ANNEX-C

SOIL AND LAND SUITABILITY

ANNEX - C

SOIL AND LAND SUITABILITY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ATTACHEMENT

1. INTRODUCTION

For the appraisal of the land suitability for the irrigation development, the soil survey was carried out in the 12 existing irrigation projects scattered in the whole of country of Ghana in phase I study, on October to December in 1995. Through phase I study, the description survey was carried out at 118 test pits on the 12 project areas, and the chemical and physical analysis of soils was also done for about 300 soil samples which were taken from 118 test pits. (These results are presented in Attachment-I) Based on the result of the study, a provisional soil maps of the 12 projects were prepared and the tentative land classification was also assessed for the project areas.

Prior to the phase II study, five (5) project areas (Ashaiman, Aveyime, Kpando-Torkor, Mankessim and Okyereko) were selected as the priority development project from 12 projects by assessment of comprehensive view point such as economical viability, development need, development potentials, environmental impacts, etc. Then, the soil classification and land classification of the priority development areas were reviewed and revised in phase II study The soil map units and provisional soil maps were also revised in this study. Based on the results of the review works, the irrigation suitability was re-assessed with the respect to the soil mapping units according to the USBR system.

2. GENERAL DESCRIPTION OF THE PROJECT AREAS

2.1 Location and Physiography

The following five project areas are selected as the priority rehabilitation project. The location and phyiographic characteristics are shown in the following table.

Project Area	Location	Landscape
1. Ashaiman	Tema district, Great Accra region	Basin of the Dzorwulu river
2. Aveyime	South-Tongu district, Volta region	Flood plain along the Volta river
3. Kpando-Torkor	Kpando district, Volta region	Hill area surrounding the Volta Lake
4. Mankessim	Mfantsiman district, Central region	Hill and plain area (undulating) along the Okyi river
5. Okyereko	Winneba district, Central region	Basin of tributary of the Ayensu river

2.2 Agro-climate

The four (4) priority project areas (Ashaiman, Aveyime, Mankessim, Okyereko) fall in the coastal savannah zone and the rest (Kpando-Torkor) in the transition zone. The coastal savannah zone has two (2) rainy seasons, i.e. March to July and September to November. In the main rainy season form March to July, about 70 % of annual rainfall is observed. While, the transition zone has a rainy season from April to October and a dry season from November to March. The dominant rainfall is recorded on May and June. The detail explanations of each climatic zone are mentioned in Annex B. The mean annual meteorological data of the areas are summarised as follows:

Project Area	Average temperature (°C)			Rainfall	Humidity	Evaporation
	Max.	Min.	Mean	(mm)	(%)	(mm)
Ashaiman	30.0	23.3	25.0	698	84	1886
Aveyime	32.7	22.4	27.5	1170	77	-
Kpando-Torkor	31.9	22.3	27.1	1342	77	1801
Mankessim	29.6	23.0	26.3	1024	86	1697
Okyereko	- ditto -	- ditto -	- ditto -	803	- ditto -	- ditto -

Remarks :Available period for data are basically for 30 years of 1960 to 1990.
Source : Annex B

2.3 Land Use and Vegetation

At present, several land use types are recognise in the project areas. The hill area in Kpando-Torkor and Mankessim projects are generally covered by bush (ticket) or grassland which are under shifting cultivation system. The plain area in Ashaiman, Aveyime, Okyereko are mostly used for paddy field or sometimes abandoned, due to poor irrigation system. The general features of land use and vegetation conditions are summarised as follows:

Project Area	in Project Area	around Project Area
Ashaiman	- Paddy, Upland	- Bush, Settlements,
Aveyime	- Paddy, Upland	- Bush (Ticket), Upland
Kpando-Torkor	- Upland, Bush (Ticket), Grassland	- Upland, Bush (Ticket), Grassland, Sugarcane
Mankessim	- Upland, Bush (Ticket), Grassland	- Upland, Bush (Ticket), Grassland, Sugarcane
Okyereko	- Paddy, Upland	- Upland, Bush (Ticket), Grassland, Settlements

3. SURVEY PROCEDURE

3.1 Existing Data

Following data were fully referred for identification of present soil condition in the priority areas.

Project		Existing Data and Information
1	Ashaiman	Draft soil maps (1/4800, 1995), Aerialphoto map (1/15000), Topographic map (1/5000), IDC annual report
2	Aveyime	General layout plan (1/5000), Aerialphoto map (1/15000), Topographic map (1/5000)
3	Kpando-T	Soil map (1/5000), General layout plan (1/5000), Aerialphoto map (1/15000), Topographic map (1/5000)
4	Mankessim	General layout plan (1/4800), Aerialphoto map (1/15000), Topographic map (1/5000)
5	Okyereko	Soil map (1/2500), Aerialphoto map (1/15000), Topographic map (1/5000)

Among them, existing soil maps of Ashaiman and Okyereko areas were useful for grasping soil condition of the areas, and the topographic maps prepared at 1996 were also used as the base maps of the areas.

3.2 Soil Survey

Soil survey consists of three procedures such as soil description survey, interpretation of aerial photographs and laboratory analysis of soil sample. As mentioned above, the soil description survey and laboratory analysis were carried out in phase I study. Then, the provisional soil maps were prepared based on the results of phase I study.. Through the interpretation of aerial photographs on a scale of 1/15,000, taken in April, 1996, the topographic, land use and drainage conditions were confirmed and the semi-detail soil maps were prepared on the basis of the provisional maps in the phase II study.

(1) Soil description survey

Since it is recognised that the soil formation has a close relationship to the physiographic (topographical) condition in general, the soil test profile sites were selected taking account of the topographical position and accessibility of the sites. About 120 cm deep pits were dug at 48 sites in the five project areas at a density of 1 pit per about 25 ha and described according to the FAO criteria in "Guidelines for Soil Profile Description." The location of test pits were shown in Figures C-1 to C-5. At the same time, the soil samples were collected from all test pits for the laboratory test. The soils were sampled from three predetermined depths of 0-20 cm, 40-60 cm and 80-100 cm form surface.

(2) Laboratory test

Laboratory test aims at clarification of the physical and chemical properties of soils of the project areas. The analysis of the all samples were carried out by the soil science department in the University of Ghana. The surface soils (0-20 cm) of all test pits and the subsoil (40-60 & 80-100 cm) of typical soil units were analysed with respect to the following eight (8) parameter. The other soils were analysed for only pH, EC and soil texture.

1) Physical Analysis

- Particle size distribution (Soil texture)

2) Chemical Analysis

- pH value (1: 2.5 H_2O)
- Electrical conductivity (EC)
- Total carbon content
- Total nitrogen content
- Available phosphorus (Bray II method)
- Cation exchange capacity (CEC) at pH 7.0
- Exchangeable cations, i.e. Ca, Mg, Na and K

3.3 Interpretation of aerial photographs

The provisional soil maps were prepared based on results of soil description survey and laboratory test analysis. Since the high coincidence has been recognised between Physiography and soil formation in phase I study, the provisional soil map units were basically followed the physical conditions of the areas. Therefore, to clarify and grasp the physiographic condition of the selected project areas in detail, the aerialphoto interpretation was applied in phase II study. In addition to the aerialphoto interpretation, the confirmation survey also was carried out on the field in phase II study. After the works, the provisional soil maps were revised.

3.4 Classification and Mapping

The soil are classified into soil units according to the legend or "Soil Map of the World" produced by FAO/UNESCO (1988). The soil mapping units were set up for constructing the systematic legend of the soil maps. Pursuant to the survey methodology, the soil maps were also prepared by physiographic approach. Consequently, the highest categories of the legend was given by physiographic terms, i.e. hill, old terrace, plain, etc. These physiographic units are further divided into the lower categories on the basis of topographic conditions, drainability, etc. These subdivisions represent mapping units on which one or more soil units are identified.

3.5 Land Use Survey

The present land use conditions were surveyed and identified in phase II study. Interpretation of aerialphotos were fully referred and the field observation including interview survey with project staff and farmers were also carried out for confirmation. Finally, present land use maps of the priority project areas were prepared at the scale of 1/5,000.

3.6 Land Evaluation

Land evaluation is the process of interpretation of basic information gathered during the soil survey, i.e. soil, topography, drainage condition and other aspects of land. In assessing the land suitability for irrigation farming, land qualities were selected and graded according to the specific criteria based on the USBR system. Through the land evaluation, the location and extent of suitable land for irrigation farming were demarcated on land suitability classification map. This information is applied for the selection of the future irrigated land and crops making comparison of the many crop alternatives.

4. SOILS

4.1 Results of Field Survey and Laboratory Tests

The soil descriptions in the priority project areas are summarised in Table C-1. The laboratory test result is presented in Table C-2.

4.2 Soil Classification

On the basis of field survey records and laboratory test results, the soils are classified into the following soil units according to the legend of Soil Map of the World (FAO/UNESCO, 1988). The dominant soil units in the each project area are presented below.

	Project	FAO/UNESCO Classification
1	Ashaiman	Distric Planosols, Cambic Arenosols, Gleyic Cambisols, Dystric Vertisols
2	Aveyime	Ferralic Arenosols, Dystric Cambisols, Gleyic Cambisols, Dystric Vertisols
3	Kpando-T	Skeletic- Vertic Cambisols *1, Skeletic- Chromic Cambisols, Dystric Fluvisols / Cambic Arenosols, Skeletic-Distric Gleysols, Dystric Vertisols
4	Mankessim	Eutric Gleysols, Haplic Alisols, Ferric Alisols, Gleyic Cambisols, Skeletic-Haplic Alisols *1
5	Okyereko	Skeletic-Haplic Alisols, Cambic Arenosols, Haplic Alisols, Dystric Cambisols, Gleyic Cambisols

Remarks : *1 "Skeletic" indicates the occurrence of accumulated layer of oxidic concretions or ironstones, with a thickness of at least 25 cm.

The following paragraphs explain the baseline features of soil units identified.

1) Alisols

Alisols are moderately weathered soils with an argilic B horizon which has a high cation exchangeable capacity (CEC) and a low base saturation less than 50 % throughout. Ferric Alisols have a ferric properties with concretions and/or many coarse mottles of iron with hues redder than 7.5YR or Chromas more than 5. Haplic Alisols are the Alisols having no other diagnostic properties.

2) Arenosols

Arenosols are coarse-textured sandy soils with a high proportion of almost pure quartz. These are usually moderate deep to deep soils and well to moderately well drainage condition. Some may show characteristics of an Oxic B horizon (Ferralic Arenosols) and cambic B horizon (Cambic Arenosols), however, they do not have such horizons because the soil texture is too coarse.

3) Vertisols

Vertisols are heavy clay soils which shrink and have large deep cracks of more than 1 cm at a depth of 50 cm. The soil has a high water retention, but relatively small amount of water is available for plant growth. Dystric Vertisols have a low base saturation of less than 50 % at least between 20 cm and 50 cm from the surface.

4) Gleysols

Gleysols are poorly drained soils, in low-lying areas and in depressions, which are influenced by high groundwater table during significant period and therefore show hydromorphic properties. Dystric Gleysols have a base saturation of less than 50 % at least between 20 cm and 50 cm from the surface.

5) Planosols

Planosols have an albic E horizon with hydromorphic properties abruptly overlying a slowly permeable B horizon within 125 cm of surface. Dystric Planosols have an ochric A horizon and a low base saturation of less than 50 % at least between 20 cm and 50 cm from the surface.

6) Cambisols

Cambisols have a cambic B horizon or an umbric A horizon (dark topsoil). The Cambic B horizon is an altered horizon with a soil structure, or with some clay illuviation, or with a red color. They are in a transitional stage of development between young soils and the more matured soils. Gleyic Cambisols are those having a gleyic property within 100 cm of the surface. Chromic Cambisols are those having an ochric A horizon and a base saturation of 50 % or more and having a strong brown to red cambic B horizon. Dystric Cambisols are those having an ochric A horizon and a base saturation of less than 50 %.

7) Fluvisols

Fluvisols are developed from recent fluvial deposits, Dystric Fluvisols are those having an umblic or ochric A horizon and a low base saturation of less than 50 % at least between 20 cm and 50 cm from the surface.

8) Skeletic Phase

The skeletic phase refers to soil materials which consist of 40 % or more of coarse fragments of oxidic concretions or of hardened plinthite, ironstone or other hard materials, with a thickness of at least 25 cm. The upper part of the skeletic layer occurs within 50 cm of the surface. The difference from the petroferric phase is that the concretionary layer of the skeletic phase is not continuously cemented.

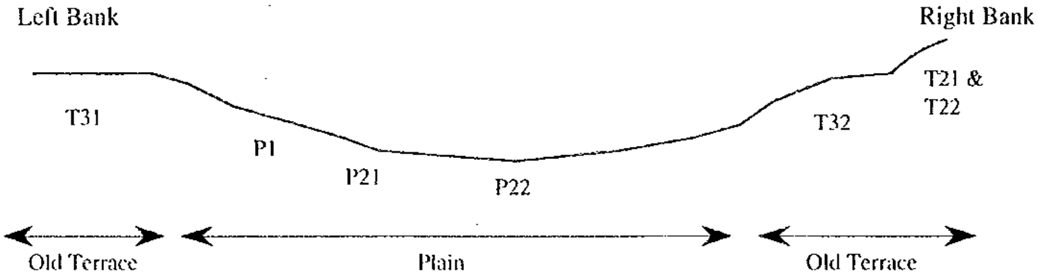
The representative profiles of each soil unit are presented in Attachment-II.

4.3 Soil Map Legend

In addition, the lands (soils) for the each project area were comprehensively classified based on the result of soil classification with consideration to the physiography, topography, texture, soil depth, and drainage condition, as the mapping units. The mapping units of each project areas are shown in Table C-3.

(1) Ashaiman Area

Ashaiman project area is consists of two (2) main physiographic forms, i.e. old terrace (T) and plain (P). The old terrace is composed by residual and colluvial materials and it consists of four (4) soil map units. The plain formed by alluvial deposition are divided into three (3) soil map units as shown below.



In the old terrace, Dystric Planosols and Cambic Arenosols can be found, while Dystric Vertisols be found in the plain area. The following table shows the general features of soil map units and the area of the units in the rehabilitation area.

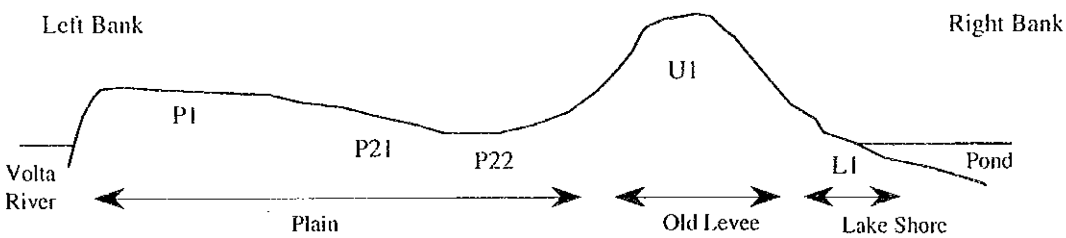
Physio-graphy	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	Texture (top-sub)	Depth	Local Name	Area*1 (ha)
Old Terrace (Upland)	T21	middle slope	Dystric Planosols	0 - 2 %	mod. well - imperfect	SL - C	mod. deep	Minya	-
	T22	middle slope	Cambic Arenosols	0 - 2 %	well - mod. well	LS - LS	deep	Agozum	-
	T31	foot slope	Dystric Planosols	0 - 1 %	mod. well - imperfect	LS - SC	mod. deep	Agawtaw	15
	T32	foot slope	Gleyic Cambisols	0 - 1 %	imperfect	LS - SC	mod. deep	Minya	-
Plain	P1	upper plain	Dystric Vertisols	0 - 1 %	poor	C - C	mod. deep	Ashaiman	18
	P21	lower-flat plain	Dystric Vertisols	0	poor - v. poor	C - C	deep	Bumbi	24
	P22	lower-flat plain	Dystric Vertisols	0	poor - v. poor	C - C	deep	Bumbi	2
	P22s<1	lower-flat plain	Dystric Vertisols (salt effected)	0	poor - v. poor	C - C	deep	Bumbi	8

Remarks : *1 Area is gross area in the rehabilitation area.
*2 Area of P22s is estimated by JICA study team

Salt-effected area were observed in the soil map unit of P22s. The value of ECe of the soils was about 6.5 - 16.0 mS/cm calculated on the basis of the data of IDC report (1993) and laboratory test results. This is classified into saline to strongly saline soil, which are difficult to get yield of paddy at optimum level, according to USDA criteria. Since the salt content of irrigation water is a low level of 0.13 mS/cm, the problem is not assumed to be caused by the irrigation water. Therefore, if the drainage system be improved and the stagnant water be flowed out, the contents of salt in the soils also will decrease. Detail explanation of soil improvement study are described in Chapter 5.

(2) Aveyime Area

The Aveyime area is formed by three (3) physiographic forms such as Plain (P), Old levee (U) and Pond shore (L), as shown below.



Total five (5) soil map units are observed in the area. The dominant units are P1 and P2 which consists of Dystric Cambisols, followed by U1 of Ferralic Arenosols, and P3 of Gleyic Cambisols. The following table shows the general features of soil map units and the area of the units in the rehabilitation area.

Physiography	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	Texture (top-sub)	Depth	Local Name	Area*1 (ha)
Levee	U 1	upper slope	Ferralic Arenosols	2 - 4 %	well	S - SL	deep	Chichiware	25
Plain	P 1	foot slope-upper plain	Dystric Cambisols	0 - 1 %	mod. well - imperfect	SL - SCL	deep	Hake	35
	P 2 1	flat plain	Dystric Cambisols	0 %	imperfect - poor	CL - C	deep	Amo	40
	P 2 2	depressional plain	Gleyic Cambisols	0 - 1 %	poor - v. poor	C - C	deep	Amo	9
Lake shore	L 1	lower slope - lake shore	Distric Vertisols	0 - 2 %	v. poor	C - C	deep	Telle	4

Remarks : *1 Area is gross area in alternative -3 under rehabilitation plan.

(3) Kpando-Torkor Area

The Kpando-Torkor project area is located along the Volta lake, and it consists of hill area which has a gentle slope of 1 to 4 % and depressional area formed along the small stream flowing into hills. The typical feature of soils in the area is a "skeletic" condition. The iron concretion accumulation in layer, which occupies the layer about 80 to 90 %, is observed below 20 cm form soil surface. Even it has a gentle slope, it can be said that the area has a high potential of land degradation. Main soil units in the hill area (H) are Vertic Cambisols and Haplic Cambisols. While soil units of stream course (R) are Dystric Planosols or Cambic Arenosols, and Dystric Gleysols are dominant in the lake shore (L). The following table shows the general features of soil map units and the area of the units in the rehabilitation area.

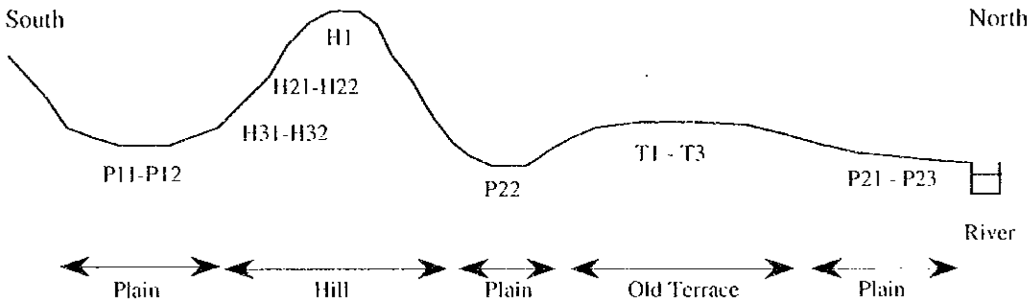
Physiography	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	Texture (top-sub)	Depth	Local Name	Area*1 (ha)
Hill	H 1	Summit	-	20%	-	-	-	-	-
	H 2 1	upper - middle slope	Skeletic-Vertic Cambisols	2 - 5 %	well	CL - gravel, C	shallow	Dzawa	198
	H 2 2	middle - lower slope	Skeletic-Vertic Cambisols	2 - 3 %	well	CL - gravel, C	mod. deep	Angera	233
	H 2 3	middle - lower slope	Skeletic-Chromic Cambisols	2 - 3 %	well	CL - gravel, C	mod. deep	Dzawa	-
	H 3	foot slope	Skeletic-Chromic and Skeletic-Gleyic Cambisols	2 - 3 %	imperfect	CL - gravel, C	mod. deep	Dzawa - Takrabe	9
	H 4	stream course	Skeletic-Gleyic Cambisols	2 - 3 %	imperfect-poor	CL - gravel, C	mod. deep	Takrabe	11
Stream course	R 1	river course	Dystric Fluvisols, Cambic Arenosols	0 - 4 %	imperfect - poor	S - S	mod. deep	Kpeyi / Afeyi	10
Lake shore	L 1	lower slope - lake shore	Skeletic-Eutric Gleysols	0 - 2 %	v. poor	CL - gravel, C	mod. deep	Torkor	-

Remarks : *1 Area is gross area in all blocks under rehabilitation plan.

(4) Mankessim Area

The Mankessim area consists of three (3) physiographic forms, as hill (H), old terrace (T) and flood plain (P). The slope of the hill area is relatively high as about 10 % of sloping.

Soil map units of the hill area are classified into three (3) types according to the topographic condition on slope, such as top, middle, low. The old terrace and flood plain are also classified into three (3) and five (5) types respectively, based on the topographic condition. The schematic section of the area are illustrated as follows:



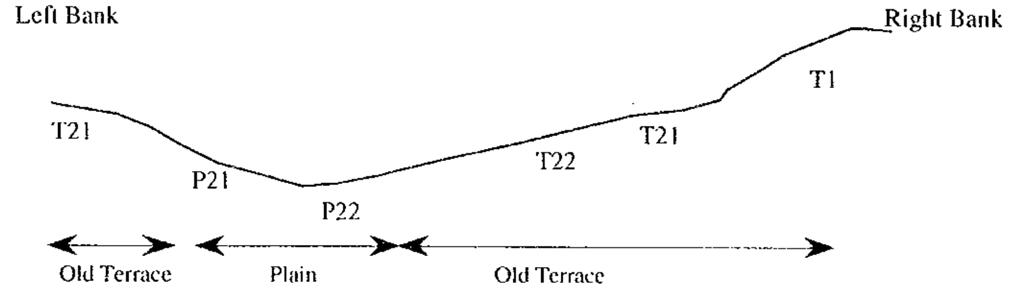
Soil units of the hill and old terrace are Skeletic-Haplic Alisols or Haplic Alisols. Those of the plain vary as Chromic, Haplic, Gleyic Cambisols and Distric Gleysols depending on the topography.

Physio-graphy	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	Texture (top-sub)	Depth	Local Name	Area*1 (ha)
Hill	**H1**	ridge or summit	Skeletic-Haplic Alisols	2 - 4 %	well	L - gravel & C	shallow	Swedru	-
	H21	middle slope	Skeletic-Haplic Alisols	10 %	well	SL - gravel & SCL	shallow	Nsaba	3
	H22	middle slope	Skeletic-Haplic Alisols	45 %	-	-	-	-	-
	H31	foot slope	Skeletic-Haplic Alisols	4 - 8 %	well	SL - gravel & SCL	shallow	Nsaba	10
	H32	foot slope (bottom)	Skeletic-Haplic Alisols	2 - 3 %	imperfect	SL - gravel & CL	shallow - mod. deep	-	6
Old terrace (Old plain)	**T1**	upper terrace	Ferric Alisols	5 %	mod. well	SL - gravel & CL	shallow - mod. deep	Biaim	-
	T2	middle terrace	Ferric Alisols	2 - 4 %	well - mod. well	SL - gravel & CL	mod. deep	Biaim	20
	T3	lower terrace	Ferric Alisols - Gleyic Cambisols	1 - 2 %	imperfect	SL - C	mod. deep	Biaim - Kakum	4
Plain	**P11**	upper plain	Chromic Cambisols	2 - 6 %	well - mod. well	SL - gravel & CL	mod. deep	Biaim	-
	P12	flat plain	Haplic Cambisols	1 - 2 %	imperfect	SL - SC	deep	-	44
	P21	alluvial plain	Gleyic Cambisols	0 %	poor	C	deep	Kakum	9
	P22	alluvial plain	Gleyic Cambisols	0 %	poor	C	deep	Kakum	-
	P22	valley bottom	Dystric Gleysols	0 - 1 %	v. poor	C	deep	Oda	-

Remarks : *1 Area is gross area in alternative - 2 under rehabilitation plan.

(5) Okyereko Project Area

The physiographic condition of the Okyereko project is similar with the Ashaiman project area. The land consists of two (2) main physiographic forms of old terrace (T) and plain (P) as shown below.



Gravel layer is laid in the subsurface of the soils in the old terrace, and the depth at the gravels from surface varies depending on the topography. The effective soil depth of T1 is shallow, and the one of T2 is more deep and better condition for cultivation. The soils units of the old terrace are Haplic Alisols or Cambic Arenosols. While, the soils of the plain have been formed by alluvial deposition, hence the soils have a fine texture with enough depth. The soil units of the plain are classified into Dystric Cambisols and Gleyic Cambisols.

Physio-graphy	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	Texture (top-sub)	Depth	Local Name	Area*1 (ha)
Old terrace (Upland)	**T1**	terrace remnant	Skeletic-Haplic Alisols	3 - 4 %	well-mod. well	SL - gravel (C)	shallow	Simpa	3
	T21	middle-lower slope	Haplic Alisols	2 -3 %	mod. well	SCL - gravel & SC	mod. deep	Akroso	17
	T22	middle-lower slope	Cambic Arenosols	2 -3 %	mod. well - imperfect	SL - gravel & C	deep	Nta	9
Plain	**P21**	upper plain	Distric Cambisols	0 - 1 %	imperfect	CL - C	deep	Kakum	34
	P22	flat plain	Gleyic Cambisols	0 %	poor	C - C	deep	Oyibi	30
	P22s <1	flat plain	Gleyic Cambisols (salt effected)	0 %	poor	C - C	deep	Oyibi	2

Remarks : *1 Area is gross area in alternative - 3 under rehabilitation plan.
<1 Area of P22s is estimated by JICA study team

The salt-effected soils were also found in the Okyereko area. This is presently expanded along the drain and occupies at about 2 ha in the existing irrigated area. According to the laboratory test results, ECe is 7 to 23 mS/cm in surface. However, since the irrigation water is salt free which is about 0.2 mS/cm, the salinity condition will be improved under the proper drainage system. Detail explanation of soil improvement study are described in Chapter 5.

The distribution of each mapping unit in each project area is presented on the semi-detailed soil map in Figure C-1 - C-5.

5. PROBLEM SOILS

The following problem soils were identified in the priority projects through the study.

5.1 Salinity Soil

(1) Present Condition

12 ha in Ashaiman and 2 ha in Okyereko are estimated as a salinity soils, respectively. The salinity soils of both areas were observed in poorly drained fields along the drain. The area of salinity soils is small part and just found at spot in the area, however both project areas have still potential lands to be effected under poor drainage system. As the following table shows, the ECe values of surface soils are high and they are classified into saline to strongly saline soil (saline soil: 8-15 mS/cm, strongly saline soil: over 15 mS/cm), and also some of these also shows a sodic property. Presently, most of these salt-effected lands are abandoned to cultivate rice.

Project area		Texture	pH	ECe *1 (mS/cm)	ESP (%)
Ashaiman	Surface-1	L	6.6	16.5	18
	Surface-2	SCL	7.2	6.8	7
Okyereko	Surface-1	SL	4.9	23.0	14
	Surface-2	SiCL	6.0	7.5	8

Remarks: The values of ECe were calculated from data of EC (1:5)

(2) Reclamation Measures

The following land managements are proposed for the reclamation of salinity soils.

1) Flushing

In the saline soils, most of salts are assumed to be concentrated on or near the surface, because of the low infiltration and poor drainage. Therefore, surface flushing (flooding, puddling, draining) prior to the leaching may accelerate and improve the leaching process.

2) Leaching

This is by far the most effective procedure for removing salts from the root zone of soils. As useful rule of thumb is that a unit depth of water will remove nearly 80 % of salts from a unit soil depth. Salt concentration of surface soil will be decreased and it of subsurface will be increased after irrigation. Therefore, if the salty drainage water be removed out to the project area under proper drainage system, the salinity condition of the area will be improved.

3) Mulching

During periods of high evapotranspiration between the two (2) irrigation terms and of fallow, there is a tendency for the leached salt to return to the soil surface. The practices that reduce evaporation from the soil surface and encourage downward flux of soil water will help to control root zone salinity. Therefore, mulching is assumed to be effective for improving the salinity condition, especially on fallow and upland cropping, in addition to establishment of proper drainage system.

(3) Salt Balance Study

The preliminary estimate of the salt balance under proposed cropping pattern is carried out using the method of Bouman's quantitative calculation technique. This calculation model is composed of three (3) parts, i) water balance, ii) salt balance, and iii) efficiency leaching. The detailed calculation of the model is presented in Attachment-III in this Annex. The calculation of the salt balance in both project areas are done under the following assumptions.

Assumption	Ashaiman	Okyereko
Drainability	Well (improved)	Well (improved)
Reclamation before irrigation	None	None
Irrigation loss	20%	20%
EC of irrigation water *1	0.13 mS/cm	0.20 mS/cm
ECe of root zone	8.8 - 16.6	5.1 - 23.0
Cropping pattern	Paddy - Tomato (1st year) Paddy - Okra (2nd year)	Paddy - Paddy
Root zone	50cm	50cm

Remarks : *1 Data from IDC report (1993) and EIA report (1995)

The results of calculation are presented in Table C-4, and summarised as follows:

(Unit : mS/cm)

Project Area	Initial ECe of root zone	After irrigation 1 year	2 year	3 year
Ashaiman	13.2	4.0	1.5	0.9
	16.6	4.8	1.7	1.0
Okyereko	6.8	1.4	0.5	0.4
	23.0	3.8	0.9	0.5

The results show that even the soils of 16.6 and 23.0 mS/cm classified into strongly saline soil (over 16 mS/cm) will be improved to slightly saline (4 - 8 mS/cm) to salt free soils (less than 4.0 mS/cm) after 1 year irrigation under the proposed cropping pattern. Finally, ECe of soils in root zone will be stabilised at about 0.5 after 5 year's irrigation. A significant leaching effect by irrigation water can be expected under the proper drainage system, since the irrigation water of both areas is not effected by salt as 0.13 - 0.20 mS/cm.

These might be optimistic projections. The results of the calculation could change from suitable results to undesirable ones in case of lowest percolation rate even under proper drainage system. Consequently, some reclamation measures mentioned above are required to be applied before and on the farming operation periods. By this way, the yield loss due to the salinity may be eliminated. Concretely, it is recommended to carry the flushing and leaching (irrigating) works out in the salt effected fields immediately after establishment drainage system prior to the farming operation, if possible.

5.2 Shallow Soil

(1) Present Condition

The soil which has a "skeletic" phase is major in Kpando-Torkor Since the effective depths of soils to the skeletic layer is about 20 to 50 cm, it is assumed to be a high potential for land degradation. Once the surface soil is removed out, the lands will be changed to un-usable land for any purposes. The slope of the area is, however, gentle as 2 to 3 % , the rain intensity is relatively high in rainy season. In fact, the depth of soils in present irrigated fields is shallower than the one under secondary forest. Therefore, it is apparent that the land use and farming practice is key factors for the sustainability.

(2) Improvement measures

The proper land management is required when the land be used for agricultural purpose, especially on intensive farming. In other word, the countermeasures for land erosion such as contour hedgerow, contour ditches & drainage canals, mixed planting, contour plowing, etc, need to be introduced into the project activities on the implementation and also operation phases. Table C-5 shows recommendable measures and practices for control of soil erosion, and the following shows its summary.

Measures	Descriptions	Phase
1. Contour hedgerow	Vegetative rows or strips established along the contour. Trees serve as live barrier to surface runoff and soil erosion. If the nitrogen fixing crops or trees such as leguminous crops are used, it can improve soil condition.	Implementation and Operation
2. Contour bund	They are earth bunds, thrown across the slope to act as a barrier to runoff, and to break up a slope into segments shorter in length than is required to generate overland flow. They are frequently used with strip-cropping system.	Implementation and Operation
3. Contour ditches & drainage canal	They are digging structures established in the hillsides to check the erosive power of surface runoff by tapping soil particles. Drainage canal are used as the outlet for contour ditches. It runs downslope and empty into other outlets.	Implementation
4. Contour plowing	It is a plowing method to create furrows following the contour of the land.	Operation
5. Contour planting	It is a planting method following the contour of the land. The crops planted act as barriers to the force of surface runoff.	Operation
6. Mulching	The mulching is the covering of the soil with crop residues such as straw, maize stalks, palm fronds or standing stubbles. The effect of mulching is the reducing of raindrop impact and of the velocity of runoff.	Operation

However, even the land conservation measures mentioned above be applied in the fields, monitoring works are also needed to be carried out to grasp the progress of soil erosion at susceptive area. Through the monitoring works, it will be possible for not only to identify constraints of the countermeasures but also to find alternatives to match with farming and farmers' conditions. The monitoring procedure are described in Annex F.

6. LAND EVALUATION

The land evaluation for each project area were carried out according to the USBR (US. Bureau of Reclamation) system which had been applied to number of irrigation projects in many countries. In the present study, the system was slightly modified to match with the present condition of the project areas and project purposes.

6.1 Land Suitability Classes

(1) Basic Assumption

There are two (2) kinds of interpretative land classification as follows:

(a) Current land suitability: an appraisal of the suitability if land for irrigation without significant land improvement measures as to alter the present limitations and qualities of the land.
(b) Potential land suitability: an appraisal of the potential suitability of the land for irrigation with significant land improvement measures as to require improvement level and type of land.

In order to clarify the suitability for the future development, the appraisal of potential land suitability is carried out in the present study. Hence, the appraisal is done under the following conditions:

(a) Sufficient irrigation water of good quality is supplied to the areas. Irrigability is, therefore, not considered.
(b) Proper drainage network is established. This allows to remove stagnant water in the minor depressions and to improve the salinity conditions.
(c) Inherent fertility of soils is not considered as a major factor. The soils can be made productive by fertilisation.
(d) Distance to market, accessibility, regional location, skill or resources of farmers are not considered in the criteria for evaluation rating.

(2) Land Suitability Classes

According to the specific criteria, six (6) suitable classes are designated as follows.

Suitability Classes	Description
Class S1 : Highly suitable	Land of high productivity for most crops under irrigation with medium costs of development and management associated with the land.
Class S2 : Moderately suitable	Land of moderately productivity due to slight to moderate limitations in land characteristics with moderate costs for development and management.
Class S3 : Marginally suitable	Land of marginally productivity due to moderate to severe limitations in land characteristics with relatively high costs for development and management.
Class S4 : restricted suitable	Land of restricted productivity due to severe limitations in land characteristics with high costs and/or specific land use for development and management.
Class NS1 : Provisionally unsuitable	Lands which are considered unsuitable for irrigation but require further investigation.
Class NS2 :Unsuitable	Lands which are unsuited for irrigation due to severe limitations in soils, topography, or drainage.

(3) Specific Criteria

Based on the following land qualities, the land suitability for the future land use with irrigation is evaluated. Table C-6 and C-7 give the specific criteria for wetland rice and upland crops.

(a) soil deficiencies (symbol 's')
- effective depth
- texture
- toxicity (alkalinity and salinity)

(b) Drainage condition (symbol 'd')

(c) Topography (symbol 't')
- slope
- micro-relief

The project areas could be classified into the two (2) development type, i.e. upland crops (vegetables) development and wetland rice development. Therefore, the land evaluation is also made according to the each development type as shown below.

Project	Land evaluation type
1. Ashaiman	wetland rice and upland crops
2. Aveyime	wetland rice and upland crops
3. Kpando-Torkor	upland crops
4. Mankessim	upland crops
5. Okyereko	wetland rice and upland crops

6.2 Result of Land Evaluation

The land suitability maps of priority project areas are presented in Figures C-6 to C-10. Table C-8 shows the extent of each suitability class in the rehabilitation areas, and they are summarised as follows:

Land Suitability Classes for Wetland Rice

(Unit : ha)

Project Area	Sub area	SR1 - SR3	SR4	NSR	Total
1. Ashaiman		59	8	0	67
2. Aveyime	Alternative-1	64	0	10	74
	Alternative-2	83	0	11	94
	Alternative-3	87	0	25	112
3. Okyereko	Alternative-1	37	9	0	46
	Alternative-2	61	13	0	74
	Alternative-3	82	13	0	95

Land Suitability Classes for Upland Crops

(Unit : ha)

Project Area	Sub area	S1 - S3	S4	NS	Total
1. Ashaiman		59	8	0	67
2. Aveyime	Alternative-1	74	0	0	74
	Alternative-2	94	0	0	94
	Alternative-3	112	0	0	112
3. Kpando-Tor	Block-A	12	121	0	133
	Block-B	0	71	0	71
	Block-C	161	6	0	167
	Block-D	90	0	0	90
4. Mankessim	Alternative-1	32	0	0	32
	Alternative-2	92	3	0	96
5. Okyereko	Alternative-1	44	0	2	46
	Alternative-2	72	0	2	74
	Alternative-3	94	0	2	95

As a basic rule, it was kept that non-suitable area is not selected for future rehabilitation. Therefore, non-suitable areas for both crop types are not shown in the rehabilitation area, however, NS can be seen in the above tables. The area classified into S4 in the Kpando-Torkor has a only 20 cm of effective soil depths and a skeletic layer is observed below 20 cm. As mentioned in Chapter 5, these lands have a high potential of land degradation. When the lands are used for agriculture purpose, a careful attention and proper conservation works should be taken. In addition, the monitoring works of soil erosion effect are also needed for the sustainable using.

The salinity area are also classified into the class 4, because the project will establish a proper drainage system. According to the result of the calculation, it is estimated that about 70 % of salt in the area will be leached out after 1 year's irrigation under proper drainage system. Hence the lands even strongly effected by salt are considered to be possible to get the expected yields.

7. PRESENT LAND USE

Various land use types were observed in the five priority project areas. In plain area, land are mainly used for paddy fields, while, those in the hill area are used for upland crop fields, grasslands and bushes under shifting cultivation system. The distribution of each land use in the priority projects areas are presented on land use maps in Figs. C-11 to C-15. The extent of the land use units in the rehabilitation area of the projects are shown in Table C-9, and summarised as follows:.

Ashaiman

Land Use	Map Unit	ha	%
Paddy fields (developed)	Pd	65	97
Upland fields (developed)	Ud	1	1
Grassland	G	1	2
Total		67	100

Remarks : *1 Area is gross area in rehabilitation area.

Aveyime

Land Use	Map Unit	ha	%
Paddy fields (developed)	Pd	69	62
Paddy fields (undeveloped)	Pr	1	1
Upland fields (developed)	Ud	5	4
Upland fields (rainfed)	Ur	10	9
Grassland	G	11	9
Bush, Shrub	B	15	13
Grove	W	1	1
Swamp	S	1	1
Buildings and garden	V	1	1
Total		112	100

Remarks : *1 Area is gross area in alternative - 3 under rehabilitation plan.

Kpando-Torkor

Land Use	Map Unit	ha	%
Upland fields (developed)	Ud	27	6
Upland fields (rainfed)	Ur	76	16
Grassland	G	142	31
Bush, shrub	B	216	47
Grove	W	0	0
Total		461	100

Remarks : *1 Area is gross area in alternative - 2 under rehabilitation plan.

Mankessim

Land Use	Map Unit	ha	%
Paddy fields (undeveloped)	Pr	1	1
Upland fields (developed)	Ud	17	18
Upland fields (rainfed)	Ur	25	26
Orchard	O	4	4
Grassland	G	40	42
Bush, Shrub	B	1	1
Grove	W	7	8
Total		96	100

Remarks : *1 Area is gross area in alternative - 2 under rehabilitation plan.

Okyereko

Land Use	Map Unit	ha	%
Paddy fields (developed)	Pd	43	45
Paddy fields (undeveloped)	Pr	2	2
Upland fields	U	6	6
Grassland	G	44	46
Grove	W	0	1
Total		95	100

Remarks : *1 Area is gross area in alternative - 2 under rehabilitation plan.

In the Ashaiman and Aveyime projects, the rehabilitation area mainly consists of the existing farm land which is under developed condition. While, in the other projects, the existing farm land occupies only about 20 to 50 % of the area. Especially it is notable in the Kpando-Torkor project that most of the land are under grassland or bush. However, grassland and bush areas are also used for agricultural land under the shifting cultivation system of 3 to 4 year's rotation.

TABLES

Table C-1 General Description of Soil Profile

Location No.	Depth of Horizon	Color		Texture	Structure			Consistence	Mottling				Remarks
		wet (moist)	dry		grade	type	size		abundance	size	contrast	color	
As-1	0-10	10YR2/1.5	-	SL	w-m	sbk	m	ss, sp (wet)	f	f	f	7.5YR4/6	
	10-27	2.5Y4/2 (90%), 5YR4/8 (10%)	-	C.LS	w	sbk	f-m	ns, np (wet)	c	f	d	5YR4/8	
	27-45	2.5Y4/2	-	C.LS	w	sbk	f-m	ns, np (wet)	f	f-c	f	10YR4/6	
	45-62	10YR6/2	-	S	w	sbk	f-m	ns, np (wet)	-	-	-	-	
	62-70	2.5Y3/1 (90%), 10YR5/8 (90%)	-	SCL	m	sbk	f-m	ss, sp (wet)	c	f	f	10YR5/8	water seepage
	70-94	7.5Y4/2 (60%), 5Y5/6 (40%)	-	SC	m-s	abk-sbk	m	s, p (wet)	c	m	f	5Y5/6	common clay ill., few quart gravel (0.1-0.2cm)
	94-120	7.5Y5/1	-	SC	m-s	sbk-sbk	m	s, p (wet)	f	m	f	5Y5/4	common clay ill., few quart gravel (0.1-0.2cm)
As-2	0-10	7.5YR2/1 (70%), 7.5YR4/6 (30%)	-	SiCL	m	sbk	m	s, p (wet)	f-c	c	d	7.5YR4/6	
	10-33	7.5YR2/1 (40%), 5YR4/8 (60%)	-	SiCL	w	sbk	f-m	vs, vp (wet)	m	m	f-d	5YR4/8	few Mn soft conc.
	33-56	5Y2/1	-	SiC	w	sbk	f	vs, vp (wet)	-	-	-	-	few quart gravels
	56-79	5Y2/2 (60%), 10Y2/1 (40%)	-	SiC	w	sbk	m	vs, vp (wet)	m	m	d	10Y2/1	many Mn motlle, common CaCO3 conc. and quart gravels
	79-120	10Y2/1	-	SiC	w	sbk	m	vs, vp (wet)	-	-	-	-	common residual roots, common fine quart gravels
As-3	0-22	10YR4/2	10YR4/2 (60%), 7.5YR5/8 (40%)	LS	w	sbk	f-m	vfr (moist)	m	f-m	f	7.5YR5/8	
	22-50	10YR5/2 (60%), 7.5YR5/6 (40%)	-	C.SL	m	sbk	f-m	fr (moist)	m	f-m	f-d	7.5YR5/8	
	50-110	10YR6/2 &7/4 (70%), 10YR6/8 (30%).	-	gravel, SCL		massive		s, p (wet)	c	m	f	7.5YR6/8	few Mn conc. (0.2-0.5cm : 5%), few-common frint & round quart gravels
	110+	-	-										composing rock
As-4	0-10	2.5Y6/2	-	C	w-m	sbk	f-m	s, p (wet)	-	-	-	-	few gravels (0.2-2.0cm : >5%)
	10-42	5Y4/2	-	C	m-s	sbk	m-c	ss, sp (wet)	-	-	-	-	common clay ill.
	42-80	5Y4/2 (60%), 5Y3/1 (40%)	-	C	m-s	sbk	m-c	ss, sp (wet)	-	-	-	-	common clay ill. (5Y3/1)
	80-110	5Y4/3 (60%), 5Y3/1 (40%)	-	C	m-s	sbk	m-c	ss, sp (wet)	-	-	-	-	common clay ill. (5Y3/1)
	110+	2.5Y7/6 (70%), 5Y3/2 (30%)	-	C		massive			-	-	-	-	pararent materials
As-5	0-6	-	2.5Y2/1	C	m-s	sbk	m	s, p (wet)	-	-	-	-	
	6-22	2.5Y2.5/1	-	C	m	sbk	m	s, p (wet)	f	f	f	7.5YR4/8	root channel motlle
	22-40	7.5Y3/1	-	C	m	sbk	f-m	s, p (wet)	f	f-m	f	10YR4/6	root channel motlle
	40-63	7.5Y4/1 (70%), 7.5Y3/1 (30%)	-	C	m	sbk	f-m	s, p (wet)	f	f	f	10YR4/6	root channel motlle, common clay ill. (7.5Y3/1)
	63-88	5Y4/2 (60%), 7.5Y3/1 (40%)	-	C	m	sbk	m	s, p (wet)	-	-	-	-	common clay ill. (7.5Y3/1), few root residures
	88-120+	5Y4/2 (50%), 7.5Y3/1 (50%)	-	C	m	sbk	m	s, p (wet)	-	-	-	-	common clay ill. (7.5Y3/1), few root residures
As-6	0-4	2.5Y2/1	2.5Y3/2 (60%), 2.5Y2/1 (40%)	C	m-s	sbk	m	vfi (moist)	c	f	f	10YR5/8	root channel motlle
	4-25	10YR3/2	10YR3/1 & 5/1 (70%), 10YR4/6 (30%)	C	m-s	sbk	m	fi (moist)	c	f	f	10YR4/6	few medium-coarse quart gravel
	25-40	2.5Y2/1	-	C	m	sbk	m	fi (moist)	f-c	f	f	10YR4/6	
	40-55	5Y3/1 (70%), 10YR4/6 (30%)	-	C	m-s	sbk	m	vfi (moist)	f-c	f-m	f	10YR4/6	very few Mn conc. (0.2-1.0cm : 2%)
	55-80	5Y3/1 (80%), 10YR4/6 (20%)	-	C	m	sbk	m	s, p (wet)	f-c	f	f	10YR4/6	common polished clay ill.
	80-120+	5Y3/1 (80%), 5Y3/2 (20%)	-	C	m	sbk-abk	m-s	s, p (wet)	f	f	f	10YR4/6	many polished clay ill.
Av-1	0-18	10YR4/2 (80%), 7.5YR4/6 (20%)	10YR5/2 (70%), 7.5YR4/6 (30%)	SL	m	sbk	f-m	fr (moist)	c	f	f-d	7.5YR4/6	surface soil was removed out.
	18-40	10YR4.5/2 (80%), 7.5YR4/6 (20%)	10YR4.5/2 (70%), 7.5YR4/6 (30%)	C. SL	w-m	sbk	f-m	fr (moist)	c	f-m	f-d	7.5YR4/6	
	40-70	2.5Y6/6 (60%), 7.5YR5/8 (40%)	-	SCL	m-s	sbk	f-m	fr (moist)	c-m	m-c	f-d	7.5YR5/8	few Fe & Mn soft conc.
	70-100	2.5Y6/2 (35%), 10YR6/6 (35%), 7.5YR4/6 (30%)		SCL	m	sbk	m-c	fi (moist)	m	m-c	f	7.5YR4/6	few Fe & Mn soft conc. (1.0 cm), few clay ill
	100-120+	2.5Y7/1 (35%), 5YR4/8 (65%)	-	gravel, SCL	m-s	sbk	m-c	fi (moist)	m	c	d	5YR4/8	abundant Fe soft conc. (like a plinthite)
Av-2	0-20	10YR3/2	10YR3/2	CL	m-s	sbk	f-m	h (dry)	-	-	-	-	
	20-35	10YR4/1 (35%), 10YR4/2 (35%), 7.5YR5/8 (30%)		C	s	sbk-abk	m	vh (dry)	c-m	f	f	7.5YR5/8	very few clay ill.
	35-50	7.5YR4/2 (60%), 7.5YR5/8 (40%)		C	s	sbk-abk	f-m	h (dry)	m	m-c	f	7.5YR5/8	few clay ill
	50-80	10YR5/3 (50%), 7.5YR5/8 (50%)		C	s	sbk-abk	m-c	vfi (moist)	m	f-m	f-d	7.5YR5/8	
	80-120+	5Y6/1 (40%), 10YR5/8 (60%)		C	s	sbk-abk	m-c	vfi (moist)	m	m-c	f-d	10YR5/8	
Av-3	0-10	2.5Y3.3.5/2 (80%), 7.5YR6/8 (20%)	2.5Y3.5/2 (80%), 7.5YR6/8 (20%)	SiCL	s	sbk	f-m	h (dry)	c-m	f	f-d	7.5YR5/8	surface soil was removed out.
	10-22	2.5Y3.5/2 (80%), 7.5YR6/8 (20%)	2.5Y4/2 (80%), 7.5YR6/8 (20%)	SiCL	s	sbk	m-c	h (dry)	c-m	f	f-d	7.5YR5/8	
	22-53	2.5Y5/3 (20%), 10YR5/8 (60%), 5YR5/8 (20%)		gravel, C	s	sbk-abk	f-m	h (dry)	m	m-c	f	10YR5/8	many medium-coarse soft Fe conc. (5YR5/8)
	53-85	5Y5/1 (10%), 10YR6/6 (70%), 7.5YR5/8 (20%)		C	s	sbk-abk	m-c	fi (moist)	f-c	f	f	7.5YR5/8	
	85-120+	2.5Y5/2 (10%), 10YR6/6 (80%), 7.5YR5/8 (10%)		C	s	sbk-abk	m-c	fi (moist)	f	f-m	f	7.5YR5/8	few mediumsoft Fe conc., root channel Mn motdle, few clay ill.
Av-4	0-10	2.5Y4/3 (80%), 7.5YR5/8 (20%)	2.5Y6/4 (80%), 7.5YR6/8 (20%)	SiC	s	sbk	f-m	h (dry)	c	f	f-d	7.5YR5/8	
	10-20	2.5Y4/3 (80%), 7.5YR5/8 (20%)	2.5Y4/3 (80%), 7.5YR5/8 (20%)	C	s	sbk	f-m	h (dry)	c	f	f-d	7.5YR5/8	
	20-42	2.5Y5/3 (60%), 7.5&10YR5/8 (40%)	-	C	m-s	sbk	m-c	fi (moist)	m	m-c	f	7.5YR5/8	few-common clay ill/
	42-90	10YR6/6 (80%), 7.5YR5/8 (10%), 10YR5/2 (10%)		CL	m-s	sbk	f-m	fr-fi (moist)	f	f-m	f	7.5YR5/8	few clay ill. (10YR5/2)
	90-120+	10YR6/6 (30%), 10YR5/4 (70%)		CL	m	sbk	f-m	fr-fi (moist)	f	f-m	f	7.5YR5/8	few soft fine & root channel Mn conc.
Av-5	0-15	2.5Y4/3(80%), 7.5YR5/8 (20%)	2.5Y5/3 (80%), 7.5YE5/8 (20%)	C	s	sbk	m	h (dry)	c	f-m	f	7.5YR5/8	surface soil was removed out.
	15-30	5Y6/1 (50%), 7.5YR5/8 (50%)	5Y6/2 (50%), 7.5YR5/8 (50%)	C	s	sbk	m	h (dry)	m	f-m	d	7.5YR5/8	
	30-50	5Y7/1 (70%), 7.5YR5/8 (30%)		SiC	m-s	sbk	f-m	fr-fi (moist)	c	m-c	d	7.5YR6/8	
	50-120+	5Y7/1 (30%),2.5Y7/3 (30%), 7.5YR6/8 (40%)		SiC	m	sbk	f-m	fr (moist)	m	c	d	7.5YR6/8	few soft coarse Fe & Mn conc.
Av-6	0-8	7.5YR2/1 (90%), 7.5YR5/8 (10%)	2.5Y4/1 (90%), 7.5YR6/8 (10%)	C	s	sbk	f-m	vh (dry)	c	f-m	f	7.5YR5/8	
	8-40	7.5YR3/1 (80%), 7.5YR5/8 (20%)	2.5Y4/1 (80%), 7.5YR6/8 (20%)	C	s	co & abk	m-c	vh (dry)	c-m	f	f-d	7.5YR5/8	crack (width 0.2cm from 8-30cm)
	40-65	7.5YR3/1 (80%), 7.5YR5/8 (20%)		C	s	abk	f-m	vfi (moist)	c-m	f	f	7.5YR5/8	
	65-100	2.5Y4/1 (90%), 7.5YR6/8 (10%)		C	m	abk	f-m	fi (moist)	c	f-m	f	7.5YR6/8	shrinking clay
	100-120+	2.5Y4/1 (90%), 7.5YR6/8 (10%)		C.SC	m	sbk-abk	m-c	fi (moist)	c	f-m	f-d	7.5YR6/8	many shining quartz sands
Av-7	0-38	7.5YR4/3-4/6	7.5YR6/3	C.S	w	sbk	f-m	lo (dry)	-	-	-	-	
	38-62	7.5YR4/6	7.5YR5/6	C.S	w	sbk	f-m	s (dry)	-	-	-	-	few medium-coarse Mn conc. (0.5-2.0 cm)
	62-78	5YR4/8		C.SL	w-m	sbk	f-m	vfr (moist)	f	m	f-d	2.5YR3/6	few O.M inclusion
	78-120+	5YR4/8 (50%), 2.5YR3/4 (50%)		C.SL	m	sbk	f-m	vfr (moist)	c-m	m	f	2.5YR3/4	
Av-8	0-10	7.5YR3.5/3	7.5YR6/3	C.LS	m	sbk	f-m	h (dry)	-	-	-	-	surface soil was removed out.
	10-20	7.5YR3.5/3	7.5YR4/3	C.LS	m	sbk	f-m	h (dry)	f	f	f	5YR3/6	motlling is the inclusion part of the 3rd layer
	20-68	5YR3/6	-	C.LS-SL	m	sbk	f-m	fr-fi (moist)	f	f-m	f	5YR3/2	motles of O.M., few fine Mn conc. (0.1 cm)
	68-90	5YR3/6		C.SL	m	sbk	f-m	fr (moist)	f	f-m	f	5YR3/2	motles of O.M., few medium soft-hard Mn conc. (>1.0cm)
	90-120+	5YR3/6 (50%), 10YR6/6 (30%), 2.5YR3/3 (20%)		C.SL-C.SCL	s	sbk	f-m	fi (moist)	-	-	-	-	abundant coarse soft Fe & Mn conc (like a plinthite)
Av-9	0-10	10YR3/2	10YR4/2	SiCL	m-s	sbk	f	h (dry)	f	f	f	7.5YR5/8	
	10-30	2.5Y5/4 (50%), 5YR3/6 (50%)		C	s	sbk	f-m	fi (moist)	m	f-m	f-d	5YR3/6	
	30-50	2.5Y5/4 (60%), 5YR3/6 (40%)		C	m	sbk	m	fi (moist)	m	f-m	f-d	5YR3/6	
	50-80	5Y6/3 (60%), 5YR5/8 (40%)		C	m-s	sbk	m-c	fi (moist)	m	f-m	f	5YR5/8	
	80-120+	5Y6/3 (50%), 7.5YR5/8 (50%)		C	m-s	sbk	m-c	fi (moist)	m	m-c	f	7.5YR5/8	few very fine faint Fe motlle 5YR5/8
Av-10	0-20	7.5YR2.5/2	10YR5/2	S		single grain		lo (dry)	-	-	-	-	
	20-30	7.5YR3/2	7.5YR4/2	S		single grain		lo (dry)	-	-	-	-	
	30-60	5YR4/8		S	vw	sbk	f-m	lo-vfr (moist)	-	-	-	-	
	60-90	5YR3/6		S	vw	sbk	f-m	lo-vfr (moist)	-	-	-	-	
	90-120+	5YR3/6		LS-SL	w	sbk	f-m	vfr (moist)	-	-	-	-	clay ill. (2.5YR3/4), rare Mn conc.

Table C-1 General Description of Soil Profile

Location No.	Depth of Horizon	Color: wet (moist)	Color: dry	Texture	Structure: grade	Structure: type	Structure: size	Consistence	Mottling: abundance	Mottling: size	Mottling: contrast	Mottling: color	Remarks
Kp-1	0-25	10YR3/2		C	s	sbk	m-c	vh (dry)	-	-	-	-	
	25-55	2.5YR4/3 (20%), 10YR4/2 (80%)		gravel, C, SCL	s	co-sbk	m-c	vh (dry)	-	-	-	-	many fine Fe & Mn conc. (0.1cm ; 20-30%)
	55-85	2.5Y5/4		gravel, C	s	pr-co-abk	m-c	vfi (moist)	-	-	-	-	many fine Fe & Mn conc. (0.1cm ; 30%)
	85-120+	5Y6/6 (40%), 2.5Y6/6 (60%)		gravel, C	s	pr-co-abk	m-c	fi (moist)	m	m-c	f	2.5Y6/6	common - many Fe & Mn conc. (0.2-0.5cm ; 10-20%)
Kp-2	0-20	10YR2.5/2	10YR4/2	L	s	cr	f-m	h (dry)	-	-	-	-	few fine Fe & Mn conc. (5%)
	20-38	10YR4/2 (40%), 5YR3/6 + 7.5YR6/8 (60%)		gravel, C	m	sbk	f-m	sh-h (dry)	-	-	-	-	abundant medium-coarse Fe & Mn conc. (60-70%)
	38-65	2.5Y6/2 (80%), 7.5YR5/8 (20%)		gravel, C	s	pr-co	m-c	vfi (moist)	c	f	f-d	7.5YR5/8	common fine-medium Fe & Mn conc. (10%)
	65-78	2.5Y6/3 (60%), 7.5YR6/8 (20%), 10YR2/2 (10%), 5YR3/6 (10%)		gravel, C	m	abk	m-c	fi (moist)	m	f	d	7.5YR6/8	abundant fine-medium Fe & Mn conc. (40-50%)
	78-120+	2.5Y7/2 (60%), 5YR5/8 + 7.5YR5/8 (40%)		gravel, C	m-s	abk	m-c	fi (moist)	m	f-m	d	7.5YR5/8	abundant f-m Fe & Mn conc. (60%), few decomposing rocks, few quartz
Kp-3	0-15	10YR2/2 (85%), 7.5YR5/8 (15%)		L-CL	s	cr-sbk	f-m	fi (moist)	f	f	f-d	7.5YR5/8	
	15-28	10YR3.5/2 (80%), 7.5YR4/6 (20%)		CL-C	m	sbk	f-m	fi (moist)	c	f-m	f	7.5YR4/6	many fine Fe & Mn conc. (0.1cm ; 5%)
	28-46	10YR4/4 (60%), 10YR4/2 (40%)		gravel, C	m	sbk	f-m	fr (moist)	-	-	-	-	many fine-medium Fe & Mn conc. (0.1-0.3cm ; 20%)
	46-65	10YR4/4 (70%), 10YR4/3 (20%), 7.5YR4/6 (10%)		gravel, C	m	sbk	f-m	fr (moist)	f	f-m	f	7.5YR4/6	many medium-coarse Fe & Mn conc. (0.3-0.5 ; 40%)
	65-100+	10YR5/2 (70%), 10YR5/6 (30%)		gravel, C	m	sbk	f-m	s, p (wet)	c	m	f	10YR5/6	many medium-coarse Fe & Mn conc. (0.3-0.5 ; 30%), GWT at 100cm
Kp-4	0-12	7.5YR2/2	7.5YR4/2	L	s	cr	f-m	vh (dry)	-	-	-	-	common Fe & Mn conc. (10%)
	12-27	7.5YR3/2	7.5YR4/2	gravel, L-CL	single grain			lo (dry)	-	-	-	-	dominant Fe & Mn conc. (80%)
	27-35	7.5YR4/4	7.5YR4/3	gravel, L-CL	single grain			lo (moist)	-	-	-	-	dominant Fe & Mn conc. (80%)
	35-120+	-	-	-	-	-	-	-	-	-	-	-	iron pan & decomposing rocks
Kp-5	0-12	7.5YR2/2	7.5YR3/2	gravel, CL	s	sbk	f-m	vh (dry)	-	-	-	-	common soft Fe & Mn conc. (10%), many hard Fe & Mn conc. (25%)
	12-78	-	-	-		-			-	-	-	-	iron pan & decomposing rocks
	78-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rocks
Kp-6	0-15	7.5YR2/1	7.5YR3/1	SCL-CL	s	cr	m-c	h (dry)	-	-	-	-	common fine - medium Fe & Mn conc. (10%)
	15-65	-	-	-		-			-	-	-	-	iron pan & decomposing rocks
	765-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rocks
Kp-7	0-15	7.5YR3/2	7.5YR7/2	S-LS	w-m	cr	-	sh (dry)	-	-	-	-	
	15-46	7.5YR4/6	7.5YR6/6	LS	m	sbk	-	sh (dry)	-	-	-	-	
	46-81	5YR5/6	-	SCL	s	sbk	-	fi (moist)	-	-	-	-	
	81-116	5YR5/6 (30%), 10YR6/6 (60%), 7.5YR1.7/1(10%)		SCL	m	sbk-abk	m	fr-fi (moist)	m	f	f	10YR6/6	few charcol inclusion
	116-130+	2.5Y7/6 (50%), 5YR5/8 (50%)		SC	s	pr-co-abk	m	fi (moist)	m-c	d	d	5YR5/8	
Kp-8	0-15	7.5YR3/3	7.5YR5/3	LS	m	sbk	f-m	sh-h (dry)	-	-	-	-	
	15-37	7.5YR4/6	7.5YR5/6	LS-S	w-m	sbk	f-m	sh (dry)	-	-	-	-	
	37-72	7.5YR5/6	7.5YR5/8	S	w	sbk	f-m	vfr (moist)	-	-	-	-	
	72-115	7.5YR5/6	7.5YR5/8	LS	m	sbk	f-m	vfr (moist)	-	-	-	-	
	115-120+	5YR6/8	-	SL	m	sbk	f-m	fr-fi (moist)	-	-	-	-	
Kp-9	0-22	7.5YR3/2	7.5YR3/2	S	single grain			lo (moist)	-	-	-	-	
	22-50	7.5YR5/3 (95%), 7.5YR6/8 (5%)	-	S	single grain			lo (moist)	f	f	f	7.5YR6/8	
	50-75	7.5YR6/4 (95%), 7.5YR6/8 (5%)	-	S	single grain			lo (moist)	f	m	f-d	7.5YR6/8	
	75-105+	10YR7/3 (50%), 7.5YR6/3 (40%), 7.5YR6/8 (10%)		S	single grain			ns, np (wet)	f	m-c	f	7.5YR6/8	few soft Fe conc., few m-c Fe & Mn conc., GWT at 105cm
Kp-10	0-15	10YR3/3	10YR5/3	gravel, L	w	sbk	f-m	h (dry)	-	-	-	-	abundant Fe conc. (0.2-0.5cm ; 60%)
	15-80	7.5YR4/4	-	-		-			-	-	-	-	dominant Fe conc. (0.2-0.5cm ; 90-95%)
	80-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rocks
Kp-11	0-15	7.5YR3/3	7.5YR5/3	L	s	cr	f-m	h (dry)	-	-	-	-	
	15-110+	-	-	-	-	-	-	-	-	-	-	-	iron pan (Fe conc. ; 90-95%)
Kp-12	0-12	7.5YR3/2	7.5YR4/3	L-CL	s	sbk	f-m	vh (dry)	-	-	-	-	
	12-28	5YR4/3.5	5YR4/4	CL-C	s	sbk-abk	m	vh (dry)	-	-	-	-	few fine Fe & Mn conc.
	28-43	5YR4/4	-	gravel, C	s	sbk	f-m	fi (moist)	-	-	-	-	many fine-medium Fe & Mn conc (0.2-0.5cm ; 20-30%)
	43-70	5YR4/6	-	gravel, C	s	sbk	f-m	fi (moist)	-	-	-	-	many fine-medium Fe & Mn conc (0.2-0.5cm ; 40%)
	70-90	5YR4/6	-	gravel, C	s	sbk	f-m	fi (moist)	-	-	-	-	many Fe & Mn conc. (0.2-0.5cm ; 50%), decomposing rock inclusion
	90-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rock (sand stone)
Kp-13	0-13	7.5YR2/1	7.5YR5/1	SL-L	m	cr	f-m	sh (dry)	-	-	-	-	few fine Fe & Mn conc. (5%)
	13-29	7.5YR3/2	7.5YR6/2	gravel, SL	m	sbk	f-m	sh (dry)	-	-	-	-	abundant fine-medium Fe & Mn conc. (0.2-0.5cm ; 50%)
	19-85	7.5YR5/3	7.5YR8/2	-	-	-	-	-	-	-	-	-	dominant fine-medium Fe & Mn conc. (0.2-0.5cm ; 90%)
	85-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rocks + Fe & Mn conc.
Kp-14	0-5	2.5YR3/2 (70%), 7.5YR6/8 (30%)	-	CL	m-s	sbk	f-m	h-vh (dry)	m	f-m	d	7.5YR6/8	
	5-30	10YR4/3 (80%), 5YR4/8 (20%)	-	C	s	pr-co-abk	m-c	eh (dry)	c	f-m	f-d	5YR4/8	few fine-medium Fe & Mn conc. (5%)
	30-52	5Y4/2 (75%), 7.5YR5/8 (25%)	-	C	s	pr-abk	c	vh-eh (dry)	c	f-m	f	7.5YR5/8	common fine-medium Fe & Mn conc. (5-10%)
	52-80	5Y5/4 (80%), 2.5Y6/8 (80%)	-	gravel, C	s	abk	m-c	vfi (moist)	c	f-m	f	2.5Y6/8	common fine-medium Fe & Mn conc. (10%)
	80-120+	5Y6/2 (20%), 5Y6/4 (60%), 7.5YR5/8 (20%)		gravel, C		massive		vfi (moist)	c	f	f	7.5YR5/8	common medium-caorse soft & hard Fe & Mn conc., quartz gravel
Kp-15	0-10	7.5YR2/1		L-CL	m-s	sbk-cr	f-m	h (dry)	-	-	-	-	few fine-medium Fe & Mn conc. (0.1-0.3cm ; 5%)
	10-38	7.5YR2/1		gravel, L	vw	sbk	f-m	s (dry)	-	-	-	-	abundant fine-medium Fe & Mn conc. (0.1-0.3cm ; 50%)
	38-85	2.5Y7/2 (60%), 7.5YR6/8 (10%), 10YR1.7/1 (10%), 2.5Y6/6 (10%)		gravel, C	s	pr-co-abk	m-c	vh (dry)	c	c	f-d	2.5Y6/6	abundant f-c Fe & Mn conc. (0.2-2cm 70%), common decomposing rock accumulation of Mn soft conc in 70-75 cm
	85-100+	-	-	C	-	-	-	-	-	-	-	-	decomposing rock
Kp-16	0-12	7.5YR2/1 (50%), 5YR4/6 (50%)	7.5YR3/1 (50%), 5YR5/8 (50%)	L	w	cr	f-m	s-sh (dry)	-	-	-	-	abundant burned root residue (red ; 5YR4/6)
	12-50	7.5YR3/2	7.5YR4/2	gravel, L	single grain			lo (moist)	-	-	-	-	dominant fine-medium Fe & Mn conc. (80-90%)
	50-100	2.5Y7/2 (60%), 7.5YR5/8 (40%)		gravel, C	s	abk-sbk	m-c	fr (moist)	m	m-c	d	7.5YR5/8	dominant fine-medium Fe & Mn conc. (80%), decomposing rock
	100-120+	-	-	-	-	-	-	-	-	-	-	-	decomposing rock

Table C-1 General Description of Soil Profile

Location No.	Depth of Horizon	Color: wet (moist)	Color: dry	Texture	Structure: grade	Structure: type	Structure: size	Consistence	Mottling: abundance	Mottling: size	Mottling: contrast	Mottling: color	Remarks
Man-1	0-2	-	-	-	-	-	-	-	-	-	-	-	accumulation of organic matter
	2-5	2.5Y4/2	-	C	m	cr	f	s, p (wet)	-	-	-	-	-
	5-13	5Y4/1 (80%), 10YR4/6 (20%)	-	C	m	sbk	f-m	s, p (wet)	c	f	f	10YR4/6	root channel mottle
	13-30	10Y5/1 (70%), 5YR5/8 (30%)	-	C	w-m	sbk	f-m	s, p (wet)	c-m	m	d-p	5YR5/8	-
	30-50	10YR6/1 (50%), 7.5YR5/8 (50%)	-	C	m	sbk	f-m	s, p (wet)	m	m-c	f-d	7.5YR5/8	-
	50+	-	-	-	-	-	-	-	-	-	-	-	groundwater table at 50 cm
Man-2	0-5	2.5Y3/1	2.5Y4/1 (70%), 2.5Y3/2 (30%)	C	m-s	sbk	f-m	fi (moist)	-	-	-		
	5-15	5Y3/1 (80%), 7.5YR4/6 (20%)	-	C	m	sbk	f-m	fi (moist)	c	f	f	7.5YR4/6	
	15-26	2.5Y5/2 (60%), 10YR5/8 (30%), 10YR4/1 (10%)		C	m-s	sbk	m-c	s, p (wet)	c-m	m	f	10YR5/8	few fine - medium Mn conc. (>5%)
	26-35+	10YR6/3 (80%), 7.5-10YR5/8 (50%)	-	SCL	-	massive	-	s, p (wet)	m	m	f-d	7.5YR5/8	few Mn & Fe conc. (0.1-0.5cm : 5%), groundwater at 25cm)
Man-3	0-13	7.5YR4/2	7.5YR6/2	L	s	sbk	m	vh (dry)	f	f	f	7.5YR4/6	
	13-30	7.5YR4/6	7.5YR5/6	SCL	s	sbk	m	vh (dry)	f	f	f	7.5YR4/6	few fine Mn soft conc.
	30-70	7.5YR4/6 (50%), 7.5YR5/8 (50%)	-	SCL	m-s	sbk	f-m	fi-vfi (moist)	-	-	-	-	common clay ill , common Mn mottle&conc. (0.2cm:15%)
	70-110+	7.5YR4/6 (50%), 7.5YR5/8 (50%)	-	SCL	w-m	sbk	f-m	fr (moist)	-	-	-	-	common clay ill ,
													common fine- coarse Mn conc (0.1-1.0cm:10%)
Man-4	0-8	5YR3/3.5	5YR5/4	L-CL	s	sbk	f-m	vh (dry)	-	-	-	-	
	8-32	2.5YR4/6	2.5YR5/6	C	m-s	sbk	f-m	vh (dry)	-	-	-	-	
	32-55	2.5YR3/6	2.5YR5/6	gravel, C		single grain		-	-	-	-	-	abundant Quartz gravel (1-3cm : 70%)
	55-100	2.5YR4/8	2.5YR5/6	gravel, C	m-s	sbk	f-m	vh (dry)	-	-	-	-	many Quartz gravel (0.1-0.5cm : 20%)
	100-120+	2.5YR4/6	2.5YR5/6	C	s	sbk	f-m	vh (dry)	-	-	-	-	common clay ill.
Man-5	0-7	2.5Y3/3	2.5Y6/2.5	SL	m	sbk	f-m	h (dry)	f	f	f	10YR4/6	root channel mottle
	7-16	2.5Y4/3	2.5Y6/2.5 (50%), 2.5Y5/2 (50%)	SL	m	sbk	m-c	h (dry)	f	f	f	7.5YR5/8	root channel mottle
	16-37	10YR7/3 (70%), 7.5YR6/8 (30%)	10YR7/3 (70%), 7.5YR6/8 (30%)	SCL	s	sbk	m-c	vh (dry)	m	f-m	f-d	7.5YR6/8	
	37-50	2.5YR6/2 (40%), 2.5-7.5YR6/8 (60%)	-	gravel, SCL	s	sbk	f-m	vh (dry)	c-m	f-m	f-d	7.5YR5/8	abundant Mn mottle & conc. (1cm ; 50%)
	50-63	10YR6/3 (40%), 10YR6/8 (40%), 10YR5/2 (20%)		gravel, SC	m-s	sbk-abk	f-m	vh (dry)	m	m-c	f-d	10YR6/8	common clay ill. 10YR5/2, common Fe & Mn conc. (10%)
	63-84	10YR6/3 (30%), 10YR6/8 (30%), 10YR5/2 (40%)		gravel, C	m	sbk-abk	f-m	h (dry)	c-m	f-m	f-d	10YR6/8	many clay ill. 10YR5/2, many Fe & Mn conc.
	84-120+	10YR7/3 (40%), 10YR6/8 (40%), 5YR4/8 (20%)		gravel, C	w-m	sbk	f-m	fr (moist)	m	m	f-d	10YR6/8	common Fe & Mn conc (10%)
												5YR4/8	
Ma-6	0-10	10YR3/1	10YR6/1	SL	m	cr	f	s (dry)	-	-	-	-	
	10-20	10YR3/2	10YR4/2	C. SL	m	sbk	f-m	h (dry)	-	-	-	-	
	20-70	10YR4/3	10YR6/2 (80%), 10YR5/8 (20%)	C. SL	m	sbk	m	h (dry)	c	f-m	f	10YR5/8	
	70-100	10YR6/6 (40%), 10YR5/8 (40%), 10YR5/3 (20%)		SCL	m	abk-sbk	m	vh (dry)	f	m	f-d	10YR5/8	common clay ill. 10YR5/3
	100-120+	10YR6/6 (40%), 10YR5/8 (10%), 10YR5/3 (50%)		SCL	m	abk-sbk	f-m	fr-fi (moist)	f & c	f & m	f & d	10YR5/8	common-many clay ill. 10YR5/3
												2.5YR3/6	
Mn-7	0-15	2.5Y4/2	2.5Y4/2 (50%), 2.5Y6/2 (50%)	SL	m	cr-sbk	f-m	sh (dry)	-	-	-	-	
	15-35	2.5Y4/3	2.5Y4/3 & 2.5Y6/3	SL	m	sbk	f-m	h (dry)	f	f	f	10YR5/8	
	35-60	2.5Y5/3	2.5Y6/4 (50%), 2.5Y5/3 (50%)	SL	m	sbk	f-m	fr (moist)	f	f	f	10YR5/8	
	60-100	2.5Y6/6 (80%), 10YR5/2 (20%)	-	SCL	m	sbk	m	fr (moist)	f	n	d	5YR5/8	common clay ill. 10YR5/2
	100-120+	2.5Y6/6 (40%), 10YR5/2 (40%), 5YR4-6/8		SCL	m	sbk-abk	f-m	fr (moist)	c	c	d-p	10YR4-6/8	few Mn conc. (0.1cm : 2%)
Mn-8	0-5	10YR2.5/2	10YR3/2	gravel, SL		single grain		-	-	-	-	-	abundant quartz gravel (0.1-3cm : 70%)
	5-20	10YR4/2	-	gravel, SL		single grain		-	-	-	-	-	abundant quartz gravel (0.1-5cm : 80%)
	20-50	5YR5/8	-	gravel, CL		massive		-	-	-	-	-	abundant quartz gravel (0.1-5cm : 60%)
	50-85	5YR5/8	-	gravel, CL		massive		-	-	-	-	-	many quartz gravel (20%), abundant Fe conc. (60%)
	85-120+	5YR5/8	-	-									composing rock
Mn-9	0-14	2.5YR3/2	2.5YR3/2.5	C	s	sbk	f-m	vh (dry)	-	-	-	-	
	14-64	2.5YR3/6	-	gravel, C		massive		-	-	-	-	-	abundant quartz gravel (0.2-5cm)
	64-110	2.5YR3.5/6	-	gravel, C		massive		-	-	-	-	-	many quartz gravel (0.2-5cm) & Many Fe conc., few clay ill.
	110-120+	2.5YR3/6	-	C		massive		-	-	-	-	-	few quartz gravel (0.2-5cm) & few Fe conc.
Mn-10	0-15	10YR3/2	10YR4/2	SL	m-s	sbk	f-m	h (dry)	-	-	-	-	
	15-35	7.5YR4/3	7.5YR5/6	SL	m	sbk	f-m	vh (dry)	-	-	-	-	
	35-70	5YR3/4 (80%), 5YR2/1 (20%)	-	CL	m	sbk	f-m	vh (dry)	-	-	-	-	few clay ill , common Mn conc. (0.1 cm)
	70-90	5YR4/8	-	CL	m-s	sbk-abk	m	vh (dry)	-	-	-	-	common Mn conc. (0.1cm), common clay ill. 7.5YR4/4
	90-120+	5YR4/8	-	SCL-CL	m-s	sbk-abk	m	vh (dry)	-	-	-	-	many Mn conc. (0.1cm), common clay ill. 7.5YR4/4
Mn-11	0-5	7.5YR4/3	7.5YR5/3	SL	s	sbk	f-m	h (dry)	-	-	-	-	
	5-18	5YR4/6	5YR5/3 (50%), 5YR4/6 (50%)	CL	s	sbk	f-m	h (dry)	-	-	-	-	
	18-60	5YR3/6	5YR3/6 (60%), 5YR4/6 (40%)	CL	s	sbk-abk	m-c	h (dry)	-	-	-	-	common clay ill , few quartz gravel (5%), few Mn conc.
	60-100	5YR3/6	5YR3/6 (50%), 5YR4/6 (50%)	gravel, C	s	sbk-abk	f-m	h (dry)	-	-	-	-	common clay ill., many quartz gravels & Mn conc. (20%)
	100+												abundant quartz gravels
Mn-12	0-5	10YR2/1	-	-	-	-	-	-	-	-	-	-	
	5-15	10Y4/1	-	C		massive		vs, vp (wet)	f	f	f		
	15+	10GY7/1	-	C		massive		vs, vp (wet)					groundwater table at 15 cm
Ok-1	0-10	10YR2/1	10YR2/1 (80%), 7.5YR4/6 (20%)	SiCL	m	cr	f-m	fi (moist)	c	f	f	7.5YR4/6	
	10-38	10YR4/2	10YR4/2 &5/2 (80%), 7.5YR4/6 (20%)	SiCL	m	sbk	f-m	fi (moist)	c	f-m	f	7.5YR4/6	common fine-medium soft Mn conc.
	38-70	10YR5/2 (60%), 7.5YR4/6 (40%)	-	C	m	sbk	m-c	fr (moist)	m	f-m	f	7.5YR4/6	few fine-medium soft Mn conc.
	70-120+	2.5Y5/2 (30%), 10YR5/8 (70%)	-	C	m	sbk	m-c	s, p (wet)	m	m-c	f	10YR5/8	few fine-medium soft Mn conc.
Ok-2	0-10	10YR3/2	-	CL	s	sbk	s-m	fi (moist)	f	f	f	10YR4/6	few fine-medium Mn conc.
	10-22	10YR2.5/2	-	C	s	sbk	m	fi (moist)	c	f	f	7.5YR4/6	few fine-medium Mn conc.
	22-50	10YR5/2 (35%), 7.5YR4/6 (35%), 10YR1.7/1 (30%)		gravel, C	s	sbk-abk	m-c	fi (moist)	m	m	f-d	7.5YR4/6	abundant medium coarse Mn conc (60%)
	50-65	2.5Y5/2 (40%), 7.5YR4/6 (40%), 10YR1.7/1 (20%)		gravel, C	s	abk	m-c	fi (moist)	m	m	f	7.5YR4/6	many fine-medium Mn conc. (30%)
	65-120+	2.5Y5/2 (35%), 7.5YR4/6 (35%), 10YR1.7/1 (30%)		gravel, C	s	abk	m-c	fi (moist)	-				abundant fine-medium Mn conc. (50%), few Ca conc. (0.1 cm)
Ok-3	0-20	10YR2/2	10YR2/2 (70%), 7.5YR4/6 (30%)	C. SL	w	sbk	f-m	fr (moist9	c	f	f	7.5YR4/6	
	20-35	10YR4/4	-	gravel, SL		massive		ss, sp (wet)	f	f	f	7.5YR4/6	abundant fine-medium quartz gravels (60-80%)
	35-55	2.5YR6/3 (35%), 7.5Y5/8 (30%), 5YR4/8 (35%)		gravel, C		massive		s, p (wet)	m	m-c	f-d	5Y4/8	abundant medium quartz gravels (1-5cm : 70%)
	55-85	2.5YR7/2 (50%), 2.5YR4/6 (50%)	-	C		massive		s, p (wet)	m	m	d-p	2.5YR4/6	composing rocks
	85+	-	-										
Ok-4	0-10	2.5Y3/1	2.5Y3/1	C	m	sbk	m	vfi (moist)	c	f	f	7.5YR4/6	root channel mottles
	10-25	5Y4/1	2.5Y3/1 (80%) 7.5YR4/6 (20%)	C	m	sbk	m-c	s, p (wet)	c-m	m-c	f-d	7.5YR4/6	
	25-60	5Y5/1 (70%), 7.5YR4/6 (30%)	-	C		massive		s, p (wet)	c-m	f-m	f-d	7.5YR4/6	
	60-120+	7.5Y5/1 (80%), 7.5YR4/6 (20%)	-	C		massive		s, p (wet)	c	f-m	f-d	7.5YR4/6	

Table C-2 Result of Soil Laboratory Analysis

Project	Sample ID	Layer	Particle size			Texture	pH (H2O)	EC (1:5)	Org.-C	Tot -N	C/N	Ava.-P	CEC	changeable Cations (me/10(				BSP
			Sand	Silt	Clay		(1:2.5)	(uS)	(%)	(%)		(ppm)		Ca	Mg	K	Na	(%)
Ashaiman	As-1	0-20	79.8	7.8	12.8	LS	6.7	42	1.48	0.06	24.7	3.6	24.6	3.50	1.16	0.09	0.16	20.0
Ashaiman	As-1	20-40	88.7	3.9	7.4	LS	7.5	33	0.19	0.03	6.3	2.0	18.2	0.74	0.57	0.19	0.17	9.2
Ashaiman	As-1	60-80	45.1	11.3	43.6	SC	8.2	171	0.06	0.01	6.0	1.2	49.2	7.23	0.32	0.16	2.15	20.0
Ashaiman	As-2	0-20	45.1	28.8	26.1	L	6.2	243	1.31	0.1	13.1	4.6	32.6	6.87	4.34	0.17	0.80	37.3
Ashaiman	As-2	40-60	23.0	38.8	38.6	CL	6.3	196	0.73	0.09	8.1	2.1	40.1	8.20	5.21	0.20	0.86	36.1
Ashaiman	As-2	80-100	58.3	19.3	22.4	SCL	6.6	241	1.13	0.06	18.8	4.7	28.2	5.53	4.44	0.26	0.61	38.4
Ashaiman	As-3	0-20	81.9	4.5	13.6	LS	6.2	28	0.56	0.06	9.3	449.0	15.0	1.88	1.11	0.08	0.10	21.1
Ashaiman	As-3	40-60	63.1	3.3	33.6	SCL	6.7	66	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-3	80-100	46.8	7.1	46.1	SC	7.1	180	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-4	0-20	29.0	23.6	47.4	C	7.5	130	1.05	0.09	11.7	1.3	32.5	15.81	6.78	0.43	0.60	72.7
Ashaiman	As-4	40-60	26.7	19.7	53.6	C	8.1	153	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-4	80-100	20.0	11.4	68.6	C	8.5	452	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-5	0-20	26.0	37.9	36.1	CL	7.6	192	1.18	0.09	13.1	18.1	25.0	7.86	5.22	0.61	0.37	56.2
Ashaiman	As-5	40-60	20.2	37.7	41.1	C	7.6	389	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-5	80-100	18.1	33.3	48.6	C	8.2	203	-	-	-	-	-	-	-	-	-	-
Ashaiman	As-6	0-20	50.2	21.1	28.6	SCL	6.4	157	1.40	0.13	10.8	13.6	33.0	5.95	5.47	0.49	0.58	37.8
Ashaiman	As-6	40-60	30.0	28.9	41.1	CL	6.1	913	0.64	0.05	12.8	1.5	29.9	6.87	6.38	0.15	2.62	53.6
Ashaiman	As-6	80-100	35.0	25.2	39.9	CL	7.5	1942	0.51	0.04	12.8	2.0	36.5	8.12	6.56	0.14	3.36	49.9
Aveyime	Av-1	0-20	73.2	4.3	22.5	SCL	5.2	498	1.18	0.14	8.4	1.0	28.0	1.71	0.82	0.27	0.25	10.9
Aveyime	Av-1	20-40	54.8	10.2	35.0	SCL	5.5	715	0.41	0.1	4.1	0.4	37.2	2.69	0.58	0.05	0.79	11.0
Aveyime	Av-1	60-80	63.0	3.3	33.8	SCL	8.4	1161	0.22	0.04	5.5	0.4	42.2	6.00	0.72	0.05	2.17	21.2
Aveyime	Av-2	0-20	31.4	33.6	35.0	CL	4.9	270	1.44	0.13	11.1	0.6	39.0	2.25	2.12	0.36	0.28	12.8
Aveyime	Av-2	40-60	12.0	29.3	58.8	C	5.1	237	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-2	80-100	11.5	32.3	56.3	C	5.1	705	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-3	0-20	34.5	31.8	33.8	CL	5.4	491	1.09	0.14	7.8	2.1	39.0	3.62	2.40	0.05	0.42	16.6
Aveyime	Av-3	40-60	24.6	25.4	50.0	C	6.0	891	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-3	80-100	36.4	24.9	38.8	CL	6.5	1181	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-4	0-20	37.2	24.1	38.8	CL	5.5	755	0.96	0.12	8.0	0.6	44.1	2.62	2.28	0.08	1.96	15.7
Aveyime	Av-4	40-60	44.5	20.5	35.0	CL	6.3	225	0.41	0.06	6.8	0.3	55.6	3.35	2.53	0.05	4.56	18.9
Aveyime	Av-4	80-100	52.5	16.3	31.3	SCL	7.6	216	0.16	0.05	3.2	0.2	37.5	2.80	2.47	0.05	5.00	27.5
Aveyime	Av-5	0-20	14.8	30.3	55.0	C	5.1	615	0.80	0.07	11.4	0.5	47.5	3.97	7.38	0.26	0.77	26.0
Aveyime	Av-5	40-60	55.5	14.6	30.9	SCL	5.7	1378	0.13	0.04	3.3	0.4	35.8	2.27	3.72	0.08	1.96	22.5
Aveyime	Av-5	80-100	57.5	17.5	25.0	SCL	5.8	183	0.10	0.04	2.5	0.4	43.5	2.06	3.43	0.05	4.78	23.7
Aveyime	Av-6	0-20	6.9	43.1	50.0	C	4.8	452	2.27	0.12	18.9	0.4	36.3	3.65	3.00	0.40	0.77	21.5
Aveyime	Av-6	40-60	8.6	31.5	60.0	C	5.0	405	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-6	80-100	17.5	16.3	66.3	C	4.9	805	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-7	0-20	91.6	1.0	7.5	S	6.3	477	0.32	0.03	10.7	2.2	42.1	0.64	0.33	0.09	0.03	2.6
Aveyime	Av-7	40-60	88.3	0.4	11.3	LS	6.1	67	0.22	0.02	11.0	0.6	26.0	0.57	0.28	8.50	0.13	36.4
Aveyime	Av-7	80-100	74.0	1.0	25.0	SCL	5.4	97	0.16	0.02	8.0	0.5	16.4	1.75	1.07	0.30	0.05	19.3
Aveyime	Av-8	0-20	88.0	0.8	11.3	LS	6.2	239	0.48	0.05	9.6	7.7	28.4	1.40	0.50	0.11	0.04	7.2
Aveyime	Av-8	40-60	72.7	2.3	25.0	SCL	6.0	364	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-8	80-100	75.8	0.5	23.8	SCL	5.4	222	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-9	0-20	11.1	43.9	45.0	SiC	5.1	321	1.95	0.1	19.5	1.3	47.9	3.97	4.20	0.24	0.41	18.4
Aveyime	Av-9	40-60	1.2	31.3	67.5	C	5.1	1407	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-9	80-100	1.2	36.3	62.5	C	4.8	515	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-10	0-20	89.4	0.6	10.0	LS	6.5	206	0.54	0.04	13.5	2.5	24.8	1.39	0.60	0.31	0.03	9.4
Aveyime	Av-10	40-60	88.5	0.3	11.3	LS	6.2	102	-	-	-	-	-	-	-	-	-	-
Aveyime	Av-10	80-100	80.7	0.6	18.8	SL	5.5	116	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-1	0-20	22.3	37.4	40.4	C	6.0	25	2.78	0.12	23.2	2.0	43.0	9.87	6.50	0.09	0.12	38.5
Kpando-T.	Kp-1	20-40	27.9	24.2	47.9	C	6.3	14	1.05	0.08	13.1	1.1	38.2	9.03	6.56	0.08	0.34	41.9
Kpando-T.	Kp-1	60-80	21.1	26.1	52.9	C	7.7	63	0.48	0.04	12.0	0.5	40.1	10.34	5.57	0.03	0.53	41.1
Kpando-T.	Kp-2	0-20	40.0	37.1	22.9	L	5.8	10	2.97	0.14	21.2	1.0	33.7	6.20	5.13	0.07	0.17	34.3
Kpando-T.	Kp-2	40-60	28.1	19.0	52.9	C	5.3	19	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-2	80-100	40.9	16.2	42.9	C	5.5	15	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-3	0-20	26.2	45.9	27.9	CL	6.3	44	3.18	0.21	15.1	2.0	28.8	13.65	6.72	0.15	0.19	72.0
Kpando-T.	Kp-3	40-60	30.3	28.1	41.6	C	5.7	13	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-3	80-100	40.4	19.2	40.4	C	6.7	15	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-4	0-20	51.7	27.9	20.4	L	6.0	19	3.22	0.12	26.8	1.5	22.1	4.31	3.54	0.09	0.03	36.0
Kpando-T.	Kp-5	0-20	45.8	30.0	24.1	L	6.2	29	2.55	0.14	18.2	0.8	38.9	8.93	4.93	0.11	0.05	36.0
Kpando-T.	Kp-6	0-20	31.6	44.3	24.1	L	6.6	30	3.51	0.2	17.6	0.8	28.4	5.47	5.47	0.13	0.04	39.2
Kpando-T	Kp-7	0-20	79.7	9.9	10.4	LS	6.9	12	0.61	0.06	10.2	4.1	15.1	0.75	0.75	0.08	0.02	10.6
Kpando-T.	Kp-7	40-60	67.7	9.2	22.9	SCL	4.9	6	0.29	0.06	4.8	0.9	94.0	0.81	0.81	0.08	0.08	1.9
Kpando-T.	Kp-7	80-100	55.2	12.0	32.9	SCL	5.2	3	0.38	0.05	7.6	0.7	41.6	1.56	1.56	0.06	0.06	7.8
Kpando-T.	Kp-8	0-20	82.8	7.0	10.4	LS	6.6	20	0.57	0.06	9.5	5.6	14.4	0.63	0.63	0.07	0.02	9.4
Kpando-T.	Kp-8	40-60	83.5	7.3	9.1	LS	6.9	6	-	-	-	-	-	-	-	-	-	-
Kpando-T	Kp-8	80-100	82.7	4.5	12.9	LS	6.5	5	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-9	0-20	84.8	7.4	7.9	LS	5.4	9	0.73	0.06	12.2	1.7	14.6	0.98	0.19	0.10	0.05	9.0
Kpando-T.	Kp-9	40-60	89.9	4.7	5.4	S	5.7	2	0.13	0.03	4.3	1.6	12.4	0.22	0.06	0.05	0.02	2.8
Kpando-T.	Kp-9	80-100	86.2	5.9	7.9	LS	7.4	6	0.03	0.02	1.5	1.1	13.2	0.15	0.08	0.05	0.01	2.2
Kpando-T.	Kp-10	0-20	56.8	24.9	15.4	SL	5.9	15	1.72	0.1	17.2	1.9	20.6	4.70	3.51	0.15	0.04	40.8
Kpando-T.	Kp-11	0-20	57.8	28.1	14.1	SL	5.8	66	2.65	0.13	20.4	1.8	20.0	5.55	3.40	0.19	0.06	46.0
Kpando-T.	Kp-12	0-20	43.0	39.1	17.9	L	6.2	87	2.23	0.14	15.9	12.5	20.6	6.41	3.41	0.26	0.07	49.4
Kpando-T.	Kp-12	40-60	36.9	30.2	32.9	CL	5.3	66	-	-	-	-	-	-	-	-	-	-
Kpando-T.	Kp-13	0-20	46.8	36.5	16.6	L	5.2	61	2.55	0.15	17.0	1.8	39.6	4.95	3.51	0.08	0.04	21.7
Kpando-T.	Kp-14	0-20	47.3	29.8	22.9	L	5.2	62	1.53	0.13	11.8	2.2	25.4	5.04	4.19	0.08	0.46	38.5
Kpando-T.	Kp-14	40-60	41.2	23.5	35.4	CL	8.2	300	0.32	0.06	5.3	1.0	25.7	6.20	6.29	0.07	4.78	67.5
Kpando-T.	Kp-14	80-100	31.8	15.3	52.9	C	8.9	482	0.24	0.05	4.8	0.8	32.2	7.64	6.59	0.05	7.61	68.1
Kpando-T	Kp-15	0-20	49.8	34.8	15.4	L	6.8	86	3.03	0.17	17.8	2.8	24.5	11.67	3.49	0.12	0.1	62.9
Kpando-T.	Kp-16	0-20	45.5	30.4	24.1	L	5.1	54	2.39	0.15	15.9	0.7	30.4	6.82	4.10	0.15	0.14	36.9

Table C-2 Result of Soil Laboratory Analysis

Project	Sample ID	Layer	Particle size			Texture	pH (H2O) (1:2.5)	EC (1:5) (uS)	Org.-C (%)	Tot -N (%)	C/N	Ava.-P (ppm)	CEC	changeable Cations (me/10				BSP (%)
			Sand	Silt	Clay									Ca	Mg	K	Na	
Mankessin	Man-1	0-20	15.8	31.8	55.4	C	4.6	218	3.19	0.21	15.2	1.6	23.0	1.82	2.04	0.20	0.50	19.8
Mankessin	Man-1	20-40	15.0	33.9	51.1	C	5.1	62	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-2	0-20	32.7	23.7	43.6	C	5.5	72	3.93	0.3	13.1	7.8	49.3	4.23	3.28	0.53	0.31	17.0
Mankessin	Man-2	20-40	39.3	19.5	41.1	C	5.7	31	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-3	0-20	61.2	16.5	22.4	SCL	5.8	45	0.80	0.08	10.0	2.4	15.0	0.95	1.08	0.30	0.09	16.1
Mankessin	Man-3	40-60	40.3	13.6	46.1	C	5.9	48	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-3	80-100	38.1	17.1	44.9	C	4.8	47	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-4	0-20	48.1	21.6	30.4	SCL	5.4	45	1.47	0.14	10.5	1.6	49.0	1.21	1.53	0.41	0.07	6.6
Mankessin	Man-4	40-60	33.4	16.2	50.4	C	4.5	38	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-4	80-100	28.3	26.3	45.4	C	4.8	38	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-5	0-20	63.9	19.5	16.6	SL	5.3	31	0.96	0.09	10.7	13.6	14.1	0.61	0.49	0.28	0.04	10.1
Mankessin	Man-5	40-60	47.1	17.5	35.4	SCL	4.6	138	0.26	0.04	6.5	1.8	34.6	0.41	0.19	0.14	0.05	2.3
Mankessin	Man-5	80-100	37.9	19.2	42.9	C	4.6	28	0.16	0.04	4.0	1.0	23.5	0.29	0.33	0.11	0.05	3.3
Mankessin	Man-6	0-20	74.2	15.4	10.4	SL	6.5	31	0.80	0.07	11.4	7.1	22.9	1.63	0.58	0.44	0.05	11.8
Mankessin	Man-6	40-60	75.2	9.5	15.4	SL	6.0	4	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-6	80-100	48.6	9.8	41.6	C	5.0	28	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-7	0-20	69.9	17.2	12.9	SL	5.2	94	0.45	0.05	9.0	2.1	22.8	0.51	0.35	0.07	0.04	4.3
Mankessin	Man-7	40-60	61.2	18.4	20.4	SCL	4.5	10	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-7	80-100	44.7	17.4	37.9	CL	4.6	31	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-8	0-20	58.3	23.9	17.9	SL	5.8	47	2.14	0.19	11.3	2.5	28.4	2.52	2.66	0.36	0.05	19.7
Mankessin	Man-8	40-60	49.4	15.3	35.4	SC	4.3	20	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-8	80-100	35.5	14.2	50.4	C	4.4	20	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-9	0-20	44.2	28.0	27.9	CL	6.0	45	2.30	0.2	11.5	1.9	31.1	3.19	2.33	0.53	0.07	19.7
Mankessin	Man-9	40-60	20.0	24.7	55.4	C	4.9	35	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-9	80-100	20.0	24.7	55.4	C	4.9	27	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-10	0-20	74.9	11.0	14.1	SL	6.5	43	0.80	0.08	10.0	6.4	26.9	1.37	0.96	0.46	0.07	10.6
Mankessin	Man-10	40-60	56.3	13.4	30.4	SCL	5.2	53	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-10	80-100	51.0	12.4	36.6	SC	5.1	35	-	-	-	-	-	-	-	-	-	-
Mankessin	Man-11	0-20	65.0	22.1	12.9	SL	5.5	22	1.15	0.11	10.5	1.3	12.6	1.02	0.98	0.09	0.04	16.9
Mankessin	Man-11	40-60	49.5	20.2	30.4	SCL	4.8	19	0.51	0.05	10.2	0.5	30.1	0.45	0.66	0.12	0.04	4.2
Mankessin	Man-11	80-100	56.9	12.8	30.4	SCL	5.2	15	0.90	0.05	18.0	0.3	59.3	0.46	0.71	0.51	0.07	3.0
Mankessin	Man-12	0-20	22.1	35.1	42.9	C	4.6	300	3.06	0.05	61.2	1.7	45.0	2.38	2.30	2.55	1.43	19.2
Okyereko	Oky-1	0-20	38.4	37.5	24.1	L	6.0	89	1.36	0.1	13.6	2.1	17.4	3.07	3.77	0.18	0.63	44.0
Okyereko	Oky-1	20-40	28.9	23.3	47.9	C	5.2	154	-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-1	60-80	28.9	24.0	47.1	C	5.4	384	-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-2	0-20	38.4	26.2	35.4	L	5.8	48	2.46	0.18	13.7	4.6	49.1	6.48	5.48	0.55	0.22	25.9
Okyereko	Oky-2	40-60	29.2	27.9	42.9	CL	5.1	146	-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-2	80-100	45.3	16.8	37.9	SCL	4.6	565	-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-3	0-20	75.2	9.5	15.4	SL	6.4	39	0.91	0.08	11.4	1.2	26.6	2.35	2.80	0.18	0.35	21.4
Okyereko	Oky-3	40-60	75.2	4.4	20.4	SCL	6.6	43	-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-3	80-100				-			-	-	-	-	-	-	-	-	-	-
Okyereko	Oky-4	0-20	15.5	34.2	50.4	C	6.5	420	1.79	0.12	14.9	1.4	29.3	5.30	6.00	0.43	1.44	44.9
Okyereko	Oky-4	40-60	1.6	56.8	41.6	SiC	5.2	835	0.41	0.05	8.2	0.6	36.6	4.58	6.02	0.10	2.00	34.7
Okyereko	Oky-4	80-100	1.6	30.6	67.9	C	5.0	959	0.32	0.05	6.4	0.5	59.6	4.25	6.21	0.12	2.13	21.3
Okyereko	surface-1	0-20	74.4	12.7	12.9	SL	4.9	3630	0.80	0.06	13.3	7.3	25.8	2.76	4.98	0.13	3.5	44.1
Okyereko	surface-2	0-20	13.9	44.5	41.6	SiC	6.0	1166	2.17	0.11	19.7	1.9	28.8	4.98	5.73	0.33	2.27	46.2
Ashaiman	surface-1	0-20	48.3	33.8	17.9	L	6.6	2630	1.98	0.17	11.6	14.4	18.3	7.61	4.16	0.24	3.43	82.1
Ashaiman	surface-2	0-20	61.3	18.3	20.4	SCL	7.2	1060	4.12	0.15	27.5	29.6	31.0	5.87	3.76	0.90	2.05	40.6

Table C-3 Mapping Unit Description of the Priority Projects

Scheme	Physiography	Map Unit	Topography	Soil Unit	Slope	Drainage Condition	color	Texture (top-sub)	Depth	others	Local Na
Ashaiman	Old Terrace	U21	middle slope	Dystric Planosols	0 - 2 %	mod. well - imperfect	yellow - olive gray	SL - C	mod. deep	(terrace land), gravel layer	Minya
	(Upland)	U22	middle slope	Cambic Arenosols	0 - 2 %	well - mod. well	brown - yellowish red	LS - LS	deep	(terrace land)	Agozu
		U31	foot slope	Dystric Planosols	0 - 1 %	mod. well - imperfect	grayish yellow - gray	LS - SC	mod. deep	(terrace land)	Agawta
		U32	foot slope	Gleyic Cambisols	0 - 1 %	imperfect	grayish yellow brown	LS - SC	mod deep	surface soil was removed out on land development.	Minya
	Plain	P1	upper plain	Dystric Vertisols	0 - 1 %	poor	black-dark gray	C - C	mod. deep		Ahaima
		P21	lower-flat plain	Dystric Vertisols	0 %	poor - v. poor	black-dark gray	C - C	deep		Bumbi
		P22	lower-flat plain	Dystric Vertisols	0 %	poor - v. poor	black-dark gray	C - C	deep	potential area for salt-affected soils	Bumbi
		P22s	lower-flat plain	Dystric Vertisols (salt effected)	0 %	poor - v. poor	black-dark gray	C - C	deep	salt-affected soil	Bumbi
Aveyme	Levee	U1	upper slope	Ferralic Arenosols	2 - 4 %	well	brown - reddish brown	S - SL	deep		Chichiw
	Plain	P1	foot slope-upper plain	Dystric Cambisols	0 - 1 %	mod. well - imperfect	yellowish brown	SL - SCL	deep		Hake
		P21	flat plain	Dystric Cambisols	0 %	imperfect - poor	yellowish brown	CL - C	deep		Amo
		P22	depressional plain	Gleyic Cambisols	0 - 1 %	poor - v. poor	dark olive - gray	C - C	deep		Amo
	Lake shore	L1	lower slope - lake shore	Distric Vertisols	0 - 2 %	v. poor	black-dark gray	C - C	deep		Tefle
Kpando-Torkor	Hill	H1	Sumit	-	20%	-	-	-	-		-
		H21	upper - middle slope	Skeletic-Vertic Cambisols	2 - 5 %	well	brownish black - yellowish brown	CL - gravel, C	shallow		Dzawa
		H22	middle - lower slope	Skeletic-Vertic Cambisols	2 - 3 %	well	brownish black - reddish brown	CL - gravel, C	mod. deep	accumulation of Fe conc.	Anger
		H3	foot slope	Skeletic-Chromic Cambisols / Skeletic-Gleyic Cambisols	2 - 3 %	imperfect	brownish black - dull yellow	CL - gravel, C	mod. deep	transition soil unit between H2 and L1	Dzawa Takrab
		H4	stream course	Skeletic-Gleyic Cambisols	2 - 3 %	imperfect-poor	brownish black - glay	CL - gravel, C	mod. deep	accumulation of Fe conc. GWT at 100cm	Takrab
	Stream course	R1	river course	Dystric Fluvisols, Cambic Arenosols	0 - 4 %	imperfect - poor	brownish black - dull yellowish brown	S - S	mod. deep	GWT at 100 cm	Kpeyi / A
	Lake shore	L1	lower slope - lake shore	Skeletic-Dystric Gleysols	0 - 2 %	v. poor	brownish black - glay	CL - gravel, C	mod. deep	GWT is high	Torkor
Mankessim	Hill	H1	ridge and higher part of slope	Skeletic-Haplic Alisols	2 - 4 %	well	reddish brown	L - gravel & C	shallow		Swedr
		H21	middle slope	Skeletic-Haplic Alisols	10 %	well	reddish brown	gravel & SL - gravel & SCL	shallow		Nsaba
		H22	middle slope	Skeletic-Haplic Alisols	45 %	-	-	-	-		-
		H31	foot slope	Skeletic-Haplic Alisols	4 - 8 %	well	reddish brown	gravel & SL - gravel & SCL	shallow		Nsaba
		H32	foot slope (bottom)	Skeletic-Haplic Alisols	2 - 3 %	imperfect	yellowish blown	SL - gravel & CL	shallow - mod. deep		-
	Old terrace	T1	upper terrace	Ferric Alisols	5 %	mod well	reddish brown	SL - gravel & CL	shallow - mod. deep		Biaim
	(Old plain)	T2	middle terrace	Ferric Alisols	2 - 4 %	well - mod. well	reddish brown	SL - gravel & CL	mod. deep		Biaim
		T3	lower terrace	Ferric Alisols - Gleyic Cambisols	1 - 2 %	imperfect	reddish brown / yellowish brown	SL - C	mod. deep	transition soil unit between T2 and P21	Biaim Kakum
	Plain	P11	upper plain	Chromic Cambisols	2 - 6 %	well - mod. well	reddish brown	SL - gravel & CL	mod. deep		Biaim
		P12	flat plain	Haplic Cambisols	1 - 2 %	imperfect	brownich black - yellowish brown	SL - SC	deep		-
		P21	alluvial plain	Greyic Cambisols	0 %	poor	yellowish brown	C	deep		Kakum
		P22	alluvial plain	Greyic Cambisols	0 %	poor	yellowish brown - grey	C	deep	GWT at 30cm, sublect seasonal flood	Kakum
		P22	valley bottom	Dystric Gleysols	0 - 1 %	v. poor	grey	C	deep	GWT at 30cm, sublect seasonal flood	Oda
Okyereko	Old terrace	T1	terrace remnant	Skeletic-Haplic Alisols	3 - 4 %	well-mod. well	brownish black - grayish yellow	SL - gravels (C)	shallow	(terrace land), gravel layer	Simpa
	(Upland)	T21	middle-lower slope	Cambic Arenosols	2 -3 %	mod well - imperfect	grayish brown - yelloish brown	SL - gravel & C	deep	(terrace land)	Nta
		T22	middle-lower slope	Haplic Alisols	2 -3 %	mod. well	grayish brown - yelloish brown	SCL - gravel & SC	mod. deep	(terrace land)	Akrosc
	Plain	P21	upper flat plain	Distric Cambisols	0 - 1 %	imperfect	brownish black - grayish yellow	CL - C	deep		Kakum
		P22	lower flat plain	Gleyic Cambisols	0 %	poor	brownish black - gray	C - C	deep	potential area for salt-affected soils	Oyibi
		P22s	lower flat plain	Gleyic Cambisols	0 %	poor	brownish black - gray	C - C	deep	salt-affected soil	Oyibi

Table C-4 Results of Salt Balance Study

1. Ashaiman Project Area

Case 1 : ECe 13.2 mS/cm

(Unit : mS/cm)

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1 st year						
Initial ECe of Soils	13.2	11.7	10.9	6.9	6.0	5.2	4.5	4.2	4.7	4.6	4.6	4.2
ECe of Soils after Irrigation	11.7	10.9	6.9	6.0	5.2	4.5	4.2	4.7	4.6	4.6	4.2	4.0
						2 nd year						
Initial ECe of Soils	4.0	4.0	4.1	2.6	2.4	2.1	1.8	1.7	2.2	2.1	1.7	1.5
ECe of Soils after Irrigation	4.0	4.1	2.6	2.4	2.1	1.8	1.7	2.2	2.1	1.7	1.5	1.5
						3 rd year						
Initial ECe of Soils	1.5	1.4	1.3	0.9	0.8	0.7	0.7	0.6	1.0	1.0	1.0	0.9
ECe of Soils after Irrigation	1.4	1.3	0.9	0.8	0.7	0.7	0.6	1.0	1.0	1.0	0.9	0.9

Case 2 : ECe 16.6 mS/cm

(Unit : mS/cm)

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1 st year						
Initial ECe of Soils	16.6	14.7	13.7	8.7	7.5	6.5	5.7	5.2	5.7	5.7	5.6	5.2
ECe of Soils after Irrigation	14.7	13.7	8.7	7.5	6.5	5.7	5.2	5.7	5.7	5.6	5.2	4.8
						2 nd year						
Initial ECe of Soils	4.8	4.8	5.0	3.2	2.8	2.5	2.2	2.0	2.5	2.4	1.9	1.8
ECe of Soils after Irrigation	4.8	5.0	3.2	2.8	2.5	2.2	2.0	2.5	2.4	1.9	1.8	1.7
						3 rd year						
Initial ECe of Soils	1.8	1.5	1.5	1.0	0.9	0.8	0.7	0.7	1.1	1.1	1.1	1.0
ECe of Soils after Irrigation	1.5	1.5	1.0	0.9	0.8	0.7	0.7	1.1	1.1	1.1	1.0	1.0

2. Okyereko Project Area

Case 1 : ECe 6.8 mS/cm

(Unit : mS/cm)

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1 st year						
Initial ECe of Soils	6.8	5.9	5.6	5.3	4.2	3.6	3.0	2.6	2.4	2.2	1.6	1.5
ECe of Soils after Irrigation	5.9	5.6	5.3	4.2	3.6	3.0	2.6	2.4	2.2	1.6	1.5	1.4
						2 nd year						
Initial ECe of Soils	1.4	1.2	1.2	1.2	1.0	0.9	0.7	0.7	0.6	0.6	0.5	0.5
ECe of Soils after Irrigation	1.2	1.2	1.2	1.0	0.9	0.7	0.7	0.6	0.6	0.5	0.5	0.5
						3 rd year						
Initial ECe of Soils	0.5	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.4
ECe of Soils after Irrigation	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4

Case 2 : ECe 23.0 mS/cm

(Unit : mS/cm)

Description	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
						1 st year						
Initial ECe of Soils	23.0	19.6	18.5	17.6	13.7	11.7	9.9	8.4	7.6	7.1	5.0	4.4
ECe of Soils after Irrigation	19.6	18.5	17.6	13.7	11.7	9.9	8.4	7.6	7.1	5.0	4.4	3.8
						2 nd year						
Initial ECe of Soils	3.8	3.3	3.2	3.0	2.4	2.1	1.8	1.6	1.4	1.3	1.0	0.9
ECe of Soils after Irrigation	3.3	3.2	3.0	2.4	2.1	1.8	1.6	1.4	1.3	1.0	0.9	0.9
						3 rd year						
Initial ECe of Soils	0.9	0.9	0.9	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4
ECe of Soils after Irrigation	0.9	0.9	0.8	0.7	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.5

Table C-5 List of Recommendable Soil Erosion Control Measures

Descriptions	Merits	Demerits
Vegetative Measures		
1. Contour hedgerow (Strip cropping) Vegetative rows or strips established along the contour. Trees serve as live barrier to surface runoff and soil erosion. If the nitrogen fixing crops or trees such as leguminous crops are used, it can improve soil condition.	1. Economical 2. Adaptable to various conditions 3. Easier to establish and repair 4. Durable if maintained properly 5. Improve the soil condition, if nitrogen fixing crops are used	1. It takes some time to attain benefits 2. Less effective when slope is too steep 3. Hedgerows may pose competition with crops
2. Mulching The mulching is the covering of the soil with crop residues such as straw, maize stalks, palm fronds or standing stubbles. The effect of mulching is the reducing of raindrop impact and of the velocity of runoff.	1. Economical 2. Adaptable to various conditions 3. Easier to establish and repair 4. Keeping of soil moisture and temperature 5. Improve the soil condition	1. Application of mulch may be required on each cropping season in tropical area 2. It requires a large amount of grasses (materials) for mulching
3. Agroforestry It is a system to incorporate trees within a farming system by planting them on land.	1. Economically 2. Trees can provide fuels, fodder, fruits, etc. to the farmers.	1. It takes some time to attain benefits 2. Trees may pose competition with crops 3. Less effective when slope is too steep
Structural Measures		
4. Contour bunds They are earth bunds, 1.5 to 2 m wide, thrown across the slope to act as a barrier to runoff, to form a water storage area on their upslope side and to break up a slope into segments shorter in length than is required to generate overland flow. They are frequently used with strip-cropping system.	1. Relatively easier to construct and repair 2. They are suitable for slopes of 1 to 7 degree.	1. The effectiveness is limited when heavy rains continue long. 2. The effectiveness is limited when used in very steep slope.
5. Waterways (Contour Ditches and Drainage Canals) They are digging structures established in the hillsides to check the erosive power of surface runoff by tapping soil particles. Drainage canal (grass waterways) are used as the outlet for contour ditches. It runs downslope and empty into river system or other outlets.	1. Relatively easier to construct and repair 2. Ditches and canals can be good water impoundment structures that can hold water for plants.	1. The effectiveness is limited when heavy rains continue long. 2. The effectiveness is limited when used in very steep slope.
Cultural Measures		
6. Contour Plowing It is a plowing method to create furrows following the contour of the land.	1. It increases water absorption capacity the soil. 2. It also reduces both the quantity and velocity of surface runoff.	1. A bit difficult to plow properly.
7. Contour Planting It is a planting method following the contour of the land. The crops planted act as barriers to the force of surface runoff.	1. Easy to adopt	1. The effect is not high, if only it is adopted .

Table C-6 Land Suitability Criteria for Wetland Rice

Land Characteristics (deficiency categories)	S1	S2	S3	S4	NS1 and NS2
Soil characteristics (s)					NS1
Textures	Topsoil : Fine SL to C Subsoil : C but non-compacted	Topsoil : Fine SL to CL Subsoil : SC to C but non-compacted	Topsoil : SL to CL Subsoil : SCL to CL but non-compacted	Topsoil : Couse SL to SCL Subsoil : SL to SCL	Includes lands which require additional investigations to determine their irrigability
Depth To clear sand or gravels To decomposing rock	over 80 cm less than 80 cm	over 50 cm less than 50 cm	over 30 cm less than 30 cm	over 20 cm -	
Alkalinity (pH)	pH (H2O) less than 7.5 for non-calcareous soils and less than 8.6 for calcareous soils	pH (H2O) less than 9.0 for non-calcareous soils and non-sodic	pH (H2O) less than 9.0 for non-calcareous soils and ESP less than 10 %	pH (H2O) less than 9.0 for non-calcareous soils and ESP less than 15 %	Includes lands which do not meet minimum requirement for the other land classes and not suitable for irrigation.
Salinity (ECe)	Total salts not to exceed 0.2 %, ECe less than 4 mS/cm	Total salts not to exceed 0.5 %, ECe less than 8 mS/cm	Total salts not to exceed 0.5 %, ECe less than 8 mS/cm	Total salts slightly to exceed 0.5 %, ECe less than 16 mS/cm	These includes lands with very shallow soils, excessive concentrations of salts throughout horizons, pH values above 9.0, etc.
Topography (t)					
Slope (%)	Less than 1 %	Less than 1 %	Less than 2 %	Less than 2 %	
Slope (%) (Terrace land)					
Surface (micro-relief)	Smooth except for gilgal and minor undulations	Smooth except for gilgal and minor undulations (sink holes)	Somewhat irregular but no major gulleys, sink holes or dissection	Somewhat irregular but no major gulleys, sink holes or dissection	
Drainability (d)					
Drainage Condition	Well drained to imperfect drained. May have survace water for short periods.	Well drained to poorly drained. May have survace water for several months.	Well drained to extermly poorly drained. May have survace water for major part of the year.	Extermly well to poorly drained. May have survace water for major part of the year.	
Vegetation (v)					
Vegetation	woody covers less than 20 %. Clearing cost small	woody covers less than 40 %. Clearing required but at a moderate cost	woody covers less than 80 %. Expensive clearing cost	woody covers less than 100 %. Expensive clearing cost	

Table C-7 Land Suitability Criteria for Upland Crops

Land Characteristics (deficiency categories)	S1	S2	S3	S4	NS1 and NS2
Soil characteristics (s)					
Textures	Sandy loam to friable clay loam	Sandy loam to very permeable clay, non-compacted	Loamy sand to permeable clay	Gravelly loamy sand to clay	NS1 Includes lands which require additional investigations to determine their irrigability
Depth (s) to sand, gravel	90cm plus and greater than 150 cm to impermeable horizon	60cm plus and greater than 120 cm to impermeable horizon	45cm plus and greater than 100 cm to impermeable horizon	15cm plus and greater than 90 cm to impermeable horizon	
Alkalinity (pH)	pH (H2O) less than 7.5 for non-calcareous soils and less than 8.6 for calcareous soils	pH (H2O) less than 9.0 for non-calcareous soils and non-sodic	pH (H2O) less than 9.0 for non-calcareous soils and ESP less than 10 %	pH (H2O) less than 9.0 for non-calcareous soils and ESP less than 15 %	NS2 Includes lands which do not meet minimum requirement for the other land classes and not suitable for irrigation.
Salinity (ECe)	Total salts not to exceed 0.2 %, ECe less than 4 mS/cm	Total salts not to exceed 0.5 %, ECe less than 8 mS/cm	Total salts not to exceed 0.5 %, ECe less than 8 mS/cm	Total salts slightly to exceed 0.5 %, ECe less than 12 mS/cm	These includes lands with very shallow soils, impermeable soils, excessive concentrations of salts throughout horizons, pH values above 9.0, etc.
Topography (t)					
Slope (%)	Flat to very gently undulating (less than 2%)	Flat to very gently undulating (less than 5%)	Flat to undulating (less than 8%)	Flat to rolling on smooth slope (less than 20%)	
Surface (micro-relief)	Even enough to require only small amounts to levelling and no heavy grading	Moderate grading required but in amount feasible at reasonable cost	Heavy and expensive grading required	Heavy and expensive grading required	
Drainability (d)					
Drainage Condition	Well drained to moderately well drained. No flooding	Well drained to imperfect drained. May have survace water for short periods.	Well drained to poorly drained. May have survace water for several month.	Well drained to extermly poorly drained. May have survace water for several months.	
Vegetation (v)					
Vegetation	woody covers less than 20 %. Clearing cost small	woody covers less than 40 %. Clearing required but at a moderate cost	woody covers less than 80 %. Expensive clearing cost	woody covers less than 100 %. Expensive clearing cost	

Table C-8 Result of Land Evaluation

Project	Map Unit	Soil Unit	Specific Criteria for Paddy					Specific Criteria for Upland Crops					Area
			soil (s)	topo. (t)	drain. (d)	vege. (v)	Class	soil (s)	topo. (t)	drain. (d)	vege. (v)	Class	(ha)
shaiman	U21	Dytric Planosols	3	1	2	1	SR3s	2	1	1	1	S2s	-
	U22	Cambic Arenosols	N1	1	3	1	NSR1	3	1	1	1	S3s	-
	U31	Dytric Planosols	2	1	1	1	SR2s	2	1	2	1	S2sd	15.4
	U32	Gleyic Cambisols	2	1	1	1	SR2s	2	1	2	1	S2sd	-
	P1	Dystric Vertisols	2	1	2	1	SR2sd	3	1	3	1	S3sd	17.6
	P21	Dystric Vertisols	2	1	2	1	SR2sd	3	1	3	1	S3sd	24.4
	P22	Dystric Vertisols	2	1	2	1	SR3d	3	1	3	1	S3sd	1.9
	P22s	Dystric Vertisols	4	1	2	1	SR4s	4	1	3	1	S4	7.7
veyme	U1	Ferric Arenosols	N1	2	3	1	NSR1	3	2	1	1	S3s	25.3
	P1	Dystric Cambisols	3	1	2	1	SR3s	1	1	2	1	S2d	34.6
	P21	Dystric Cambisols	1	1	1	1	SR1	2	1	3	1	S3d	39.5
	P22	Gleyic Cambisols	1	1	2	1	SR2d	3	1	3	1	S3sd	9.0
	LI	Distric Vertisols	2	2	2-3	1	SR3d	3	1	3	1	S3sd	3.5
pando- orkor	H1	-	-	-	-	-	-	4	N2	1	3	NS2	-
	H21	Skeletic-Vertic Cabisols	-	-	-	-	-	4	2	1	2	S4s	198.4
	H22	Skeletic-Vertic Cabisols	-	-	-	-	-	3	2	1	2	S3s	233.0
	H3	Skeletic-Vertic Cambisols / Skeletic Geyic Cambisols	-	-	-	-	-	3	2	2	2	S3s	8.6
	H4	Skeletic-Gleyic Cabisols	-	-	-	-	-	3	2	3	2	S3sd	11.2
	RI	Cambic Arenosols, Dystric Fluvisols	-	-	-	-	-	3	2	2	2	S3s	9.9
	L1	Skeletic Dystric Gleysols	-	-	-	-	-	3	1	3	1	S3sd	-
ankessim	H1	Skeletic-Haplic Alisols	-	-	-	-	-	3	N2	1	3	NS2	-
	H21	Skeletic-Haplic Alisols	-	-	-	-	-	3	4	1	2	S4t	3.3
	H22	Skeletic-Haplic Alisols	-	-	-	-	-	3	N2	1	2	NS2	-
	H31	Skeletic-Haplic Alisols	-	-	-	-	-	3	3	1	2	S3st	9.7
	H32	Skeletic-Haplic Alisols	-	-	-	-	-	3	2	2-3	2	S3sd	6.2
	T1	Ferric Alisols	-	-	-	-	-	3	3	2	1	S3st	-
	T2	Ferric Alisols	-	-	-	-	-	3	2	2	1	S3s	19.6
	T3	Ferric Alisols - Gleyic Cambisols	-	-	-	-	-	3	1	3	1	S3sd	3.5
	P11	Chromic Cambisols	-	-	-	-	-	2	2	1	1	S2st	-
	P12	Haplic Cambisols	-	-	-	-	-	1	1	2	1	S2d	44.1
	P21	Gleyic Cambisols	-	-	-	-	-	2	1	3	1	S3d	9.1
	P22	Gleyic Cambisols	-	-	-	-	-	2	1	4	1	S4d	-
	P3	Dystric Grleysols	-	-	-	-	-	3	1	N1	1	NS1	-
Okyereko	T1	Skeletic-Ferric Alisols	4	2	3	1	SR4s	3	2	1	1	S3s	2.7
	T21	Haplic Alisols	3	2	2	1	SR3s	2-3	2	1	1	S3s	17.1
	T22	Cambic Arenosols	4	1	3	1	SR4s	3	1	2	1	S3s	8.7
	P21	Dystric Cambisols	1	1	1	1	SR1	2	1	2	1	S2sd	33.5
	P22	Gleyic Cambisols	2	1	2	1	SR2sd	3	1	3	1	S3sd	31.7
	P22s	Gleyic Cambisols	4	1	2	1	SR4s	N1	1	3	1	NS1	1.6

Remarks : <1 : The area is the gross area including roads, rivers, canals, etc.

Table C-9 Extent of Land Suitability Class for Wetland Rice and Upland Crops

(1) Wetland Rice (Paddy)

(Unit : ha)

Class	Ashaiman	Aveyime			Okyereko		
		Alter-1	Alter-2	Alter-3	Alter-1	Alter-2	Alter-3
SR1	0.0	34.0	39.5	39.5	13.2	33.5	33.5
SR2	57.4	9.0	9.0	9.0	16.6	20.9	31.7
SR3	1.9	21.5	34.6	38.0	6.8	6.8	17.1
SR4	7.7	0.0	0.0	0.0	9.3	13.0	13.0
NSR	0.0	9.7	11.1	25.3	0.0	0.0	0.0
Total	67.1	74.1	94.1	111.8	45.9	74.1	95.3

Remarks : Area is gross area, including field bund, farm road, etc.

(2) Upland Crops

(Unit : ha)

Class	Ashaiman	Aveyime			Kpando-Torkor							Mankessim		Okyereko		
		Alter-1	Alter-2	Alter-3	Block A		Block B		Block C		Block D	Alter-1	Alter-2	Alter-1	Alter-2	Alter-3
					Low	High	Low	High	Low	High	Low					
S1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S2	15.4	21.5	34.6	34.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	44.1	13.2	33.5	33.5
S3	43.9	52.6	59.6	77.2	7.0	4.7	0.0	0.0	94.4	66.6	90.0	32.2	48.1	31.1	39.0	60.2
S4	7.7	0.0	0.0	0.0	70.7	50.9	34.4	36.7	0.0	5.7	0.0	0.0	3.3	0.0	0.0	0.0
NS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.6	1.6
Total	67.1	74.1	94.1	111.8	77.8	55.6	34.4	36.7	94.4	72.2	90.0	32.2	95.6	45.9	74.1	95.3

Remarks : Area is gross area, including field bund, farm road, etc.

Table C-10 Present Land Use in the Rehabilitation Area

.and Use Categories	Map Unit	Ashaiman Area (ha)	Ashaiman Rate (%)	Aveyime Altanative-1 Area (ha)	Aveyime Altanative-1 Rate (%)	Aveyime Altanative-2 Area (ha)	Aveyime Altanative-2 Rate (%)	Aveyime Altanative-3 Area (ha)	Aveyime Altanative-3 Rate (%)	Mankessim Altanative-1 Area (ha)	Mankessim Altanative-1 Rate (%)	Mankessim Altanative-2 Area (ha)	Mankessim Altanative-2 Rate (%)
. Agricultural land													
1.1 Paddy field (developed)	Pd	65.3	97.4	68.8	92.8	68.8	73.1	68.8	61.6	-	-	-	-
1.2 Paddy field (undeveloped)	Pr	-	-	-	-	0.5	0.5	1.0	0.9	1.4	4.4	1.4	1.5
1.3 Upland crop field (developed)	Ud	0.5	0.7	4.6	6.2	4.6	4.9	4.6	4.1	17.0	52.6	17.0	17.7
1.4 Upland crop field (undeveloped)	Ur	-	-	-	-	2.5	2.6	9.7	8.7	6.1	18.9	25.0	26.1
1.4 Orchard field	O	-	-	-	-	-	-	-	-	0.2	0.7	3.7	3.9
Sub-total		65.8	98.1	73.4	99.0	76.3	81.1	84.1	75.3	24.7	76.7	47.1	49.3
. Non-agricultural land													
2.1 Grassland	G	1.3	1.9	0.5	0.6	1.7	1.8	10.6	9.5	7.2	22.2	40.3	42.1
2.2 Bush, Shrub	B	-	-	-	-	15.0	15.9	15.0	13.4	-	-	1.2	1.2
2.3 Glove	W	-	-	0.3	0.4	0.5	0.6	0.7	0.7	0.3	1.0	7.0	7.3
2.4 Swamps	S	-	-	-	-	0.6	0.7	0.6	0.6	-	-	-	-
2.5 House, others	V	-	-	-	-	-	-	0.7	0.6	-	-	-	-
Sub-total		1.3	1.9	0.7	1.0	17.8	18.9	27.6	24.7	7.5	23.3	48.4	50.7
3round Total		67.1	100.0	74.1	100.0	94.1	100.0	111.8	100.0	32.2	100.0	95.6	100.0

Remarks : Figuers of area indicates the gross area of the land use.

.and Use Categories	Map Unit	Kpando-Torkor Block-A : Low Area (ha)	Block-A : Low Rate (%)	Block-A : High Area (ha)	Block-A : High Rate (%)	Block-B : Low Area (ha)	Block-B : Low Rate (%)	Block-B : High Area (ha)	Block-B : High Rate (%)	Block-C : Low Area (ha)	Block-C : Low Rate (%)	Block-C : High Area (ha)	Block-C : High Rate (%)	Block-D Area (ha)	Block-D Rate (%)
. Agricultural land															
1.3 Upland crop field (developed)	Ud	27.1	34.9	-	-	-	-	-	-	-	-	-	-	-	-
1.4 Upland crop field (undeveloped)	Ur	13.7	17.6	29.2	52.5	2.6	7.5	1.6	4.4	2.2	2.3	8.9	12.3	17.5	19.4
Sub-total		40.8	52.4	29.2	52.5	2.6	7.5	1.6	4.4	2.2	2.3	8.9	12.3	17.5	19.4
2. Non-agricultural land															
2.1 Grassland	G	34.2	43.9	13.4	24.0	-	-	-	-	13.2	14.0	13.9	19.3	67.7	75.2
2.2 Bush, Shrub	B	2.8	3.6	12.7	22.8	31.9	92.5	35.0	95.6	79.0	83.7	49.4	68.4	4.9	5.4
2.3 Glove	W	-	-	0.3	0.6	-	-	-	-	-	-	-	-	-	-
Sub-total		37.0	47.6	26.4	47.5	31.9	92.5	35.0	95.6	92.2	97.7	63.3	87.7	72.5	80.6
3round Total		77.8	100.0	55.6	100.0	34.4	100.0	36.7	100.0	94.4	100.0	72.2	100.0	90.0	100.0

Remarks : Figuers of area indicates the gross area of the land use.

Land Use Categories	Map Unit	Okyereko Altanative-1 Area (ha)	Altanative-1 Rate (%)	Altanative-2 Area (ha)	Altanative-2 Rate (%)	Altanative-3 Area (ha)	Altanative-3 Rate (%)
1. Agricultural land							
1.1 Paddy field (developed)	Pd	43.0	93.7	43.0	58.0	43.0	45.1
1.2 Paddy field (undeveloped)	Pr	-	-	-	-	2.1	2.2
1.3 Upland crop field (developed)	Ud	0.2	0.5	4.1	5.6	5.8	6.1
Sub-total		43.2	94.1	47.1	63.6	50.9	53.4
2. Non-agricultural land							
2.1 Grassland	G	2.3	4.9	26.6	35.8	44.0	46.2
2.2 Glove	W	0.4	0.9	0.4	0.6	0.4	0.5
Sub-total		2.7	5.9	27.0	36.4	44.4	46.6
Ground Total		45.9	100.0	74.1	100.0	95.3	100.0

Remarks : Figuers of area indicates the gross area of the land use.

FIGURES

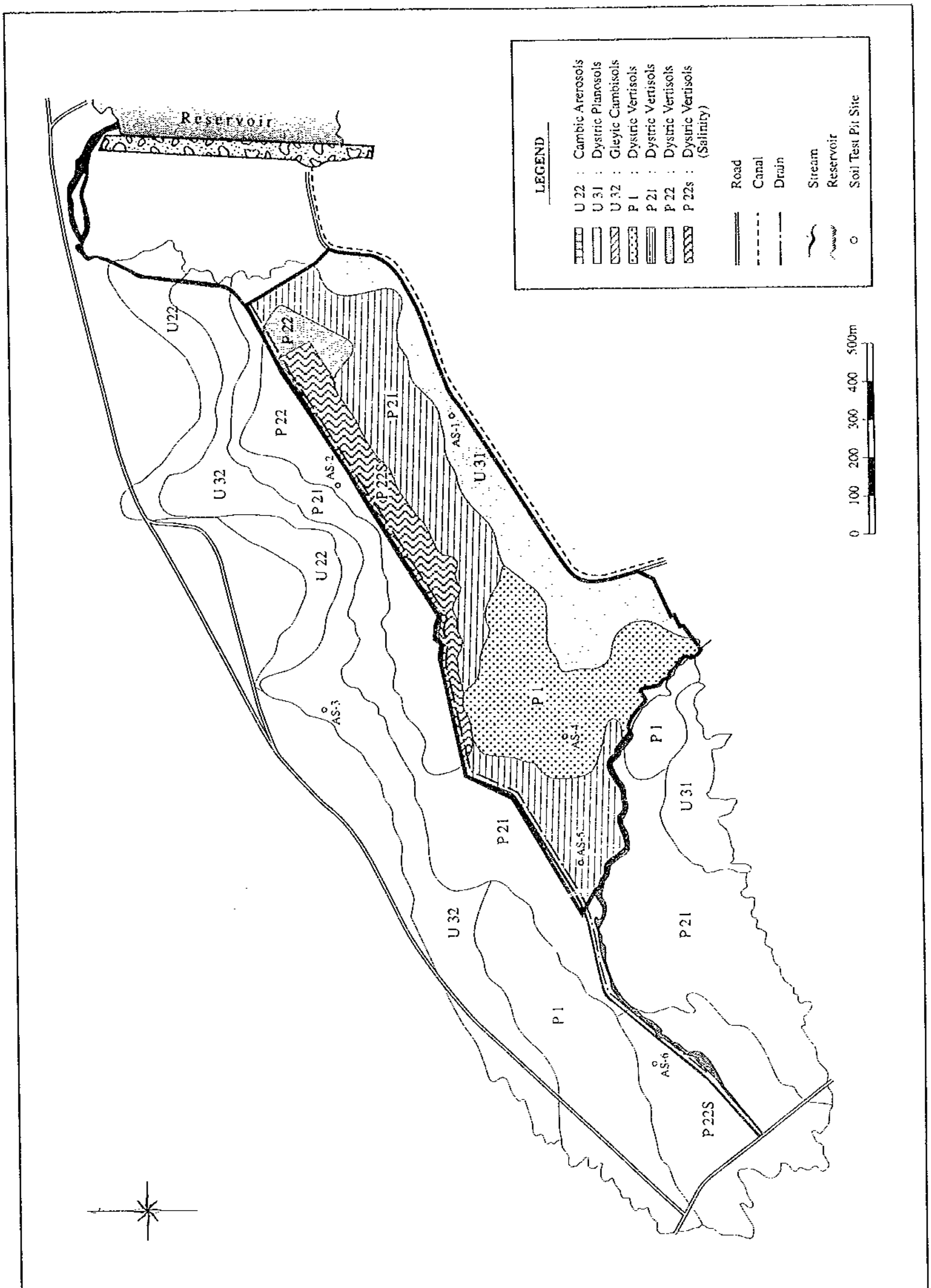


Figure C-1
Soil Map of Ashaiman Project Area

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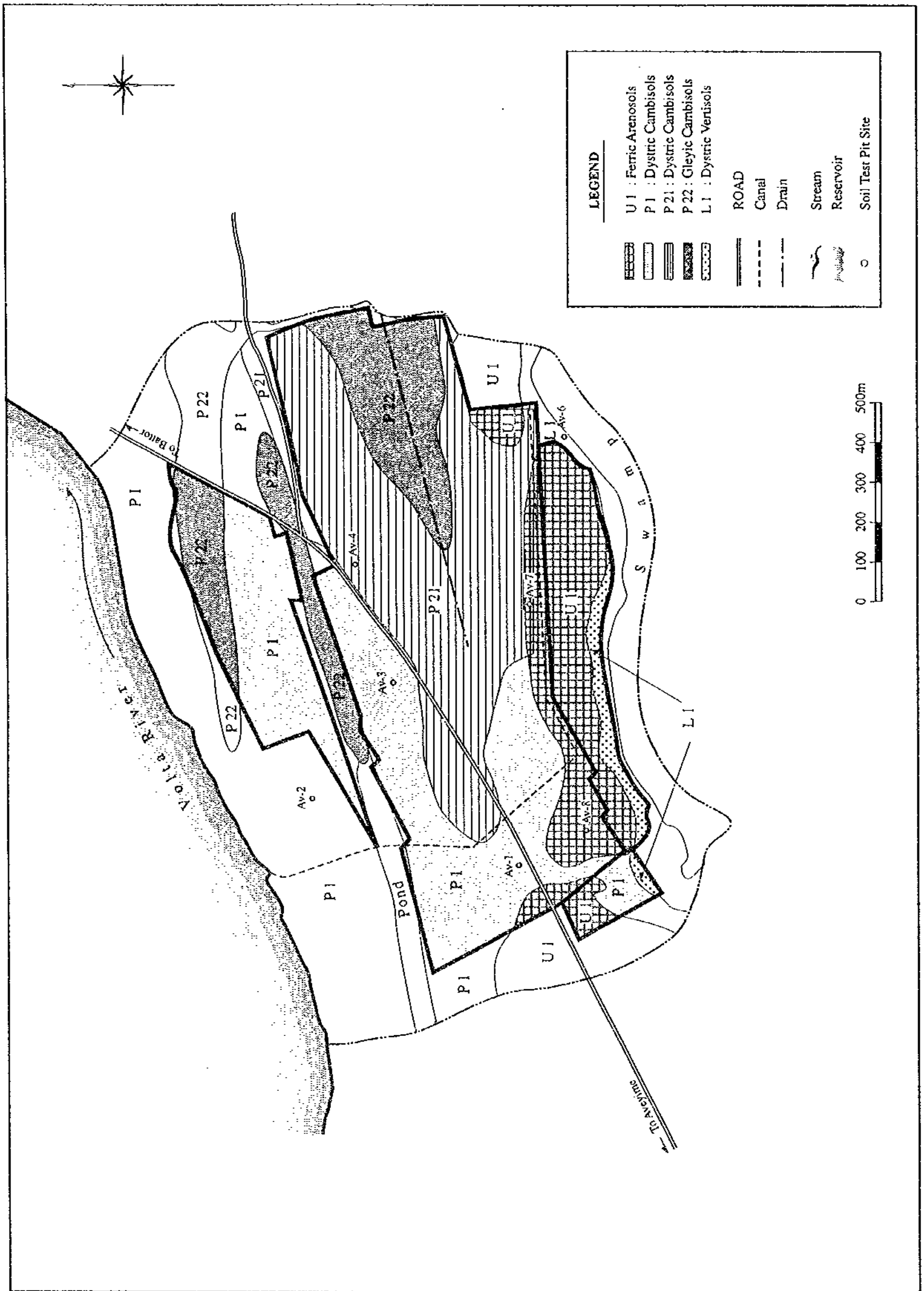

Figure C-2 **Soil Map of Aveyime Project Area**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

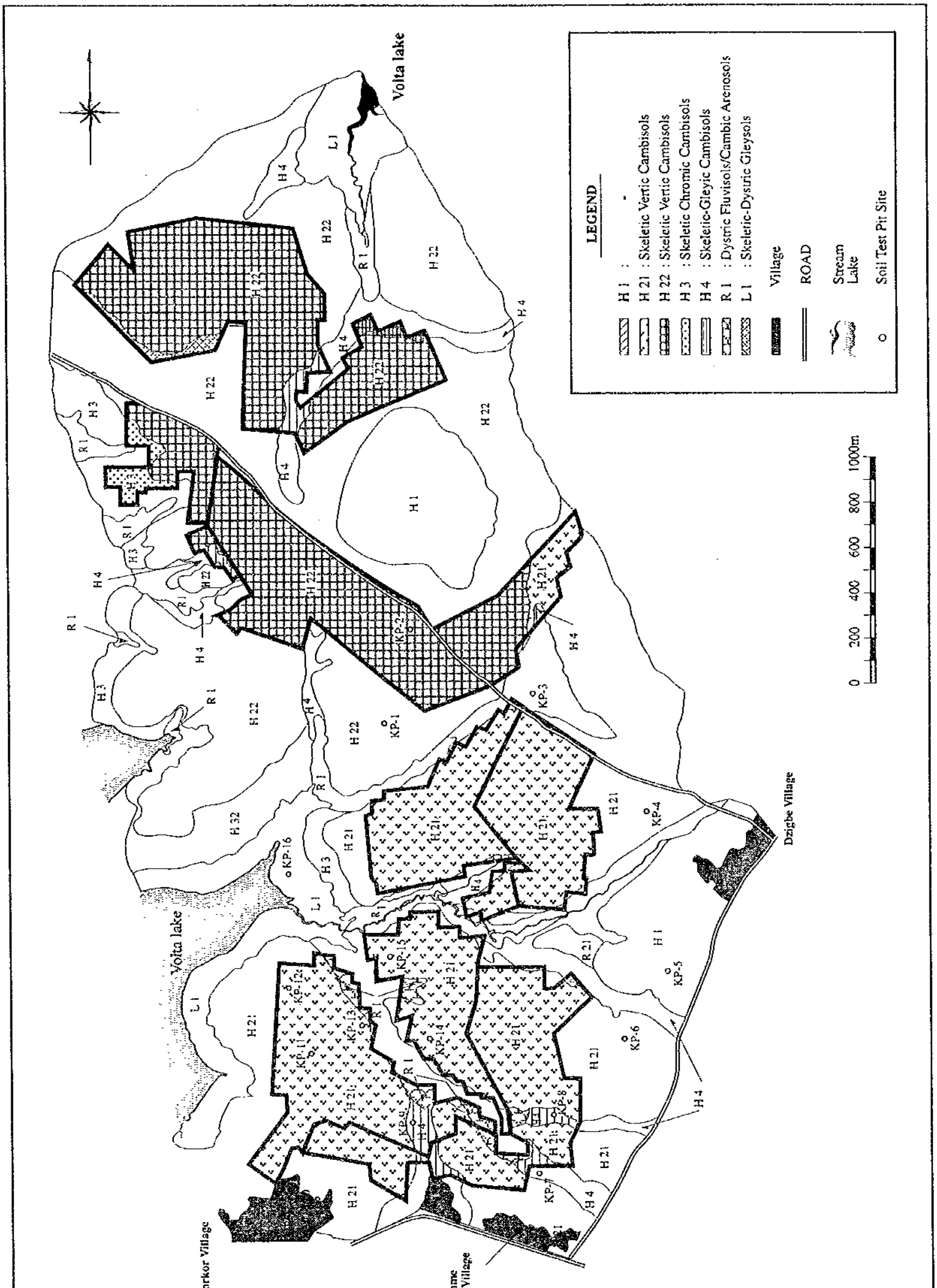

Figure C-3
Soil Map of Kpando-Torkor Project Area

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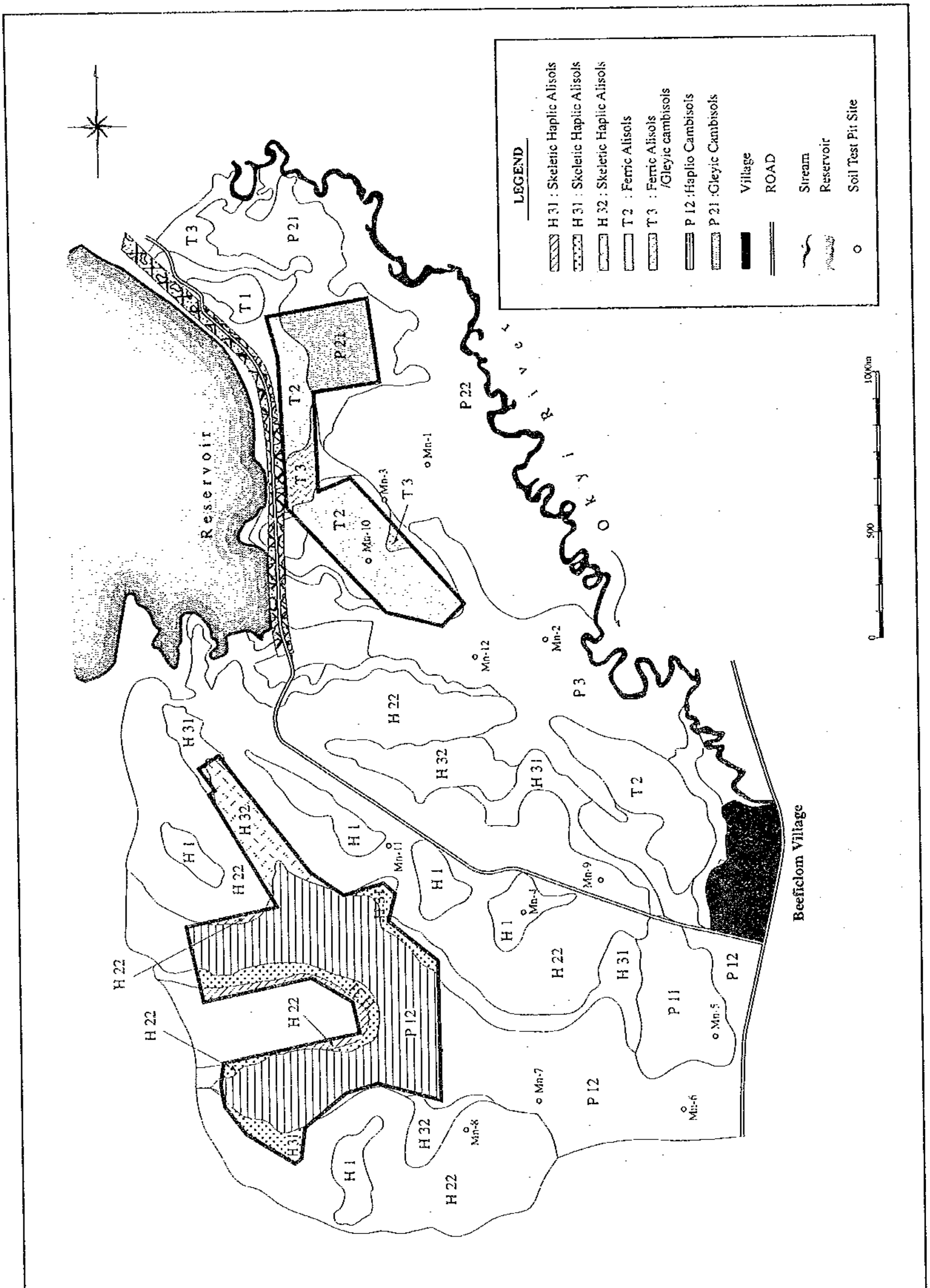

Figure C-4
Soil Map of Mankessim Project Area

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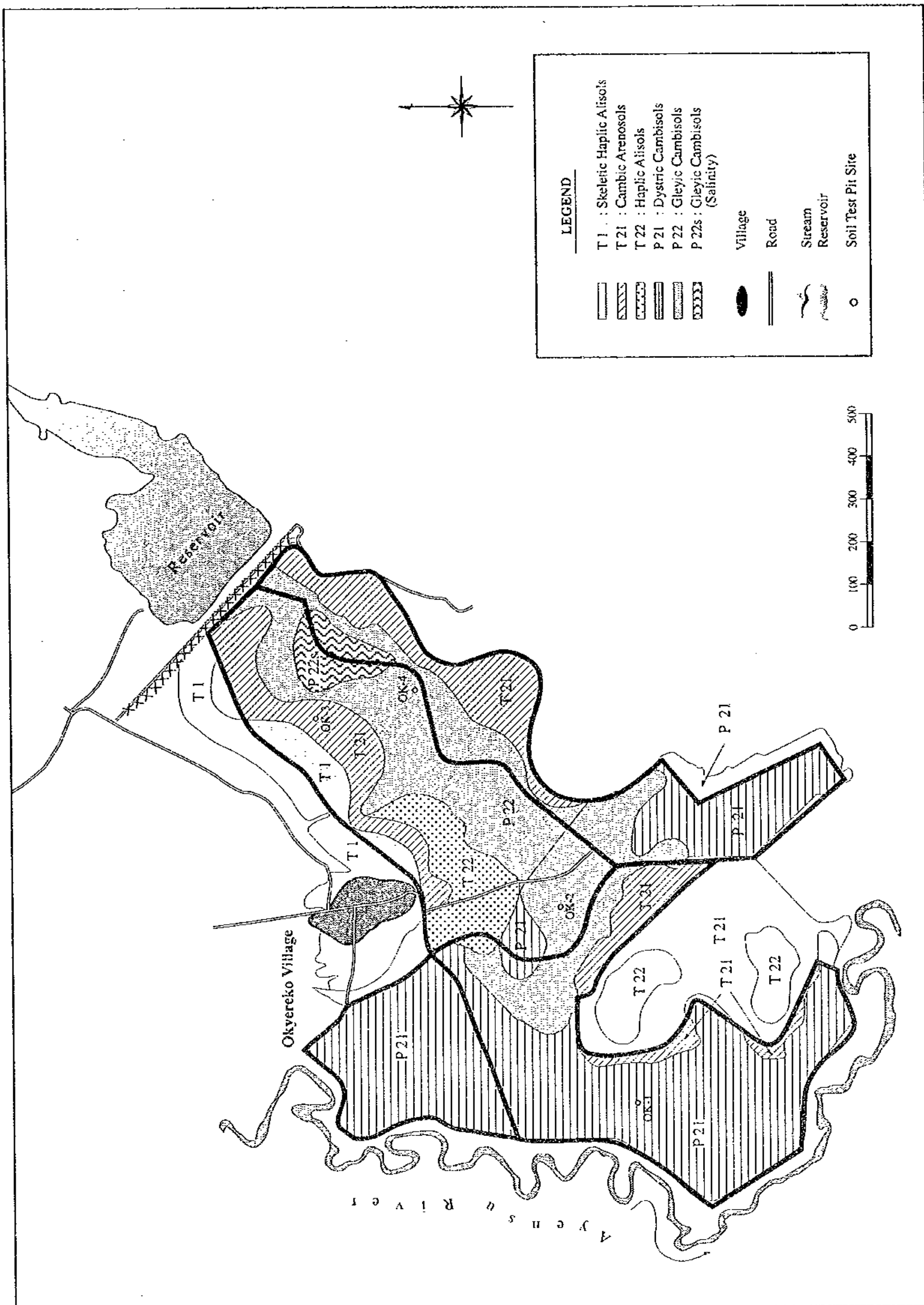

Figure C-5 **Soil Map of Okyeneko Project Area**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA**
	Japan International Cooperation Agency

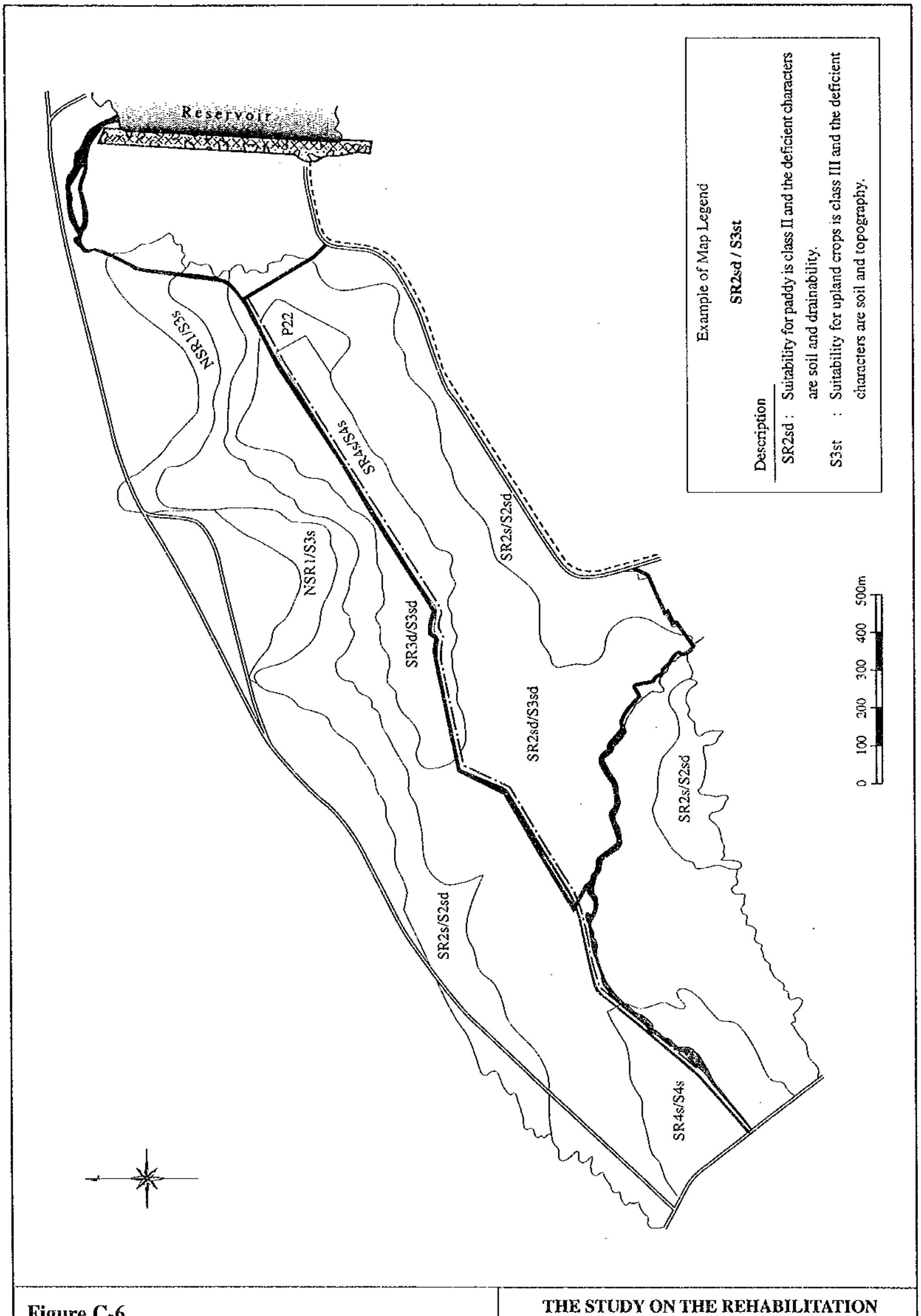

Figure C-6
Irrigation Suitability Map of Ashaiman Project Area

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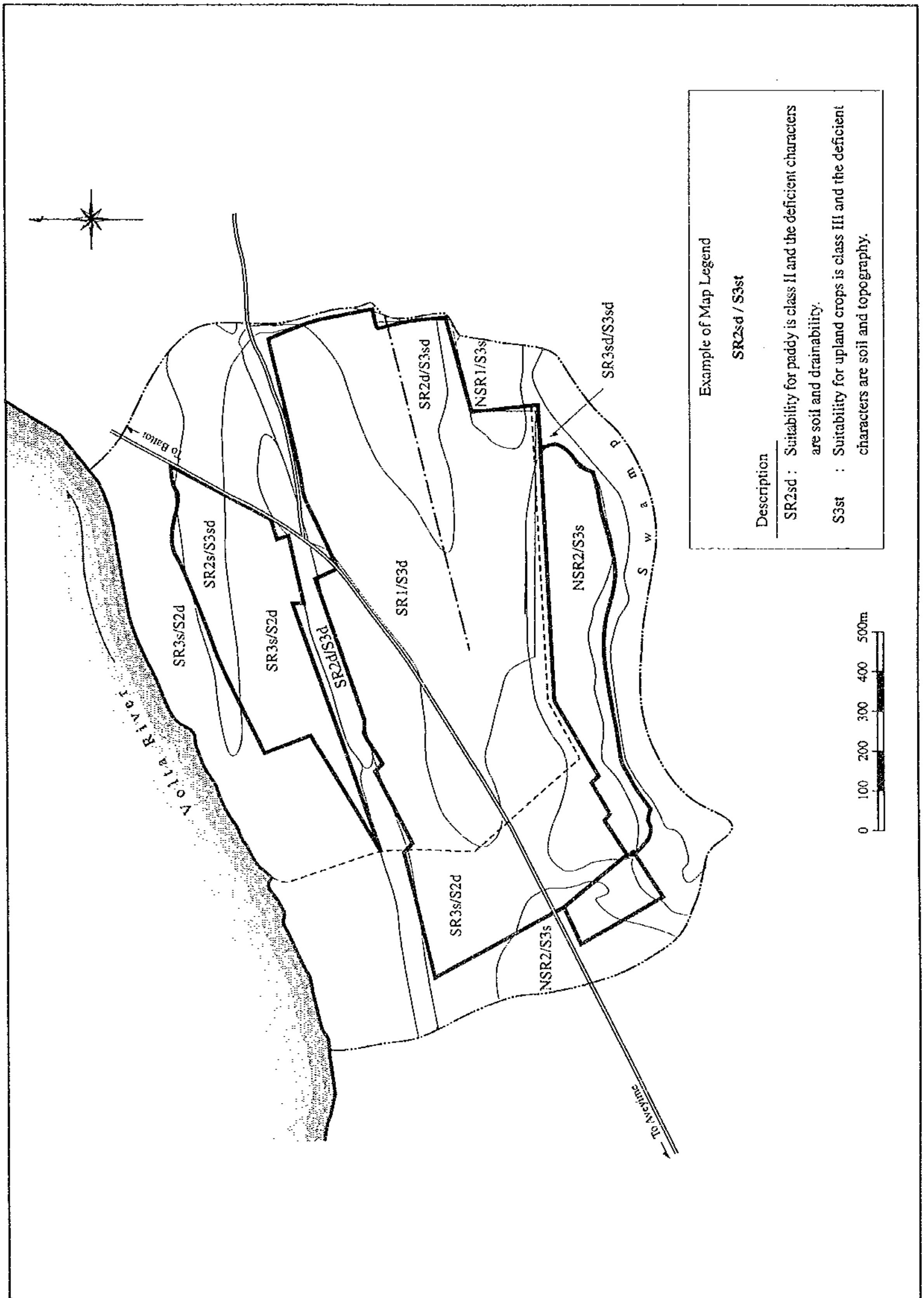

Figure C-7 **Irrigation Suitability Map of Aveyime Project Area**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA**
	Japan International Cooperation Agency

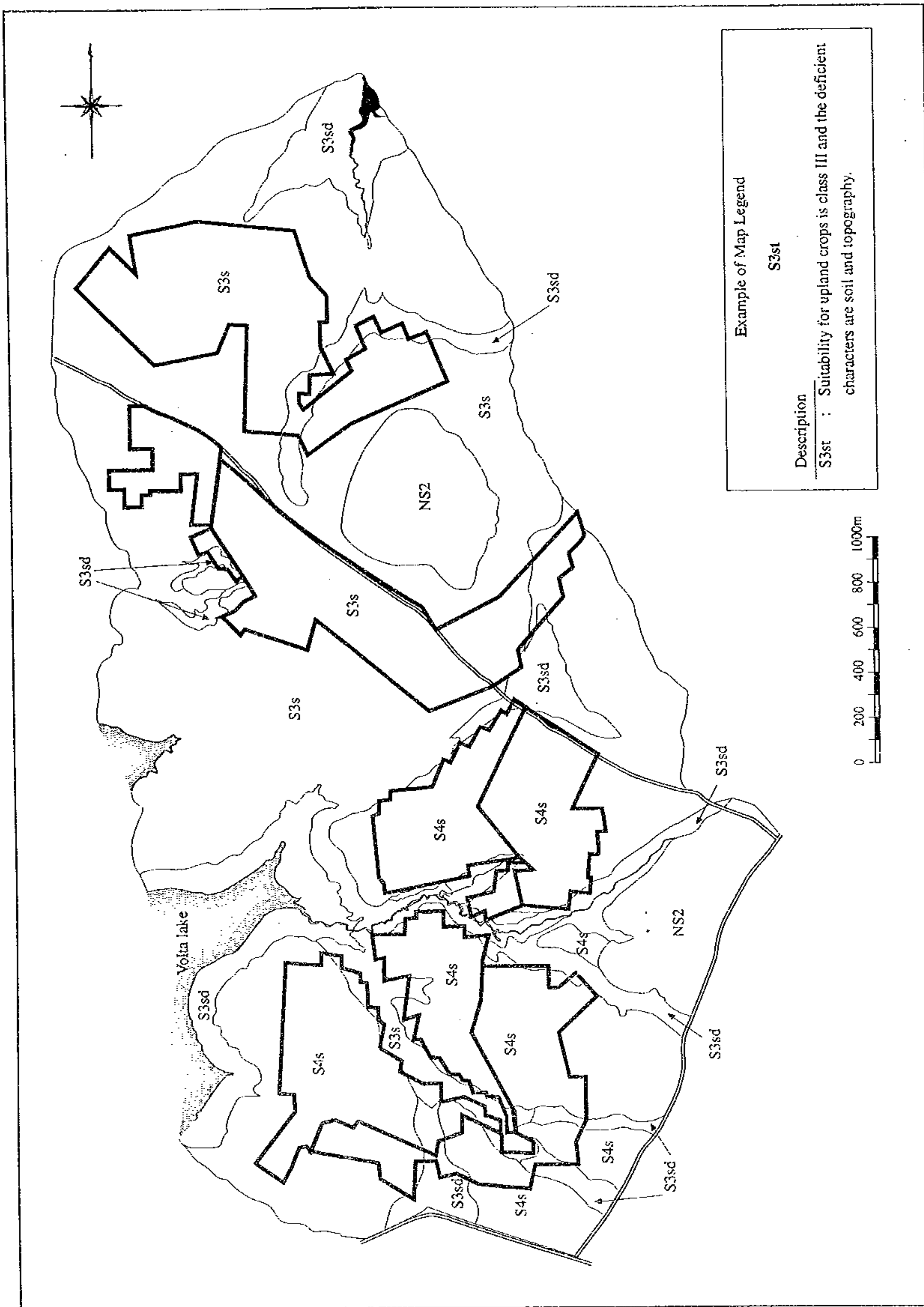

Figure C-8

Irrigation Suitability Map of Kpando-Torkor Project Area

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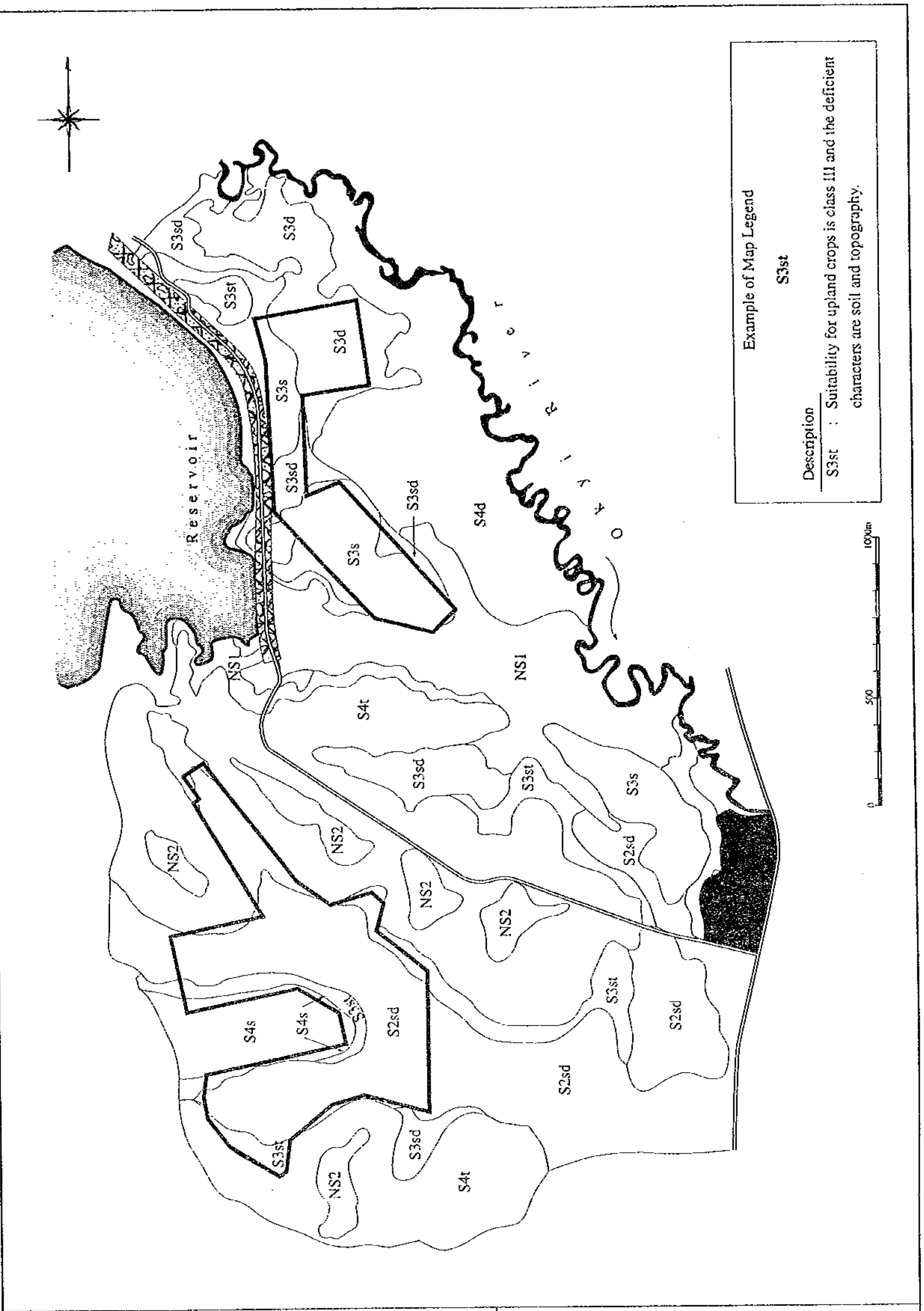

Figure C-9
Irrigation Suitabilityl Map of Mankessim Project Area

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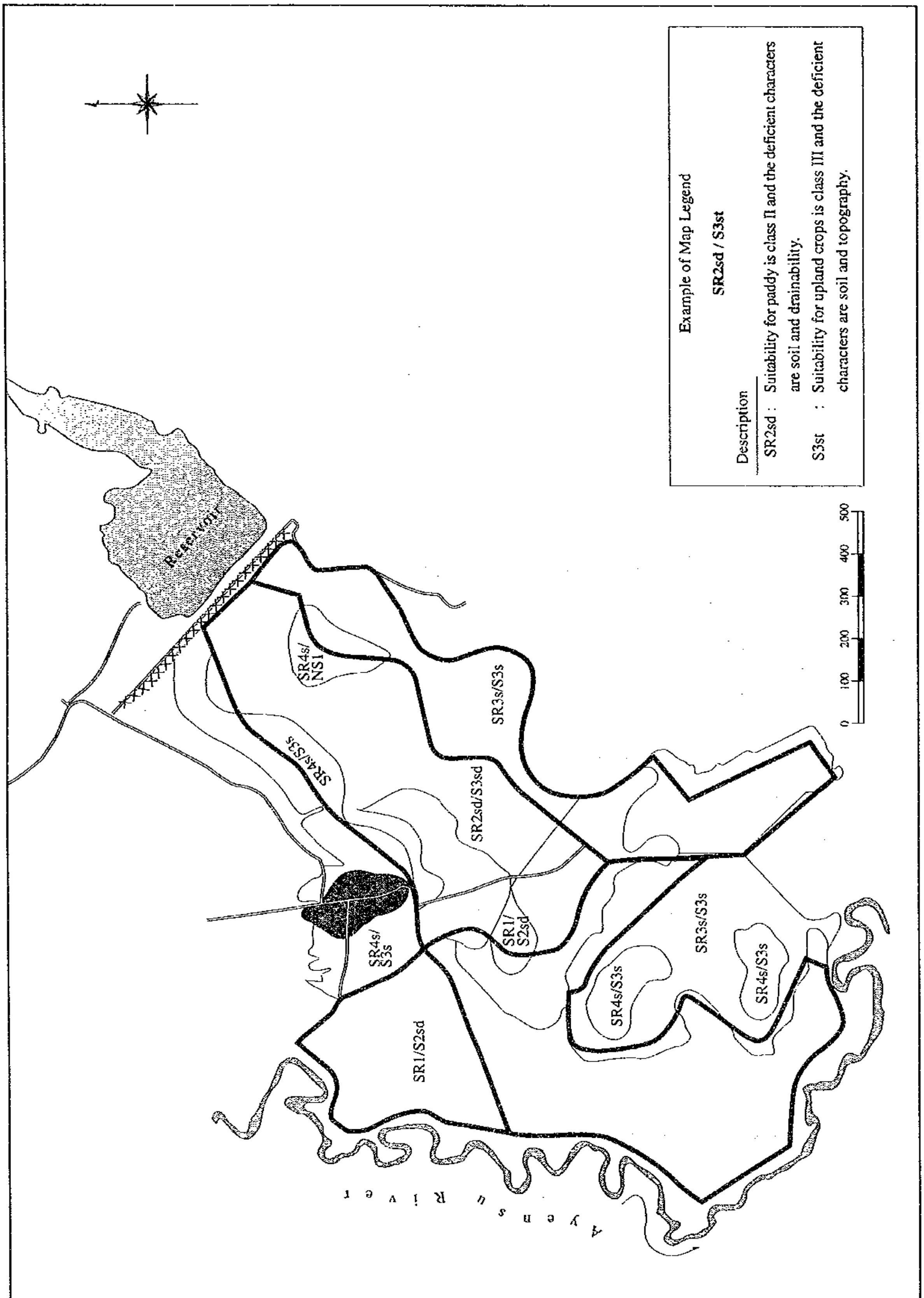

Figure C-10

Irrigation Suitability Map of Okyereko Project Area

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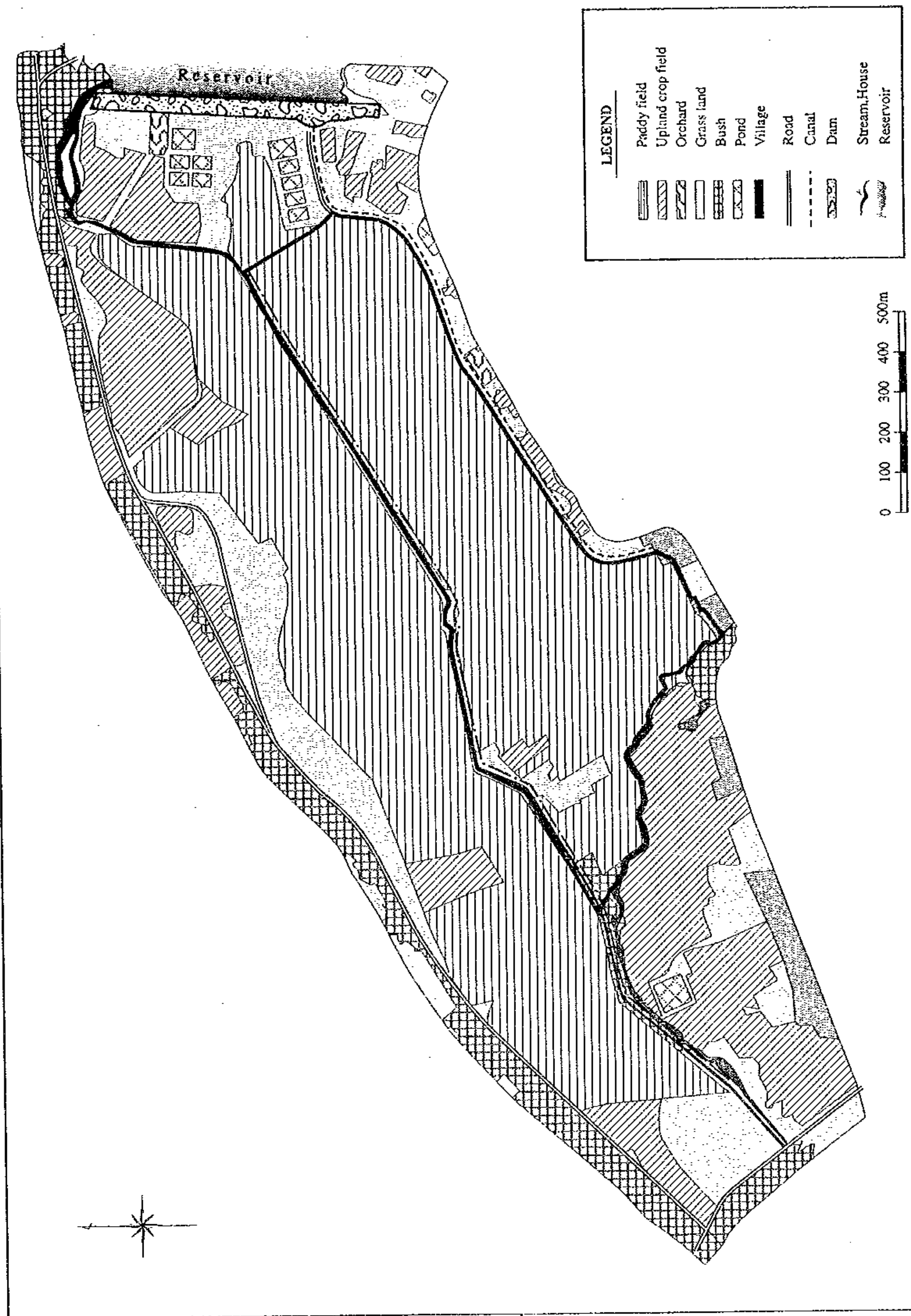

Figure C-11

Present Land Use Map of Ashaiman Project Area

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

Japan International Cooperation Agency

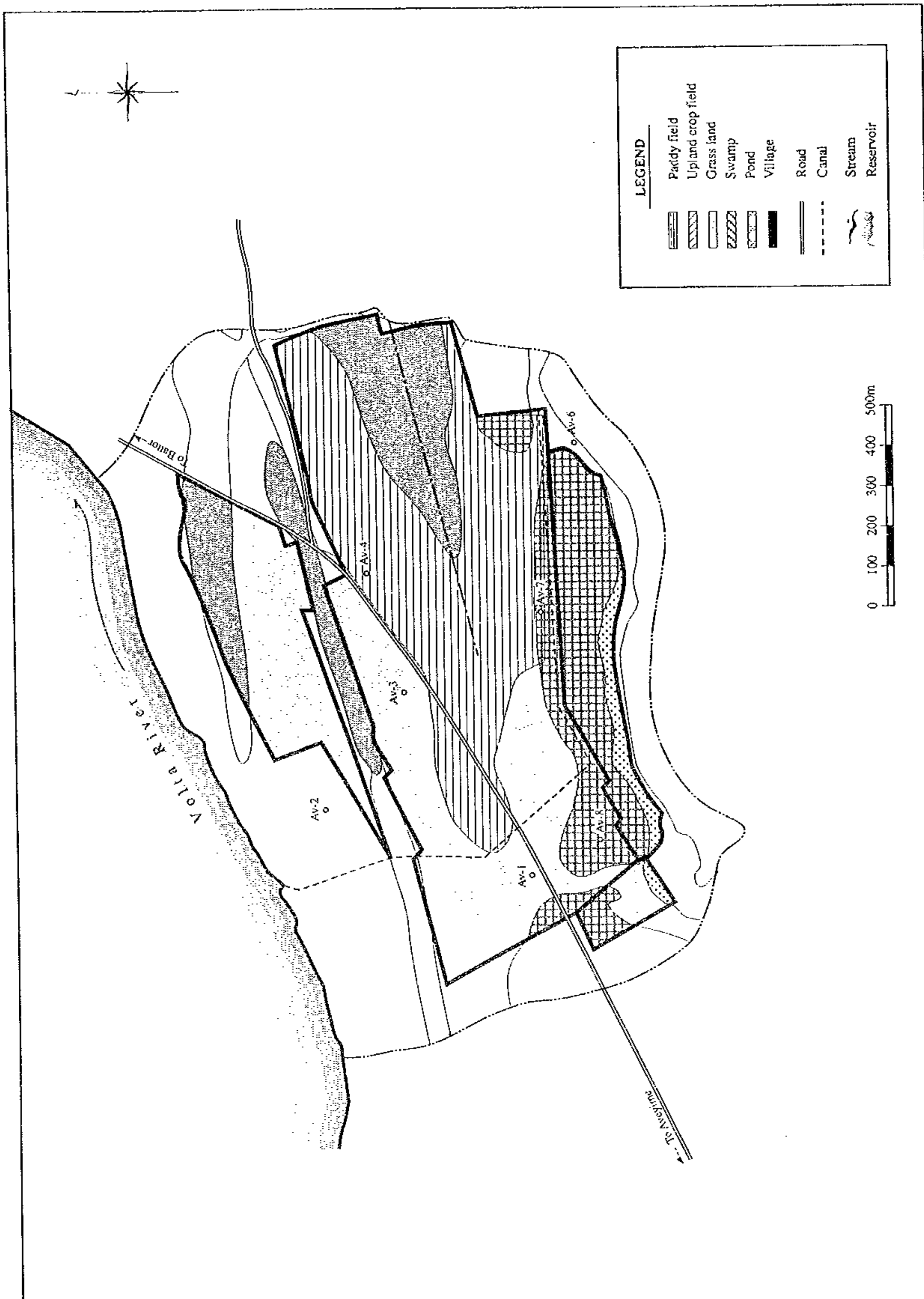

Figure C-12 **Present Land Use Map of Aveyime Project Area**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA** Japan International Cooperation Agency

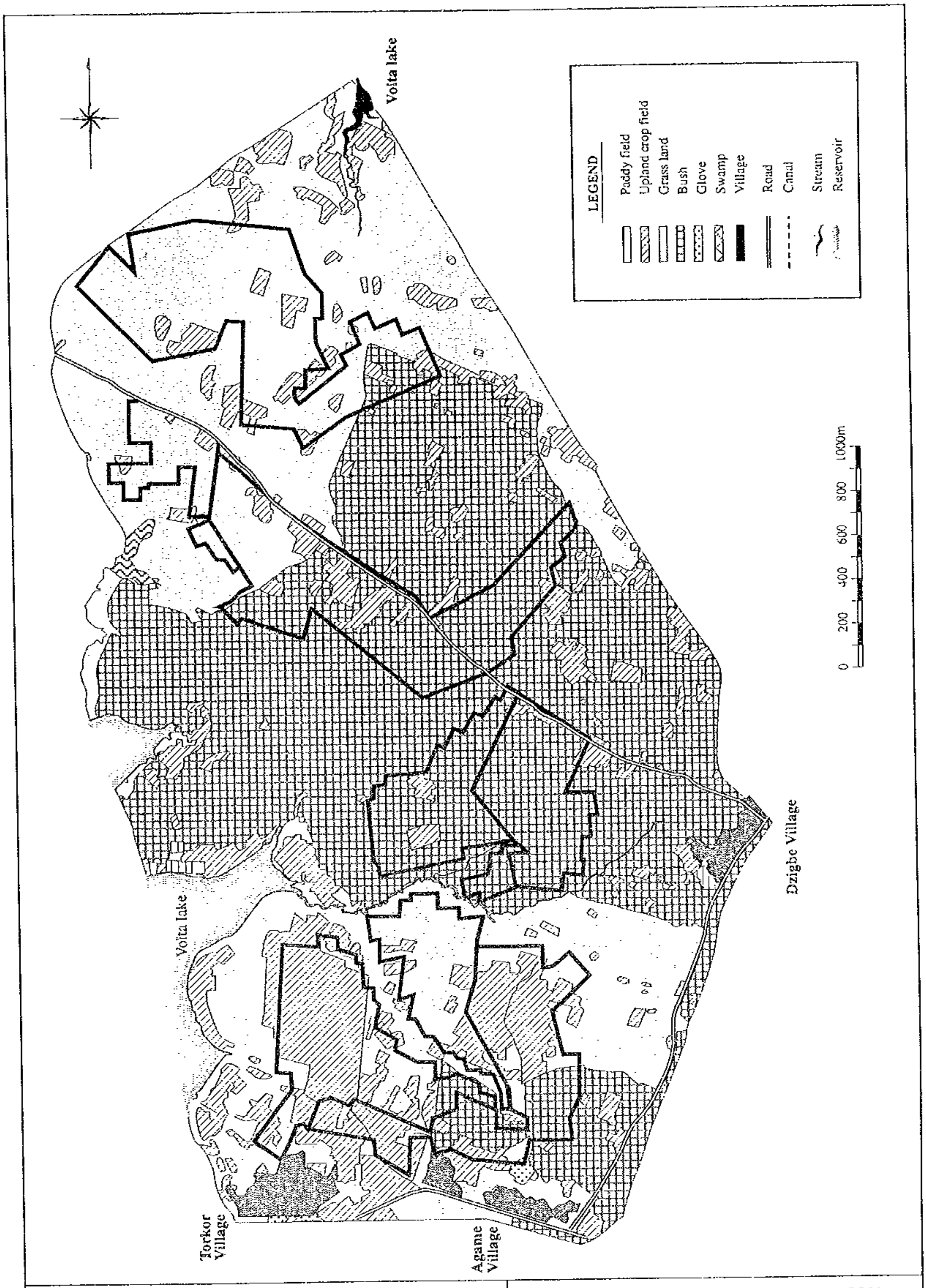

Figure C-13 Present Land Use Map of Kpando-Torkor Project Area	THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA Japan International Cooperation Agency

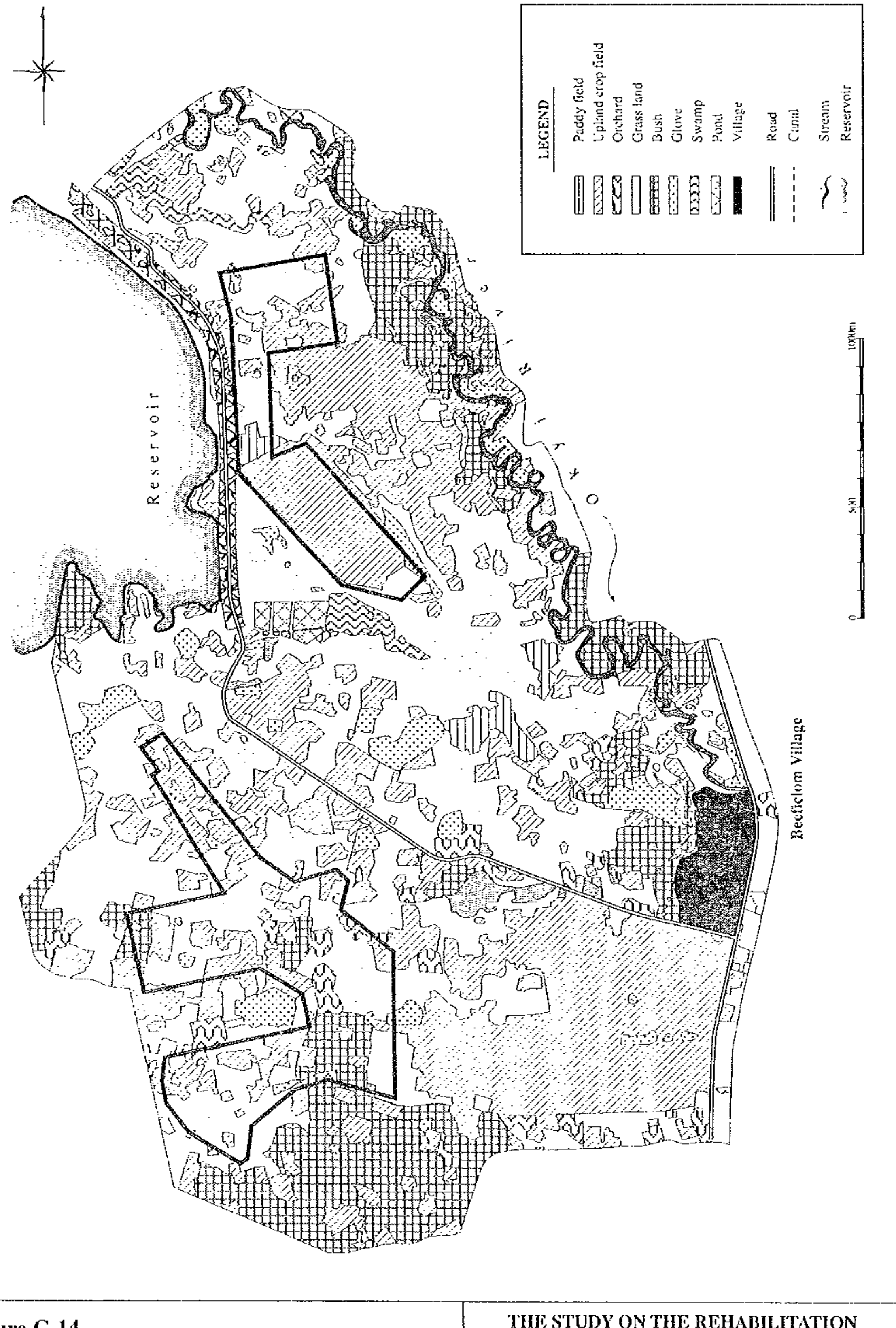

Figure C-14 **Present Land Use Map of Mankessim Project Area**	**THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA**
	Japan International Cooperation Agency

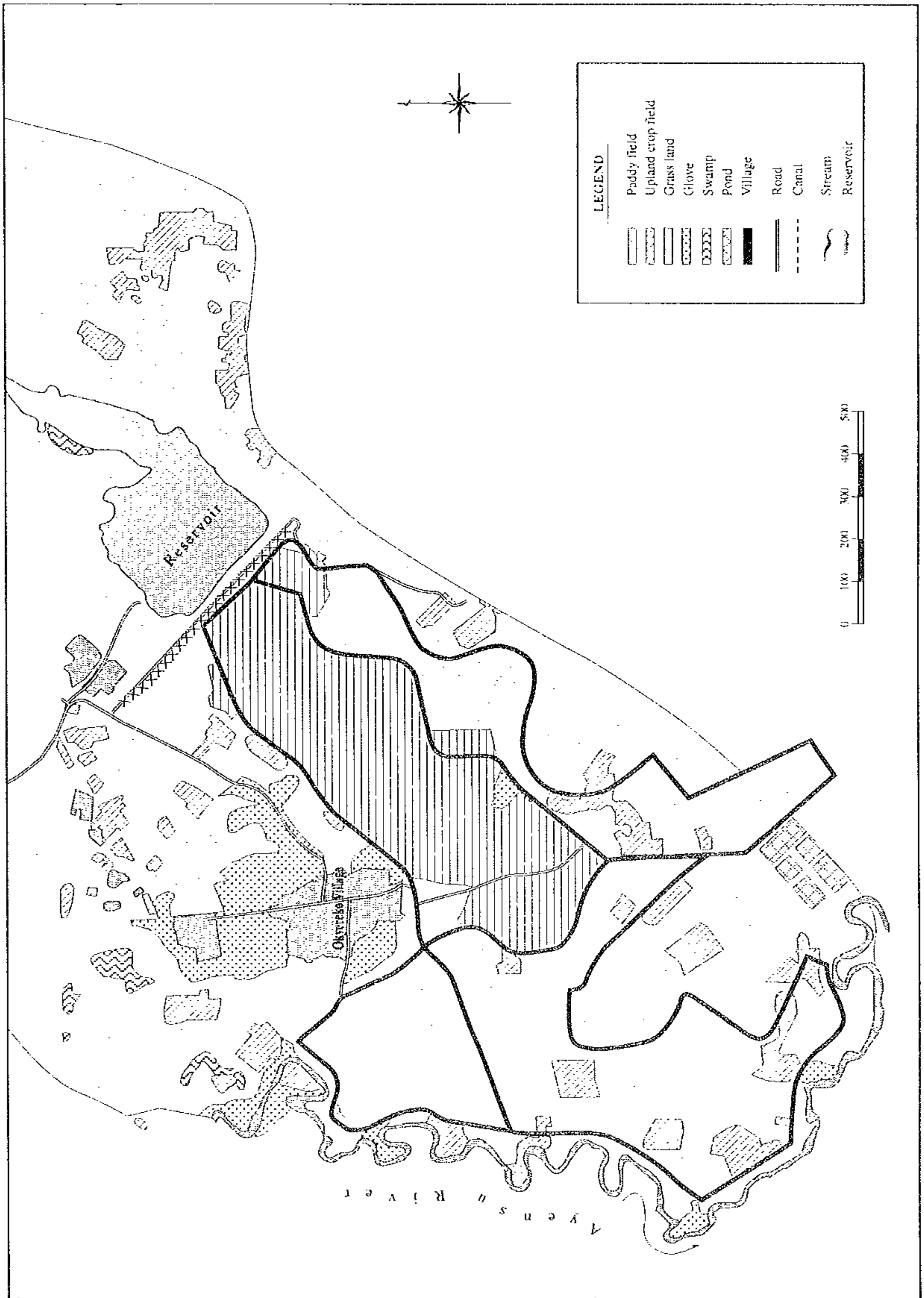

Figure C-15
Present Land Use Map of Okyereko Porject Area

THE STUDY ON THE REHABILITATION OF IRRIGATION PROJECTS IN THE REPUBLIC OF GHANA

Japan International Cooperation Agency