6	0.01
0-15	0.09	0.66	1530	7000	15900	50					30	920	100		21.2	0.75
15-50	0.08	0.44	1520	9450	17400	33					40	1080	120		32.4	1.35
50-100	0.06	0.24	970	6100	11850	11					20	850	100		20.4	0.84
100-120	0.04	0.14	780	4100	10450	5					20	670	90		4.8	0.20

A350

A351

ANALYSES OF AUGURED SAMPLES
OF MUJAYLIS SERIES (MAP UNIT 8)

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ANALYSES

	Depth cm	% Moist. o.d.s.	Bulk density g/ml a.d.s.	pH 1:5 H ₂ O	pH 1:5 IMKCL	pH 1:5 0.01M CaCl ₂	Cond. mmhos 1:5H ₂ O 25°C	% CaCO ₃ a.d.s.	Soluble cations meq % a.d.s.		Exchangeable cations meq % a.d.s.				CEC meq % a.d.s.
									Na	K	Na	K	Mg	Ca	
180	0-15			8.8			3.77	5.5	8.4	0.0	9.7	1.4	1.4	32.0	8.3
	15-50			9.8			0.95	5.5	2.3	0.0	7.0	0.8	2.3	26.4	7.8
	50-100			9.6			1.28	7.5	3.3	0.0	14.0	0.8	7.2	47.2	17.4
	100-120			9.4			1.23	10.0	3.2	0.0	16.5	0.6	9.6	48.5	25.9
181															
	0-15			9.4			5.45	11.0	33.6	0.1	25.5	2.5	5.0	37.4	21.6
	15-50			9.0			2.72	7.5	12.4	0.0	21.0	3.2	7.0	41.7	27.2
	50-100			9.2			0.60	16.0	2.0	0.0	7.9	1.3	16.9	49.5	29.6
	100-120			8.9			0.70	22.0	1.4	0.0	6.8	0.5	19.0	>50.0	27.5

Depth cm	% Total N o.d.s.	% Org.C o.d.s.	Total contents ppm			Available P ppm	Mechanical analysis				Trace elements ppm			B ppm	SO ₄ ²⁻ meq %	% Gypsum
			P	K	Mg		2 000- 250 μm	250- 50 μm	50- 2 μm	<2 μm	Cu	Mn	Zn			
181	0-15													8.92		
	15-50															
	50-100															
	100-120															

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ANALYSES

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