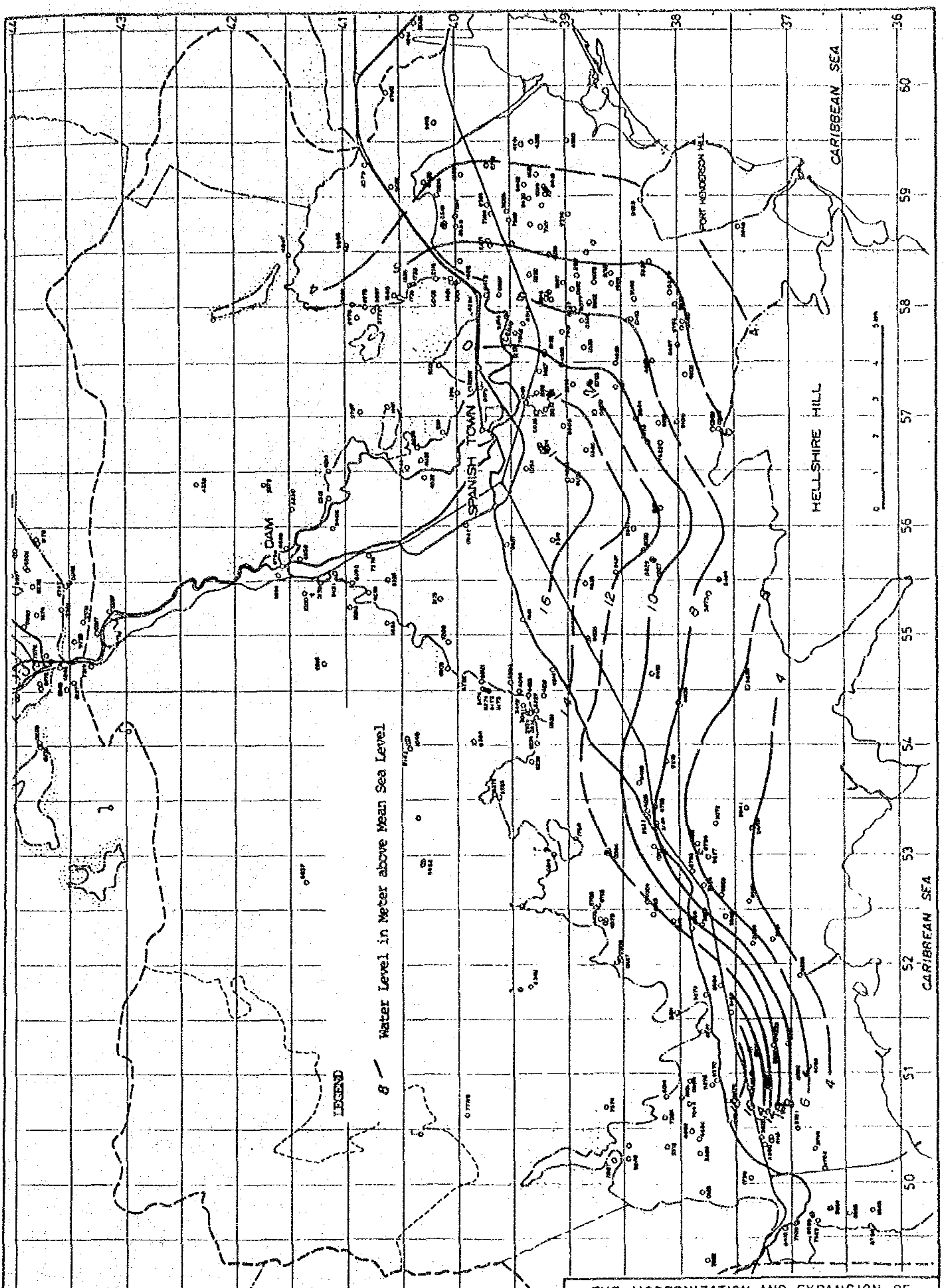
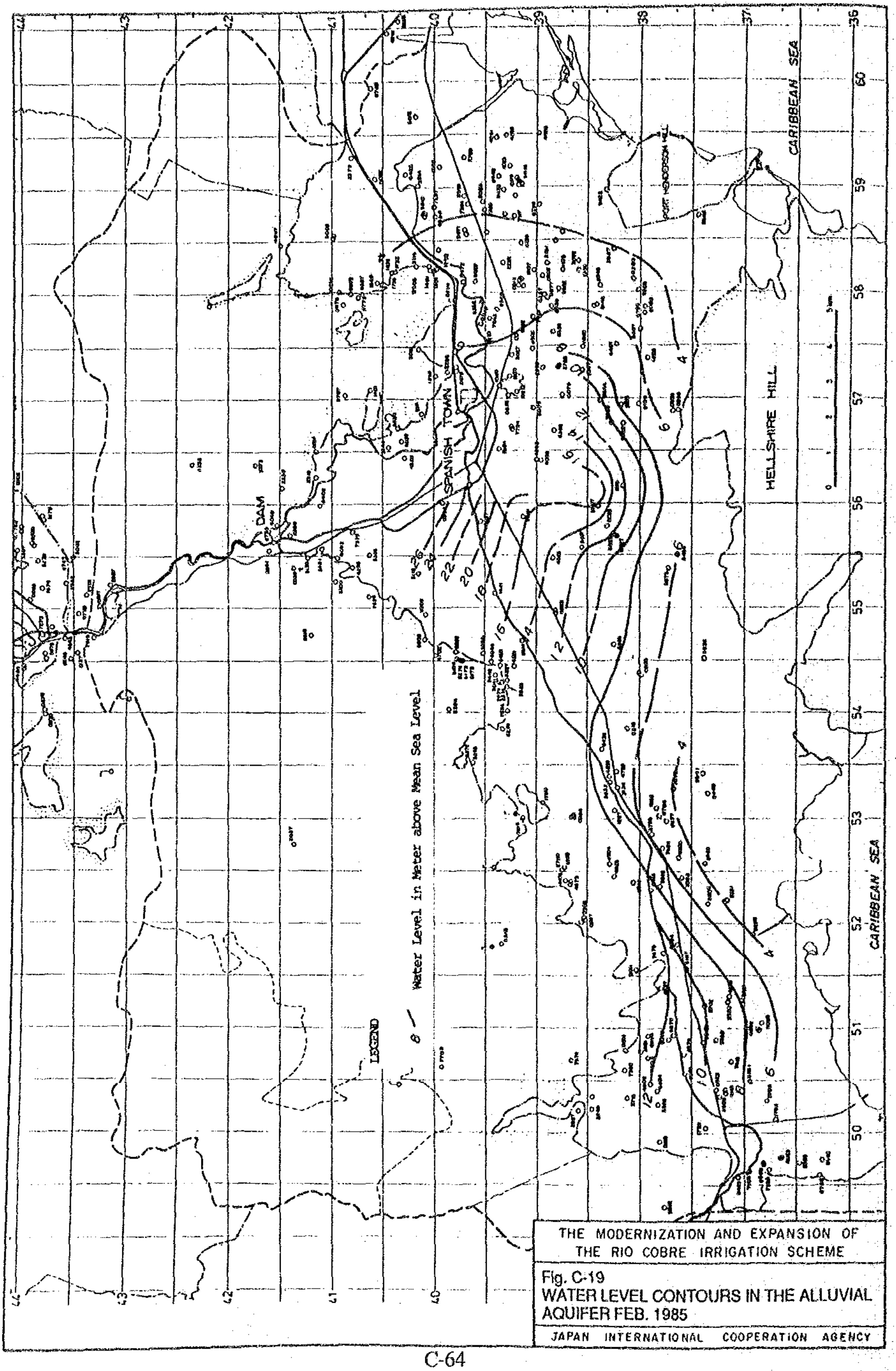


THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-18
WATER LEVEL CONTOURS IN THE ALLUVIAL AQUIFER AUG. 1972

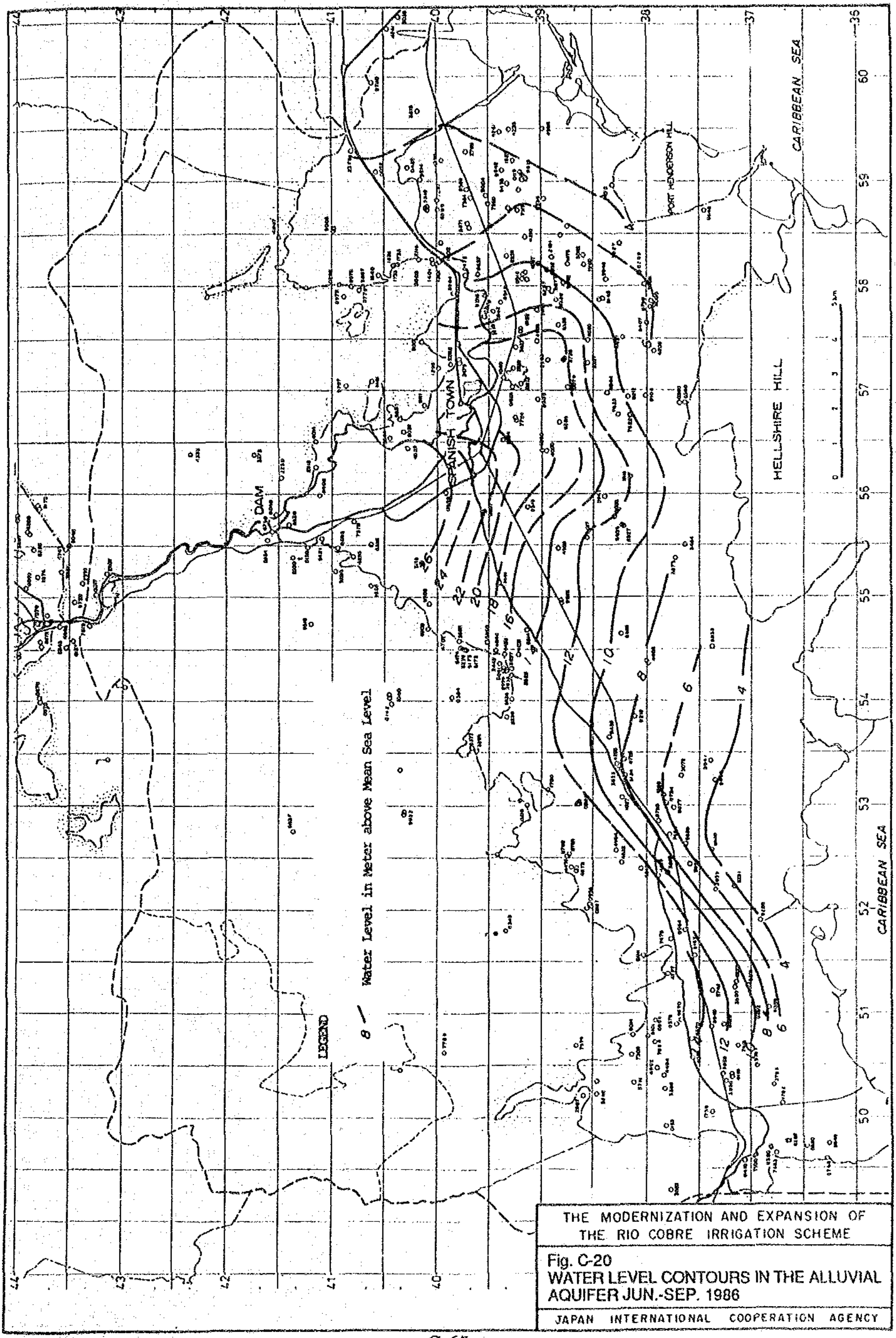
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-19
WATER LEVEL CONTOURS IN THE ALLUVIAL AQUIFER FEB. 1985

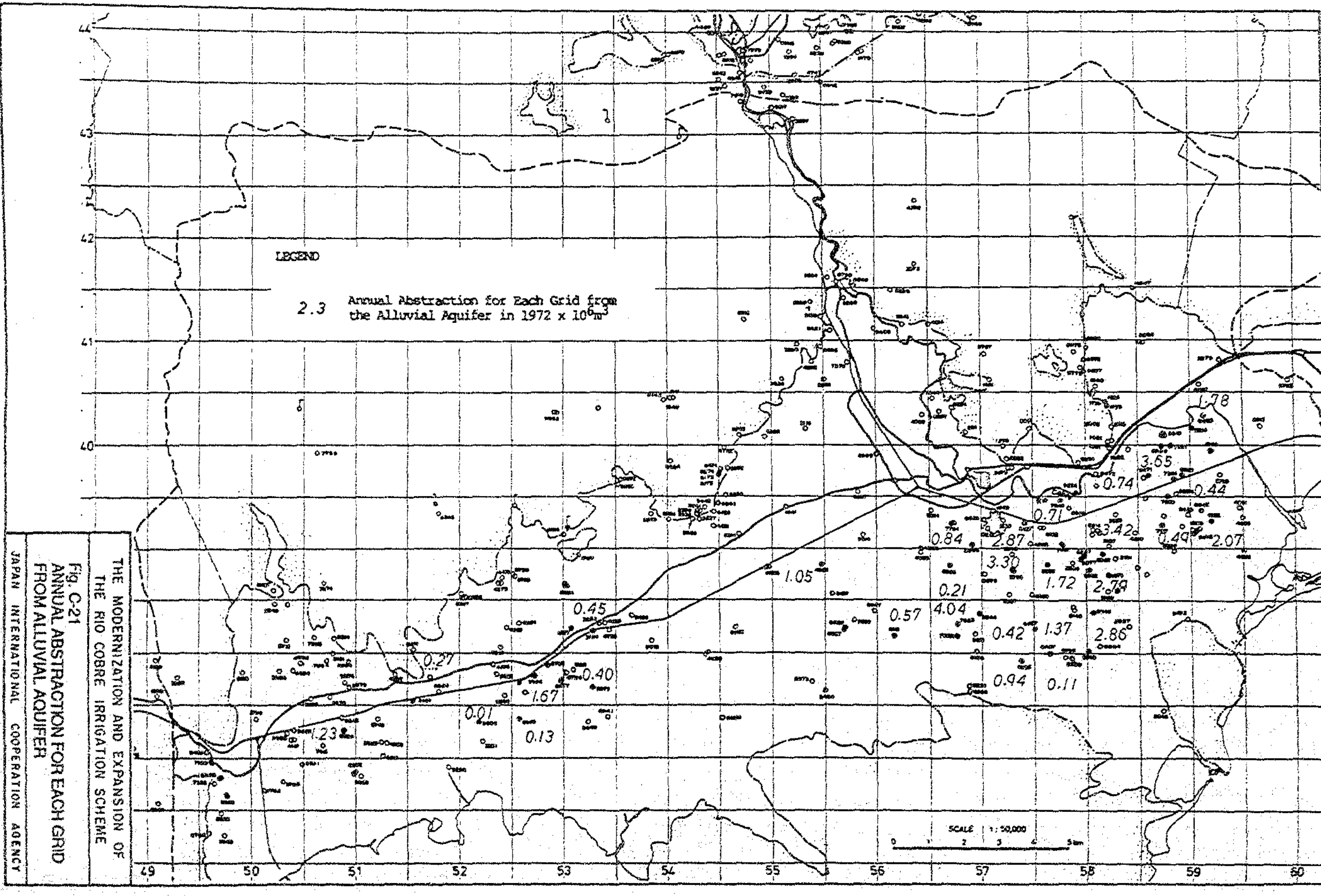
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-20
WATER LEVEL CONTOURS IN THE ALLUVIAL AQUIFER JUN.-SEP. 1986

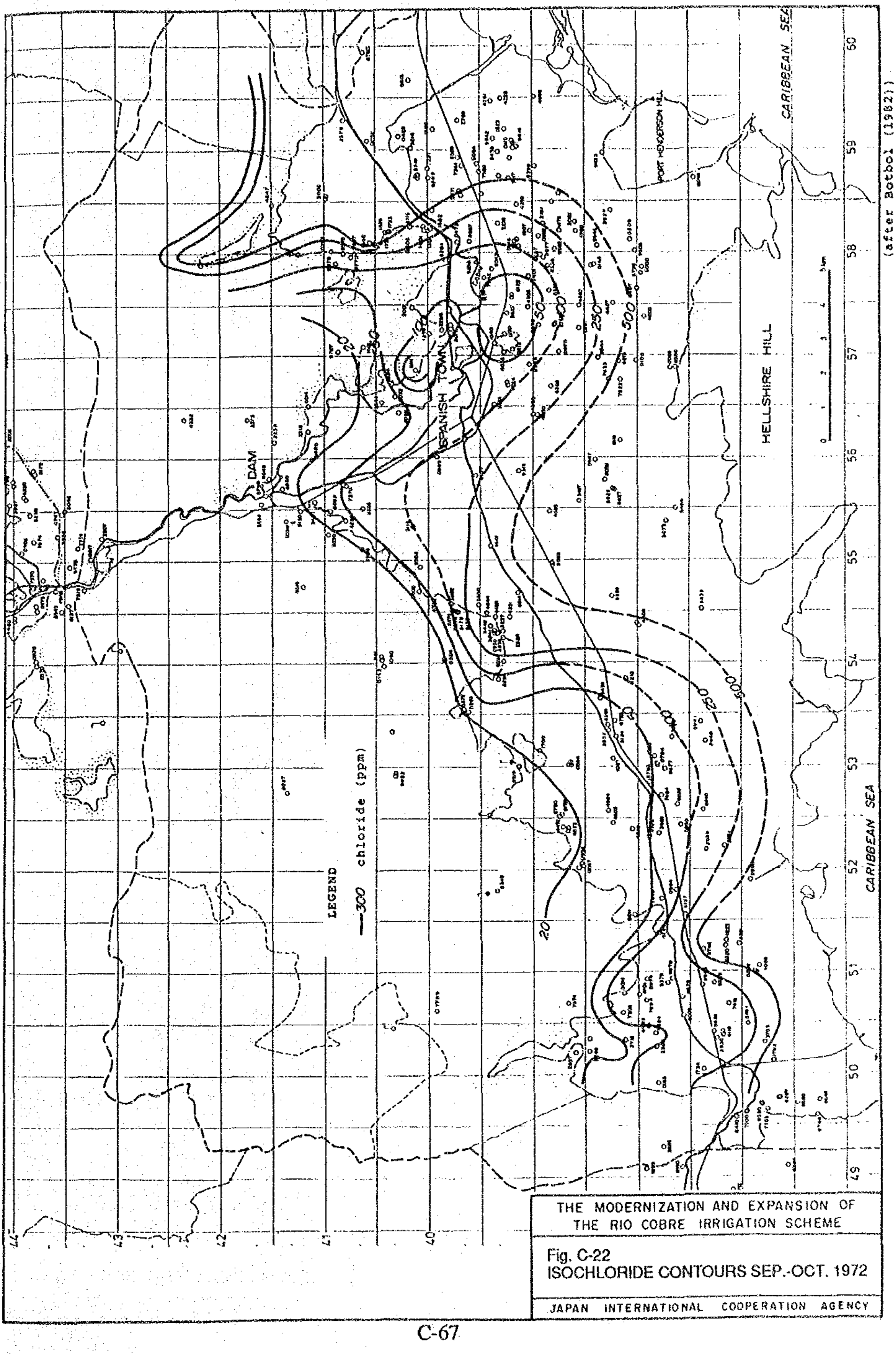
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-21
ANNUAL ABSTRACTION FOR EACH GRID FROM ALLUVIAL AQUIFER

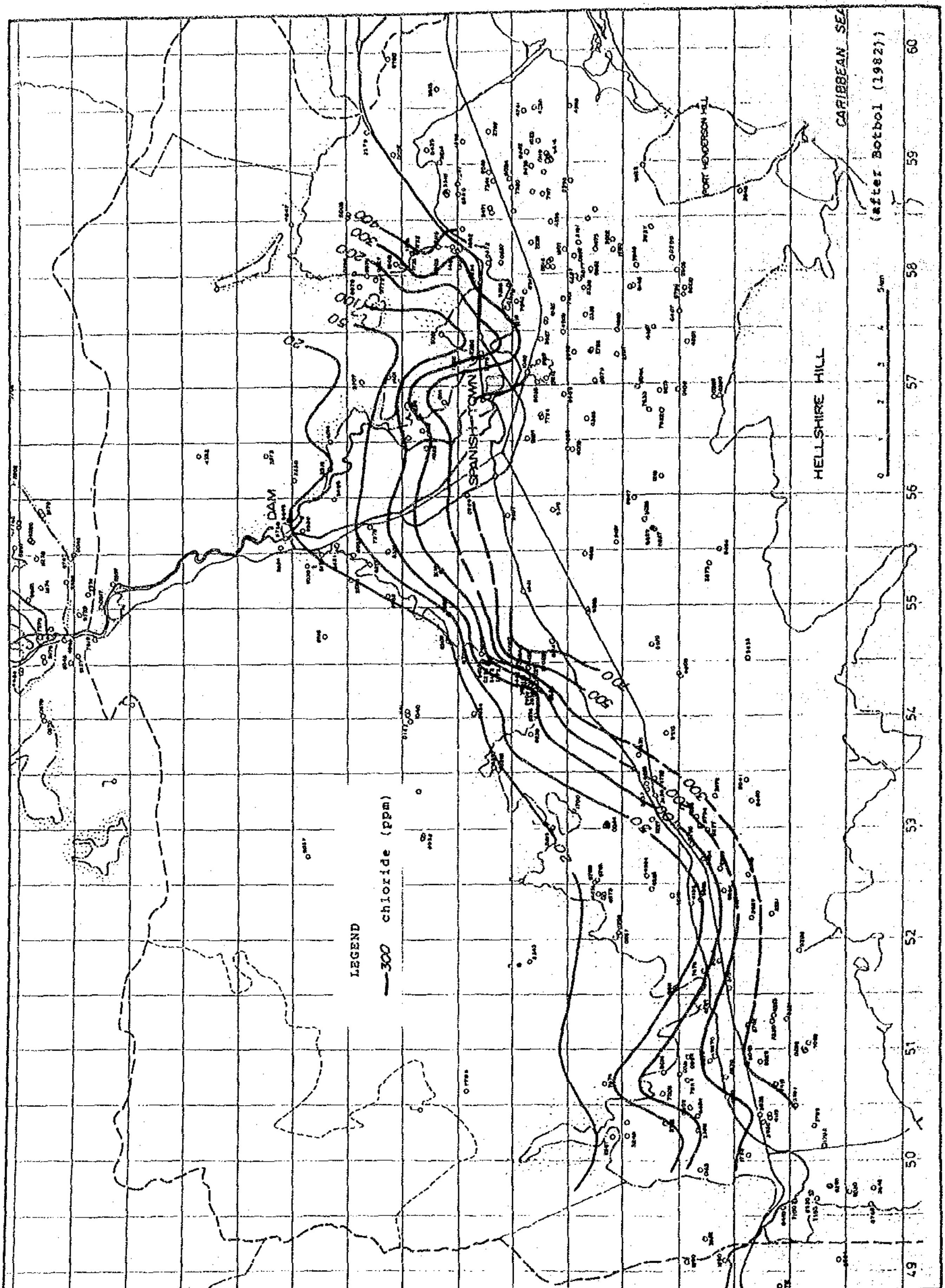
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-22
ISOCHLORIDE CONTOURS SEP.-OCT. 1972

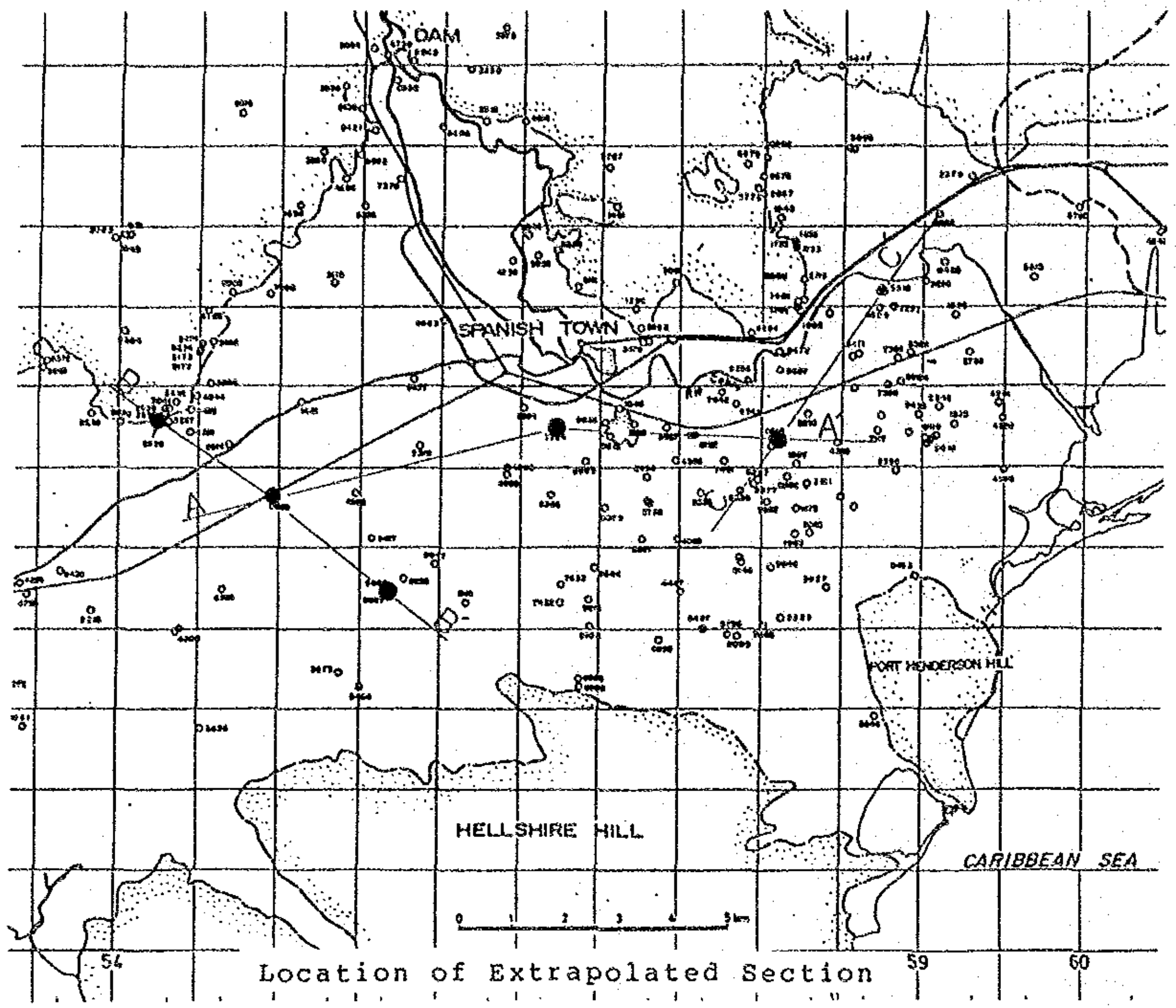
JAPAN INTERNATIONAL COOPERATION AGENCY



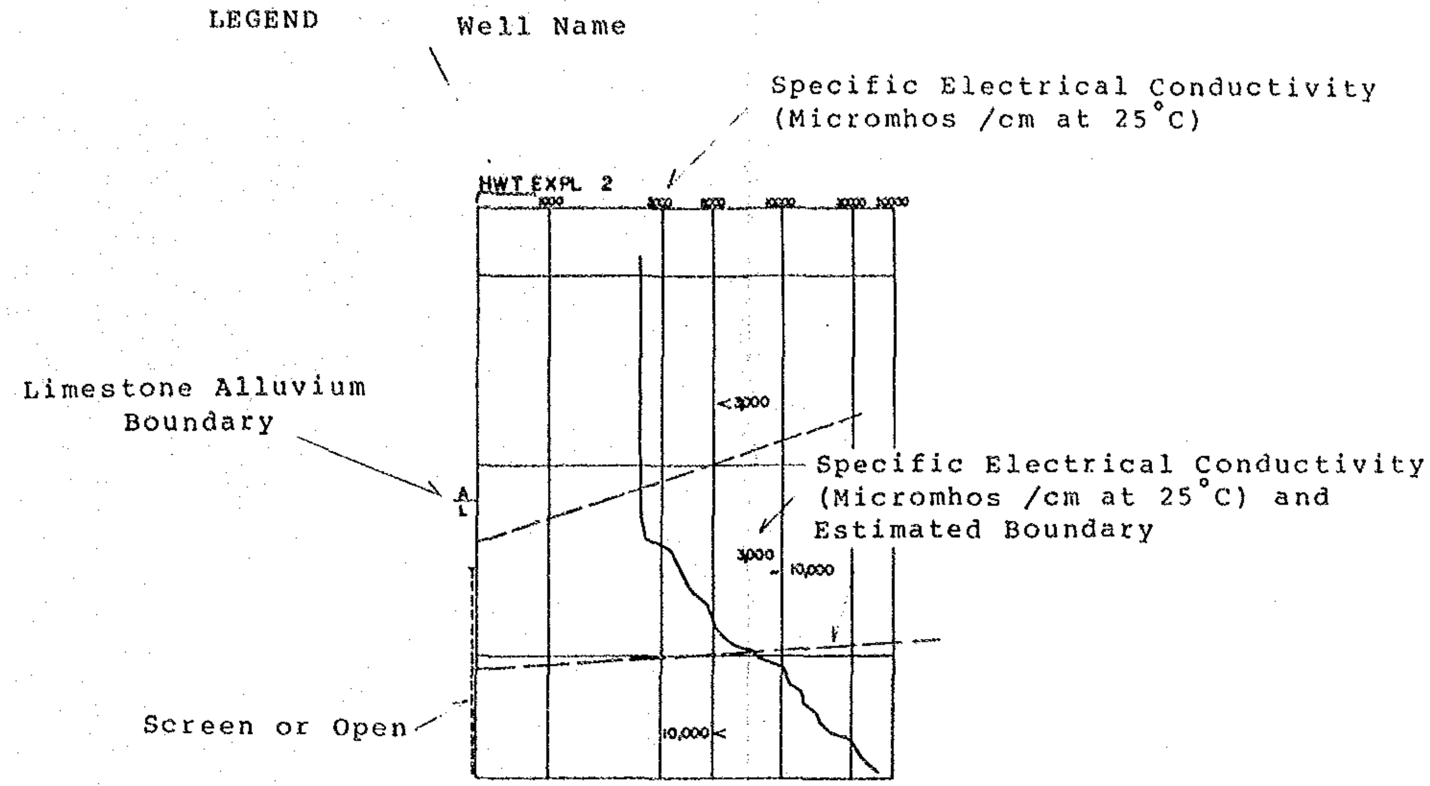
THE MODERNIZATION AND EXPANSION OF
THE RIO COBRE IRRIGATION SCHEME

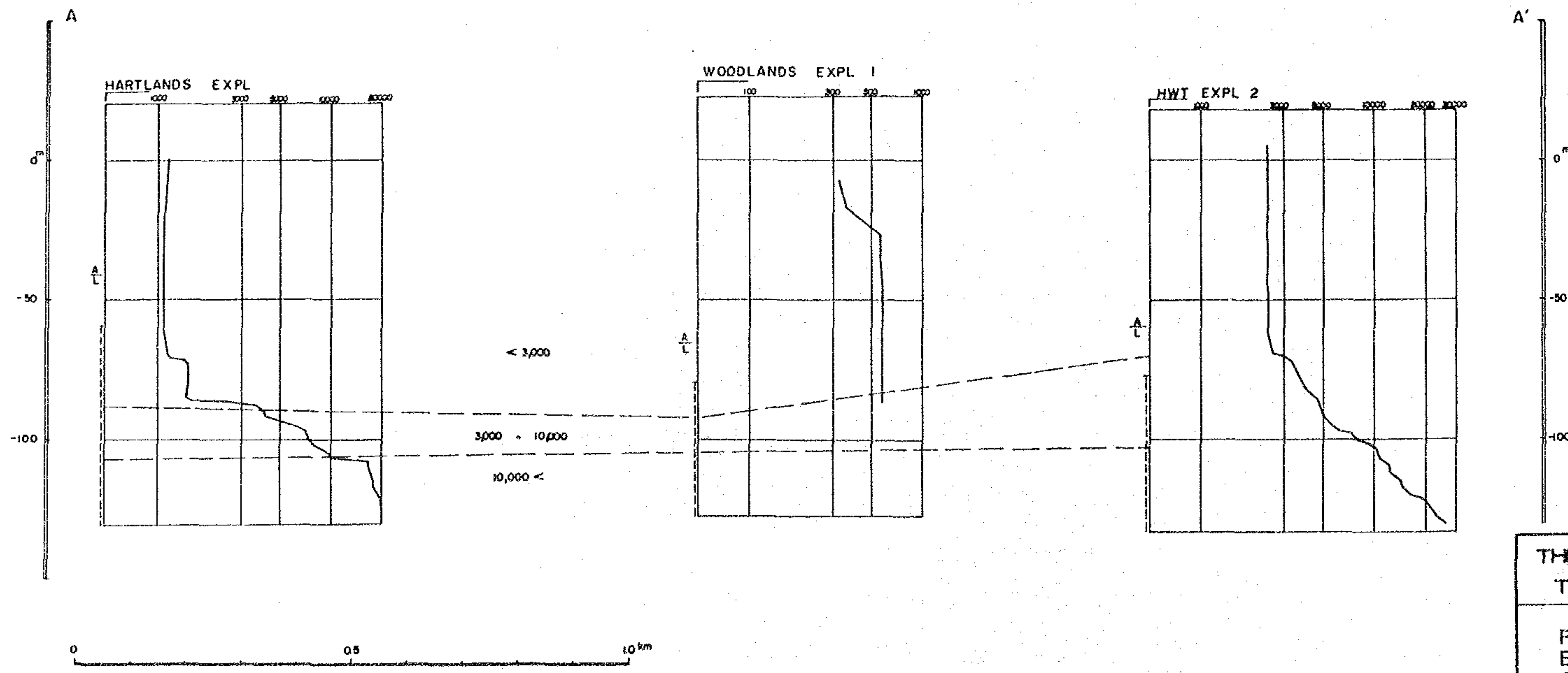
Fig. C-23
ISOCHLORIDE CONTOURS DEC. 1980

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

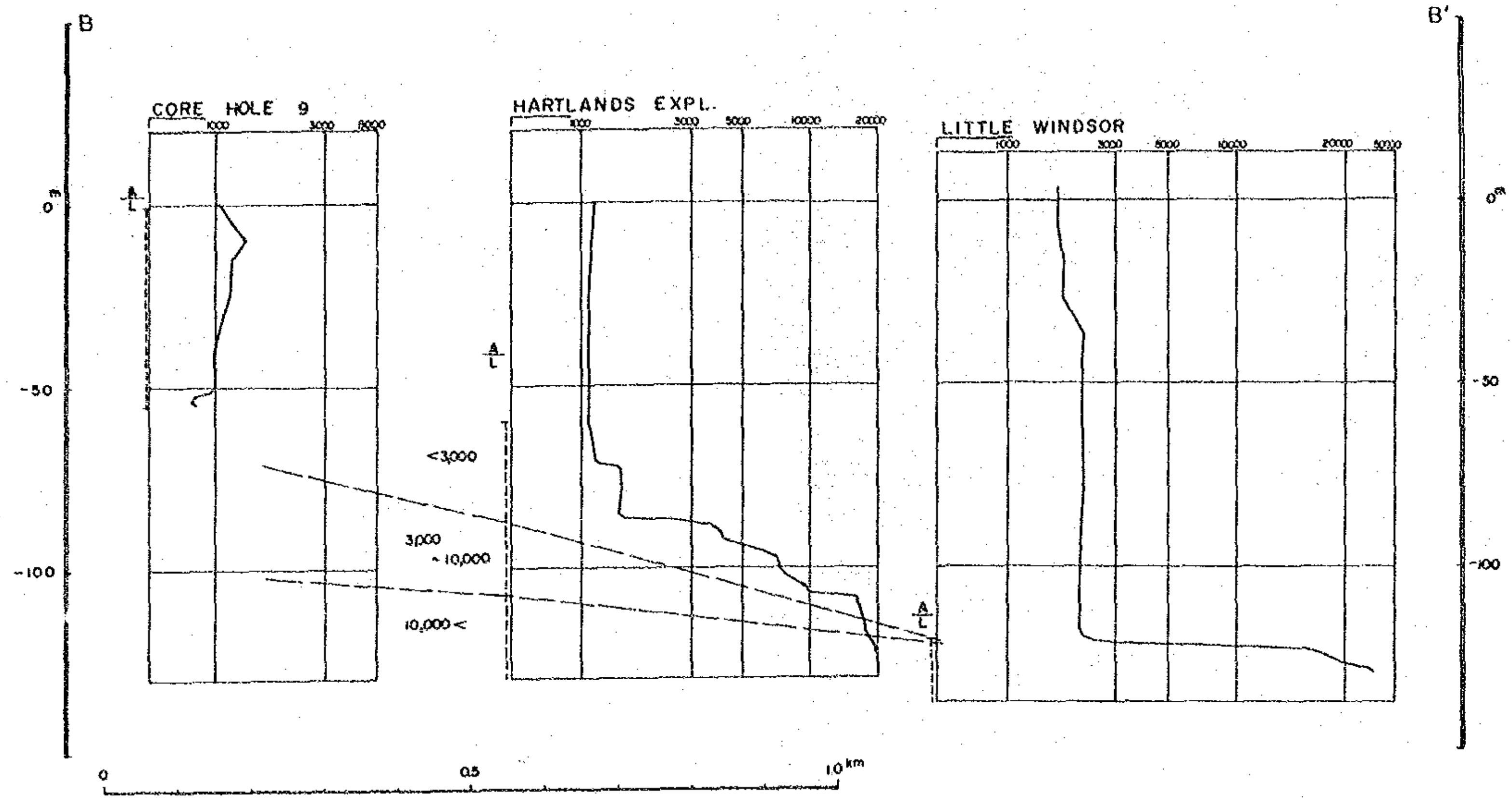


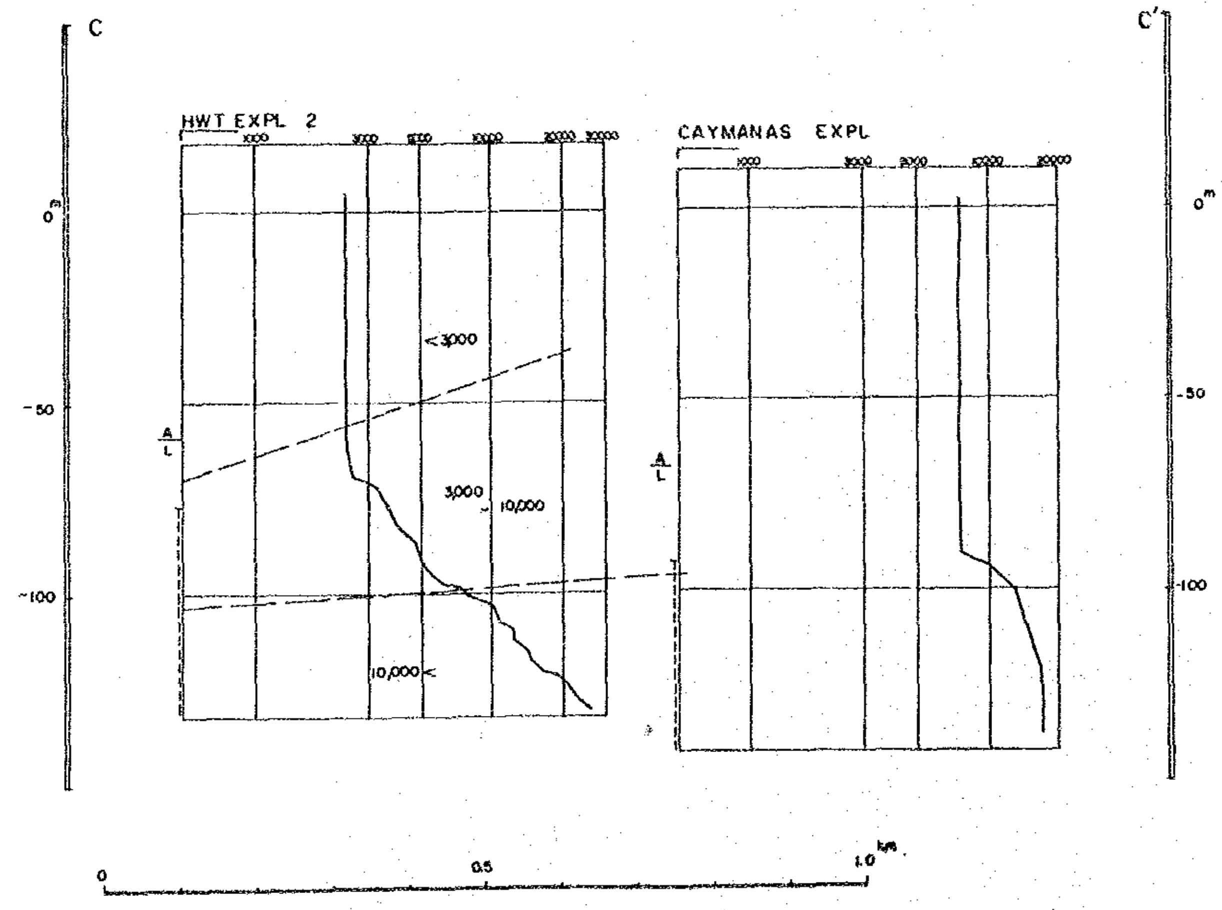


THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-24 (1/2)
EXTRAPOLATED SECTION ACROSS ELECTRICAL CONDUCTIVITY PROFILE

JAPAN INTERNATIONAL COOPERATION AGENCY

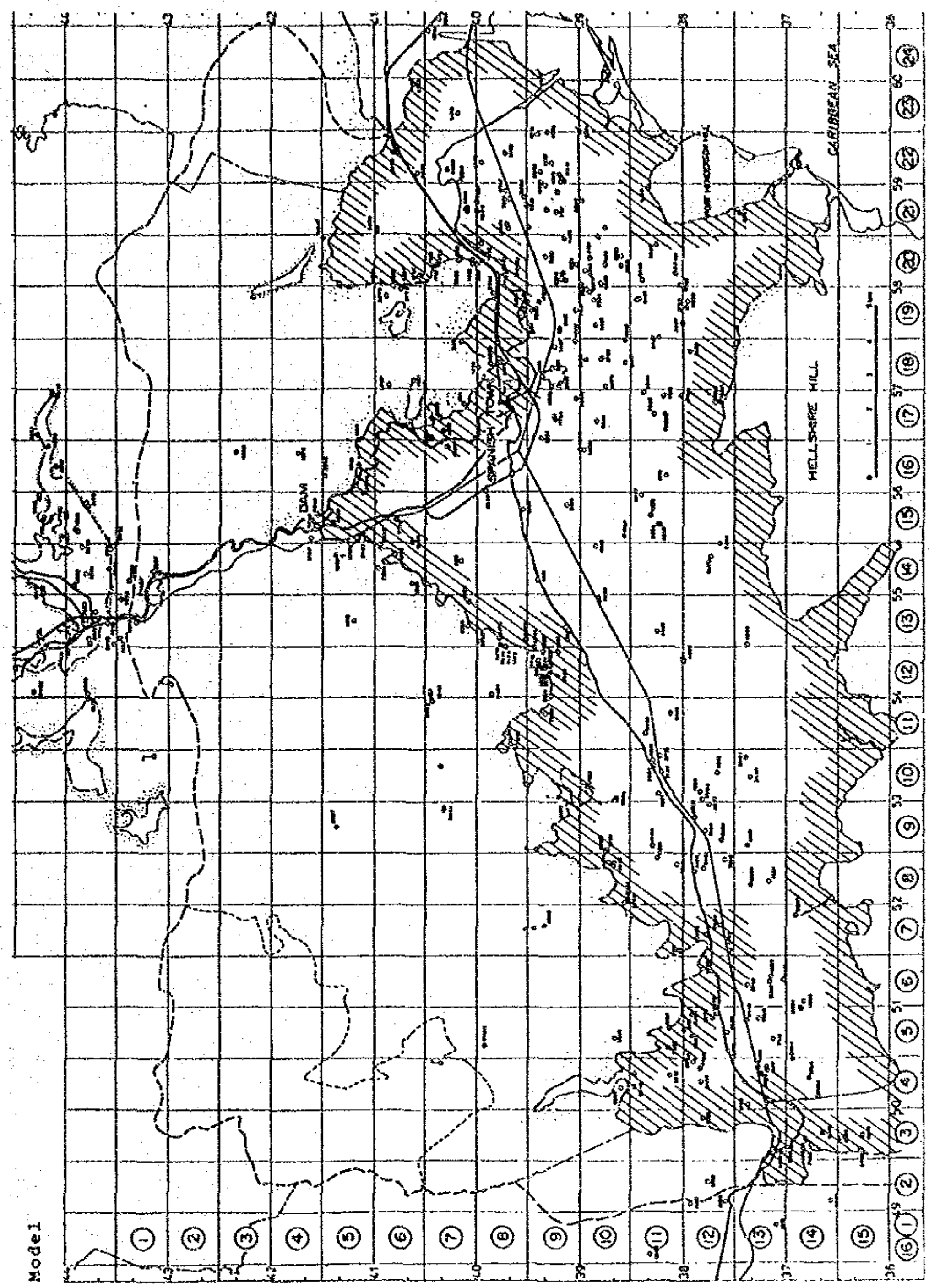




THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-24 (2/2)
EXTRAPOLATED SECTION ACROSS ELECTRICAL CONDUCTIVITY PROFILE

JAPAN INTERNATIONAL COOPERATION AGENCY



LEGEND

Boundary of Lower Rio Cobre Basin

Limestone Alluvium Boundary

Alluvial Groundwater Basin

Unconfined Aquifer] Limestone Groundwater Basin

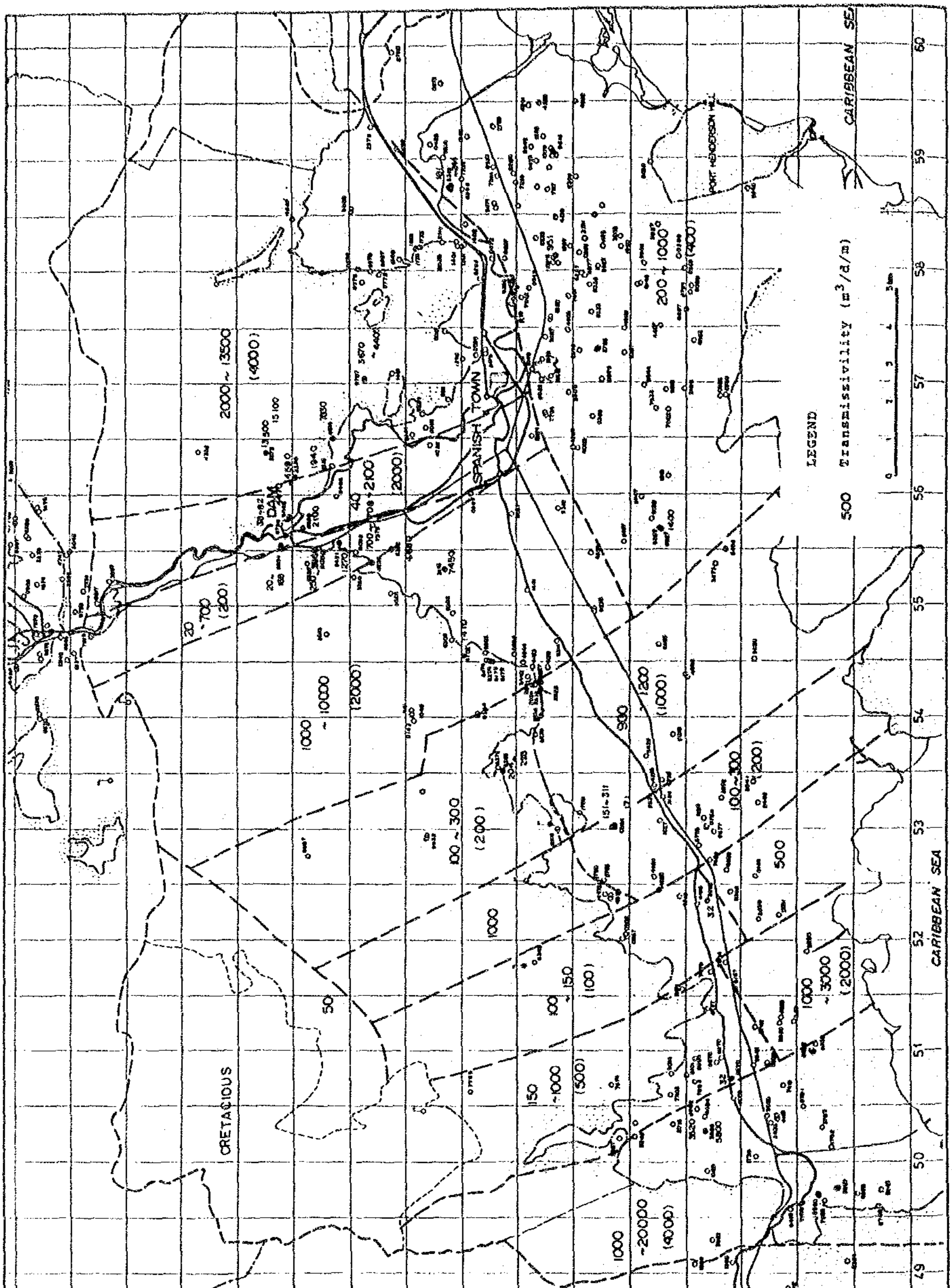
Confined Aquifer]

⑥ Grid Number of Simulation Model

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-25
DISTRIBUTION OF GROUNDWATER BASIN

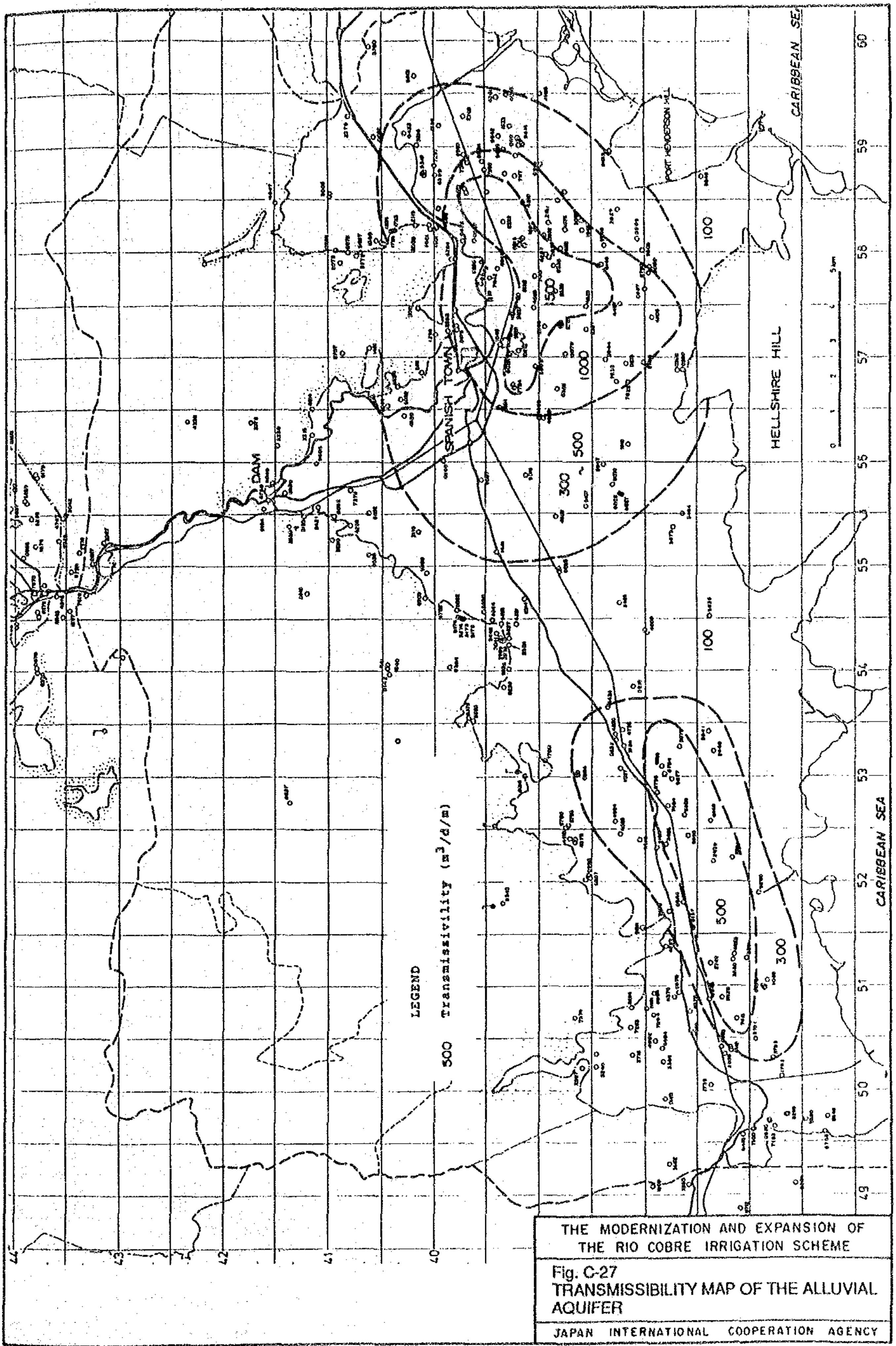
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-26
TRANSMISSIBILITY MAP OF THE LIMESTONE AQUIFER

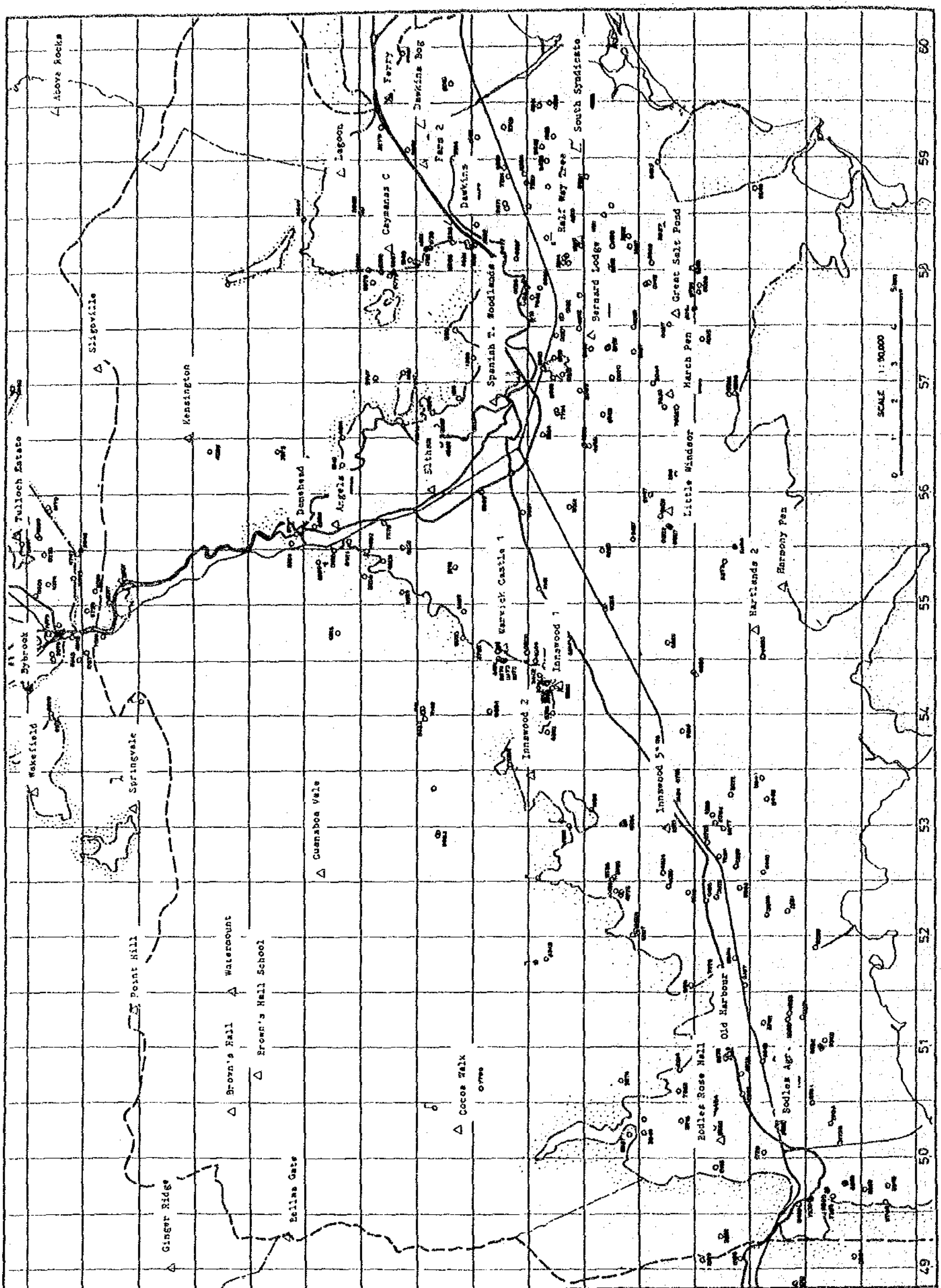
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-27
TRANSMISSIBILITY MAP OF THE ALLUVIAL AQUIFER

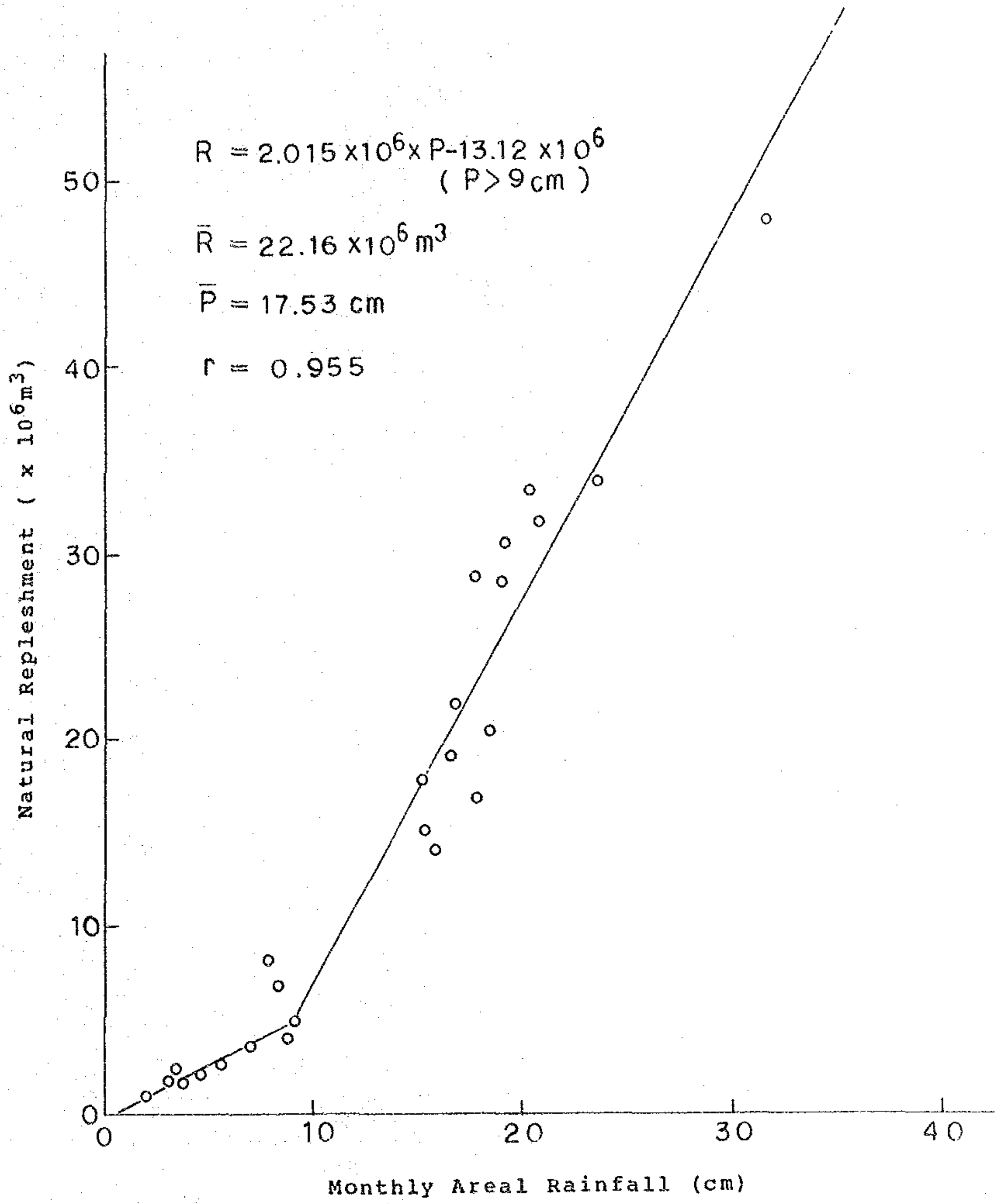
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

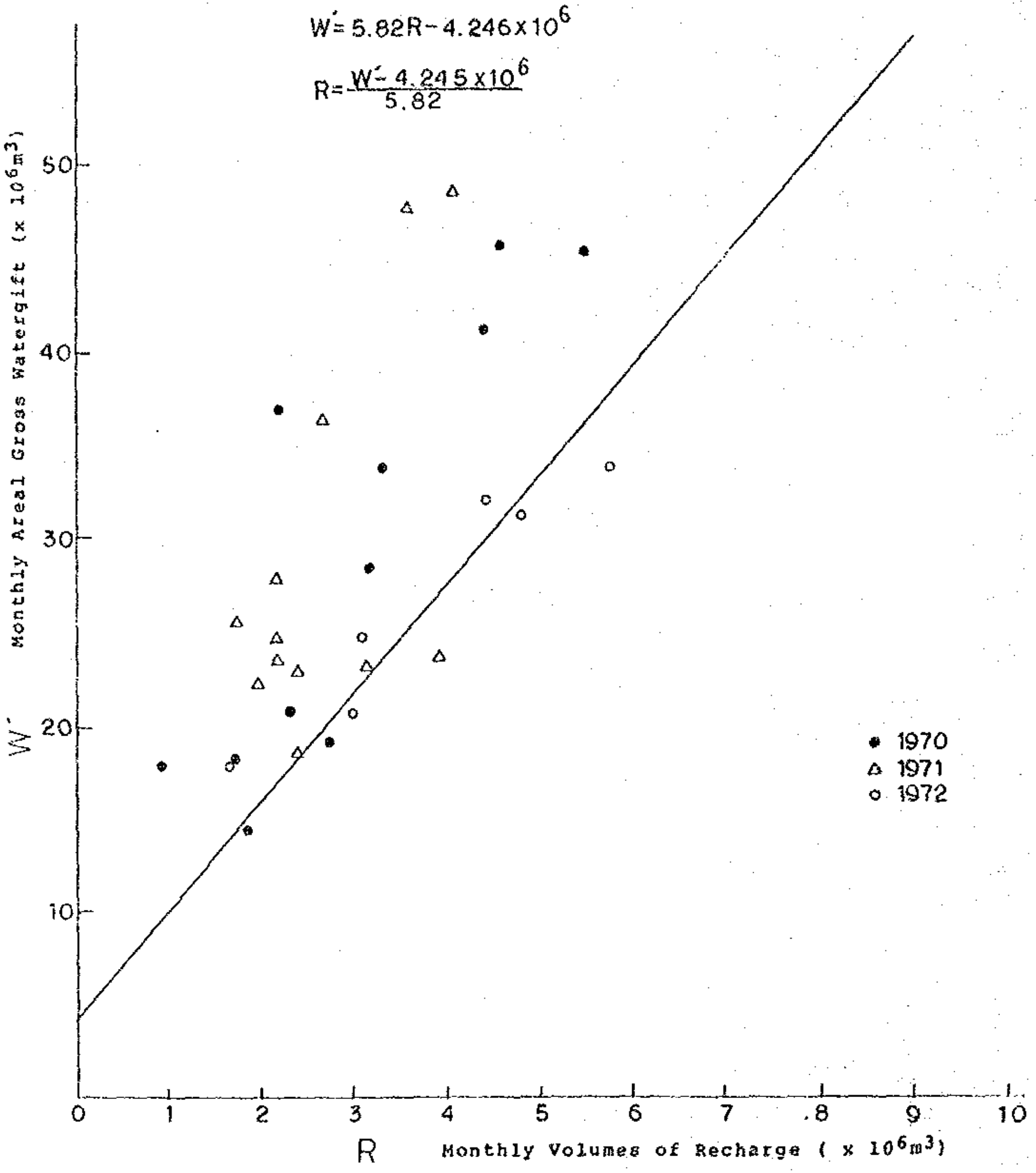
Fig. C-28
RAINFALL STATION MAP

JAPAN INTERNATIONAL COOPERATION AGENCY



(after UNDP, 1974)

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME
Fig. C-29 GRAPH OF NATURAL REPLENISHMENT VS ANNUAL RAINFALL FOR THE LIMESTONE OUTCROPS
JAPAN INTERNATIONAL COOPERATION AGENCY

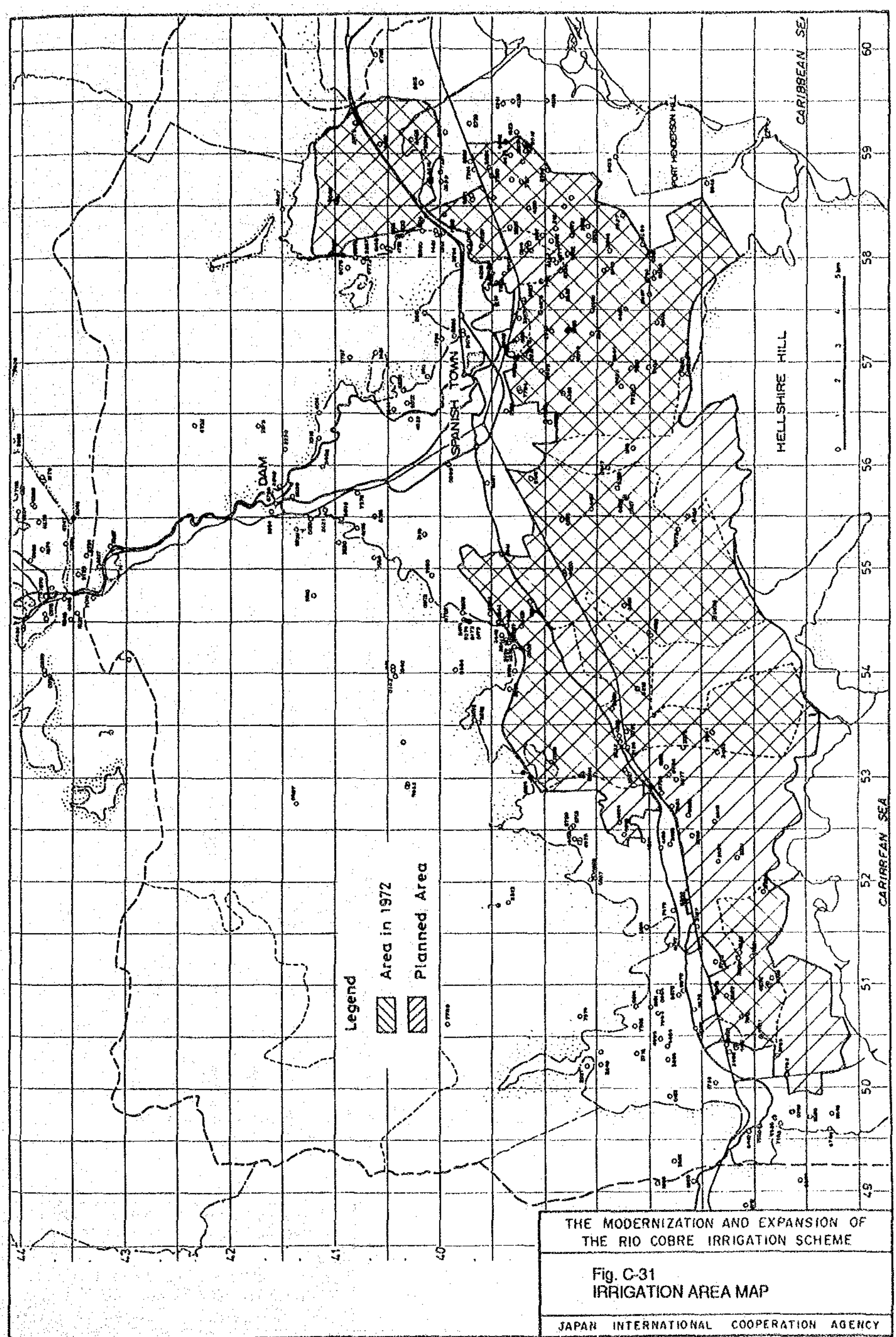


(after UNDP, 1974)

THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

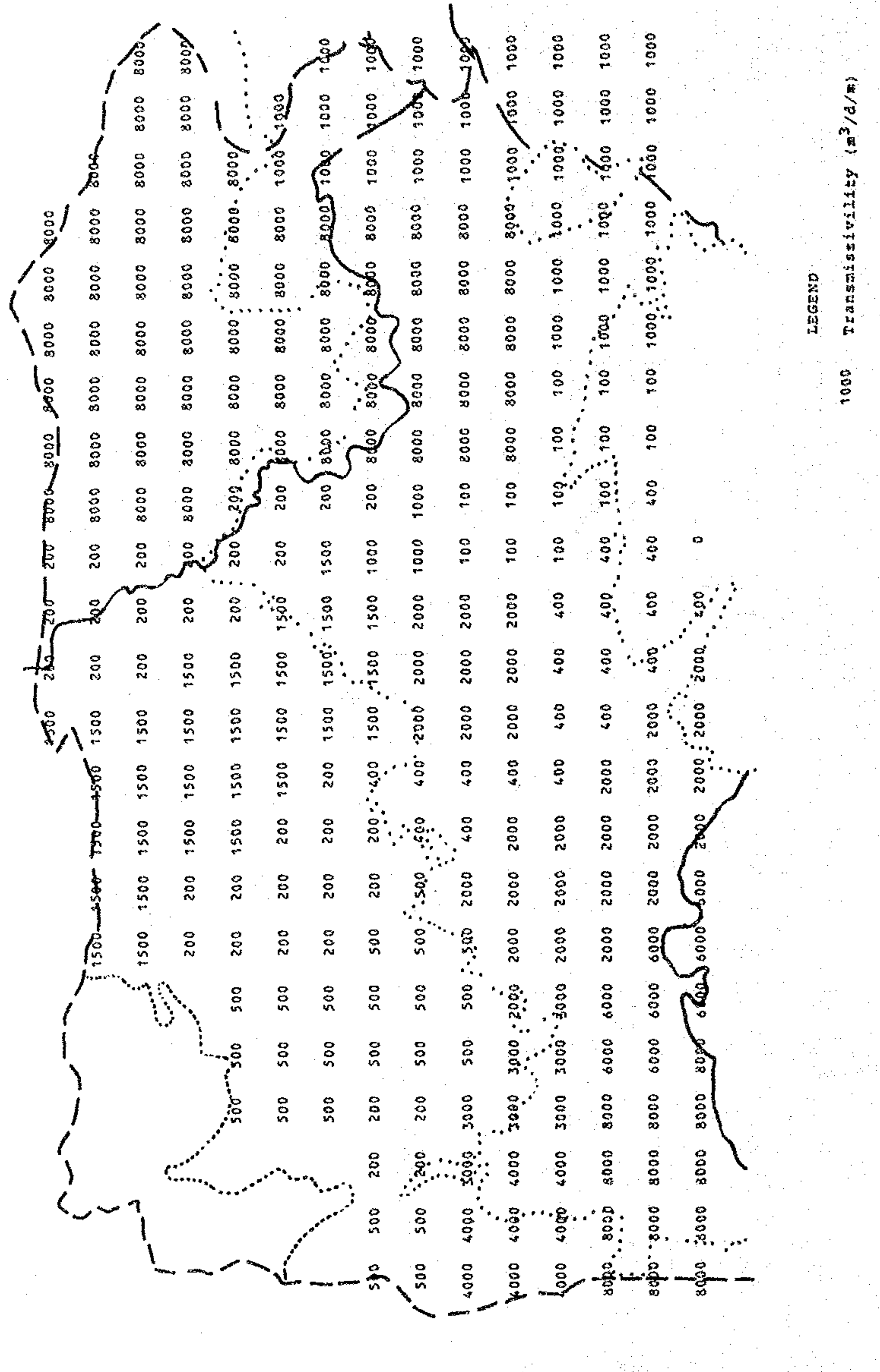
Fig. C-30 GRAPHS OF MONTHLY VOLUMES OF RECHARGE VS MONTHLY AREAL GROSS WATERGIFT FOR THE ALLUVIAL PLAINS

JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

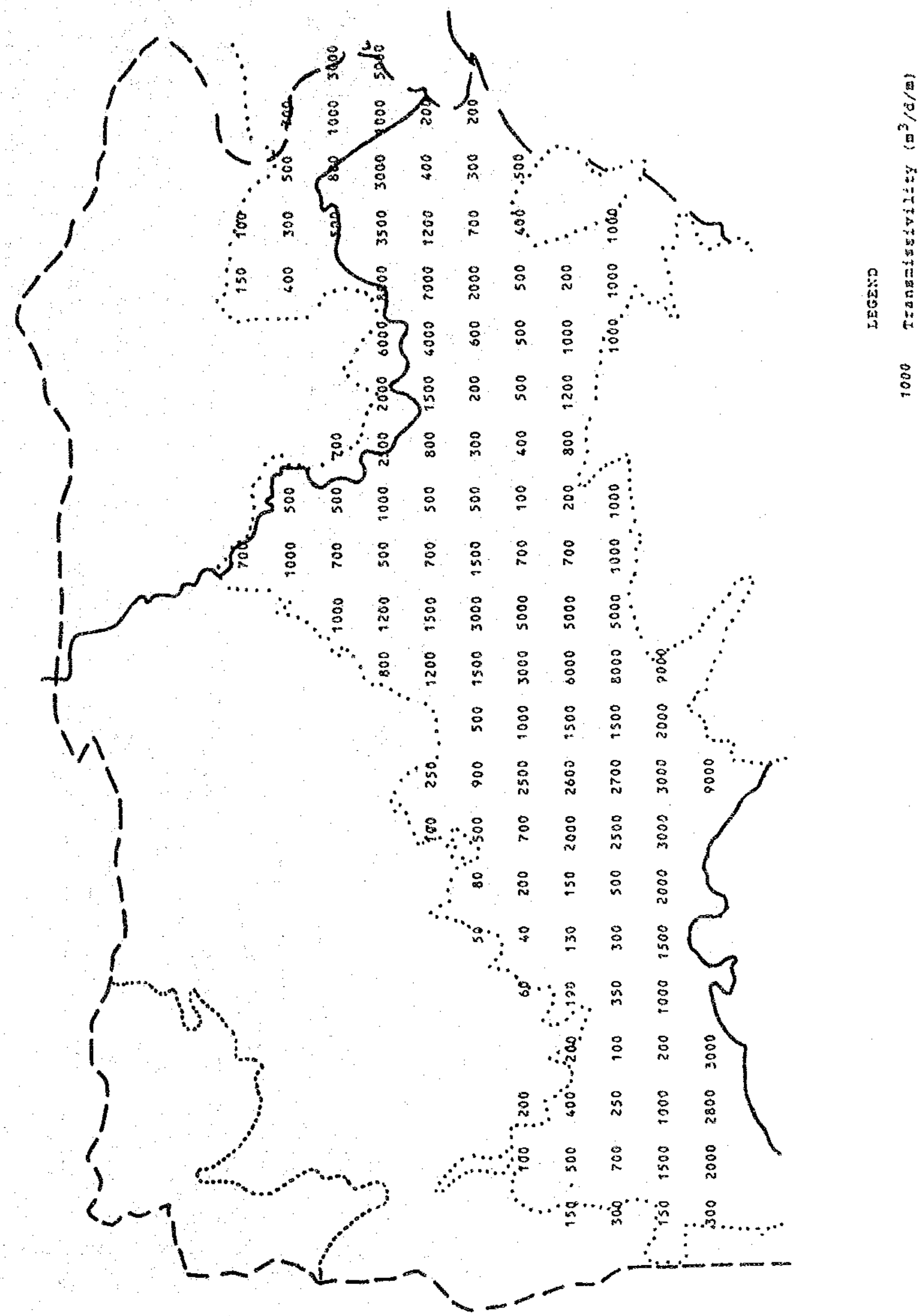
Fig. C-31
IRRIGATION AREA MAP



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-32
MAP OF TRANSMISSIBILITY AFTER INDENTIFICATION OF THE LIMESTONE AQUIFER

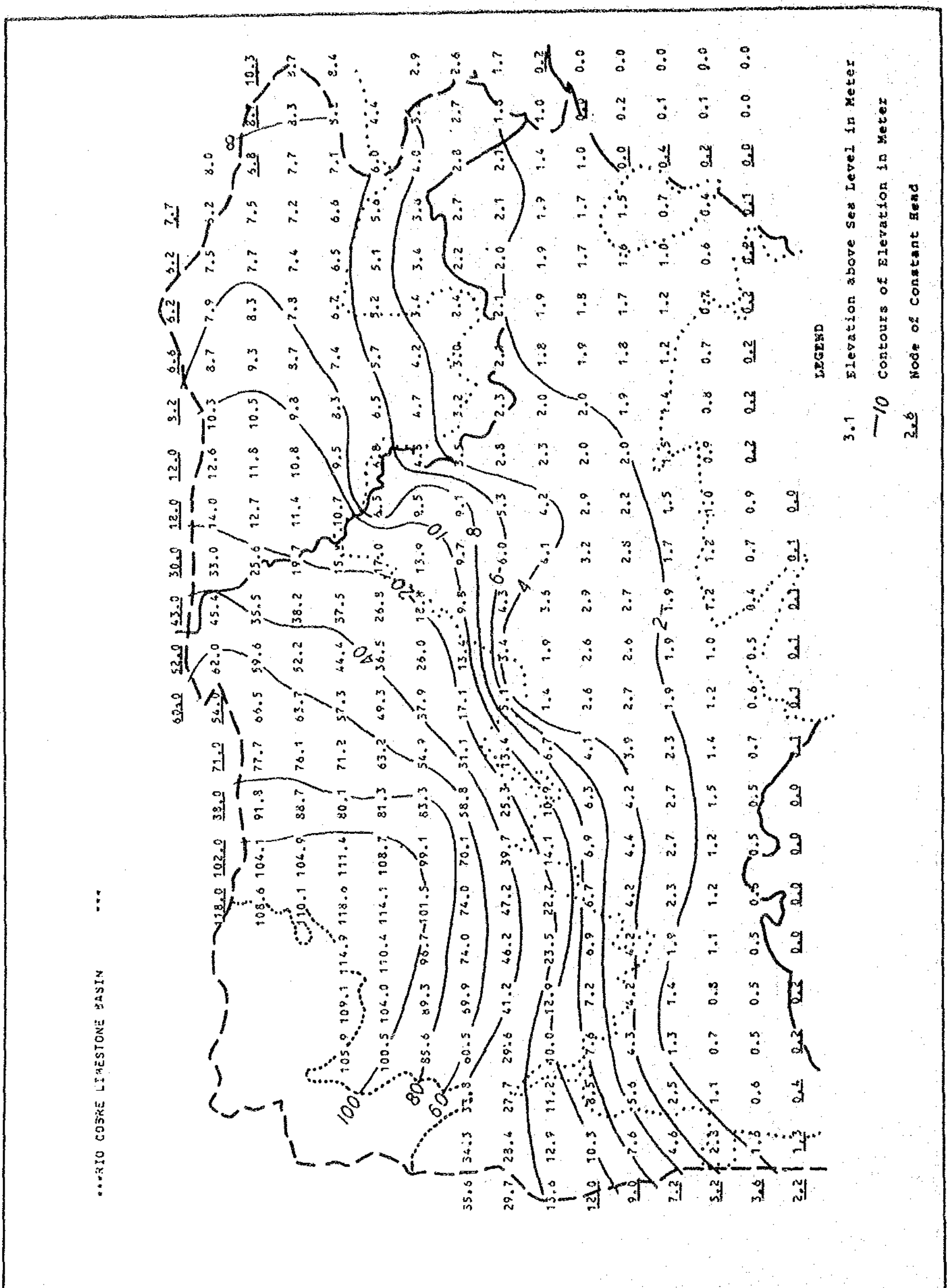
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-33
MAP OF TRANSMISSIBILITY AFTER INDENTIFICATION OF THE ALLUVIAL AQUIFER

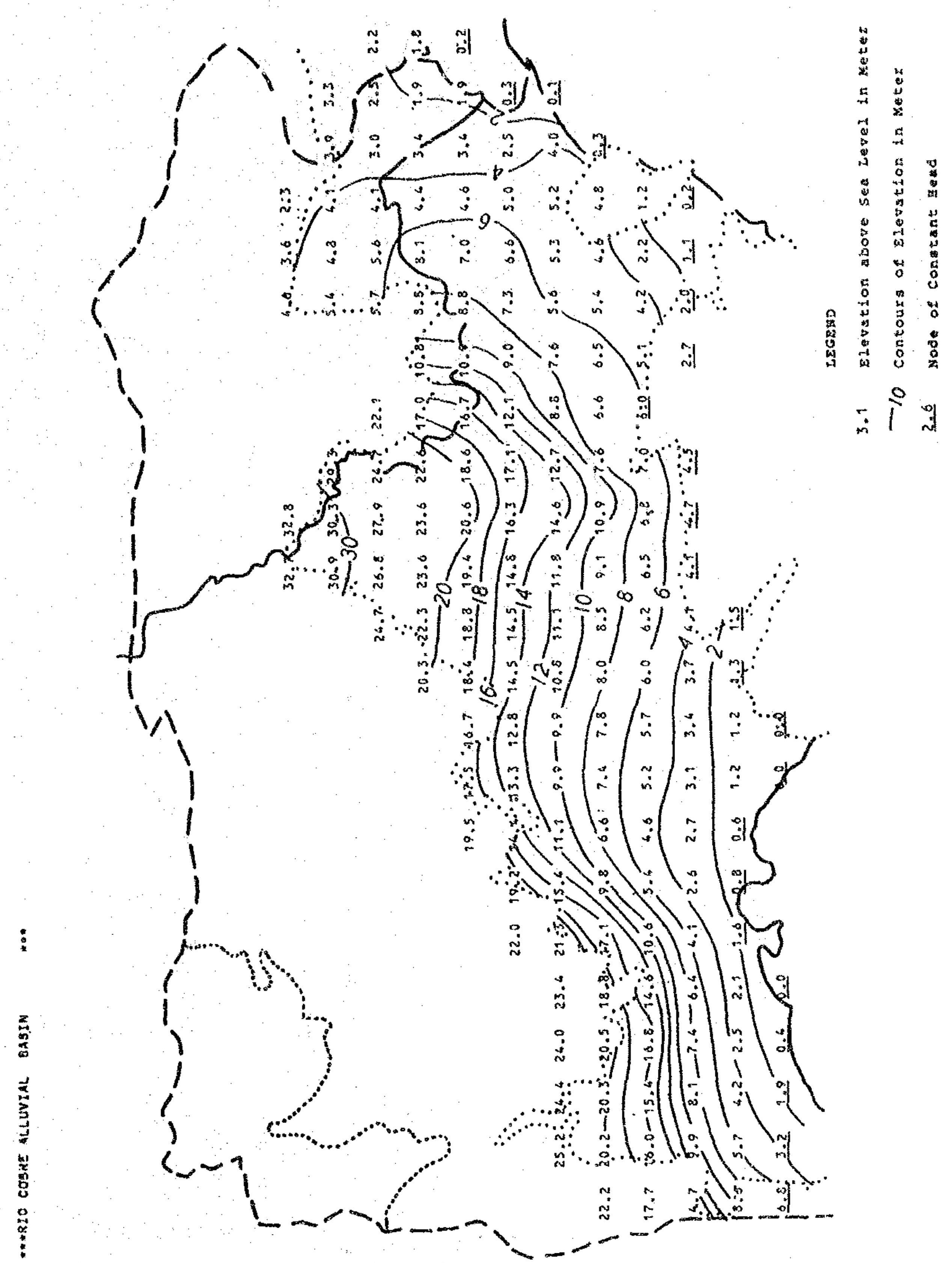
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-34
INDENTIFIED WATER LEVEL CONTOURS IN THE LIMESTONE AQUIFER AUG. 1972

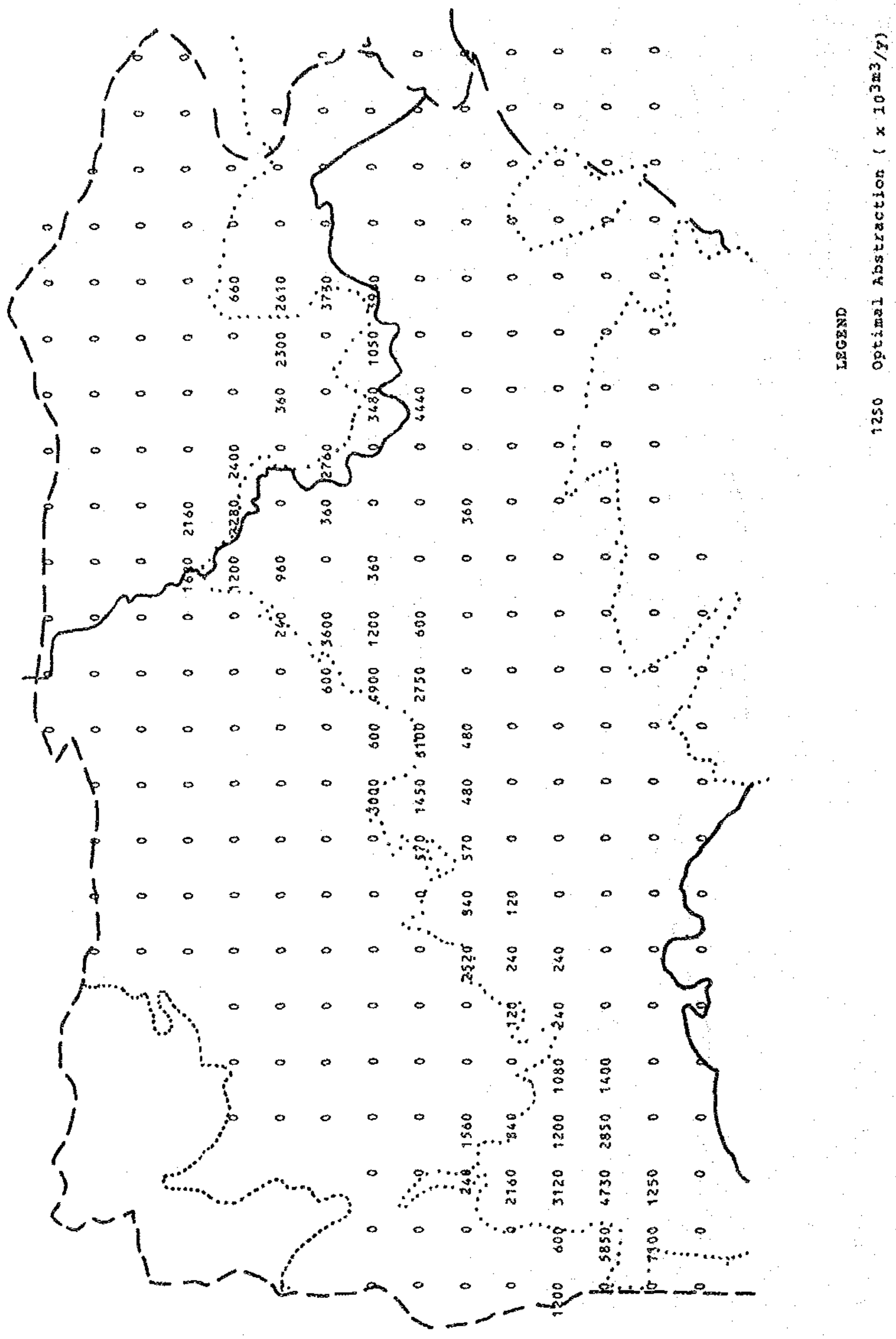
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-35
IDENTIFIED WATER LEVEL CONTOURS IN THE ALLUVIAL AQUIFER AUG. 1972

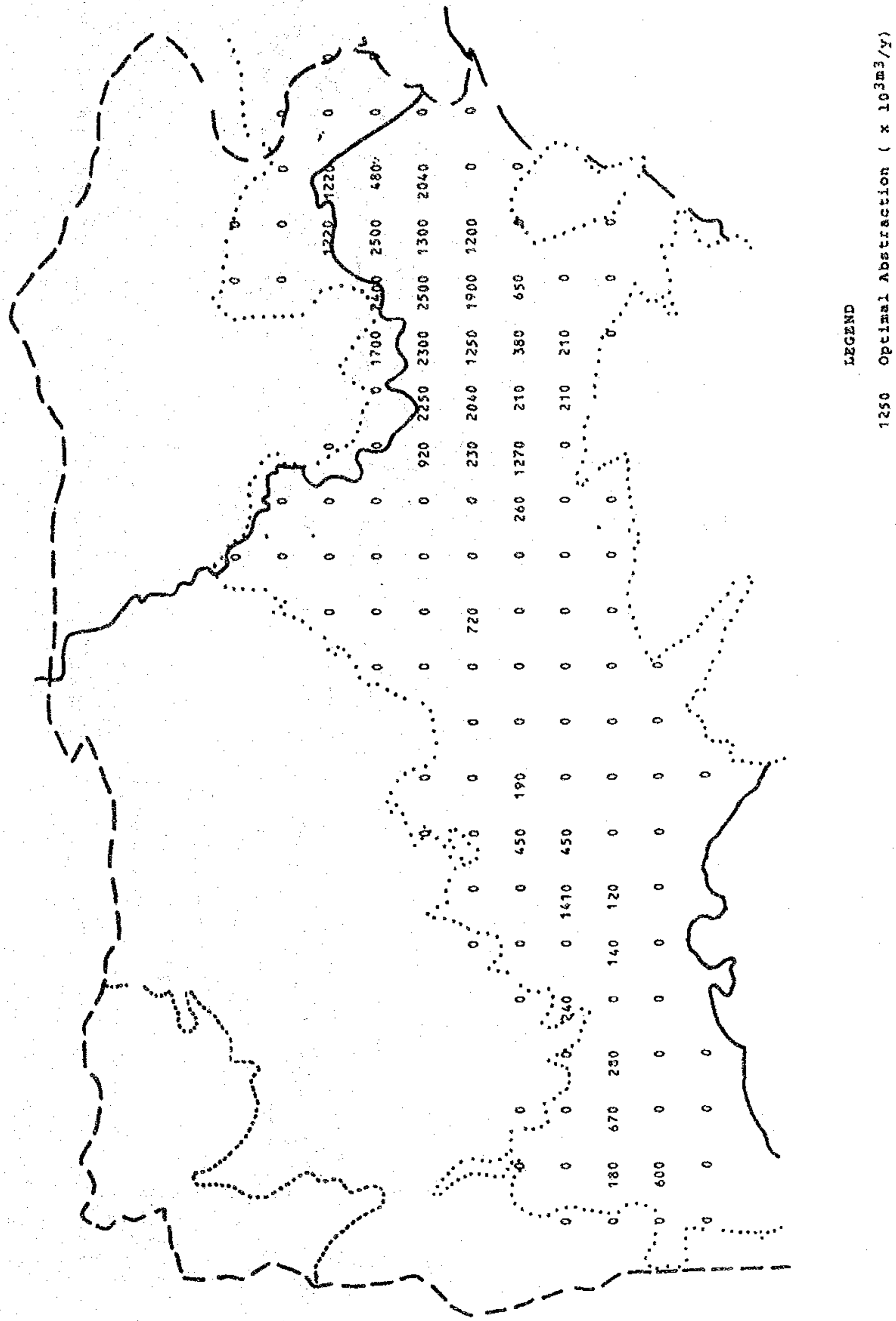
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-36
OPTIMAL ABSTRACTION FOR EACH GRID FROM THE LIMESTONE AQUIFER

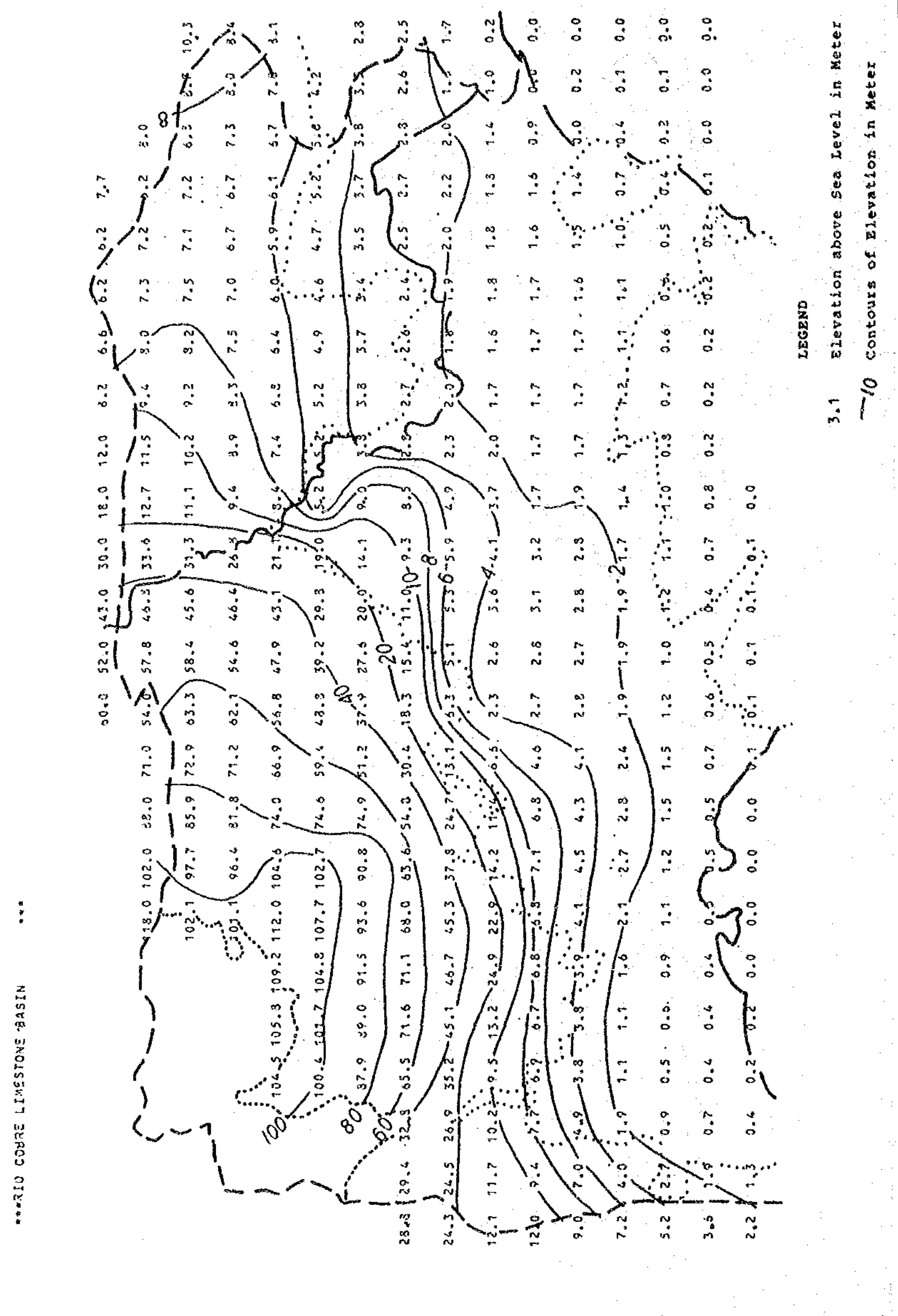
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-37
OPTIMAL ABSTRACTION FOR EACH GRID FROM THE ALLUVIAL AQUIFER

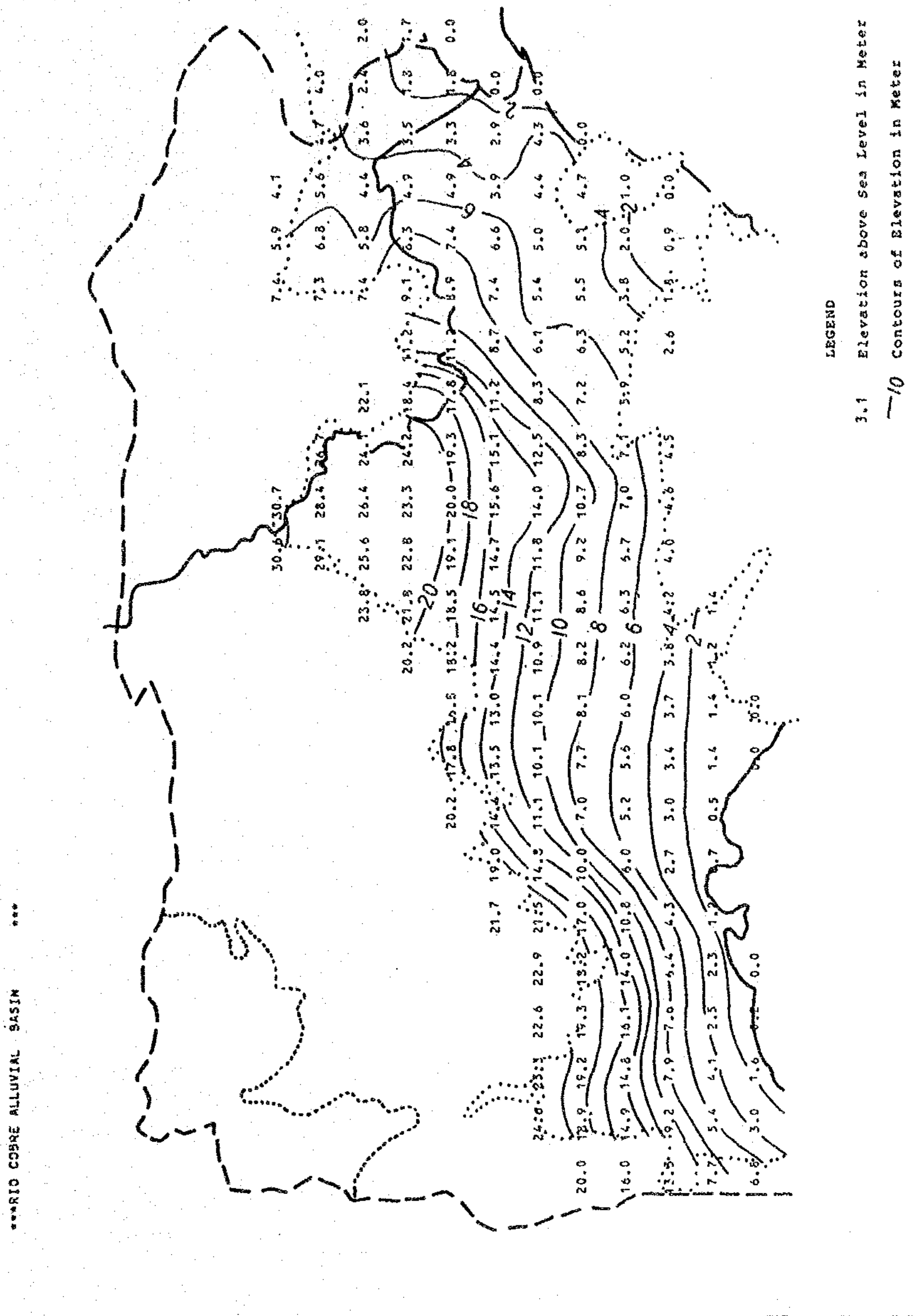
JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-38
CALCULATED GROUNDWATER LEVEL OF THE LIMESTONE AQUIFER

JAPAN INTERNATIONAL COOPERATION AGENCY



THE MODERNIZATION AND EXPANSION OF THE RIO COBRE IRRIGATION SCHEME

Fig. C-39
CALCULATED GROUNDWATER LEVEL OF THE ALLUVIAL AQUIFER

JAPAN INTERNATIONAL COOPERATION AGENCY

ANNEX - D

SOILS AND LAND CAPABILITY CLASSIFICATION

ANNEX-D

SOILS AND LAND CAPABILITY CLASSIFICATION

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1. INTRODUCTION

Soil survey and land classification were introduced into Jamaica with the publication of a Technical Guide Sheet for the main soil types in the island in 1955. The soil survey was followed in the late 50's by a National Soil Survey conducted by the Soil Survey and Research Section of the Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad, W.I. The first report on the Soil Survey, known as "Green Books", was published on the parish of St. Catherine, in March 1958. A recent soil report was published on the whole country in 1982, entitled "Jamaica-Resource Assessment" by the Comprehensive Resource Inventory and Evaluation System (CRIES) Project. The "Greenbooks", though containing little information on the chemical and physical properties and characteristics of soils have had very positive effects on agriculture in Jamaica. Agricultural planning has however become more demanding over the past three decades, and recognition of this fact prompted the Government of Jamaica, through the Soil Survey Unit of the Rural Physical Planning Division of the Ministry of Agriculture to re-inventory the soils of the island using new and internationally acceptable standards to allow for both physical and chemical characterization and correlation of soils in the island.

A semi-detailed soil map of the southern plains of the parish of St. Catherine was prepared in 1985 by the Soil Survey staff of the Rural Physical Planning Division (RPPD) Ministry of Agriculture in Jamaica. Furthermore, "Soil and Land Use Survey of the Coastal Plains of St. Catherine, Jamaica" was published in 1986 based on the results of Soil Survey Project. The main contents of this annex are taken from the descriptions given in this publication as verified and elaborated by an own studies under this project. D-1

2. SOIL SURVEY METHODOLOGY

2.1 Soil Survey by Soil Survey Project, JAMAICA

The survey carried out by the Soil Survey Unit involved a combination of photo-interpretation and field work. In order to establish the field legend, two (2) sample areas of approximately 200 ha each were selected using the former Soil and Land Use Survey map. One sample area was selected in the recent alluvium and the other in the old alluvium.

Auger borings of 100 to 120 cm of soil depth were made for the identification of soils. An average of one auger observation per 50 ha was maintained but could vary according to the complexity of the soil pattern. The number of auger boring sites was about 500.

Representative sites of the soil series were selected and major profile pits were dug, described and sampled. A total of 52 profiles were described the FAO Guidelines for soil profile description.

A total of 250 samples for soil analysis were collected from these profile pits of an average depth of 180 cm and submitted to the laboratory for routine analysis. Undisturbed core samples for pF determination were collected from ten profile pits. The pF 2.0 and pF 4.2 of soils were measured for estimation of available water capacity.

Infiltration test (intake-rate test) were carried out at ten (10) sites using the double ring infiltrometer.

2.2 Soil Survey for Checking

In order to study and check the soil environment of major soil types, checking of the soil was carried out using auger boring at 19 sites in the study area. The survey sites were pre-selected from the soil map prepared by the Soil Survey Project, Jamaica and are shown in Fig. D-1.

Physical soil properties are necessary must be studied in order to plan the effective irrigation and to improve the soil characteristics. Soil samples for physical analysis were therefore collected by core sampling method of auger hole. Soil samples were collected from the surface (0 to 20 cm), subsurface (20 to 40 cm) and subsoil layer (40 to 60 cm). Items of physical analysis were bulk density, water constants of pF 2.0 and pF 4.2. Solid and void ratio of soils can be calculated from the bulk density and soil density (2.65 g/cm^3).

Drainage of soils must be studied in order to decide the most suitable irrigation method and land use. Intake-rate tests using the double ring infiltrometer were carried out at eight (8) sites of major soil series taking into account the land use such as sugar cane, pasture, paddy, fruit and vegetable. According to demand, surface and subsurface intake-rate were measured in order to check the internal drainage of the soils.

2.3 Soil Legend

In the design of the soil legend by the Soil Survey Project, mapping units have been grouped according to their occurrence in the landscape (physiography). Mapping units in each physiographic unit have been grouped on the basis of differences in parent material. Further sub-division in the legend have been made according to the degree of profile differentiation and soil development. Each mapping unit in the sub-division was differentiated depending on the specific soil characteristics such as soil depth, colour, texture and salinity. D-1

3. SOIL MAPPING UNITS

According to the soil map prepared by the Soil Survey Project, a total of 27 mapping units were identified. Their mapping units include 16 consolidation, one (1) association, two (2) complexes, two (2) undifferentiated soils and six (6) miscellaneous areas. The mapping units are briefly described according to the guidelines of the Soil Survey Manual and soil classification was carried out according to Soil Taxonomy.

The complete soil legend which includes some new soil series and associations is shown in Table D-1 and the main soil characteristics of the major mapping units are shown in Table D-2. A detailed description of the soil mapping units is given under the item of soil series description. Land capability classes for the mapping units are described in Chapter 6 under land capability classification. Extents of mapping units in the study area are shown in Table D-3. General description of the mapping units is as follows:

(1) PRb1 - Caymanas clay loam - loam:

These soils are deep, well drained, brown, stratified, fine silty soils. They occur in level, smooth areas on the recent alluvial plain.

(2) PRb2 - Dawkins clay loam - loam:

These soils are deep, well drained, stratified, medium textured soils with surface soils of clay loam and loam textures. They occur on level, smooth areas near stream channels and old river beds.

(3) PRb3 - Whim clay loam:

These soils are deep, well drained, moderately medium textured soils developed on recent alluvium of river plains. The soils occur on level, smooth sites along major stream channels.

(4) PRb4 - Ferry silty clay:

These soils are deep, moderately well drained, grayish brown, strong calcareous, stratified and fine textured soils, typically with high silt content. They are developed over recent alluvium and occur at the lower end of the constant seaward sloping part of the coastal plain.

(5) PRb4a
This mapping unit is similar to Ferry silty clay but differs in the amount of sodium salts in the subsoil and substratum. The soils occur in the low-lying areas bordering the sea and water-logged areas nearby.

(6) POc1 - Lodge clay, saline-sodic:

These soils are moderately well drained, deep, reddish brown, cracking clay soils occurring on slightly elevated sites on the old alluvial plain.

(7) POc1/sa - Lodge clay, saline-sodic:

These soils are similar to Lodge clay but differ in the amount of salinity and sodicity in the surface layers. The soils occur on lower slopes of the clay plain towards the sea.

(8) POc2 - Churchpen clay:

These soils are imperfectly drained, deep, brown and dark yellowish brown cracking soils. The soils occur on level plains in relatively large areas towards the centre of the study area.

(9) POc2/sa - Churchpen clay, saline-sodic:

The saline-sodic phase of Churchpen clay is similar to Churchpen clay but differs in the amount of sodium and other slats in the substratum. The soils occur on low-lying positions bordering Churchpen clay towards the sea.

(10) POc3 - Bodles clay:

These soils are imperfectly drained, deep, mixed yellowish red and brown firm cracking clay soils. The soils occupy slightly concave sites on the alluvial clay plain and occur towards the extreme western extremity of the study area.

(11) POc4 - Horse Cave clay:

These soils are deep, imperfectly drained, yellowish brown firm cracking clay with typically a dark yellowish brown granular surface mulch. The soils are developed on old alluvium.

(12) POc5 - Salt Island clay:

These are deep, imperfectly drained, cracking clay soils. The soils occupy level, smooth sites on the lower slopes of the clay plain towards the sea. They are developed on old alluvium where salinization in the sub-surface has been caused by sea water intrusion.

(13) POc6 - Sydenham clay:

These soils are imperfectly drained, deep, brown and dark greyish brown mottled firm clays. The soils occupy level, smooth sites and slightly concave positions on the clay plain.

(14) POc6/sa - Sydenham clay, saline-sodic:

These soils are similar to Sydenham clay, but differ in salinity and sodicity in the substratum. The soils occur mainly towards the centre of the study area.

(15) POc7 - Springfield clay:

These soils are poorly drained, deep, very dark grey and brown mottled cracking clays occurring in slightly depressed sites on the old alluvial plain and along shallow drainage ways.

(16) POd1 - Colbeck clay:

These soils are well drained, deep, yellowish red to reddish brown clays. They occur on elevated sites on the old alluvial plain in intermediate positions towards the limestone hills.

(17) POA1 - Colbeck-Bodles Association:

This mapping unit consists of an association of Colbeck soils occupying the upper parts and crests, and Bodles soils on the lower sites of the undulating plain.

(18) HLC1 - Rockland - Hellshire Complex:

The mapping unit consists of a complex of Rockland (about 50%) and Hellshire (about 30%). Hellshire stony loam is a somewhat excessively drained, shallow, red to reddish brown stony loam and clay loam developed over limestone. They occupy the relatively small areas between Rockland.

(19) HLC2 - Union Hill Ustic Variant - Hellshire complex:

This mapping unit consists of a complex of Union Hill soils comprising about 60% and Hellshire soils about 30% of the mapping unit. Both soils are developed on limestone rocks. Union Hill Ustic Variant is a somewhat excessively drained, moderately shallow, strong brown, stony clay loam and clay with a very dark brown, stony to gravelly clay loam surface soil.

(20) TMX1 - "Salina" Undifferentiated:

These are extremely saline areas located between the sea, mangrove swamps and the alluvial coastal plain soils.They consist of poorly drained, deep, strongly saline and sodic soils of varying textures.

(21) TMX2 - "Mangrove" Undifferentiated:

The mapping unit consists of areas that are covered with a thick growth of mangrove trees. They occur along the sea coast and inlets and are always under saline water.

4. SOIL CLASSIFICATION

The soils in the study area are classified into five(5) orders, seven(7) sub-orders, nine(9) great-groups and ten(10) sub-groups in the higher categories of classification as shown in Table D-4. The five(5) orders are Mollisols, Vertisols, Inceptisols, Entisols and Alfisols. Soil classification at the family level are shown in Table D-5 and are correlated with the FAO/UNESCO system.

4.1 *Soil Series Description*

4.1.1 Soils formed on recent alluvium

(1) Caymanas Series (PRb1)

Caymanas soils are members of the fine silty, mixed, isohyperthermic, Typic Haplustolls. The soils are well drained, deep, dark yellowish brown with a characteristically dark brown and very dark grayish brown humic surface layer. They are developed on recent alluvium where they occupy smooth sites mainly on somewhat higher terraces of the Rio Cobre fan deposits.

<u>Typical Profile</u> : <u>Caymanas loam</u>

The following profile was examined at Lime Tree Grove, St. Catherine. It has approximate 391000 N and 576000 E. The site is on a smooth, level plain at an elevation of about 16 m and under irrigated sugar cane.

Ap1 0-15 cm. Very dark grayish brown (10YR 3/2) moist and dark brown (10YR 3/3) dry loam; strong angular and subangular blocky structure; very hard (dry) firm (moist) and sticky and plastic (wet); common coarse, many medium and fine pores; common fine, few medium roots; worm casts and ants; non-calcareous; clear smooth boundary; pH 7.9.

Ap2 15-34 cm. Very dark grayish brown (10YR 3/2) moist and dark yellowish brown (10YR 3/4) dry loam; moderate coarse medium angular and subangular blocky structure; extremely hard (dry), firm (moist), very sticky and plastic (wet); few medium, many fine pores; few fine roots; non calcareous; gradual boundary; pH 8.0.

Bw1 34-64 cm. Dark yellowish brown (10YR 4/4) moist and yellowish brown (10YR 5/4) dry silt loam; weak, medium and fine subangular blocky structure; very sticky and very plastic (wet); common medium, many fine pores; few medium and fine roots; calcareous; gradual boundary; pH 8.2.

Bw2 64-122 cm. Dark yellowish brown (10YR 4/4) dry and dark yellowish (10YR 3/4) moist silt loam; weak medium and fine subangular blocky structure; very sticky and plastic (wet); few medium, common fine pores; few fine roots; strongly calcareous; gradual boundary; pH. 8.3.

Thickness of the A horizon ranges from 20 to 35 cm and it has typically moist colour values of 2 or 3 and dry colour values of 3 or 4. Organic matter level is more than 1% (mollic epipedon). Typical textures are generally clay loam and loam, silty clay loam and silt loam, infrequently silty clay. Structure is strong, medium angular and subangular blocky. The cambic B horizon has a hue of 10YR values of 4 to 6 and chroma of 4 to 6. Typical textures are silty clay loam, silt loam and loam high in silt, becoming sandy loam and lighter with increasing depth. Substratum with fine-sandy textures often occurs below 100 cm. Structure is weak, coarse and medium blocky. Few gravels may occur in places.

Caymanas soils are strongly calcareous. Soil reaction (pH) ranges from mildly to moderately alkaline throughout. The soils are non-saline and non-sodic throughout. Permeability is moderately rapid to rapid. Natural fertility is high. Workability is relatively easy and seedbeds are easy to prepare. Caymanas soils occur on the same landscape as the Dawkins and Ferry soils. The Dawkins soils are coarse loamy and occur along streams and old stream channels. Ferry soils occur on the lowest part of the alluvial fan and are clayey in the subsurface layers and substratum. Caymanas soils occupy extensive flat areas mainly in the eastern part of the survey area.

(2) Dawkins Series (PRb2)

Dawkins soils are coarse loamy, mixed, isohyperthermic, Typic Haplustolls (formerly Caymanas sandy loam) occur on recent alluvial fans on level, smooth sites along the Rio Cobre and old stream channels. They are deep, well drained soils with a typically dark brown and very dark grayish brown humic surface layer. A horizon has weak, coarse, blocky structure and subsurface layers are weak, coarse, blocky to massive loams and sandy loams, becoming more sandy with depth.

Typical Profile : Dawkins loam

The following profile was examined at Cow Park farm, St. Catherine. It has approximate coordinates 396000 N and 585000 E. The site is on a flat alluvial plain in an abandoned sugarcane cane field.

Ap 0-40 cm. Dark brown (10YR 3/3) both moist and dry loam; weak, coarse subangular blocky; hard (dry), friable (moist), non sticky and non plastic (wet); few medium and common fine pores; many very fine and few medium roots; very few hard, small, irregular iron and manganese nodules; clear, smooth boundary; pH 8.2.

Bw1 40-90 cm. Dark yellowish brown (10YR 4/4) moist and light yellowish brown (10YR 6/4) dry loam with a band of fine sand at 90 to 98 cm; few fine faint yellowish red (5YR 5/6) mottles; weak, coarse subangular blocky; slightly hard (dry), friable (moist), non sticky and non plastic (wet); common very fine and few medium pores; common very fine and few fine roots; abrupt, smooth boundary; pH 8.4.

C 90-150 cm. Yellowish brown (10YR 6/4) moist loam with few fine faint yellowish red (5YR 5/8) moist mottles; weak, coarse subangular blocky; slightly hard (dry), friable (moist), non sticky and non plastic (wet); few fine and common very fine roots; pH 8.4.

The A horizon is 20 to 45 cm thick and typically dark, with a hue of 10YR and values and chroma of 2 or 3 and dry values of 3 or 4. (mollic epipedon). Textures range from clay loam to loam, high in silt. Subsoils have a hue of 10YR, with values of 3 to 5 and chroma of 3 to 8. Textures range from fine sandy loam to loam and loamy fine sand, and structure is weak, coarse, subangular, blocky. Substratum often has sandy texture, with gravels in places. It is calcareous throughout. Permeability is rapid. Soils are highly calcareous and soil reaction (pH) ranges from neutral to moderately and strongly alkaline. They are non-saline and non-sodic throughout. Natural inherent fertility is high. Workability is good and seedbeds are easy to prepare.

The soils occur on levees in relatively small areas along streams and old stream channels in the eastern part of the survey area.

Dawkins soil forms part of the same landscape as Caymanas and Ferry soils. Caymanas and Ferry soils have fine silty and fine control sections respectively.

(3) Whim Series (PRb3)

Whim soils are fine loamy, mixed, isohyperthermic, Udic Haplustolls that occur on smooth and level somewhat higher terraces of recent alluvium along stream channels. They consist of well drained, deep, dark yellowish, brown, moderately fine textured soils with a typically very dark grayish brown humic surface layer.

Typical Profile : Whim clay loam

The following profile was located in the Bushy Park area, St. Catherine about 50 m along the Coleburns Gully from the aqueduct. It can be found at approximate coordinates 373000 N and 528000 E. The site is on level land under irrigated sugar cane.

Ap 0-23 cm. Very dark grayish brown (10YR 3/2) moist and (10YR 4/2) dry clay loam; medium angular and subangular blocky; firm (moist), slightly sticky and plastic (wet); few medium tubular and vesicular pores; common medium and fine roots; few worm cast; few iron nodules; clear smooth boundary; pH 7.5.

Bw1 23-38 cm. Brown to dark brown (10YR 4/4) moist clay loam; moderate coarse and medium angular and subangular blocky; firm (moist), sticky and plastic (wet); patchy, thin cutans on ped faces; many medium and few fine tubular pores; common medium vesicular pores; common medium and few fine roots; many worm casts; gradual, smooth boundary; pH 7.8.

Bw2 38-90 cm. Dark yellowish brown (10YR 4/4) moist with inclusions of brown to dark brown (10YR 4/3) moist sandy clay loam; moderate to weak, coarse parting to medium and fine angular and subangular blocky; firm (moist), slightly sticky and plastic (wet); patchy, thin clay cutans on ped faces; common medium and fine tubular and common medium vesicular pores; very few medium and fine roots, common worm casts; common rounded gravels; clear, smooth boundary; pH 8.0.

C1 90-140 cm. Brown to dark brown (10YR 4/3) moist sandy clay loam; weak coarse parting to medium and fine angular and subangular blocky; firm (moist), slightly plastic (wet); many fine, few medium tubular and few medium and fine vesicular pores; very few medium roots; pH 8.0.

The A horizon has a hue of 10YR and infrequently 7.5 YR with typically moist colour value and chroma of 2 or 3; dry value may be 3 or 4 (mollic epipedon). Texture is clay loam but may be sandy clay. The subsoil has a hue of 10YR and infrequently 7.5YR with values of 3, 4 or 5 and chroma of 2 to 4. Texture ranges from sandy clay to clay loam. The structure is moderate, coarse to medium subangular to angular blocky. Substratum below 100 cm sandy clay loam but may be sandy loam or more sandy in places.

Calcareousness is variable but generally slightly to strongly calcareous throughout. Natural fertility is high. Workability is good and seedbeds are relatively easy to prepare. Soil reaction (pH) is mildly to moderately alkaline. The soils are non saline and non-sodic. Whim soils occur in association with Lodge, Churchpen and Salt Island soils that all occupy older alluvium of the clay plain. They are relatively minor in extent and occur in two (2) relatively small areas along the Coleburns and Bowers gullies.

(4) Ferry Series (PRb4)

Ferry soils are fine, mixed, isohyperthermic, Typic Haplustolls. They occur on level, smooth areas on the lower part of the alluvial fan. They are moderately well drained, deep, silty clay loam with a dark brown, silty clay, humic surface soil. The subsoils are fine clayey, high in silt and have common mottles.

<u>Typical Profile</u> : <u>Ferry silty clay</u>

The following profile was examined at Caymanas Estate, St. Catherine. It occurs at approximate coordinates 410000 N and 589000 E. The site is flat and under irrigated sugar cane.

Ap 0-20 cm. Dark brown (10YR 3/3) moist silty clay; moderate strong, medium and fine subangular blocky structure; hard (dry), sticky and plastic (wet); common, very fine roots; few calcareous shell fragments clear smooth boundary; pH 7.7.

Bw1 20-60 cm. Dark yellowish brown (10YR 4/4) moist silty clay with a band of sand between 40-60 cm and few fine, faint and strong brown (7.5YR 4/6) mottles; moderate, coarse subangular blocky, parting to moderate, fine angular and subangular blocky; very firm (moist), sticky and plastic (wet); few medium and common fine pores; few fine and common very fine roots; few worm cast; few white calcareous gravels; abrupt, wavy boundary; pH 8.2.

Bw2 60-90 cm. Grayish brown (2.5Y 5/2) moist silty clay loam with many medium distinct brown (7.5YR 5/6) mottles; moderate, coarse subangular blocky; friable (moist), sticky and plastic (wet); few medium and common fine pores; few fine and very fine roots; few shells and decayed roots; abrupt, wavy boundary; pH 8.4.

Bw3 90-140 cm. Dark grayish brown (2.5Y 4/2) moist silty clay loam with many medium, prominent dark yellowish brown (10YR 3/4) moist mottles; coarse columnar structure; sticky, plastic (wet); few medium and common fine tubular pores; few fine roots; clear, smooth boundary; pH 7.8.

C1 140-154 cm. Light brownish gray (2.5Y 6/2) moist silty clay loam with few fine distinct, strong brown (7.5YR 5/6) mottles; massive structure; friable (moist), slightly and sticky (wet); few fine pores; common shells; pH 7.8.

The A horizon from 18 to 30 cm has a typically 10YR hue with both value and chroma of 2 or 3 moist and a value of 3 to 5 when dry. Its texture ranges from silty clay to clay and silty clay loams. Structure ranges from strong to moderate, fine and medium angular blocky. The B-horizon has a hue of 10YR or 2.5Y with moist values of 4 to 6 and chroma of 2 to 5. Subsoils are moderate to weak, coarse to medium blocky silty clay, clay and silty clay loam. A band of sandy texture often occurs between 40 and 60 cm depth. Distinct brown and gray mottles may occur below 50 cm. Lower subsurface layers and substratum may have lighter textures of sandy loams, loamy fine sand and sands often below 100 cm. Ferry soils are strongly calcareous throughout. Soil reaction (pH) ranges from mildly and moderately to strongly alkaline in lower substratum. Permeability is moderately rapid and available moisture capacity is high. Ferry soils are non to slightly saline in the topsoil and upper subsurface layers but may become moderately saline in the substratum especially in low-lying areas near the sea or near swamps. They may also be sodic in lower portions of the profile. Natural fertility is high. Ferry soils resemble Caymanas and Dawkins soils which occur in the same landscape but have finer textures. They occur in relatively large areas in the eastern and north eastern part of the survey area bordering the sea and its inlets.

4.1.2 Soils formed on old alluvium

(1) Lodge Series (POc1)

Lodge soils are fine, montmorillonitic, isohyperthermic, Typic Chromusterts that occupy nearly level to level sites on the clay plain. They are moderately well drained, deep and characteristically have reddish brown to brown colours. They crack deeply when dry, and slickensides are common in the lower part of the solum. Soil permeability is slow when wet.

Typical Profile : Lodge clay loam

The following profile was located on Lodge Farm approximately 1.5 km south of Bodles Research Station, St. Catherine in the Old Harbour area. Its location is on coordinates at approximately 36900 N and 504000 E. The site is located on a level plain in a pasture field.

Ap 0-28 cm. Dark brown (7.5YR 3/2) moist clay loam; moderate, medium subangular blocky parting to granular; firm (moist), slightly sticky and plastic (wet); well developed pressure faces; common fine tubular and vesicular pores; common fine roots; few worm casts; common round manganese concretions; clear wavy boundary; pH 7.3.

AC1 28-50 cm. Reddish brown (5YR 3/3) moist clay; moderate coarse and medium angular and subangular blocky; firm (moist), plastic (wet); common weakly developed slickensides; few fine pores; few fine roots; few worm casts; common fine manganese concretions; clear smooth boundary; pH 7.8.

AC2 50-90 cm. Reddish brown (5YR 3/3) moist clay loam; strong, coarse and medium angular and subangular blocky; firm (moist), plastic (wet); many large well developed slickensides; few fine pores; few fine roots; common fine manganese concretions; diffuse , smooth boundary; pH 7.8.

C 90-140 cm. Reddish brown (5YR 3/3) moist clay loam; moderate, medium angular blocky; firm (moist), sticky and plastic (wet); common poorly developed slickensides; few fine pores; very few fine roots; few rounded manganese concretions; common lime gravels; pH 7.8.

The moist colours of the upper 30 cm of the A horizon are typically 7.5YR and 5 YR with chroma of 2 or 3 and value of 3. Infrequently moist surface colours in the lower part may have values of more than 3. Thickness of the A horizon ranges from 20 to 40 cm.

The subsurface layer has strong coarse block structure with large well developed slickensides. Colour is typically 5YR but may be 7.5YR, with values of 3 to 5 and chroma of 3 to 6. Mottles are characteristically absent. Profiles are non to slightly calcareous throughout. Soil reaction (pH) ranges from slightly acid to neutral in the surface layers becoming moderately alkaline below.

Lodge clay is generally non-sodic throughout but may become sodic around 100cm and below.The surface layers are generally low in soluble salts but the content may increase to slightly and moderately saline in the lower part and substratum where few salt streaks may be present. Lodge clay forms part of the same landscape as Churchpen, Bodles and Colbeck soils but is better drained than Churchpen clay and Bodles clay. Unlike Colbeck clay, it is a deep, cracking clay soil. Lodge soils are difficult to work because of the heavy clay which become very hard when dry and very sticky when wet. It can only be cultivated under a narrow range of soil moisture conditions. The lodge series is limited in extent and occurs exclusively towards the western part of the survey area.

(2) Churchpen Series (POc2)

Soils of the Churchpen series are fine, montmorillonitic, isohyperthermic, Typic Chromusterts occurring on nearly level old alluvium and marine deposits. They are imperfectly drained, deep and characteristically have dark brown surface soil colours. Cracks are common and gilgai are generally well developed where the soil is undisturbed. Permeability is slow when wet.

Typical Profile : Churchpen clay

The following profile was on the Bernard Lodge estate, St. Catherine. It occurs at approximate coordinates 377000 N and 572000 E. The site is on a nearly level plain under irrigated sugar cane. Elevation is approximately 13 m.

Ap 0-32 cm. Dark brown (10YR 3/3) moist clay; strong, medium and fine subangular blocky; slightly hard when dry and slightly firm when moist, sticky and plastic (wet); common fine tubular pores; common fine, few medium roots; ants and worms in horizon; few fine manganese concretions and limestone gravels; clear, smooth boundary, pH 8.3.

AC 32-106 cm. Dark yellowish brown (10YR 4/6) moist clay; coarse to medium subangular blocky; manganese stains present; firm (moist), sticky and plastic (wet); common well developed; few medium tubular pores; common medium, few fine roots; soft manganese concretions and common limestone graves; diffuse boundary ; pH 8.2.

C1 106-150 cm. Yellowish brown (10YR 5/8) moist clay; common medium angular and subangular blocky; firm (moist), sticky and plastic (wet); common well developed slickensides; few medium tubular pores; common, medium, few fine tubular pores; common manganese concretions and limestone gravels; pH 8.4.

The A horizon is 20 to 50 cm thick and has predominantly hue of 10YR and moist value and chroma of 2 or 3 respectively. It is clayey but may range from sandy clay to silty clay with few gravels in places near the hills. The AC and C horizons have mainly 10YR hue with occasionally 7.5YR and 2.5Y, values are 3,4 or 5 and chroma 4, 5 or 6 to 8. Slickensides are well developed and are many. Depth of the cracks where not irrigated and dry, range from 50 to 80 cm (1 cm wide). Texture is clay throughout, with clay % ranging from 40 to 60. Towards the recent alluvial soils in the eastern part of the area substratum may be sandy below one metre. Few gray and reddish brown mottles may occur, starting from 50 cm and increasing with depth. It is non to slightly calcareous. Salt and sodium content is variable both within the profile and in extent. Generally, they are non saline to non sodic in topsoil, becoming slightly to moderately saline below. Soil reaction (pH) ranges from neutral to moderately alkaline in topsoil, becoming milding to moderately alkaline.

Churchpen series occurs in the same landscape as Sydenham, Lodge and Springfield Series. Churchpen soils are better drained than Springfield soils whereas Lodge clay is better drained than Churchpen clay, having typically reddish brown colours in the substratum. Sydenham clay has chroma of less than 1.5 in the surface layer. The soils are very extensive, mainly in the central portion of the survey area. Individual areas are usually large.

(3) Bodles Series (POc3)

Bodles soils are fine, montmorillonitic, isohyperthermic, Typic Chromusterts, occupying level, smooth, slightly concave sites on the old alluvial clay plain. They are deep, imperfectly drained, mixed brown and yellowish red distinctly mottled clay. The soils crack when dry and permeability is very slow when wet. Slickensides are well developed in the lower substratum. They are slightly to moderately saline in the substratum.

Typical Profile : Bodles clay

The following profile was examined at Bodles Research Station, St. Catherine. It occurs on coordinates 375000 N and 504000 E. The site is located in level, smooth irrigated pasture.

A1 0-21 cm. Dark brown (10YR 3/3) moist clay loam; moderate, coarse and medium subangular block breaking into medium and fine subangular blocky; hard (dry), firm (moist), sticky and plastic (wet); few medium tubular and common medium vesicular pores; very few worm casts; few iron and manganese concretions; clear, irregular boundary; pH 8.0.

AC1 21-52 cm. Yellowish brown (10YR 5/3) moist and yellowish red (5YR 4/6) moist clay; strong, coarse subangular blocky; hard (dry), firm (moist), sticky and plastic (wet);sticky, plastic (wet); few pressure faces; many medium vesicular pores; very few roots; few small iron manganese concretions; gradual, wavy boundary; pH 7.4.

AC2 52-64 cm. Mixed brown (10YR 5/3) moist and yellowish red (5YR 4/6) moist clay; strong, coarse subangular blocky; hard (dry), firm (moist), sticky and plastic (wet); many slickensides; many very fine tubular common medium and fine vesicular pores; common fine roots; few small manganese concretions, gradual, smooth boundary; pH 7.1.

ACg1 64-76 cm. Yellowish red (5YR 4/6) clay with common distinct gray (5YR 6/1) moist and reddish gray (5YR 5/2) moist mottles; strong, coarse angular and subangular blocky; hard (dry), firm (moist), sticky and plastic (wet); very fine tubular and few medium vesicular pores; common very fine roots; few salt crystals; clear, wavy boundary; pH 6.5.

AC4 76-94 cm. Reddish brown (5YR 4/3) moist clay loam strong, coarse angular blocky and subangular blocky; hard (dry), firm (moist), sticky and plastic (wet); few medium pores; very few fine roots; gradual, smooth boundary; pH 6.3.

AC5 94-140 cm. Dark brown (7.5YR 4/2) moist sandy clay; strong, coarse and medium angular and subangular blocky; hard (dry) firm (moist); common well developed slickensides; few medium vesicular pores; very few fine roots; common hard manganese concretions; pH 6.3.

Thickness of the A horizon ranges from 15 to 30 cm and has typically 10YR hue and colour value and chroma of 2 or 3. Textures range from clay to clay loam in places. The underlying layer is 10YR with values of 3 to 5 and chroma of 3 to 6. The texture ranges from clay loam to clay and sandy clay. The structure is strong, coarse, blocky, with common well developed slickensides.

Gray and white mottles are common. Few gypsum crystals occur in some pedons. Bodles soils are non calcareous to slightly calcareous. Soil reaction (pH) ranges from moderately to mildly alkaline in the upper parts to neutral below.

The A and AC horizons are non saline and non sodic but become generally slightly to moderately saline below 50 cm. This soil is difficult to work because of heavy surface soil textures that become hard when dry and sticky when wet. Overall fertility is fair to high. Permeability is slow when wet.

Bodles soils resemble many of the other cracking soils of the clay plain but they have mixed mottled colours in the substratum. The soils are very limited in extent and occur in relatively small sections in the western part of the survey area.

(4) Horse Cave Series (POc4)

Horse Cave soils are classified as fine, montmorillonitic, isohyperthermic, Entic Chromusterts. They occur on level, smooth areas occupying slightly lower sites on the clay plains that are separated from the sea by limestone hills that partially enclose them. They are imperfectly drained, deep, yellowish brown cracking clays with a well developed mulch. They have a moderately to strongly saline substratum.

Typical Profile : Horse Cave clay

The following profile was examined at March Pen, St. Catherine, at an elevation of 6 m above sea level. The location is found at approximate coordinates 374000 N and 561000 E. The site is on a level plain and is left in ruinate.

Ap 0-18 cm. Dark yellowish brown (10YR 4/4) moist clay; strong, coarse parting into fine granules; very hard (dry), firm (moist), sticky and plastic (wet); common medium and fine tubular pores; few vesicular; common medium and fine roots; ants present; clear, smooth boundary; pH 7.7.

AC1 18-57 cm. Yellowish brown (10YR 5/4) moist clay; strong, coarse and medium subangular blocky; very hard (dry), sticky and plastic (wet); few medium and fine tubular and few fine interstitial pores; common fine roots; few medium, common manganese concretions; gradual, smooth boundary; pH 8.4.

C1 57-120 cm. Dark yellowish brown (10YR 4/6) moist clay with inclusion of dark brown (10YR 4/3); strong, coarse and medium subangular blocky; very firm (moist), sticky and plastic (wet); common pressure faces and few moderately well developed slickensides; few fine vesicular and tubular pores; few fine roots; manganese concretions present; gradual, smooth boundary pH 7.9.

C2 120-150 cm. Yellowish brown (10YR 5/6) clay with inclusions of dark brown (10YR 4/3); moderate coarse and medium subangular blocky; very firm when moist and sticky plastic when wet; few pressure faces and few moderately well developed slickensides; few fine vesicular and few pores; few fine roots; manganese concretion present; pH 7.5. Cracks at the surface extends to a depth of 107 cm.

The undistributed soil shows that gilgai is well developed together with a rather thick granular surface mulch. Thickness of the A horizon ranges from 15 to 40 cm. Moist colours are 10YR hue with values of 4 to 6 and chroma of 2 to 4. Characteristically, it has a strong, fine subangular blocky to granular surface mulch ranging in thickness from to 10 to 20 cm. Colours of the subsurface layer are 10YR with values of 4 to 6 and chroma of 4 to 8. Texture is clay throughout with moderately well developed slickensides. The soil is calcareous throughout. A and AC horizons are non saline becoming moderately to strongly saline below 40 to 60 cm depth. Sodicity is variable but may increase with depth. Soil reaction (pH) is mildly alkaline in topsoil becoming mildly to moderately alkaline below. Permeability is very low when wet.

Horse Cave soils occur within the same landscape as Salt Island and Churchpen non to slightly saline, lacks the thick surface mulch and has a darker surface layer. Soils of the Horse Cave series are not very extensive. They occur in two relatively large areas towards the southern portion of the plains near the Hellshire Hills.

(5) Salt Island Series (POc5)

Salt Island soils are fine, montmorillonitic, isohyperthermic, Typic Chromusterts. They occupy rather low-lying position on the old alluvial clay plain towards the sea. They are imperfectly drained, deep, dark brown cracking clay soils that are strongly saline and sodic throughout. Surface mulch with gilgai is prominent where undisturbed. Slickensides are common and well developed.

Typical Profile : Salt Island clay

The following profile was described at Hartlands St. Catherine approximately 3 km south east of Hartlands Farm House. Its approximate coordinates are 374000 N and 549000 E. The site is on level ruinate land that was under irrigated sugar cane many years ago.

Ap 0-35 cm. Very dark grayish brown (10YR 3/2) moist clay; moderate, coarse medium and fine subangular blocky structure; firm (moist), sticky and plastic (wet); few medium and fine tubular pores; common medium and few fine roots; few shells; gradual smooth boundary; pH 7.8.

AC 35-93 cm. Dark yellowish brown (10YR 5/8) moist clay with few faint yellowish brown (10YR 5/6) mottles; medium and fine angular and subangular blocky structure; firm (moist), sticky and plastic (wet); common well developed slickensides; few fine tubular pores; few fine decayed roots; common fine soft manganese nodules; gradual smooth boundary; pH 7.9.

C1 93-140 cm. Dark yellowish brown (10YR 4/6) moist clay; moderate medium and fine subangular blocky; firm (moist), sticky and plastic (wet); common well developed slickensides; few fine tubular pores; few fine and medium roots; common gypsum crystals below 128 cm; common manganese concretions; pH 8.3.

Moist colours of the upper 30 cm of the A horizon are typically 10YR hue with a value and chroma of 2 or 3. Its thickness ranges from 30 to 50 cm and it is overlain by a surface mulch of strong, fine, granular structure. Textures are clay to sandy clay.

The AC horizon has 10YR hue and infrequently 2Y with values of 3 to 6 and chroma of 3 to 8. Texture is clay throughout with moderate to strong, coarse to medium subangular and angular blocky structure and well developed slickensides. This soil is strongly saline and sodic throughout. The occurrence of gypsum is quite variable in the amount and depth at which it occurs. It usually occurs below 50 cm increasing with depth. Reaction (pH) ranges from mildly alkaline in the surface layers to moderately alkaline below. The soil is slightly calcareous throughout. Permeability is very slow when wet.

Salt Island soils resemble Horse Cave soils that have non to slightly saline surface layers, "Salinas",. Churchpen and Sydenham soils. Sydenham soils have a dark gray surface layer. Both Churchpen and Sydenham soils are non saline and non sodic in the surface layers and upper parts of the substratum. It differs from the "Salinas" in that these salinas are poorly drained. Salt Island clay is fairly extensive in the southern parts of the survey area bordering the mangrove swamp and "Salinas".

(6) Sydenham Series (POc6)

Soils of the Sydenham series are fine, montmorillonitic, isohyperthermic, Typic Pellusterts. They are imperfectly drained, deep, dark yellowish brown and brown clays with typically a dark gray gritty surface layer. They occupy the smooth level slightly concave sites on the old alluvial plain. Cracks are well developed when not irrigated. Slickensides are well developed in the substratum. Permeability is very slow when wet.

Typical Profile : Sydenham clay

The following profile was examined at Corletts, about 2 km south of Spanish Town. Its approximate location is at co-ordinates 391000 N and 563000 E. The site is level smooth, slightly concave.

A1 0-33 cm. Very dark gray (10YR 3/1) moist clay; moderate, medium and fine subangular blocky; very firm (moist), very sticky and plastic (wet); common, fine and few medium vesicular pores; few fine interstitial pores; many fine, few coarse and medium roots; many ants present; many fine grains (white); gradual wavy boundary; pH 8.4.

AC 33-65 cm. Dark grayish brown (2.5Y 4/2) moist clay with strong, brown (7.5YR 5/6) mottles along root channels; moderate, coarse and medium subangular blocky; hard when dry; very firm (moist), very sticky and plastic (wet); common medium to coarse slickensides; few fine and medium tubular and vesicular pores; common fine and few coarse roots; many white grains; gradual, diffuse boundary; pH 8.5.

C1 65-105 cm. Brown (10YR 5/3) moist clay; moderate, coarse medium and fine subangular blocky; hard when dry, very firm (moist), very sticky and plastic (wet); many slickensides; few fine pores; few fine and few coarse roots; many white grits; gradual smooth boundary; pH 7.9.

C2 105-125 cm. Dark yellowish brown (10YR 4/4) moist sandy clay loam; massive; very firm moist, very sticky and plastic (wet), hard when dry; many pressure faces; few fine pores; few roots; many very fine gypsum; grits present; many manganese nodules; clear, smooth boundary; pH 7.1.

C3 125 cm. Dark yellowish brown (10YR 4/6) moist sandy clay weak coarse and medium angular blocky; slightly sticky and plastic (wet), firm (moist); common slickensides and pressure faces; common fine tubular pores; few fine roots; common manganese stains; common gypsum crystals; pH 7.3.

The surface layer is about 15 to 40 cm thick with very dark gray gritty cracking clay, having values of less than 4 and chroma of less than 1.5. AC and C horizons have hue of 10YR and 2.5Y, with values of 3 to 6 and chroma of 2 to 4. Mottles are few or common in the lower subsoil, fine and medium size in shades of brown, dark brown, olive brown and greenish gray. Slickensides are common and structure is strong, coarse and medium blocky. Depth of cracks ranges from 50 to 80 cm when dry.

Soil reaction (pH) is mildly to moderately alkaline in the upper horizons becoming neutral to moderately acid in the substratum. The soils are non-saline in the topsoils, becoming slightly saline in lower substratum and moderately saline in places. They are non sodic throughout. Substratum is clayey but may become more sandy below 100 cm towards the contact zone with the recent alluvial soils. They are non to slightly calcareous. Few gypsum crystals may occur in lower subsoils. The soils are very slowly permeable when wet. Inherent fertility is high. Sydenham soil resembles many of the other cracking clay soils on the clay plain. However, Sydenham clays have typically very dark gray surface colours. They occur in relatively large units mainly in the central parts of the survey area.

(7) Springfield Series (POc7)

Soils of the Springfield series are fine, montmorillonitic, isohyperthermic, Aquic Chromuderts. They occupy the shallow and level depressions of the old alluvial clay plain. They are poorly drained, deep, yellowish brown mottled clay soils with well developed slickensides in the substratum. Surface cracks are common when dry.

Typical Profile : Springfield clay

The following profile was described at Spring Gardens, approximately 2.5 km of Spring Village, St. Catherine. It occurs at approximate co-ordinates 392000 N and 528000 E. The site is on level, smooth, slightly concave part of the clay plain under irrigated sugarcane.

A1 0-38 cm. Very dark grayish brown (10YR 3/2) moist clay;a moderate, fine subangular blocky structure; firm (moist), very sticky and very plastic (wet); few pressure faces; common medium and fine vesicular pores; many medium and fine roots; clear, wavy boundary; pH 8.1.

ACg 38-70 cm. Yellowish brown (10YR 5/4) moist clay with common distinct mottles of (10YR 5/6), (2.5Y 6/2) and (2.5Y 5/2); strong, coarse, angular and subangular blocky structure; firm (moist), very sticky and plastic (wet); common intersecting slickensides; few medium and fine roots; few to common distinct manganese stains; diffuse, wavy boundary; pH 8.2.

Cg 70-125 cm. Yellowish brown (10YR 5/4) moist clay with many prominent (2.5Y 6/2) and 10YR (5/6) mottles; strong, coarse angular and subangular blocky structure breaking into medium angular and subangular blocky structure; firm (moist), very sticky and plastic (wet); many large slickensides; few medium and fine tubular pores; few medium and fine roots; common lime specks; common to many manganese concretions; few very fine gypsum crystals; pH 8.4.

The moist surface colours of the A-horizon are typically 10YR hue although infrequently also 2.5Y hue. The surface layer usually has a value of 3 and chroma of 2 or 3. Thickness ranges from 20 to 50 cm.

The AC and C horizons have 10YR and 2.5Y hue, with values of 4 to 6 and chroma of 3 to 6. Mottles are common or many and are shades of grey, yellowish brown and greenish gray. Slickensides are well developed and large and the structure is strong, coarse, blocky.

The soils are stiff clays that are very sticky and plastic when wet. They are slightly calcareous throughout. Few gravels may occur throughout the profile. Gypsum may be found in the lower substratum where soluble salts may also be found in small quantities usually not harmful to crops. They are non saline in surface layers, becoming slightly saline below. Soil reaction (pH) ranges from mildly to moderately alkaline throughout and occasionally neutral in the lower substratum. It is non sodic throughout.

Springfield clay is of limited extent and occurs in relatively small areas mainly in the central part of the survey area. Springfield soils differ from the other cracking clay soils in that they are poorly drained.

4.1.3 Soils with strong profile differentiation

(1) Colbeck Series (POd1)

The soils of Colbeck series are fine, mixed, isohyperthermic, Udertic Paleustalfs. They occupy elevated areas of the alluvial clay plains being transitional to the limestone hills. They are well drained, deep, mixed, yellowish red and brown, fine textured soils with a clay (loam) surface layer developed on old alluvium. They crack to a certain extent.

Typical Profile : Colbeck clay

The following profile was examined at the Colbeck Estate, St. Catherine. It is found at approximate co-ordinates 384000 N and 499000 E. The site is located in an undulating landscape with slopes ranging from 3 to 5%.

A1 0-11 cm. Dark yellowish brown (10YR 4/4) moist clay loam; strong, fine subangular blocky; very firm (moist), sticky and plastic (wet); many medium vesicular and few large tubular pores; many fine roots; common worm casts; abrupt, smooth boundary; pH 5.2.

BA 11-26 cm. Yellowish brown (10YR 5/6) moist clay with many medium faint mottles of (5YR 5/6) and (10YR 6/3); moderate, medium subangular blocky; sticky and plastic (wet); common fine tubular and vesicular pores; few fine roots; common medium manganese concretions; gradual, smooth boundary; pH4.7.

Bt1 26-67 cm. Yellowish red (5YR 5/6) moist clay with many medium, distinct mottles of 2.5Y 6/2; moderate, coarse and medium angular and subangular blocky resembling cutans; firm (moist), sticky and plastic (wet); many stress faces; common fine tubular pores; very few fine pores; common fine manganese concretions; clear, wavy boundary; pH 4.4

Bt2 67-120 cm. Yellowish red (5YR 4/6) moist clay with many large mottles of (10YR 5/3); strong, coarse angular blocky structure; very firm (moist), sticky and plastic (wet); many well developed slickensides; common medium and fine manganese concretions: pH 3.9.

The A horizon has hue of 10YR with colour value of 3 to 5 and chroma of 3 to 6. Textures are predominantly clay and clay loam but may be sandy clay loam with few gravels in places. Its thickness ranges from 10 to 20 cm.

The argillic B horizon has a hue of 5YR and 7.5YR with colour values of 3 to 5 and chroma of 2 to 6. It is moderate, coarse and medium subangular blocky. Prominent mottles with hues of 10YR and 2.5Y, with values of 4 to 6 and chroma of 2 and 3 are common. The subsoil is non saline to slightly saline. Lower subsoils may be sodic. Permeability is slow after the initial wetting. Inherent fertility is fair.

Colbeck clay differs from Bodles clay, in that, it is found on elevated physiographic positions. It also occurs in association with Bodles clay on a gently undulating landscape. It differs from Lodge clay in its physiographic position, which is somewhat better drained and has less cracking properties. Colbeck soils are rather limited in extent. They occur towards the extreme western part of the survey area.

4.1.4 Soils formed on limestone

(1) Hellshire Series (HLC1)

The soils of the Hellshire series are loamy-skeletal, mixed, isohyperthermic, Lithic Ustropepts developed over hard white limestone rocks. They are somewhat excessively drained, shallow reddish brown stony loam and clay loams on steep slopes. Natural vegetation consists of drought tolerant shrubs and grasses.

The surface layer generally has a hue of 10 and 7.5YR with colour values and chroma of 2 to 4. Thickness ranges from 5 to 20 cm. Textures consist of stony loam, stony clay loam and stony sandy clay loam. The subsoil colours include hue of 5 and 2.5YR with moist values and chroma of 2 to 4. Textures are loams to clay loams with high gravel and stone content consisting of limestone fragments. Thickness ranges from 10 to 20 cm. Thickness of limestone rocks ranges between 15 and 25 cm. Runoff is high because of steep slopes that are generally more than 20%. Permeability is very rapid.

The soils resemble Union Hill soils which are moderately shallow and occur on less steep slopes. The soils occur mainly on the Port Henderson, Hellshire hills in the southern part of the survey area and on few isolated limestone hills elsewhere.

(2) Union Hill Series (HLC2)

Union Hill soils are clayey - skeletal, mixed, isohyperthermic, Lithic Ustropepts. They are developed on limestone rocks with slopes ranging from 10 to 30%. They are somewhat excessively drained, moderately shallow, reddish brown stony loams and clay loams.

The surface layer is 10YR with colour values and chroma of 2 to 3. Textures are stony clay loam and sandy clay loam. Thickness ranges from 10 to 25 cm. The subsoil has 10YR and 7.5YR hue with colour values of 3 to 5 and chroma of 4 to 8. The textures range from stony clay to gravelly clay and clay loams. The thickness of bedrock ranges from 30 to 50 cm. Runoff is moderately high. Permeability is moderate. Inherent fertility is fair.

Union Hill soils resemble the Hellshire soils that are shallow and generally occur on steeper slopes. Union Hill soils are limited in extent. They occur on the same landscape with Hellshire soils and Rockland with which they usually form a soil complex.

4.2 Soil Profile Diagram in the Study Area

Soil surveys for checking of soil profile description prepared by the Jamaican Soil Survey Project were carried out at the major soil series during Work I and Work II. Soil profile diagrams in Work I and Work II are shown in Fig. D-2 and Fig. D-3, respectively.

Soil series (PRb1, PRb2 and PRb3) formed on recent alluvium show from coarse to medium texture within the soil layer. On the other hand, soil series (POc1,POc2,POc3,POc5 and POc6) formed on old alluvium show the fine clayey texture.

Mottles within the soil profile are recognized in the soils formed under the poor the drainage, especially the Salt Island series (POc5). Hard pan within the soil profile can be found mainly in old alluvial soils. These hard pans are impossible to penetrate by the cone penetrometer. Therefore, these hard pans are important soil layers for plant growth and water movement. Drought in dry season and wetness in rainy season may be controlled by such hard pans. Subsoil improvement in the study area is a very important factor in order to increase the crop production.

4.3 Soil Map of the Study Area

The semi-detailed soil map (1/50.000) prepared by the Jamaican Soil Survey Project, 1986, consists of twenty seven (27) mapping units as shown in Fig. D-4. Soil series formed on recent alluvium are mainly distributed along the Rio Cobre, the Coleburns Gully and the Plantain River. Soil series formed on old alluvium are mainly distributed on the western plain in the study area. Limestone soils are mainly distributed in the limestone hill. Tidal flats and swamps are distributed along the coastal zone in the study area.

5. CHARACTERISTICS OF MAJOR SOILS

5.1 Identification of Clay Mineral Composition

According to the X-ray diffraction analysis by the Soil Survey Project, clay minerals of recent alluvial soils (Dawkins loam and Ferry silty clay) are a mixed clay mineral of kaolinite and smectite.The most dominant clay mineral in subsoils is kaolinite. Caymanas loam soils collected from the sugar cane field in the Caymanas Estate consist of a mixed clay mineral of kaolinite (about 40%), vermiculite (about 35%), illite (about 5%) and primary minerals as gibbsite, quartz and cristobalite. The X-ray diffraction patterns of the soils are shown in Fig. D-5.

Lodge clay soils (POc1) belonging to old alluvium consist of a mixed clay mineral of kaolinite and smectite.

On the other hand, Salt Island soils (POc5) and Sydenham soils (POc6) contain a dominant clay mineral of montmorillonite. Soils (POc5) collected from the paddy field in the Amity Hall consist of a mixed clay mineral of montmorillonite (about 45%), kaolinite (about 35%) and primary minerals as gibbsite, quartz and cristobalite. The family name of old alluvial soils are almost a montmorillonite. High cation exchange capacity of old alluvial soils is caused by a montmorillonite clay mineral.

5.2 Chemical Properties of Soils

Forty eight (48) soil samples were collected for soil analysis in the study area. Chemical analyses of collected samples were carried out by Soil Laboratory of Soil Survey Unit, Rural Physical Planning Division. The results of chemical analysis of typical soil series are shown in Table D-6. Characteristics of the typical soil series are as follows:

(1) Caymanas Series (PRb1)

Their surface layer is mollic epipedon because organic matter content is more than 1%. These are strongly calcareous. Soil reaction (pH) ranges from mildly to moderately alkaline throughout. The soils are non-saline and non-sodic. Natural fertility is relatively high. Their subsurface has the cambic horizon showing hue of 10YR, value of 4 to 6 and chroma of 4 to 6.

(2) Dawkins Series (PRb2)

Their A horizon is mollie epipedon. These are calcareous throughout and soil reaction ranges from moderately to strongly alkaline. They are non-saline and non-sodic throughout. Natural fertility is relatively high.

(3) Whim Series (PRb3)

Their A horizon has mollic epipedon. These soils are slightly to strongly calcareous throughout and soil reaction is mildly to moderately alkaline. The soils are non-saline and non-sodic. Natural fertility is high, because cation exchange capacity (CEC) is more than 25.

(4) Ferry Series (PRb)

Their A horizon is mollic epipedon. These are strongly calcareous throughout and soil reaction ranges from mildly to strongly alkaline. The soils are non saline to slightly saline in the subsoil. Natural fertility is high. Available phosphate (P2O5) and potassium (K2O) are very low contents.

As mentioned above, soils formed on recent alluvium have mollic epipedon and are calcareous throughout. They are non-saline and non-sodic and their natural fertility is relatively high.

(5) Lodge Series (POc1)

Their A horizon is mollic epipedon containing more than 1% of organic matter. The soil profiles are non to slightly alkaline and these are generally non-sodic throughout. Natural fertility is relatively high because cation exchange capacity is about 30 meq/100g or more. Available phosphate and potassium contents are at low levels.

(6) Churchpen Series (POc2)

Their A horizon is mollic epipedon having few fine manganese concretions and limestone gravels. These are non to slightly calcareous, and sodium contents are variable within the profile. These are non-saline and non-sodic. Soil reaction is moderately alkaline. Natural fertility is high. Available phosphate is very low.

(7) Bodles Series (POc3)

Their A horizon is mollic epipedon having few iron and manganese concretions. These are non-saline in top and moderately saline in the subsoils. The sodium contents are in low level corresponding to non-sodic condition. Natural fertility is relatively high but available phosphate is very low. These soil profiles are non calcareous. Base saturation is 100%.

(8) Horse Cave Series (POc4)

Their A horizon is mollic epipedon containing more than 2% of organic matter. A horizon is non-saline and subsoil layer ranges from moderately to strongly saline. Sodicity is non-sodic but increase with depth. Soil reaction is mildly alkaline. Cation exchange capacity shows very high values of 45 meq/100g or more. Available phosphate is in low level but potassium content is high.

(9) Salt Island Series (POc5)

Their A horizon is mollic epipedon with few shells. Subsoils has common well developed slickensides and fine soft manganese nodules. The salinity is strongly saline and sodic throughout. Soil reaction ranges from mildly alkaline in the top layers to moderately alkaline below. The soil is slightly calcareous and has gypsum in the profile. Cation exchangeable capacity is very high. Available phosphate and potassium are in low level.

(10) Sydenham Series (POc6)

These are imperfectly drained and surface soil shows a dark gray. Soil reaction is strongly alkaline in the top layer. These are non-saline and non-sodic. Natural fertility is relatively high but available phosphate is at low level.

(11) Springfield Series (POc7)

Soil reaction ranges from mildly to moderately alkaline throughout. They are non-saline and non-sodic. Cation exchange capacity is high but available phosphate and potassium are very low .

(12) Colbeck Series (POd1)

The subsoil has common medium manganese concretions and is argillic B horizon. The subsoil is non-saline. Lower subsoil may be sodic. Natural fertility is fair. Soil reaction is acidic throughout.

As mentioned above, soils formed on old alluvium have generally high cation exchange capacity and show relatively high fertility. However, their available phosphate content is low in comparison with recent alluvial soils. Soil chemical properties of the typical soil series are illustrated in Fig.D-6.

5.3 Salinity and Alkalinity of Soils

5.3.1 Soil salinity

Annual average rainfall in the study area is about 950 mm. Therefore, the weather is classified as semi-arid. The soils in the semi-arid region are generally subjected to the hazard of salt accumulation due to evaporation. The soils in the study area are found to be affected by salt in many places. Saline soils along the coastal zone are formed due to the effect of sea water.

Soil salinity in the inland area may be formed by the salt accumulation of the heavy use of saline groundwater for irrigation and/or evaporation of soil water.

Salinity survey in the study area was carried out by Soil Survey Unit, RPPD MOA in 1984. Total number of the observation sites is approximately two hundred and fifty (250). Sample soils for measurement of electrical conductivity (EC) were collected from soil depth of 0 to 20 cm, 40 to 60 cm and 80 to 100 cm at the site. Salinity and salinization patterns of soil profiles are stated below:

Class I Land	Class II Land	Class III Land	Class IV Land
Soils are non-saline (ECe less than 4 mS/cm) throughout the soil depth of one meter or more.	Soils are non-saline in the top layer of 60 to 80 cm, and slightly to strongly saline (ECe over 4 to 16 mS/cm) below. Also this class contains soils that are moderately saline (ECe 4 to 8 mS/cm) in top soil of 20 to 40 cm thickness and non-saline in subsoil.	Soils are non-saline in top soil of 20 to 40 cm thickness, and strongly saline (ECe over 16 mS/cm) in the subsoil.land:	Soils consist of top soil showing salinity varying between slight to strong (ECe over 4 to 16 mS/cm) and subsoil showing salinity between moderate and strong levels (ECe over 8 to 16 mS/cm).

The salinity map according to the four (4) classes of land was prepared on 1/50,000 scale of the study area. The salinity map is shown in Fig. D-7. Class I land occupies approximately 10,800 ha in the study area and comprise mainly coarse and fine loam soils of recent alluvial origin, viz., Caymanas, Dawkins and Whim soil series. The soils can be used for crop production.

Class II land occurs in some parts of the recent alluvial deposits (Caymanas and Ferry silty clay series) and in many parts of the old alluvial fine clay soils such as Church Pen, Lodge, Springfield and Sydenham series. The area of Class II land is roughly 4,100 ha. The soils can be used for crop production.

Class III land occurs mainly in old alluvial soils such as Bodles, Church Pen, Lodge, Sydenham, Horse Cave and Salt Island clay series in the western half of the study area. The area of Class III land is roughly 6,700 ha.

Class III land possesses a possible salinity harard to its plant growth. It is considered that the salt is caused by the decreasing effect of leaching due to its poor drainability. In order to improve its drainability, the subsoiling and the application of organic matters, therefore, should be considered. Besides, the improvement of soil salinity can be made by means of soil conditioners such as Gypsum and Sulphur.

Class IV land is mainly found along to the coastal zone in the study area. It covers approximately 1,100 ha in upland area except for miscellaneous areas. Most of the soils are imperfectly to poorly drained and belong to the old alluvium, viz., Lodge, Churchpen and Salt Island clay series. The area of Amity Hall belonged to Class IV has been succeeded in paddy cropping. The soil of this class, therefore, is considered for paddy culture only at the present time. The remainders occupy the area of 4,700 ha (17%).

According to the survey of soil salinity in the period successive to the first paddy culture, the electric conductivity in top and sub-soils are 3 mS/cm and 6 mS/cm respectively.

The possible implementation of paddy culture in such a soil is likely considered due to leaching conditions and the effect of salt dilution occured in logged water in these paddy fields.

As a result from the above, the paddy culture can be introduced to soils of Class IV possessing a salinity hazard in order to establish its cropping pattern toward the water demand for irrigation.

5.3.2 Soil alkalinity

Soil reaction of the study area shows an alkalinity which ranges from week (pH7 to 8) to moderate (ph8 to 8.5) values as shown in Fig. D-6. The pH value of top soils shows a weak alkalinity, lower than that of subsoils. The pH value of recent alluvial soils ranges generally in a moderate alkalinity throughout these soil profiles. The pH value of old alluvial soils ranges also from weak to moderate alkalinities throughout. Soils in the study area can be classified into saline alkali soils depending on the pH value.

Besides, the values of exchangeable sodium percentage (ESP) of soils except for Salt Island Series, which affects the soil alkalinity, is 15% or less as shown in Fig. D-6. The ESP value of top soils ranges less than 5% corresponding to non-alkali soils. The ESP value of subsoils, however, is higher than that of top soils. The ESP value of recent alluvial soils is lower than that of old alluvial soils. As mentioned above, old alluvial soils are relatively in higher alkalinity in comparison with recent alluvial soils due to a decrease in leaching caused by their poor drainability.

Generally, soil alkalinity is mainly augmented with the increase in content of sodium carbonates. Crops under weak and moderate alkali soils show symptoms of a nutrient deficiency due to a decrease in the solubility of phosphate and minor elements such as boron, iron, copper, manganese and so on. Therefore, upland crops in the study area showing a nutrient deficiency are recognized from place to place.

Even though soils in Caymanas area consist of a weak alkalinity, their upland crops including ornamental trees recently show a deficiency in minor elements. This deficiency of minor elements can be solved by the foliar application. Therefore, the symptom of deficiency in various crops must be identified by means of a monitoring system, and corresponding chemical application must be done by proper methods as soon as possible.

Besides, in order to control and improve the alkalinity of soils, corresponding soil conditioners such as gypsum and sulfur might be applied in accordance with corresponding demands. The subsoiling and drain-system applied for an increase in drainability of soils should be performed in order to protect the accumulation of alkaline salts as sodium carbonates, especially for old alluvial soils with poor drainabillity.

5.4 Physical Properties of Soils

5.4.1 Three phase distribution of soils

Bulk density of various soils are shown in Table D-8. Bulk density of soils in the study area are generally in high values of about 1.5 g/cm^3, especially in subsoils. Bulk density of surface soils shows lower values than that of subsoils, because the soil structure are developed by the soil management under cropping. General physical properties of soils are shown in Table D-8.

Solid volumes calculated from the bulk density show generally high values. Solid volumes of Caymanas soils have low values in comparison with other soils due to the coarse texture and good structure of the soils. Solid volumes of surface soils are smaller than that of subsoil in old alluvium because of the decrease of particle packing by the tillage of surface layer. Since solid volumes of subsoils have very high values due to hard pan, it is necessary for them to be ploughed in order to improve the soil structure of root zone.

On the other hand, void volumes of recent alluvial soils are larger than those of old ones. As mentioned in the water retention of soil, the void volume of recent alluvial soil is occupied mainly by the capillary pore spaces, but that of old alluvial soil is occupied mainly by non-capillary pores. Therefore, infiltration of recent alluvial soils is relatively high in comparison with old ones.

5.4.2. Water retention of soils

Water retention (pF 2.0 and pF 4.2) of recent alluvial soils are relatively low in comparison with old ones. However, available water contents of recent alluvial soils show remarkably high values because the wilting point (pF 4.2) of soils is very low owing to kaolinite clay minerals. Besides, wilting points of old alluvial soils except for Churchpen soils show relative high values owing to montmorillonite clay minerals. Therefore, the recent alluvial soils are suitable for upland cropping in the view of the available water storage and good soil structure. On the contrary, it is necessary to be careful with the water management of old alluvial soils to prevent drought since they have low available water storage.

Field moisture regime has been observed by random sampling under dry conditions near the wilting moisture level. Irrigation practices in the study area is therefore important to maintain and increase crop production.

5.5 Infiltration of Major Soil Series

Survey sites of intake-rate test were decided in due consideration on typical soil series and existing land use. The eight (8) survey sites are shown in Fig. D-1. In order to analyse the intake-rate, soil profile survey and soil physical properties were measured at the same sites with intake-rate test.

Intake-rate tests using the double ring infiltrometer were carried out on the major soil series in the study area. Relationship between cumulatively infiltration (D mm) and elapsed time (T min) can be expressed by essentially straight lines on both logarithmic graph paper as shown in Fig. D-8(1/2) to Fig. D-8(2/2). D (mm) and I (intake-rate mm/min) are related to T (min) by the following equations:

$$D = C \times Tn, \qquad I = C \times nT^{(n-1)}$$

Basic intake-rate, IB mm/hr, is related to T by the following equation:

$$IB = 60Cn\{600(1-n)\}^{(n-1)}$$

Mean values of basic intake-rate are shown in Table D-8.

5.5.1 Intake-rate of recent alluvial soils

Caymanas (PRb1), Dawkins (PRb2) and Whim (PRb3) soil series belonging to the category of recent alluvial soils show intake-rate ranges from very high to moderate.

Caymanas soils in the Horticulture Centre show extremely high intake-rates. The basic intake-rate is 221 mm/hr. It is considered that such high intake-rate might be caused by the coarse or medium texture and good structure of soils. Therefore, these soils are not suitable for rice paddy cultivation due to leakage of the irrigation water.

Dawkins soils in the Bernard Lodge Vegetable Farm show relatively high intake-rates. The basic intake-rate is 12 mm/hr. Irrigation practices at the farm mainly involve the use of the sprinkler method in order to make effective use of irrigation water.

Whim soils in the Guardsman's Farm show moderate intake-rates due to ploughing of soils under vegetable cropping. The basic intake rate is 5.7 mm/hr.

5.5.2 Intake-rates of old alluvial soils

Most soils belonging to the category of old alluvium consist of the clayey soils. Therefore, their intake-rate ranges are generally low.

Lodge soils in the Brampton Mango Farm show a moderate intake-rate. The basic intake-rates is 4.4 mm/hr. Soils of this type have been ploughed deeply for plantation of mango.

Churchpen soils in Innswood Estate show high intake-rate due to many cracks in the surface layer, but the intake-rate of the subsoil is low. The basic intake-rate of surface and subsoil layers are 21 and 1.8 mm/hr, respectively.

Bodles soils in the Bodles Agriculture Station showed high intake-rates due to their good soil structure under improved pasture. The basic intake-rates of surface and subsoil layers are 21 and 1.8 mm/hr respectively.

Salt Island soils at the paddy field in Amity Hall showed very low intake-rates due to a heavy clayey soil. The basic intake-rate is only 0.4 mm/hr. Such land is suitable only for paddy field and fish pond.

Sydenham soils at McCooks Pen area in Innswood Estate showed a very low intake-rate and a basic intake-rate of 0.4 mm/hr. At present, the arable land is being used for the cropping of sugar cane. Drainage of this land is necessary in order to increase the production of sugar cane.

Soil profile diagrams at the survey sites are shown in Fig. D-3 and the physical properties of the soils are shown in Table D-7.

6. LAND CAPABILITY CLASSIFICATION

6.1 Basic Consideration for Land Classification

Land capability classification in the study area was carried out by the Soil Survey Unit, Rural Physical Planning Division, MOA, in 1985. Land classification is based on the Land Capability Classification System used in the USDA/SCS, but had been modified and adopted to suit Jamaican conditions.

Land capability of soils in the study area is classified into I to IV classes by the following classification criteria. According to the land classification of the Soil Survey Unit, capability classes of I to IV are suitable for arable land while class V is limited arable land and class VI is unsuitable for arable land.

6.2 Land Capability for Upland Crops

Land capability for upland crops is classified into some sub-classes in accordance with the following limitations.

Degree of Limitations	Sodicity: (a) (Exchangeable Sodium %)	Depth: (d) (in cm)	Salinity: (s) (ECe, mS/cm)	Erosion: (e) (Slope %)	Wetness: (w) (drainage)
None	15 >	100 <	0-4	0-2	good
Slight	15 >	50-100	4-8	2-8	moderately good to imperfect
Moderate	15-25	25-50	8-16	8-30	poorly
Severe	25 <	25 >	16 <	30 <	very poor

Workability (P) is mainly used when downgrading the heavy cracking clay soils because of heavy texture in the surface layer.

Sub-classes in the Class II are IIw (wetness), IIpw (workability and wetness) and IIpe (workability and erosion). Sub-classes in the Class III are IIIwp (wetness and workability) and IIIsa (salinity and sodicity). Sub-class in the Class IV is only IVsa (salinity and sodicity). Sub-classes in the Class V are Vsa (salinity and sodicity) and Vde (depth and erosion). Land capability classes of various soil series are shown in Table D-3. Land capability of the recent alluvial soils is higher than that of the old alluvial soils because the former have medium soil texture and high fertility. The land capability map of the study area is shown in Fig. D-9.

Arable land is suitable for intensive agricultural use on a sustained economic basis. Optimum crop production will be obtained under suitable crop rotation, irrigation and soil conservation practices. Extent of the arable land is approximately 18,900 ha.

Limited arable land has very severe limitation such as salinity, sodicity, shallowness, stoniness, very steep slopes, risk of severe erosion, etc. The extent of the limited arable land is approximately 2,200 ha.

Non arable land consists of rock outcrops, very shallow soils, very wet and extremely saline areas. The extent of this area is approximately 6,400 ha.

6.3 Land Capability for Rice Culture

Essential requirements for rice culture are considered as follows:

Effective Soil Depth (d)	Workability (p)	Leakage of Irrigation Water (l)	Salinity (s)	Sodicity (a)
The depth that is a distance from surface to its parent material, is a factor to be considered in the evaluation of land capability for rice culture.	Germination and growth of rice plants require good physical properties of soil for tillage of root zone which is affected by the texture and consistency of surface soils.	Irrigation water on paddy land must be maintained for a considerable period for plant growth. Therefore, soils showing high infiltration are not suitable for ricepaddy, especially where there is a shortage of irrigation water.	Rice plants show tolerance to salinity up to certain level. However, strong salinity of soils poses very severe limitation for normal growth of rice plants.	The limitation due to sodicity is similar to the degree of salinity as mentioned for upland crops.

Land capability classification in the study area was carried out based on the data of soil analysis, reconnaissance survey and information obtained from the Rural Physical Planning Division, (RPPD), MOA. Sub-classes on rice culture are as follows;

Sub-classes in the Class II are IIp (workability) and IIw (wetness). Sub-classes in the Class III are IIIl (leak) and IIIps (workability, salinity). Sub-class in the Class IV is found only on IVl(leak). Sub-classes in the Class V are found on Vl(leak), Vsa (salinity, sodicity) and Vp (workability).

Land capability classes of various soil series are shown in Table D-3 and D-9. Recent alluvial soils are ranked in the low classes in land capability because of higher infiltration due to coarse texture of soils. Old alluvial soils having fine texture are generally suitable for rice paddy field. Soils formed on limestone are not suitable for rice paddy due to the shallow depth and steep slopes. The land capability map for rice culture is shown in Fig. D-10.

Potential arable land for rice culture consists of Classes II to IV and the total area of this land is approximately 13,500 ha. The extent of this land is small in comparison with that for upland crops.

Limited arable land has strong limitations such as leakage of irrigation water, salinity, sodicity and workability. The area of such land is approximately 7,500 ha. The extent of this land is large in comparison with that for upland crops because of the increase in the area of highly permeable soils.

Non-arable land has very severe limitations such as leakage of irrigation water and strong salinity. The extent of this land is roughly 6,400 ha.

6.4 Crop Suitability of Various Soil Series

Crop suitability classes are similar to land capability classes. However, a rating for crop suitability is evaluated from a viewpoint of the response of soil fertility for individual crop production. Such soil response differs depending on the chemical and physical properties of soils through soil management and the inherent characteristics of the plants. For example, soils which are suitable for sugar cane culture should be free from toxic chemicals and have a fine texture, good permeability, fertility and a favourable water regime. On the other hand, a rice crop may be suitable for other soil environments due to the aquatic nature of the crop. Therefore, any soils in land capability Class I may be considered suitable for sugar cane and marginally suitable for rice.

According to the report of Jamaica Soil Survey Project, crop suitability classes are grouped into four (4) classes as follows:

Highly Suitable (S1)	Moderately Suitable (S2)	Marginally Suitable (S3)	Not Suitable (S4)
The crop grows well and will produce relatively high yields. For the crop under consideration, the soil has favourable physical characteristics and high fertility and is responsive to good management.	Crop yield will be moderate. The soil has less favourable physical and chemical properties for the crop, medium fertility and moderately response for soil management.	The crop can produce marginal yields, soil characteristics are unfavourable for crop production.	Crop production is very difficult due to unfavourable soil characteristics for cropping.

Crop suitability classes for various soil mapping units are shown in Table D-10. Generally, crop suitability is similar to land capability classes except for rice and Virginia tobacco. Soil series belong to recent alluvial soils are ranked into low suitable classes for rice culture due to very good drainage.

7. RECOMMENDATION

In our previous survey, field tests taking account of measures toward the improvement of salinization and alkalinization were not carried out. Remedial measures on salinization and alkalinization are, therefore, limited to a general consideration without practical measures.

Due to the importance of salinization problem in land conservation in long term and the increasing of crop production, technical measures on salinity are, therefore, recommended to be established by the execution of following studies.

(1) Investigations on salinization-causes in poor-drainage areas

- (a) Affection due to poor drainability
- (b) Affection due to sea water intrusion
- (c) Affection due to the quality of irrigation water

(2) Studies on remedial measures toward salinity

- (a) Leaching test under poor drained land, especially evaluation of water requirement for leaching
- (b) Drainability test under application of subsoiling and organic materials
- (c) Improvement test by soil conditioners as gypsum and sulphur
- (d) Necessity of open ditch and underdrain for internal drainage, and
- (e) Improvement of salinity by introduction of paddy culture with the establishment of cropping pattern.

In order to increase the crop production, technical measures on alkalinity are recommended to be established by the execution of following studies.

(1) Investigation on alkalinization-causes in upland fields, especially contents of dominant alkali elements such as sodium carbonate.

(2) Investigation on nutrient deficiency due to alkalinity, especially on the solubility and inactivation of minor elements in the pH range of alkalinity.

(3) Investigation on the system for monitoring deficiency symptoms of various crops, including the method of chemical application such as the foliar application.

(4) Investigation on the improvement of alkali soils, especially on the gypsum and sulfur application.

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