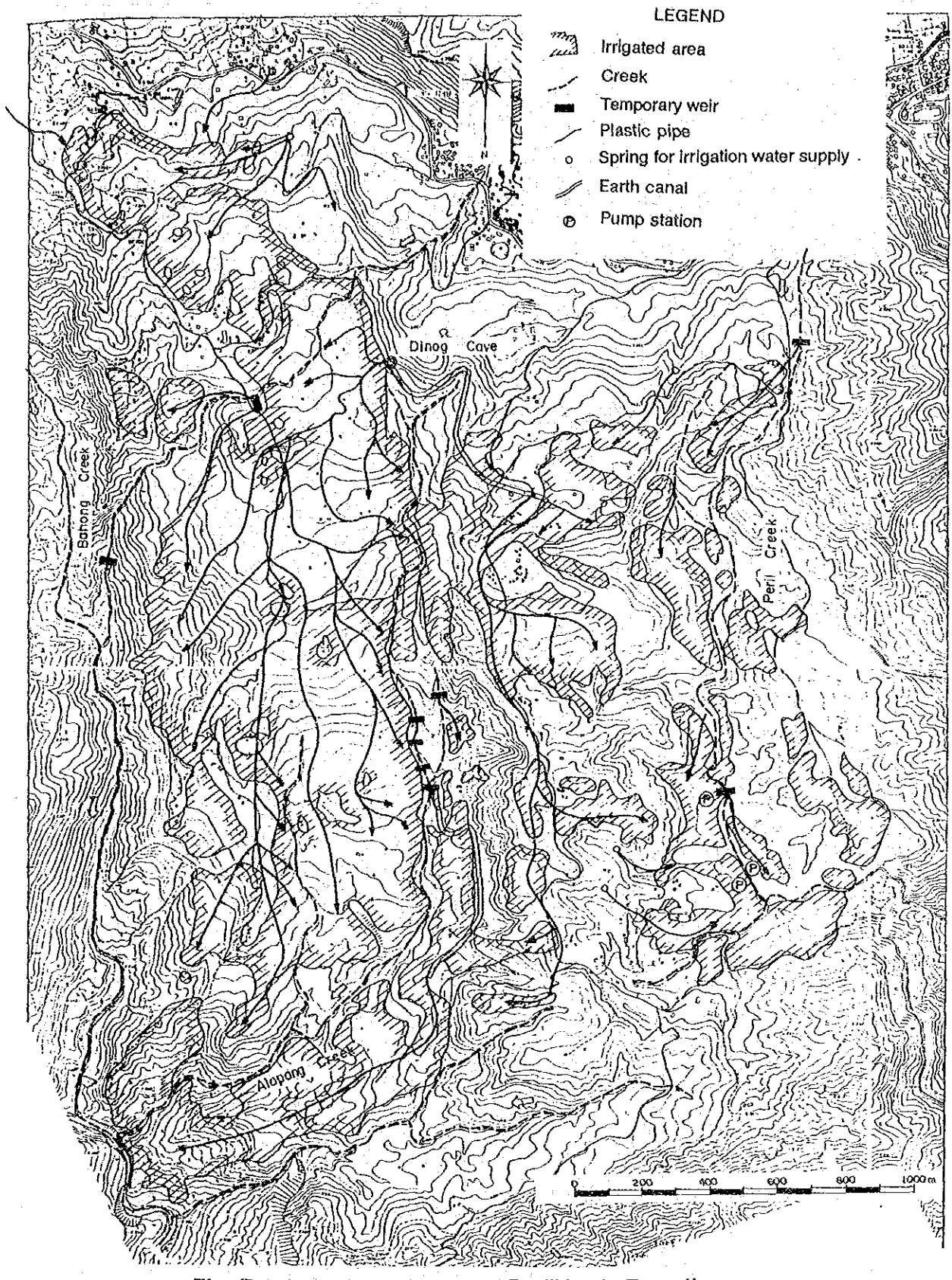

Fig. F.1.4 Existing Irrigation Facilities in Zone II

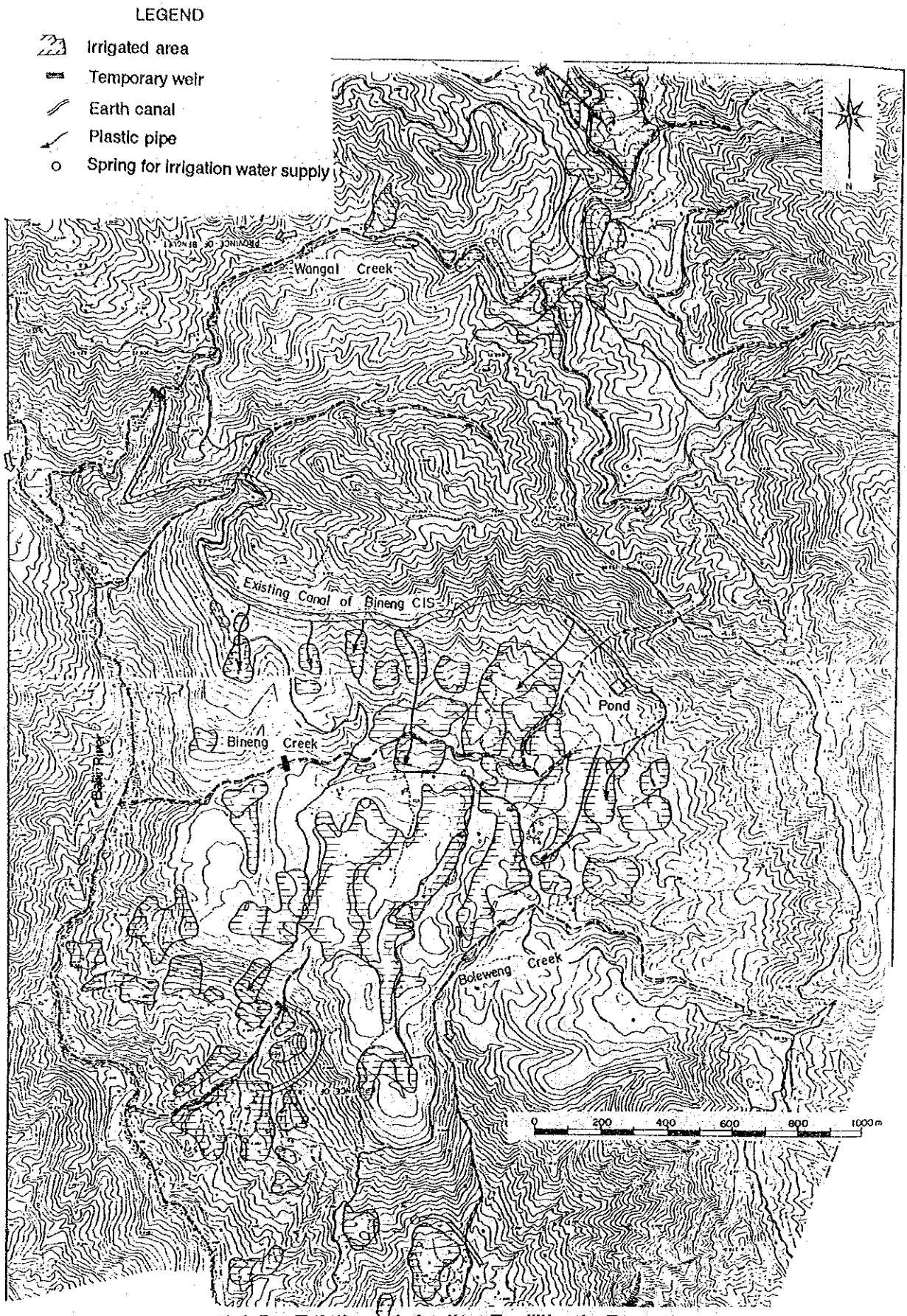

Fig. F.1.5 Existing Irrigation Facilities in Zone III

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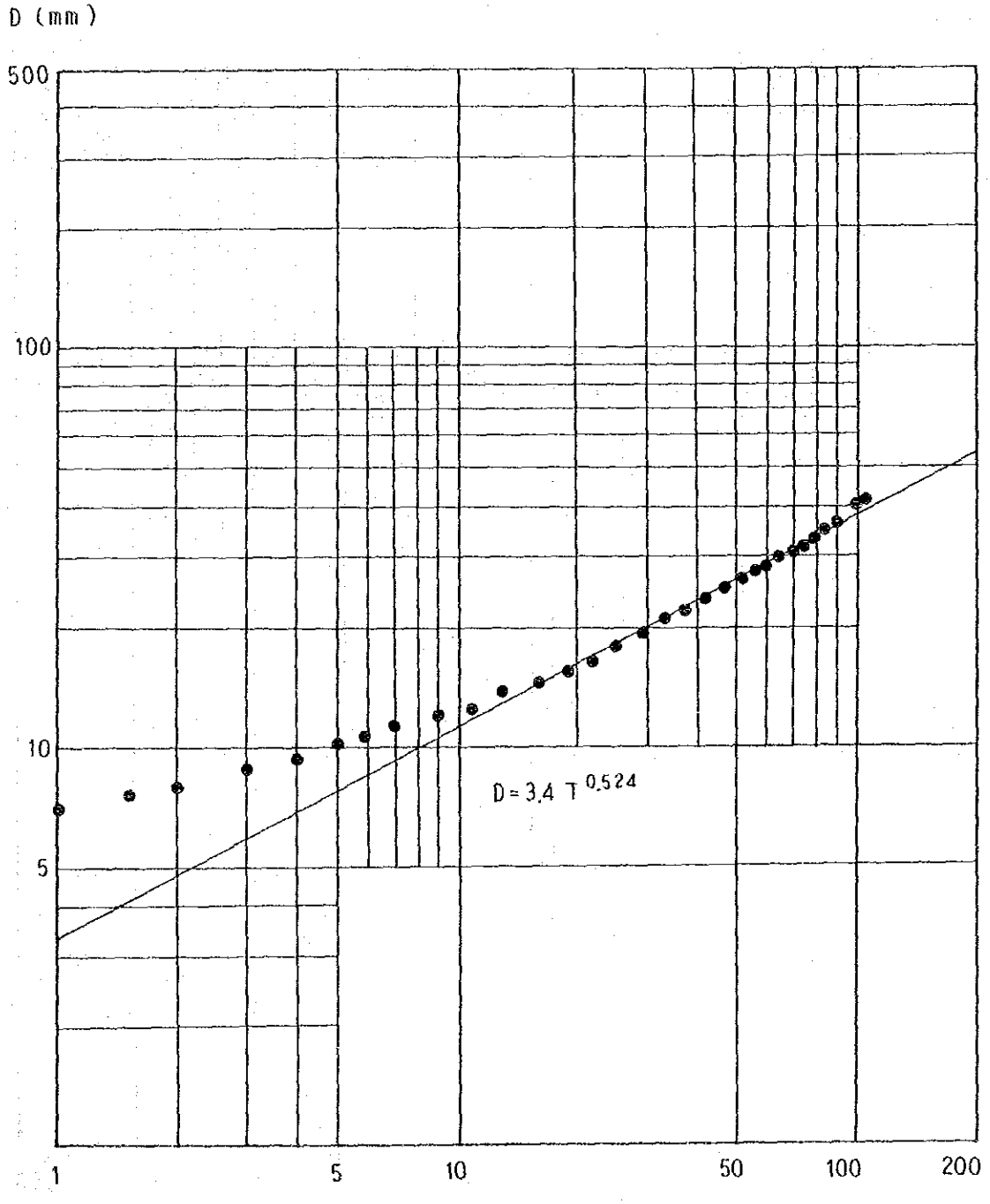


Fig. F.1.6 Integrated Infiltration Data (1)

Zone II, Pit no.2

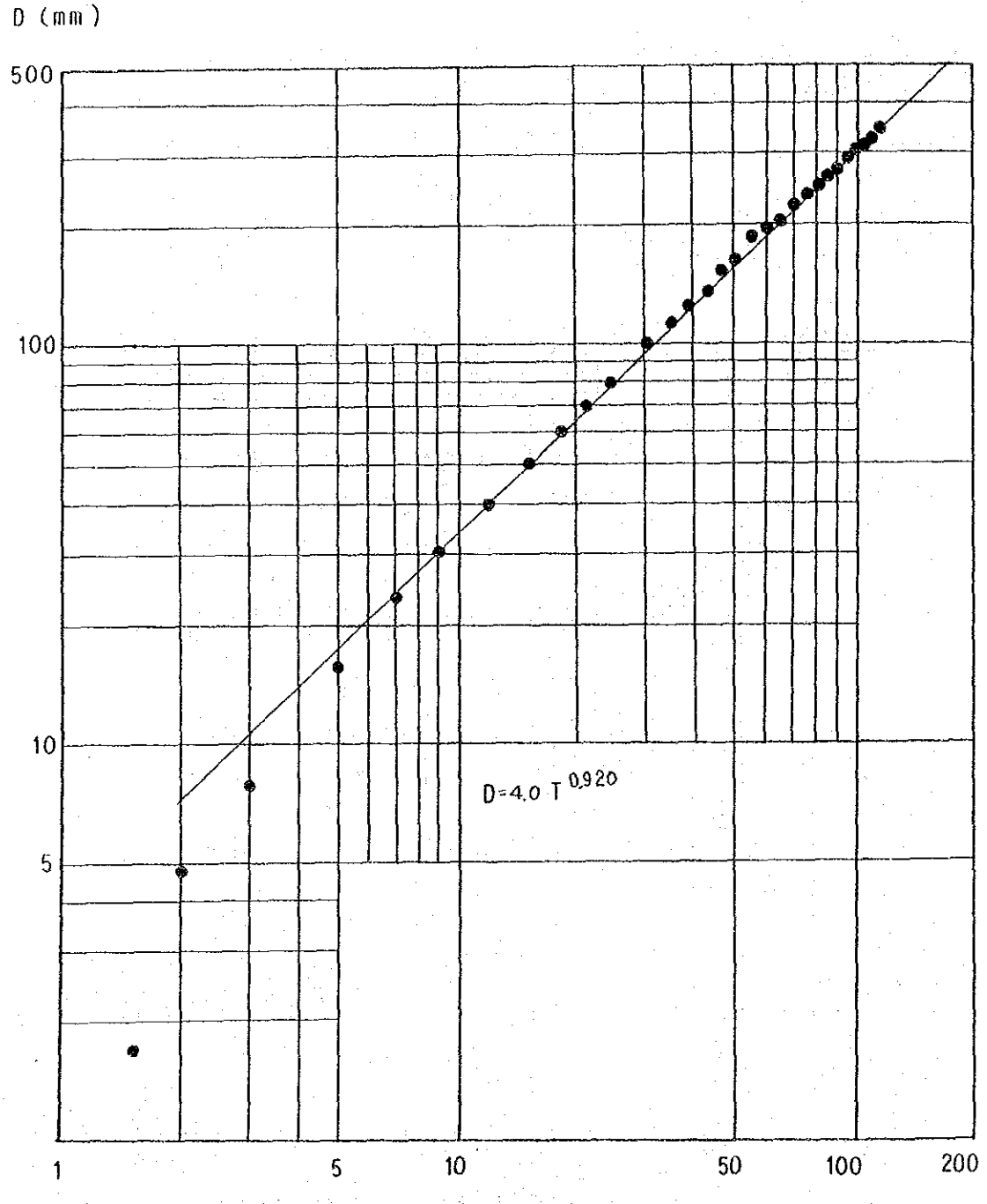


Fig. F.1.6 Integrated Infiltration Data (2)

Zone II, Pit no.6

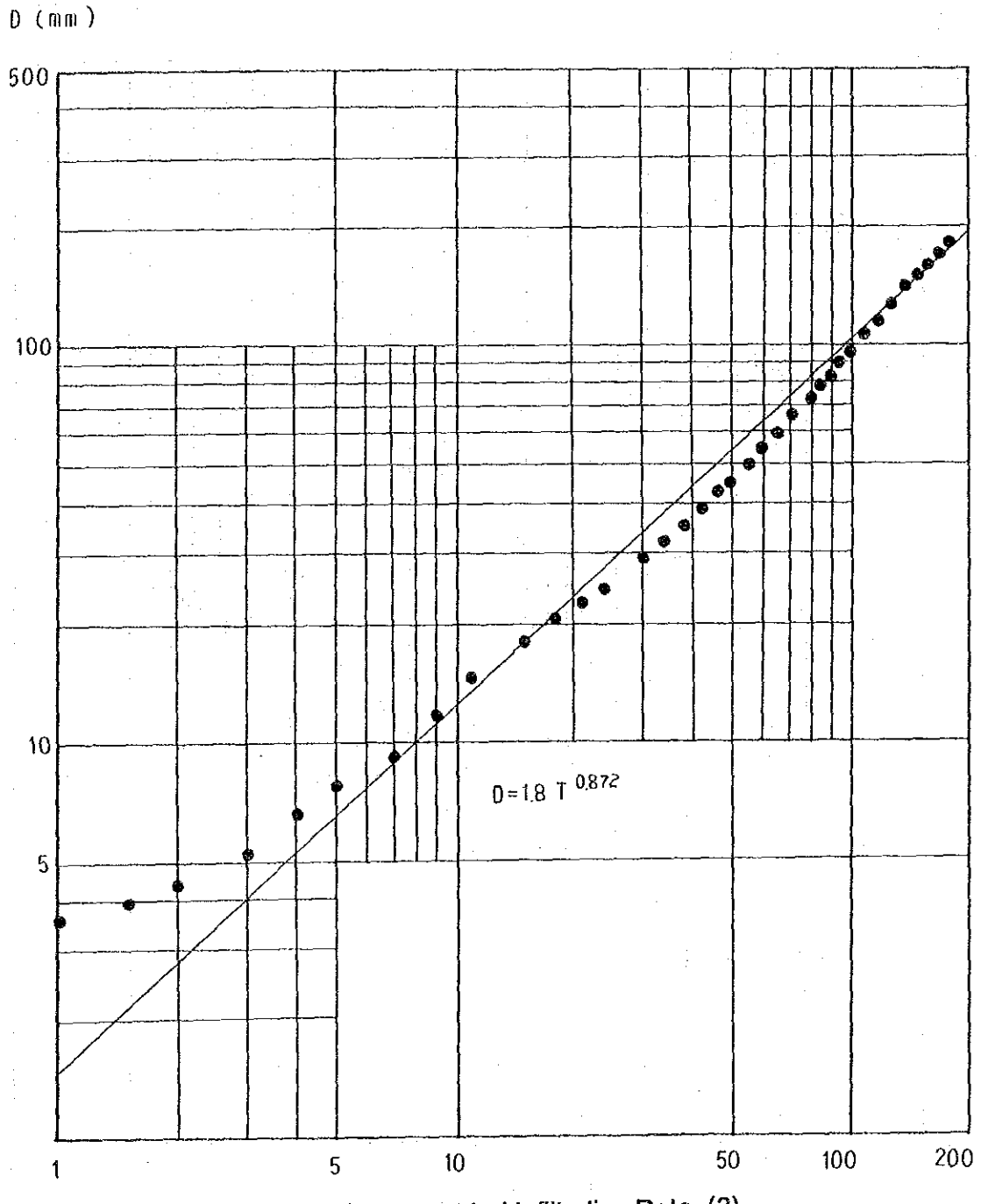


Fig. F.1.6 Integrated Infiltration Data (3)

Zone II, Pit no. 9

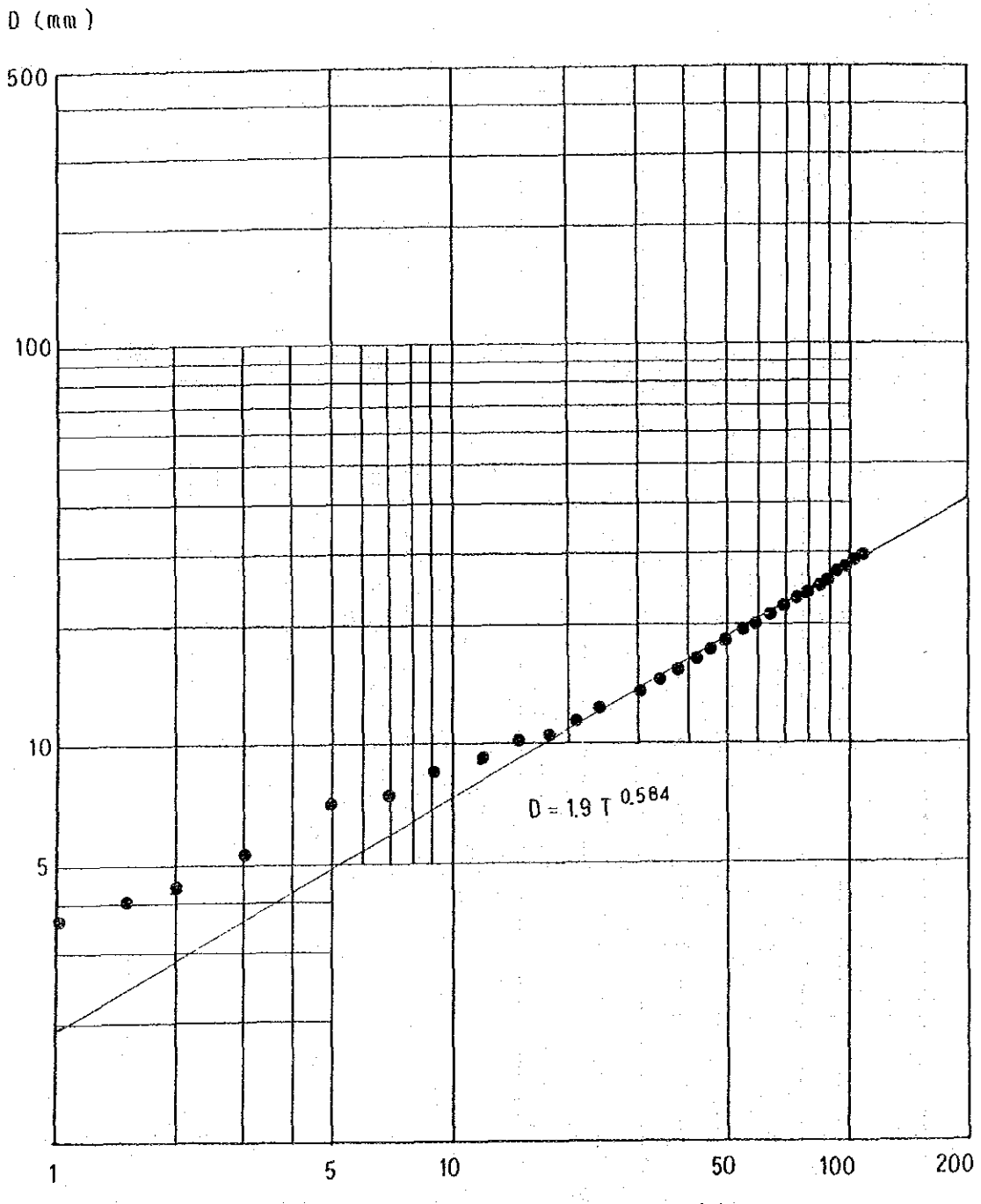


Fig. F.1.6 Integrated Infiltration Data (4)

Zone III, Pit no.5

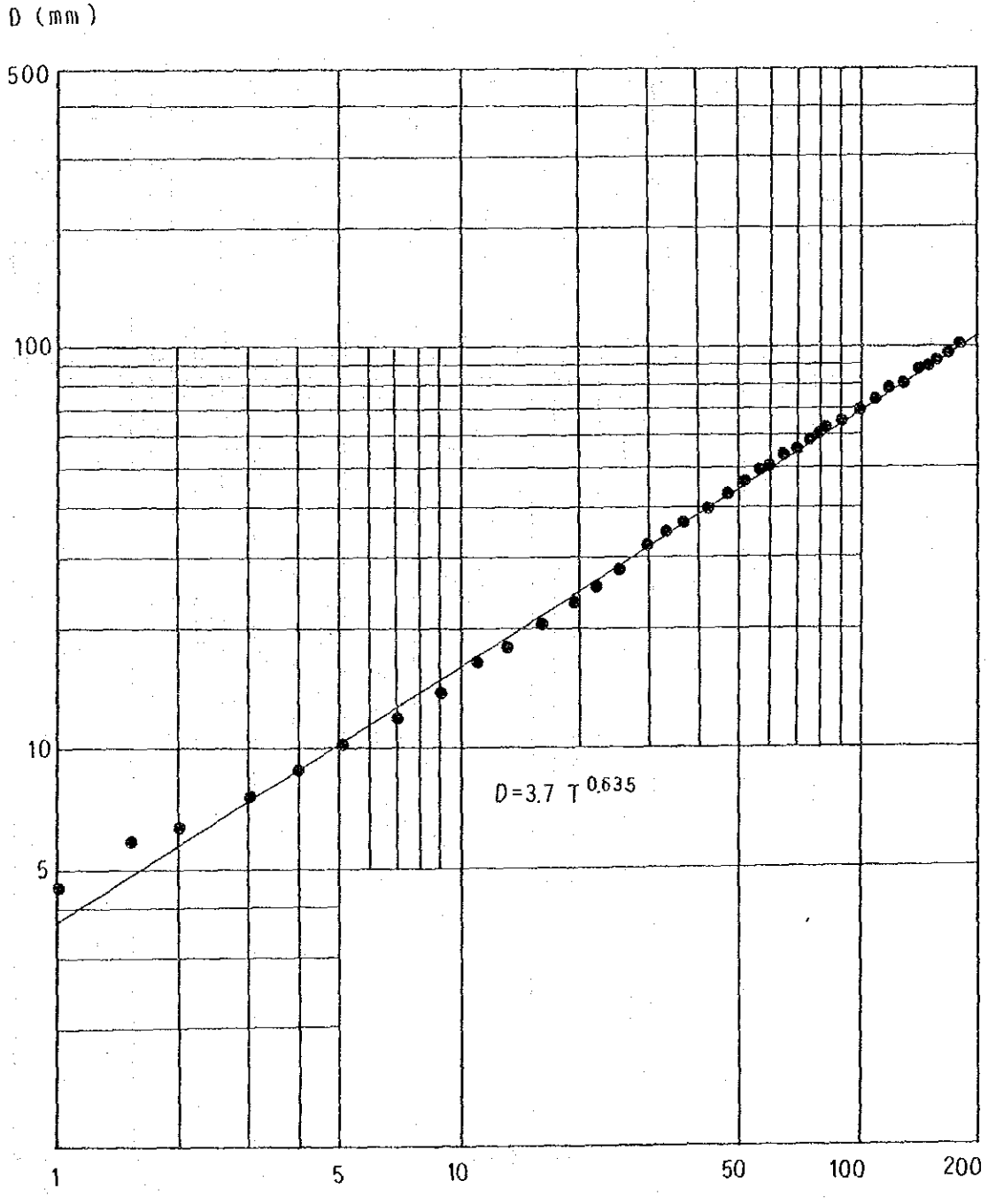


Fig. F.1.6 Integrated Infiltration Data (5)

Zone III, Pit no.7

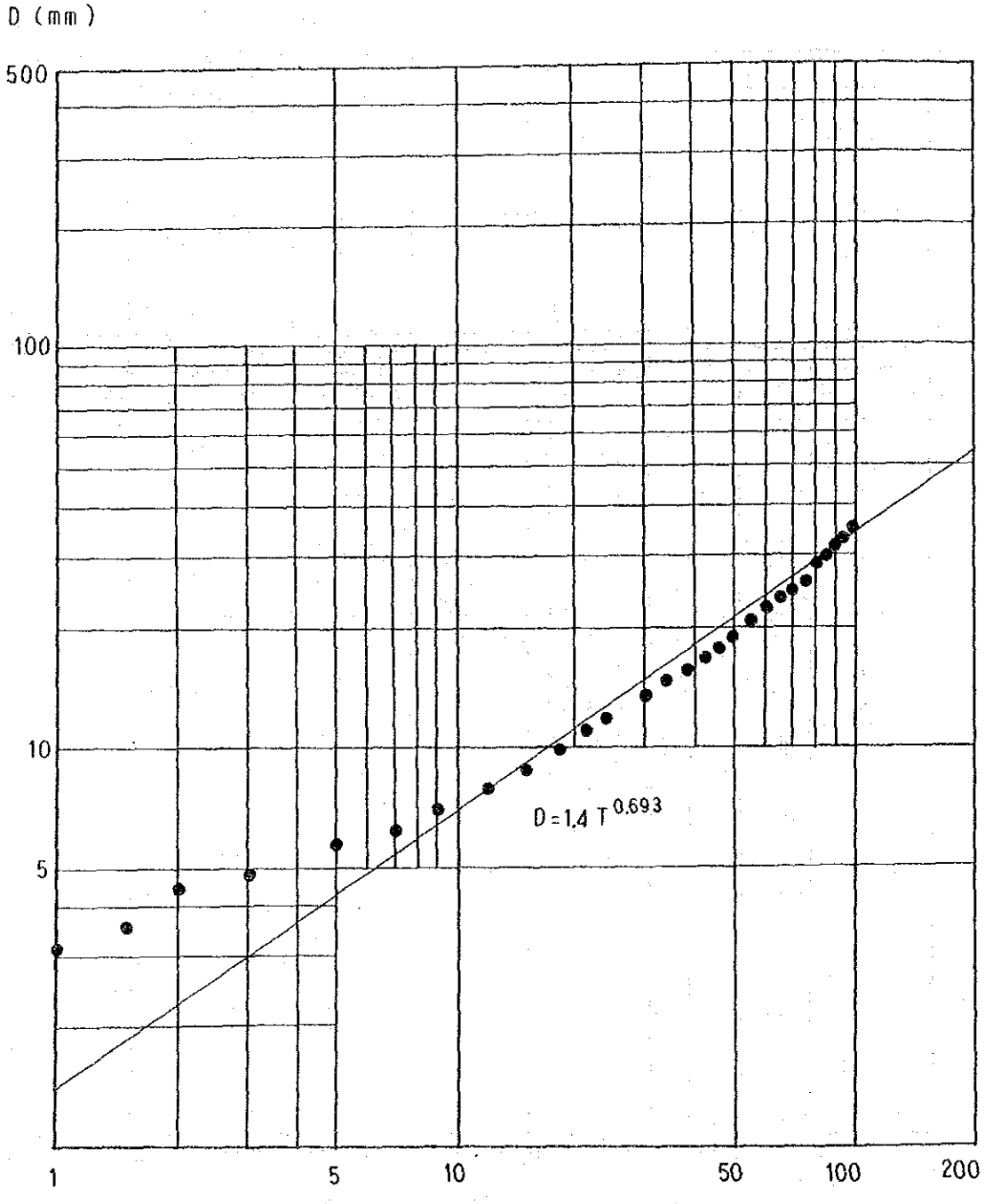
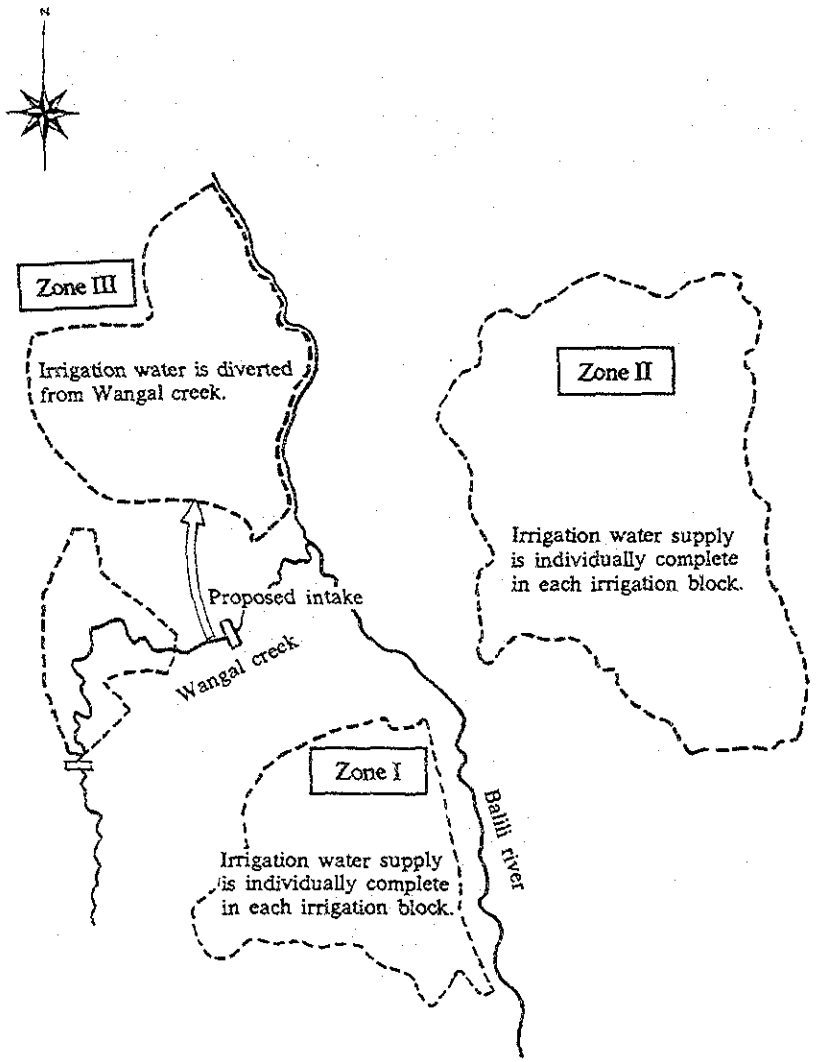
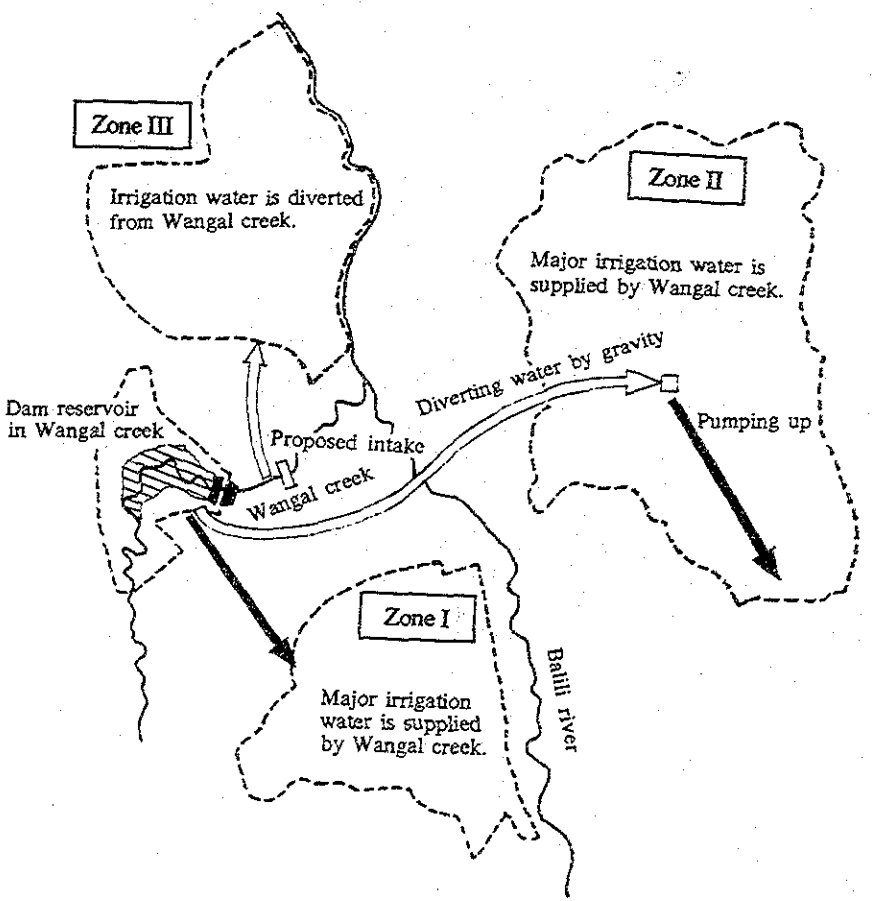


Fig. F.1.6 Integrated Infiltration Data (6)



for Alternatives A, B

In this case, dem reservoir is inevitably required owing of necessity of enomous reservoir capacity.



for Alternative C

Fig. F 2.1 Schematic Diagram of Major Water Source for Irrigation Development Alternatives

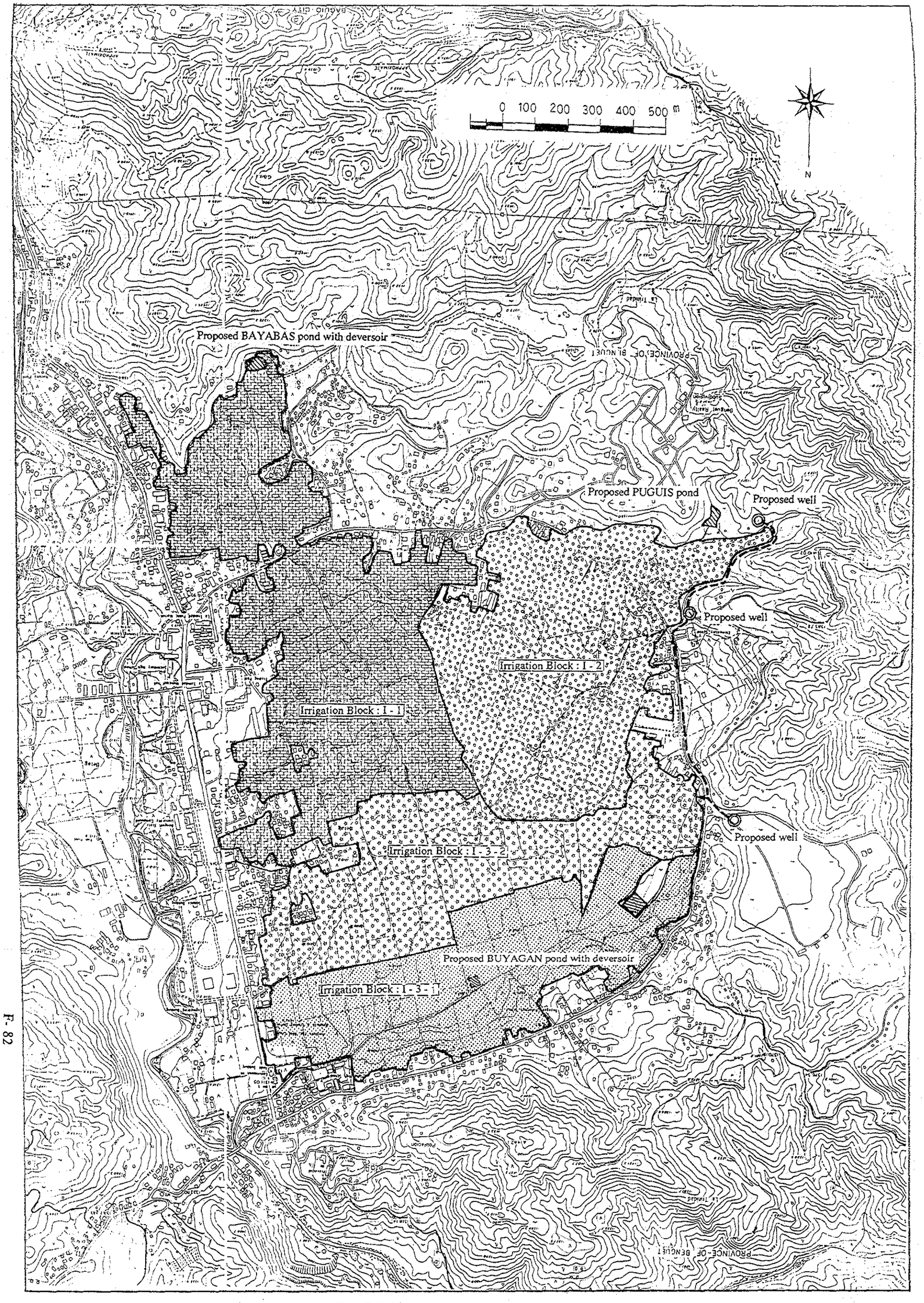


Fig. F.2.2 Proposed Irrigation Block in Zone I

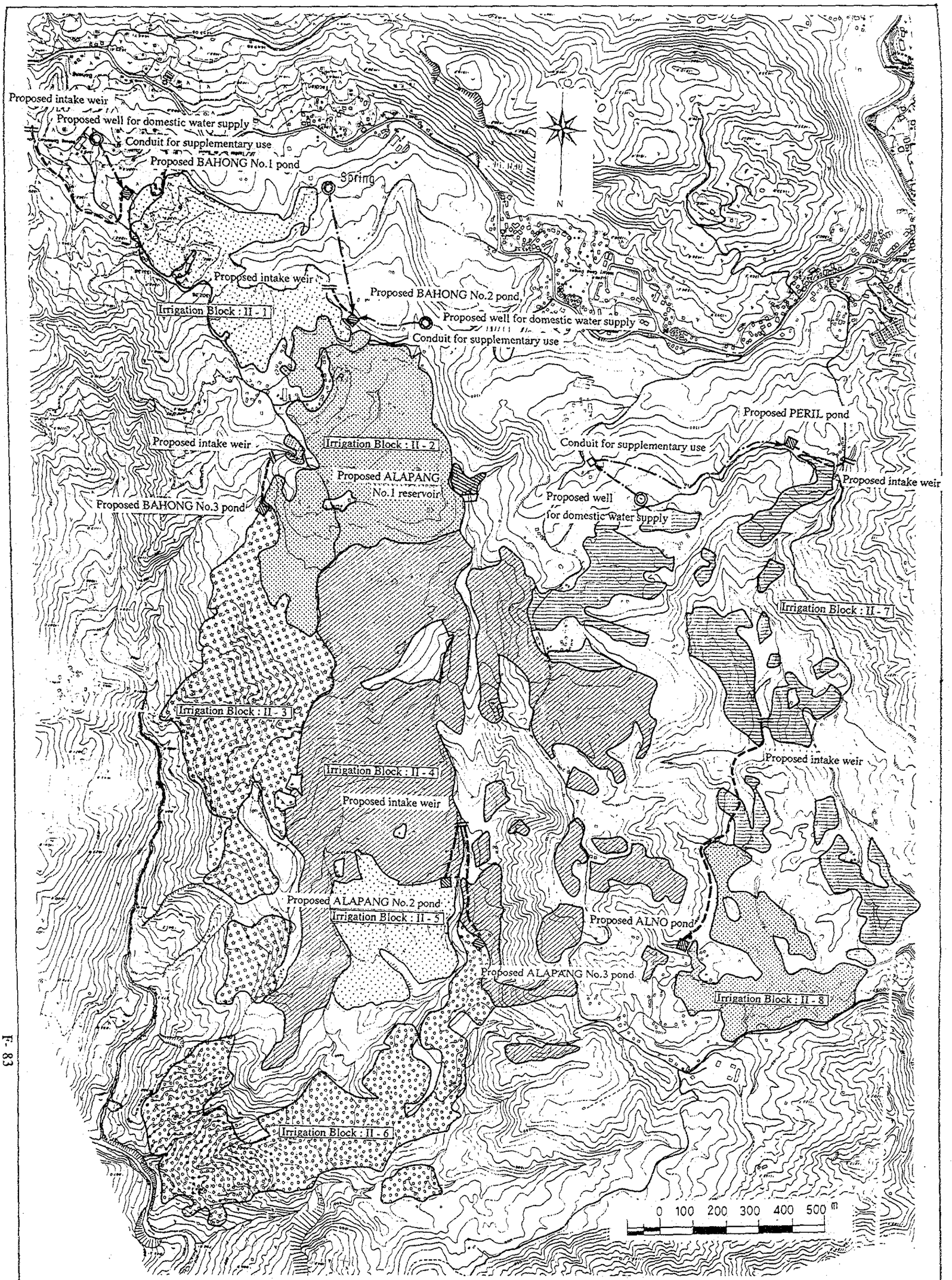


Fig. F.2.3 Proposed Irrigation Block in Zone II

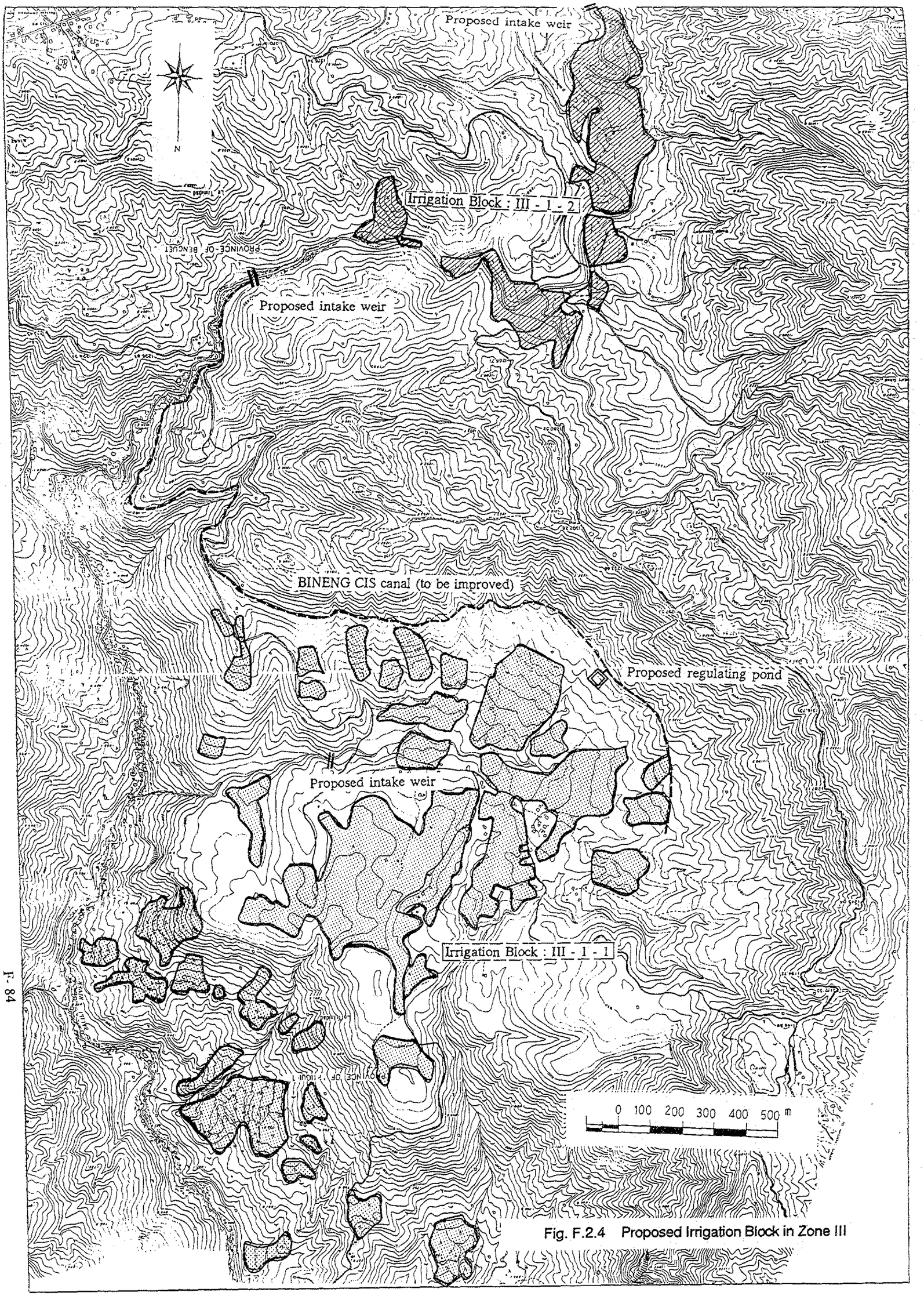


Fig. F.2.4 Proposed Irrigation Block in Zone III

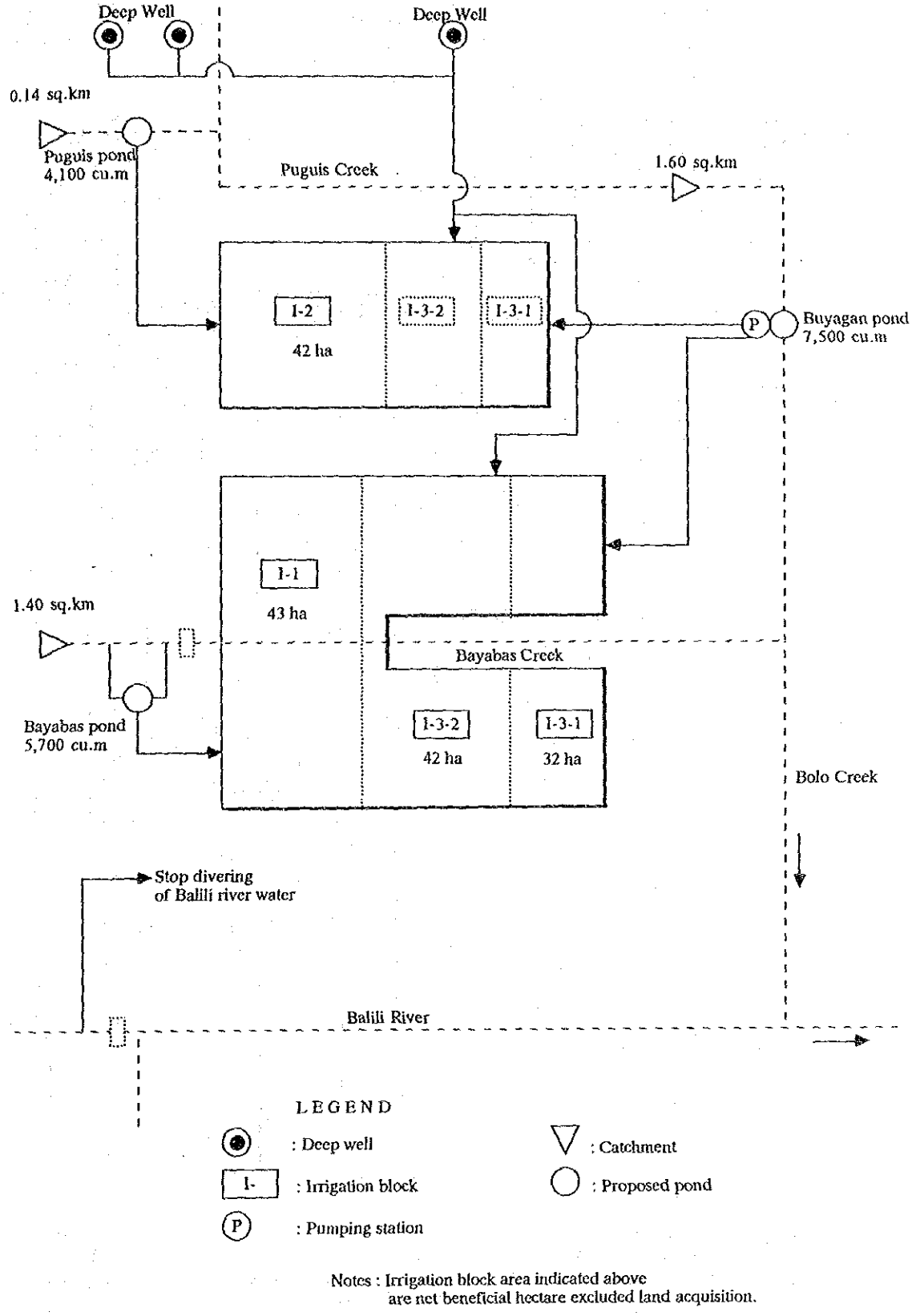


Fig. F.2.5 Schematic Diagram of Proposed Irrigation Block in Zonre I

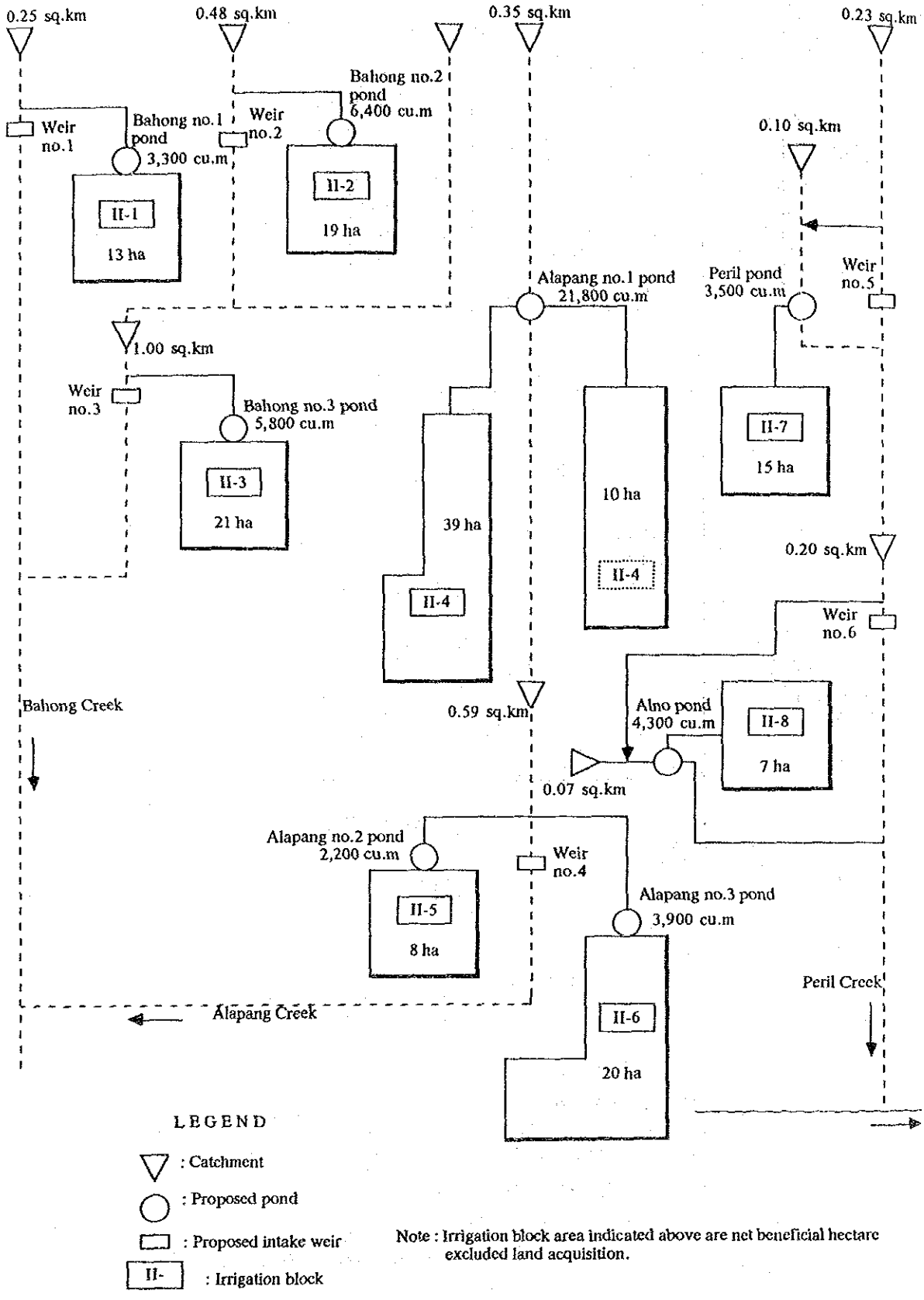


Fig. F.2.6 Schematic Diagram of Proposed Irrigation Block in Zone II

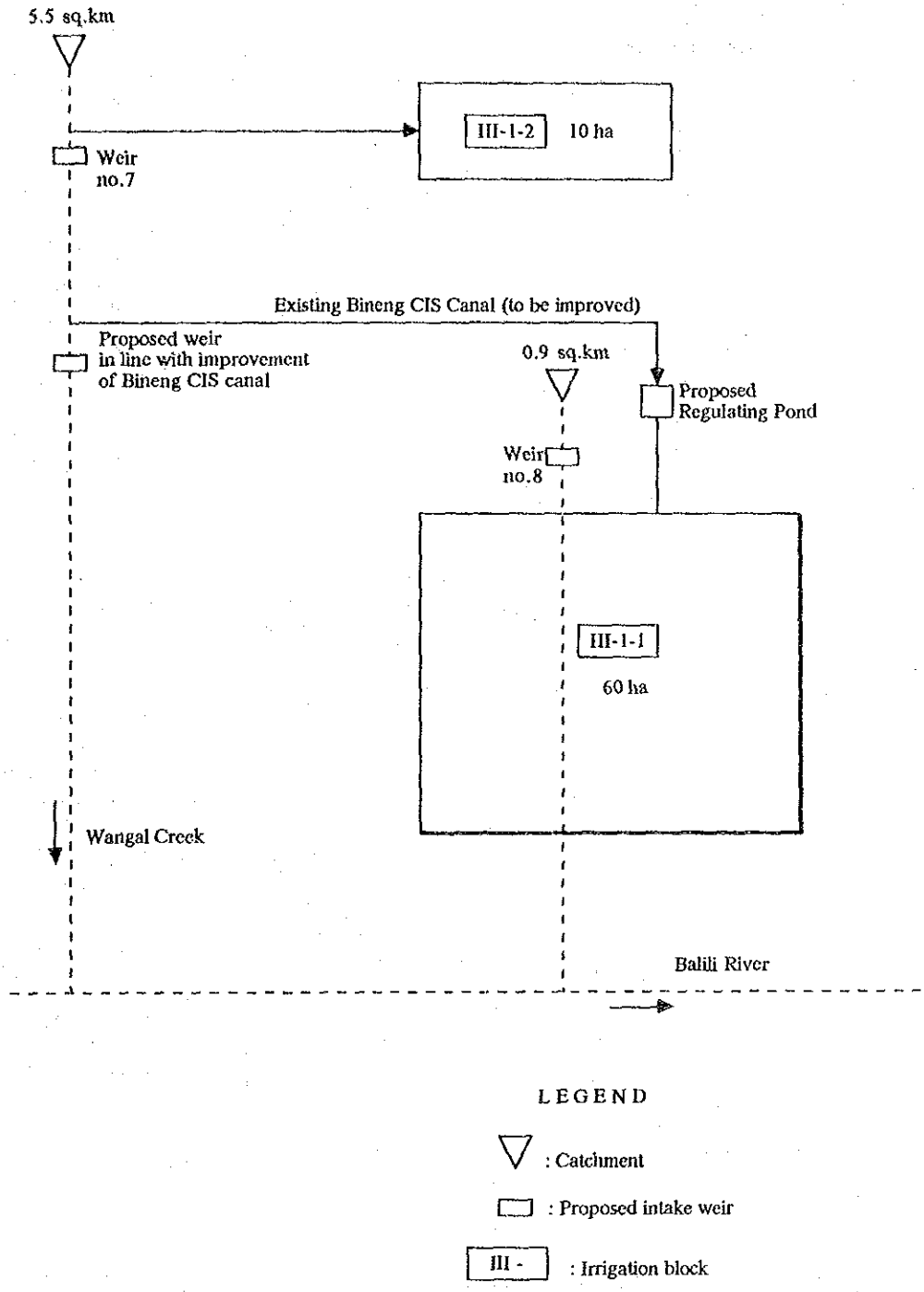


Fig. F.2.7 Schematic Diagram of Proposed Irrigation Block in Zone III

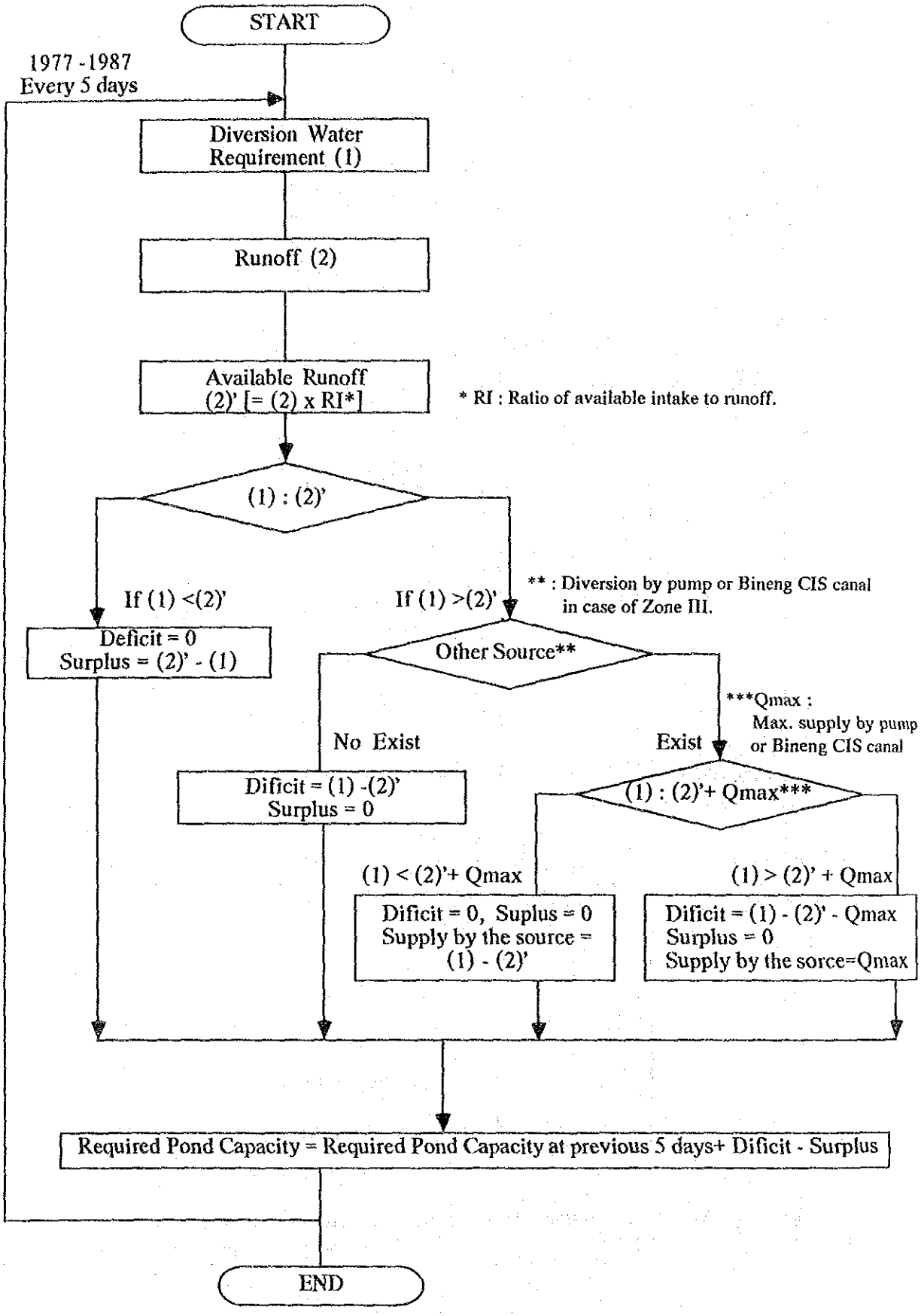


Fig. F.2.8 Flow Chart of Water Balance Calculation

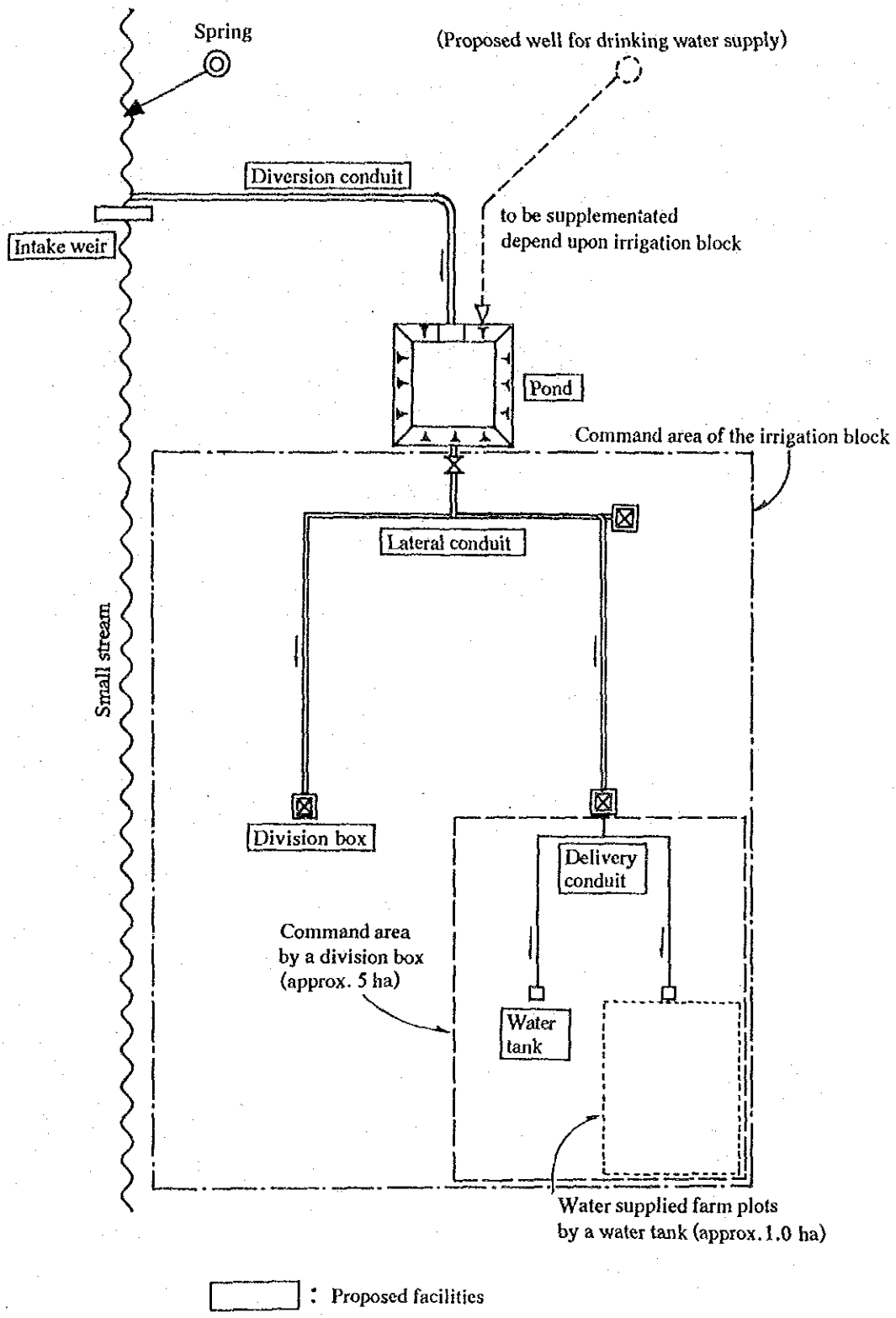


Fig. F 2.9 Schematic Diagram of Proposed Irrigation System

APPENDIX G

DRAINAGE AND FLOODING

APPENDIX G DRAINAGE AND FLOODING

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APPENDIX G DRAINAGE AND FLOODING

1. PRESENT CONDITION

Zone I in the Project area forms a basin ranging from EL. 1,500 meters to EL. 1,309 meters and with slope of 0.5 - 0.6 percent, 6.8 sq.kms as catchment area.

Rainfall in Zone I is drained into several creeks, which flows into the Bolo creek.

The Bolo creek flows from west to east and joins into the Balili river through northern portion of Zone I, which is a main drainage channel of the area. The Balili river which is major stream in the Project area with about 40 meters river width, flows from the mountain areas of Baguio City located southern part of La Trinidad. A number of household garbage and the market refuse has been partly thrown into the creeks. So that, flow obstruction may be caused by the disposal in the small creeks as well as the Bolo creek.

At the confluence of the Balili river with the Bolo creek, water flow is not always smooth, because of angulated connection form of both streams. At just downstream of the confluence, where national road bridge exists, the flowing section becomes small.

In the survey term, cross sectioning and profile leveling survey of both streams were carried out, and found that the difference of altitude between the Balili river bed and the Bolo creek bed is only 0.5 - 1.0 m, and resulted in poor drainage especially in flood season.

As for Zone II and Zone III, there is no surface drainage problem due to steep topographical conditions. If anything, the soil erosion on the slopes may raises by heavy rainfall.

Seepage water is especially observed at the paddy field in Zone III. If paddy field in Zone III is requested to convert to upland crop, some drainage treatment to overcome seepage may be required. According to the interviewing survey, however, most of rice cultivating farmers in Zone III have no intention to convert the land category. Rice planting in Zone III was continuously proposed in this project in line with farmer's intention. The drainage problem to be caused by the conversion of land category from paddy field to upland field will unlikely arise.

2. FLOOD ANALYSIS

2.1 Inundation Analysis

Flat area in Zone I of the Project, so called Trinidad Valley, has been almost every year attacked by flood, and a considerable damage has been recorded.

Hereinafter, the study on the mechanism of flooding in Zone I has been carried out by means of a inundation simulation, in order to grope the countermeasure for flooding.

An inundation simulation is most suggestive and useful in order to grasp the cause of inundating phenomenon, and to consider countermeasures so as to decrease the damages.

Schematic diagram of drainage condition is illustrated as Fig.G.2.1.

The inundating condition can be analyzed under the equation presented as follows:

$$dv(t)/dt = Qin(t) - Qout(t) \quad \text{----------} \quad (1)$$

V(t), : [=V(h(t))]	Inundated water volume at Zone I, which is a function of h(t)
Qin(t) :	Discharge from the Bolo creek catchment.
Qout(t), : [=Qout(H(t),h(t))]	Drainage discharge to the Balili river from the Bolo creek catchment, which is a function of H(t), h(t) and hydraulic condition of the Bolo creek.
H(t) :	Water stage of the Balili river at the confluence with the Bolo creek.
h(t) :	Inundated stage of Zone I.

Every functions mentioned above would be formulated so as to meet with present conditions. Inundation analysis can be conducted in equation (1) with the functions.

2.2 Runoff Analysis

The kinematic wave method was recommended in Appendix C. Meteorology and Hydrology in accordance with the runoff characteristic.

Divided catchment blocks for the analysis are illustrated in Fig.G.2.2 and Fig.G.2.3. Parameters of the blocks are given as listed in Table G.2.1.

Most important parameter among them is the equivalent roughness (N), which would be fixed so as to match the estimated discharge to observed data in the Ambiong creek.

The comparison between the both is presented in Table G.2.2 and Fig.G.2.4, which can be reasonably judged as well matched, in considering the difference of rainfall between in the Ambiong watershed and in the Baguio PAGASA station which was utilized in the analysis. According to the result, (N) at 0.2 was fixed , that categorization for bare or grassed hilly land. In other words, the result was hydrologically reflected the characteristic of the watershed.

2.3 Water Stage of the Balili River at the Confluence

The quantity of water flown into the Balili river from the Bolo creek, is functioned by the difference between the Balili river water stage and the Bolo creek water stage, the stage means the situation of inundation in Zone I. The water stage of the Balili river is estimated under the uniform flow analysis with analyzed discharge, because of relatively steep vertical river slope at 1 percent.

2.4 Others

Expected area for inundation in Zone I is shown in Fig.G.2.5, the relation between the water stage and the inundation water volume in Zone I is also shown in Fig.G.2.6.

3. SIMULATION OF TYPHOON GADING IN 1986

As based upon the simulation method mentioned above, Typhoon GADING in 1986 which caused a biggest flood for the last over ten years, was simulated in order to confirm the appropriateness of the methodology.

According to the results presented in Table G.2.3 and Fig.G.2.7, the maximum inundated water stage was estimated at EL. 1311.29 meters on noon of July 10th, 1986. As for actual water stage on the same date, the highest water stage was recorded at EL. 1311.20 - 1311.30 meters in the Commission on Audit Office along the national highway. A coincidence of both maximum water stages proved the accuracy of the analysis.

4. ESTIMATED INUNDATED AREA

Regarding to the simulation of Typhoon GADING in 1986, the inundated area was estimated at approximately 110 hectares in Zone I. Inundation range would be almost fixed the variation and amount of rainfall which causes runoff from the catchment area.

Accordingly, design rainfall patterns on several return period floods have been composed, maximum inundated area or water stage in several return period has been computed with the rainfall patterns.

4.1 Design Rainfall Pattern

By the meteorological investigation, a heavy rain in the wet season had continued for two or three days at most. Therefore, duration of the design rainfall pattern was fixed at three days, and distributed with the probable rainfall intensity curves which are proposed in this study. The peak rainfall intensity is to be positioned in the center of the pattern.

4.2 Inundation Analysis on Several Return Period

Some design rainfall patterns on several return period are composed as listed in Table G.2.4, and inundation analysis was carried out, which are presented in Table G.2.5 to Table G.2.7 and Fig.G.2.8 to Fig.G.2.10.

Maximum inundated water stage and area on several return periods are listed as follows:

WATER STAGE AND AREA

Return period (year)	Maximum inundated level El.(m)	Maximum inundated area (hectare)
5	1310.52	88.1
10	1311.34	118.8
20	1311.97	142.8
50	1313.05	175.6

The relation between return period and inundated area is shown in Fig.G.2.11.

5. CONSIDERATION FOR THE INUNDATION PROBLEM

According to the result of inundation analysis mentioned previously, respectable inundation arose even on five year return period. Considering the result, a counter flow from the Balili river into the Bolo creek, might be happened owing to a higher water stage in the Balili river than the Bolo creek (that phenomenon was confirmed in interviewing survey around Zone I). Therefore, the lack of flowing capacity of the Balili river which caused rising of water stage, was concluded as a main cause of the inundation besides a poor flowing capacity of the Bolo creek.

By the way, a lack of flowing capacity of creeks cause partial inundation even in a higher portion of Zone I. Existing creeks should be apprised whether the creeks hold enough flowing capacity or not. Through the check, it made clear that the Bayabas creek at the crossing with the national road in Pico caused inundation in up-stream of the creek.

6. PROPOSED DRAINAGE WORKS AND PRELIMINARY DESIGN

As described in previous section, the flood inundation in Zone I is a result of flowing capacity deficiency of the Balili river. The Bolo creek also produce a heavy inundation because of its small flowing capacity.

To solve the drainage problems, the following improvement works and facilities are proposed, and preliminary design on the necessary for such facilities are carried out:

- Balili river improvement
- Bolo creek improvement
- Partly reform of cross section in the Bayabas creek
- Related drainage facilities

These river and creeks will be improved so as not to be inundated when flood of five year return period occurs.

The peak discharge at the design flood was estimated as follows :

River or Creek	Catchment Area (km^2)	Peak discharge of five return period (m^3/sec.)
Balili river	24.6	282.2
Bolo creek	6.8	85.8

Design discharge at every creeks would be estimated by following equation.

$Q = f \times r \times A / 3.6$

Q : Design discharge (m^3/s)

f : Runoff coefficient (= 0.8)

r : Rainfall intensity

(= $60.829/(T^{0.342} - 0.165)$, T : concentration time is regarded as one hour)

A : Catchment area (km^2)

The proposed works are shown as follows :

(1) Balili river improvement

The river improvement is 425 meter in length. Design river bed gradient is decided at 1/450 to flow smoothly and to prevent scouring.

Design cross section of the river is with 16 meter bed width, and with 1:2.0 side slope.

River bed has to be excavated more that 2 meter at crossing of national road, so as not to obstruct the inflow from the Bolo creek. Since the Balili river cross section becomes insufficient at the point, both river side slopes are required with retaining wall lining.

There is a location of the temporary weir to divert irrigation water to the Dinog cave in the right side of upstream of the confluence, so that the river bed shall be maintained as it is.

For the purpose, a river bed consolidation weir is proposed at beginning point of the river improvement.

(2) Bolo creek improvement

The river improvement is 1,400 meters in length and 10 meters in bed width, 1:1.0 side slope. Design river bed gradient is designed with 1/1,000.

River bed of the creek has to be excavated 2 meters on an average so that design water level of the Bolo creek will not exceed the lowest field elevation along the creek.

Present angulated alignment should be aligned, and strengthened with retaining wall at the downstream of the creek.

Installation of a regulating sluice gate is proposed on the middle stream of the Bolo creek to maintain water level to protect overdrainage in the dry season.

(3) Reform of cross section in the Bayabas creek

Some narrow width portions in the Bayabas creek, which have caused partial inundation holding bed width less than 5 meter are proposed to enlarge. About half of total length is necessary to improve.

(4) Others

In Barangay Pico, poor road crossing structures with the national road on the Bayabas creek and the Pico creek were founded, which have caused severe inundation in foot of the mountain in Pico. The crossing structures would be replaced by box culvert with a sufficient flowing capacity.

Besides above, a spot in the Puguis creek where has caused partial inundation is proposed to improve.

Proposed drainage works are summarized below :

Items	Quantity
Improvement of the Balili river	Total length : 425 meters (river bed width 16 meters, side slope 1 : 2.0) improved length with retaining wall : 250 meters river bed consolidation weir :1 no.
Improvement of the Bolo creek	Total length : 1,400 meters (river bed width 10 meters, slide slope 1 : 1.0)
Reform of cross section in the Bayabas creek	Total length : 500 meters (for the part of the creek for less than 5 meters river bed width)
New construction of the Bayabas creek	Total length : 500 meters
Others	Road crossing structure : 2 nos. (in the Bayabas creek and the Pico creek) Installation of sluice gate in the Bolo creek Improvement for edged bending : in the Puguis creek

Table G.2.1 Catchment Characteristic of Divided Blocks

Block	Right Side			Left Side			Stream			Stream name
	Slope length	k	p	Slope Length	k	p	Stream length	K	P	
1	2840	0.62	0.6	607	0.62	0.6	3800	1.010	0.63	Balili River
2	280	0.62	0.6	720	0.62	0.6	1800	1.010	0.63	Ambiong (s) Creek
3	273	0.62	0.6	818	0.62	0.6	1100	1.010	0.63	Balili River
4	560	0.58	0.6	680	0.58	0.6	2500	0.803	0.63	Ambiong (N) Creek
5	500	0.58	0.6	200	0.58	0.6	1000	2.704	0.61	Balili River
6	500	0.62	0.6	600	0.62	0.6	2000	0.803	0.63	Lubas Creek
7	625	0.58	0.6	250	1.62	0.6	800	2.704	0.61	Balili River
8	400	0.62	0.6	500	0.62	0.6	1000	0.803	0.63	Tawang Creek
9	625	0.58	0.6	125	1.62	0.6	800	2.704	0.61	Balili River
10	371	1.62	0.6	1571	0.76	0.6	3500	1.704	0.68	Bolo Creek
Ambiong Station	560	0.58	0.6	680	0.58	0.6	1000	0.803	0.63	Ambiong (N) Creek

Notes : k, p are parameters for run off characteristics of catchment slope ($h = kq^P$)
K, P are parameters for run off characteristics of stream ($w = KQ^P$)

Table G.2.2 Comparison between Observed and Caluculated Discharge at Ambiong Station (1)

Hour	Min.	Rainfall	Observed Dis.	Calculated Dis. (1)	Calculated Dis. (2) *
0	30			0.001	0.07
1	0	0.0		0.002	0.07
1	30			0.002	0.07
2	0	0.0		0.003	0.07
2	30			0.004	0.07
3	0	0.0		0.005	0.07
3	30			0.006	0.07
4	0	0.0		0.007	0.08
4	30			0.007	0.08
5	0	0.0		0.008	0.08
5	30			0.009	0.08
6	0	0.0		0.010	0.08
6	30			0.011	0.08
7	0	0.0		0.012	0.08
7	30			0.012	0.08
8	0	0.0	0.07	0.013	0.08
8	30			0.014	0.08
9	0	1.0	0.07	0.015	0.08
9	30			0.016	0.08
10	0	2.0	0.07	0.034	0.10
10	30			0.132	0.20
11	0	11.0	0.11	0.695	0.76
11	30			1.143	1.21
12	0	9.0	0.17	1.256	1.33
12	30			1.326	1.40
13	0	12.5	0.46	1.412	1.48
13	30			1.154	1.22
14	0	0.5	0.48	0.786	0.85
14	30			0.564	0.63
15	0	3.0	0.72	0.594	0.66
15	30			0.903	0.97
16	0	13.5	2.10	1.279	1.35
16	30			2.390	2.46
17	0	29.0	7.00	3.307	3.38
17	30			2.497	2.57
18	0	3.0	4.21	1.548	1.62
18	30			1.158	1.23
19	0	8.5	0.61	0.999	1.07
19	30			0.874	0.94
20	0	4.5	1.45	0.768	0.84
20	30			0.625	0.69
21	0	1.5	0.59	0.490	0.56
21	30			0.419	0.49
22	0	4.0	0.60	0.392	0.46
22	30			0.394	0.46
23	0	2.5	0.57	0.386	0.45
23	30			0.382	0.45
24	0	3.0	0.58	0.384	0.45
24	30			0.386	0.46
25	0	3.5	0.59	0.400	0.47
25	30			0.398	0.47
26	0	2.0	0.56	0.375	0.44
26	30			0.403	0.47
27	0	6.0	0.56	0.511	0.58
27	30			0.642	0.71
28	0	6.5	0.56	0.741	0.81
28	30			0.670	0.74
29	0	0.5	0.56	0.495	0.56
29	30			0.389	0.46
30	0	4.0	0.56	0.370	0.44
30	30			0.363	0.43

* : Considering base flow

Table G.2.2 Comparison between Observed and Caluculated Discharge at Ambiong Station (2)

Hour	Min.	Rainfall	Observed Dis.	Calculated Dis. (1)	Calculated Dis. (2) *
31	0	2.0	0.56	0.345	0.41
31	30			0.327	0.40
32	0	2.0		0.309	0.38
32	30			0.286	0.35
33	0	2.0		0.264	0.33
33	30			0.240	0.31
34	0	0.5		0.207	0.28
34	30			0.192	0.26
35	0	3.5		0.243	0.31
35	30			0.310	0.38
36	0	4.0	0.56	0.386	0.45
36	30			0.442	0.51
37	0	3.0	0.59	0.477	0.55
37	30			0.641	0.71
38	0	11.5	1.01	0.979	1.05
38	30			1.132	1.20
39	0	6.0	2.14	1.003	1.07
39	30			0.800	0.87
40	0	1.0	0.81	0.681	0.75
40	30			0.964	1.03
41	0	21.0	9.19	1.937	2.01
41	30			2.943	3.01
42	0	27.5	7.51	3.267	3.34
42	30			2.536	2.60
43	0	7.5	5.24	1.836	1.90
43	30			1.613	1.68
44	0	15.0	2.60	1.748	1.82
44	30			2.358	2.43
45	0	24.5	4.54	2.930	3.00
45	30			3.082	3.15
46	0	23.5	3.58	3.140	3.21
46	30			3.440	3.51
47	0	30.0	3.63	3.679	3.75
47	30			3.125	3.19
48	0	17.0	4.16	2.986	3.06
48	30			3.825	3.89
49	0	41.0	3.79	5.327	5.40
49	30			8.020	8.09
50	0	28.0	8.40	9.242	9.31
50	30			8.983	9.05
51	0	25.0	16.27	8.048	8.12
51	30			6.632	6.70
52	0	15.0	3.21	5.485	5.55
52	30			5.649	5.72
53	0	17.5	2.64	5.580	5.65
53	30			4.014	4.08
54	0	6.0	2.96	2.697	2.77
54	30			1.758	1.83
55	0	2.0	0.46	1.165	1.23
55	30			0.855	0.92
56	0	1.0	0.38	0.642	0.71
56	30			0.484	0.55
57	0	1.0	0.32	0.392	0.46
57	30			0.326	0.39
58	0		0.00	0.248	0.32
58	30			0.179	0.25
59	0			0.134	0.20
59	30			0.100	0.17
60	0			0.075	0.14
60	30			0.057	0.13

* : Considering base flow

Table G.2.2 Comparison between Observed and Caluculated Discharge at Ambiong Station (3)

Hour	Min.	Rainfall	Observed Dis.	Calculated Dis. (1)	Calculated Dis. (2) *
61	0			0.046	0.12
61	30			0.036	0.11
62	0			0.026	0.10
62	30			0.017	0.09
63	0			0.010	0.08
63	30			0.006	0.07
64	0			0.003	0.07
64	30			0.001	0.07
65	0			0.000	0.07
65	30			0.000	0.07
66	0			0.000	0.07
66	30			0.000	0.07
67	0			0.000	0.07
67	30			0.000	0.07
68	0			0.000	0.07
68	30			0.000	0.07
69	0			0.000	0.07
69	30			0.000	0.07
70	0			0.000	0.07
70	30			0.000	0.07
71	0			0.000	0.07
71	30			0.000	0.07

* : Considering base flow

Table G.2.3 Result of Inundation Analysis in Zone I
for 1986 Typhoon GADING (1)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
1	0.19	1306.05	0.34	1306.29
2	0.52	1306.09	0.47	1306.29
3	1.75	1306.19	0.72	1306.29
4	3.58	1306.30	1.36	1306.32
5	4.86	1306.37	2.24	1306.40
6	5.57	1306.41	3.08	1306.51
7	5.81	1306.42	3.52	1306.63
8	5.67	1306.41	3.22	1306.72
9	5.39	1306.40	2.84	1306.76
10	5.05	1306.38	2.53	1306.78
11	4.72	1306.36	2.30	1306.77
12	5.28	1306.39	2.56	1306.77
13	20.03	1306.97	4.56	1306.91
14	42.13	1307.63	15.67	1307.55
15	56.76	1307.98	27.46	1308.38
16	64.17	1308.15	30.14	1308.88
17	66.49	1308.20	30.14	1309.01
18	69.03	1308.25	30.74	1309.03
19	76.60	1308.40	33.32	1309.06
20	82.56	1308.52	37.02	1309.13
21	85.61	1308.57	38.87	1309.20
22	86.61	1308.59	39.06	1309.27
23	86.80	1308.60	39.06	1309.33
24	99.58	1308.80	40.37	1309.39
25	177.83	1309.89	50.44	1309.65
26	224.14	1310.47	63.01	1310.14
27	235.99	1310.62	66.67	1310.53
28	237.51	1310.63	66.67	1310.76
29	237.62	1310.64	66.67	1310.89
30	239.79	1310.66	67.17	1310.98
31	250.56	1310.79	69.28	1311.05
32	255.81	1310.86	71.46	1311.12
33	256.94	1310.87	72.11	1311.19
34	257.05	1310.87	72.11	1311.24
35	257.06	1310.87	72.11	1311.28
36	247.13	1310.75	69.15	1311.29
37	192.23	1310.07	59.12	1311.22
38	164.81	1309.71	48.03	1311.08
39	155.41	1309.59	43.33	1310.90
40	153.18	1309.56	42.96	1310.71
41	152.90	1309.56	42.96	1310.57
42	145.93	1309.46	42.15	1310.45
43	113.13	1309.00	35.75	1310.32
44	87.72	1308.61	26.90	1310.14
45	76.30	1308.40	22.13	1309.93
46	72.18	1308.31	20.02	1309.66
47	71.06	1308.29	20.02	1309.46
48	69.00	1308.25	19.88	1309.31

Table G.2.3 Result of Inundation Analysis in Zone I
for 1986 Typhoon GADING (2)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
49	63.02	1308.12	18.87	1309.18
50	57.40	1308.00	16.91	1309.06
51	54.35	1307.93	15.51	1308.75
52	52.99	1307.90	14.96	1308.51
53	52.54	1307.88	14.87	1308.43
54	52.57	1307.89	14.88	1308.41
55	52.94	1307.89	14.94	1308.41
56	53.32	1307.90	15.06	1308.42
57	53.53	1307.91	15.16	1308.43
58	53.62	1307.91	15.20	1308.43
59	53.65	1307.91	15.21	1308.43
60	50.09	1307.83	14.96	1308.41
61	40.73	1307.59	13.33	1308.30
62	30.08	1307.29	9.96	1308.10
63	22.37	1307.05	7.36	1307.87
64	18.09	1306.90	5.58	1307.66
65	15.93	1306.82	4.96	1307.50
66	14.42	1306.77	4.33	1307.38
67	12.34	1306.69	3.87	1307.28
68	9.92	1306.60	3.27	1307.18
69	7.88	1306.51	2.67	1307.08
70	6.41	1306.45	2.20	1306.99
71	5.40	1306.40	1.86	1306.91
72	4.71	1306.36	1.59	1306.83
73	4.09	1306.33	1.37	1306.77
74	3.42	1306.29	1.18	1306.71
75	2.73	1306.25	1.02	1306.65
76	2.16	1306.21	0.86	1306.60
77	1.73	1306.18	0.73	1306.55
78	1.39	1306.16	0.62	1306.50
79	1.12	1306.14	0.54	1306.46
80	0.90	1306.12	0.49	1306.42
81	0.72	1306.11	0.44	1306.38
82	0.58	1306.09	0.41	1306.35
83	0.48	1306.08	0.37	1306.32
84	0.40	1306.07	0.35	1306.29
85	0.34	1306.07	0.33	1306.29
86	0.30	1306.06	0.31	1306.29
87	0.26	1306.06	0.30	1306.29
88	0.23	1306.05	0.29	1306.29
89	0.21	1306.05	0.28	1306.29
90	0.18	1306.05	0.27	1306.29
91	0.16	1306.04	0.26	1306.29
92	0.15	1306.04	0.26	1306.29
93	0.14	1306.04	0.25	1306.29
94	0.12	1306.04	0.25	1306.29
95	0.11	1306.04	0.24	1306.29
96	0.10	1306.03	0.24	1306.29

Table G.2.4 Design Rainfall Pattern

(Unit : mm/hr)

Hour	Return Period (Year)			Hour	Return Period (Year)		
	5	10	20		5	10	20
1	3.6	3.0	3.4	37	72.8	85.3	97.5
2	3.6	3.2	3.6	38	31.0	38.8	46.5
3	3.7	3.3	3.9	39	25.1	32.1	39.0
4	3.7	3.5	4.0	40	22.0	28.5	35.0
5	3.8	3.6	4.2	41	20.0	26.2	32.4
6	3.8	3.7	4.3	42	18.5	24.5	30.5
7	3.8	3.8	4.4	43	17.4	23.2	29.0
8	3.8	3.8	4.5	44	16.5	22.1	27.8
9	3.8	3.9	4.6	45	15.8	21.2	26.8
10	3.8	3.9	4.7	46	15.2	20.5	25.9
11	3.8	4.0	4.7	47	14.6	19.9	25.2
12	3.8	4.0	4.7	48	14.2	19.3	24.6
13	7.2	8.1	6.5	49	8.6	8.6	8.3
14	7.3	8.2	7.1	50	8.6	8.6	8.3
15	7.4	8.2	7.5	51	8.4	8.6	8.3
16	7.5	8.3	7.8	52	8.3	8.6	8.3
17	7.6	8.4	8.0	53	8.1	8.5	8.2
18	7.8	8.5	8.1	54	8.0	8.5	8.2
19	7.9	8.5	8.2	55	7.8	8.5	8.1
20	8.0	8.5	8.3	56	7.7	8.4	7.9
21	8.2	8.6	8.3	57	7.6	8.3	7.7
22	8.3	8.6	8.3	58	7.5	8.3	7.3
23	8.5	8.6	8.3	59	7.4	8.2	6.9
24	8.6	8.6	8.3	60	7.3	8.1	6.1
25	14.0	19.0	24.3	61	3.8	4.0	4.7
26	14.4	19.6	24.9	62	3.8	4.0	4.7
27	14.9	20.2	25.6	63	3.8	3.9	4.6
28	15.5	20.9	26.4	64	3.8	3.9	4.6
29	16.2	21.7	27.3	65	3.8	3.8	4.5
30	17.0	22.6	28.4	66	3.8	3.7	4.4
31	18.0	23.8	29.7	67	3.8	3.6	4.3
32	19.2	25.3	31.4	68	3.7	3.5	4.1
33	20.9	27.2	33.6	69	3.7	3.4	4.0
34	23.3	30.1	36.8	70	3.7	3.3	3.8
35	27.4	34.8	42.0	71	3.6	3.1	3.5
36	37.5	46.1	54.5	72	3.5	2.9	3.2

Table G.2.5 Result of Inundation Analysis in Zone I
for 5 Year Return Period (1)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
1	0.33	1306.07	0.29	1306.29
2	0.96	1306.13	0.38	1306.29
3	2.75	1306.25	0.47	1306.29
4	4.96	1306.38	0.87	1306.33
5	6.38	1306.45	1.45	1306.41
6	7.28	1306.49	2.08	1306.51
7	8.12	1306.52	2.63	1306.60
8	8.89	1306.56	2.85	1306.69
9	9.34	1306.58	2.88	1306.77
10	9.45	1306.58	2.86	1306.82
11	9.41	1306.58	2.84	1306.86
12	9.54	1306.58	2.85	1306.88
13	10.86	1306.64	3.02	1306.91
14	13.40	1306.73	3.48	1306.95
15	15.62	1306.81	4.10	1307.03
16	17.05	1306.86	4.70	1307.11
17	18.08	1306.90	5.22	1307.19
18	18.87	1306.92	5.51	1307.27
19	19.40	1306.94	5.59	1307.32
20	19.78	1306.96	5.68	1307.36
21	20.13	1306.97	5.77	1307.39
22	20.49	1306.98	5.87	1307.41
23	20.87	1307.00	5.98	1307.43
24	21.78	1307.03	6.10	1307.45
25	25.60	1307.15	6.54	1307.49
26	30.44	1307.30	7.79	1307.59
27	34.05	1307.41	9.18	1307.73
28	36.74	1307.48	10.29	1307.87
29	38.93	1307.54	10.94	1307.97
30	40.93	1307.60	11.40	1308.04
31	43.13	1307.65	11.96	1308.11
32	45.84	1307.72	12.64	1308.17
33	49.39	1307.81	13.51	1308.25
34	54.59	1307.93	14.71	1308.35
35	63.81	1308.14	16.58	1308.50
36	113.85	1309.01	22.05	1309.01
37	282.21	1311.17	66.73	1309.55
38	245.40	1310.73	85.77	1310.26
39	186.63	1310.00	59.47	1310.52
40	149.80	1309.51	42.64	1310.48
41	130.24	1309.24	37.55	1310.36
42	118.68	1309.08	34.18	1310.23
43	110.57	1308.96	31.74	1310.10
44	104.29	1308.87	29.87	1309.97
45	99.22	1308.79	28.37	1309.80
46	94.99	1308.73	27.13	1309.67
47	91.39	1308.67	26.07	1309.55
48	86.06	1308.58	24.66	1309.45

Table G.2.5 Result of Inundation Analysis in Zone I
for 5 Year Return Period (2)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
49	72.81	1308.33	21.98	1309.34
50	61.17	1308.08	18.52	1309.22
51	55.00	1307.94	15.90	1309.08
52	51.88	1307.87	14.73	1308.76
53	50.25	1307.83	14.33	1308.47
54	49.24	1307.81	14.08	1308.37
55	48.39	1307.79	13.84	1308.33
56	47.59	1307.77	13.61	1308.30
57	47.22	1307.76	13.43	1308.29
58	48.03	1307.78	13.45	1308.28
59	48.88	1307.80	13.73	1308.30
60	47.14	1307.75	13.79	1308.30
61	40.64	1307.59	12.78	1308.24
62	33.14	1307.38	10.57	1308.10
63	28.60	1307.25	8.79	1307.94
64	26.55	1307.18	7.71	1307.82
65	25.61	1307.15	7.26	1307.73
66	25.28	1307.14	7.18	1307.68
67	25.31	1307.14	7.25	1307.65
68	25.44	1307.15	7.30	1307.64
69	25.55	1307.15	7.34	1307.64
70	25.62	1307.15	7.36	1307.64
71	25.66	1307.15	7.38	1307.65
72	25.02	1307.13	7.32	1307.64
73	20.14	1306.97	6.71	1307.60
74	13.62	1306.74	5.07	1307.49
75	8.55	1306.54	3.48	1307.32
76	5.49	1306.40	2.43	1307.15
77	3.78	1306.31	1.79	1307.00
78	2.80	1306.25	1.33	1306.87
79	2.19	1306.22	0.90	1306.76
80	1.75	1306.19	0.52	1306.67
81	1.36	1306.16	0.41	1306.59
82	1.01	1306.13	0.33	1306.51
83	0.71	1306.11	0.26	1306.45
84	0.49	1306.08	0.21	1306.40
85	0.32	1306.06	0.20	1306.35
86	0.20	1306.05	0.20	1306.30
87	0.12	1306.04	0.20	1306.29
88	0.08	1306.03	0.20	1306.29
89	0.05	1306.03	0.20	1306.29
90	0.03	1306.02	0.20	1306.29
91	0.02	1306.02	0.20	1306.29
92	0.01	1306.02	0.20	1306.29
93	0.01	1306.02	0.20	1306.29
94	0.01	1306.02	0.20	1306.29
95	0.00	1306.02	0.20	1306.29
96	0.00	1306.02	0.20	1306.29

Table G.2.6 Result of Inundation Analysis in Zone I for 10 Year Return Period (1)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
1	0.38	1306.07	0.30	1306.29
2	1.11	1306.14	0.39	1306.29
3	3.03	1306.27	0.50	1306.29
4	5.27	1306.39	0.93	1306.34
5	6.65	1306.46	1.55	1306.43
6	7.51	1306.50	2.19	1306.53
7	8.28	1306.53	2.72	1306.62
8	8.93	1306.56	2.88	1306.71
9	9.19	1306.57	2.85	1306.78
10	9.10	1306.57	2.79	1306.82
11	8.84	1306.55	2.71	1306.85
12	8.79	1306.55	2.67	1306.86
13	10.45	1306.62	2.86	1306.88
14	13.92	1306.75	3.44	1306.94
15	16.86	1306.85	4.25	1307.02
16	18.67	1306.92	5.07	1307.13
17	19.92	1306.96	5.79	1307.24
18	20.77	1306.99	6.07	1307.34
19	21.21	1307.01	6.13	1307.40
20	21.44	1307.02	6.17	1307.44
21	21.58	1307.02	6.22	1307.46
22	21.69	1307.02	6.25	1307.48
23	21.74	1307.03	6.28	1307.49
24	22.79	1307.06	6.33	1307.50
25	30.36	1307.30	7.08	1307.56
26	39.51	1307.56	9.54	1307.75
27	45.83	1307.72	12.28	1307.99
28	50.07	1307.83	14.12	1308.20
29	52.91	1307.89	14.81	1308.34
30	55.29	1307.95	15.37	1308.42
31	57.96	1308.01	16.04	1308.48
32	61.27	1308.08	16.85	1308.55
33	65.64	1308.18	17.89	1308.63
34	85.52	1308.57	20.08	1308.85
35	162.60	1309.69	33.52	1309.20
36	282.56	1311.17	67.79	1309.84
37	392.07	1312.42	105.48	1310.58
38	304.63	1311.43	100.82	1311.23
39	226.64	1310.50	71.34	1311.34
40	187.12	1310.01	53.59	1311.24
41	167.09	1309.74	47.99	1311.09
42	154.50	1309.58	44.28	1310.90
43	145.31	1309.45	41.53	1310.71
44	138.08	1309.35	39.39	1310.54
45	132.17	1309.27	37.64	1310.39
46	127.21	1309.20	36.19	1310.27
47	122.96	1309.14	34.95	1310.16
48	114.43	1309.02	32.82	1310.05

Table G.2.6 Result of Inundation Analysis in Zone I
for 10 Year Return Period (2)

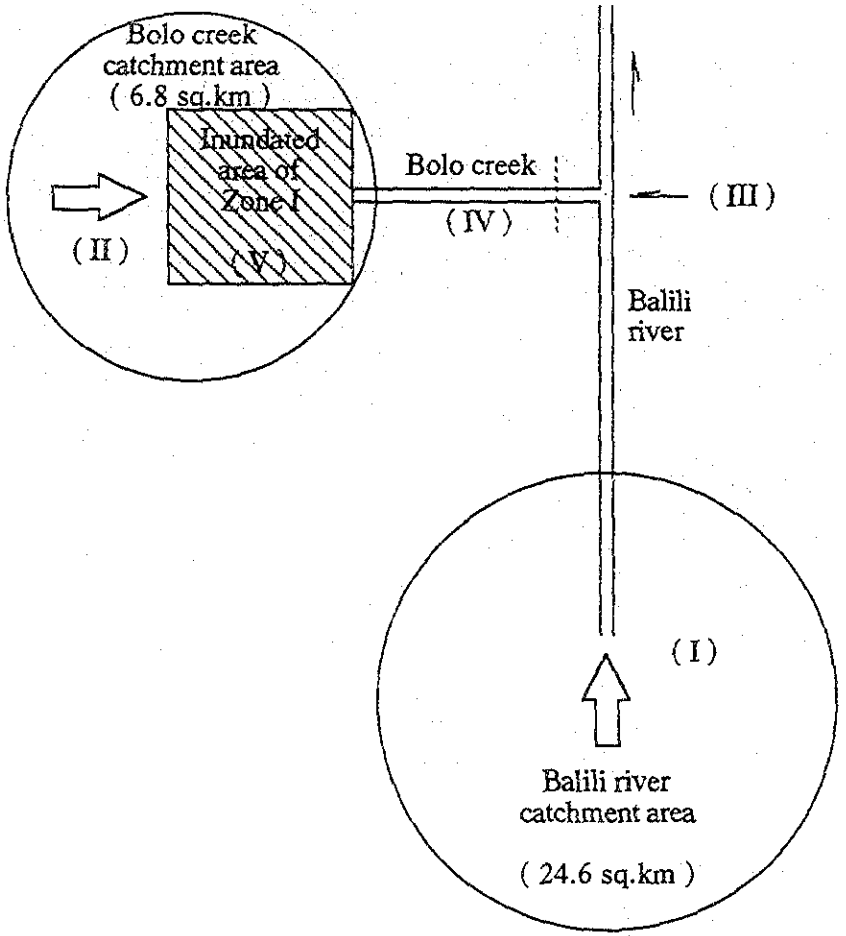
Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
49	89.53	1308.64	27.80	1309.89
50	67.83	1308.22	21.36	1309.66
51	57.86	1308.01	17.04	1309.43
52	53.93	1307.92	15.15	1309.23
53	52.52	1307.88	14.82	1309.07
54	52.10	1307.87	14.80	1308.70
55	51.82	1307.87	14.74	1308.47
56	51.48	1307.86	14.65	1308.41
57	51.60	1307.86	14.58	1308.39
58	52.95	1307.89	14.73	1308.40
59	54.20	1307.92	15.18	1308.42
60	51.49	1307.86	15.31	1308.42
61	42.92	1307.65	13.93	1308.34
62	33.11	1307.38	10.76	1308.16
63	27.07	1307.20	8.48	1307.95
64	24.57	1307.12	7.17	1307.79
65	23.80	1307.09	6.72	1307.68
66	23.81	1307.09	6.59	1307.62
67	24.24	1307.11	6.85	1307.59
68	24.84	1307.13	7.06	1307.60
69	25.40	1307.15	7.24	1307.61
70	25.88	1307.16	7.38	1307.63
71	26.27	1307.17	7.50	1307.65
72	25.76	1307.16	7.53	1307.66
73	20.66	1306.99	6.96	1307.62
74	13.91	1306.75	5.22	1307.51
75	8.73	1306.55	3.57	1307.34
76	5.61	1306.41	2.48	1307.17
77	3.85	1306.32	1.82	1307.01
78	2.85	1306.26	1.33	1306.88
79	2.23	1306.22	0.87	1306.77
80	1.77	1306.19	0.48	1306.67
81	1.35	1306.16	0.24	1306.58
82	0.95	1306.12	0.20	1306.50
83	0.60	1306.10	0.20	1306.44
84	0.35	1306.07	0.20	1306.38
85	0.19	1306.05	0.20	1306.33
86	0.11	1306.04	0.20	1306.29
87	0.06	1306.03	0.20	1306.29
88	0.04	1306.02	0.20	1306.29
89	0.01	1306.02	0.20	1306.29
90	0.00	1306.02	0.20	1306.29
91	0.00	1306.02	0.20	1306.29
92	0.00	1306.02	0.20	1306.29
93	0.00	1306.02	0.20	1306.29
94	0.00	1306.02	0.20	1306.29
95	0.00	1306.02	0.20	1306.29
96	0.00	1306.02	0.20	1306.29

Table G.2.7 Result of Inundation Analysis in Zone I
for 20 Year Return Period (1)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
1	0.58	1306.09	0.33	1306.29
2	1.74	1306.18	0.45	1306.29
3	4.23	1306.34	0.67	1306.31
4	6.70	1306.46	1.23	1306.38
5	8.20	1306.53	2.03	1306.50
6	9.23	1306.57	2.80	1306.62
7	10.17	1306.61	3.34	1306.73
8	10.77	1306.63	3.36	1306.82
9	10.82	1306.64	3.29	1306.89
10	10.57	1306.63	3.21	1306.93
11	10.20	1306.61	3.11	1306.95
12	10.06	1306.60	3.03	1306.96
13	11.57	1306.66	3.15	1306.97
14	14.87	1306.79	3.73	1307.01
15	17.56	1306.88	4.51	1307.09
16	19.11	1306.93	5.26	1307.19
17	20.09	1306.97	5.88	1307.28
18	20.63	1306.99	6.06	1307.36
19	20.75	1306.99	6.04	1307.41
20	20.61	1306.99	6.01	1307.43
21	20.32	1306.98	5.94	1307.44
22	19.88	1306.96	5.85	1307.44
23	19.24	1306.94	5.71	1307.42
24	20.47	1306.98	5.54	1307.41
25	33.08	1307.38	6.34	1307.50
26	47.81	1307.77	10.68	1307.82
27	57.76	1308.00	15.46	1308.22
28	63.72	1308.14	18.17	1308.52
29	67.15	1308.21	18.74	1308.67
30	69.89	1308.27	19.41	1308.75
31	72.95	1308.33	20.20	1308.82
32	76.74	1308.40	21.18	1308.89
33	94.52	1308.72	24.21	1309.01
34	170.59	1309.79	38.18	1309.29
35	241.45	1310.68	62.35	1309.90
36	351.52	1311.97	90.80	1310.52
37	450.09	1313.05	126.82	1311.28
38	352.03	1311.97	116.68	1311.89
39	265.88	1310.98	82.96	1311.97
40	224.84	1310.48	64.54	1311.82
41	204.17	1310.22	58.46	1311.63
42	190.60	1310.05	54.42	1311.44
43	180.44	1309.92	51.42	1311.26
44	172.39	1309.81	49.06	1311.10
45	165.78	1309.73	47.12	1310.94
46	160.19	1309.65	45.48	1310.77
47	155.39	1309.59	44.07	1310.63
48	142.84	1309.42	41.77	1310.50

Table G.2.7 Result of Inundation Analysis in Zone I
for 20 Year Return Period (2)

Hour (hr)	Balili R. Discharge (m^3/s)	Balili R. Water Stg. (m)	Bolo C. Discharge (m^3/s)	Water Stage (m)
49	104.60	1308.87	33.21	1310.34
50	68.53	1308.24	22.12	1310.12
51	52.96	1307.89	16.50	1309.82
52	48.15	1307.78	13.74	1309.49
53	47.14	1307.75	12.85	1309.24
54	47.82	1307.77	13.39	1309.05
55	48.77	1307.79	13.74	1308.58
56	49.49	1307.81	13.98	1308.39
57	50.44	1307.83	14.18	1308.35
58	52.51	1307.88	14.54	1308.37
59	54.39	1307.93	15.17	1308.41
60	52.25	1307.88	15.46	1308.43
61	44.13	1307.68	14.22	1308.36
62	34.74	1307.43	11.17	1308.19
63	29.31	1307.27	9.02	1307.99
64	27.39	1307.21	7.88	1307.85
65	27.05	1307.20	7.51	1307.76
66	27.46	1307.21	7.63	1307.72
67	28.26	1307.24	7.96	1307.72
68	29.11	1307.26	8.23	1307.74
69	29.84	1307.28	8.46	1307.76
70	30.46	1307.30	8.65	1307.79
71	30.97	1307.32	8.80	1307.81
72	29.69	1307.28	8.89	1307.81
73	23.18	1307.07	8.36	1307.77
74	15.58	1306.81	5.83	1307.63
75	10.37	1306.62	3.96	1307.43
76	7.18	1306.48	2.76	1307.24
77	5.14	1306.38	1.93	1307.08
78	3.88	1306.32	1.25	1306.93
79	3.06	1306.27	0.71	1306.81
80	2.40	1306.23	0.51	1306.70
81	1.78	1306.19	0.31	1306.61
82	1.25	1306.15	0.21	1306.53
83	0.88	1306.12	0.20	1306.46
84	0.61	1306.10	0.20	1306.40
85	0.42	1306.08	0.20	1306.35
86	0.30	1306.06	0.20	1306.31
87	0.23	1306.05	0.20	1306.29
88	0.18	1306.05	0.20	1306.29
89	0.13	1306.04	0.20	1306.29
90	0.08	1306.03	0.20	1306.29
91	0.05	1306.03	0.20	1306.29
92	0.03	1306.02	0.20	1306.29
93	0.02	1306.02	0.20	1306.29
94	0.02	1306.02	0.20	1306.29
95	0.02	1306.02	0.20	1306.29
96	0.02	1306.02	0.20	1306.29



Required functions for simulation :

(I) Runoff from the Balili river catchment

(II) Runoff from the Bolo creek catchment

(III) Water stage of the Balili river at junction with the Bolo creek

(IV) Hydrolic condition of the Bolo creek

(V) Relation between inundated water volume and water stage at Zone I

Fig. G.2.1 Schematic Diagram of Drainage Condition for Simulation

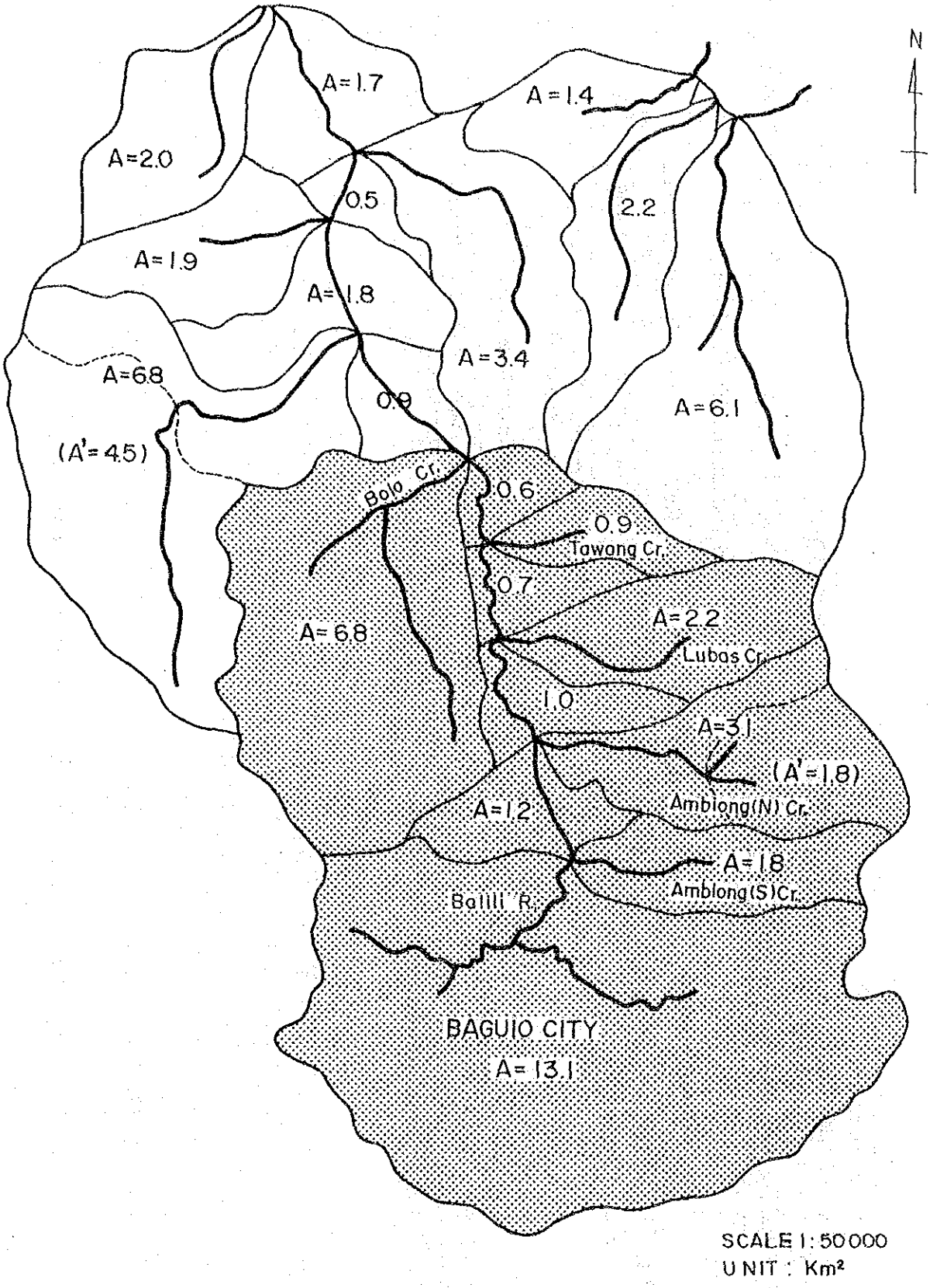


Fig. G.2.2 Catchment for Flood Simulation

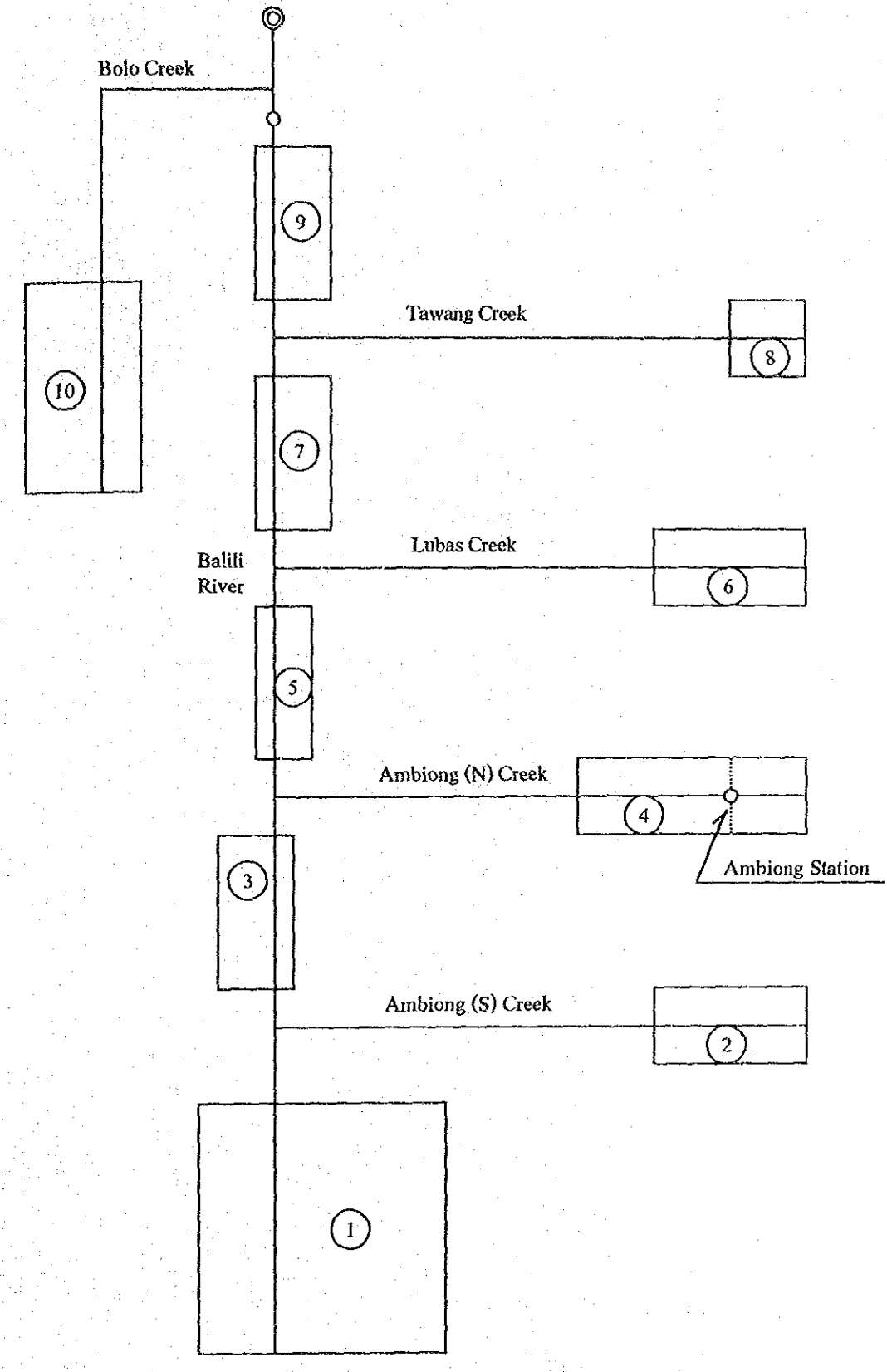


Fig. G.2.3 Schematic Diagram of Catchment Block

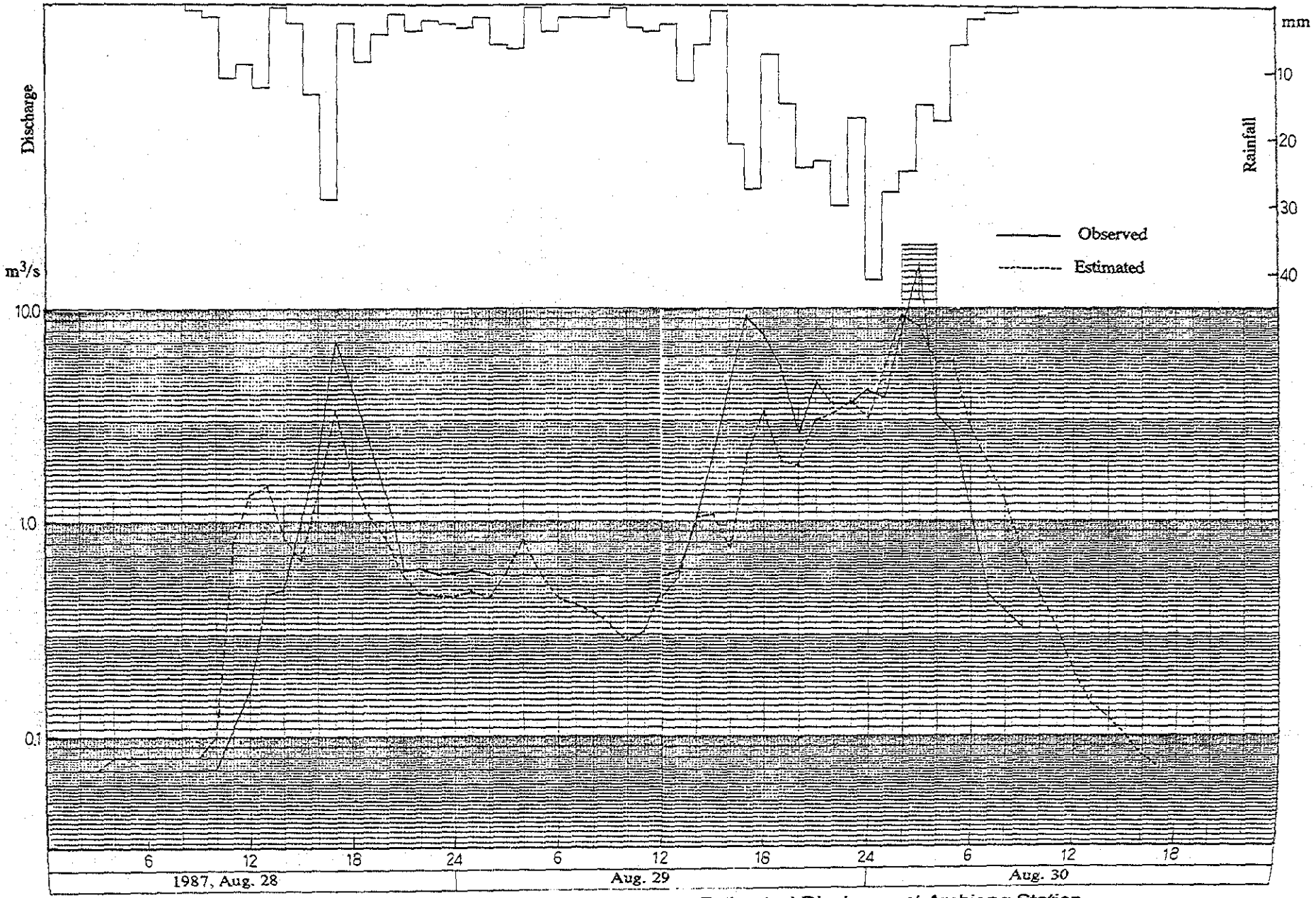


Fig. G.2.4 Comparison between Observed and Estimated Discharge at Ambiong Station

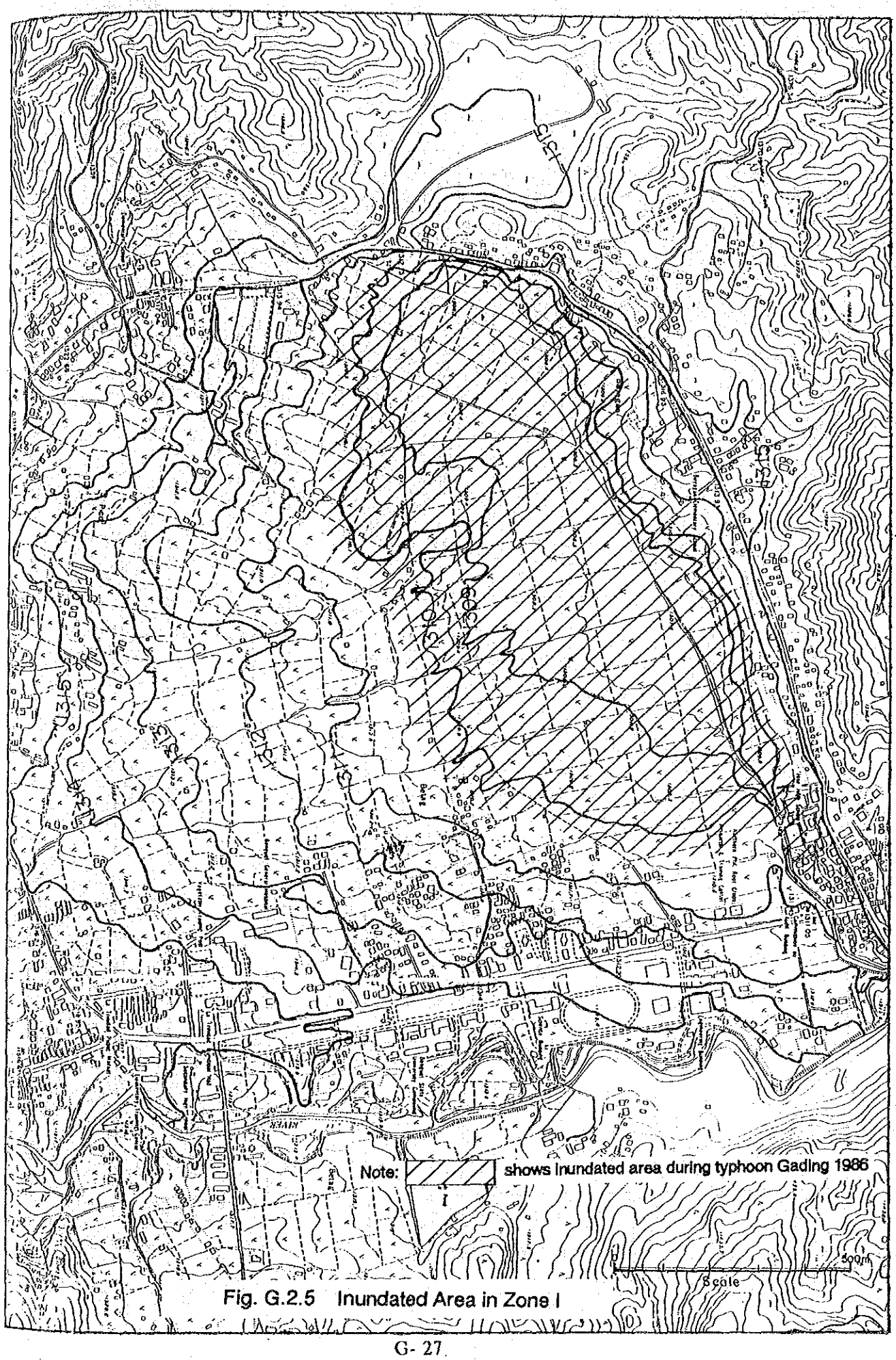
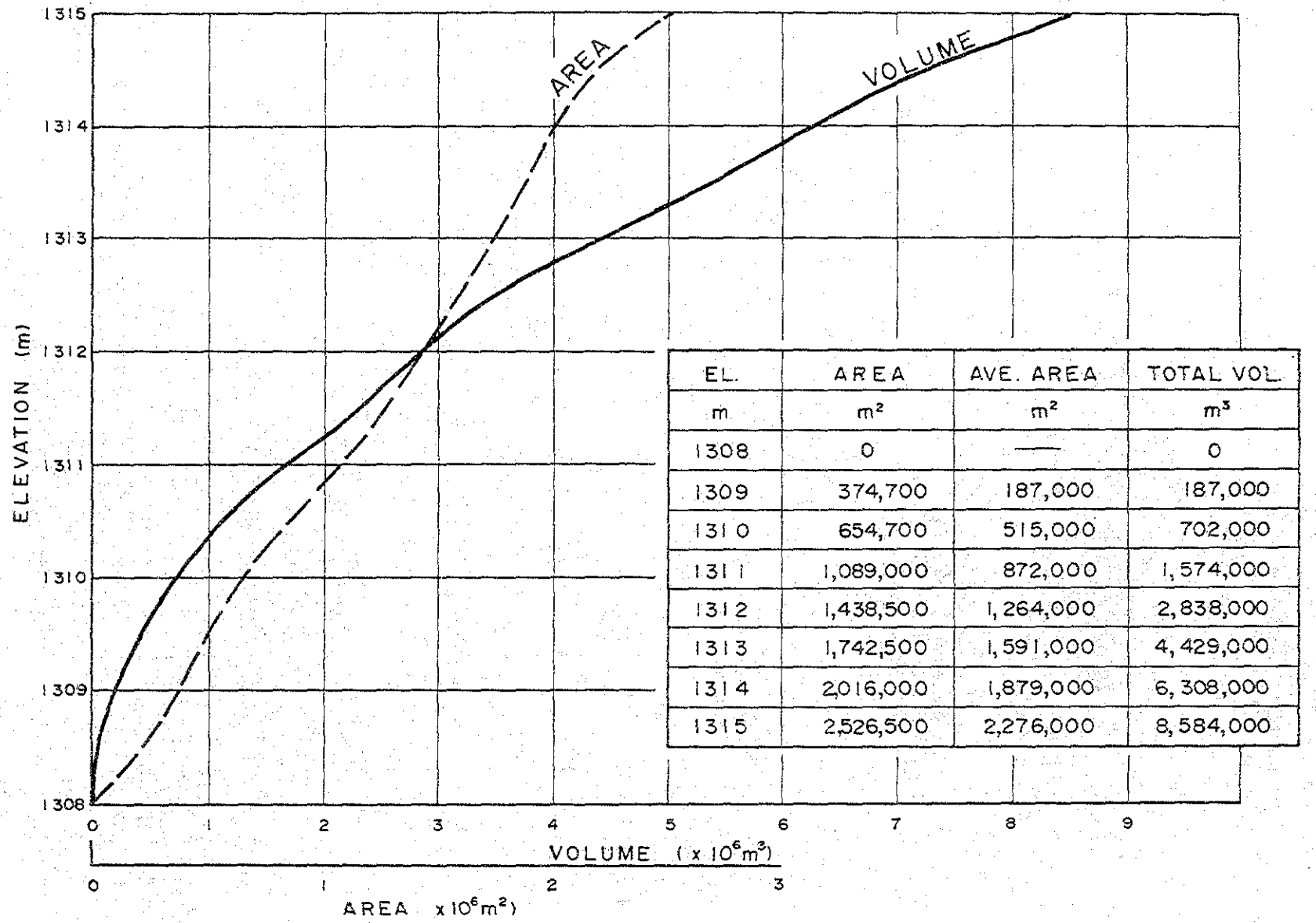


Fig. G.2.5 Inundated Area in Zone I



EL.	AREA	AVE. AREA	TOTAL VOL.
m	m^2	m^2	m^3
1308	0	—	0
1309	374,700	187,000	187,000
1310	654,700	515,000	702,000
1311	1,089,000	872,000	1,574,000
1312	1,438,500	1,264,000	2,838,000
1313	1,742,500	1,591,000	4,429,000
1314	2,016,000	1,879,000	6,308,000
1315	2,526,500	2,276,000	8,584,000

Fig. G.2.6 Relation Curve of Water Stage and Inundation Water Volume

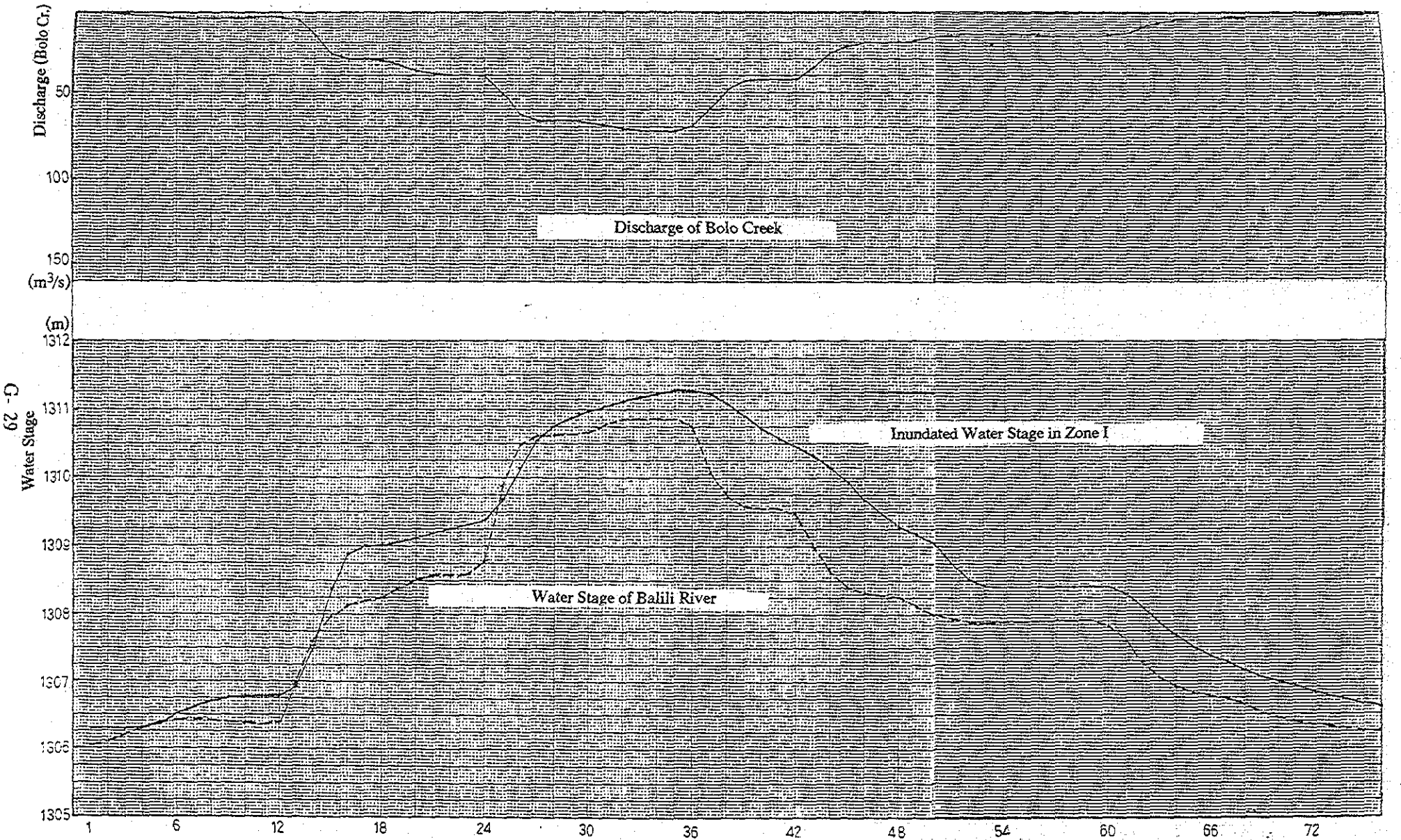


Fig. G.2.7 Result of the Simulation of Typhoon GADING, 1986

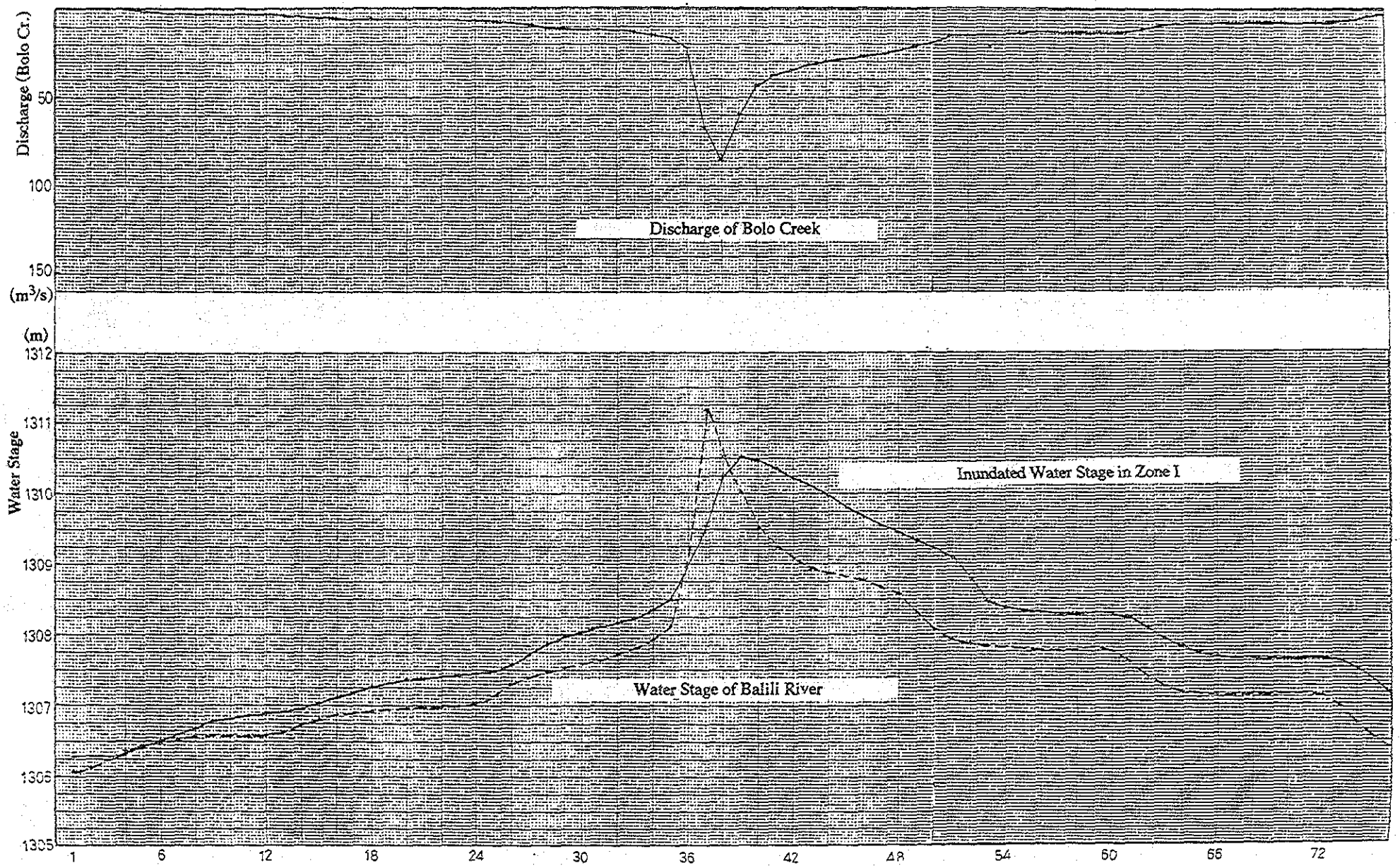


Fig. G.2.8 Result of the Simulation in Five Year Return Period

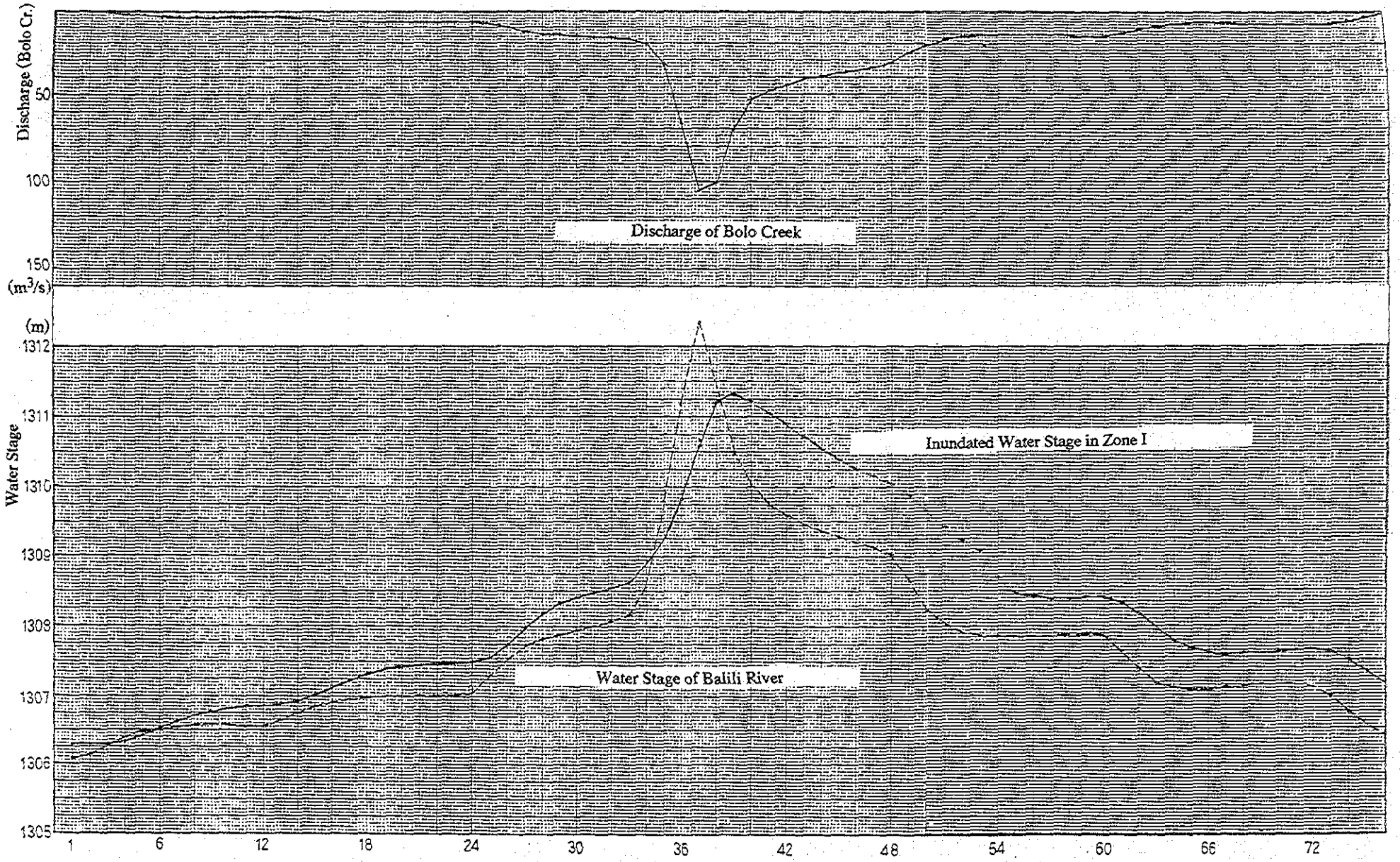


Fig. G.2.9 Result of the Simulation in Ten Year Return Period

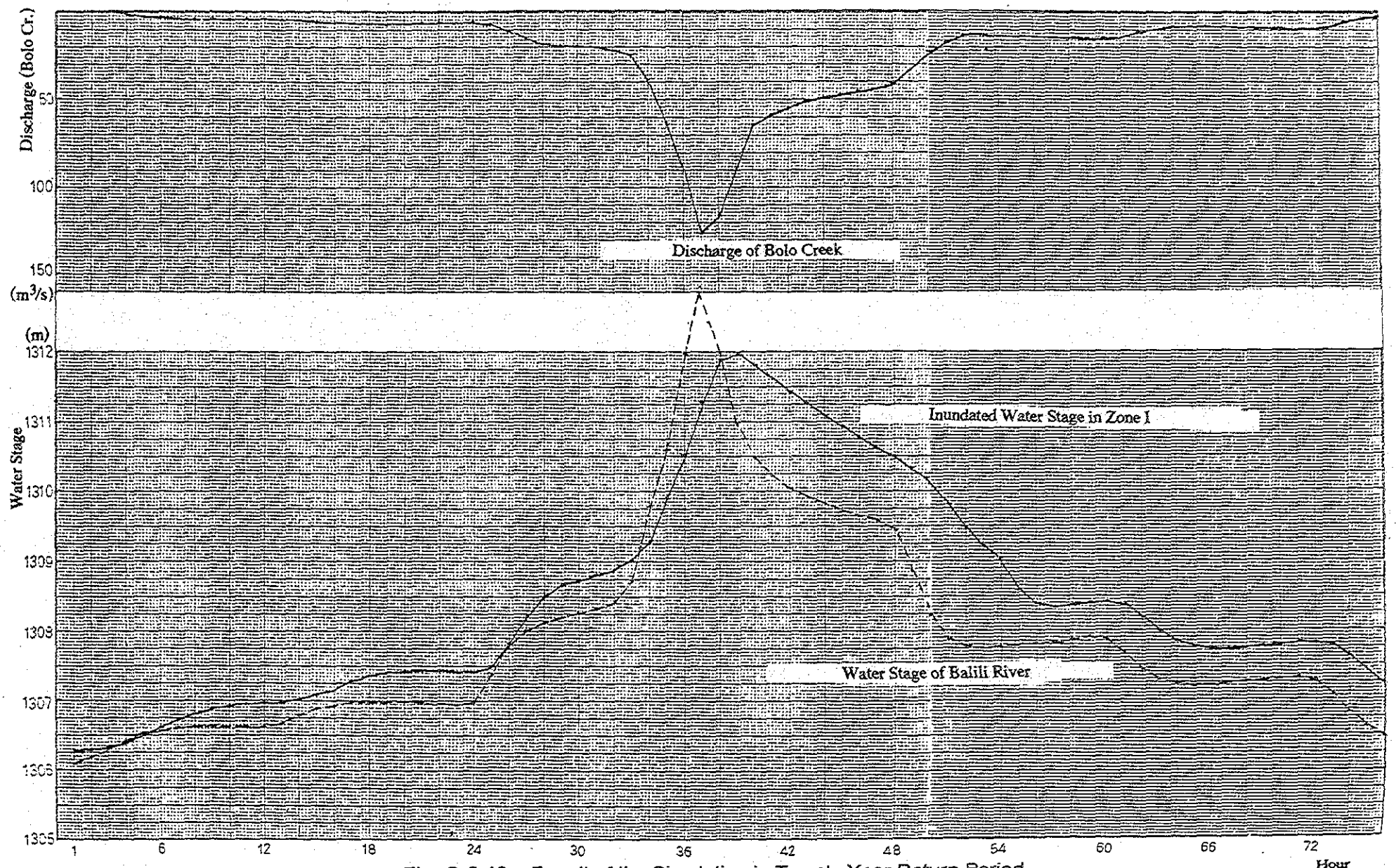


Fig. G.2.10 Result of the Simulation in Twenty Year Return Period

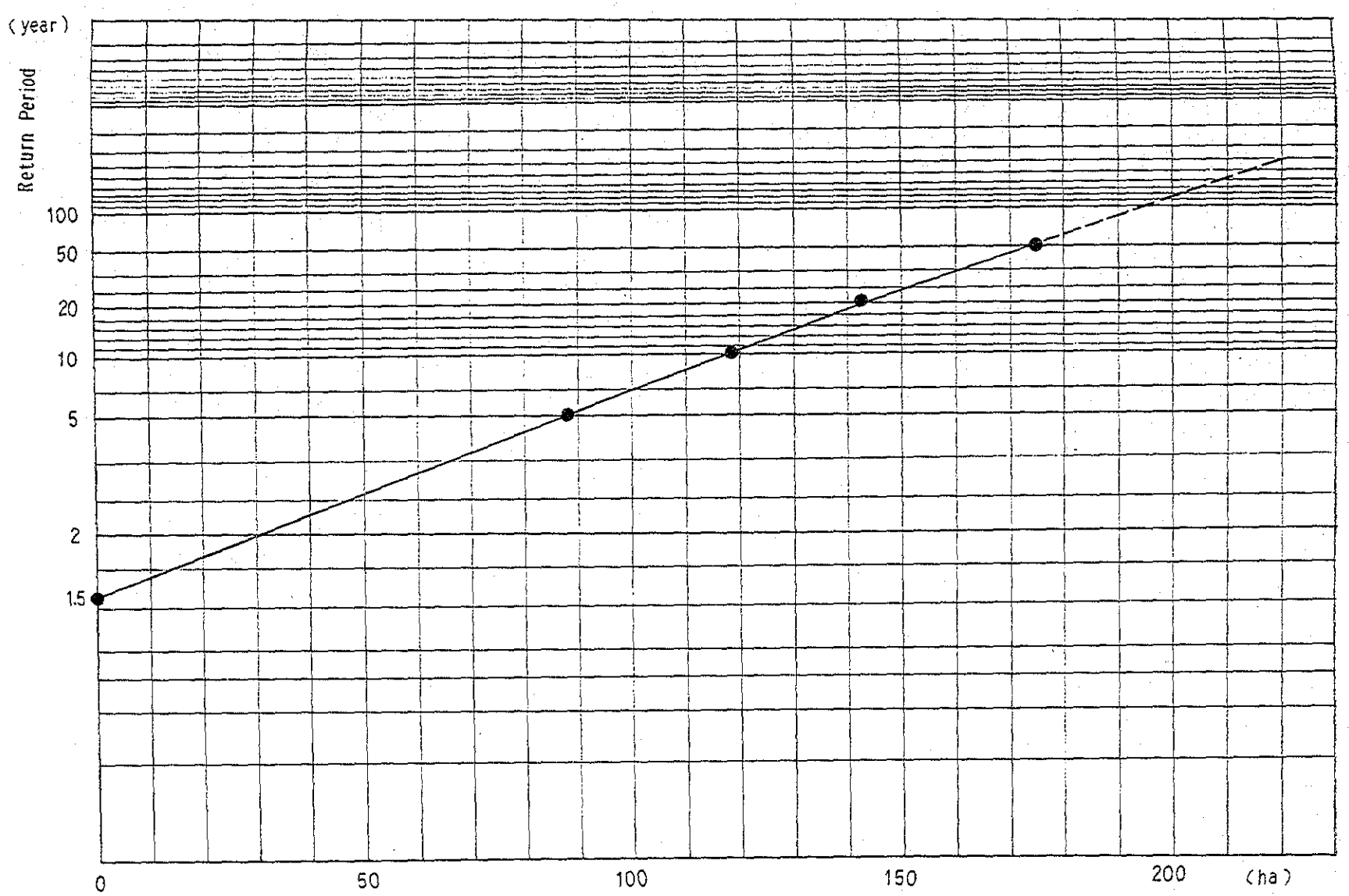


Fig. G.2.11 The Relation between Return Period and Inundation Area