THE FEASIBILITY STUDY ON
THE WESTERN LEGAZPI IRRIGATION AND
RURAL DEVELOPMENT PROJECT IN THE PHILIPPINES

TABLES

Table C 2.1 Soil Profiles Description (1/9)

Pit No. 3

Soil Taxonomic Unit	: Very fine clayey, Oxyaquic Eutrochrepts		
Geomorphic Unit/Land form			
Physiographic Position	: Side slope	slope	: 8 %
Surrounding landform	: Gently sloping hills	Elevation	: 90 m
Parent Material	: Limestone	Erosion	: none
Internal Drainage	: Well drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: no encounter upto 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 7	Brown (7.5 YR. 4/4) moist; Silty clay; Sticky, plastic, firm; Medium angular breaking to subangular blocky structure; No mottles; Few partially weathered shale and limestone fragments; Few fine tubular pores; Few roots; Clear smooth boundary with underlying horizon.
BC	7 to 25	Light brown (7.5 YR 6/4) moist; Silty clay; Slightly sticky, plastic slightly firm; Moderate medium angular breaking to subangular blocky structure; No mottles; Many partially weathered shale and limestone fragments.
R	Below 25	Hard shale/limestone bedrock.

Pit No. 4

Soil Taxonomic Unit	: Very fine clayey, Oxyaquic Eutrochrepts		
Geomorphic Unit/Land form			
Physiographic Position	: Sideslope	Slope	: 8 %
Surrounding landform	: low hills	Elevation	: 90 m
Parent Material	: Limestone	Erosion	: none
Internal Drainage	: Well drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: no encounter upto 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 15	Brown to dardk brown (7.5 YR. 4/4) moist; Clay loam; Slightly sticky, Slighlly plastic, firm; Moderate medium and coarse angular to subangular blocky structure; No mottles; Few partially weathered limestone fragments. Many fine roots; Clear smooth boundary.
Bw1	15 to 41	Light brown (7.5 YR 6/4) moist; Clay loam; Slightly sticky, Slightly plastic, firm; Weak fine and medium angular breaking to granular structure; No mottles; Common black concretions of Fe and Mn. Few fine tubular pores; Few fine roots; Clear irregular boundary.
Bw2	41 to 63	Pinkish gray (7.5 YR 6/2) moist; Clay loan; Slighlly sticky, slightly plastic, Firm; Moderately fine and medium and coase angular to subangular blocky structure; No mottles; Common black concretions of Fe and Mn;
C	Fron 63	Partially weathered limestone materials

Table C 2.1 Soil Profiles Description (2/9)

Pit No. 7

Soil Taxonomic Unit	: Oxyaquic Tropopsament		
Geomorphic Unit/Land form			
Physiographic Position	: Level to near level	Slope	: 2 %
Surrounding land form	: Plain	Elevation	: 70 m
Parent Material	: Pyroclastic	Erosion	: none
Internal Drainage	: Poorly drained	Flooding	: Flash floods
Rock outcrops	: none	Stoniness	: none
Depth to water table	: 26 cm		

Soil Horizon	Depth (cm)	Description
Ap	0 to 18	Very dark gray (10 YR. 3/1) moist; Sandy loam; Non sticky, nom plastic, Friable; Structureless; No mottles; Few fine roots; Clear smooth boundary with underlying horizon.
B	18 to 52	Black (10 YR 2/1) moist; Sandy loam; Structureless; No mottles; Non sticky; non plastic; Friable
C	From 52	Pyroclastic materials

Pit No. 9

Soil Taxonomic Unit	: Very fine clayey, Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Alluvial plain	Slope	: 1 to 3 %
Surrounding landform	: Level to near level	Elevation	: 70 m
Parent Material	: Limestone	Erosion	: none
Internal Drainage	: Imperfectly drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: 120 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 16	Dark grayish brown (10 YR. 4/2) moist; Sandy clay; Slightly ticky, slightly plastic, firm; Weak medium angular breaking to granular structure; Few small gravels; No mottles; Few fine tubular pores; Many fine and few medium roots; Diffuse irregular boundary with underlying horizon.
B1	16 to 52	Pale brown (10 YR 6/3) moist; Sany clay; Weak medium angular breaking to granular structure; No mottles; Sticky, plastic, firm; Few fine pores; Few small gravels; Many fine roots; Clear irregular boundary with underlying horizon.
B2	52 to 85	Light yellowish brown (10 YR 6/4) moist; Sandy clay; Slightly ticky, slightly plastic, firm; Moderate medium angular breaking to granular structure; No mottles; Many small black concretions of Fe and Mn; Few fine roots; Clear irregular boundary.
BC	85 to 120	Yellowish brown (10 YR 5/6) moist; Sandy clay; Slightly ticky, slightly plastic, firm; Moderate medium angular breaking to granular structure; No mottles; Many soft and hard limestone fragments; Many black concretion of Fe and Mn; Few fine pores; Few fine roots.
C	120 to 150	Partially weathered hard limestone materials with few clay cutans.

Table C 2.1 Soil Profiles Description (3/9)

Pit No. 13

Soil Taxonomic Unit	: Typic Endoaqualf		
Geomorphic Unit/Land form			
Physiographic Position	: Level to Undulating	Slope	: 5 %
Surrounding land form	: Level to nearly level	Elevation	: 75
Parent Material	: Tuffacious sandstone	Erosion	: Slight
Internal Drainage	: Imperfectly drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: No encoutered upto 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 19	Very dark gray (10 YR. 3/1) moist; Sandy clay loam; Slightly sticky, slightly plastic, firm; Weak to moderate angular blocky structure; No mottles; Few fine and medium roots; Clear smooth boundary with underlying horizon.
B1	19 to 51	Light brownish gray (2.5 YR. 6/2) moist; Sandy clay; Slightly sticky, slightly plastic, firm; Moderate to strong bockly structure; Common light yellowish brown mottles; Few fine and medium roots; Clear boundary.
B2	51 to 71	Light gray (2.5 YR. 7/2) moist; Clay; Sticky, plastic, firm; Weak to moderately strong blocky structure; Clear stratified layers of Fe and Mn concretions; Few fine roots; Smooth wavy boundary with C horizon.
C	71 to 150	Light gray (2.5 YR 7/2) moist; Concretionary clay derived from weathering tuffacious sandstone; Common concretions of Fe and Mn; Few fine roots.

Pit No. 15

Soil Taxonomic Unit	: Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Nearly level	Slope	: 3 %
Surrounding landform	: Nearly level and low hills	Elevation	: 90 m
Parent Material	: Limestone	Erosion	: none
Internal Drainage	: Imperfectly drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: no encounter upto 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 18	Grayish brown (10 YR. 5/2) moist; Sandy clay loam; Slightly ticky, slightly plastic, firm; Moderate fine angular to subgranular blocky structure; Few small angular gravels; No mottles; Many fine roots; Difuse irregular boundary with underlying horizon.
B1	18 to 46	Yellowish brown (10 YR 5/4) moist; Clay; Sticky, plastic, firm; Moderate medium angular to subangular blocky structure; No mottles; Many small black concretions of Fe and Mn; Many fine roots; Clear wavy boundary with underlying horizon.
B2	46 to 73	Light gray (10 YR 6/1) moist; Clay; Moderate medium and coarse angular to subangular structure; Sticky, plastic, firm; No mottles; Common small black concretions of Fe and Mn; Many fine roots; Clear wavy boundary with lower horizon.
C	73 to 150	Pale brown (10 YR 6/3) moist; Moderate fine and medium angular to subangular blocky structure; Few small black concretions of Fe and Mn.

Table C 2.1 Soil Profiles Description (4/9)

Pit No. 19

Soil Taxonomic Unit	: Very fine clayey, Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Side of hilly landscape	Slope	: 3 %
Surrounding landform	: Undulating	Elevation	: 95 m
Parent Material	: Tuffaceous sandstone	Erosion	: none
Internal Drainage	: Imperfectly drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: no encounter up to 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 23	Very dark gray (7.5 YR 1/3) moist; Silty clay loam; Slightly sticky, plastic, slightly firm; Common yellowish brown (10 YR 5/8) mottles; Moderate subangular and blocky structure; Few medium and fine roots; Clear smooth boundary with underlying horizon.
B1	23 to 73	Dark gray (10 YR 4/1) and yellowish brown (10 YR 5/8) mottles; Clay; Sticky, plastic, firm; Common black concretions of Fe and Mn; Few very fine roots; Clear smooth boundary.
B2	73 to 127	Dark gray (10 YR 4/1) moist; Clay; Sticky, plastic, firm; Common highly weathered turffaceous sandstone; Common brown (10 YR 5/8) mottles; Common pebble size black concretions of Fe and Mn; Very fine roots; Clear smooth boundary with underlying horizon.
C	127 to 150	Highly weathering tuffaceous sandstone.

Pit No. 21

Soil Taxonomic Unit	: Very fine clayey, Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Level to near level	Slope	: 1 %
Surrounding landform	: Level with localized hills	Elevation	: 90 m
Parent Material	: Alluvial	Erosion	: none
Internal Drainage	: Poorly drained	Flooding	: none
Rock outcrops	: none	Stoniness	: none
Depth to water table	: 60 cm		

Soil Horizon	Depth (cm)	Description
Ap	0 to 18	Dark grayish brown (10 YR 4/2) moist; Clay; Sticky, plastic, firm; Weak fine angular breaking to granular structure; No mottles; Few fine tubular pores; Many fine roots; Diffuse irregular boundary with underlying horizon.
AB	18 to 46	Grayish brown (10 YR 5/2) moist; Clay; Very sticky, plastic, Weak medium angular breaking to granular structure; firm; Few fine pores; Few fine roots; Diffuse irregular boundary.
B	46 to 68	Light brownish gray (10 YR 6/2) moist; Clay; Very sticky, plastic, firm; Moderate medium and coarse columnar structure; No mottles; Few fine patchy of clay cutans on ped face; Many black concretions of Fe and Mn; Few fine roots; Clear boundary.
C	68 to 150	Light gray to gray (10 YR 6/1) moist; Clay; Very sticky, plastic, firm; Moderate medium and coarse angular breaking to columnar structure; No mottles; Few fine patchy clay cutans. Few black concretions of Fe and Mn.

Table C 2.1 Soil Profiles Description (5/9)

Pit No. 22

Soil Taxonomic Unit	: Very fine clayey, Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Level to near level	Slope	: 2 %
Surrounding landform	: Level to near level	Elevation	: 90 m
Parent Material	: Shales residium	Erosion	: none
Internal Drainage	: Imperfectly drained	Flooding	: Slight
Rock outcrops	: Few	Stoniness	: none
Depth to water table	: 95 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 16	Dark brown (10 YR 3/3) moist; Loam; Slightly sticky, Plastic, Firm; Weak blocky structure breaking into subangular structure. Very fine gray *mottles; Common grass roots; Clear smooth boundary with underlying* horizon.
B	16 to 95	Dark gray brown (10 YR 4/2) moist; Clay; Slightly sticky and plastic, firm; Weak to moderate subangular blocky structure; Clear smooth boundary with underlying horizon.
C	95 to 150	Brown (10 YR 5/3) moist; Clay; Slightly sticky and plastic, firm; Moderate to strong blocky structure; Common pale brown mottles.

Pit No. 25

Soil Taxonomic Unit	: Very fine clayey, Typic Endoaqualfs		
Geomorphic Unit/Land form			
Physiographic Position	: Level to near level	Slope	: 1 %
Surrounding landform	: Near level	Elevation	: 90 m
Parent Material	: Turffacious sandstone	Erosion	: none
Internal Drainage	: *Poorly drained*	*Stoniness*	: *none*
Flooding	: Slight seasonal	Rock outcrops	: none
Depth to water table	: 120 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 17	Dark brown (7.5 YR 3/2) moist; Silty clay; Sticky, plastic, firm; Few *fine distinct gray (10 YR 5/1) mottles; Moderate fine angular to subangular* blocky structure; Few fine and medium roots; Clear smooth boundary with underlying horizon.
B1	17 to 41	Dark reddish brown (5 YR 3/3) moist; Clay; Sticky, plastic, firm; Few fine distinct gray (10 YR 5/1) mottles; Moderate fine an medium angular to subangular blocky structure; Few fine roots; Gradual wavy boundary with underlying horizon.
B2	41 to 82	Gray (10 YR 5/1) moist; Clay; Sticky, plastic, firm; Few fine distinct brown (10 YR 5/3) mottles; Few thin patchy clay cutans on ped faces; Few fine pores; *Gradual wavy boundary.*
C	82 to 150	Dark gray (10 YR 4/1) moist; Clay; Slightly sticky, plastic, firm; No mottles; Moderate to strong medium angular to subangular blocky structure; Few thin patchy clay cutans.

Table C 2.1 Soil Profiles Description (6/9)

Pit No. 32

Soil Taxonomic Unit	: Oxyaquic Tropopsamment		
Geomorphic Unit/Land form			
Physiographic Position	: Nearly level alluvial plain	Slope	: 2 %
Surrounding landform	: Level	Elevation	: 90 m
Parent Material	: Pyroclastic	Erosion	: Slight
Internal Drainage	: Poorly drained	Flooding	: Slight
Rock outcrops	: none	Stoniness	: none
Depth to water table	: 53 cm		

Soil Horizon	Depth (cm)	Description
Ap	0 to 18	Gray (10 YR 5/1) moit; Sandy clay loam; Slightly sticky, non plastic, friable; No mottles; Few fine roots; Diffuse irregular boundary.
B	18 to 56	Light gray (10 YR 6/1) moist; Sandy clay loam; Weak granular structure; non sticky; non plastic; friable; Few fine roots; Gradual irrigular boundary.
C	56 to 89	Light gray (10 YR 7/2) moist; Sandy clay loam; Weak granular structure; Non plastic; Friable.

Pit No. 33

Soil Taxonomic Unit	: Oxyaquic Tropopsamment		
Geomorphic Unit/Land form			
Physiographic Position	: Nearly level	Slope	: 2 %
Surrounding landform	: Narrow plain	Elevation	: 90 m
Parent Material	: Pyroclastic	Erosion	: Slight
Internal Drainage	: Poorly drained	Flooding	: Slight
Rock outcrops	: none	Stoniness	: none
Depth to water table	: 18 cm		

Soil Horizon	Depth (cm)	Description
Ap	0 to 16	Dark gray (10 YR 4/1) moist; Loam; Structureless; Non sticky, Non plasstic, Friable; No mottles Few fine roots; Gradual smooth boundary with underlying horizon.
C	16 to 72	Black (10 YR 2/1) moist; Loamy sand; Non sticky, non plastick; Loose; Structureless; No mottles; Very few fine roots.

Table C 2.1 Soil Profiles Description (7/9)

Pit No. 35

Soil Taxonomic Unit	: Oxyaquic Tropopsamment		
Geomorphic Unit/Land form			
Physiographic Position	: Level	Slope	: 1 %
Surrounding landform	: Broad plain	Elevation	: 90 m
Parent Material	: Pyroclastic	Erosion	: None
Internal Drainage	: Poorly drained	Flooding	: Slight
Rock outcrops	: None	Stoniness	: None
Depth to water table	: 30 cm		

Soil Horizon	Depth (cm)	Description
Ap	0 to 14	Gray (10 YR 5/1) moist; Sandy loam; Non sticky; Non plastic; Friable; Weak coarse breaking to granular structure; No mottles; Many fine roots; Clear smooth boundary with underlying horizon.
B	14 to 44	Dark gray (10 YR 4/1) moist; Sandy loam; Non sticky; Non plastic; Friable; Structureless; Few fine roots; Clear boundary.
C1	44 to 71	Very dark gray (10 YR 3/1) moist; Sandy loam; Non sticky; Non plastic; Friable; Structureless; Many small and medium gravels; Clear smooth boundary with underlying horizon.
C2	71 to 120	Black (10 YR 2/1) moist; Sandy loam; Non sticky; Non plastic; Loose; Structureless; Many small and medium gravels.

Pit No. 39

Soil Taxonomic Unit	: Very fine clayey, Oxyaquic, Eutrochrepts		
Geomorphic Unit/Land form			
Physiographic Position	: Nearly level	Slope	: 2 %
Surrounding landform	: Level with some terraces	Elevation	: 80 m
Parent Material	: Shales	Erosion	: None
Internal Drainage	: Somewhat poorly drained	Flooding	: None
Rock outcrops	: None	Stoniness	: None
Depth to water table	: 110 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 24	Brown (7.5 YR 5/2) moist; Clay; Sticky, plastic, firm; Moderate angular, breaking to subangular structure; No mottles; Few fine and medium roots; Clear smooth boundary with underlying horizon.
Bw1	24 to 68	Light brownish gray (10 YR 6/2) moist; Clay; Moderate angular breaking to subangular structure; Common fine distinct gray (10 YR 6/1) mottles; Sticky, plastic, firm; Few fine roots; Diffuse irregular boundary with underlying horizon.
BW2	68 to 102	Grayish (10 YR 5/2) moist; Clay; Sticky, plastic, firm; Moderate medium and coarse angular breaking to subangular blocky structure; Common fine distinct clear gray (10 YR 5/1) mottles; Diffuse irregular boundary.
BC	102 to 150	Light gray (10 YR 7/1) moist; Clay; Sticky, plastic, firm; Weak angular breaking to subangular blocky structure; Few fine distinct clear gray (10 YR 5/2) mottles;

Table C 2.1 Soil Profiles Description (8/9)

Pit No. 40

Soil Taxonomic Unit	: Oxyaquic Eutrochrepts		
Geomorphic Unit/Land form			
Physiographic Position	: Sideslope	Slope	: 2 %
Surrounding landform	: Gently sloping	Elevation	: 95 m
Parent Material	: Shales	Erosion	: None
Internal Drainage	: Imperfectly drained	Flooding	: None
Rock outcrops	: None	Stoniness	: None
Depth to water table	: No encountere up to 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 21	Very dark gray brown (10 YR 5/2) moist; Clay; Sticky, plastic, firm; Moderate angular, breaking to subangular blocky structure; No mottles; Many fine and medium roots; Clear smooth boundary with underlying horizon.
Bt1	21 to 73	Dark gray brown (10 YR 4/2) moist; Clay; Very sticky, plastic, firm; Moderate angular breaking to subangular blocky structure; No mottles; Few thin clay cutans; Few fine roots; Gradual irregular boundary.
Bt2	73 to 108	Yellowish brown (10 YR 5/4) moist; Clay; Sticky, plastic, firm; Moderate medium angular breaking to subangular blocky structure; Common fine distinct grayish (10 YR 5/2) mottles; Few thin clay cutans; Very fine roots Clear wavy boundary with underlying horizon.
BC	108 to 150	Light gray (10 YR 7/2) moist; Clay; Sticky, plastic, firm; Weak angular breaking to subangular structure; No mottles;

Pit No. 42

Soil Taxonomic Unit	: Oxyaquic Eutrochrepts		
Geomorphic Unit/Land form			
Physiographic Position	: Moderate slope	Slope	: 12 %
Surrounding landform	: Sloping	Elevation	: 105 m
Parent Material	: Tuffacious shales	Erosion	: None
Internal Drainage	: Well drained	Flooding	: None
Rock outcrops	: None	Stoniness	: None
Depth to water table	:		

Soil Horizon	Depth (cm)	Description
A	0 to 18	Dark brown (10 YR 3/3) moist; Clay loam; Slighlly ticky, plastic, firm; Weak moderate angular to subangular blocky structure; Very few subangular to rounded gravels; No mottles; Many fine and few medium roots; Clear wavy boundary with underlying horizon.
Bt	18 to 57	Brown (10 YR 5/2) moist; Clay loam; Slighlly sticky, plastic, firm; Moderate fine angular to subangular blocky structure; Few small rounded gravels; No mottles; Few fine and medium roots; Clear wavy boundary.
Bt2	57 to 101	Light gray (10 YR 7/2) moist; Clay; Sticky, plastic, firm; Common fine distinct yellowish brown (10 YR 5/4) mottles; Few soft and hard black concretions of Fe and Mn; Few partially weathered rock fragments; Smooth boundary with underlying horizon.
BC	101 to 150	Strong brown (7.5 YR 5/8) moist; Clay; Sticky; plastic, firm; Many fine and medium dark yellowish mottles; Moderate fine and Medium angular to subangular blocky structure; Common partially weathered rock fragments.

Table C 2.1 Soil Profiles Description (9/9)

Pit No. 45

Soil Taxonomic Unit	: Very fine clayey, Typic Hapludalf		
Geomorphic Unit/Land form			
Physiographic Position	: Undulating	Slope	: 5 %
Surrounding landform	: Steep	Elevation	: 130 m
Parent Material	: Turffacious shale	Erosion	: Slight
Internal Drainage	: Imperfectly drained	Flooding	: None
Rock outcrops	: None	Stoniness	: None
Depth to water table	: 110 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 19	Dark yellowish brown (10 YR 3/6) moist; Silty clay loam; Slightly sticky, slightly plastic, firm; Weak to moderately strong blocky structure; No mottles; Clear smooth boundary with underlying horizon.
B	19 to 59	Dark yellowish brown (10 YR 3/6) moist; Slightly sticky, plastic, very firm; Strong prismatic structure; Presence of highly weathered turffaceous rock; No mottles; Clear wavy boundary.
C1	59 to 79	Dark yellowish brown (10 YR 4/6) moist; Clay; No mottles; Presence of fragmented highly weathered rocks. Clear boundary.
CR	79 to 150	Gray (5 YR 4/2) moist highly weathered shale with tuffacious materials.

Pit No. 49

Soil Taxonomic Unit	: Typic Hapludalf		
Geomorphic Unit/Land form			
Physiographic Position	: Sloping land	Slope	: 5 %
Surrounding landform	: Gently sloping	Elevation	: 90 m
Parent Material	: Tuffacious shale	Erosion	: None
Internal Drainage	: Well drained	Flooding	: None
Rock outcrops	: None	Stoniness	: Slight
Depth to water table	: No encountered up to 150 cm		

Soil Horizon	Depth (cm)	Description
A	0 to 18	Dark brown (10 YR 4/4) moist; Loam; Slightly sticky, non plastic; Moderate fine angular to subangular blocky structure; No mottles; Few fine and medium roots; Clear Smooth boundary with underlying horizon.
B1	18 to 47	Dark brown (10 YR 3/3) moist; Clay; Sticky, plastic, firm; Moderate fine and medium angular to subangular blocky structure; Few rounded to subangular gravels; No mottles; Few fine pores; Few fine and medium roots; Clear wavy boundary.
B2	47 to 83	Yellowish brown (10 YR 5/4) moist; Clay loam; Slightl sticky, Slightly plastic, Slightly firm; Moderate medium angular to subangular blocky structure; Few partially weathered shales; No mottles; Few medium roots; Gradual wavy boundary with underlying horizon.
C1	83 to 121	Brown (7.5 YR 5/4) moist; Clay loam; Slightly sticky, slightly plastic, slightly firm; Weak moderate angular to subangular blocky structure; No mottles; Common black concretions of Fe and Mn; Many partially weathered fragments of rocks. Few fine and medium roots; Gradual wavy boundary with underlying horizon.
C2	121 to 150	Strong brown (7.5 YR 5/8) moist; Silt clay; Sticky, plastic, firm; Moderate fine angular to subangular blocky structure; Many partially weathered rock fragments.

Table C 2.2 Result of Laboratory Analysis of Soil Samples (1/5)

Pit No.	Soil Dept (cm)	Particle Size Distribution			Texture	pH	O. M.	Total N	Phosphorous	Exchangeable Bases (meq/100 gr.)					CEC	BSP
		% of Sand	% of Silt	% of Clay		(in Water)	(%)	(%)	(ppm)	Ca	Mg	Na	K	Total		
1	0 to 30	48	23	29	SCL	6.1	3.0	0.20	3.8	9.3	3.9	0.1	0.3	13.6	24.7	55
	30 to 60	10	7	83	Clay	6.8	0.5	0.04	0.7	31.8	6.9	0.4	0.2	39.3	49.8	79
	60 to 100	4	2	94	Clay	7.5	0.5	0.05		41.4	6.6	0.4	0.2	48.6	57.1	85
2	0 to 30	67	25	8	SL	6.8	3.0	0.21	3.9	4.1	0.7	0.1	0.2	5.1	16.1	32
	30 to 60	58	34	8	SL	6.7	4.3	0.24	3.5	5.4	0.4	0.1	0.2	6.1	24.2	25
	60 to 100	72	21	7	SL	6.5	1.4	0.16		1.9	0.3	0.2		2.4	13.4	18
3	0 to 30 Water table	22	32	46	Clay	5.5	2.6	0.16	0.9	13.1	14.0	0.2	0.1	27.4	52.3	52
4	0 to 30	29	32	39	CL	5.5	1.6	0.20	1.3	27.8	13.9	0.2	0.1	42.0	61.2	69
	30 to 60	32	31	37	CL	5.7	0.9	0.10	0.9	32.7	14.4	0.1	0.1	47.3	63.3	75
	60 to 100	40	39	21	Loam	6.3	0.3	0.04		27.0	8.0	0.6	0.1	35.7	46.3	77
5	0 to 30	20	29	51	Clay	5.7	2.4	0.15	2.3	20.1	8.6	0.1	0.2	29.0	46.7	62
	30 to 60	25	19	56	Clay	5.8	1.1	0.14	0.7	19.8	7.4	0.2	0.1	27.5	42.2	65
	60 to 100	27	16	57	Clay	5.6	0.7	0.11		19.8	7.1	0.2	0.1	27.2	42.9	63
6	0 to 30	62	21	17	Silty Clay	6.0	2.4	0.16	2.1	4.0	2.9	0.1	0.2	7.2	17.2	42
	30 to 60	56	15	29	Silty Clay	6.4	0.9	0.07	0.9	19.7	3.1	0.2	0.1	23.1	32.2	72
	60 to 100	47	3	50	Clay	6.4	0.4	0.05	0.7	18.9	3.9	0.3	0.1	23.2	32.4	72
7	0 to 30	70	17	13	SL	6.0	2.5	0.13	6.0	3.5	2.6	0.2	0.1	6.4	15.3	42
	30 to 60	77	14	9	SL	6.8	0.7	0.02	1.5	2.0	1.4	0.2	0.0	3.6	9.5	38
	Water table															
8	0 to 30	60	20	20	SL	6.3	3.7	0.14	2.0	8.0	4.0	0.3	0.1	12.4	24.5	51
	30 to 60	46	5	49	SC	6.5	0.8	0.07	0.9	16.5	4.0	0.3	0.1	20.9	33.0	63
	60 to 100	16	7	77	Clay	7.8	0.6	0.06	0.8	53.7	4.9	0.2	0.1	58.9	62.0	95
9	0 to 30	50	11	39	SC	7.4	1.1	0.06	1.1	20.0	3.7	0.3	0.1	24.1	32.3	75
	30 to 60	50	20	30	SC	6.4	2.5	0.05	2.8	12.1	4.4	0.2	0.1	16.8	29.2	58
	60 to 100	54	8	38	SC	6.5	0.7		1.1	16.6	2.3	0.3	0.1	19.3	28.6	67
10	0 to 30	40	18	42	Clay	6.5	2.1	0.13	1.4	13.9	4.4	0.3	0.1	18.7	31.2	60
	30 to 60	17	8	75	Clay	7.0	0.6	0.03	0.8	28.5	5.8	0.5	0.1	34.9	45.6	77
	60 to 100	18	8	74	Clay	7.7	0.4	0.05	0.6	50.0	5.5	0.5	0.2	56.2	63.6	88

Table C 2.2 Result of Laboratory Analysis of Soil Samples (2/5)

Pit No.	Soil Dept (cm)	Particle Size Distribution			Texture	pH	O. M.	Total N	Phosphorous	Exchangeable Bases (meq/100 gr.)					CEC	BSP
		% of Sand	% of Silt	% of Clay		(in Water)	(%)	(%)	(ppm)	Ca	Mg	Na	K	Total		
11	0 to 30	36	38	26	Loam	6.0	2.4	0.18	1.2	10.0	6.4	0.2	0.1	16.7	32.1	52
	30 to 60	26	28	46	Clay	6.3	1.3	0.19	0.9	11.9	6.9	0.2	0.0	19.0	33.7	56
	60 to 100	32	29	39	CL	6.0	0.8	0.13		7.6	6.0	0.2	0.0	13.8	25.5	54
12	0 to 30	40	30	30	CL	6.1	1.6	0.09	2.7	6.3	4.7	0.2	0.0	11.2	20.3	55
	30 to 60	42	19	39	CL	7.0	0.5	0.12	1.1	10.2	7.8	0.5	0.0	18.5	26.8	69
	60 to 100	28	21	51	Clay	7.1	0.3	0.12		15.5	19.1	0.6	0.1	35.3	43.7	81
13	0 to 30	54	17	29	SCL	6.8	1.2	0.07	1.7	8.9	4.7	0.2	0.1	13.9	23.0	60
	30 to 60	50	10	40	SC	7.1	0.4	0.03	1.3	15.5	6.6	0.3	0.0	22.4	30.7	73
	60 to 100	37	5	58	Clay	7.4	0.4	0.03		34.0	5.6	0.3	0.1	40.0	47.4	84
14	0 to 30	50	21	29	SCL	6.6	2.1	0.16	4.9	10.2	4.6	0.3	0.1	15.2	25.4	60
	30 to 60	36	7	57	Clay	7.9	0.6	0.05	1.1	31.3	5.3	0.4	0.1	37.1	40.2	92
	60 to 100	38	14	48	Clay	8.2	0.7	0.05		41.1	3.5	0.3	0.1	45.0	47.0	96
15	0 to 30	46	19	35	SCL	7.0	1.2	0.08	1.3	14.2	6.1	0.7	0.1	21.1	33.7	63
	30 to 60	41	12	47	CL	7.0	0.5	0.04	0.9	15.4	6.8	0.6	0.0	22.8	35.3	65
	60 to 100	18	3	79	Clay	7.3	0.4	0.03	0.6	31.1	7.6	0.7	0.2	39.6	48.0	83
16	0 to 30	36	25	39	CL	6.7	1.5	0.08	0.9	25.4	6.7	0.4	0.1	32.6	45.0	72
	30 to 60	43	19	38	CL	6.7	0.7	0.06	0.7	13.5	6.1	0.3	0.1	20.0	32.0	63
	60 to 100	17	9	74	Clay	7.0	0.3	0.02		23.7	14.6	0.5	0.2	39.0	50.2	78
17	0 to 30	37	34	29	CL	6.2	3.1	0.20	1.5	13.1	7.1	0.3	0.1	20.6	35.9	57
	30 to 60	33	27	40	Clay	6.3	1.2	0.10	0.8	15.8	6.2	0.3	0.1	22.4	35.6	63
	60 to 100	19	24	57	Clay	6.7	1.0	0.07		30.7	5.9	0.3	0.1	37.0	49.5	75
18	0 to 30	39	41	20	Loam	6.0	5.4	0.32	3.6	7.9	6.0	0.4	0.3	14.6	33.9	43
	30 to 60	39	41	20	Loam	6.1	2.4	0.20	3.3	9.2	4.9	0.4	0.1	14.6	37.7	39
	60 to 100	15	33	52	Clay	6.4	1.4	0.10		11.4	7.1	0.4	0.0	18.9	33.1	57
19	0 to 30	29	36	35	CL	6.2	2.0	0.16	6.0	12.6	7.4	0.3	0.2	20.5	33.9	60
	30 to 60	23	24	53	Clay	6.8	0.6	0.05	1.3	18.7	14.5	0.6	0.1	33.9	46.3	73
	60 to 100	9	22	69	Clay	6.0	0.4	0.04		24.5	17.6	0.6	0.2	42.9	55.4	77
20	0 to 30	41	32	27	CL	6.9	1.8	0.13	2.6	10.7	6.3	0.6	0.0	17.6	26.7	66
	30 to 60	29	17	54	Clay	6.9	0.7	0.07	1.1	11.3	6.3	1.4	0.0	19.0	29.3	65
	60 to 100	15	11	74	Clay	7.0	0.5	0.05		18.7	7.6	1.2	0.1	27.6	37.0	75

Table C 2.2 Result of Laboratory Analysis of Soil Samples (3/5)

Pit No.	Soil Dept (cm)	Particle Size Distribution			Texture	pH (in Water)	O. M. (%)	Total N (%)	Phosphorous (ppm)	Exchangeable Bases (meq/100 gr.)					CEC	BSP
		% of Sand	% of Silt	% of Clay						Ca	Mg	Na	K	Total		
21	0 to 30	22	37	41	Clay	6.8	2.6	0.22	11.8	14.8	12.0	0.4	0.6	27.8	38.1	73
	30 to 60	29	34	37	CL	6.5	2.0	0.15	8.7	8.9	6.8	0.5	0.4	16.6	27.7	60
	60 to 100	29	22	49	Clay	6.7	0.2	0.02		14.3	15.1	1.4	0.1	30.9	41.2	75
22	0 to 30	39	38	23	Loam	7.9	3.9	0.27	22.3	34.8	34.0	0.4	0.6	69.8	75.9	92
	30 to 60	23	34	43	Clay	7.5	1.3	0.09	10.4	15.8	7.8	0.4	0.6	24.6	31.9	77
	60 to 100	27	26	47	Clay	7.0	0.6	0.08		10.2	7.1	0.6	0.3	18.2	26.3	69
23	0 to 30	29	38	33	CL	6.3	3.9	0.25	3.4	10.4	6.5	0.7	0.1	17.7	34.0	52
	30 to 60	27	35	38	CL	6.5	2.3	0.16	2.8	10.5	7.5	0.6	0.1	18.7	32.9	57
	60 to 100	11	29	60	Clay	7.2	1.0	0.08		15.0	14.1	0.6	0.1	29.8	42.3	70
24	0 to 30	37	37	26	Loam	6.1	2.4	0.14	2.5	5.1	4.5	0.1	0.1	9.8	21.8	45
	30 to 60	32	17	51	Clay	6.3	0.6	0.06	0.8	6.7	7.5	0.7	0.1	15.0	25.2	60
	60 to 100	10	17	73	Clay	6.8	0.3	0.04		12.1	21.2	0.9	0.2	34.4	42.5	79
25	0 to 30	31	41	28	CL	6.4	2.3	0.31	16.9	13.5	13.7	0.1	1.0	28.3	42.5	67
	30 to 60	25	43	32	CL	6.4	1.1	0.19	25.2	11.3	8.2	0.6	0.7	20.8	39.7	52
	60 to 100	14	31	55	Clay	6.4		0.07		13.2	15.5	0.6	0.4	29.7	43.0	69
26	0 to 30	35	40	25	Loam	7.7	4.9	0.31	39.1	35.4	3.1	0.2	0.7	39.4	44.5	89
	30 to 60	27	34	39	CL	7.4	1.3	0.10	16.8	15.1	4.6	0.3	0.8	20.8	28.9	72
	60 to 100	23	28	49	Clay	6.9	0.7	0.07		10.1	6.9	0.6	0.4	18.0	28.3	64
27	0 to 30	25	42	33	CL	6.5	2.0	0.15	26.0	10.1	5.0	0.4	0.1	15.6	27.7	56
	30 to 60	23	36	41	Clay	6.8	1.2	0.08	4.6	9.9	5.0	0.4	0.1	15.4	26.6	58
	60 to 100	16	29	55	Clay	6.7	0.6	0.06		8.4	5.5	0.4	0.1	14.4	23.5	61
28	0 to 30	35	41	24	Loam	6.1	3.0	0.23	18.6	6.2	5.0	0.2	0.7	12.1	23.2	52
	30 to 60	23	28	49	Clay	6.4	0.8	0.07	3.8	5.8	6.0	0.7	0.5	13.0	23.2	56
	60 to 100	18	31	51	Clay	6.5	0.6	0.06		6.5	6.5	0.8	0.5	14.3	24.6	58
29	0 to 30	29	39	32	CL	6.4	1.9	0.15	4.6	5.8	4.5	0.9	0.1	11.3	23.0	49
	30 to 60	27	29	44	Clay	6.3	0.4	0.03	5.0	6.5	5.4	1.1	0.1	13.1	24.3	54
	60 to 100	19	27	54	Clay	6.4	0.2	0.03		7.4	6.5	1.4	0.1	15.4	26.8	57
30	0 to 30	28	37	35	CL	6.3	2.1	0.17	14.3	6.3	4.1	1.0	0.2	11.6	22.2	52
	30 to 60	25	29	46	Clay	6.1	1.1	0.08	8.4	4.9	4.1	0.8	0.5	10.3	20.3	51
	60 to 100	24	28	48	Clay	6.6	0.3	0.03		5.4	5.0	1.0	0.4	11.8	21.7	54

Table C 2.2 Result of Laboratory Analysis of Soil Samples (4/5)

Pit No.	Soil Dept (cm)	Particle Size Distribution			Texture	pH	O. M.	Total N	Phosphorous	Exchangeable Bases (meq/100 gr.)					CEC	BSP
		% of Sand	% of Silt	% of Clay		(in Water)	(%)	(%)	(ppm)	Ca	Mg	Na	K	Total		
31	0 to 30	31	33	36	CL	6.6	1.4	0.10	4.1	7.3	4.9	0.9	0.1	13.2	22.6	58
	30 to 60	17	35	48	Clay	6.2	1.2	0.08	3.6	9.4	5.3	1.2	0.1	16.0	27.9	57
	60 to 100	15	29	56	Clay	6.7	0.6	0.07		12.0	6.2	0.7	0.1	19.0	29.9	64
32	0 to 30	28	40	32	CL	6.8	1.9	0.13	28.9	10.1	7.1	0.6	0.3	18.1	26.5	68
	30 to 60	19	36	45	Clay	6.9	1.3	0.10	40.0	10.6	9.0	0.6	0.3	20.5	28.1	73
	60 to 100	32	31	37	CL	6.4	1.1	0.04		10.4	6.7	0.5	0.3	17.9	25.0	72
33	0 to 30	50	33	17	Loam	5.3	2.7	0.19	7.6	4.6	3.2	0.3	0.2	8.3	16.4	51
	30 to 60	35	56	9	Silt Loam	5.5	0.7	0.04	6.9	21.0	1.7	0.2	0.1	23.0	24.9	92
	60 to 100	55	35	10	SL	4.9	1.1	0.06		1.8	1.3	0.2	0.1	3.4	6.5	52
34	0 to 30	49	35	16	Loam	6.1	2.4	0.17	5.7	7.0	1.8	0.4	0.1	9.3	20.7	45
	30 to 60	41	27	32	CL	6.5	1.5	0.13	6.6	8.4	2.1	0.7	0.1	11.3	19.9	57
	60 to 100	37	25	38	CL	6.4	1.3	0.06		9.2	1.1	0.6	0.1	11.0	19.3	57
35	0 to 30	55	37	8	SL	5.4	2.9	0.12	3.2	3.1	1.8	0.3	0.1	5.3	10.2	52
	30 to 60	73	17	10	SL	5.6	0.9	0.06	3.3	2.2	2.1	0.2	0.1	4.6	6.5	71
	60 to 100	87	7	6	LS	6.0	0.2	0.01		1.2	1.1	0.1	0.1	2.5	3.5	71
36	0 to 30	67	19	14	SL	6.5	2.4	0.14	10.3	6.7	4.5	0.2	0.2	11.6	19.6	
	30 to 60	83	11	6	SL	7.6	0.1	0.00	2.5	1.2	1.0	0.2	0.1	2.5	2.5	100
	60 to 100	88	6	6	Sand	7.2	0.1	0.01		0.7	0.7	0.1	0.1	1.6	1.6	100
37	0 to 30	64	27	8	SL	6.4	1.7	0.12	9.1	2.8	1.4	0.1	0.1	4.4	8.4	52
	30 to 60	81	13	6	LS	6.7	1.1	0.07	10.3	2.2	1.2	0.1	0.1	3.6	4.6	78
	60 to 100	88	6	6	Sand	6.8	0.3	0.03		6.8	0.4	0.1	0.0	7.3	7.3	100
38	0 to 30	31	37	32	CL	6.4	1.8	0.14	2.0	8.6	3.3	0.4	0.2	12.5	22.4	56
	30 to 60	22	32	46	Clay	6.4	1.1	0.07	2.5	7.8	4.5	1.0	0.1	13.4	23.5	57
	60 to 100	13	31	56	Clay	6.4	0.6	0.04		10.9	5.8	0.7	0.0	17.4	27.2	64
39	0 to 30	29	37	34	CL	6.5	2.2	0.12	24.8	6.7	6.5	0.3	0.9	14.4	26.1	55
	30 to 60	23	31	46	Clay	6.5	1.5	0.09	10.6	8.7	4.3	1.1	0.2	14.3	25.4	56
	60 to 100	23	25	52	Clay	6.8	0.5	0.04		9.4	5.8	1.7	0.2	17.1	28.0	61
40	0 to 30	27	25	48	Clay	6.6	0.5	0.04	1.0	10.1	6.2	0.3	0.0	16.6	26.1	64
	30 to 60	28	28	44	Clay	6.5	1.3	0.09	1.0	9.4	4.4	0.3	0.0	14.1	23.5	60
	60 to 100	30	37	33	CL	6.6	2.0	0.15	3.0	9.0	4.1	0.2	0.0	13.3	22.6	59

Table C 2.2 Result of Laboratory Analysis of Soil Samples (5/5)

Pit No.	Soil Dept (cm)	Particle Size Distribution			Texture	pH (in Water)	O. M. (%)	Total N (%)	Phosphorous (ppm)	Exchangeable Bases (meq/100 gr.)					CEC	BSP
		% of Sand	% of Silt	% of Clay						Ca	Mg	Na	K	Total		
41	0 to 30	42	32	26	Loam	6.0	2.3	0.15	2.8	7.7	3.8	0.3	0.1	11.9	20.0	60
	30 to 60	43	25	32	CL	6.3	0.8	0.09	1.4	8.2	3.7	0.4	0.0	12.3	19.4	63
	60 to 100	38	16	46	Clay	6.0	0.5	0.04		8.8	4.5	0.5	0.0	13.8	19.0	73
42	0 to 30	31	39	30	CL	6.1	2.8	0.21	31.1	8.0	4.5	0.3	0.1	12.9	23.4	55
	30 to 60	27	35	38	CL	6.7	1.3	0.09	3.4	9.7	5.9	1.1	0.0	16.7	24.3	69
	60 to 100	23	29	48	Clay	6.7	0.3	0.04		9.9	6.7	1.2	0.0	17.8	24.4	73
43	0 to 30	26	39	35	CL	6.4	2.4	0.14	2.8	10.1	4.8	0.3	0.0	15.2	25.7	59
	30 to 60	18	31	51	Clay	6.0	1.7	0.10	0.6	9.0	3.8	0.5	0.1	13.4	25.8	52
	60 to 100	16	29	55	Clay	6.0	1.0	0.08		8.0	3.5	0.4	0.1	12.0	22.9	52
44	0 to 30	26	35	39	CL	6.2	1.6	0.11	2.1	7.6	4.0	0.4	0.1	12.1	22.0	55
	30 to 60	14	28	58	Clay	6.2	0.9	0.05	0.3	8.7	5.4	0.8	0.0	14.9	25.8	58
	60 to 100	28	26	45	Clay	6.0	0.4	0.07		10.2	6.3	1.1	0.0	17.6	30.9	57
45	0 to 30	28	37	35	CL	5.8	4.1	0.21	2.1	17.0	7.8	0.2	0.2	25.2	40.3	63
	30 to 60	16	27	57	Clay	6.0	1.3	0.08	0.6	21.7	15.0	0.2	0.1	37.0	55.0	67
	60 to 100	8	23	69	Clay	6.2	1.1	0.06		25.6	15.0	0.3	0.1	41.0	54.6	75
46	0 to 30	38	37	25	Loam	7.3	3.8	0.26	17.8	27.9	3.8	0.2	0.6	32.5	36.6	89
	30 to 60	21	30	49	Clay	7.0	0.8	0.06	4.4	9.9	7.1	0.7	0.5	18.2	27.4	66
	60 to 100	18	28	54	Clay	6.8	0.6	0.06		9.2	6.4	0.9	0.5	17.0	26.4	64
47	0 to 30	34	39	27	Loam	5.8	3.0	0.17	2.3	9.1	7.0	0.2	0.2	16.5	26.8	62
	30 to 60	30	31	39	CL	6.4	1.4	0.12	0.3	11.7	6.8	0.2	0.1	18.8	29.2	64
	60 to 100	32	25	43	Clay	6.4	0.8	0.05		12.4	7.3	0.3	0.1	20.1	30.7	65
48	0 to 30	28	38	35	CL	6.4	2.4	0.14	1.7	8.9	4.1	0.2	0.0	13.2	24.6	54
	30 to 60	20	31	49	Clay	6.3	1.7	0.11	0.9	8.9	3.9	0.4	0.1	13.3	26.4	50
	60 to 100	16	28	56	Clay	6.3	1.1	0.09		8.9	3.9	0.5	0.1	13.4	24.6	54
49	0 to 30	32	41	27	Loam	6.0	2.3	0.17	0.8	9.5	6.8	0.1	0.0	16.4	29.9	55
	30 to 60	26	32	42	Clay	6.1	1.3	0.12	0.6	11.3	7.2	0.2	0.0	18.7	31.6	59
	60 to 100	35	31	34	CL	5.9	0.7	0.06		7.7	5.2	0.2	0.0	13.1	24.0	55
50	0 to 30	32	42	27	Loam	6.3	2.8	0.15	1.0	9.5	6.6	0.2	0.1	16.4	28.1	58
	30 to 60	28	32	40	Clay	6.3	1.4	0.08	0.3	11.5	7.0	0.2	0.1	18.8	28.5	66
	60 to 100	37	25	38	CL	6.2	0.8	0.05		11.0	6.7	0.3	0.1	18.1	29.3	62

Table C 3.1 Land Suitability Classification in the Study Area

Soil Group	Soil Mapping Unit	Area (ha)	Land Utilization Type		
			Wetland Rice	Diversified annuals Crop	Tree Crops
A	10-A d1	610	S2 x	S3 d x	S3 dkx
	10-A f1	80	S2 fx	N	N
	20-A d1	350	S2 x	S3 dt	S3 dk
	30-A d1	4,130	S2 x	S3 dt	S3 dk
	30-A f1	490	S2 f x	N	N
	50-A d1	110	S2 x	S3 dt	S3 dk
Sub-total A		5,770			
B	20-B	760	N	S2 st	S2 dk
	30-B	560	N	S2 st	S2 dk
	50-B	420	N	S2 st	S2 dk
Sub-total B		1,740			
C	20-C e1	1,090	N	S3 st	S3 sk
	30-C e1	1,140	N	S3 st	S3 sk
	50-C e1	150	N	S3 st	S3 sk
Sub-total C		2,380			
D	20-D e2	90	N	N	N
	30-D e2	190	N	N	N
Sub-total D		280			
N	10-A f3	20	N	N	N
Sub-total Agricultural Land		10,190			
Residential and Others		420			
Total		10,610			
Highly Suitable Land (S1)			0	0	0
Moderately Suitable Land (S2)			5,770 ha	1,740 ha	1,740 ha
Marginally Suitable Land (S3)			0	7,580 ha	7,580 ha
Not Suitable Land (N)			4,420 ha	870 ha	870 ha

Source: Soil Survey and topographic map at scale 1:4,000, JICA Study Team 1995

Limiting factors: d : drainage; s : slope; f : flood; t: texture; k: effective soil depth; x : fertility (CEC)

Criteria for Suitability Classification

Land Use Type and Factor Evaluated	Highly Suitable (S1)	Moderately Suitable (S2)	Marginally Suitable (S3)	Not Suitable (N)
Drainage				
Diversified Crops	Well	Not Used	Imperfect	Poor or Excessive
Tree Crops	Well	Not Used	Imperfect	Poor or Excessive
Lowland Rice	Well to Poor	Not Used	Not used	Excessive
Slope (%)				
Diversified Crops	0 to 8	8 to 18	18 to 25	More than 25
Tree Crops	0 to 8	8 to 18	18 to 25	More than 25
Lowland Rice	0 to 3	3 to 8		More than 8
Soil Texture				
Diversified Crops	Fine to medium	Not Used	Coarse	Very coarse
Tree Crops	Fine to medium	Not Used	Coarse	Very coarse
Lowland Rice	Fine	Medium	Moderately Coarse	Coarse
Fertility (CEC)				
Diversified Crops	More than 24	16 to 24	Less than 16	Not Used
Tree Crops	More than 25	16 to 24	Less than 17	Not Used
Lowland Rice	More than 26	16 to 24	Less than 18	Not Used
Soil Depth (cm)				
Diversified Crops	More than 75	75 to 50	50 to 25	Less than 25
Tree Crops	More than 150	150 to 100	100 to 50	Less than 50
Lowland Rice	More than 60	51 to 60	20 to 50	Less than 20

Table C 4.1 Major Types of Farm Land Use in Philippines, Bicol Region, Albay Province, Camalig, Daraga, and the Study Area

(Unit:ha)

Mayor Land Use	Philippines		Bicol Region		Albay Province		Camalig		Daraga		Study Area *	
	ha	%	ha	%		%	ha	%	ha	%	ha	%
All Classes of Farm Lands	9,974,871	100.0	936,174	100.0	134,620	100.0	9,405	100	7,922	100.0	10,190	100.0
Homelot	63,025	0.6	4,135	0.4	712	0.5	28	0.3	31	0.4	26	0.3
Temporary Crops	5,332,770	53.5	276,706	29.6	48,379	35.9	1,851	19.7	2,494	31.5	1,770	17.4
Permanent Crops	4,172,540	41.8	609,202	65.1	83,885	62.3	7,358	78.2	5,355	67.6	7,080	69.4
Temporarily Fallow	70,505	0.7	2,550	0.3	257	0.2	18	0.2	4	0.1	11	0.1
Temporary Meadows / Pasture	83,682	0.9	10,391	1.1	452	0.3	12	0.1	12	0.1	14	0.1
Permanent Meadows/ Pasture	130,943	1.3	26,365	2.8	453	0.4	0	0.0	18	0.2	-	-
Wood Land and Forest	70,144	0.7	6,084	0.7	363	0.3	101	1.1	0	0.0	0	0.0
All Others Lands	51,263	0.5	720	0.1	119	0.1	36	0.4	7	0.1	1,290	12.7

Sources: NSO. 1991 Census of Agriculture;

Note : * Study Team based on topographic map made in 1995, JICA

Table C 4.2 Present Land Use in the Study Area by Barangay

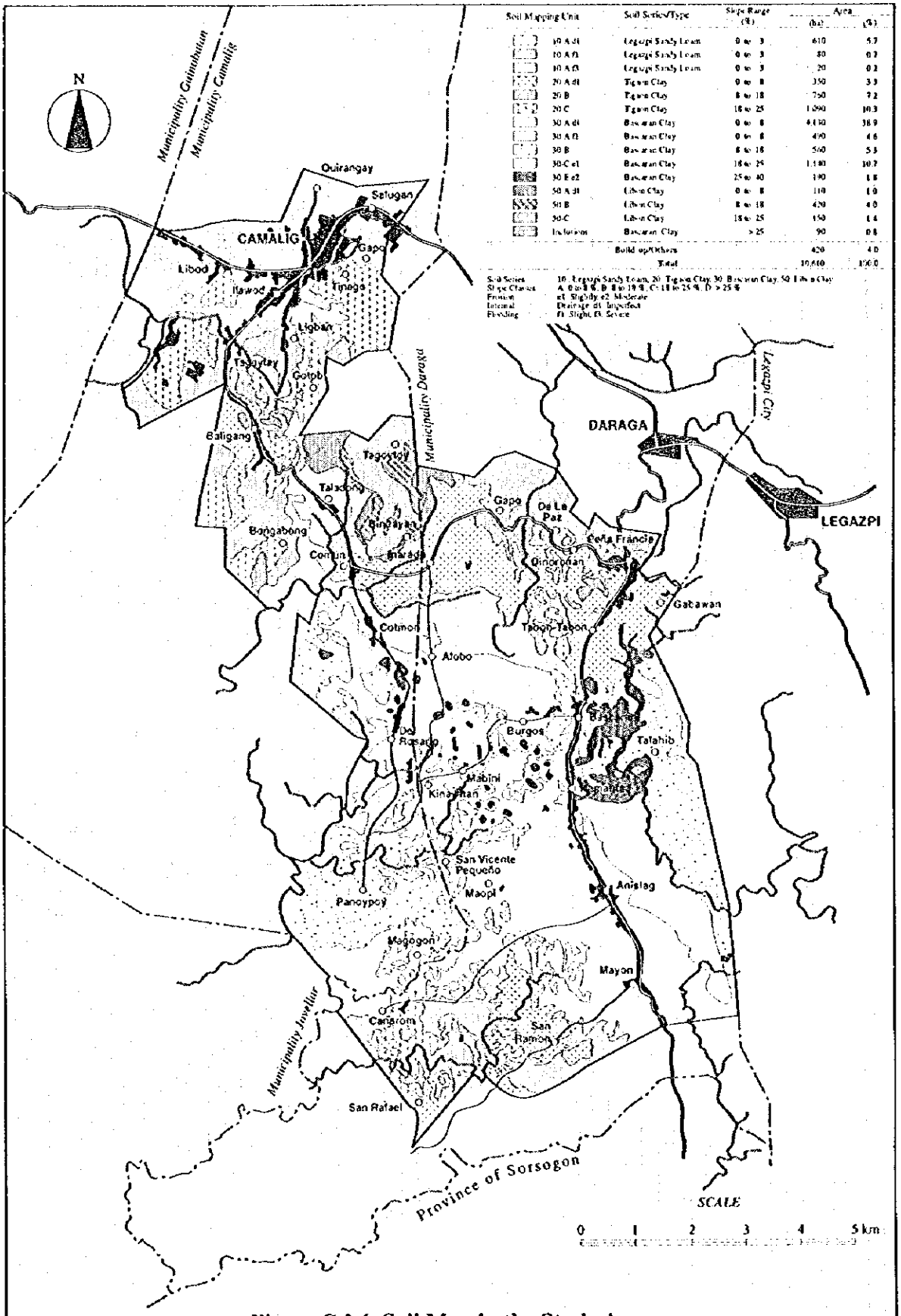
(Unit : ha)

Municipality / Barangay		Total Area (ha)	Paddy Field	Coconut	Upland Crops (Open areas)	Shrubs and Grass	Agricultural Lands Total	Residential and Others
Camalig								
C-1	Quirangay	651	62	375	5	192	634	17
C-2	Salugan	105	0	76	6	14	96	9
C-3	Gapo	88	21	50	8	7	86	2
C-4	Poblacion	36	1	1	0	25	27	9
C-5	Tinago	65	0	53	0	9	62	3
C-6	Ilawod	187	67	77	2	19	165	22
C-7	Libod	327	194	85	3	18	300	27
C-8	Ligban	91	34	45	1	8	88	3
C-9	Tagaytay	387	56	243	5	60	364	23
C-10	Gotob	91	38	37	4	9	88	3
C-11	Baligang	347	10	226	20	76	332	15
C-12	Tagoytoy	127	0	91	8	21	120	7
C-13	Taladong	203	8	158	4	27	197	6
C-14	Binitayan	69	16	41	2	7	66	3
C-15	Comun	157	37	89	4	16	146	11
C-16	Bongabong	316	21	218	10	55	304	12
C-17	Cotmon	595	74	420	11	78	583	12
C-18	Del Rosario	246	3	212	0	18	233	13
C-19	Panoypoy	455	3	421	3	20	447	8
C-20	Magogon	240	5	190	20	17	232	8
	Total	**4,783**	**650**	**3,108**	**116**	**696**	**4,570**	**213**
Daraga								
D-1	Inarado	682	109	467	7	83	666	16
D-2	Gapo	389	16	285	12	70	383	16
D-3	De La Paz	73	0	62	2	6	70	3
D-4	Dinoronan	61	18	30	2	8	58	3
D-5	Peña Francia	194	7	124	7	45	180	14
D-6	Alobo	161	86	60	2	8	156	5
D-7	Tabon-Tabon	208	61	113	0	24	198	10
D-8	Gabawan	93	24	46	3	12	85	8
D-9	Mabini	124	23	89	0	8	120	4
D-10	Kinawitan	79	0	63	5	8	76	3
D-11	Burgos	149	47	84	2	11	140	9
D-12	Bascaran	424	63	289	8	48	408	16
D-13	Talahib	432	11	370	9	30	420	12
D-14	Namantao	363	36	279	6	27	348	15
D-15	San Vicente Pequeño	64	49	12	0	2	63	1
D-16	Maopi	253	22	199	3	20	242	11
D-17	Anislag	656	46	442	55	91	634	22
D-18	Canaron	247	29	190	11	15	245	2
D-19	San Ramon	785	21	534	130	84	769	16
D-20	Mayon	357	32	216	40	50	338	19
D-21	San Rafael	33	0	28	0	3	31	2
	Total	**5,827**	**700**	**3,982**	**304**	**653**	**5,630**	**207**
Study Area Total		**10,610**	**1,350**	**7,090**	**420**	**1,340**	**10,200**	**420**

Source: MAS; PCA; MPDO; Study Team

THE FEASIBILITY STUDY ON
THE WESTERN LEGAZPI IRRIGATION AND
RURAL DEVELOPMENT PROJECT IN THE PHILIPPINES

FIGURES



Soil Mapping Unit	Soil Series/Type	Slope Range (%)	Area (ha)	Area (%)
10 A dl	Legazpi Sandy Loam	0 to 3	610	5.7
10 A fl	Legazpi Sandy Loam	0 to 3	80	0.7
10 A fl	Legazpi Sandy Loam	0 to 3	20	0.2
20 A dl	Tigaon Clay	0 to 8	350	3.3
20 B	Tigaon Clay	8 to 18	760	7.2
20 C	Tigaon Clay	18 to 25	1,090	10.3
30 A dl	Bascaran Clay	0 to 8	4,130	38.9
30 A fl	Bascaran Clay	0 to 8	490	4.6
30 B	Bascaran Clay	8 to 18	560	5.3
30-C el	Bascaran Clay	18 to 25	1,140	10.7
30 E e2	Bascaran Clay	25 to 40	190	1.8
50 A dl	Libon Clay	0 to 8	110	1.0
50 B	Libon Clay	8 to 18	420	4.0
50-C	Libon Clay	18 to 25	150	1.4
Inclusion	Bascaran Clay	> 25	90	0.8
	Build up/Others		420	4.0
	Total		10,610	100.0

Soil Series: 10 - Legazpi Sandy Loam, 20 - Tigaon Clay, 30 - Bascaran Clay, 50 - Libon Clay
Slope Classes: A: 0 to 8 %, B: 8 to 18 %, C: 18 to 25 %, D: > 25 %
Erosion: el - Slightly, e2 - Moderate
Internal Drainage: dl - Imperfect
Flooding: fl - Slight, f3 - Severe

Figure C 2.1 Soil Map in the Study Area

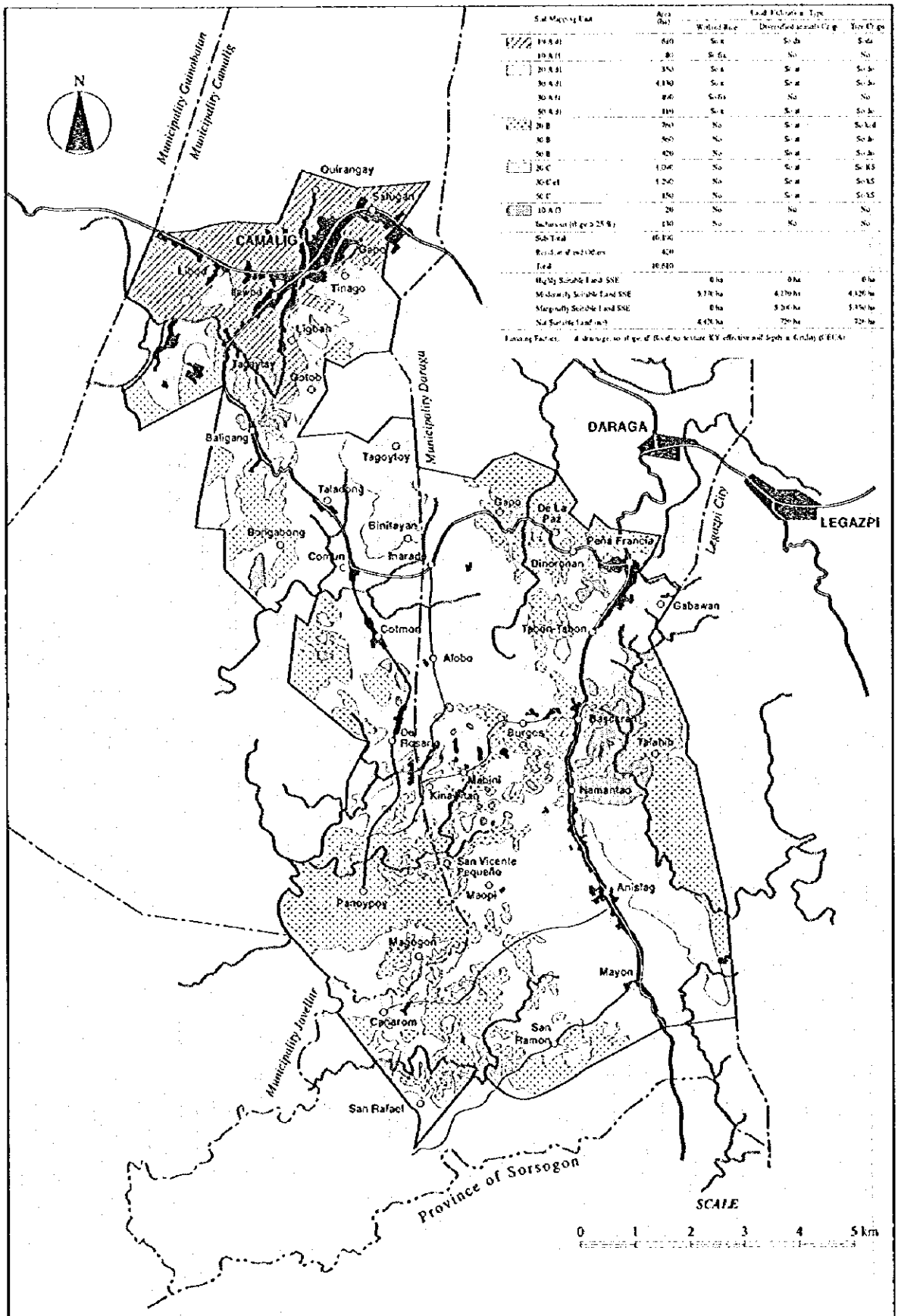


Figure C 3.1 Land Suitability Map in the Study Area

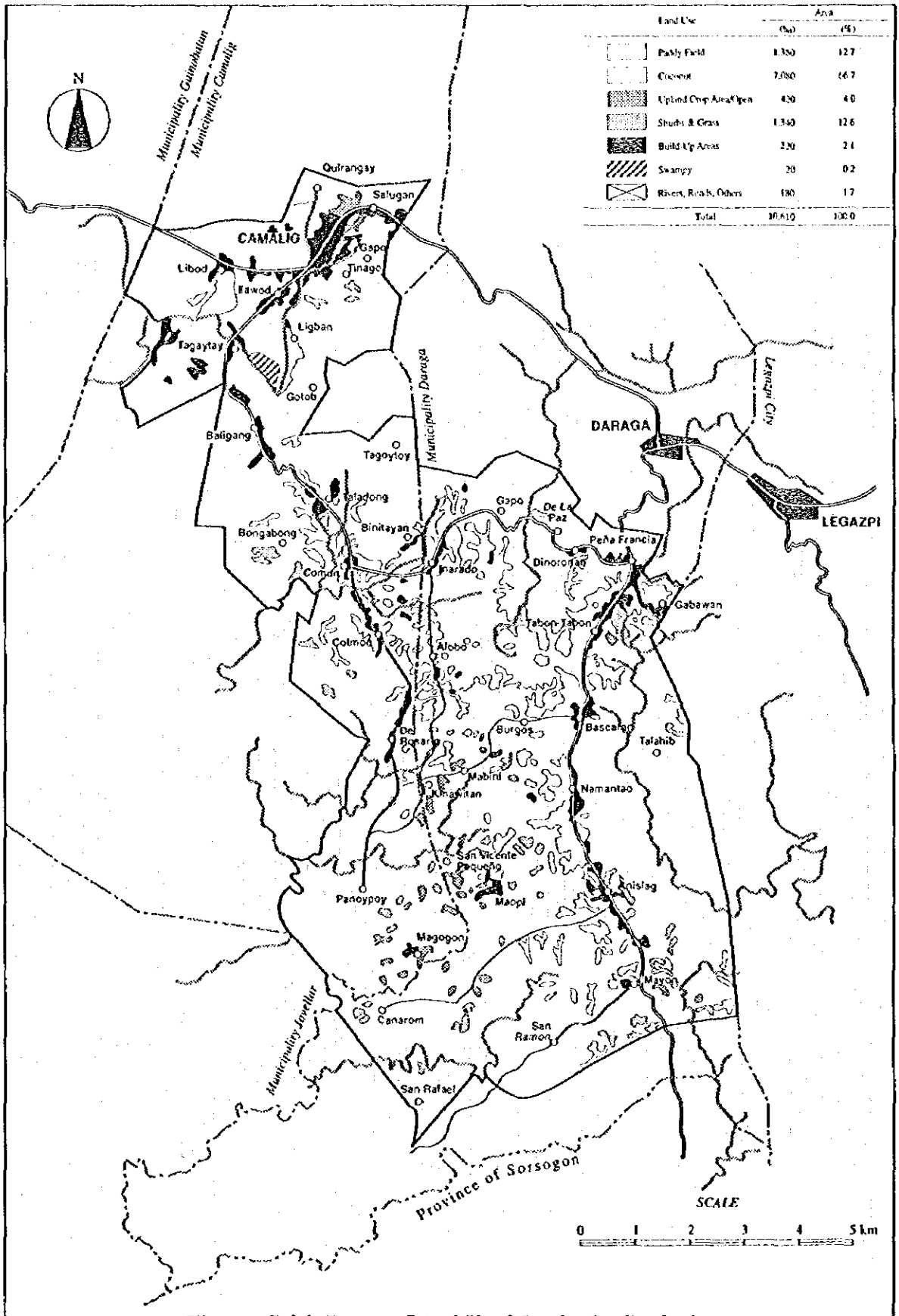


Figure C 4.1 Present Land Use Map in the Study Area

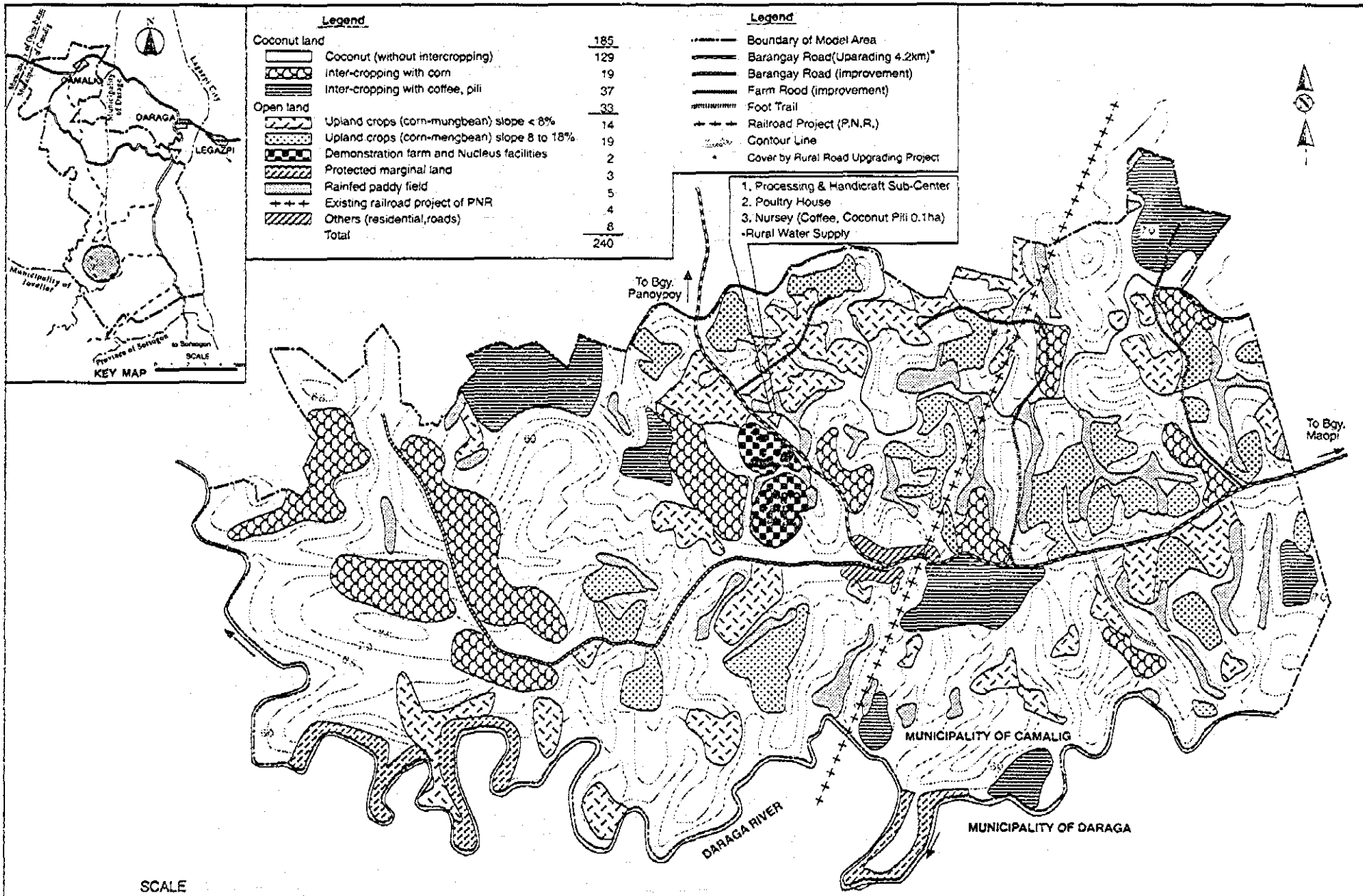


Figure C 5.1 Proposed Land Use Map in Magogon Upland Model Area

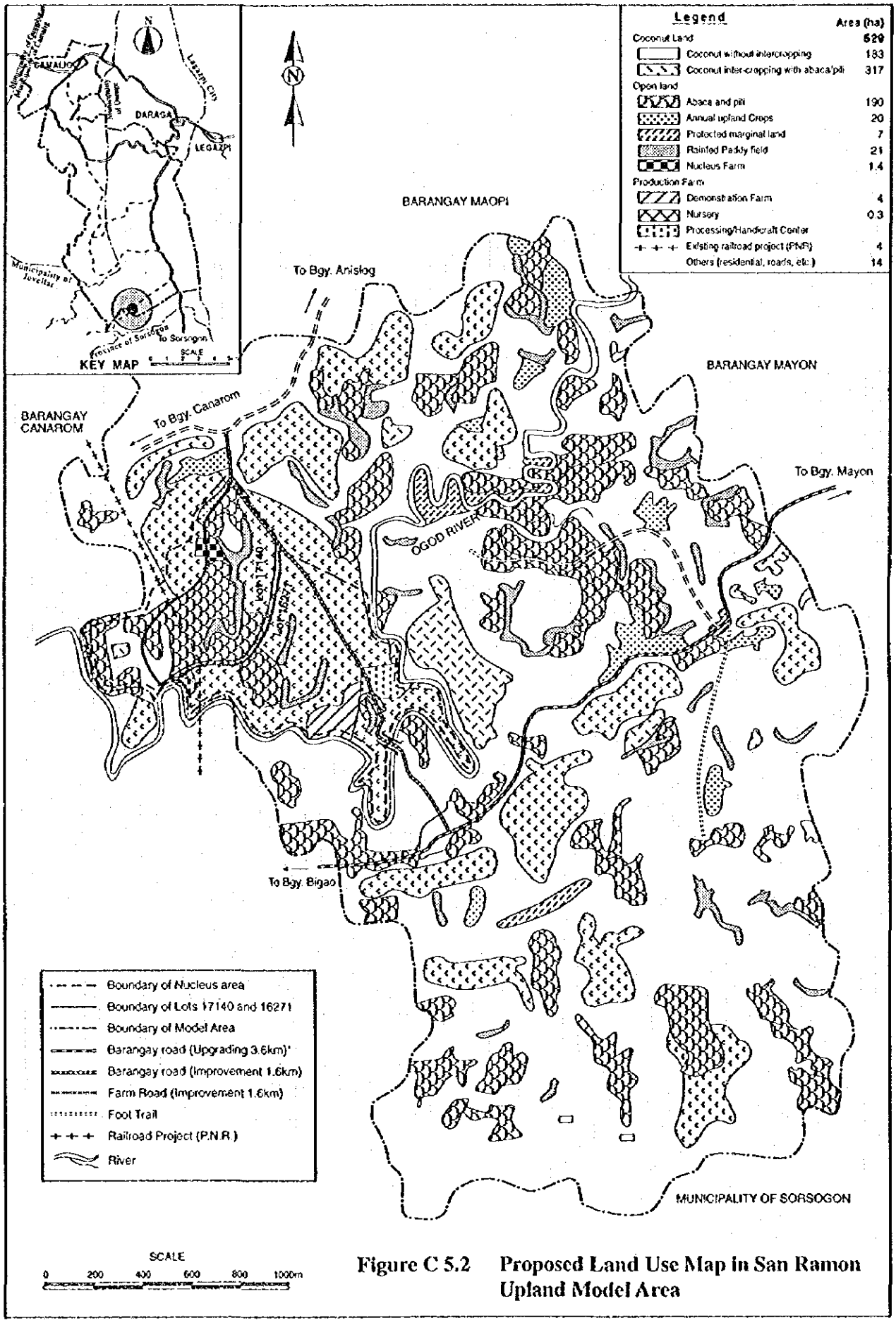


Figure C 5.2 Proposed Land Use Map in San Ramon Upland Model Area

ANNEX D

IRRIGATION AND DRAINAGE

ANNEX D

IRRIGATION AND DRAINAGE

Table of Contents

Page

Page

List of Tables

List of Figures

1. BACKGROUND OF IRRIGATION DEVELOPMENT

1.1 Regional Irrigation Development Programs

In accordance with the information of NIA regional office, arable lands of regional areas is about 1.12 million ha, and potential irrigation areas could be estimated at about 213,000 ha.

Out of the potential irrigation areas of about 213,000 ha, approximately 116,000 ha which is about 55% of total potential areas have been developed as irrigation services areas. The existing irrigation services areas are divided into 3 categories such as national irrigation systems of 15 locations, communal irrigation systems of 1941 locations and private irrigation systems of 546 locations.

In NIA's regional development program for the 5 years from 1996 to 2000, communal irrigation systems of 367 locations which have total development services areas of 66,190 ha are scheduled to implement. A development goal of irrigation services areas is scheduled to attain about 86% of total potential areas by the year of 2000.

1.2 Provincial Irrigation Development Programs

1.2.1 Present Irrigation Development

In accordance with the irrigation profile updated by 1994, the total arable land of Albay is about 159,000 ha, and irrigation potential areas are estimated at about 50,000 ha. Currently irrigated areas are estimated at about 29,500 ha, and percentage of irrigation development is about 59%. Irrigation areas are only paddy fields. Existing irrigation schemes consists of 4 national irrigation system schemes, 66 communal irrigation system schemes and 248 private irrigation system schemes. Irrigation services area of each system are national irrigation system of 1,950 ha, communal irrigation system of 8,600 ha and private irrigation system of 18,900 ha.

Potential areas of about 20,500 ha are available for future irrigation development in provincial area. NIA provincial office has an intention to develop potential areas of about 14,500 ha by the year of 2000.

1.2.2 National Irrigation System (NIS)

At present, the 4 national irrigation systems of about 1,950 ha are constructed in the provincial area, and a year round paddy cultivation are conducted in all paddy fields. The systems have been handed over to the 6 IA groups, water management is conducted by each IA group together with a federation of IAs under NIA's technical assistance. Irrigation methods of all the systems are gravity.

1.2.3 Communal Irrigation System (CIS)

Existing communal irrigation systems are constructed at 66 locations in the provincial area, and the CISs are broadly divided into two (2) groups such as (i) NIA's assisted system and (ii) other Government agencies' assisted system.

Irrigation methods of the CISs are mainly gravity irrigation, while, pump irrigation systems are also constructed at some CISs.

1.2.4 Irrigation Development Programs

According to the NIA's development program in the provincial area for the 5 years by 2000, communal irrigation projects of 91 locations are scheduled to develop, and the total areas to

be developed could be attained at about 14,600 ha, and level of future irrigation development is scheduled to attain at 88% of potential irrigation development areas. NIA has already identified 8 CIS projects in the Study area.

1.3 Irrigation Development around the Study Area

1.3.1 Existing Communal Irrigation Systems (CIS)

(1) General Features of CISs

Existing CISs of 2 locations, namely Pandan - Bongalon CIS and Cullat CIS are scattered around the Study area. All irrigation areas are covered by paddy field, and gravity irrigation method are established. System of farm ditch, drainage canals and farm to market roads are not fully constructed. Irrigation area of Cullat CIS has been affected by urbanization, and irrigation area is decreased from the initial developed area of 90 ha to current area of 35 ha. Salient features of each the CIS are as follows:

- Pandan - Bongalon CIS
  - Water resources : Gulang - Gulang creek
  - Irrigation area : 30 ha
  - Intake method : Concrete diversion dam
  - Irrigation canal : approximately 2.0 km
  - IA member : 32 house hold
  - Crop calendar : Paddy -Paddy

- Cullat CIS
  - Water resources : Yawa river
  - Irrigation area : 35 ha
  - Intake method : Diversion dam
  - Crop calendar : Paddy -Paddy

(2) Water Management of Existing CIS

(a) Water right of the existing CIS

In accordance with the list of water permit grantees issued by National Water Resources Board, water rights of the Pandan - Bongalon CIS, is accepted by the year of 1995, and water right of Cullat CIS is being processed for the issuance of permit.

(b) Irrigators' associations

All decision are made by CIS board. The board consists of board director (chairman of board), some directors (representatives of IA member) and executing body which are headed by IA president. The IA president has 5 executive officers such as secretary, administration, treasurer, etc.. In case of the 2 existing CISs, members of IA are 141 member of Libod - Bariw - Minto CIS. Average irrigation services area of the 2 CISs are less than 1.0 ha. The majority form of participation are payment of irrigation fees by paddy and cooperation of labor power for repairing an maintenance works of their irrigation facilities.

(c) Current water operation

Water operation for the CIS areas are conducted based on crop schedule and water distribution plan which are determined at the board meeting. However, in the field, water operation rule and system are not functioned well.

Measurement of irrigation water discharge are carried out at some turnout and/or division box of canals. Systematic water management which covers overall irrigation area are not found out because of lack of on-farm facilities such as farm ditches and drains and weak extension of transfer of technology.

Members of IA have an experience to meet some trouble on water operation during paddling and harvest seasons such as no timely water supply during puddling season and non timely evacuation of standing water in the paddy field during harvest season. Moreover, any systematic operation are not functioned in case of emergencies such as floods and drought flows. Therefore, the majority of IA members are generally keen to implement on-farm development. However, the on-farm development are not realized to implement because of weak co-operation of IA members.

(d) Water charges

Water charge of both CISs are collected 50 kg/season in Libod - Bariw - Minito CIS and 75 kg/season in Pandan - Bongalon CIS as an irrigation fee. Collection of water charges is not big problems for management of CISs.

(e) Objections of water management

Major objections of water management are ;

that IA member can not sufficiently get the opportunity of technical guidance in the fields and/or training programs on water management through agencies concerned, because of lack of on-farm development facilities ; and

that number of water masters/gatekeepers are not sufficient for ordinary water operation. Measurement of irrigation water discharge are not carried out at main canal system because of lack of human resources.

(3) Maintenance Works of Existing CIS

(a) Activities of maintenance works

Executing body of minor maintenance works is IA, and maintenance works such as reshaping of canal sections, grass cleaning, small repairing works of structures, cleaning of drainage canal are carried out by means of labor contribution from IA member or employment of labor using their budget.

On the other hand, large and complicated maintenance works such as rehabilitation of big structures, canal lining and large rehabilitation works of drainage canals are technically consulted and implemented by NIA under agreement between NIA and IA.

(b) Objections of maintenance works

Objections of maintenance works are insufficient budget which are sustained by irrigation fees. IAs have tried to get credit for maintenance works, but there are no success cases in both CISs.

1.3.2 Plan on Camalig-Comun-Cotmon Communal Irrigation System

After an identification of the project, the detailed survey and study were conducted by NIA Provincial Office, and the feasibility study report was prepared in 1988. Main purpose of the plan is to make revitalization of current agriculture activities, specially paddy production in temporary irrigation system schemes as well as rainfed fields by the reconstruction of

concrete diversion dam at an abandoned weir site of Ligban river and the establishment of main and lateral canals networks.

Concrete diversion dam is proposed at the abandoned weir site which was constructed in the 1950's, but was damaged by the mud flow during the major eruption of Mayon volcano in 1968. The areas to be irrigated is mainly scattered in the 4 barangay areas, namely, Barangay Ligban, Barangay Taladong, Barangays Comun-Inarado. The irrigation water will be supplied to paddy field of about 650 ha, and the crop intensity is expected 200%. Canal network is planed to consist of main canal of 9 km, lateral canal of 15 km, farm ditches of 36.4 km and related structures of 84 nos.

The development areas are overlapped with the northern part of Study area. However, present status of the plan is one of the candidate projects of the communal irrigation development program undertaken by NIA.

2. PRESENT CONDITIONS IN THE STUDY AREA

2.1 Topography

Topographical conditions are broadly separated 3 categories, such as (i) flood plain of Ligban rivers, (ii) flat terrace expanded southward from hills of Camalig - Daraga towns and (iii) rolling hills.

Flood plain of Ligban river is located in the south eastern area of Camalig town, and flood plain has a gentle slope ranging 1/100 to 1/400 from north to southwest. The elevation of flood plain ranges from 110 m to 99 m above mean sea level. The Ligban river is flowed down from hillside in the northern area and takes river courses in central areas of the flood plain to Barangay Tagaytay. River water has much suspended and bed loads consisting of sand to gravel during flood. Sand sedimentation is found out at some structure sites. River bed raising is generally confirmed along river courses. Flood plain is generally covered by rainfed paddy field of about 160 ha, and majority of soils are sandy loam to clayey soils.

Flat terrace which is located in south area from hills of Camalig - Daraga towns. The area is covered by rainfed paddy field and some isolated small hills. The elevation of terrace area ranges from 96 m to 86 m above mean sea level, and the area is estimated at about 600 ha. The area has a few rivers which flow out in rainfed paddy field to 3 directions such as north, west and south areas from the terrace. The rivers origin in the hills surrounding the terrace area. Soils of terrace are loam to clay.

Rolling hills are expanded in southern area from the flat terrace. Altitude of rolling hills range from about 40 m to 90 m above mean sea level, and the height of hills ranges from 40 m to 80 m. Majority hill slopes are less than 25% except for slopes near hill tops. Generally, the rolling hills are covered by coconut land and grass land. Main river is Jovellar river which flow out from central area of the rolling hills to south westward.

2.2 Existing Irrigation Areas

Small irrigation systems which have small permanent diversion dams with main canal system, pump station with main canal system and temporary brush dams with canal systems are found out in paddy field of Barangays Ligban, Taladong, Comun, Cotmon and Inarado of the Study area.

Existing irrigation schemes are broadly divided into 3 types such as communal irrigation system (CIS), small water impounding management project (SWIM) and private schemes. Salient features of these existing schemes are as follows.

(a) Libod - Bariw - Minto Communal Irrigation System (CIS)

The CIS is located in the 3 barangay areas of Camalig

Water resources	:	Libod river
Irrigation area	:	90 ha
Intake method	:	Concrete diversion dam
Irrigation canal	:	approximately 3.5 km
Drainage canals	:	approximately 1.0 km
Crop calendar	:	Paddy -Paddy

(b) Gabawan Small Water Impounding Management Project (SWIM)

The project aims to increase paddy production through irrigation development, to strengthen institution/supporting system and to enhance small farmers' income. The

project is being constructed by DPWH. The dam and reservoir area are located out side of the Study area, but irrigation area is included in the Study area. Salient features of the project are as follows.

Reservoir	
Active storage capacity	: 0.130 MCM
Dam	
Type	: Modified Homogeneous Earthfill
Height	: 6.10 m
Crest length	: 156.0 m
Irrigation and drainage canal including farm ditch	: 4,350 m
Access road	: 400 m
Irrigation area	: 39 ha in net area
Cropping calendar	: 3 times paddy cultivation

(c) Private schemes

In Barangay Inarado area, 3 existing small irrigation schemes are functioned by using concrete diversion dams and canal networks. Irrigation services areas are estimated at about 30 ha in total, and about 35 households belong to the systems. Simple concrete diversion dams are constructed to off take irrigation water from river, and main irrigation canals are earth canals. Farm ditch and drainage canals are not constructed. In Barangay Taladong area, one (1) pump irrigation scheme is constructed to irrigate about 5 ha. Water resource of this scheme is Taladong creek.

On the other hand, temporary irrigation systems which consist of brush dam and main canal system are found out in the Study area. But, exact irrigation areas are not clarified, because of seasonal practices of irrigation and no available data of irrigation areas.

In Barangay Cotmon area, an excavated reservoir project is being implemented for irrigation of about 10 ha of paddy field. Executing body of the project is the Barangay. The reservoir capacity is planed about 0.01 MCM. The Barangay expect technical assistance to NIA.

2.3 Floods and Sand Sedimentation

2.3.1 Floods and Inundation Areas

Floods always occur any rivers and streams in the Study area during and after heavy rainfall. During this survey period, heavy floods are found out immediately after typhoon Rosing in November 1995.

Flood of Ligban river are always over topped at flood control dikes located near the abandoned diversion dam of Barangay Ligban due to raising river bed. Floods always attack residential area and paddy fields located near the river course. Backwater which is caused by choking of river flow section at bridge of Barangay Ligban suffer paddy fields located upstream from the abandoned diversion dam. Inundation period by back water could be estimated at about half day based on the result of interview survey. Furthermore, paddy fields located near the Tagaytay bridge are also suffered from flood due to much sand sedimentation and backwater from more lower reach of Ligban river.

Water logging area is expanded along old river course of Ligban near Barangay Tagaytay. This inundation is caused by raising of river bed at Tagaytay bridge after changing in river course. The area is estimated at about 12 ha.

Floods of Abogao river always suffer paddy fields which are located at depression areas along the river course because of backwater occurred at crossing structures of road and railways such as cross drains and bridges. Inundation periods are always influenced by magnitudes of floods

Floods of other rivers and streams are smoothly evacuated along river courses, and distinguished inundation problems are not found out.

2.3.2 Sabo and Lahar flows of Mayon Volcano

The nearest potentials of mud flow in the Mayon volcano to the Study area are old lahar flows located at northern area from Camalig town. The lahar flow are not much active at present, and some amount of volcanic sand, gravel, cobble stones and boulders are always flushed out to main course of Ligban river during heavy rainfall and flood.

Regional DPWH has already constructed sabo facilities such as mud flow control dikes along the old lahar courses, and mud flow are much well controlled to flush out into Ligban river during flood.

During typhoon Rosing, new activities of mud flow occur in upper stream of Ligban river from Camalig town, and a lot of sand, gravel, cobble stones and boulders flushed out and desilted in downstream from Camalig town. Due to new sand sedimentation, over topping of flood occurs at flood control dike in upper stream of abandoned diversion dam.

Tinago river, tributary of the Ligban river has rather appreciated vegetation composing coconut land and bush areas. Activities of mud flow are not found out, but soil erosion are found out during heavy rainfall and flood.

2.3.3 Watershed Management

Coconut lumber business are found out in small hills of Polangui to Ligao municipality areas. In these areas, after cutting of coconut trees, reforestation activities are not conducted, and problems on soil erosion in hillside areas, flush floods in rainy season and much decrease of river flows are found out.

Watershed management problem are not entirely occurred in coconut lands even low land of paddy field at present. Concerning with watershed management in upper stream of Ligban river, watershed areas are broadly divided into 2 areas such as old lahar flow areas and vegetation areas covered by coconut and bush lands. It is absolutely impossible to carry out some activities of watershed management in the old lahar flow area because of active mud flow. But, as for the vegetation areas covered by coconut and bush lands, current vegetation conditions shall be maintained for future water resources development.

2.3.4 Sand Sedimentation in Rivers

Sand sedimentation problems are specially found out in Ligban river, of which are caused by mud flow from Mayon volcano. Ligban river is one of most upper stream tributaries of the Quinali river, and sedimentation problem in the Quinali rivers basin is most significant subject from flood control view point. Some sections of the Ligban river are used as quarry sites of construction materials such as sand and gravel. Sand sedimentation in other rivers are not so much even after floods.

2.3.5 Damages due to Floods and Typhoons

In accordance to the disaster maps of both municipality areas and formal damage reports on 5 typhoons which have attacked the province area for these 3 years from January 1993 to November 1995, damage in both municipality areas are shown in Table D.2.1 and summarized as follows.

Items		Damage due to typhoon			
		Camalig Muni.		Daraga Muni.	
		Max.	Min.	Max.	Min.
1	Casualties (nos.)				
	Confirmed dead	0	0	8	0
	Injured	0	0	11	0
2	Damage to houses (nos.)				
	Total	500	29	855	2
	Partial	3,414	564	2,637	0
3	Damage to agriculture (ha)				
	Paddy	119	34	535	0
	Corn	4	0	30	0
	Vegetable	22	0	90	0
	Fruit trees	118	0	101	0
4	Damage to livestock (heads)	859	15	135	0
5	Damage to infrastructure (P 10x3)	3,300	0	3,000	100

2.4 Soil Erosion and Land Conservation

2.4.1 Soil Erosion and Land Slides

In according to disaster maps of both municipality areas which issued by provincial disaster operation center, small land slides are found out in hill sides of 3 barangay areas. Soil erosion are not significant problems in the Study area, except for the upper stream from Camalig town.

2.4.2 Current Land Conservation Practices and Plans

Inter-crops cultivation are found out in gentle hilly slopes of some coconut lands of southern parts of the Study area. Inter-crops are maize, banana, coffee, etc. Farming system are ploughing by animal power in seeding period, manual irrigation during the most drought spell and manual harvesting. However, any technology of land and soil conservation such as alley cultivation method of inter-crops and farm bunds for soil conservation are not found in these farms. Moreover, the studies and plans on land and soil conservation are not made yet.

2.5 Drainage System

2.5.1 Existing Drainage Systems

In existing irrigation areas, drainage canal systems are not fully established yet. Evacuation of surplus rain water is conducted farm plot by farm plot due to a lack of farm drain ditches. The evacuated rain water is conveyed through natural streams to main rivers.

The majority of rainfed paddy fields in the Study area have similar conditions of drainage canal systems in the existing irrigation areas.

2.5.2 Existing Drainage Facilities

Since drainage canals of existing irrigation systems are not well developed in the Study area as mentioned above, main drainage facilities are crossing structures of roads and rail ways such as cross drains and bridges.

As a result of reconnaissance survey on drain systems in the Study area, it is clear that crossing structures of national roads from Barangay Camalig to Barangay Cotmon and rail ways don't have sufficient flow capacities to deal with the certain probable flood discharges, and that these structures are one of reasons for flood and water logging problems in rainfed paddy fields.

2.6 Irrigation and Drainage Water Requirement

2.6.1 Current Estimation Method of Irrigation Water Requirements

In accordance with a review of study reports and documents on water requirements of paddy cultivation in the provincial area, the modified Penman method is ordinarily adopted, and standard figures of peak irrigation water requirement is given as 2.0 lit./sec./ha for the convenience for plan and design of irrigation facilities.

2.6.2 Current Estimate Method of Drainage Water Requirements

Several estimation methods of drainage water requirement for paddy cultivation are currently applied for plans and studies of irrigation and drainage development. The basic conditions and assumption for these estimation methods could be summarized below.

For paddy field

Probable rainfall	:	3-day consecutive rainfall of 80% exceedance occurrence, or Max. daily rainfall of 90% exceedance occurrence
Drainage period	:	3 days
Retaining water in paddy field	:	100 mm to 150 mm

For upland fields

Estimation method	:	Rational method or Unit hydrograph method based on runoff data
Probable rainfall	:	Max. daily rainfall of 80% or 90% exceedance occurrence

2.7 Construction Materials and Equipment

(1) Market Conditions of Construction Materials

A lot of kinds and types of construction materials such as reinforcement bar, cement, etc. are available in the Study area. However, markets of reinforcement bar and cement have an imbalance conditions between supply and demand in the beginning of the fiscal year, specially, in January and February.

Since quarry sites of aggregates for concrete such as sand and gravel are located in some sabo control areas and rivers of Mayon volcano, transportation costs of aggregates will affect market prices of these materials.

(2) Hiring System of Construction Equipment

NIA and DPWH have rental systems of their own construction equipment, and one (1) workshop and motor pool of DPWH is located near the Study area. Local construction contractors who are rather low qualified contractors, always hire these construction equipment.

3. CONSTRAINTS TO IRRIGATION DEVELOPMENT

3.1 Physical Constraints

The following constraints are pointed out for future development plan based on the results of reconnaissance survey.

(1) Water Resources Development

Ligban river for diversion dam development
- Watershed problems in hill slopes of Mayon volcano which are covered by old lahar flows
- Thin vegetation mainly covered by grass lands and coconut lands
- Much suspended and bed loads during floods
- Sedimentation in river bed
- Flush flood

Other rivers for dam and reservoir development
- Small catchment areas for reservoir
- Small reservoir pockets in topographical aspect
- Thin vegetation mainly covered by coconut lands

(2) Irrigation and Drainage Development

Ligban - Tagaytay area (Camalig Diversion Dam)
- Sedimentation and low flow capacity of Ligban river
- Flood control of Ligban river
- Backwater problem in upper stream from abandoned diversion dam during floods
- Low drainage capacity in down stream of Ligban river and inundation problem during floods
- Water logging in southern part of the area
- A little porous soils such as sandy clay to silt clay in and around paddy fields

Taladong area (Dam No.1)
- Scattered paddy fields along Taladong creek
- Small scale of paddy fields

Comun - Cotmon - Inarado - Tabon Tabon areas (Dam No.2 & No.3)
- Inundation problem in paddy fields along Abogao river due to low capacities of drainage facilities during heavy rainfall and floods

Namantao area (Dam No.4)
- Rather elevated paddy fields against water resources for irrigation development
- Small scale of paddy fields
- Undulated coconut lands for upland crops cultivation

San Ramon area (Dam No.5)
- Undulated coconut lands for upland crops cultivation

3.2 Constraints to Maintenance Works and Water Management

In and around the Study area, 3 existing CISs are located. As results of the interview survey on maintenance works and water management in these existing CISs which have functioned for more than 10 years, constraints to maintenance works of irrigation facilities and water

management are summarized below. These constraints could be assumed to find out in the proposed CISs in the Study area.

(1) Maintenance Works

- *insufficient budget which are sustained by irrigation fees*
  IAs have tried to get credit for maintenance works, but there are no success cases in the CISs.

(2) Water Management

- If IA is organized by some barangays, water operation problems are found out in tertiary and/or quaternary irrigation blocks consisting of different barangay farmers' lands. IAs have water operation rules and water distribution schedule which are confirmed under the IA board, but these problems are mainly caused by disregards of co-operation of IA members.

- IA members, specially, board director of IA and some key IA member, have the *opportunity of technical guidance and training programs on water management by* NIA, but , technical guidance are not efficiently extended in IA member because of lack of on-farm development facilities and some discrepancy between field conditions and instructions of technology.

- Number of water masters/gatekeepers are not sufficient for ordinary water operation, and measurement of irrigation water discharge are not carried out at main canal system because of lack of human resources.

4. BASIC DEVELOPMENT CONCEPT

(1) Early Return of Irrigation Development

Main aim of low land irrigation development is to establish double paddy cultivation by providing irrigation facilities. Taking into consideration that farmers' background of paddy production in the existing rainfed paddy field and high local demand of rice, early return can be much expected through investment for irrigation development.

(2) Stabilization of First (Rainy) Season Paddy Cultivation

Main paddy cultivation is conducted, as for current paddy cultivation in the rainfed paddy field of the Study area, from June to October in the rainy season, and the second paddy cultivation for the dry season is being conducted depending to the availability of water resources. Land soaking and puddling works of the first (rainy) season paddy start in June to July, but preparation works of first season paddy are always affected by rainfall conditions. The harvesting is conducted in October to November, but harvesting and production of paddy are also suffered from typhoons in October to November. The second paddy cultivation period is 4 months from middle of December to April.

Cropping pattern of the first paddy can be improved to start more early time by providing irrigation facilities. As a result, more stable cropping calendar of double paddy cultivation can be established, and the typhoons damages of paddy cultivation can be avoided. Furthermore, water control for farming practices of paddy fields such as application of fertilizing and weed control can be improved, and rather high yield of paddy can be expected.

(3) Effective Water Use

Water resources of irrigation development are generally small scales in the Study area comparing with existing rainfed paddy areas, because of small watersheds of dams. While, local demand of irrigation development will be comparatively high, and irrigation area will be expected to expand as much as possible.

For integration of both components, effective water use shall be taken consideration in the irrigation development plan. Increase of irrigation efficiency shall be pointed out by means of canal lining and on-farm development. Canal lining aims to decrease seepage loss of canal, and on-farm development effects timely water operation at farm plot level. Specially, this concept shall be considered in the irrigation development plan of Ligban - Tagaytay area (Camalig diversion dam area).

(4) Simple Irrigation Facilities for Easy Maintenance Work

Except for main water resources facilities such as dams and storage reservoirs, irrigation and drainage facilities shall be simply designed and constructed as much as possible for easy maintenance works which will be conducted by IAs.

(5) Mitigation of Flood Damage in Paddy Fields

Rainfed paddy fields of the Study area have been suffered from inundation water and floods during storm rainfall. These inundation and floods are mainly caused by back water from some drainage structures and/or infrastructure such as bridges. Specially, in Ligban - Tagaytay area (Camalig diversion dam area), rainfed paddy fields are suffered from mud flow from Mayon volcano and back water from much sand sedimentation at existing bridges and crossing structures. In order to sustain rather high yield and production of paddy, drainage development and minor flood control plans shall be made. However, flood control of Ligban river around Barangay Tagaytay area is mainly affected by back water from lower reach of Ligban river (confluence point of San Francisco river with Ligban river), and this flood problem can not be

solved at only one (1) river section. Overall flood control plan in Quinali river shall be discussed. Therefore, flood control plan around Barangay Tagaytay area will be deleted from the scope of the Study.

(6) Mitigation of Water Logging in Paddy Fields

In Ligban - Tagaytay area, water logging area of about 12 ha are always found out along old river course of Ligban river during dry season and are widely expanded during rainy season. Water logging might be caused by much sand sedimentation occurred at Tagaytay bridge after change in river course and by gentle slope of lower reach of Ligban river from Tagaytay bridge to Barangay Trapicia. Expansion of water logging always coincide with flood problem around Tagaytay area. Taking into account technical reasons of water logging, sedimentation and flood, overall flood control system of Quinali river basin including Ligban river shall be discussed. However, for mitigation of water logging problem in Tagaytay area during rainy season, minor and temporary control plan on expansion of water logging area shall be made.

(7) Early Establishment of Water Management

As a result of interview survey on water management and maintenance works of existing CISs located around the Study area, technical water management systems are not fully established yet. The majority of IA' member have met some troubles on water management in fields, specially, in planting and harvest season. Main reasons of these problems are lack of systematic farm and drain ditches and insufficient extension works of water operation. Agriculture production and crop calendar in these CISs areas are always affected by these problems. Therefore, water management system shall be established in the proposed irrigation areas in early stage of project implementation. The following aspects of water management shall be taken consideration.

- establishment of on-farm system including construction of systematic farm ditches and drain ditches
- construction of discharge measurement facilities and operation rules
- establishment of technical guidance programs on water operation
- strengthening of extension works
- establishment of supporting system for credit
- adjustment between administration boundary and irrigation boundary

(8) Decrease of Amortizing Cost of Irrigation Facilities

Construction costs of water resources facilities such as diversion dams, dams and incidental facilities are so expensive. If present amortizing system of IAs are sustained, IAs' future activities of maintenance, water management, agriculture production will be weak. Therefore, before commencement of project implementation, a way of amortizing shall be discussed to decrease IAs' load.

5. IRRIGATION DEVELOPMENT PLAN

5.1 Potential Irrigation Areas

Irrigation development is concentrated into low land areas (rainfed paddy fields) in view of location of existing rainfed paddy fields, land resources, topography and implementation of agrarian land reform program of coconut lands, and a diversion dam and 4 storage dams are evaluated for the irrigation development. Potential irrigation areas of respective areas are examined as mentioned below.

(1) Ligban - Tagaytay area (Camalig diversion dam area)

Based on available water resources of the Tinago river in all seasons which are examined through water balance, potential of irrigation development could be theoretically estimated at the maximum 130 ha as paddy field. At present, the Ligban - Tagaytay area are covered by rainfed paddy fields of 159 ha, and all lands are evaluated to be suitable for paddy fields in view from land resources aspect.

Taking into account topographical conditions of these rainfed paddy fields, the design water level at Camalig diversion dam and loss of land resources due to on-farm development including farm roads, potential areas for irrigation development is estimated at 130 ha.

(2) Taladong area (Dam No.1 area)

Rainfed paddy field of about 36.5 ha are scattered in downstream from dam No.1. Potential areas of irrigation development are theoretically estimated at 50 ha as paddy fields based on water balance of reservoir. After overlying the evaluation results of land suitability and topographical conditions, irrigation services area could be estimated at 33 ha.

(3) Comun - Inarado areas (Dam No.2 area) and Tabon Tabon area (Dam No. 3 area)

In the same manners of evaluation on availability of water resources and land resources mentioned above, the potential areas of irrigation development could be estimated at 190 ha in the plan of Dam No.2 and 84 ha in that of Dam No.3.

(4) Namantao area (Dam No.4 area)

Potential areas of irrigation development are theoretically estimated at 480 ha as paddy fields. There are, at present, existing rainfed paddy fields of 110 ha in this planing area. The existing rainfed paddy fields are evaluated as suitable land for paddy fields. Therefore, existing rainfed paddy field areas could fully become irrigation services areas. But since the existing rainfed paddy fields are rather elevated comparing to surface water elevation of reservoir, pumping up of water from reservoir to paddy fields will need. Water head of pumps will be required about 35 m.

In view from land resources evaluation, upland crop fields development could be expected in hill slope areas near the reservoir and slopes along the Patagok river. These areas are mainly covered by coconut lands at present. If irrigation demand for upland crop fields is clarified before and during implementation of agrarian land reform program, irrigation development plan could be made.

(5) San Ramon area (Dam No.5 area)

Upland field development will need, following to the implementation of agrarian land reform program. In this Study stage, the exact development areas are not specified around the reservoir area, but if water demand and development areas can be confirmed in future, irrigation development plan could be made.

The potential areas of respective irrigation development are finally summarized below.

Name of Planning Area	Potential Area (ha)
Ligban - Tagaytay area (Camalig diversion dam area)	130
Taladong area (Dam No.1 area)	33
Comun - Inarado areas (Dam No.2 area)	190
Tabon Tabon area (Dam No. 3 area)	84
Namantao area (Dam No. 4 area)	110

5.2 Proposed Irrigation Method

Taking into consideration the easy maintenance works of facilities and cheaper operation costs, extension of gravity irrigation method could be proposed as much as possible, and for increase of effective water use, canal lining shall be applied in main canal systems.

On farm level, irrigation method shall be gravity method with on-farm development facilities such as irrigation farm ditches and drain ditches.

5.3 Irrigation Water Requirements

(1) *Potential Evapo-transpiration*

Potential evapo-transpiration is estimated by the modified Penman method based on the climatic data of Guinobatan station, Albay Province.

(Unit: mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
109	115	136	165	158	144	118	124	114	112	105	99	1,498

(2) Crop Coefficient (Kc)

Crop coefficient (Kc) for paddy is determined based on the reference data described in the FAO irrigation and drainage paper 24, the revised version 1977.

(3) Land Preparation Water Requirement/Land Soaking Requirement

According to study reports on irrigation development in and around the Study areas, the land soaking and land preparation water requirement are given about 250 mm for the first paddy cultivation (wet season paddy) and 200 mm for the second paddy cultivation (dry season paddy) due to different hardness of land soaking work in wet and dry seasons. Furthermore, similar requirements for land soaking and land preparation are also used in the study papers on irrigation development in the provincial area which are provided by provincial NIA office.

In the Study, the water requirements of land preparation and land soaking are estimated at 250 mm for the first paddy cultivation (wet season paddy) and 200 mm for the second paddy cultivation (dry season paddy).

(4) Nursery Requirement

Nursery requirement is estimated based on the following equation with conditions mentioned below.

$$N = (LP + (Kc \times ETo + P) \times T) \times A$$

where,

Nursery requirement (N)		
Potential evapo-transpiration (ETo)	:	4 mm/day for the first paddy 5.5 mm/day for the second paddy
Percolation (P)	:	3 mm/day in Ligban-Tagaytay area 2 mm/day in Comun-Cotmon area and Inarado-Tabon Tabon area
Nursery bed (A)	:	5% of total paddy field
Nursery period (T)	:	20 days
Land preparation requirement (LP)	:	250 mm/time for the first paddy 200 mm/times for the second paddy
Crop coefficient (Kc)	:	0.8

The nursery requirements for each area and season could be generally estimated as follows.

Area	Nursery Requirement (mm)	
	First paddy	Second paddy
Ligban-Tagaytay area	19	18
Comun-Cotmon and Inarado-Tabon Tabon area	18	17

(5) Percolation

As for a field test results on percolation which have been conducted at 4 rainfed paddy fields of the Study area during the Study period, the measured percolation could be summarized as follow:

Area	Type of Soils	Measured Percolation (mm/day)
Ligban-Tagaytay area	Sandy clay to Silt clay	2 - 3
Comun-Cotmon area	Clay loam to Clay	1 -2
Inarado-Tabon Tabon area	Clay loam to Clay	less than 1

On the other hand. in accordance with the study report on soil and land resources evaluation in Albay Province 1988 published by DA, the areas mentioned above are concludes as the moderate hydraulic conductivity area.

Based on the soil characteristics mentioned above, the following percolation rates are adopted for the estimation of irrigation water requirement for paddy.

Area	Type of Soils	Designed Percolation (mm/day)
Ligban-Tagaytay area	Sandy clay to Silt clay	3
Comun-Cotmon and Inarado-Tabon Tabon areas	Clay loam to Clay	2

(6) Probable Rainfall

The probable rainfall with a 80% chance of drought year is estimated as follows based on the rainfall data of Legazpi and Guinobatan stations.

(Unit: mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
203	113	114	109	137	215	251	229	249	269	331	348	2,568

(7) Effective Rainfall

Effective rainfall is estimated to apply the estimation curve of effective rainfall which are gotten by water balance calculation in paddy field based on the short term rainfall data (10 years) of Legazpi station. The estimation curve is shown in Figure D.5.1.

(8) Net Irrigation Requirement

Net irrigation requirement of paddy is calculated by the following formula.

$$NIR = Kc \times ETo + P + N + LP - RE$$

where,

NIR	:	Net irrigation requirement
Kc	:	Crop coefficient
ETo	:	Potential evapo-transpiration
P	:	Percolation
N	:	Nursery requirement
LP	:	Land preparation requirement
RE		Effective rainfall

Net irrigation requirements in each irrigation area are estimated as follows.

Irrigation Area	Net Irrigation Requirement (mm)	
	First Paddy	Second Paddy
Ligban - Tagaytay area	321	304
Comun - Inarado - Tabon Tabon, Namantao areas	238	212

(9) Overall Irrigation Efficiency

Overall irrigation efficiency is estimated at 45% based on the following assumption.

i	Conveyance efficiency of main and lateral canals	81%	because of lining canals
ii	Operational efficiency	80%	
iii	Field application efficiency	70%	
	Overall efficiency	45%	

(10) Seasonal Gross Irrigation Water Requirement

Seasonal gross irrigation water requirements in each the area are estimated to divide net irrigation requirement by overall irrigation efficiency, and the following seasonal requirements are estimated. The detailed estimation is shown in Tables D.5.1 to D.5.2.

Irrigation Area	Seasonal Irrigation Requirement (mm)	
	First Paddy	Second Paddy
Ligban - Tagaytay are	713	676
Comun - Inarado - Tabon Tabon, Namantao areas	527	472

5.4 Comparison Study between Previous CIS Plan and New Plan

5.4.1 Previous Plan of Camalig-Comun-Cotmon CIS

Irrigation water will be scheduled to off take at the abandoned weir of Ligban river and to supply to irrigation services areas of Barangays Ligban and Tagaytay by irrigation canal networks which are laid out at both banks. Intake water level at the abandoned weir will be approximately 102 m, and design discharge is estimated at about 0.6 m^3/sec..

Irrigation water will be also conveyed to other irrigation services areas of Barangays Comun, Cotmon and Inarado through left main canal network. Irrigation services areas are proposed about 90 ha in Barangays Ligban and Tagaytay and 560 ha in Barangays Comun, Cotmon and Inarado.

However, since irrigation water requirement for double paddy cultivation is updated about 1.2 lit./sec./ha at present, and maximum irrigation service areas will be theoretically estimated at about 210 ha based on the water balance calculation at abandoned weir site.

Stilling basin is not laid out at head sections of both main canals because of gentle river gradient and no sufficiently elevated area near the proposed intake weir. Left main canal is laid out along old course of Ligban river, and extended to existing railway which are connecting between Guinobatan and Legazpi. The left main canal is, furthermore, extended to Barangay Comun and Inarado areas through long and deep cut canal sections which are planned in small hill areas. Height of deep cut sections will be estimated at maximum 7 m, and the deep cut sections are continued about 400 m.

Drainage development plan is not entirely planned in irrigation services area.

5.4.2 New Plan of Camalig Diversion Weir

Irrigation water is off taken at Tinago river which is one of the tributaries of Ligban river, and intake weir is proposed at about 50 m upper stream from confluence with Ligban river. Because a lot of boulders are always flush out in main river course of Ligban from mud flow potentials of Mayon Volcano during flood, but heavy flushing of boulders are not found out along the tributary, and an intake weir shall avoid heavy bolder attack to sustain appreciated future maintenance works. Intake water level will be about 108 m, and design discharge will be about 0.16 m^3/sec.. Since the proposed weir site is technically confirmed to be sufficiently strong foundation by geological investigation, movable type weir with sluice gates are laid out, and river dikes will be proposed in 100 m upper stream from weir site to prevent back water problem and minor flood.

A stilling basin is laid out at the elevated area along Ligban river, of which it will be easy to flush out sediments materials to Ligban river. A diversion structure is also proposed at about 200 m downstream from stilling basin, and 2 main canals are provided to supply irrigation water into both irrigation areas of existing national road. Irrigation service areas will be expected about 130 ha.

A flood way of about 200 m will be laid out around the abandoned intake weir to prevent minor flood and back water problem in irrigation service areas which are located at upper stream from the abandoned intake weir. For alleviation of expansion of water logging area

occurred depressed areas along railway of Barrage Tagaytay during rainy season, control dikes with provision of drains and flap gates will be proposed.

Irrigation development of Barangay Comun and Inarado areas will be covered by other irrigation systems such as Dam No.1 and/or Dam No.2 irrigation systems. Irrigation service areas will be expected about 33 ha in Dam No.1 irrigation system and about 190 ha in Dam No.2 irrigation system.

5.4.3 Technical Comparison of Both Plans

The previous plan has a technical objections such as ejection of sediment in stilling basin and water conveyance method by a mean of deep open cut sections of left main canal and related structures such as culverts for existing railways. It will be heavy for water users organization (IA) to conduct future maintenance works of stilling basins and deep open cut sections of left main canal. Even if other alternatives on deep open cut canal such as a long culvert or pump up system are proposed, maintenance and operation works of the structures and/or facilities will not be easy and cheaper.

The new plan has a possibility to obtain more irrigation service areas of about 40 ha in Barangay Ligban and Tagaytay area due to selection of proposed intake weir site, but available water for irrigation is decreased due to the decrease of water shed area. In this plan, dike to prevent expansion of water logging is proposed, but the proposed facilities will be in common with components of the previous plan. Irrigation service area will be decreased comparing to the that of the previous plan, but the irrigation service areas covered by the previous plan could be irrigated by development of other water resources such as Dam No.1 and Dam No.2.

The advantageous and disadvantageous aspects of both plans could be summarized below.

Advantageous aspects of the previous plan

- More availability of water flow at the intake weir comparing to the new plan

Advantageous aspects of the new plan

- Higher intake water level and extension of irrigation services areas of Barangay Ligban - Tagaytay areas, about 40 ha
- Easy operation and maintenance of sedimentation around intake weir site
- Easy prevention of intrusion of suspended and bed loads in main canals
- Alleviation of damages of intake weir
- Prevention of back water and flood problem near the abandoned weir site

Disadvantageous aspects of the previous plan

- No possibility of automatic ejection of sediments in stilling basin
- Manual dredging and/or evacuation of sediments in stilling basin
- Huge amount of earth works at deep open cut sections of left main canals

Common aspects

- Specified off-taking method at intake gates to prevent intrusion of much suspended and bed loads
- Periodical dredging works in Ligban river, specially, river sections from the abandoned intake weir site to Barangay Tagaytay
- Construction of control dikes and flap gates for prevention of expansion of water logging
- Drainage canal development including farm drains

Therefore, as a result of technical comparison, the new plan could be much attractive, comparing to the previous plan. Salient features and technical subjects of both plans are summarized in Table D.5.3.

5.5 Layout of Irrigation and Drainage Development

Layouts of the following 5 irrigation and drainage development plans are evaluated based on the water resources development plans of 5 locations.

- Ligban - Tagaytay area (Camalig diversion dam area)
- Taladong area (Dam No.1 area)
- Comun - Inarado area (Dam No. 2 area)
- Tabon Tabon area (Dam No. 3 area)
- Namantao area (Dam No.4 area)

(1) Ligban - Tagaytay Area (Camalig diversion dam area)

Irrigation water is off taken at Camalig diversion dam and supply to services areas of 130 ha. Diversion dam is movable weir type, and a stilling basin is also provided at head race section. Main canal system consists of head race, 2 main canals and 3 lateral canals. Total length of main canals is approximately 6 km. Main drainage canals are provided 4 routes of approximately 3.5 km in length.

In line with provision of main drainage canal system, flood control dike of about 2.2 km in length is provided to prevent an expansion of water logging area. A flood way is provided about 250 m at upper and lower river sections from an abandoned weir of Ligban.

Specified subject of this plan is that periodic dredging work of Ligban river will be needed at sections from abandoned weir sites to downstream from Tagaytay bridge. Future maintenance and dredging works will be trusted to DPWH and/or LGUs. If the other flood control project, namely, the Bicol river basin flood control will be accomplished in the future, the necessity of periodic dredging will be decreased. Salient features of the layout are shown below.

Irrigation area	:	130 ha	
Irrigation tertiary block	:	21 nos.	
Off-taking method of irrigation water	:	Movable weir and intake gate	
Intake discharge	:	0.16 m^3/sec	
Irrigation canals and related structures			
- Head race	:	1 no.	0.27 km
- Main canal	:	2 nos.	4.1 km
- Lateral canal	:	3 nos.	1.6 km
- Stilling basin	:	1 no. L = 50 m, W = 30 m	
- Diversification structure	:	1 no.	
- Culvert	:	1 no.	
- Aqueduct	:	1 no.	
Drainage canals and related structures			
- Main drains	:	4 nos.	3.5 km
Flood control facilities			
- Flood dikes	:	2.2 km	
- Flap gates	:	5 nos.	
- Flood way	:	250 m	

(2) Taladong Area (Dam No.1 area)

A small impounding pound with an active capacity of 7,000 m^3 is provided. Irrigation water is off taken by intake structure of dam. Irrigation area is 33 ha. Main canal system consist of a main canal, 2 lateral canals. Main drainage canals of 2 routes are also provided. Total lengths of main canal and drain systems are respectively about 4.7 km and about 1.7 km.

Specified subject is that irrigation service areas are scattered along the Taladong river, and the services areas are located very far from the proposed dam sites. Each tertiary irrigation block consists mostly of small irrigation areas of less than 3 ha. Therefore, a long canal will be needed to supply irrigation water to the services areas. The irrigation area is entirely small. Salient features of the layout are shown below.

Dam and Reservoir			
Dam			
- Dam type	:	Earthfill Type	
Reservoir			
- Active Reservoir Capacity	:	0.003 MCM	
Irrigation area	:	33 ha	
Irrigation tertiary block	:	16 nos.	
Off-taking method of irrigation water	:	Intake gates of reservoir/gravity	
Intake discharge	:	0.035 m^3/sec	
Irrigation canals and related structures			
- Main canal	:	1 no.	1.91 km
- Lateral canal	:	2 nos.	2.76 km
- Aqueduct	:	1 no.	
- Culvert	:	2 nos.	
Drainage canals and related structures			
- Main drains	:	3 nos.	1.74 km
- Cross drains	:	2 nos.	

(3) Comun - Inarado Area (Dam No. 2 area)

Water resource development facilities is a small impounding pound with an active capacity of 0.64 MCM, and irrigation water is off taken by intake structure of dam for covering services areas of 190 ha. Main canal system consisting of a main canal, 5 lateral canals and main drainage system consisting of a flood way, a main drain, 5 lateral drains and 2 sub lateral drains are provided. Total lengths of main canal and drain systems are respectively 10.5 km and 14.3 km.

Specified subject is that inundation and water logging problems always occur after heavy rainfall due to insufficient flow capacity of crossing structures of the railway and roads and meandering sections of existing rivers and streams. Therefore, the shortening of river course and enlargement of flow capacities of crossing structures will be required. Furthermore, since existing river will be utilized as flood way of spillway, the enlargement of the river sections will be required, if necessary. In addition, a resettlement plan for about 30 households located at the reservoir area will be necessary. Salient features of the layout are shown below.

Dam and Reservoir		
Dam		
- Dam type	:	Earthfill Type
Reservoir		
- Active Reservoir Capacity	:	0.64 MCM
Saddle dam	:	1 location
Irrigation area	:	190 ha
Irrigation tertiary block	:	61 nos.

Off-taking method of irrigation water	:	Intake gates of reservoir/gravity	
Intake discharge	:	0.18 m^3/sec	
Irrigation canals and related structures			
- Main canal	:	1 no.	2.0 km
- Lateral canal	:	5 nos.	8.5 km
- Diversification structure	:	1 no.	
- Culvert	:	7 nos.	
- Aqueduct	:	1 no.	
Drainage canals and related structures			
- Main drains including flood way	:	2 nos.	7.1 km
- Lateral drains	:	5 nos.	4.6 km
- Sub lateral drains	:	2 nos.	2.6 km
- Bridge	:	1 no.	
- Cross drains	:	4 nos.	

(4) Tabon Tabon Area (Dam No. 3 area)

A small impounding pond with an active capacity of 0.23 MCM is provided for irrigation development of 84 ha. Irrigation water is off taken by intake structure of dam. Main canal system consists of head race, 2 main canals and a lateral canal. Total length of main canal system id about 7.4 km. Main drains consisting of 2 main drains and 3 lateral drains is approximately 5 km in length.

Specified subject is that irrigation service areas are located very far from the proposed dam site, and a long head race of about 2 km will be needed. Therefore, the operation of the dam and water management at on-farm level will be extremely difficult. Furthermore, paddy fields of about 5 ha will be submerged due to construction of dam and reservoir. Salient features of the layout are shown below.

Dam and Reservoir			
Dam			
- Dam type	:	Earthfill Type	
Reservoir			
- Active Reservoir Capacity	:	0.23 MCM	
Saddle dam	:	2 locations	
Irrigation area	:	84 ha	
Irrigation tertiary block	:	20 nos.	
Off-taking method of irrigation water	:	Intake gate of dam/gravity	
Intake discharge	:	0.09 m^3/sec	
Irrigation canals and related structures			
- Head race	:	1 no.	2.0 km
- Main canal	:	2 nos.	4.3 km
- Lateral canal	:	2 no.	1.1 km
- Culvert	:	2 nos.	
Drainage canals and related structures			
- Main drains	:	2 nos.	3.8 km
- Secondary drains	:	3 nos.	1.2 km
- Cross drains	:	1 no.	

(5) Namantao Area (Dam No.4 area)

Irrigation water is off taken by pump laid out near a small impounding pond which has an active reservoir capacity of 64,000 m^3, and conveyed by pipe line of about 2.3 km provided at hill slopes to irrigation services areas. Pumps needs a capacity of 6.9 m^3/min. in total and a

water head of about 35 m. Irrigation services areas is 110 ha. Main canal systems consisting of a main canal and 6 lateral canals.

Specified subject is that irrigation service areas are located at a rather elevated terrace, and pump irrigation system will be needed. Furthermore, pipeline system will be need at the head race sections because the pipeline routes are covered by steep slopes of hills. Salient features of the layout are shown below.

Dam and Reservoir			
Dam			
- Dam type	:	Earthfill Type	
Reservoir			
- Active Reservoir Capacity	:	0.07 MCM	
Irrigation area	:	110 ha	
Irrigation tertiary block	:	33 nos.	
Off-taking method of irrigation water	:	pump up	
Water head of pumps	:	about 35 m	
Pump operation	:	*24 hours operation at a peak time*	
Pump capacity	:	3.5 m^3/min.	
Numbers of pumps	:	3 nos. including a standby pump	
Irrigation canals and related structures			
- Pipe line	:	1 no.	2.3 km
- Main canal	:	1 no.	3.0 km
- Lateral canal	:	6 nos.	9.9 km

5.6 Recommendable Model Rural Development Project

Technical soundness of development plan on each the layout is discussed below (refer to Table D.5.4.). As a result of the discussion on technical soundness, two (2) development plans, namely Camalig diversion dam plan and Dam No.2 plan will be recommended to have higher priority as model rural development project in the low land area.

(1) Camalig Diversion Dam Plan

Objections of irrigation and drainage development plans are not found out. However, maintenance works of Ligban river, specially, dredging works of river sediment shall be taken care by Government agency concerned.

(2) Dam No. 1 Plan

Objection of water resources development is low reliability of water storage at reservoir because of small scale reservoir and geological judgment of high seepage of reservoir area. In view of irrigation and drainage development aspects, since irrigation services areas are locally scattered as small blocks, long conveyance canals shall be provided to cover all the services areas. Scale of irrigation and drainage development is entirely small. Technical soundness of overall could be judged rather low.

(3) Dam No.2 Plan

Objections of water resources and irrigation and drainage development are not found out.

(4) Dam No.3 Plan

Objection of water resources development is 2 sub dams which total dam length will be approximately 170 m with height ranging from 2 m to 4 m, and paddy fields to be submerged by construction of dam. The paddy field is estimated at about 5 ha. The other objections of

irrigation and drainage development are higher canal density caused by a long head race and canal layout at cliff sections near dame site. Technical soundness could be judged low.

(5) Dam No.4 Plan

Objection of water resources development is rather low normal high water level of reservoir against the elevation of irrigation services area, and the required water head of pump will be approximately 35 m. The objections of irrigation and drainage development are higher canal density caused by a long pipe line of head race section and pipe layout at cliff sections of hilly area. Technical soundness could be judged rather low.

6. THE MODEL RURAL DEVELOPMENT PROJECT AREAS

6.1 Topography

(1) Camalig Diversion Low Land Model Development Project Area

Irrigation area is extended in flood plain of the Ligban river from near Camalig town to Barangay Tagaytay area and in the lowest skirt areas of the Mayon volcano. The Ligban river has a steep river gradient ranging from 1/30 to 1/200 in upstream from Barangay Irawod. River course stretches to down stream with rather gentle slope of 1/1,000 to 1/2,000. Flood plain expands in the down stream from an abandoned weir, and the lowest area of flood plain is suffered from seasonal flood in rainy season, and small swampy area of about 12 ha is found out. Elevation of rainfed paddy field ranges from 110 m to 99 m above mean sea level, and the slope of rainfed paddy field is of a range from 0.2% to 0.5%. Rainfed paddy field area is estimated at about 160 ha. River course is always unstable in the downstream area due to much river sedimentation and big flood discharge.

(2) Dam No.2 Low Land Model Development Project Area

The area is covered by rainfed paddy field in flat plain and coconut land in hilly area with small undulation. A river, namely, Abogao river flows between the hilly area and flat plain. A tributary of the Abogao river also flows in the central area of flat terrace. Rainfed paddy field expands at both banks of the tributary. Its' area is estimated at about 460 ha. In the western boundary, additional rainfed paddy field expanded toward outside of the project area. Elevation of rainfed paddy field ranges from 85 m to 95 m, and slope of rainfed paddy field is approximately 0.5%. Small hills are mainly covered by coconut trees, and undulated. Elevation of hilly areas is more than 100 m, and hill slope ranges from 3% to 20%.

6.2 Water Resources

(1) Catchment Area

Catchment area of the Tinago and the Abogao rivers are respectively estimated at 8 km^2 and 1.8 km^2. Vegetation of both catchment areas are coconut land and grass land. At present, sever problem of soil erosion is not found out in both the river basins.

(2) Runoff

In accordance with runoff analysis, seasonal runoff of the both river is estimated at diversion weir and dam sites as shown below. Runoff is estimated to analysis relationship between rainfall and runoff in adjacent river basins which have the similar characteristics of river basin such as drainage area size and vegetation. In case of the estimation of runoff in the Tinago river, runoff data of the Nasisi River and the Ugsong River and rainfall data of Guinobatan station are used. For the estimation of runoff at Dam No.2, runoff data of the Cumadcad River, the Malbog River, and the Pili River in Castilla, Sorsogon and rainfall data of Castilla rainfall station are used.

Mean Monthly Runoff

Unit : 1,000 m3

Dam Site	Jan.	Feb.	Mar.	Apri.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Diversion Dam	1,131	625	629	610	765	1,211	1,420	1,292	1,405	1,509	1,851	1,928	14,356
Dam 2	300	167	168	161	203	317	371	337	366	396	488	515	3,794

6.3 Irrigation and Drainage

(1) Existing Irrigation Schemes

Existing irrigation systems are found out at 6 sites of 4 barangays, namely, Gapo, Inarado, Comun and Binitayan barangays. All existing systems are constructed by private farmers. Irrigation water is off-taken in the Abogao and/or its' tributaries by simple stone and concrete weir, and conveyed in earth main canals. Main purpose of these irrigation system is to carry out supplementary irrigation for rainy season paddy, but water supply is also conducted for dry season paddy depending to available run-off of the river. Total irrigation area is roughly estimated at about 30 ha in dry season.

	Barangay	Water Resources	Irrigation Facilities	Irrgation Area (ha)	Irrigated Crops
1	Gapo	Abagao river	Simple concrete structure	1	paddy
2	Inarado	Abagao river	Stone and Concrete weir	10	paddy
			Main canal L = 160 m		
			Lateral Canals L = 1.5 km		
3	Inarado	Abogao river	Stone and Concrete weir	9	paddy
			Main canal L = 200 m		
4	Comun	Abogao river	Stone and Concrete weir	9	paddy
			Main canal L = 200 m		
5	Comun	Abogao river	Stone and Concrete weir	1	psddy
6	Binitayan	Tributary of the Abogao	Stone and Concrete weir	1	paddy
	Total			31	

(2) O&M Work of Existing Irrigation Scheme

Owner of the existing irrigation systems is private farmer. Primitive activities on water management and maintenance works which are conducted by small water user groups, are found out.

In an Inarado (item No.3 of table shown above) case, an owner of intake structure and main canal system is one (1) farmer, and water users of about 30 farmers are belong to this system. Numbers of water users are always flexible in dry season due to the water availability of the river. Water management system is not fixed yet in water users group. Maintenance works are carried out by the owner, using labor power. Maintenance cost of irrigation facilities is earned by collection of water charge from water users. Water charge is one (1) cavan per season. But, when water users participate to maintenance works as labor, water charge is free.

(3) Flood Control Works of Ligban River

DPWH has provided annual budget in 1996 for rehabilitation works of existing flood control facilities along the Ligban river. The rehabilitation works is scheduled to carry out at existing flood control facilities constructed at river sections from approximately 300 m upstream of the abandoned weir including dredging works in downstream of the Ligban river. As a result of meeting and discussion with regional office of DPWH, flood control component in the Camalig diversion lowland model development project is over-laid with the DPWH' rehabilitation plan to support the DPWH' implementation in 1996.

7. CONSTRAINTS AND DEVELOPMENT STRATEGY

(1) Constraints

Constraints on irrigation and drainage development in the both lowland model development projects are generally same constraints presented in the previous study period. However, railway improvement and development project started, and implementation activities of railway development are found out in the Dam No. 2 lowland model development project area, further cooperation of the project implementation of irrigation and drainage development will be needed through implementation of canal and drainage network in future. Physical constraints to irrigation development are summarized in the each case.

(a) Camalig Diversion Low Land Model Development Project

- Flood control in the upper stream from the proposed diversion weir
- Watershed problems in hill slopes of Mayon volcano which are covered by old lahar flows and flushing flood in the Ligban river
- Sedimentation in lower reach of the Ligban river during flood
- Inundation water in the lower reach of the Ligban river

(b) Dam No.2 Low Land Model Development Project

- Small catchment area for reservoir
- Small reservoir pocket from topographical view point
- Further cooperation with construction of crossing structures for irrigation and drainage canals with railway development project

(2) Development Strategies

Strategies of irrigation and drainage development for both projects are to increase rice production through establishment of double paddy cultivation, water management including effective water use and easy maintenance work system. Furthermore, the Camalig diversion lowland model development project also aims mitigation of flood damage and water logging in paddy field.

8. OUTLINE OF THE PROJECTS

8.1 Camalig Diversion Lowland Model Development Project

(1) Irrigation Area

Irrigation area is determined to be 130 ha in view of maximum water resource development and land capability of rainfed paddy field.

(2) Irrigation Water Requirement

Irrigation water requirement is estimated by the following formula based on the potential evapo - transpiration. Potential evapo - transpiration is calculated by Modified Penman method based on climatic and rainfall data obtained at the Guinobatan station.

$$IR = (Kc \times ETo + P + N + LP - RE)/Ef$$

where,

IR	:	Irrigation water requirement
Kc	:	Crop coefficient
ETo	:	Potential evapo-transpiration
P	:	Percolation
N	:	Nursery requirement
LP	:	Land preparation requirement
RE	:	Effective rainfall
Ef	:	Overall irrigation efficiency

Seasonal irrigation water requirements are estimated at 713 mm for the first season paddy and 676 mm for the second season paddy.

(3) Design Discharge of Irrigation Canal

Design discharge of irrigation canals and related structures is estimated to multiply irrigation area by peak irrigation water requirement. The peak irrigation water requirement is estimated at 1.21 lit./sec./ha. Design discharge of intake structure is 0.16 m^3/sec.. Design discharges of main and lateral irrigation canals are illustrated in irrigation flow diagram (Figure D.8.1).

(4) Diversion Weir and Settling Basin

Diversion weir is designed as Ogee type. Length of weir is 22 m and height is 0.5 m. Intake water level is determined as EL. 112.00 m taking into consideration the minimum required water level at each turnout and settling basin. Aprons is provided in upper stream and down stream of diversion weir. Furthermore, flood protection dikes are provided about 300 m in upper stream and 240 m in down stream along both banks in order to control back water and/or flood. Typical sections of diversion weir are shown in Figure D.8.2.

Settling basin is designed 2 lanes type to accelerate siltation of suspended load. Slope of flushing channel to river is designed as 1/8.

(5) Design Flood Discharge

Design flood discharge of diversion weir is adopted 81 m3/sec. of the 50-year flood, taking into account back water conditions and flood control in upper stream area from the weir. Design flood water level is determined EL. 113.90 m at diversion weir.

(6) Drainage Requirement and Design Discharge

Drainage requirements are broadly divided into the 2 requirements, such as (i) drainage requirement in irrigation area (paddy field) and (ii) drainage requirement in upland fields (hilly areas) of outside project area.

Drainage requirement in irrigation area is determined to apply the maximum daily rainfall of the 90% probability and 3-day drainage period. The maximum daily rainfall is adopted at 304 mm, and the drainage requirement is estimated at 9.8 lit./sec. Drainage requirement in hilly area is estimated by rational method, and basically determined 12.5 m^3/sec./ km^2. Design discharge of main drain is determined to multiply drainage area by drainage requirement. Design discharges of main drains and flood channel are illustrated in Figure D.8.3.

(7) Canal Layout

Irrigation water is off taken at diversion weir of the Tinago river. Siltation of suspended load in water is carried out at the settling basin and flushed out to the Ligban river . Water is conveyed through main irrigation canal networks. Irrigation canal network consists of one (1) main canal of approximately 2.3 km, 2 lateral canals of approximately 3.3 km and related structures of about 60 nos. Main canal is designed as concrete lined canal to sustain effective water use. Lateral A canal is crossed provincial road with culvert and extended to right bank area of the road. Measuring devices of irrigation water are designed as broad crest weir at turnout structure and staff gauge at division box. Main canal network is connected with on-farm development canal system such as main farm ditch and supplementary farm ditch. Drainage canal network is consists of 3 main drains and tertiary drains. Farm road with 3.0 m-width is provided along main canal network, and furthermore, link road is laid out to connect with the farm road and/or existing roads in order to make convenient transportation of agricultural input and output and water management. Farm roads is paved by gravel.

Flood channel is provided about 1.4 km including along the Ligban river course to evacuate flood and muddy flow from Mayon volcano.

Protection dike of about 3.3 km is also provided at the edge of inundation area to protect the expansion of inundation water in down stream of the Ligban river. Flap gates are provided at crossing point of protection dike with main and tertiary drains. Canal layout is illustrated in Figure D.8.4, and salient features of the project are summarized in Table D.8.1.

(8) Gate Keeper House

Gate keeper house is laid out at left bank of diversion weir to carry out operation of intake gate and to conduct monitoring works for maintenance and water management. The gate keeper house is concrete house and is provided a office space.

(9) Short Cut of Ligban River Course

Much sedimentation and siltation is appeared in upper stream from the abandoned weir, and over-topping flow which occurs due to the heavy sedimentation, attacks residential area in left band of river. Furthermore, more down stream of river is unstable due to other sedimentation during typhoon season. For solution of the problems on over-topping flow and unstable river course, short cut and straight out of river course are planned along the river as shown in Figure D.8.4.

(10) Dredging Works in Down Stream of Ligban River

Dredging works shall be carried out in the river sections from short-cut portion near the abandoned weir to protection dike site of inundation area as the periodical maintenance works in future.

8.2 Dam No.2 Lowland Model Development Project

(1) Irrigation Area

Potential irrigation area is determined 190 ha from water resources development view point. However, the extension of irrigation area can be planned to additional 205 ha of existing rainfed paddy area by rotation of irrigation water supply from topography and soil suitability view points. Irrigation development area is expanded by 395 ha.

(2) Irrigation Water Requirement

Irrigation water requirement is estimated by the same manner mentioned in the section 4.1.2. (2). Seasonal irrigation water requirements are estimated at 527 mm for the first paddy and 472 mm for the second paddy.

(3) Design Discharge

Peak irrigation water requirement is estimated at 1.04 lit./sec. ha. Design discharge of intake structure is about 0.2 m^3/sec.. Design discharges of main and lateral irrigation canals are illustrated in irrigation flow diagram (Figure D.8.5).

(4) Dam and Reservoir

In accordance with reservoir storage curves shown in Figure D.8.6, normal high water level (N.H.W.L.) and low water level (L.W.L.) of dam are respectively determined at EL. 108.5 m and EL. 100.5 m. Active storage capacity is estimated at 680, 000 m^3, and dead storage capacity is assumed at 20,000 m^3. Surface water area of reservoir is estimated at about 40 ha in the N.H.W.L. and 4 ha in the L.W.L. Design flood water level (D.F.W.L.) is determined at EL. 109. 0 m.

Dam is designed as earth fill dam of homogeneous type. Slopes of upstream and downstream are respectively determined at 1:3.0 and 1:2.5, and rock rip rap of 1.0 m in thickness is provided in upstream slope. In downstream slope, toe drain is provided to sustain a stability of seepage. Dam height is determined at 16.8 m at the center of dam axis, and length of dam is 278 m. Crest width of dam is 6 m and macadam pavement of 5 m-width is provided. Emergency spillway is provided at right bank of reservoirs, and intake tower is provided at left abutment of dam. This intake tower has double functions such as off-taking irrigation water in ordinary time and spillway function during flood. Operation power of intake gate is designed to use electric power. Typical sections of dam are shown in Figure D.8.7.

(5) Design Flood Discharge of Emergency Spillway

Design flood discharge is determined at 48 m^3/sec. as the probable flood of 200-year, taking into consideration properties of downstream area of dam such as village area, railway project, agriculture farm land and social infrastructure. The design flood discharge of 48 m^3/sec. is planned to evacuate water of 33 m3 /sec. through emergency spillway and water of 15 m3/sec. through intake tower. The emergency spillway is side spillway type, and crest length of emergency spillway is 51.0 m.

(6) Access Road and Flood way

Access road of dam is provided to extend existing barangay road and cross with the flood way. A bridge is planned at crossing point with the flood way. Access road has 4.5 m-width and paved by gravel, and the total length is approximately 0.9 km. Flood way with earthen and

trapezoidal section is laid out to use the Abogao river course as much as possible by short-cut and straight out of existing river course. Design flood discharge is 48 m^3 /sec.

(7) Drainage Requirement and Design Discharge

The same drainage requirements described in the section 4.1.2 (6) are adopted in this plan. Design discharges of main and lateral drains are illustrated in Figure D.8.8.

(8) Canal Layout

Irrigation water is off taken by intake tower of dam and conveyed through main canal networks. A side spillway is provided at about 110 m downstream from outlet of intake tower to evacuate excess water, and measuring devices is provided at just downstream of the side spillway as shown in Figure D.8.9.

Main canal network consists of one (1) main canal and 11 lateral canals. Length of canals are approximately 11 km of main canal and 11 km of lateral canals. Main canal network has related structures of about 160 nos. Drainage canal network consists of 2 main drains and 9 lateral drains, and total length of main and secondary drains is approximately 17 km. A flood way , namely main drain No.1 is provided about 4 km from downstream from side spillway to Barangay Comun area. The flood way is laid out to utilize existing Abogao river course as much as possible. Main drainage network has related structures of about 30 nos. Crossing structures with rail way are planed to provide at 7 sections of canals and drains. The crossing structures are culvert, rail way bridge and cross drain. Out of the 7 crossing structures, rail way bridges are laid out at 2 sections of main drain No. 1. Farm road with 3.0 m-width is provided along main canal network, and furthermore, link road of approximately 1.8 km is connected with farm road and/or existing roads in order to make convenient transportation of agricultural input and output and water management. The farm roads is paved by gravel. Salient features of the model project are shown in Table D.8.1.

(9) Gate Keeper House

Gate keeper house is laid out near left abutment of dam to carry out water management of intake tower and a side spillway at main canal and to conduct monitoring works for maintenance and water management. The gate keeper house is concrete house and is provided a office space.

9. DESIGN

9.1 Design Concept

Irrigation canal is designed to be lined by pre-cast concrete blocks in order to sustain easy maintenance works of canal such as repairing of canal lining, cleaning and reshaping of canal section. For more easy operation, simple measuring structures such as broad crest weir and staff gauge are designed.

9.2 Design Standard

Design on earthfill dam, diversion weir, canals and related structures are made to refer to the standards issued by National Irrigation Administration (NIA),Philippines and the Ministry of Agriculture, Forestry and Fishery, Japan.

9.3 Design of Canals and Related Structures

(1) Canal and Drain

Irrigation canals are designed to be the lined canal for main canal and the earth canal for secondary and lower grade canals, and the canal, except for the canal proposed in the build-up area, basically has a trapezoidal section. The inside slope of canal is 1:1.0. Type of canal lining is concrete block. Weephole is also designed to provide in excavation section of canals. Typical sections of canal and drain are shown in Figures D.9.1 to D.9.2.

Maximum velocity on canal is determined 1.0 m/sec. for concrete lining and 0.6 m/sec. for earth canal taking into consideration stable hydraulic flow and prevent soil erosion. Minimum velocity of canal is determined 0.30 m/sec. to prevent aquatic plants' growth and siltation.

Drainage canal is earth canal with trapezoidal section, and inside slope is designed to be 1:1.0. Maximum velocity of drain is deigned 2.0 m/sec. during peak discharge to prevent soil erosion.

Roughness coefficient (n) of canals are determined as follow.

Concrete lining	n = 0.02
Earth canal	
Irrigation canal	n = 0.025
Drain	n = 0.04

Free board of canal (F) is determined by the following formula.

$F>0.05 \times h+(V^2/(2 \times g))+0.1$

(2) Dam and Reservoir

1) Dam storage volume curves

Based on information of the detailed topographical maps (scale 1/1,000) of reservoir area, reservoir storage curves are prepared as shown in Figure D.8.6. Normal high water level (N.H.W.L.) of dam is determined at EL. 108.5 m, taking into consideration the elevation of the right bank of dam abutment. Low water level (L.W.L.) of dam is determined at EL. 100.5 m, based on the elevation of main irrigation canal and maintenance works of culvert portion of intake tower. Therefore, active storage and dead capacities are respectively estimated at 680, 000 m^3, and 20,000 m^3. Design flood water level (D.F.W.L.)

is determined at EL. 109. 0 m, taking into consideration overflow depth of flood, 0.5 m. Surface water area of reservoir is estimated at about 40 ha in the N.H.W.L. and 4 ha in the L.W.L..

2) Flood analysis

Design flood discharge is determined as the 200-year flood, taking into consideration land property of the downstream area from dam, such as village areas, railway, other infrastructure and paddy field. The flood discharge is estimated at 48 m^3/sec by using rational method. The design flood is released through emergency spillway and intake tower. The discharge of 48 m^3/sec. is diverted the discharge of 15 m^3 /sec. into the intake tower which is nearly equivalent to the 3-year flood discharge and the remaining of 33 m^3 /sec, into the emergency spillway. The overflow depth of the discharge is determined 0.5 m at the crest of the emergency spillway.

3) Dam type

According to the result of geological investigation, it is clarified that the embankment materials of dam are able to obtain in hills located around dam site, and excavated materials of dam site are also useful for embankment. Furthermore, soils for embankment materials are categorized as SC to ML which are identified by the USBR standards. Therefore, earthfill dam of the homogeneous type is adopted.

4) Dimension of dam

Elevation of dam crest is 110.0 m taking into consideration of free board of 1. 0 m above the design flood water level (D.F.W.L.), and gravel pavement of 0.3 m in thickness is designed at dam crest. Dam foundation is determined as the medium weathered rock zone which is impervious layer (seepage coefficient of less than 2.0 legion) and has N-value of more than 20. The elevation of dam foundation is 93.5 m Therefore, dam height is 16.8 m including gravel pavement of dam crest. Width of dam crest is determined 6.0 m, taking into consideration width of reservoir, wave height, seepage coefficient of embank materials. Side slopes of dam are determined 1:3.0 at upstream slope and 1:2.5 at down stream slope according to the soil type of embankment materials (SC to ML).

5) Possibility of additional heightening of dam

In the plan, dam height is determined EL. 110.0 m, according to the topographical and geological conditions of the right abutment and the normal high water level, EL 108.5 m. The ratio of storage capacity against the total runoff amount (total runoff amount/dam capacity) is estimated at about 20%, and the effective stored ratio of dam (useful runoff amount/active capacity) is estimated at about 55% under the irrigation condition of 190 ha.

An active capacity of the reservoir can be increased by 1.9 million m^3, preparing saddle dam and additional heightening of main dam. The crest elevation of dam will be EL 116.5 m, and the normal high water level will be EL. 115.0 m. The height and length of saddle dam will be respectively 6 m and about 400 m, and length of the main dam will be 410 m. The ratio of storage capacity will be 57%, and the effective stored ratio will attain 92% under the irrigation area of 320 ha.

However, in view of hydrological aspect, the reliability of the runoff is weak because of the small watershed area of about 1.8 km^2. In addition, the impervious rock zone of the right abutment can not be expected to be sufficient,

and a lot of excavation and blanket work of abutment will be expected. Construction cost of additional heightening of dam will be high. Therefore, additional heightening of dam is not examined and recommended.

6) Stability analysis

Stability analysis of dam is made by using standards issued by Ministry of Construction, Japan, and the result of the stability analysis is summarized below. Design seismic factor is adopted at 0.15 following to the DPWH, Philippines. The two cases of stability analysis are shown in Figures D.9.3 to D.9.4.

Case	Sliding Sides	Safey Fctor	
		Without Seismic Factor	With Seismic Factor
1 Empty (after construction)	Upstream Slope	2.8	1.7
	Downstream Slope	2.4	1.6
2 Normal High Water Level	Upstream Slope	4.9	2.1
	Downstream Slope	2.1	1.3
3 Rapid Draw Down (Low Water Level)	**Upstream Slope**	2.2	1.4
	Downstream Slope	2.1	1.4

7) Design of emergency spillway

The emergency spillway is side spillway type, and the length of the crest is 51 m. The design discharge for the spillway is 33 m^3/sec. The overflow depth of the discharge is 0.5 m at the crest. The flood discharge is conveyed to the flood way through concrete and gabion channels of 30 m in length. Emergency spillway is designed to install the foundation on the original and impervious rock zone, and the elevation of the foundation is EL. 105.0 m.

8) Design of intake tower

Intake tower with a rectangular section (13 m x 5 m) is designed to obtain irrigation water by orifice through the 3 sluice gates which are installed on vertical wall of tower. Height of the intake tower is 9.5 m, and the water discharge of 15 m^3/sec. during the design flood discharge of 48 m^3/sec. is released at the upper section of the intake tower. The overflow depth is o.5 m at the crest of the upper section. The intake tower has a concrete conduit of box type (2.5 m x 4.0 m) which is underlain the main body of dam, and is connected with main canal through side spillway which can evacuate the flood discharge such as the water discharge of 15 m^3/sec. during the design flood discharge of 48 m^3/sec.. The conduit is provided on the original and fine foundation of the ground, and its length is 74 m. Furthermore, operation bridge with 4-m width is provided between the main dam and the intake tower.

9) Drain system

For stabilization of seepage flow in the main body of dam which is filled by homogeneous soils, the toe drain is provided at the lowest slope of downstream side, and under the EL. 97.0 m. The toe drain consists of gravel, cobble stone and rocks.

10) Resettlement program

The resettlement of some inhabitants of Lacag village which live in the reservoir area to be submerged after the dam construction, will be programmed to move to

some alternative areas to be provided by the local government agencies such as the regional DAR and others. As the alternative sites, the DAR has already proposed some government lands which are upland with coconut farm and bush, in and around the Study area. They are not remote areas, but It need to improve social infrastructure such as road, portable water supply, electrification, houses, etc. and to provide agricultural infrastructure such as farm land, etc. in the proposed areas.

(3) Diversion Weir and Settling Basin

1) Flood analysis

Design flood is determined as 50-year flood, taking into consideration magnitude of flood, suffered areas from flood, design flood discharge of the improvement projects adopted around the Study area and economic viability. The design flood discharge is estimated at 81 m^3/sec. by the rational method

2) Intake water level and type of diversion weir

The dam-up of the intake water level is not need at the proposed diversion weir site because any intake water level can be adopted, taking into account the required water level at head section of settling basin. Therefore, type of diversion weir is determined based on the construction cost of weir, and low dam weir is designed considering overflow depth at the weir crest. The weir is concrete weir of ogee type, and height of weir is 2.20 m. The elevation of crest and tail portion of weir are determined to be respectively EL. 112.00 m and EL. 110.60 m. The creep length of the weir is examined to cope with the piping problem of the weir, by using Bligh formula and Lane formula, and the maximum creep length is estimated at about 20. 0 m.

3) Design Flood Water Level

Design flood water level is determined to be EL. 113.90 m, taking into account the overflow depth of 1.90 m at the crest and the weir length of 20.0 m.

4) Dimension of scouring sluice

The width of scouring sluice is determined to be 1.0 m, taking into consideration the design diameter of particle to be evacuated through the scouring sluice. The design minimum diameter of particle is 0.20 m. The bottom gradient of scouring sluice is 1/200.

5) Length of apron

Length apron in the downstream from the weir is estimated by using the following formula and Lane formula.

$$L1 = 0.6 \times C \times (H1)^{0.5}$$

where,
L1 : Length of apron
C : Bligh's creep coefficient
H1 : Height deference between crest of weir and tail of apron

As a result of calibration of the formula mentioned above, the calculated length of apron is 10.6 m, but in according to the calculated length by Lane formula. the length of apron is determined to be 14.50 m. In addition, apron of 10 m is provided in the upstream from the weir.

6) Retaining wall and River Improvement

Freeboard of retaining wall of the weir is given 1.0 m in accordance with NIA standard. The crest elevation of retaining wall is designed at 114.9 m. Furthermore, flood control dike is planned to provide at both banks of the upstream and downstream from the weir to cope with the flood damage. Flood control dike is designed to be concrete of gravity type.

7) Foundation treatment of diversion weir

In accordance with the results of geological investigation, the foundation of the diversion weir is covered by loose alluvial deposits in depth of about 6 m to 8 m from ground surface, and the alluvial deposits are judged not to be reliable for foundation of the big structure such as diversion dam, etc. in term of bearing capacity. The foundation treatment by piles is recommended. Therefore, the concrete piles of 10m long is planned to attain the base foundation which is of N-value of more than 20.

8) Dimension of settling basin

Design minimum diameter of particle in the water of the canal and the critical velocity of trace force are respectively assumed to be 0.3 mm, and 0.20 m /sec.. The width of lane of the settling basin is determined to be 0.6 m by using the following formula.

$$B = q/(H \times vc)$$

where,

q : Unit discharge of one lane of the settling basin (m^3/sec.)
H : Water depth, when the silting of the minimum diameter of particle is over (m)
vc : Critical velocity of trace force (m/sec.)

Length of the lane is determined to be 11.0 m by using the following formula.

$$L = (K \times q)/(B \times vg)$$

Where,

K : Safety factor
q : Unit discharge of one lane of the settling basin (m^3/sec.)
B : Width of lane (m)
vg : Critical sinking velocity of the minimum particle (m/sec.)

(4) Canal Lining

Canal lining is planned to provide in main canal to sustain the effective water use, and the lining is broadly divided into 2 types, namely rectangular type and trapezoidal type as shown in Figure D.9.1. The lining of rectangular type is applied to the canal route located in the residential area and build-up area. The thickness of concrete lining is 0.15 m. The trapezoidal type is applied the remaining canal routes, and its thickness is 0.08 m. The lining is pre cast concrete blocks, and weephole is designed to provide in excavation section of canals.

(5) Major Structure

1) Head gate and turnout

Head gate and turnout are respectively provided at the head section of lateral canal and the head section of tertiary canal. The design of the head gate and turnout are

made in accordance with the standard of NIA. Typical sections of the structures are shown in Figures D.9.5 to D.9.6. Conduit of turnout is pre cast concrete pipe, and the dimension of the conduit is determined by the design discharge, but the minimum diameter is 0.30 m in view from maintenance aspect.

2) Measuring devices

Measuring devices are planned to provide in the downstream from head gate and turnout for water management. Measuring devices of 2 types such as broad crest weir type and staff gauge type are adopted in the design. The broad crest type is provided in the down stream from head gate and the staff gauge type, in the down stream from turnout. Typical sections of the structures are shown in Figures D.9.7.

3) Road crossing

Road crossing is planned to provide at crossing points of canal with road. Typical sections of the structure are shown in Figure D.9.8. The conduit of the structure is pre cast concrete pipe, and the diameter of the conduit is determined in accordance with the design discharge of canal and the minimum diameter of the conduit is 0.5 m. The minimum thickness of earth covering for the conduit is 0.6 m.

4) Cross drain and bridge

Cross drain or bridge are planned to provide at the crossing point of drain with canal and/or road. The type of the structure is selected due to the design discharge of the drain. The cross drain is planned to provide at the crossing point with the drain which the design discharge is less than 2.0 m3/sec.. The bridge is provided at the crossing point with main drain and flood way which have a big flood discharge of more than 10.0 m3/sec.. The width of the bridge is designed to be flexible due to the width of the connecting roads such as farm road and barangay road. The maximum span length of the bridge is 22 m. Typical sections of the structures are shown in Figures D.9.9 to D.9.10.

(6) Farm Roads

Farm roads with a gravel pavement are laid out along canals and drains. Farm road is provided along main and lateral canals . Total and effective widths are respectively 3 m and 2 m. The thickness pavement is 15 cm. Farm road is designed to link the other roads in order to intensify the effective function of canal inspection and regional transportation. Outside slope of road is 1:1.0. The shoulder portion and outside slope of the road is designed to cover by sod facing.

(7) Protection Dike

The protection dike with a 1.0 - m width is planned to provide in the swampy area in order to protect the expansion of inundation area in the Camalig diversion low land model development area. The dike is designed to sustain the crest elevation of EL. 100 m, and the height of dike is variable ranging from 2.0 m to 0.0 m. The side slope of dike is designed to 1:1.0, taking into consideration the construction material of the dike such as the borrowed materials from hilly area. The stripping thickness is designed to be 0.5 m.

9.4 Design of On-Farm Development

On-farm facilities consist of main and supplementary farm ditch, farm drain, drainage ditch and small related structures. Command area of main farm ditch is basically laid out about 20 ha, and divided into 4 to 5 sub-command areas of supplementary farm ditch. Main farm ditch and

supplementary farm ditch are designed as earth canal with trapezoidal section and have a canal density of about 125 m/ha. The related structures is provided with a density of about 0.2 nos./ha.

Farm drainage canal system is laid out to fit irrigation canal system such as main farm ditch and supplementary farm ditch, and its' density is about 100 m/ha.

10. PROJECT IMPLEMENTATION

10.1 Construction Works

(1) Camalig Diversion Lowland Model Development Project

Main construction works are concrete works of diversion dam and settling basin, earth work of irrigation and drainage canals and protection dike and concrete work of canal lining. The quantity of the main works are roughly estimated as shown below. The detailed is shown in Table D.10.1.

Diversion Dam	
Concrete work	900 m^3
Concrete pile for foundation treatment	200 m.
Earth work	
Excavation	2,300 m^3
Irrigation and Drainage Canals	
Concrete lining	360 m^3
Earth work	
Embankment	18,000 m^3
Excavation	37,400 m^3
Stripping	3,600 m^3
Protection Dike	
Earth work	
Embankment	10,100 m^3
Stripping	8,300 m^3

(2) Dam No.2 Lowland Model Development Project

Main construction works are earth works of fill dam, concrete works of intake structure and spillway, earth work of flood way, earth work of irrigation and drainage canals and concrete work of canal lining as shown below. The detailed is shown in Table D.10.1.

Earthfill Dam including intake structure and spillway	
Earth works	
Excavation	94,000 m^3
Embankment	148,000 m^3
Concrete work	1,500 m^3
Flood way	
Earth work	
Excavation	74,500 m^3
Irrigation and Drainage Canals	
Concrete lining	2,100 m^3

Earth work	
Embankment	127,700 m^3
Excavation	322,300 m^3
Stripping	16,200 m^3

10.2 Construction Time Schedule

Construction time schedule is made based on the estimated quantity of main works mentioned above, workable day in the site, construction method and program, anticipated capacities of construction equipment and physical site condition.

Production capacity of the works are roughly estimated by using construction method, combination of construction equipment and workable day. The production capacities of the main works are assumed to be 90 m3/day/team for excavation, 100 m3/day/team for embankment and 15 m3/day/unit. Workable day in the site is, in general, seasonally affected by rainfall and drainage condition, but based on the assumption of some improvement of drainage condition, the average workable day is assumed to be 15 days/month.

In the Camalig diversion lowland model area, the construction works of diversion weir and irrigation and drainage canal will be respectively taken about 7 months and about 9 months. The most critical path of implementation is the commencement of canal lining work. Therefore, total construction period including mobilization and demobilization period is assumed to be 12 months.

In the Dam No.2 lowland model area, the critical path of the implementation will be met in the construction progress of the embankment of dam and canal lining. The construction of earth dam will be taken about 18 months with more than 8 working crew teams. In addition, the construction period of irrigation and drainage canal system is assumed to be about 14 months under the condition with more than 8 working crew teams. Total construction period is assumed to be 19 months including mobilization and demobilization period. The construction time schedule is shown in Figure D.10.1.

THE FEASIBILITY STUDY ON
THE WESTERN LEGAZPI IRRIGATION AND
RURAL DEVELOPMENT PROJECT IN THE PHILIPPINES

TABLES

Table D. 2.1 Typhoon Damage in Daraga and Camalig Municipality areas (1/2)

Typhoon (Date)	Naning January 1993						Monang December 1993					
	Daraga			Camalig			Daraga			Camalig		
	(nos.)			(nos.)			(nos.)			(nos.)		
1 Casualties												
Confirmed dead	0			0			0			0		
Injured	0			0			0			0		
Missing	0			0			0			0		
2 Damage to houses												
Total	2			30			29			29		
Partial	0			639			40			597		
3 Damage to agriculture	Estimated			Estimated			Estimated			Estimated		
	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)
Rice	0	0	0	115	119	598	50	31	140	34	119	530
Corn	0	0	0	0	0	0	28	34	153	0	0	0
Vegetable	0	0	0	22	137	308	40	40	400	0	0	0
Banana	0	0	0	83	102	85	101	290	870	162	108	646
Root crops	0	0	0	0	0	0	35	20	40	0	0	0
Legumes	0	0	0	30	80	205	0	0	0	15	73	36
Fruit trees	0	0	0	0	0	0	241	2,400	723	0	0	0
4 Damage to livestock	Estimated			Estimated			Estimated			Estimated		
	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)
	0		0	15		22	0		0	25		38
5 Damage to infrastructure	Estimated			Estimated			Estimated			Estimated		
			Cost (P 1000)			Cost (P 1000)			Cost (P 1000)			Cost (P 1000)
			100			0			500			1,000

Typhoon (Date)	Akang January 1994						Garding December 1994					
	Daraga			Camalig			Daraga			Camalig		
	(nos.)			(nos.)			(nos.)			(nos.)		
1 Casualties												
Confirmed dead	0			0			1			0		
Injured	0			0			0			0		
Missing	0			0			0			0		
2 Damage to houses												
Total	38			32			20			20		
Partial	143			564			3			3		
3 Damage to agriculture	Estimated			Estimated			Estimated			Estimated		
	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)
Rice	0	0	0	119	1,004	5,018	200	228	1,158	64	140	360
Corn	0	0	0	0	0	0	30	23	114	0	0	0
Vegetable	0	0	0	22	137	3,080	90	46	460	0	0	0
Banana	0	0	0	0	0	0	100	370	740	12	81	72
Root crops	0	0	0	0	0	0	0	0	0	0	0	0
Legumes	0	0	0	0	0	0	0	0	0	0	0	0
Fruit trees	0	0	0	0	0	0	0	0	0	0	0	0
4 Damage to livestock	Estimated			Estimated			Estimated			Estimated		
	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)
	0		0	18		28	3		14	19		32
5 Damage to infrastructure	Estimated			Estimated			Estimated			Estimated		
			Cost (P 1000)			Cost (P 1000)			Cost (P 1000)			Cost (P 1000)
			2,500			3,300			2,050			0

Table D. 2.1 Typhoon Damage in Daraga and Camalig Municipality areas (2/2)

Typhoon (Date)	Rosing November 1995											
	Daraga			Camalig			Daraga			Camalig		
	(nos.)			(nos.)			(nos.)			(nos.)		
1 Casualties												
Confirmed dead	8			0								
Injured	11			0								
Missing	0			0								
2 Damage to houses												
Total	855			500								
Partial	2,637			3,414								
3 Damage to agriculture	Estimated			Estimated			Estimated			Estimated		
	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)
Rice	535	572	4,584	52	65	488						
Corn	10	30	165	4	6	51						
Vegetable	55	331	4,830	20	56	820						
Banana	101	75	4,965	118	118	708						
Root crops	15	622	1,125	0	0	0						
Legumes	0	0		26	78	486						
Fruit trees	241	2,375	6,230	16	64	768						
4 Damage to livestock	Estimated			Estimated			Estimated			Estimated		
	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)
	135		298	859		614						
5 Damage to infrastructure	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)
			3,000			500						
Typhoon (Date)												
	Daraga			Camalig			Daraga			Camalig		
	(nos.)			(nos.)			(nos.)			(nos.)		
1 Casualties												
Confirmed dead												
Injured												
Missing												
2 Damage to houses												
Total												
Partial												
3 Damage to agriculture	Estimated			Estimated			Estimated			Estimated		
	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)	Area (ha)	Product (ton)	Cost (P 1000)
Rice												
Corn												
Vegetable												
Banana												
Root crops												
Legumes												
Fruit trees												
4 Damage to livestock	Estimated			Estimated			Estimated			Estimated		
	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)	heads		Cost (P 1000)
5 Damage to infrastructure	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)	Estimated		Cost (P 1000)

Table D.5.1 Irrigation Water Requirement in Paddy Field

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec	
CROPPING PATTERN - A *Ligban - Tagaytay area*	Second (Dry) Season Paddy						First (Rainy) Season Paddy				Second (Dry) Season Paddy		
Probable Rainfall	203.0	113.0	114.0	109.0	137.0	215.0	251.0	229.0	249.0	269.0	331.0	348.0	2,568
Potential Evapo-transpiration	108.5	114.0	136.4	165.0	158.1	144.0	117.8	124.0	114.0	111.6	105.0	99.2	1497.6
CROPPING PATTERN - A													
Dry Season Paddy													
Crop Coefficient (Kc)	1.06	1.18	1.11	1.05								0.95	
Crop Evapotranspiration (ETcrop)	115.0	134.5	151.4	173.3								94.2	668
Percolation	93.0	84.0	93.0	90.0							90.0	93.0	543
Effective Rainfall	141.0	105.0	105.0	104.0							183.0	187.0	825
Area Factor	0.92	1.00	0.67	0.08								0.50	
Puddring Water	33.0										33.0	134.0	200
Nursery Water											9.0	8.0	17
Net Irrigation Requirement	83	114	59	0							0	49	304
Rainy Season Paddy													
Crop Coefficient (Kc)					0.90	1.02	1.14	1.16	1.16				
Crop Evapo-transpiration (ETcrop)					142.3	146.9	134.3	143.8	132.2				700
Percolation					93	90	93	93	90				459
Effective Rainfall				104.0	115.0	145.0	158.0	150.0	157.0				829
Area Factor					0.08	0.67	1.00	0.92	0.33				
Puddring Water					125	125							250
Nursery Water				3	13	3							19
Net Irrigation Requirement				0	42	142	69	68	0				321
Irrigation Efficiency	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Conveyance Efficiency 81 %													
Application Efficiency 56 % of paddy field													
Gross Irrigation Requirement (mm)	185	252	131	0	93	315	154	151	0	0	0	108	1,389
(lit/sec/ha)	0.69	1.04	0.49	0.00	0.35	1.21	0.57	0.56	0.00	0.00	0.00	0.40	

Table D.5.2 Irrigation Water Requirement in Paddy Field

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov.	Dec	
CROPPING PATTERN - A Comon-Inarado-TabonTabon area Namantao area	Second (Dry) Season Paddy						First (Rainy) Season Paddy				Second (Dry) Season Paddy		
Probable Rainfall	203.0	113.0	114.0	109.0	137.0	215.0	251.0	229.0	249.0	269.0	331.0	348.0	2,568
Potential Evapo-transpiration	108.5	114.8	136.4	165.0	158.1	144.0	117.8	124.0	114.0	111.6	105.0	99.2	1498.4
CROPPING PATTERN - A													
Dry Season Paddy													
Crop Coefficient (Kc)	1.06	1.18	1.11	1.05								0.95	
Crop Evapotranspiration (ETcrop)	115.0	135.5	151.4	173.3								94.2	669
Percolation	62.0	56.0	62.0	60.0							60.0	62.0	362
Effective Rainfall	141.0	105.0	105.0	104.0							183.0	187.0	825
Area Factor	0.92	1.00	0.67	0.08								0.50	
Puddring Water	33.0										33.0	134.0	200
Nursery Water											9.0	8.0	17
Net Irrigation Requirement	55	86	38	0							0	33	212
Rainy Season Paddy													
Crop Coefficient (Kc)					0.90	1.02	1.14	1.16	1.16				
Crop Evapo-transpiration (ETcrop)					142.3	146.9	134.3	143.8	132.2				700
Percolation					62	60	62	62	60				306
Effective Rainfall				104.0	115.0	145.0	158.0	150.0	157.0				829
Area Factor					0.08	0.67	1.00	0.92	0.33				
Puddring Water					125	125							250
Nursery Water				3	12	3							18
Net Irrigation Requirement				0	38	122	38	39	0				238
Irrigation Efficiency	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	
Conveyance Efficiency 81 %													
Application Efficiency 56 % of paddy field													
Gross Irrigation Requirement (mm)	122	192	84	0	85	270	85	87	0	0	0	74	1,000
(lit/sec/ha)	0.46	0.79	0.32	0.00	0.32	1.04	0.32	0.33	0.00	0.00	0.00	0.27	

Table D.5.3 Technical Comparison between Previous CIS Plan and New Plan

ITEMS	CAMALIG-COTMUN CIS	NEW PLAN
Salient Features of the Plans		
Water Resources	Ligban river (Main river course)	Tinago river (Tributary of Ligban river)
Drought Discharge (m3/sec)	0.23 m3/sec. Feb.(estimated)	0.14 m3/sec. Feb.(estimated)
Intake Site	Abandoned Weir sites of Barangay Ligban	Tinago river
Intake Method	Fixed weir and Intake gates	Movable weir and Intake gates
Intale water level (m)	102 m	108 m (estimated)
Design Discharge (m3/sec)	0.26 m3/sec. June	0.16 m3/sec. June
Irrigation Service Areas (ha)	90 ha in each crop season (wet and dry seasons) for	130 ha for Brngys. Ligban & Tagaytay
	Brngy. Ligban & Tagaytay	
	390 ha (120 ha updated) in each crop season (wet and dry	Brngys. Cotmun & Inrado areas can be covered by
	season) for Brngys. Ligban, Tagaytay, Cotmun & Inarado	Other Irrigation system such as Dam No.1 &Dam No.2
Cropping Pattern / Crop Intensity	Double paddy cultivation / 200 %	Double paddy cultivation / 200 %
Irrigation Canal System		
-Length of Main Canal	9 km	0.3 km
-Length of Lateral Canal	1.5 km	2.5 km
-Length of Farm Ditches	36.4 km	6 km
-Major Related Structures		
	Culvert L=approx.. 400m or Deep open cut D=approx.. 7 m	Stilling basin L=50 m
-Length of Drainage Canals	Non	4 km
-Length of Farm Drains	Non	2.5 km
-Flood Control Facilities	Non	Dike 2 km
-Flood way	Non	250 m
Technical Subjects and Constraints to development	1 Mud flow of Ligban river at intake weir site 2 Bolder flush out at intake weir site 3 Intrusion of much suspended and bed loads into canals 4 Rising of river bed and Flood at Barangay Tagaytay 5 Expansion of water logging at Barangay Tagaytay 6 Deep open cut at main canal routes and Soil Conservation method along deep open cut sections of main canals	1 Intrusion of much suspended and bed loads into canal sections 2 Rising of river bed and Flood at Barangay Tagaytay
Solution of development constraints	1 Dredging works around weir sites 2 Specified structures of weir and/or dredging works 3 Provision of stilling basin and manual dredging or sand pump operation for sedimentation at canal sections 4 Periodical dredging works at river sections 5 Non 6 Alternative plan on open cut method or soil conservation plan of deep cut slopes	1 Provision of stilling basin and evacuation facilities of sedimentation at head race 2 Periodical dredging works at river sections

Table D.5.4 Comparison of Technical Soundness of Each Plan

Description	Camalig Diversion Dam	Dam No.1	Dam No.2	Dam No.3	Dam No.4
1 Dam and Reservoir	Headwork & Intake gates				
Catchment area (km2)	8	2.3	1.8	1.1	4.9
Active capacity (MCM)	-	0.007	0.64	0.23	0.05
Dead capacity (MCM)	-	0.006	0.008	0.005	0.015
Needs of saddle dams (embankment)	control dike of back water	no	1 no. (L=50 m, H=2 m)	2nos. (L=80 m, H=2 m) &	no
				(L=90 m, H=4 m)	
2 Dam Foundation					
Geological Profile	limestone (D=more than 6 m)	conglomerates (D= less than 2 m)	sand stone & shale	tuff breccia (D= more than 3 m)	tuff breccia (D= more than 1 m)
Bearing capacity (N value)	more than 30 (D=more than 6 m)	low reliability	more than 30 (D=more than 6 m)	higher reliability	higher reliability
Seepage Factor (cm/sec)	Kc=less than 2.6 x 10 (-4)	high seepage, more than x 10 (-4)	Kc=less than 8.9 x 10 (-5)	low seepage, lower than x 10 (-5)	low seepage, lower than x 10 (-5)
3 Dam and reservoir area	Headwork site				
Land sliding	no	no	no	no	no
Land use	river	river & grass land	village area & coconut land	paddy field (5 ha) & coconut land	coconut land
Need of resettlement program	no	no	approx. 30 households	approx. 10 households	no
Land acquisition problem	negligible	negligible	yes	yes	negligible
4 Objections of dam and reservoir development	no problem	low reliability of water storage due	no problem	rather long sub dams & negative	lower water level of reservoir
plan (technical soundness)		to low active capacity of reservoir		benefit at reservoir area	against the elevation of irrigation
		& high seepage			services areas
5 Canal and Drain					
Objections of canal & drain layout	no	long canal network & scattered	no	long head race & canal layout at	long head race (pipe line) &
		paddy fields		steep cliff section near dam site	layout of cliff section at head race
Intake method & facilities	movable weir & intake gates	intake structure	intake structure	intake structure	pump station
Total length of main & secondary canals (km)	5.97	4.67	10.5	7.4	15.2
Irrigation area (ha)	130	33	190	84	110
Irrigation canal density (m/ha)	46	142	55	88	138
Total length of main & secondary drains (km)	3.5	1.74	14.3	5	0
Specified related structures					
Irrigation	Stilling basin, Diversification str.,	Aqueduct & Culvert	Diversification str., Aqueduct	Culvert	Culvert
	Aqueduct & Culvert		& Culvert		
Drainage	Flood control dike & Flap gates		Bridge		
6 Flood control facilities	Flood way (L=250 m)				
7 Objections of irrigation & drainage development	no problem	higher canal density & small scale	no problem	higher canal density & objection of	higher canal density, objection of
plan (technical soundness)		irrigation development		layout at cliff section near dam site	layout at cliff section of head race
					& pump up irrigation method
8 Technical soundness of overall plan	no problem	lower technical soundness	no problem	low technical soundness	lower technical soundness

Table D.8.1 Salient Features of Irrigation and Drainage System

I. Camalig Diversion Lowland Model Project		
1. Irrigation Service Area	:	130 ha
2. Major Structure		
(1) Diversion Weir		
- Type of Weir	:	Ogee Type with One Sluice Gate
- Intake Water Level	:	EL. 112.0
- No. of Intake Gate	:	1 no.
- Length of Weir	:	22 m
- Design Flood Discharge	:	81 m3/s
- Design Flood Water Level	:	EL. 113.9
(2) Settling Basin	:	1 no.
- Type	:	2-Lane Type
- Length	:	11 m
- Width	:	2 m
3. Irrigation Canal		
(1) Main Canal		
- Design Discharge	:	0.16 m3/s (130 ha)
- No. of Main Canal	:	1 no.
- Total Length of Main Canal	:	2.3 km
(2) Lateral Canals		
- No. of Lateral Canals	:	2 nos.
- Total Length of Lateral Canals	:	3.3 km
(3) Farm Road along Irrigation Canal	:	4.9 km
(4) Link Road	:	0.4 km
3. Drainage Canal		
(1) Main Drain		
- No. of Main Drains	:	3 nos.
- Total Length of Main Drains	:	2.3 km
4. Major Canal Structures	:	68 nos.
5. Protection Dike at Swamp Area		
- Length	:	3.3 km
- Flap Gates	:	3 nos.
6. River Improvement (Ligban River)	:	2.0 km
II. Dam No.2 Lowland Model Project		
1. Irrigation Service Area	:	395 ha with rotation
2. Major Structure		
(1) Small Impounding Pond		
- Active Storage Capacity	:	0.68 MCM
- Dam Height	:	16.8 m
- Dam Length	:	278 m
- No. of Intake Gates	:	3 nos.
- Design Flood Discharge	:	48 m3/s
- Floodway from Emergency Spillway	:	1.6 km
- Access Road to Dam	:	0.9 km
3. Irrigation Canal		
(1) Main Canal		
- Design Discharge	:	0.20 m3/s (190 ha)
- No. of Main Canal	:	1 no.
- Total Length of Main Canal	:	10.7 km
(2) Lateral Canals		
- No. of Lateral Canals	:	11 nos.
- Total Length of Lateral Canals	:	10.7 km
(3) Farm Road along Irrigation Canal	:	18.4 km
(4) Link Road	:	1.8 km
4. Drainage Canal		
(1) Main Drain		
- No. of Main Drain	:	2 nos.
- Total Length of Main Drains	:	8.2 km
(2) Secondary Drain		
- No. of Secondary Drains	:	9 nos.
- Total Length of Secondary Drains	:	9.2 km
5. Major Canal Structures	:	192 nos.

Table D.10.1 Major Work Quantity of Irrigation and Drainage

Description	Unit	Camalig Model Project					Dam No.2 Model Project					River Improvement
		Diversion Dam	Major Irrigation Canals	Major Drainage Canals	Major Canal Structures	On-Farm Development	Dam & Spillway	Major Irrigation Canals	Major Drainage Canals	Major Canal Structures	On-Farm Development	
A. Earth Works												
Stripping	m3	-	3,610	-	8,300	-	-	16,220	-	-	-	-
Excavation	m3	2,316	21,350	16,020	565	3,016	172,300	72,040	250,220	3,058	9,164	18,774
Backfill	m3	523	-	-	333	13	2,200	-	-	1,767	40	13,542
Embankment	m3	-	17,970	-	10,124	4,160	148,080	127,670	-	1,409	12,640	534
Grading for Road	m2	-	-	-	3,250	-	4,050	-	-	-	-	-
Macadam Pavement	m3	-	-	-	-	-	-	-	-	-	-	-
Gravel Pavement	m3	-	-	-	-	-	714	-	-	-	-	-
Clearing and Grubbing	ha	-	-	-	-	-	5	-	-	-	-	-
B. Concrete Works												
Concrete	m3	863	362	-	178	11	2,900	2,084	-	1,835	32	8,048
Reinforcement Bar	t	65.0	4.5	-	13.0	0.8	130.0	-	-	155.2	2.5	640.8
Form	m2	1,353	1,054	-	624	39	4,350	2,210	-	5,981	117	12,295
C. Stone Works												
Grouted Riprap	m3	-	-	-	16	-	-	-	-	317	-	45
Dry Riprap	m3	-	-	-	-	-	12,200	-	-	-	-	-
Gabion Mattress	m3	-	-	-	-	-	40	-	-	-	-	-
D. Metal Works												
Steel Slide Gate												
- W 1.0 x H 1.0	set	1	-	-	-	-	-	-	-	-	-	-
- W 1.0 x H 0.5	set	1	-	-	-	-	-	-	-	-	-	-
- W 1.0 x H 0.3	set	-	-	-	-	-	3	-	-	-	-	-
- W 0.6 x H 0.6	set	2	-	-	4	-	-	-	-	22	-	-
- W 0.6 x H 0.4	set	2	-	-	-	-	-	-	-	-	-	-
Flap Gate												
- W 1.0 x H 1.0	set	-	-	-	3	-	-	-	-	-	-	-
E. Other Works												
RC Pipe	m	-	-	-	322	-	-	-	-	538	-	-
RC Pile	m	200	-	-	90	-	192	-	-	190	-	-