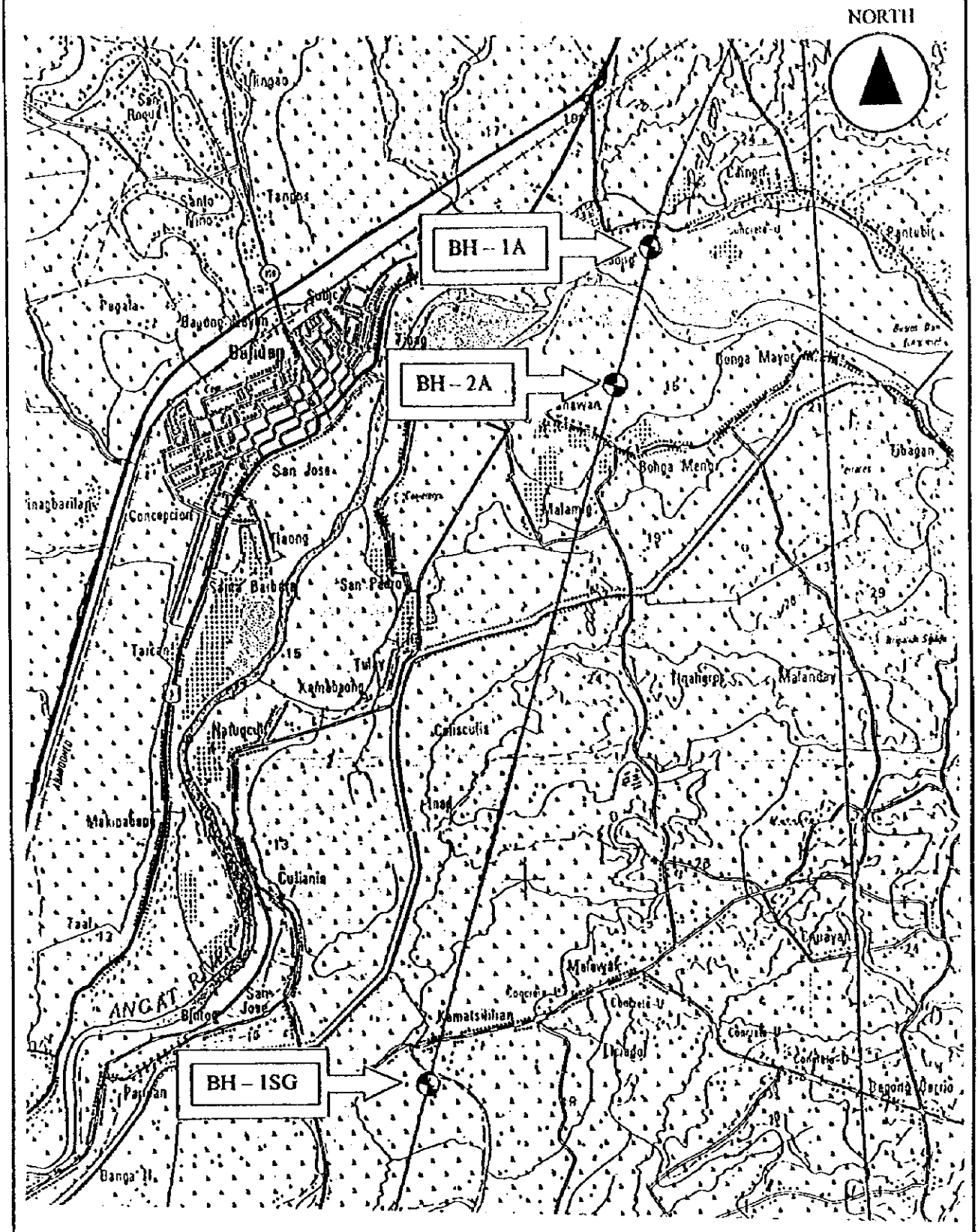
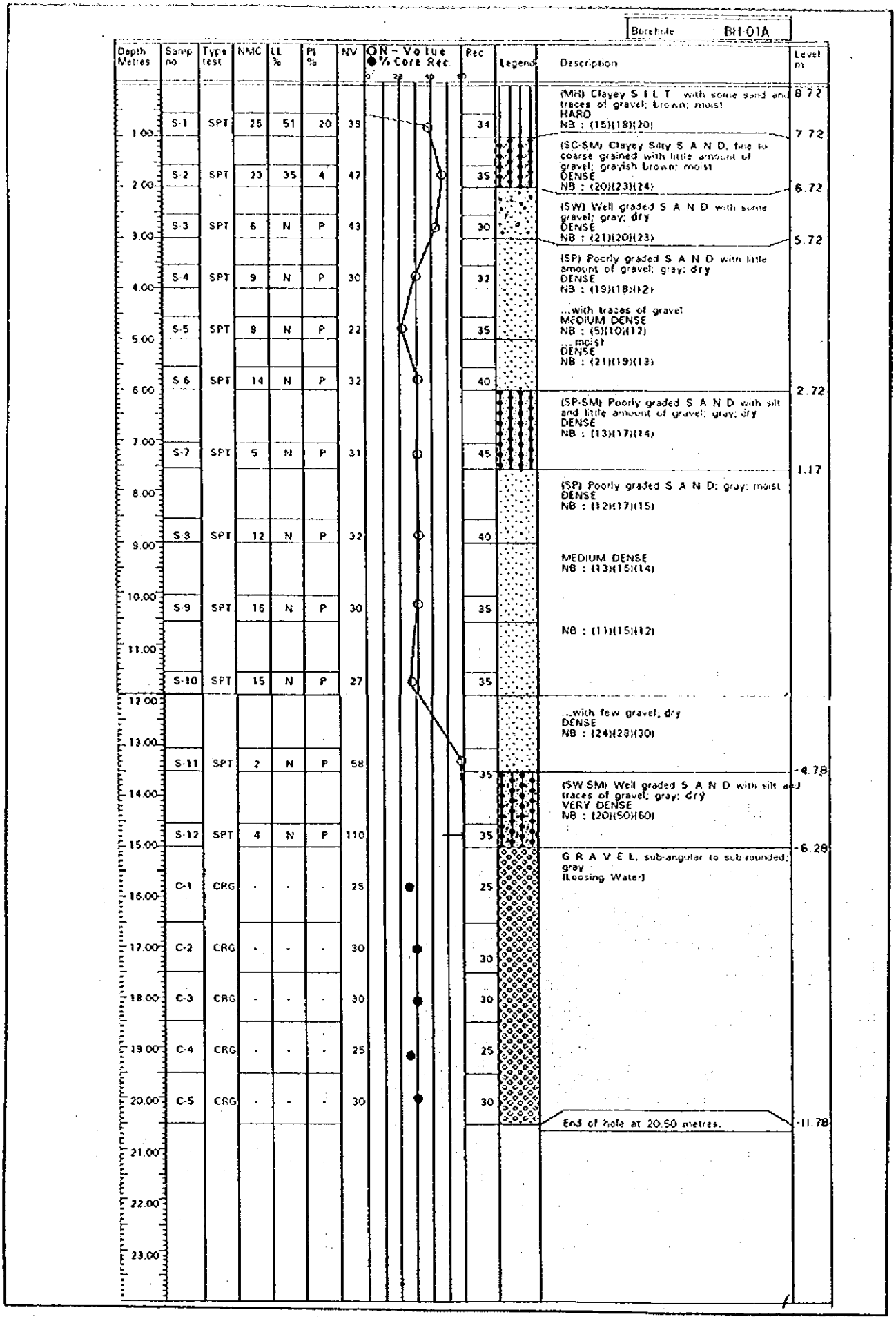
APPENDIX 12

- 12.1-1 Geo-Technical Survey Results
- 12.3-1 Hydraulic Analysis



SITE A – ANGAT RIVER

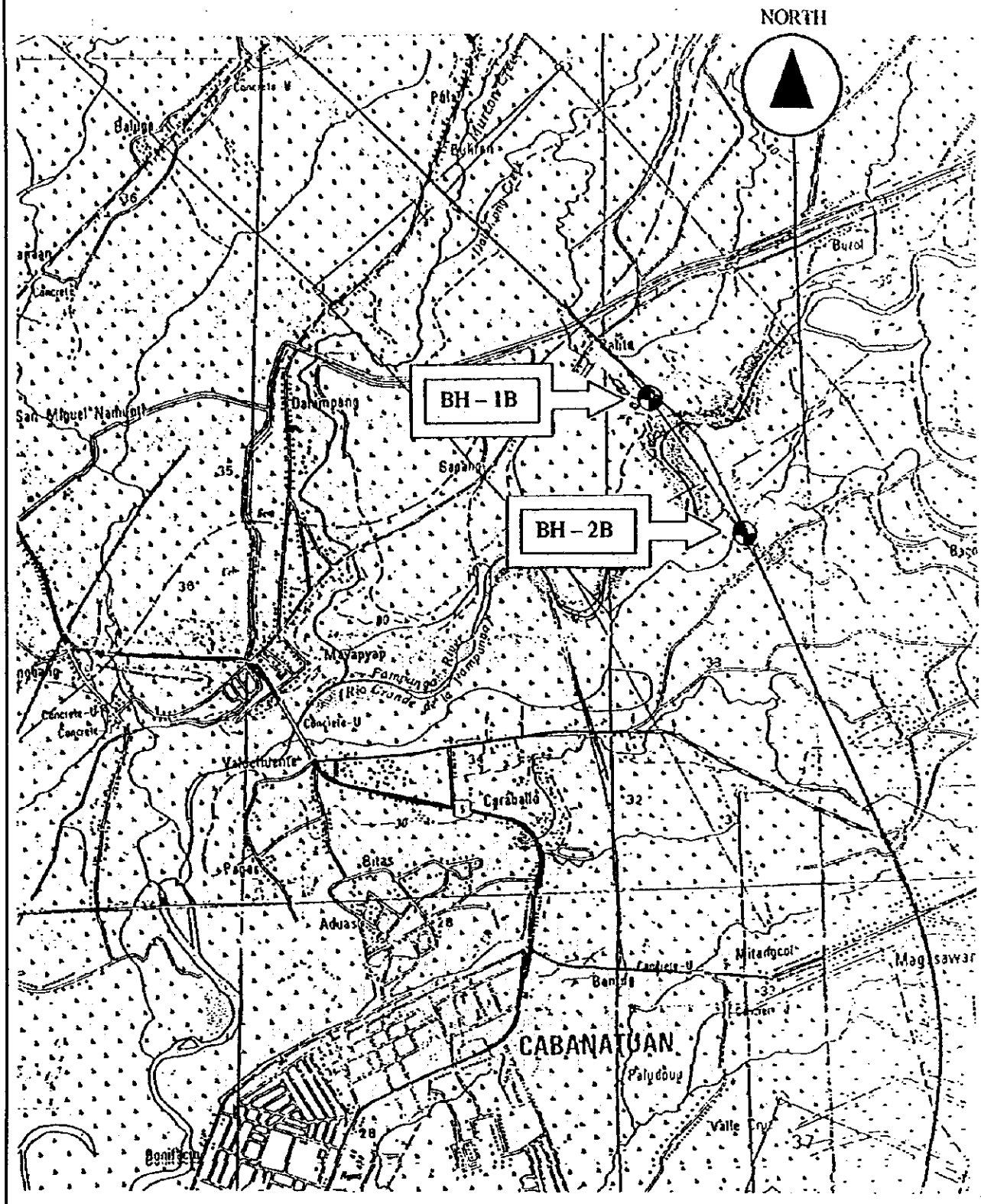

Borehole BH-01A
Depth Metres
Samp no
Type test
NMC
LL %
PI %
NV
N - Value
% Core Rec.
Rec
Legend
Description
Level m
(MH) Clayey S I L T with some sand and traces of gravel; brown; moist
HARD
NB : (15)(18)(20)
8.72
(SC-SM) Clayey Silty S A N D, fine to coarse grained with little amount of gravel; grayish brown; moist
DENSE
NB : (20)(23)(24)
7.72
6.72
(SW) Well graded S A N D with some gravel; gray; dry
DENSE
NB : (21)(20)(23)
5.72
(SP) Poorly graded S A N D with little amount of gravel; gray; dry
DENSE
NB : (19)(18)(12)
...with traces of gravel
MEDIUM DENSE
NB : (5)(10)(12)
...moist
DENSE
NB : (21)(19)(13)
2.72
(SP-SM) Poorly graded S A N D with silt and little amount of gravel; gray; dry
DENSE
NB : (13)(17)(14)
1.17
(SP) Poorly graded S A N D; gray; moist
DENSE
NB : (12)(17)(15)
MEDIUM DENSE
NB : (13)(16)(14)
NB : (11)(15)(12)
...with few gravel; dry
DENSE
NB : (24)(28)(30)
-4.78
(SW-SM) Well graded S A N D with silt and traces of gravel; gray; dry
VERY DENSE
NB : (20)(50)(60)
-6.28
G R A V E L, sub-angular to sub-rounded; gray
(Loosing Water)
End of hole at 20.50 metres.
-11.78
S-1 SPT 26 51 20 38 34
S-2 SPT 23 35 4 47 35
S-3 SPT 6 N P 43 30
S-4 SPT 9 N P 30 32
S-5 SPT 8 N P 22 35
S-6 SPT 14 N P 32 40
S-7 SPT 5 N P 31 45
S-8 SPT 12 N P 32 40
S-9 SPT 16 N P 30 35
S-10 SPT 15 N P 27 35
S-11 SPT 2 N P 58 35
S-12 SPT 4 N P 110 35
C-1 CRG - - - 25 25
C-2 CRG - - - 30 30
C-3 CRG - - - 30 30
C-4 CRG - - - 25 25
C-5 CRG - - - 30 30

Borehole BH-02A

Depth Metres	Samp no	Type test	NMC	LL %	PI %	NV	N – Value ● % Core Rec. (0 20 40 60)	Rec	Legend	Description	Level m
										(CH) Silty C L A Y with some sand, grayish brown; moist STIFF	14.72
1.00	S-1	SPT	27	62	32	10		45		NB : (3)(4)(6)	13.72
	UDS1	UDS	11	N	P	P		50		(SP-SM) Poorly graded S A N D with silt; grayish brown; moist VERY LOOSE NB : (PRESSED)	
2.00										(SP-SM) Poorly graded S A N D with silt and few gravel, grayish brown, moist DENSE	
	S-2	SPT	22	N	P	41		45		NB : (21)(23)(18)	
3.00										...with traces of gravel NB : (21)(22)(19)	
	S-3	SPT	16	N	P	41		45			
4.00										(SP) Poorly graded S A N D with some gravel; gray; dry MEDIUM DENSE	10.72
	S-4	SPT	8	N	P	17		45		NB : (23)(9)(8)	
5.00										(SW-SM) Well graded S A N D with silt and some gravel; gray; dry MEDIUM DENSE	9.72
	S-5	SPT	8	N	P	17		45		NB : (17)(9)(8)	
6.00										(SW) Well graded S A N D with gravel, gray; moist VERY DENSE	8.72
	S-6	SPT	11	N	P	66		45		NB : (30)(30)(36)	
7.00										NB : (34)(37)(42)	
	S-7	SPT	14	N	P	79		20			
8.00										(SP) Poorly graded S A N D with some gravel; gray; moist VERY DENSE	6.72
	S-8	SPT	14	N	P	75		45		NB : (32)(34)(41)	
9.00										NB : (43)(44)(47)	
10.00											
	S-9	SPT	13	N	P	91		45			
11.00										(SW) Well graded S A N D with gravel; gray; moist VERY DENSE	3.72
	S-10	SPT	12	N	P	68		45		NB : (23)(27)(41)	
12.00										NB : (21)(26)(33)	
13.00											
	S-11	SPT	13	N	P	59		40			
14.00										(GW) Well graded G R A V E L ; gray; moist DENSE	0.72
	S-12	SPT	12	N	P	44		40		NB : (29)(19)(25)	
15.00											-0.78
16.00										(SP-SM) Poorly graded S A N D with silt and gravel; gray; moist VERY DENSE	
	S-13	SPT	11	N	P	53		45		NB : (21)(24)(29)	
17.00											-2.28
										(SP) Poorly graded S A N D with little amount of gravel; gray; dry MEDIUM DENSE	
18.00	S-14	SPT	9	N	P	29		45		NB : (24)(15)(14)	
											-3.73
19.00										(SW) Well graded S A N D with some gravel; gray; moist VERY DENSE	
	S-15	SPT	13	N	P	87		30		NB : (36)(40)(47)	
20.00										End of hole at 20.00 metres.	-5.28
21.00											
22.00											
23.00											

Borehole BH-01SG

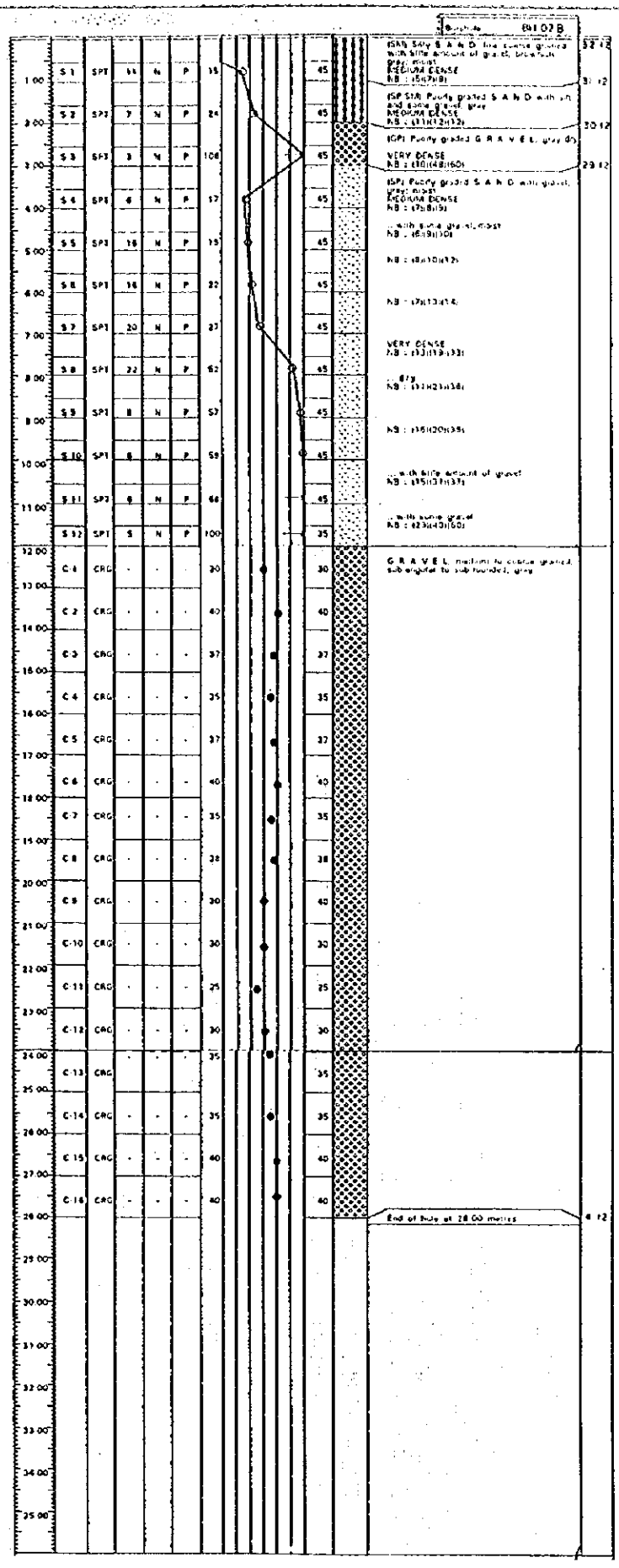
Depth Metres	Samp no	Type test	NMC	LL %	PI %	NV	SPT N-Value ● % Core Rec.	Rec	Legend	Description	Level m
										(CH) Silty C L A Y with little amount of sand, dark brown; moist	9.86
1.00	S-1	SPT	27	66	35	5		45		FIRM NB : (1)(2)(3)	
	UDS1	UDS	30	67	36	P		45		VERY SOFT NB : (PRESSED)	
2.00										...with some sand FIRM NB : (2)(2)(5)	
3.00	S-2	SPT	30	64	33	7		45			
	UDS2	UDS	40	72	40	P		45		...with few sand; very moist VERY SOFT NB : (PRESSED)	
4.00										...with little amount of sand and traces of gravel; greenish brown VERY STIFF NB : (7)(10)(14)	
	S-3	SPT	37	65	34	24		45			
5.00	S-4	SPT	34	70	38	14		45		...with little amount of sand STIFF NB : (7)(7)(7)	
											4.36
6.00	S-5	SPT	28	44	12	15		45		(ML) Sandy S I L T; greenish brown; moist STIFF NB : (7)(7)(8)	
											3.36
7.00										(SM) Silty S A N D, fine to coarse grained with some gravel; grayish brown; moist VERY DENSE NB : (14)(24)(36)	
	S-6	SPT	10	N	P	60		45			
8.00										NB : (16)(35)(41)	
	S-7	SPT	12	N	P	76		45			
9.00										NB : (60/15)	
	S-8	SPT	9	N	P	60/15		15			
10.00										...with little amount of gravel NB : (55)(60/5)	
	S-9	SPT	18	N	P	60/5		20			
11.00	C-1	CRG	-	-	-	35		35		G R A V E L with some sand, sub-angular to sub-rounded; grayish brown	0.89
											-1.89
12.00										(CH) Silty C L A Y with little amount of gravel; brown; moist HARD NB : (27)(29)(40)	
	S-10	SPT	29	63	32	69		45			-2.8
13.00										(ML) Sandy S I L T with gravel; brown; very moist HARD NB : (18)(30)(31)	
	S-11	SPT	37	42	11	61		45			-3.84
14.00										(MH) Clayey S I L T with sand; brown; moist HARD NB : (21)(27)(36)	
	S-12	SPT	25	52	20	63		45			-4.84
15.00										(ML) Sandy S I L T; brown; moist HARD NB : (20)(28)(35)	
	S-13	SPT	25	40	9	63		45			-5.84
16.00										(SM) Silty S A N D, fine to coarse grained with few gravel; brown; moist DENSE NB : (13)(14)(20)	
	S-14	SPT	14	N	P	34		45			-6.84
17.00										(SP) Poorly graded S A N D with traces of gravel; brown; moist DENSE NB : (14)(15)(22)	
	S-15	SPT	24	N	P	38		45			
18.00										NB : (14)(17)(24)	
	S-16	SPT	24	N	P	41		45		(SM) Silty S A N D, fine to coarse grained with little amount of gravel; brown; moist VERY DENSE NB : (45)(60/7)	-8.84
19.00	S-17	SPT	10	N	P	60/7		23			-9.61
20.00	S-18	SPT	9	N	P	60/2		17		(SP-SM) Poorly graded S A N D with silt and little amount of gravel; brown; moist VERY DENSE NB : (57)(60/2)	-10.33
										End of hole at 20.19 metres.	
21.00											
22.00											
23.00											

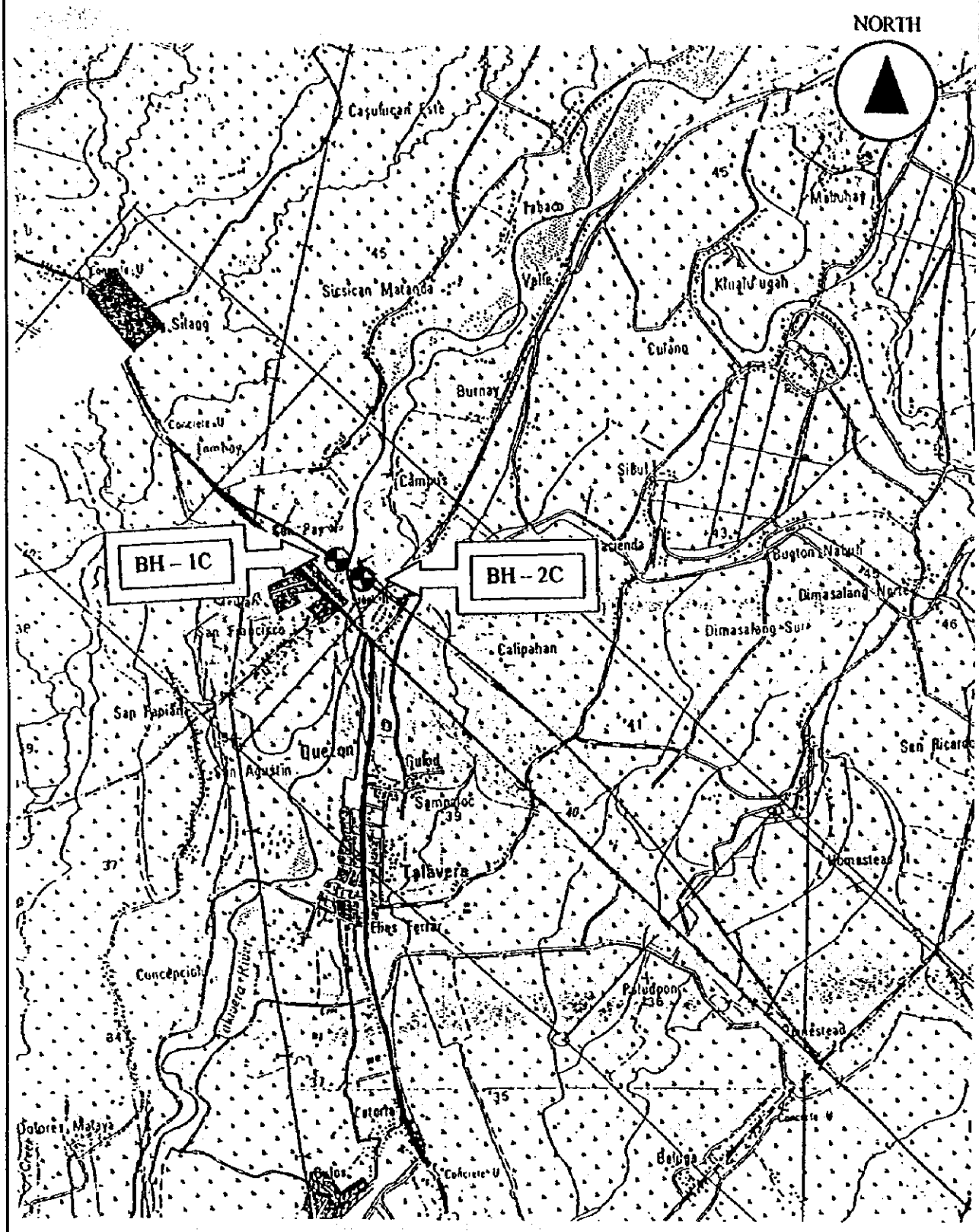


SITE B – PAMPANGA RIVER

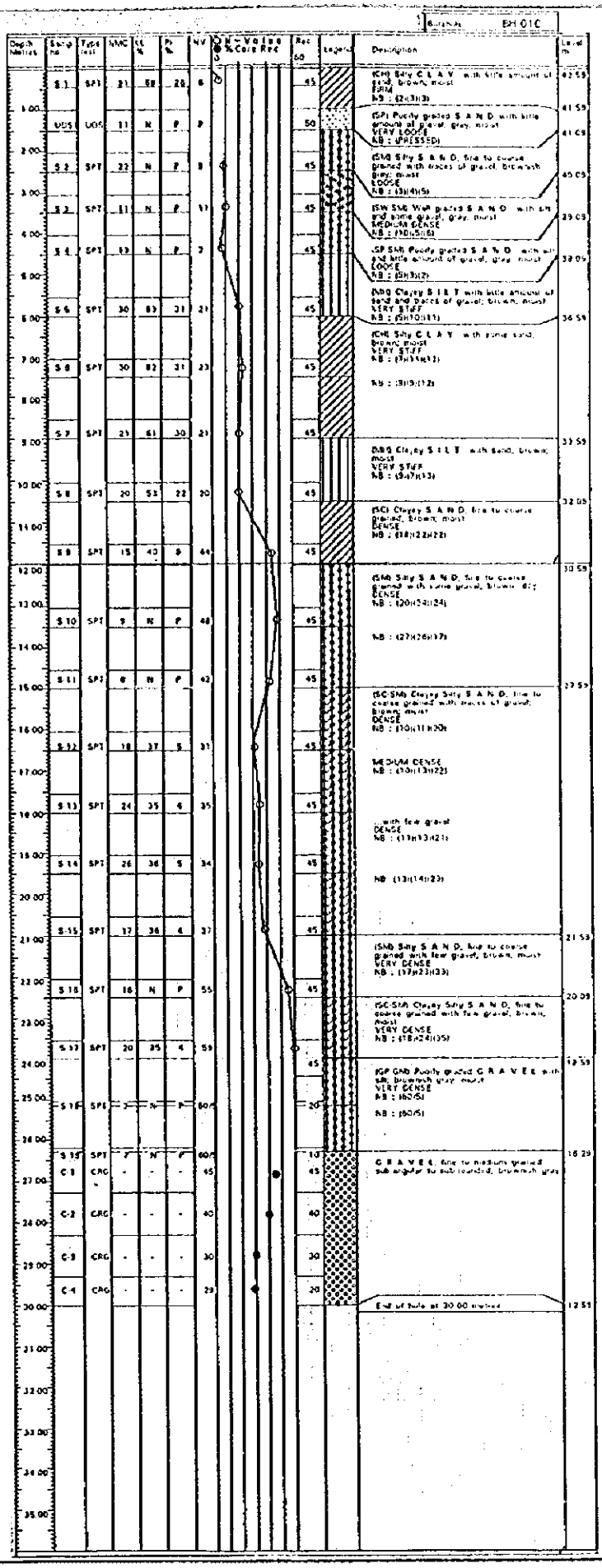
Borehole BH-01B

Depth Metres	Samp no	Type test	MMC	LL %	PI %	NV	N - Value ● % Core Rec. (0 30 40 50)	Rec	Legend	Description	Level m
											29.88
1.00	S-1	SPT	20	N	P	17		45		(SP) Poorly graded S A N D; gray; moist MEDIUM DENSE NB : (5)(7)(10)	
										...with some gravel NB : (8)(11)(15)	
2.00	S-2	SPT	22	N	P	26		45			
										...with little amount of gravel NB : (11)(11)(15)	
3.00	S-3	SPT	24	N	P	26		45			
										DENSE NB : (18)(20)(23)	
4.00	S-4	SPT	13	N	P	43		45			
										...with gravel NB : (20)(21)(27)	
5.00	S-5	SPT	17	N	P	48		45			24.68
										(SP-SM) Poorly graded S A N D with silt and some gravel; gray; moist DENSE NB : (19)(24)(26)	
6.00	S-6	SPT	12	N	P	50		40			23.68
										(SP) Poorly graded S A N D with traces of gravel; gray; moist DENSE NB :(21)(27)(20)	
7.00	S-7	SPT	17	N	P	47		35			
											22.38
8.00										(CH) Silty C L A Y with little amount of sand; gray; very moist VERY STIFF NB : (8)(10)(12)	
9.00	S-8	SPT	36	64	33	22		45			
										...with few sand NB : (10)(13)(15)	
10.00	S-9	SPT	38	66	34	28		45			
											19.38
11.00	S-10	SPT	23	N	P	55		40		(SP-SM) Poorly graded S A N D with silt and little amount of gravel; gray; moist VERY DENSE NB : (15)(25)(30)	
12.00											17.88
13.00	S-11	SPT	19	N	P	75		35		(SP) Poorly graded S A N D with little amount of gravel; gray; moist VERY DENSE NB : (28)(35)(40)	
14.00										...with few gravel NB : (30)(45)(60)	
15.00	S-12	SPT	18	N	P	105		35			
	C-1	CRG	-	-	-	25		25		G R A V E L, fine to medium grained; gray	14.88
16.00	S-13	SPT	-	-	-	60/10		5		NB : (60/10)	
	C-2	CRG	-	-	-	80		40			
17.00	C-3	CRG	-	-	-	76		38			
	C-4	CRG	-	-	-	82		41			
										End of hole at 17.60 metres.	12.28
18.00											
19.00											
20.00											
21.00											
22.00											
23.00											


Borehole BH 07 B
(SW) SAY S A N D fine coarse grained with little amount of gravel, brownish grey, moist
MEDIUM DENSE
NB : (5+7+9)
(SP SW) Poorly graded S A N D with silt and some gravel, grey
MEDIUM DENSE
NB : (11+12+13)
(GP) Poorly graded G R A V E L, grey (D)
VERY DENSE
NB : (30+(48)+60)
(SP) Poorly graded S A N D with gravel, grey, moist
MEDIUM DENSE
NB : (9+8+9)
...with some gravel content
NB : (6+9+)10
NB : (8+10+12)
NB : (7+13+14)
VERY DENSE
NB : (13+19+33)
...silty
NB : (13+23+38)
NB : (15+20+35)
...with little amount of gravel
NB : (15+37+37)
...with some gravel
NB : (23+43+60)
G R A V E L, medium to coarse grained, sub angular to sub rounded, grey
End of hole at 28.00 metres

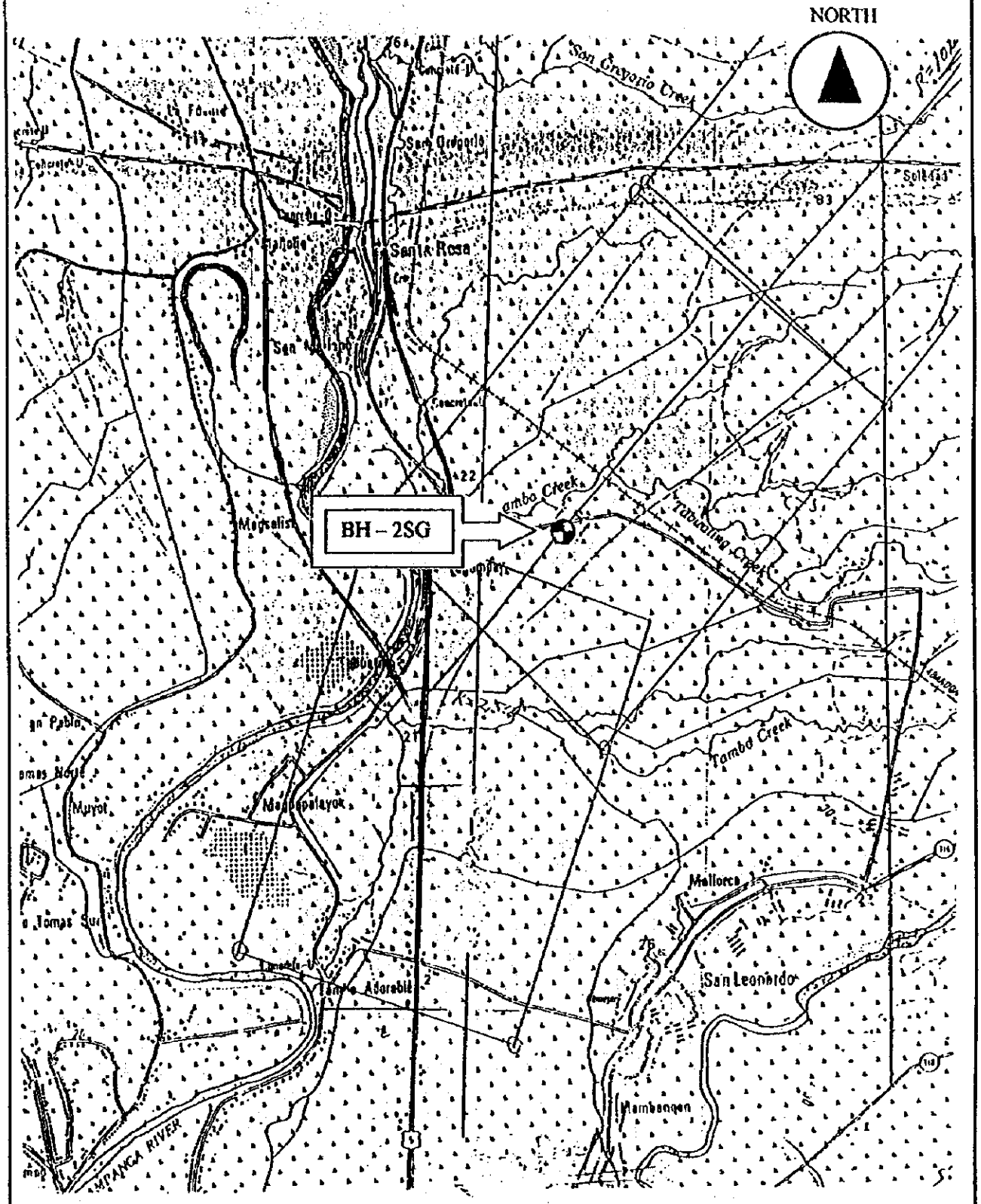


SITE C – TALAVERA RIVER


BH 01C
Depth Metres
Sample no
Type test
NMC %
LL %
PI %
NV
Qu - Value & Core Rec
Rec
Legend
Description
Level m
(CH) Silty C L A Y with little amount of sand, brown, moist
FIRM
NB : (2+3+3)
(SP) Poorly graded S A N D with little amount of gravel, grey, moist
VERY LOOSE
NB : (PRESSED)
(SM) Silty S A N D, fine to coarse grained with traces of gravel, brownish grey, moist
LOOSE
NB : (3+4+5)
(SW-SM) Well graded S A N D with silt and some gravel, grey, moist
MEDIUM DENSE
NB : (7+10+15)
(SP-SM) Poorly graded S A N D with silt and little amount of gravel, grey, moist
LOOSE
NB : (5+3+2)
(MH) Clayey S I L T with little amount of sand and traces of gravel, brown, moist
VERY STIFF
NB : (5+7+10)
(CH) Silty C L A Y with some sand, brown, moist
VERY STIFF
NB : (3+5+8)
NB : (3+5+12)
(MH) Clayey S I L T with sand, brown, moist
VERY STIFF
NB : (5+7+13)
(SC) Clayey S A N D, fine to coarse grained, brown, moist
DENSE
NB : (8+12+22)
(SM) Silty S A N D, fine to coarse grained with some gravel, brown, dry
DENSE
NB : (20+24+24)
NB : (22+26+37)
(SC-SM) Clayey Silty S A N D, fine to coarse grained with traces of gravel, brown, moist
DENSE
NB : (10+11+20)
MEDIUM DENSE
NB : (10+13+22)
with few gravel
DENSE
NB : (13+13+21)
NB (13+14+22)
(SM) Silty S A N D, fine to coarse grained with few gravel, brown, moist
VERY DENSE
NB : (17+23+33)
(SC-SM) Clayey Silty S A N D, fine to coarse grained with few gravel, brown, moist
VERY DENSE
NB : (18+24+35)
(GP-GM) Poorly graded G R A V E L with silt, brownish grey, moist
VERY DENSE
NB : (60/5)
NB : (60/5)
G R A V E L, fine to medium grained, sub angular to sub rounded, brownish grey
End of hole at 30.00 m

Borehole BH-02C

Depth Metres	Samp no	Type test	NMC	LL %	PI %	NV	N - Value / % Core Rec. (0 20 40 60)	Rec	Legend	Description	Level m
										(MH) Clayey S I L T with some sand, dark brown; moist STIFF NB : (3)(5)(5)	38.67
1.00	S-1	SPT	29	56	24	10		45			
										(SC) Clayey S A N D, fine to medium grained; dark brown; moist MEDIUM DENSE NB : (4)(6)(5)	37.67
2.00	S-2	SPT	14	41	10	11		45		NB : (4)(4)(6)	
3.00	S-3	SPT	20	45	14	10		45			35.67
										(MH) Clayey S I L T with little amount of sand; brown; moist VERY STIFF NB : (7)(7)(10)	
4.00	S-4	SPT	26	63	31	17		45		...greenish brown NB : (6)(8)(13)	
5.00	S-5	SPT	28	62	30	21		45			33.67
										(CH) Silty C L A Y with little amount of sand; greenish brown; very moist VERY STIFF NB : (5)(10)(15)	
6.00	S-6	SPT	32	61	30	25		45			32.67
										(MH) Clayey S I L T with little amount of sand; yellowish brown; moist VERY STIFF NB : (8)(12)(16)	
7.00	S-7	SPT	26	60	28	28		45			
8.00										...with some sand; brown HARD NB : (13)(20)(23)	
9.00	S-8	SPT	23	56	24	43		45			29.67
										(SC) Clayey S A N D, fine to coarse grained; brown; moist MEDIUM DENSE NB : (8)(11)(13)	
10.00	S-9	SPT	28	40	9	24		45			
11.00										(SC-SM) Clayey Silty S A N D, fine to coarse grained; brown; moist MEDIUM DENSE NB : (10)(12)(15)	28.17
	S-10	SPT	23	35	4	27		45			
12.00											
13.00										(SW-SM) Well graded S A N D with silt; grayish brown; moist VERY DENSE NB : (15)(23)(30)	
	S-11	SPT	24	N	P	53		45			
14.00										....with little amount of gravel NB : (29)(40)(48)	
15.00	S-12	SPT	17	N	P	88		45			23.67
										(SP) Poorly graded S A N D, sub-rounded to sub-angular; gray; moist VERY DENSE NB : (38)(47)(60)	
16.00	S-13	SPT	12	N	P	107		30			22.17
	C-1	CRG	-	-	-	50		25		G R A V E L, fine to medium grained, sub-rounded to sub-angular; gray	
17.00	S-14	SPT	-	-	-	60/5		0			
	C-2	CRG	-	-	-	50		20		No Recovery NB : (60/10)	
18.00										G R A V E L, fine to medium grained, sub-rounded to sub-angular; gray	21.07
										End of hole at 17.60 metres.	
19.00											
20.00											
21.00											
22.00											
23.00											



SOFT GROUND – SAN LEONARDO, NUEVA ECIJA

Borehole BH-02SG

Depth Metres	Samp no	Type test	NMC	LL %	PI %	NV	N-Value ●% Core Rec. (0 20 40 60)	Rec	Legend	Description	Level m
										(CH) Silty C L A Y with little amount of sand; brownish gray; very moist STIFF NB : (2)(4)(6)	23.3
1.00	S-1	SPT	37	69	37	10		45			
			53	75	45	P				(Top)...very moist VERY SOFT NB : (PRESSED)	
2.00	USD1	UDS	35	83	41			50		(Bottom)	
										...with traces of gravel; moist STIFF NB : (4)(5)(7)	
3.00	S-2	SPT	37	67	35	12		45			
			25	67	37	P				(Top)...with some sand; brown; brownish gray; moist VERY LOOSE NB : (PRESSED)	
4.00	UDS2	UDS	53	64	35			50		(Bottom)...very moist	19.8
5.00	S-3	SPT	30	64	32	37		45		(MH) Clayey S I L T with some sand; brownish gray; moist HARD NB : (8)(17)(20)	18.8
6.00	S-4	SPT	22	33	7	24		45		(SC-SM) Clayey Silty S A N D, fine to coarse grained with traces of gravel; brownish gray; moist MEDIUM DENSE NB : (6)(12)(12)	17.8
7.00	S-5	SPT	14	N	P	68		45		(SP) Poorly graded S A N D, brownish gray; moist VERY DENSE NB : (31)(34)(34)	16.3
8.00	S-6	SPT	16	N	P	37		35		(SP-SM) Poorly graded S A N D with silt and few gravel; brownish gray; moist DENSE NB : (8)(21)(16)	14.8
9.00	S-7	SPT	13	N	P	31		45		(SP) Poorly graded S A N D; brownish gray; moist DENSE NB : (13)(14)(17)	
10.00	S-8	SPT	12	N	P	31		45		...with few gravel; gray NB : (13)(15)(16)	
12.00										...with little amount of gravel VERY DENSE NB : (44)(47)(46)	
13.00	S-9	SPT	14	N	P	93		45			10.3
14.00										(SW-SM) Well graded S A N D with silt and some gravel; gray; moist VERY DENSE NB : (26)(35)(35)	
15.00	S-10	SPT	12	N	P	70		45		...with few gravel NB : (41)(43)(45)	
16.00	S-11	SPT	18	N	P	88		40			
17.00	S-12	SPT	18	N	P	94		38		...with little amount of gravel NB : (46)(47)(47)	5.8
18.00										(SP-SM) Poorly graded S A N D with silt and gravel; gray; moist VERY DENSE NB : (49)(50)(51)	
19.00	S-13	SPT	18	N	P	101		30		End of hole at 19.50 metres.	4.3
20.00											
21.00											
22.00											
23.00											

APPENDIX 12.3-1 HYDRAULIC ANALYSIS

1.0 INTRODUCTION

This report covers hydrologic analysis made on the proposed Angat bridge along the Plaridel–Baliwag Bypass road in Bulacan and two (2) bridges in Nueva Ecija (Pampanga and Talavera bridges) along the Cabanatuan Bypass road. It discusses the methodology, assumption, criteria and schemes in arriving at the most efficient and technically sound waterway opening at the bridge sites.

These three (3) bridges that was recommended for construction are all to be constructed along the proposed new bypass roads.

2.0 HYDROLOGICAL ANALYSIS

Hydrological analysis was conducted mainly to derive design discharges at the various points of interest. Design discharges were estimated by the Unit Hydrograph Method.

2.1 Preliminary considerations and input parameters

Preliminary considerations and input parameters used in the above mentioned methods are as follows:

2.1.1 Watershed Parameters

All the 1:50,000 and 1:250,000 map sheets covering the entire watershed areas of each bridges were obtained from National Mapping and Resources Information Agency (NAMRIA).

Watershed parameters such as areas, stream length, streambed elevation and riverbed slope were measured from each of the delineated boundaries on the 1:50,000 and/or 1:250,000 maps.

Physiographic characteristics of catchment areas taken from NAMRIA maps were verified in the field for general accuracy.

2.1.2 Design Frequency

The design frequency adopted for the bridge type of drainage structures is one (1) in fifty (50) years. These value adhere to the recommendations found in the DPWH, ADB and IBRD Guidelines.

2.1.3 Rainfall Intensity

The value of Rainfall Intensity Duration Frequency (RIDF) data were obtained from the Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). These are shown in Table 1 and Table 2.

A direct individual plotting of the short duration values against time for different return periods, however, will show that the curves tend to intersect at the higher duration. This, of course, is not true in nature.

This statistical inconsistency was corrected by Regression Analysis for each RIDF Curves using a general equation of the form shown below which generally preserves the integrity of the data and lends itself handily for practical computer applications.

$$I = A * (Tc + C)^B \quad \text{.....1}$$

Where:
I = Rainfall Intensity (mm/hr)
Tc = Time of concentration (minutes)
A = Regression intercept
B = Slope
C = Adjustment factor for best curve fit

Regression analysis for each rainfall intensity duration frequency data are shown in Appendix B.

RIDF Curves for Makinabang, Baliwag, Bulacan used for Angat bridge and Cabanatuan City used for Pampanga and Talavera bridges are shown in Figure 1 and Figure 2.

2.2 Determination of Design Discharge

2.2.1 Methodology

In order to estimate the magnitude of the design flood or discharge, Unit Hydrograph Method was used. The Unit Hydrograph were employed in the discharge computation of major drainage sites, i.e., bridge sites with drainage areas greater than 10 km^2.

2.2.2 Unit Hydrograph Method

This method consists of three (3) components, namely the unit hydrograph analysis, derivation of effective rainfall, and the flood hydrograph. These are discussed briefly in the following sub-topics.

Unit Hydrograph Analysis

The basin lag time and the instantaneous unit hydrograph were computed using the physiographic characteristics of the basin.

The lag equations that were considered are as follows.

$$Lg = 0.75\ Ct\ (LLc)^{0.30} \quad \text{.....(Snyder).....} \quad 2a$$

$$Lg = 0.6863\ Ct\ (LLc / S^{1/2})^{0.38} \quad \text{.....(Modified Snyder).....} \quad 2b$$

The original Snyder was found to be more applicable for this project.

$$D = \frac{Lg}{5.5} \quad \text{.....} \quad 3$$

Where:

Lg = lag time measured from the centroid of rainfall excess to the peak discharge of the unit hydrograph, hr.
D = unit duration of rainfall excess, hr.
Ct = coefficient representing variations in topography ranging from 1.80 to 2.20 with steeper slopes generally associated with lower values of Ct.
L = maximum travel distance along the main stream, km.
Lc = centroidal stream length of the watershed area.
S = weighted physical slope of the main water course

The peak discharge of the unit graph for a given duration of that produces 1mm of direct run-off was computed from the Snyder Equation.

$$Qp = \frac{275\ Cp\ A}{Lg} \quad \text{.....} \quad 4$$

Where:

Qp = peak discharge, m^3/sec.
Cp = coefficient ranging from 0.56 to 0.69 representing variations in slope and watershed permeability.
A = catchment area, m^2

The unit hydrograph shape was derived by proportion with Qp and the ordinates of the SCS Dimensionless Unit Hydrograph. The SCS Unit Hydrograph is shown in Figure 3.

Derivation of Effective Rainfall

The second component involves the modified SCS computation for the design storm.

Rainfall increments were computed from the watershed rainfall and rearranged in such a way as to yield maximum run-off. These rearranged increments were corrected for interception, depression storage and infiltration using SCS procedure.

Flood Hyrdrograph

The third component involves the use of the convolution equation on the derived unit hydrograph and rainfall excess and the addition of storm base flow to arrive at the total flood hydrograph.

In the absence of simultaneous rainfall run-off records, the storm base flow adopted was 10% of the peak run-off as recommended by Ven Te Chow in "Handbook of Applied Hydrology".

2.3 Computed Design Discharges

Design discharges of the three (3) bridges computed by the Unit Hydrograph Methods are shown in Appendix C.

3.0 HYDRAULIC DESIGN

3.1 Bridges

When the design discharge has been estimated. It is necessary to know the response of the river when such flood will come. The corresponding water levels and the average velocity of the flood can be determined by the hydraulic computation.

Hydraulic calculations were done primarily to determine waterway requirements taking into consideration the expected 50-year flood level. . Bridge lengths were determined such that constrictions of the main channel flow would be minimum. The result of the computation, then, becomes the basis of the design of the structure. Detailed calculations are shown in Appendix D.

3.1.1 Design Flood Level

Unconstricted Bridge Section

For bridges where constriction of the main channel flow is not expected, determination of flood level was done using the "Standard Step Method" of water surface profile computation for natural channels considering channel cross-sections in their natural shape.

Channel cross-sections were determined from the actual topographic survey. Mean bed slope for the starting section was calculated by map-scaled measurement of distances between representative spot elevations along the streambed. Manning's roughness coefficient, n, Table 3, was determined from ocular investigations.

Constricted Bridge Section

Channel constriction occurs when the need for intermediate piers and incursion of the abutment into the channel could not be avoided. Initial determination of flood level for the first two cases was base on the unconstricted condition as explained above.

Final flood level was determined considering the effect of bridge abutments and piers. In calculating the degree of constriction, several trial bridge lengths were considered such that the velocity under the bridge is not too excessive.

3.1.2 Freeboard

Freeboard is that space between the lowest structural member of the bridge (bridge soffit) and the design flood level which is allocated for different purposes such as navigation, passage of debris, etc. The minimum freeboard adopted for this project was 1.50m.

TABLES

Table 1

RAINFALL INTENSITY - DURATION - FREQUENCY DATA

for

MAKINABANG, BALIWAG, BULACAN

Based on 18 years of record

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION

Return Period (yrs)	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins	80 mins	100 mins	120 mins	150 mins	3 hrs	6 hrs	12 hrs	24 hrs
2	11.3	17.2	22.1	26.2	32.9	39.4	43.9	51.5	58.3	63.7	70.7	76.8	100.9	123.3	140.3
5	17.2	26.2	33.7	40.0	50.2	60.6	67.6	79.4	90.1	98.4	109.4	119.0	157.1	191.6	218.8
10	21.2	32.2	41.3	49.1	61.7	74.6	83.3	97.8	111.1	121.4	134.9	146.9	194.3	236.9	270.8
15	23.5	35.5	45.6	54.3	68.2	82.5	92.2	108.3	123.0	134.4	149.3	162.6	215.3	262.4	300.2
20	25.0	37.9	48.7	57.9	72.7	88.1	98.4	115.6	131.3	143.5	159.5	173.6	230.0	280.3	320.7
25	26.2	39.7	51.0	60.6	76.2	92.3	103.2	121.2	137.7	150.5	167.2	182.1	241.4	294.0	336.6
50	29.9	45.3	58.1	69.2	87.0	105.5	117.9	138.5	157.4	172.0	191.2	208.2	276.2	336.5	385.3
100	33.6	50.8	65.3	77.7	97.7	118.5	132.5	155.7	177.0	193.4	215.0	234.2	310.9	378.6	433.7

EQUIVALENT AVERAGE INTENSITY (in mm/hr) OF COMPUTED EXTREME VALUES

Return Period (yrs)	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins	80 mins	100 mins	120 mins	150 mins	3 hrs	6 hrs	12 hrs	24 hrs
2	135.6	103.2	88.4	78.6	65.8	52.5	43.9	38.6	35.0	31.9	28.3	25.6	16.8	10.3	5.8
5	206.4	157.2	134.8	120.0	100.4	80.8	67.6	59.6	54.1	49.2	43.8	39.7	26.2	16.0	9.1
10	254.4	193.2	165.2	147.3	123.4	99.5	83.3	73.4	66.7	60.7	54.0	49.0	32.4	19.7	11.3
15	282.0	213.0	182.4	162.9	136.4	110.0	92.2	81.2	73.8	67.2	59.7	54.2	35.9	21.9	12.5
20	300.0	227.4	194.8	173.7	145.4	117.5	98.4	86.7	78.8	71.8	63.8	57.9	38.3	23.4	13.4
25	314.4	238.2	204.0	181.8	152.4	123.1	103.2	90.9	82.6	75.3	66.9	60.7	40.2	24.5	14.0
50	358.8	271.8	232.4	207.6	174.0	140.7	117.9	103.9	94.4	86.0	76.5	69.4	46.0	28.0	16.1
100	403.2	304.8	261.2	233.1	195.4	158.0	132.5	116.8	106.2	96.7	86.0	78.1	51.8	31.6	18.1

prepared by:
the HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION
flood forecasting branch, pagasa

Table 2

RAINFALL INTENSITY - DURATION - FREQUENCY DATA

for

CABANATUAN CITY

Based on 33 years of record

COMPUTED EXTREME VALUES (in mm) OF PRECIPITATION

Return Period (yrs)	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins	80 mins	100 mins	120 mins	150 mins	3 hrs	6 hrs	12 hrs	24 hrs
2	12.1	18.8	24.1	28.6	36.6	45.0	50.7	57.0	62.3	66.1	70.8	75.1	92.6	108.9	127.9
5	17.5	26.9	34.3	40.5	52.4	65.0	74.6	83.3	90.5	95.6	101.6	108.7	137.8	162.6	194.5
10	21.1	32.2	41.1	48.4	62.8	78.3	90.5	100.7	109.1	115.1	121.9	131.0	167.7	198.1	238.6
15	23.1	35.3	44.9	52.9	68.7	85.8	99.4	110.5	119.6	126.1	133.4	143.5	184.5	218.1	263.4
20	24.5	37.4	47.6	56.0	72.8	91.0	105.7	117.4	127.0	133.8	141.5	152.3	196.3	232.2	280.8
25	25.6	39.0	49.7	58.5	76.0	95.1	110.5	122.7	132.7	139.7	147.7	159.1	205.4	243.0	294.3
50	28.9	44.0	56.0	65.9	85.7	107.5	125.4	139.0	150.1	158.0	166.8	180.0	233.4	276.3	335.6
100	32.2	49.0	62.3	73.3	95.4	119.8	140.1	155.2	167.5	176.1	185.7	200.7	261.2	309.3	376.6

EQUIVALENT AVERAGE INTENSITY (in mm/hr) OF COMPUTED EXTREME VALUES

Return Period (yrs)	5 mins	10 mins	15 mins	20 mins	30 mins	45 mins	60 mins	80 mins	100 mins	120 mins	150 mins	3 hrs	6 hrs	12 hrs	24 hrs
2	145.2	112.8	96.4	85.8	73.2	60.0	50.7	42.8	37.4	33.0	28.3	25.0	15.4	9.1	5.3
5	210.0	161.4	137.2	121.5	104.8	86.7	74.6	62.5	54.3	47.8	40.6	36.2	23.0	13.6	8.1
10	253.2	193.2	164.4	145.2	125.6	104.4	90.5	75.5	65.5	57.5	48.8	43.7	28.0	16.5	9.9
15	277.2	211.8	179.6	158.7	137.4	114.4	99.4	82.9	71.8	63.0	53.4	47.8	30.8	18.2	11.0
20	294.0	224.4	190.4	168.0	145.6	121.3	105.7	88.0	76.2	66.9	56.6	50.8	32.7	19.3	11.7
25	307.2	234.0	198.8	175.5	152.0	126.8	110.5	92.0	79.6	69.8	59.1	53.0	34.2	20.3	12.3
50	346.8	264.0	224.0	197.7	171.4	143.3	125.4	104.3	90.1	79.0	66.7	60.0	38.9	23.0	14.0
100	386.4	294.0	249.2	219.9	190.8	159.7	140.1	116.4	100.5	88.1	74.3	66.9	43.5	25.8	15.7

prepared by:
the HYDROMETEOROLOGICAL INVESTIGATIONS and SPECIAL STUDIES SECTION
flood forecasting branch, pagasa

Table 3

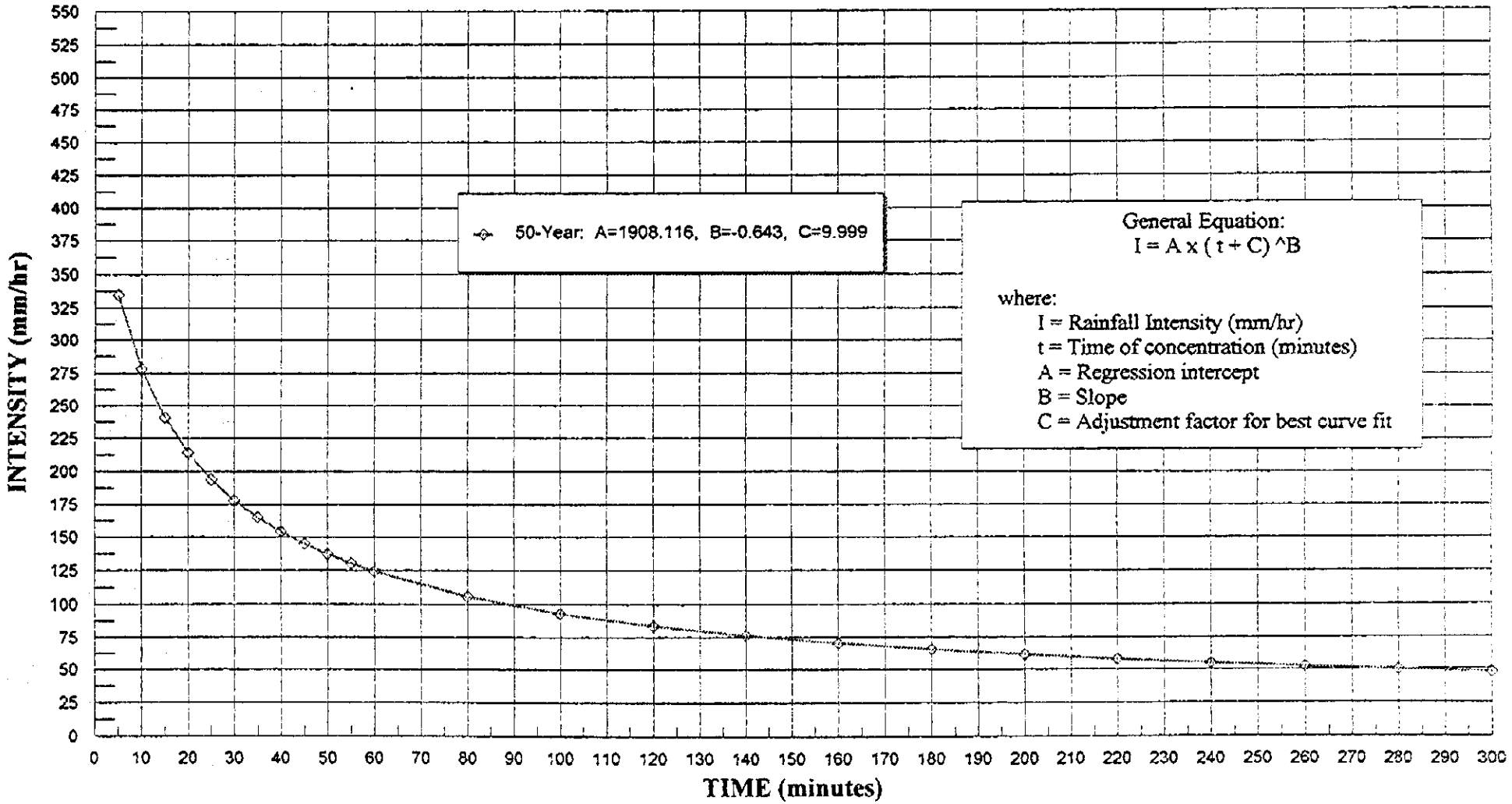
Values of Manning's Roughness Coefficient "n"

Surface Description	Range Min.	Max.
1) Natural stream channels (top flood width less than 30.0m):		
(i) Fairly regular section:		
a. Some grass and weeds, little or no brush	0.030	0.035
b. Dense growth of weeds, depth of flow materialy greater than weed height	0.035	0.050
c. Some weeds, light brush on banks	0.035	0.050
d. Some weeds, heavy brush on banks	0.050	0.070
e. Some weeds, dense trees	0.060	0.080
f. For trees within channel, with branches submerged at high flood increas all above values by	0.010	0.020
(ii) Irregular sections, with pools, slight channel meander; increase values given above about	0.010	0.020
(iii) Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high flood:		
a. Bottom of gravel, cobbles, and few boulders	0.040	0.050
b. Bottom of cobbles, with large boulders	0.050	0.070
2) Larger stream channels (top flood width greater than 30.0m):		
Reduce smaller stream coefficient by	0.010	
3) Flood Plains (adjacent to stream beds):		
Pasture, short grass, no brush	0.030	0.035
Pasture, tall grass, no brush	0.035	0.050
Cultivated land - no crop	0.030	0.040
Cultivated land - nature field crops	0.045	0.055
Scrub and scattered bush	0.050	0.070
Wooded	0.120	0.160
4) Man-made channels and ditches:		
Earth, straight and uniform	0.017	0.025
Grass covered	0.035	0.050
Dredged	0.025	0.033
Stone lined and rock cuts, smooth & uniform	0.025	0.035
Stone lined and rock cuts, smooth & irregular	0.035	0.045
Lined - metal corrugated	0.021	0.024
Lined - smooth concrete	0.012	0.018
Lined - grouted riprap	0.017	0.030
5) Pipes:		
Cast iron	0.011	0.015
Wrought iron	0.012	0.017
Corrugated steel	0.021	0.035
Concrete	0.010	0.017

Table 4.12, page 746, Design Guidelines of Bureau of Design, DPWH

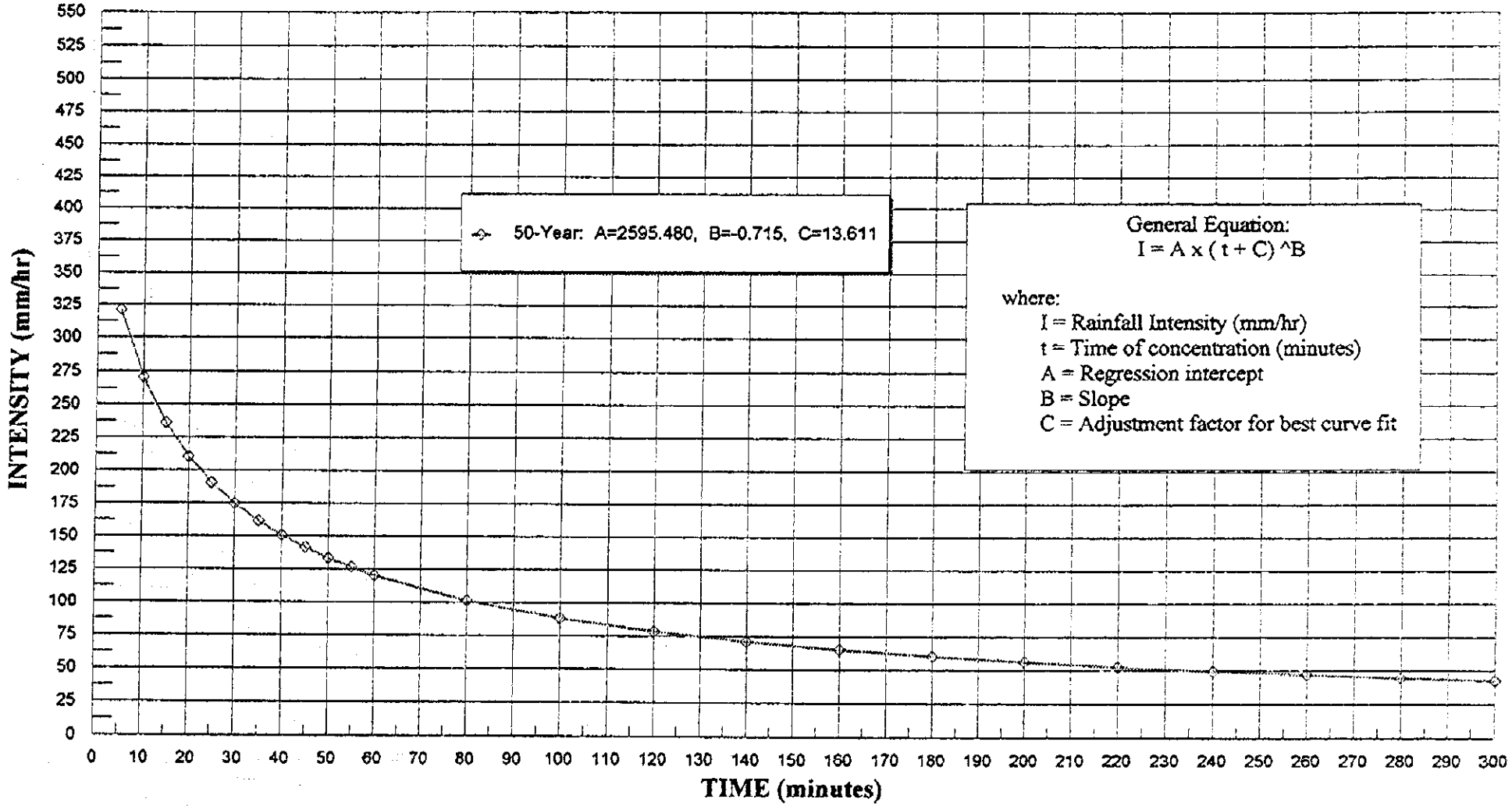
FIGURES

FIGURE 1
RAINFALL INTENSITY DURATION FREQUENCY CURVE
Makinabang, Baliwag, Bulacan
(Based on 18 years of record)



File Name: BALI-CUR.WK4

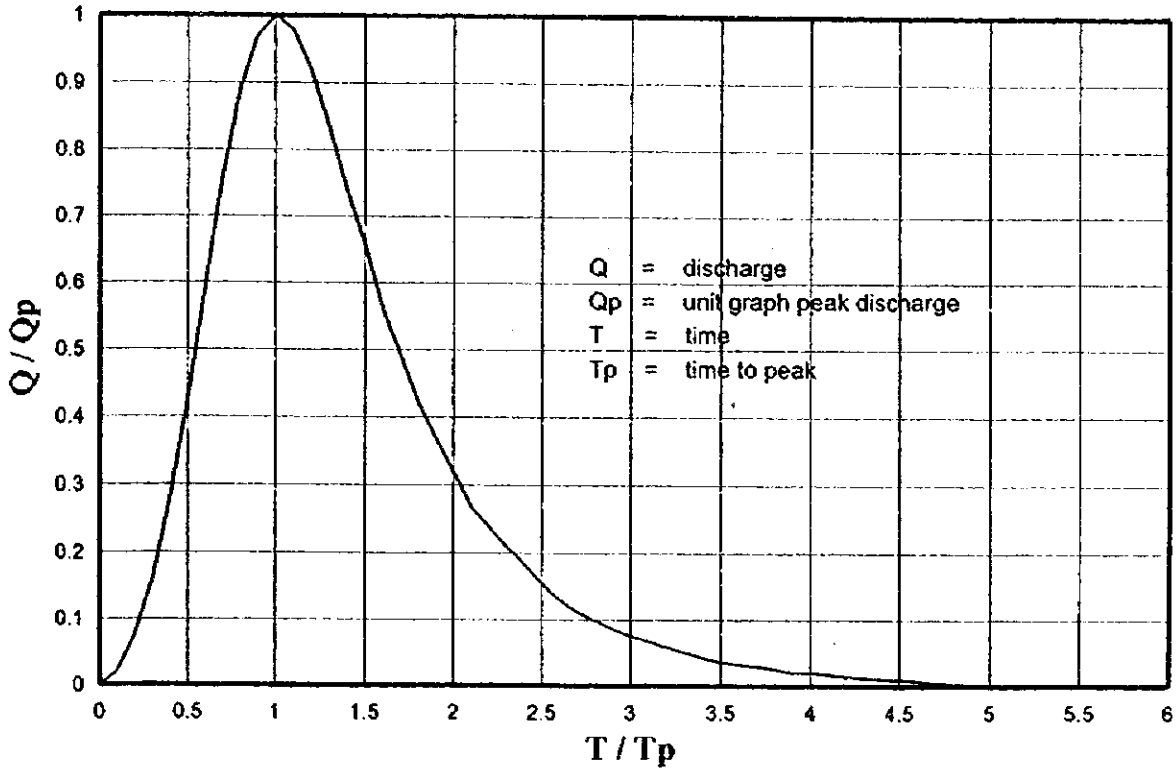
FIGURE 2
RAINFALL INTENSITY DURATION FREQUENCY CURVE
Cabanatuan City
(Based on 33 years of record)



File Name: CABA-CUR.WK4

FIGURE 3

SCS DIMENSIONLESS UNIT HYDROGRAPH
ADOPTED FROM
U. S. SOIL CONSERVATION SERVICE



APPENDIX A

BRIDGE CATCHMENT AREAS

ANGAT RIVER BRIDGE

SCALE 1: 250,000

A12-24

ANGAT RIVER BRIDGE

SCALE 1: 250,000

N

A12-24

TALAVERA RIVER BRIDGE

PAMPANGA RIVER BRIDGE

SCALE 1: 250,000

A12-25

TALAVERA RIVER BRIDGE

PAMPANGA RIVER BRIDGE

SCALE 1: 250,000

A12-25

APPENDIX B

REGRESSION ANALYSES FOR EACH RIDF CURVES

REGRESSION ANALYSIS FOR RAINFALL INTENSITY VS. DURATION

RAINFALL STATION :..... MAKINABANG, BALIWAG, BULACAN
RECURRENCE INTERVAL : 50 - YEAR RETURN PERIOD

RANK	TIME (t) (min)	(y) Io (mm/hr)	(x) (t + C) (min)	Log x	Log y	Logx Logy	$(\text{Log x})^2$	$(\text{Log y})^2$	I (mm/hr)
1	5	358.8	14.999	1.176	2.555	3.005	1.383	6.527	334.5
2	10	271.8	19.999	1.301	2.434	3.167	1.693	5.926	278.0
3	15	232.4	24.999	1.398	2.366	3.308	1.954	5.599	240.8
4	20	207.6	29.999	1.477	2.317	3.423	2.182	5.370	214.2
5	30	174.0	39.999	1.602	2.241	3.589	2.567	5.020	178.0
6	45	140.7	54.999	1.740	2.148	3.739	3.029	4.615	145.1
7	60	117.9	69.999	1.845	2.072	3.822	3.404	4.291	124.2
8	80	103.9	89.999	1.954	2.017	3.941	3.819	4.067	105.7
9	100	94.4	109.999	2.041	1.975	4.032	4.167	3.901	92.9
10	120	86.0	129.999	2.114	1.934	4.089	4.469	3.742	83.4
11	150	76.5	159.999	2.204	1.884	4.152	4.858	3.548	73.0
12	180	69.4	189.999	2.279	1.841	4.196	5.193	3.391	65.4
13	360	46.0	369.999	2.568	1.663	4.270	6.596	2.765	42.6
14	720	28.0	729.999	2.863	1.447	4.144	8.199	2.094	27.5
15	1440	16.1	1449.999	3.161	1.207	3.815	9.994	1.456	17.7
S U M				29.725	30.101	56.692	63.506	62.312	

C	=	9.999
B	=	-0.643
A	=	1908.116
R	=	-0.9983

GENERAL EQUATION: $I = A * (t + C) ^ B$

I = Rainfall Intensity (mm/hr)
t = Time of concentration (minutes)
A = Regression intercept
B = Slope
C = Adjustment factor for best curve fit

R = Regression coefficient

File Name: 50Y-BULA.WK4

REGRESSION ANALYSIS FOR RAINFALL INTENSITY VS. DURATION

RAINFALL STATION :..... CABANATUAN CITY
RECURRENCE INTERVAL : 50 - YEAR RETURN PERIOD

RANK	TIME (t) (min)	(y) Io (mm/hr)	(x) (t + C) (min)	Log x	Log y	Logx Logy	(Log x)²	(Log y)²	I (mm/hr)
1	5	346.8	18.611	1.270	2.540	3.225	1.612	6.452	320.9
2	10	264.0	23.611	1.373	2.422	3.325	1.885	5.864	270.7
3	15	224.0	28.611	1.457	2.350	3.423	2.121	5.524	235.9
4	20	197.7	33.611	1.526	2.296	3.505	2.330	5.272	210.3
5	30	171.4	43.611	1.640	2.234	3.663	2.688	4.991	174.5
6	45	143.3	58.611	1.768	2.156	3.812	3.126	4.649	141.3
7	60	125.4	73.611	1.867	2.098	3.917	3.485	4.403	120.0
8	80	104.3	93.611	1.971	2.018	3.979	3.886	4.073	101.1
9	100	90.1	113.611	2.055	1.955	4.018	4.225	3.821	88.0
10	120	79.0	133.611	2.126	1.898	4.034	4.519	3.601	78.4
11	150	66.7	163.611	2.214	1.824	4.038	4.901	3.327	67.8
12	180	60.0	193.611	2.287	1.778	4.067	5.230	3.162	60.1
13	360	38.9	373.611	2.572	1.590	4.090	6.617	2.528	37.6
14	720	23.0	733.611	2.865	1.362	3.902	8.211	1.854	23.2
15	1440	14.0	1453.611	3.162	1.146	3.625	10.001	1.314	14.2
S U M				30.154	29.667	56.623	64.839	60.835	

C	=	13.611	GENERAL EQUATION: I = A * (t + C) ^ B
B	=	-0.715	I = Rainfall Intensity (mm/hr)
A	=	2595.480	t = Time of concentration (minutes)
			A = Regression intercept
			B = Slope
			C = Adjustment factor for best curve fit
R	=	-0.99917	R = Regression coefficient

File Name: 50Y-CABA.WK4

APPENDIX C

COMPUTATION OF WATERSHED DISCHARGE

PROJECT NAME..... PLARIDEL - BALIWAG BYPASS
LOCATION..... BULACAN (ANGAT RIVER)
PREPARED BY..... rda
DATE..... Jul-99

STREAM DATA:

D.A.....	873.050	Sq. Km.
L.....	102.500	Km.
Lc.....	72.500	Km.
S.....	0.00535	
Ct.....	1.90	
Cp.....	0.69	

UNIT HYDROGRAPH PARAMETERS:

Lg.....	20.66	hrs.
Tr.....	3.76	hrs.
Tp.....	22.54	hrs.
Qp.....	8.02	m³/s

***** UNIT HYDROGRAPH ANALYSIS *****

TIME (Hrs.)	T/TP	Q/QP	Q (cms/mm)
0.00	0.000	0.000	0.000
3.76	0.167	0.057	0.457
7.52	0.334	0.200	1.604
11.28	0.500	0.429	3.441
15.04	0.667	0.708	5.678
18.80	0.834	0.917	7.354
22.56	1.001	1.000	8.020
26.32	1.168	0.939	7.531
30.08	1.335	0.802	6.432
33.84	1.501	0.658	5.277
37.60	1.668	0.512	4.106
41.36	1.835	0.403	3.232
45.12	2.002	0.319	2.558
48.88	2.169	0.253	2.029
52.64	2.335	0.202	1.620
56.40	2.502	0.154	1.235
60.16	2.669	0.118	0.946
63.92	2.836	0.095	0.762
67.68	3.003	0.075	0.602
71.44	3.169	0.062	0.497
75.20	3.336	0.047	0.377
78.96	3.503	0.035	0.281
82.72	3.670	0.031	0.249
86.48	3.837	0.023	0.184
90.24	4.004	0.019	0.152
94.00	4.170	0.016	0.128
97.76	4.337	0.011	0.088
101.52	4.504	0.009	0.072
105.28	4.671	0.005	0.040
109.04	4.838	0.003	0.024
112.80	5.004	0.000	0.000

OF ORDINATES 31

File Name: O-ANG.RDA

PROJECT NAME..... PLARIDEL - BALIWAG BYPASS
LOCATION..... BULACAN (ANGAT RIVER)
PREPARED BY..... rda
DATE..... Jul-99

***** DERIVATION OF EFFECTIVE RAINFALL *****

STORM RETURN PERIOD.....	50	YEARS
RUNOFF CURVE NUMBER.....	85	
SOIL GROUP NUMBER.....	4	

RAINFALL STATION..... MAKINABANG, BALIWAG, BULACAN
RAIFALL CONSTANTS :

A.....	1908.1160
B.....	-0.6430
C.....	9.9990

DURATION Tr (hrs.)	RAINFALL DEPTH R (mm)	RAINFALL INCREMENT (mm)	REARRANGED RAINFALL INCREMENT (mm)	NET RAINFALL (mm)
3.76	214.0	214.0	15.6	0.00
7.52	277.9	63.9	16.4	8.76
11.28	322.7	44.8	18.6	10.96
15.04	358.5	35.7	20.0	12.36
18.80	388.7	30.3	23.8	16.16
22.56	415.3	26.5	26.5	18.86
26.32	439.1	23.8	35.7	28.06
30.08	460.7	21.7	44.8	37.16
33.84	480.7	20.0	214.0	206.36
37.60	499.3	18.6	63.9	56.26
41.36	516.7	17.4	30.3	22.66
45.12	533.1	16.4	21.7	14.06
48.88	548.7	15.6	17.4	9.76
52.64	563.5	14.8	14.8	7.16

Initial Abstraction.....	14.78	mm
Retention Loss.....	7.64	mm

OF RAINFALL EXCESS..... 14

File Name: O-ANG.RDA

PROJECT NAME..... PLARIDEL - BALIWAG BYPASS
LOCATION..... BULACAN (ANGAT RIVER)
PREPARED BY..... rda
DATE..... Jul-99

***** FLOOD HYDROGRAPH *****

DRAINAGE AREA.....	873.050	Sq. Km.	Ct.....	1.90	
L.....	102.500	Km.	Cp.....	0.69	
Lc.....	72.500	Km.	CURVE NO.....	85	
SLOPE.....	0.00535		RETURN PERIOD.....	50	YEARS

RAINFALL STATION..... MAKINABANG, BALIWAG, BULACAN

DURATION Tr (HRS.)	NET RAINFALL (mm)	UNIT HYDROGRAPH ORDINATES (cms)	FLOOD HYDROGRAPH ORDINATES (cms)	TOTAL FLOOD HYDROGRAPH ORDINATES (cms)
3.76	0.00	0.457	0.000	0.000
7.52	8.76	1.604	4.003	4.403
11.28	10.96	3.441	19.059	20.965
15.04	12.36	5.678	53.370	58.707
18.80	16.16	7.354	114.660	126.126
22.56	18.86	8.020	203.716	224.088
26.32	28.06	7.531	319.708	351.679
30.08	37.16	6.432	463.399	509.739
33.84	206.36	5.277	714.392	785.831
37.60	56.26	4.106	1121.994	1234.193
41.36	22.66	3.232	1674.275	1841.703
45.12	14.06	2.558	2290.687	2519.976
48.88	9.76	2.029	2766.491	3043.141
52.64	7.16	1.620	2976.664	3274.331
56.40		1.235	2881.627	3169.789
60.16		0.946	2583.421	2841.763
63.92		0.762	2212.798	2434.078
67.68		0.602	1815.379	1996.917
71.44		0.497	1466.699	1613.369
75.20		0.377	1173.429	1290.771
78.96		0.281	932.331	1025.564
82.72		0.249	738.985	812.883
86.48		0.184	574.717	632.189
90.24		0.152	446.525	491.177
94.00		0.128	353.738	389.112
97.76		0.088	279.667	307.634
101.52		0.072	224.264	246.690
105.28		0.040	174.720	192.193
109.04		0.024	134.711	148.182
112.80		0.000	110.531	121.584
116.56			85.628	94.191
120.32			68.076	74.883
124.08			54.510	59.961
127.84			40.085	44.093
131.60			30.585	33.643
135.36			19.791	21.771
139.12			12.409	13.650
142.88			5.044	5.549
146.64			2.439	2.683
150.40			1.243	1.368
154.16			0.521	0.573
157.92			0.172	0.189
161.68			0.000	0.000

BASE FLOW.....	297.67	cms
PEAK DISCHARGE.....	3274.33	cms

File Name: O-ANG.RDA

PROJECT NAME.....CABANATUAN BYPASS ROAD SECTION
LOCATION.....NUEVA ECIJA (PAMPANGA RIVER)
PREPARED BY.....rda
DATE.....Jul-99

STREAM DATA:

D.A.....	2443.750	Sq. Km.
L.....	117.500	Km.
Lc.....	49.250	Km.
S.....	0.01186	
Ct.....	1.90	
Cp.....	0.67	

UNIT HYDROGRAPH PARAMETERS:

Lg.....	19.17	hrs.
Tr.....	3.49	hrs.
Tp.....	20.92	hrs.
Qp.....	23.49	m^3/s

***** UNIT HYDROGRAPH ANALYSIS *****

TIME (Hrs.)	T/TP	Q/QP	Q (cms/mm)
0.00	0.000	0.000	0.000
3.49	0.167	0.057	1.339
6.98	0.334	0.200	4.698
10.47	0.500	0.429	10.077
13.96	0.667	0.708	16.631
17.45	0.834	0.917	21.540
20.94	1.001	1.000	23.490
24.43	1.168	0.939	22.057
27.92	1.335	0.802	18.839
31.41	1.501	0.658	15.456
34.90	1.668	0.512	12.027
38.39	1.835	0.402	9.443
41.88	2.002	0.319	7.493
45.37	2.169	0.253	5.943
48.86	2.336	0.201	4.721
52.35	2.502	0.154	3.617
55.84	2.669	0.118	2.772
59.33	2.836	0.095	2.232
62.82	3.003	0.075	1.762
66.31	3.170	0.062	1.456
69.80	3.337	0.047	1.104
73.29	3.503	0.035	0.822
76.78	3.670	0.031	0.728
80.27	3.837	0.023	0.540
83.76	4.004	0.019	0.446
87.25	4.171	0.016	0.376
90.74	4.337	0.011	0.258
94.23	4.504	0.009	0.211
97.72	4.671	0.005	0.117
101.21	4.838	0.003	0.070
104.70	5.005	0.000	0.000

OF ORDINATES 31

File Name: O-PAMPAN.RDA

PROJECT NAME.....CABANATUAN BYPASS ROAD SECTION
LOCATION.....NUEVA ECIJA (PAMPANGA RIVER)
PREPARED BY.....rda
DATE.....Jul-99

******* DERIVATION OF EFFECTIVE RAINFALL *******

STORM RETURN PERIOD.....	50	YEARS
RUNOFF CURVE NUMBER.....	85	
SOIL GROUP NUMBER.....	4	

RAINFALL STATION..... CABANATUAN CITY
RAIFALL CONSTANTS :

A.....	2595.4800
B.....	-0.7150
C.....	13.6110

DURATION Tr (hrs.)	RAINFALL DEPTH R (mm)	RAINFALL INCREMENT (mm)	REARRANGED RAINFALL INCREMENT (mm)	NET RAINFALL (mm)
3.49	189.7	189.7	9.4	0.00
6.98	236.3	46.6	10.0	2.91
10.47	267.2	31.0	11.4	4.31
13.96	291.2	23.9	12.4	5.31
17.45	311.0	19.8	15.1	8.01
20.94	328.1	17.1	17.1	10.01
24.43	343.2	15.1	23.9	16.81
27.92	356.8	13.6	31.0	23.91
31.41	369.2	12.4	189.7	182.61
34.90	380.7	11.4	46.6	39.51
38.39	391.3	10.6	19.8	12.71
41.88	401.3	10.0	13.6	6.51
45.37	410.6	9.4	10.6	3.51
48.86	419.5	8.9	8.9	1.81

Initial Abstraction.....	9.40	mm
Retention Loss.....	7.09	mm

OF RAINFALL EXCESS..... 14

File Name: O-PAMPAN.RDA

PROJECT NAME.....CABANATUAN BYPASS ROAD SECTION
LOCATION.....NUEVA ECIJA (PAMPANGA RIVER)
PREPARED BY.....rda
DATE.....Jul-99

***** FLOOD HYDROGRAPH *****

DRAINAGE AREA.....	2443.750	Sq. Km.	CI.....	1.90	
L.....	117.500	Km.	Cp.....	0.67	
Lc.....	49.250	Km.	CURVE NO.....	85	
SLOPE.....	0.01186		RETURN PERIOD.....	50	YEARS
RAINFALL STATION.....	CABANATUAN CITY				

DURATION Tr (HRS.)	NET RAINFALL (mm)	UNIT HYDROGRAPH ORDINATES (cms)	FLOOD HYDROGRAPH ORDINATES (cms)	TOTAL FLOOD HYDROGRAPH ORDINATES (cms)
3.49	0.00	1.339	0.000	0.000
6.98	2.91	4.698	3.894	4.264
10.47	4.31	10.077	19.432	21.375
13.96	5.31	16.631	56.655	62.321
17.45	8.01	21.540	127.445	140.189
20.94	10.01	23.490	238.813	262.694
24.43	16.81	22.057	399.626	439.588
27.92	23.91	18.839	624.711	687.183
31.41	182.61	15.456	1139.670	1253.637
34.90	39.51	12.027	2078.155	2285.970
38.39	12.71	9.443	3415.747	3757.322
41.88	6.51	7.493	4946.262	5440.889
45.37	3.51	5.943	6124.771	6737.248
48.86	1.61	4.721	6631.014	7294.115
52.35		3.617	6366.969	7003.666
55.84		2.772	5615.472	6177.019
59.33		2.232	4723.080	5195.388
62.82		1.762	3797.831	4177.614
66.31		1.456	3023.135	3325.448
69.80		1.104	2404.288	2644.717
73.29		0.822	1905.970	2096.567
76.78		0.728	1508.112	1658.923
80.27		0.540	1170.787	1287.866
83.76		0.446	906.594	997.253
87.25		0.376	719.910	791.901
90.74		0.258	569.321	626.254
94.23		0.211	459.684	505.652
97.72		0.117	356.895	392.584
101.21		0.070	273.111	300.422
104.70		0.000	227.203	249.923
108.19			175.474	193.021
111.68			140.632	154.695
115.17			114.209	125.630
118.66			82.903	91.193
122.15			63.589	69.948
125.64			39.642	43.606
129.13			23.891	26.280
132.62			7.211	7.932
136.11			2.858	3.144
139.60			1.246	1.372
143.09			0.457	0.503
146.58			0.127	0.139
150.07			0.000	0.000

BASE FLOW.....	663.10	cms
PEAK DISCHARGE.....	7294.12	cms

File Name: O-PAMPAN.RDA

PROJECT NAME..... CABANATUAN BYPASS ROAD SECTION
LOCATION..... NUEVA ECIJA (TALAVERA RIVER)
PREPARED BY..... rda
DATE..... Jul-99

STREAM DATA:			UNIT HYDROGRAPH PARAMETERS:		
D.A.....	439.375	Sq. Km.	Lg	17.18	hrs.
L.....	80.750	Km.	Tr.....	3.12	hrs.
Lc.....	49.750	Km.	Tp.....	18.74	hrs.
S.....	0.01113		Qp.....	4.78	m³/s
Ct.....	1.90				
Cp.....	0.68				

***** UNIT HYDROGRAPH ANALYSIS *****

TIME (Hrs.)	T/TP	Q/QP	Q (cms/mm)
0.00	0.000	0.000	0.000
3.12	0.166	0.057	0.272
6.24	0.333	0.200	0.956
9.36	0.499	0.427	2.041
12.48	0.666	0.706	3.375
15.60	0.832	0.916	4.378
18.72	0.999	1.000	4.780
21.84	1.165	0.941	4.498
24.96	1.332	0.805	3.848
28.08	1.498	0.660	3.155
31.20	1.665	0.515	2.462
34.32	1.831	0.404	1.931
37.44	1.998	0.321	1.534
40.56	2.164	0.254	1.214
43.68	2.331	0.203	0.970
46.80	2.497	0.156	0.746
49.92	2.664	0.119	0.569
53.04	2.830	0.095	0.454
56.16	2.997	0.075	0.359
59.28	3.163	0.063	0.301
62.40	3.330	0.048	0.229
65.52	3.496	0.035	0.167
68.64	3.663	0.031	0.148
71.76	3.829	0.024	0.115
74.88	3.996	0.019	0.091
78.00	4.162	0.016	0.076
81.12	4.329	0.011	0.053
84.24	4.495	0.009	0.043
87.36	4.662	0.005	0.024
90.48	4.828	0.003	0.014
93.60	4.995	0.000	0.000

OF ORDINATES 31

PROJECT NAME..... CABANATUAN BYPASS ROAD SECTION
LOCATION..... NUEVA ECIJA (TALAVERA RIVER)
PREPARED BY.....rda
DATE.....Jul-99

******* DERIVATION OF EFFECTIVE RAINFALL *******

STORM RETURN PERIOD.....	50	YEARS
RUNOFF CURVE NUMBER.....	85	
SOIL GROUP NUMBER.....	4	

RAINFALL STATION.....CABANATUAN CITY
RAIFALL CONSTANTS :

A.....	2595.4800
B.....	-0.7150
C.....	13.6110

DURATION Tr (hrs.)	RAINFALL DEPTH R (mm)	RAINFALL INCREMENT (mm)	REARRANGED RAINFALL INCREMENT (mm)	NET RAINFALL (mm)
3.12	182.8	182.8	9.1	0.00
6.24	228.2	45.5	9.7	3.36
9.36	258.4	30.1	11.1	4.76
12.48	281.6	23.3	12.0	5.66
15.60	300.9	19.3	14.7	8.36
18.72	317.5	16.6	16.6	10.26
21.84	332.1	14.7	23.3	16.96
24.96	345.3	13.2	30.1	23.76
28.08	357.4	12.0	182.8	176.46
31.20	368.5	11.1	45.5	39.16
34.32	378.8	10.3	19.3	12.96
37.44	388.5	9.7	13.2	6.86
40.56	397.6	9.1	10.3	3.96
43.68	406.2	8.6	8.6	2.26

Initial Abstraction.....	9.10	mm
Retention Loss.....	6.34	mm

OF RAINFALL EXCESS..... 14

PROJECT NAME..... CABANATUAN BYPASS ROAD SECTION
LOCATION..... NUEVA ECIJA (TALAVERA RIVER)
PREPARED BY..... rda
DATE..... Jul-99

******* FLOOD HYDROGRAPH *******

DRAINAGE AREA.....	439.375	Sq. Km.	Ct.....	1.90	
L.....	80.750	Km.	Cp.....	0.68	
Lc.....	49.750	Km.	CURVE NO.....	85	
SLOPE.....	0.01113		RETURN PERIOD.....	50	YEARS
RAINFALL STATION.....	CABANATUAN CITY				

DURATION Tr (HRS.)	NET RAINFALL (mm)	UNIT HYDROGRAPH ORDINATES (cms)	FLOOD HYDROGRAPH ORDINATES (cms)	TOTAL FLOOD HYDROGRAPH ORDINATES (cms)
3.12	0.00	0.272	0.000	0.000
6.24	3.36	0.956	0.914	1.005
9.36	4.76	2.041	4.507	4.958
12.48	5.66	3.375	12.948	14.243
15.60	8.36	4.378	28.741	31.615
18.72	10.26	4.780	53.112	58.423
21.84	16.96	4.498	87.490	96.239
24.96	23.76	3.848	134.481	147.929
28.08	176.46	3.155	237.953	261.748
31.20	39.16	2.462	424.341	466.775
34.32	12.96	1.931	687.278	756.006
37.44	6.86	1.534	989.212	1088.133
40.56	3.96	1.214	1222.795	1345.074
43.68	2.26	0.970	1324.466	1456.913
46.80		0.746	1275.103	1402.613
49.92		0.569	1128.475	1241.322
53.04		0.454	951.561	1046.717
56.16		0.359	768.467	845.314
59.28		0.301	612.875	674.163
62.40		0.229	488.262	537.088
65.52		0.167	386.969	425.666
68.64		0.148	307.105	337.816
71.76		0.115	239.101	263.011
74.88		0.091	184.873	203.360
78.00		0.076	146.064	160.670
81.12		0.053	115.531	127.084
84.24		0.043	93.915	103.307
87.36		0.024	73.149	80.464
90.48		0.014	55.506	61.056
93.60		0.000	46.040	50.644
96.72			36.384	40.023
99.84			28.638	31.502
102.96			23.011	25.312
106.08			16.833	18.516
109.20			12.870	14.157
112.32			8.080	8.888
115.44			4.838	5.322
118.56			1.536	1.690
121.68			0.636	0.700
124.80			0.288	0.317
127.92			0.110	0.121
131.04			0.032	0.035
134.16			0.000	0.000

BASE FLOW.....	132.45	cms
PEAK DISCHARGE.....	1456.91	cms

File Name: O-TALAVE.RDA