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PROFESSIONAL
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DESIGN COMPUTATIONS
FOR
PLANT IV STORMWATER DETENTION SYSTEM
BEECH AIRCRAFT CORPORATION
WICHITA, KANSAS
JULY 31, 1985

PREPARED BY

PROFESSIONAL ENGINEERING CONSULTANTS, P.A.
1440 EAST ENGLISH
WICHITA, KANSAS 67211

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WICHITA, KANSAS 67211
(316) 262-2691

PROFESSIONAL
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PROFESSIONAL ASSOCIATION

July 31, 1985

Mr. James Beckett, P.E., Manager
Plant Engineering Department
Beech Aircraft Corporation
9709 East Central
Wichita, Kansas 67206

Attention: Joe Freemen, P.E.

Reference: Hydrologic/Hydraulic Study
Plant IV Area

Dear Mr. Beckett:

The Hydrologic/Hydraulic Study of the Plant IV Area has been completed. In order to reduce stormwater discharge rates to the downstream area, we recommend utilization of three sites for detention:

1. The radar range access road detention area, which was recently completed.

2. An area lying between Plant IV and Greenwich Road. By installing a reducer and 18" CMP end section at the inlet end of the existing 36-inch CMP culvert, the storage area available at this location may be fully utilized.

3. The area near Beech Corporation's south property line where it abuts the former David's facilities. This location lies downstream of the first two facilities and will work in conjunction with them. The Chelsea Brooke Addition Drainage Plan assumes a maximum discharge flowrate from your property of 36 cfs for the 100-year design event. The structure required to attain this reduction would be an earthen berm with a 24-inch outlet. With a design water surface of 1359 MSL, the berm should be constructed to elevation 1360 MSL to provide one foot of freeboard. We propose to soften the harsh lines of this type of structure by varying both the vertical profile and the side slopes to produce an "earth sculpture" effect.

Transmitted herewith is the set of construction drawings (4 sheets) which has been prepared to construct Items 2 and 3, above. Estimated construction quantities are included on the plans.

Two (2) copies of the hydrologic/hydraulic computations are also being transmitted.

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By copy of this letter, we are transmitting two (2) copies of the computations to the office of the City Engineer, Wichita, Kansas.

If you have any questions or require further assistance, please do not hesitate to call.

Very truly yours,

PROFESSIONAL ENGINEERING CONSULTANTS, P.A.

Michael W. Berry

Michael W. Berry, P.E.
Design Engineer

attachments

xc: Michael E. Lindebak, P.E., City Engineer,
Attn: Chris Breitenstein, P.E., w/2 attachments.
Carl Chuzy Company, Attn: Jeffrey S. Greenberg, w/o attachments.

MWB/mkm

DESIGN COMPUTATIONS
FOR
PLANT IV STORMWATER DETENTION SYSTEM
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INTRODUCTION

This report was prepared to present the results of a study undertaken to investigate the feasibility of provision of detention facilities for a site owned by Beech Aircraft Corporation. The site lies in the East 1/2 of Section 21, T27S, R2E, in Sedgwick County, Kansas, immediately upstream of David's East Addition and the proposed Chelsea Brooke Addition. Reference is made to the report entitled "Drainage Plan and Supporting Calculations, Chelsea Brooke Addition, Wichita, Sedgwick County, Kansas," dated April 16, 1985.

There are two existing and one proposed detention basin locations on the site. The recently constructed embankment and culvert for the Radar Range Facility access road was designed to act as a detention facility. A study of this site was prepared for the Chelsea Brooke drainage plan. The second existing site utilizes the roadway embankment and culvert for the Plant IV entrance from Greenwich Road.

The proposed site would be created by construction of an earthen berm along the south Beech property line with a small conduit to restrict the flow. The Chelsea Brooke Drainage Plan assumed that the 100-year design discharge from Drainage Area No. 1 (Beech property) would be restricted to no more than 36 cfs. Existing culverts at both Kellogg (US 54) and the Kansas Turnpike (I-35) are inadequate for present conditions in the watershed. Reduction of the flowrate would benefit downstream landowners by reducing the potential damage in an area which has had recurrent flooding problems in the past.

HYDROLOGIC ANALYSIS METHODOLOGY

The hydrology techniques used in this report parallel those used in the Chelsea Brooke Drainage Plan. (Reference #1.) Times of concentration were evaluated using the Soil Conservation Service (SCS) Modified Curve Number Method as presented in Technical Release #55. (Reference #2.) Rossmiller's Runoff Coefficient was used in conjunction with the Rational Formula for computation of the design discharges. (See Reference #3.) The SCS Graphical Method was also used to determine a comparative design flowrate, but these values were not used. The SCS Tabular Method Hydrograph was reduced to dimensionless coefficients and then used to create a synthetic hydrograph for each subarea. The 100-year storm was used as the design event.

HYDRAULIC ANALYSIS METHODOLOGY

For each detention basin, stage-storage relationships were established using planimetered areas on a 1 in = 100 ft scale contour map. The stage-discharge curves were developed using nomographs for culvert capacity in Hydraulic Engineering Circular No 5. (Reference #4.) Based on this information, the runoff hydrograph was routed through the "reservoir" using the Modified Puls Method. (See Appendix.)

ALTERNATIVES INVESTIGATED

The Radar Range Access Road site was studied in detail in Reference #1. In that report, the drainage area was taken to be 75 acres with an assumed impervious area of 20%. Based on the more detailed information used in this report, the drainage area was taken to be 56.9 acres, with approximately 26% imperviousness. Thus, the inflow hydrograph was modified and re-routed through the reservoir. Detailed computations are included in Section B.

The Plant IV Entrance Road currently has a 36" CMP entrance culvert. The runoff hydrograph was routed through this site, and the results indicated that little detention effect is currently taking place, but that freeboard is available.

To effect some detention benefit, smaller pipe sizes were considered: 30-inch, 24-inch, and 18-inch. For an effective reduction in flowrate and greatest utilization of the available detention volume, an 18-inch pipe is recommended. Since the theoretical 18-inch CMP operates in inlet control throughout the range of discharges experienced, this modification can be made by installing an 18-inch end section and reducer on the inlet end of the existing CMP culvert, without replacing the entire pipe. Computations for this basin are given in Section C.

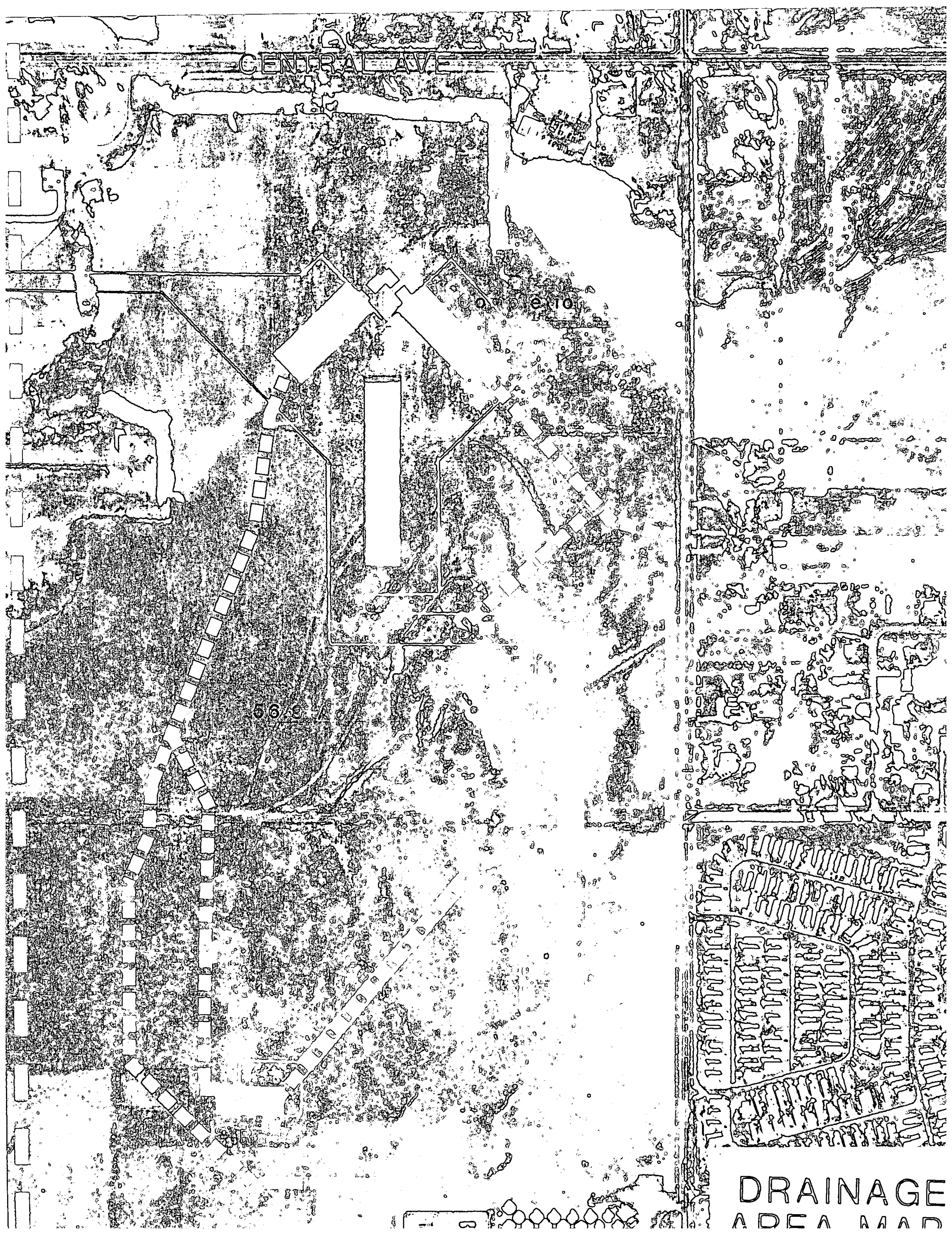
Outflow hydrographs from the above two facilities were combined with the runoff hydrograph from the lower part of the watershed to generate the inflow hydrograph for the lower detention basin. This basin was conceptualized as a berm with maximum top elevation of 1360 and a 6:1 slope on the north face. Stage-discharge and reservoir routing computations were made for 36-inch, 30-inch, and 24-inch outfalls.

The 24-inch outfall limited the discharge rate to 32 cfs at a maximum design water surface of 1359.0 MSL. Since the culvert operates in inlet control throughout its operating range, either RCP or CMP pipe may be used. A

24-inch CMP was selected to minimize cost. In the final design process, both the top elevation and the berm slopes were varied to provide a pleasing earth-sculpturing effect. Section 4 contains complete calculations for this basin.

RECOMMENDATIONS

Significant detention volumes on this site are available at three locations. By construction of an earthen berm south of Plant IV and by modifying the existing culvert under the Plant IV entrance the maximum potential volume can be utilized to reduce the 100-year design flowrate to the maximum target value of 36 cfs. This would be consistent with presumptions made in development of the Chelsea Brooke Drainage Plan for the ultimate conditions.


CENTRAL AVE
56.9 Ac
DRAINAGE
AREA MAP

M.S. 6/26/85

RADAR RANGE DETENTION BASIN

$\Sigma DA = 1.9 + 3.6 + 0.10 + 2.61 + 5.74 + 3.41 + 4.74 + 5.54 + 0.54 + 0.96 + 2.41 + 5.74 + 5.74 + 1.47 + 0.4 + 5.33 + 3.43 + 3.23 = 56.9$ Ac

Imp Area $= 1.9 + 3.25 + 2.84 + 1.56 + 0.74 + 2.07 + 0.56 + 1.08 + 0.20 + 0.03 + 0.8 = 15.03$ Ac

$\frac{15.03}{56.9} = 26\%$ 1985 Conditions

The analysis in Section B of "Chelsea Brooke Addition Drainage Plan" used a DA of 75 Ac & assumed 20% Impervious based on USGS 1"=2000' contour map. With 100'=1" scale, 2' contour aerial topo, we find impervious area = 15.03 Ac of a total of 56.9 Ac. Using this info and using the same Rossmiller methodology, we find the following (See Sh. No. ______)

$T_c = 25$ min.

$Q_{100} = 230$ cfs.

The inflow hydrograph changes based on this information. Thus, the stage-storage and outflow hydrographs will change. The stage-discharge curves & 2S/Δt + O vs O are still valid.

URBAN HYDROLOGY FOR SMALL WATERSHEDS (TR-55)
PEAK DISCHARGE WORKSHEET
FOR GRAPHICAL (T_c) METHOD (FIGURE 5-2)

Project BEECH RADAR SITE DETENTION BASIN By MWB Date 6/26/85
Checked ______ Date ______

Steps Peak Discharge Computation for up to 3 storms: Type II, Duration 24 hours.

1. Data: Watershed Condition = 26% Imp (1985 Cond.) (present or future).
   - Drainage Area (DA) = 56.9 acres. Ave. Watershed Slope (S) = 2.50 %.
   - Ponding and Swampy areas (PND) = — acres, ______ % of DA
   - Impervious Area (IMP) = 15.03 acres, 26 % of DA
   - Total Hydraulic Length (HL) = 2650 feet
   - Hydraulic Length Modified (HLM) = ______ feet, 50 % of HL

	1st Storm	2nd Storm	3rd Storm	
2. Rainfall Frequency (F)	5	50	100	yrs.
3. Rainfall Depth (P)	4.5	7.0	7.8	inches
4. Runoff Curve Number (CN) = 85 — See other side for computation				
5. Runoff Depth (Q) — Use P, CN, and Table 2-1.	2.91	5.26	6.02	inches
6. Time of Concentration (T_c) = 0.41 hrs. — See other side for computations (check one): [ ] Velocity Method [X] Lag-CN Method [ ] Other ______		x		
7. Unit Peak Discharge (q) — Use T_c and Figure 5-2		580		csm/inch of Q
		x		
8. Drainage Area $\left[\frac{DA(acres)}{640(ac/sm)}\right] = \left[\frac{56.9}{640}\right] =$		0.0889		sq. miles
		x		
*9. Ponding and Swampy Area Peak Factor — Only use % PND, F and Table E-3; when PND is spreadout in watershed and not related to T_c flow path.	—	—	—	
		=		
10. Peak Discharge Area Factor where q_p = Steps #5 x 7 x 8 x 9	150	271	310	cfs

S = 1.76

$Q = \frac{(P-0.2S)^2}{P+0.8S}$

← SCS METHOD (FOR INFO ONLY)

*If the adjustment is not applicable, enter a Factor of 1.0.

ROSSMILLER T_c = 25 min.

$i_5 = 4.27$ $i_{50} = 6.53$ $i_{100} = 7.36$

$C_5 = 0.43$ $C_{50} = 0.52$ $C_{100} = 0.55$

$Q_5 = 105$ cfs $Q_{50} = 193$ cfs $Q_{100} = 230$ cfs

(TR NOTICE 55-A, September 1981)

Project: Beech Radar Site Detention Basin
Job No.: 36-84553-2-403

RESERVOIR ROUTING TABLE

Date: 6/27/85
By: MWB

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
11.0	7	15	0	—	0	1361.3	0
11.1	8	16	11	15	2	1361.6	0
11.2	8	17	21	27	3	1361.9	1
11.3	9	21	30	38	4	1362.0	1
11.4	12	28	41	51	5	1362.1	2
11.5	16	48	57	69	6	1362.2	2
11.6	32	73	89	105	8	1362.4	4
11.7	41	131	140	162	11	1362.7	8
11.8	90	258	239	271	16	1363.0	11
11.9	168	391	445	497	26	1363.7	25
12.0	223	453	764	836	36	1364.3	40
12.1	230	409	1129	1217	44	1364.8	53
12.2	179	312	1430	1538	54	1365.4	72
12.3	133	232	1630	1742	56	1365.6	79
12.4	99	175	1744	1862	59	1365.9	89

$(3)_n + (4)_n = (5)_{n+1}$ $(5)_n - 2 \times (6)_n = (4)_n$

Project: Beech Radar Site Detention Basin RESERVOIR ROUTING TABLE
Job No.: 36-84532-2-403

Date: 6-27-85
By: NMB

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2 Ac-In
12.5	76	138	1797	1,919	61	1366.1	96
12.6	62	113	1811	1,935	62	1366.1	96
12.7	51	92	1802	1924	61	1366.1	96
12.8	41	78	1774	1894	60	1366.0	91
12.9	37	69	1734	1852	59	1365.9	89
13.0	32	62	1687	1803	58	1365.8	85
13.1	30	58	1635	1749	57	1365.7	82
13.2	28	54	1583	1693	55	1365.6	79
13.3	26	50	1529	1637	54	1365.5	76
13.4	24	45	1475	1579	52	1365.3	68
13.5	21	41	1418	1520	51	1365.2	65
13.6	20	39	1361	1459	49	1365.1	62
13.7	19	37	1302	1400	49	1365.1	62
13.8	18	35	1245	1339	47	1365.0	59
13.9	17	33	1188	1280	46	1364.9	56

$(3)_n + (4)_n = (5)_{n+1}$ $(5)_n - 2 \times (6)_n = (4)_n$

14.0 16

B-6

Project: 36-84558-2-403
Job No.: BEECH DRAINAGE
RADAR SITE DET. BASIN

RESERVOIR ROUTING TABLE

Date: 7/2/85
By: MKB
Page 3 of 4

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	AcIn/Hr	AcIn/Hr	AcIn/Hr	AcIn/Hr	AcIn/Hr	Ft MSL	Ac In
14.0	16	32	1133	1221	44	1364.8	53
14.1	15.6	31	1079	1165	43	4.8	53
14.2	15.3	30	1026	1110	42	4.7	51
14.3	15.0	30	974	1056	41	4.6	48
14.4	14.6	29	926	1004	39	4.5	45
14.5	14.2	28	879	955	38	4.5	45
14.6	13.9	28	833	907	37	4.4	43
14.7	13.6	27	789	861	36	4.3	40
14.8	13.2	26	746	816	35	4.3	40
14.9	12.8	25	706	772	33	4.2	37
15.0	12.5	25	667	731	32	1364.1	35
15.1	12.2	24	628	692	32	4.1	35
15.2	11.8	23	592	652	30	4.0	32
15.3	11.5	23	557	615	29	3.9	30
15.4	11.1	22	524	580	28	1363.9	30

$(3)_n + (4)_n = (5)_{n+1}$ (0.75)

$(5)_n - 2 \times (6)_n = (4)_n$

Project: 36-84558-2-403
Job No.: BEECH RADAR SITE DETENTION BASIN

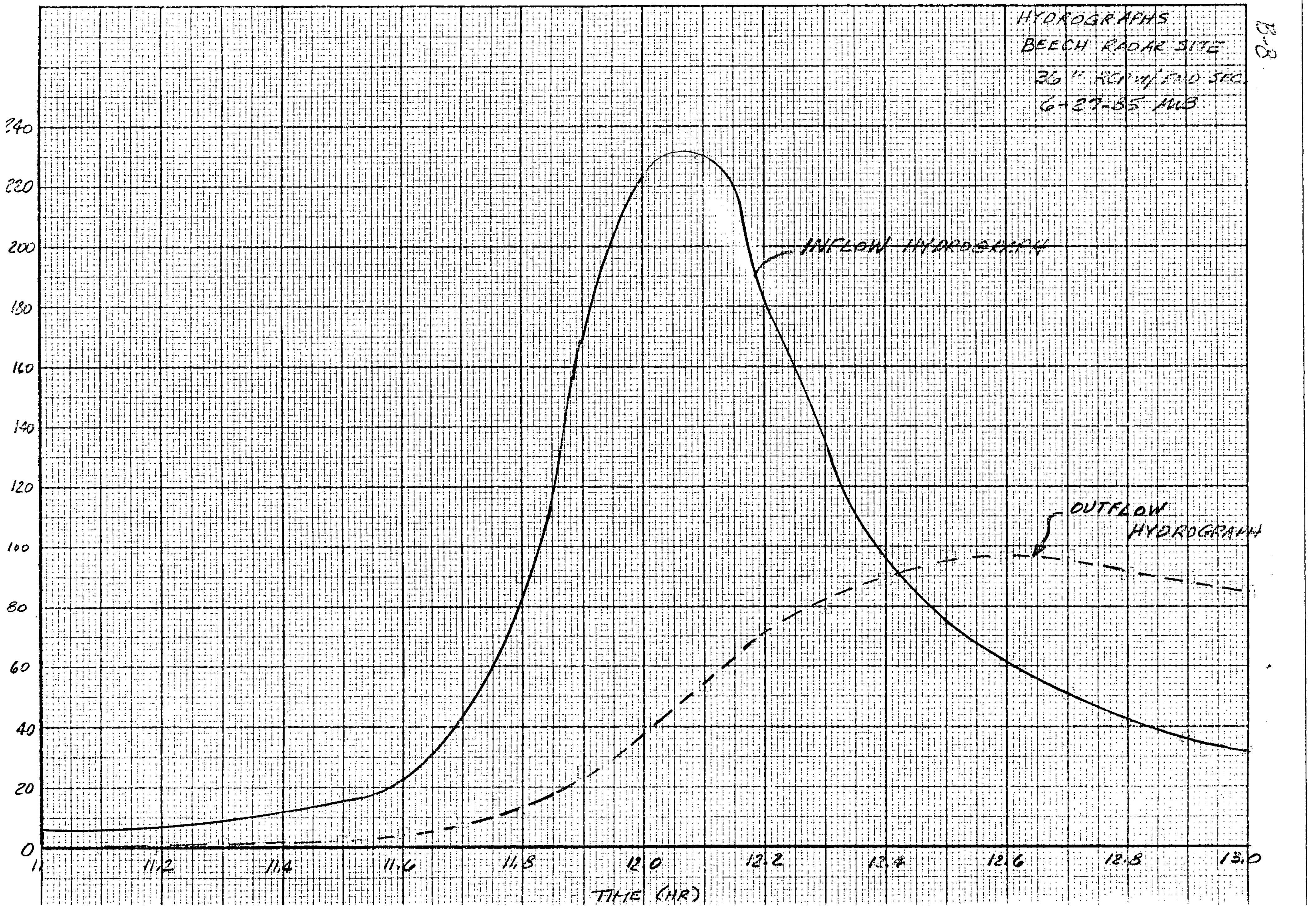
RESERVOIR ROUTING TABLE

Date: 7/2/85
By: MB

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
15.5	10.8	21	492	546	27	1363.8	28
15.6	10.4	20	461	513	26	1363.6	23
15.7	10.0	20	431	481	25	1363.6	23
15.8	9.7	19	403	451	24	1363.6	23
15.9	9.4	18	376	422	23	1363.5	22
16.0	9.0	18	350	394	22	1363.4	20

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$


HYDROGRAPHS
BEECH RADAR SITE
36" RCP w/ END SEC.
6-27-85 MWB
INFLOW HYDROGRAPH
OUTFLOW HYDROGRAPH
240
220
200
180
160
140
120
100
80
60
40
20
0
11.2
11.4
11.6
11.8
12.0
12.2
12.4
12.6
12.8
13.0
TIME (HR)

URBAN HYDROLOGY FOR SMALL WATERSHEDS (TR-55)
PEAK DISCHARGE WORKSHEET
FOR GRAPHICAL (T_c) METHOD (FIGURE 5-2)

Project: BEECH SURFACE DRAINAGE PLANT & ENTRANCE — By: MWB — Date: 6/24/85

Checked: ______ — Date: ______

Steps — Peak Discharge Computation for up to 3 storms: Type II, Duration 24 hours.

1. Data: Watershed Condition = Future Max. Anticipated (present or future).

   Drainage Area (DA) = 12.9 acres. Ave. Watershed Slope (S) = ______ %.

   Ponding and Swampy areas (PND) = — acres, ______ % of DA

   Impervious Area (IMP) = 1.8 acres, 20 % of DA

   Total Hydraulic Length (HL) = 1500 feet

   Hydraulic Length Modified (HLM) = — feet, 0 % of HL

	1st Storm	2nd Storm	3rd Storm	
2. Rainfall Frequency (F)	5	50	100	yrs.
3. Rainfall Depth (P)	4.5	7.0	7.8	inches

S = 1.90

4. Runoff Curve Number (CN) = 84
   See other side for computation

5. Runoff Depth (Q) — Use P, CN, and Table 2-1.	2.82	5.14	5.91	inches

6. Time of Concentration (T_c) = 0.46 hrs. ← USE
   See other side for computations (check one): [ ] Velocity Method; [✓] Lag-CN Method; [ ] Other ______

x

7. Unit Peak Discharge (q) — Use T_c and Figure 5-2: 540 csm/inch of Q

x

8. Drainage Area $\left[\frac{DA(acres)}{640(ac/sm)}\right] = \left[\frac{12.9}{640}\right] =$ 0.0202 sq. miles

x

*9. Ponding and Swampy Area Peak Factor — Only use % PND, F and Table E-3; when PND is spreadout in watershed and not related to T_c flow path.	1.0	1.0	1.0	
10. Peak Discharge Area Factor — where q_p = Steps #5 x 7 x 8 x 9	30.8	56.1	64.4	cfs ← For Info Only

*If the adjustment is not applicable, enter a Factor of 1.0.

ROSSMILLER METHOD

$i_5 = 4.09$ in/hr $i_{50} = 6.25$ in/hr $i_{100} = 7.04$ in/hr

$C_5 = 0.41$ $C_{50} = 0.49$ $C_{100} = 0.51$

$Q_5 = 21.6$ cfs $Q_{50} = 39.5$ cfs $Q_{100} = 46.3$ cfs

USE

C-2

TR-55 GRAPHICAL (T_c) METHOD, PEAK DISCHARGE WORKSHEET (CONT.)

Steps from other side

4. Runoff Curve Number (CN)

Hydrologic Soil Group (Appendix B)	Land Use Description Include Treatment, Practice & Condition (Table 2-2)	CN (Table 2-2) (3)	% or Area (acres) (4)	Product (3)x(4) (5)
D	Pasture	80	80%	
D	Imp.	98	20%	
		Totals =		

CN (weighted) = $\frac{\text{total col. 5}}{\text{total col. 4}}$ [______] = ______ ; use CN = **84**

5. Time of Concentration (T_c) Select computation method, (a) is recommended.

(a) Velocity Method

Reach	Description of Flow 1/	Length (ft.) (3)	Velocity (ft/sec) (4)	Travel Time (sec.) (3) ÷ (4)
	Pasture, overland, 1.5% slope	1500	0.85	29.4 min
			Totals =	sec.

1/ Use Figure 3.1 for overland flow portion of travel time.

T_c = $\frac{\text{Total Travel Time (sec.)}}{3{,}600 \text{ (sec./hr.)}}$ = [______ / 3,600] = **0.5** hrs.

(b) Lag-CN Method

(1) Unadjusted Lag (L)
Use HL, S, CN, and Figure 3-3. — **0.31** hrs.

x

*(2) Hydraulic Length Modified Lag Factor
Use % HLM, CN, and Figure 3-4. — **1.0** close!

x

*(3) Impervious Area Lag Factor
Use % IMP, CN, and Figure 3-5. — **0.88**

x

(4) Constant (T_c = 1.67L) — 1.67

=

(5) Time of Concentration (T_c)
where T_c = (1)x(2)x(3)x(4) — **0.46** hrs.

36-84558-2-403
Beech Surface Drainage
6-24-85 MWB

STAGE STORAGE
DETENTION AREA
PLANT 4 ENTRANCE

Top Road = $1368.\underline{7}$
℄ (N) = $1364.\underline{47}$ > 36" CMP w/ End Sections
℄ (S) = $1363.\underline{96}$

Areas by planimeter on 1"=100', 2' contour map.

Elev.	Area, Ac	Δh, in	ΔVol, Ac-In	ΣVol, Ac-In
$1364.\underline{5}$	0			0
		18	4.5	
1366	0.25			4.5
		24	13.4	
1368	0.87			17.9
		8	8.4	
$1368.\underline{7}$	1.23			26.3

C-4

36 – 84558-2-403
Beech Surface Drainage
6/24/85 MWB

36" CMP STAGE-DISCHARGE
PLANT 4 ENTRANCE INLET CONTROL
36" CMP w/ End Section $IE = 1364^{47} \approx 1364^{5}$
USE SCALE (1)

ELEV ft MSL	HW ft	HW/D	Q cfs
1364.5	0	0	0
1365	0.5	0.17	
1366	1.5	0.50	11
1367	2.5	0.83	27
1368	3.5	1.17	44
1368^{7}	4.2	1.40	53 = Begin weir flow

2S/Δt+O vs. O Use Δt = 0.1 hr

Elev (ft MSL)	S (Ac-In)	2S/Δt (Ac In/Hr)	2S/Δt + O Ac-In/Hr	O Ac-In/Hr
1364.5	0	0	0	0
1365	2	40	45	5
1366	4.5	90	101	11
1367	11	220	247	27
1368	17.9	358	402	44
1368.7	26.3	526	576	50

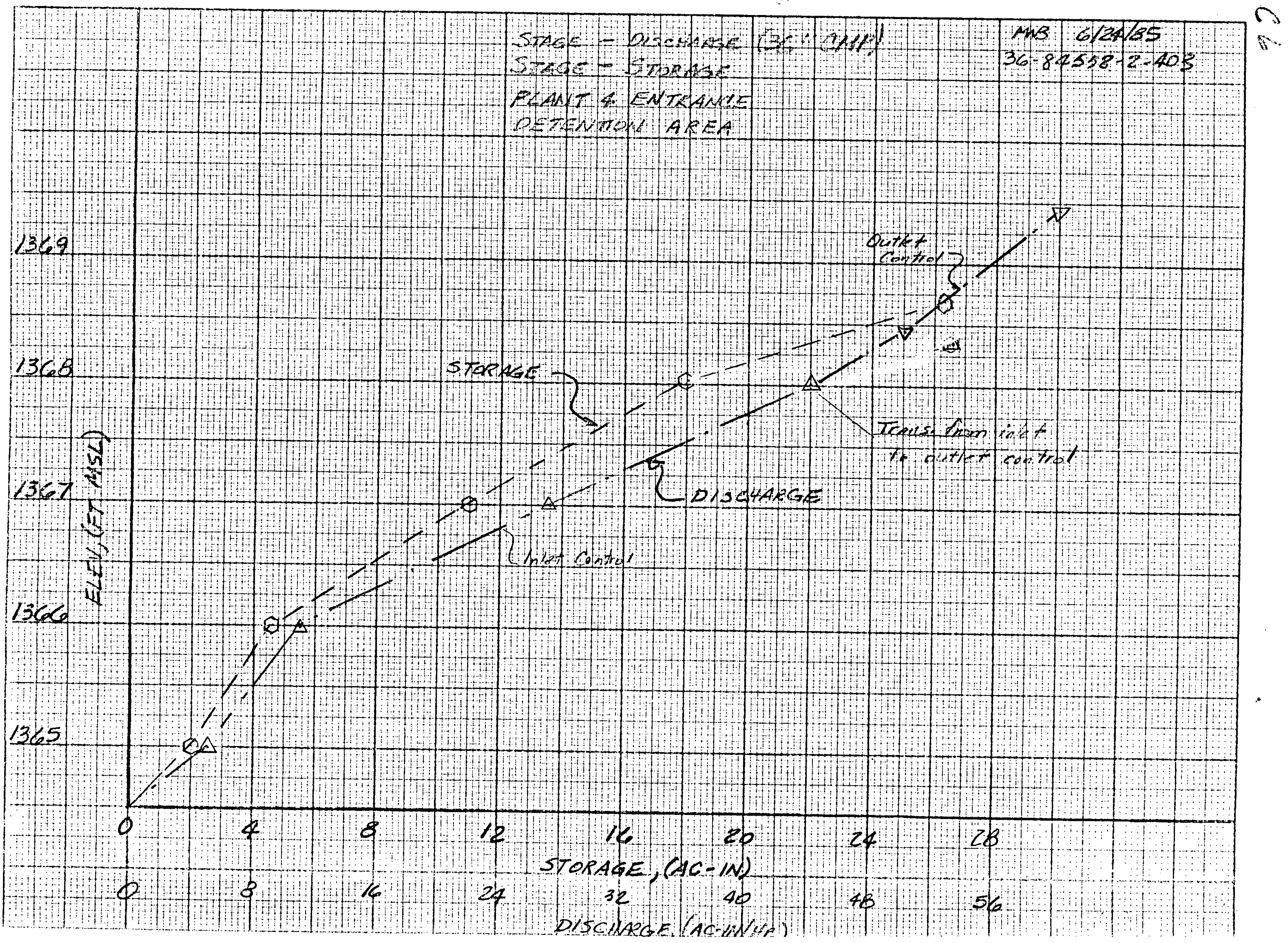
MWB 6/25/85
36-84558-2-403

STAGE DISCHARGE
OUTLET CONTROL
PLANT 4 ENTRANCE
DETENTION AREA
36" x 35' CMP w/ END SECTIONS

Assume TW = 0 LS_o = 0.5'   Inlet ℄ = 1364^5 Outlet ℄ = 1364^0

DISCHARGE	H	d_c	$d_c + D/2$	h_o	LS_o	HW	Elev
0							
10							
20	0.3'	1.4'	2.2'	2.2'	0.5	2.0	1366.5
30	0.68'	1.8'	2.4'	2.4'	0.5	2.6	1367.1
40	1.2'	2.1'	2.55'	2.55'	0.5	3.25'	1367.75
50	1.8'	2.3'	2.65'	2.65'	0.5	3.95'	1368.45
60	2.7'	2.5'	2.75'	2.75'	0.5	4.95'	1369.45

C6



STAGE - DISCHARGE (36" CMP)
STAGE - STORAGE
PLANT & ENTRANCE
DETENTION AREA
MWB 6/24/85
36-84558-2-403
1369
1368
1367
1366
1365
ELEV, (FT MSL)
Outlet Control
STORAGE
Trans. from inlet to outlet control
DISCHARGE
Inlet Control
0
4
8
12
16
20
24
28
STORAGE, (AC-IN)
0
8
16
24
32
40
48
56
DISCHARGE (AC-IN/HR)

C-7

Project: 36-84538-2-403
Job No.: BEECH DRAINAGE
PLANT 4 ENT

RESERVOIR ROUTING TABLE

Date: 6/25/85
By: MWB
Page 1 of 3

(1) Time Hr	(2) I_1 Ac-In/Hr	(3) I_1+I_2 Ac-In/Hr	(4) $\frac{2S_1}{\Delta t} - O_1$ Ac-In/Hr	(5) $\frac{2S_2}{\Delta t} + O_2$ Ac-In/Hr	(6) Outflow O_2 Ac-In/Hr	(7) Elev. ft MSL	(8) Storage S_2 Ac In
11.0	2	4	0	—	0	1364.5	0
11.1	2	4	4	4	0	1364.5	0
11.2	2	4	6	8	1	1364.6	0.4
11.3	2	5	8	10	1	1364.6	0.4
11.4	3	6	9	13	2	1364.7	0.8
11.5	3	8	11	15	2	1364.7	0.8
11.6	5	12	13	19	3	1364.8	1.2
11.7	7	22	19	25	3	1364.8	1.5
11.8	15	43	31	41	5	1365.0	3.2
11.9	28	68	56	74	9	1365.7	3.8
12.0	40	86	98	124	13	1366.1	5.2
12.1	46	90	146	184	19	1366.5	7.8
12.2	44	81	184	236	26	1366.9	10.2
12.3	37	66	207	265	29	1367.1	11.6
12.4	29	52	211	273	31	1367.2	12.2

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

C-8

Project: BEECH DRAINAGE
Job No.: 36-84558-2-403
PLANT 4 EVT

RESERVOIR ROUTING TABLE

Date: 6/25/85
By: MAB

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	ft MSL	Ac-In
12.5	23	41	205	263	29	1367.1	11.6
12.6	18	33	192	246	27	1367.0	10.9
12.7	15	27	177	225	24	1366.8	9.6
12.8	12	22	160	204	22	1366.7	8.8
12.9	10	19	144	182	19	1366.5	7.8
13.0	9	18	129	163	17	1366.4	6.1
13.1	9	17	115	147	16	1366.3	5.6
13.2	8	15	104	132	14	1366.2	5.4
13.3	7	13	93	119	13	1366.2	5.4
13.4	6	11	82	106	12	1366.1	5.2
13.5	5	10	71	93	11	1366.0	4.6
13.6	5	10	61	81	10	1365.8	4.0
13.7	5	9	55	71	8	1365.5	3.2
13.8	4	8	50	64	7	1365.4	3.0
13.9	4	8	44	58	7	1365.4	3.0

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

RESERVOIR ROUTING TABLE

Project: Beech Drainage
Job No.: 36-84558-2-403
Plant 4 Ext Det Basin

Date: 7/2/85
By: MB
Page 3 of 3

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac-In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac-In
14.0	4	8	40	52	6		
14.1	4	8	36	48	6		
14.2	4	8	34	44	5		
14.3	4	8	32	42	5		
14.4	4	7	30	40	5		
14.5	3	6	27	37	5		
14.6	3	6	25	33	4		
14.7	3	6	23	31	4		
14.8	3	6	21	29	4		
14.9	3	6	19	27	4		
15.0	3	6	19	25	3		
15.1	3	6	19	25	3		
15.2	3	6	19	25	3		
15.3	3	6	19	25	3		
15.4	3	6	19	25	3		

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

C-10

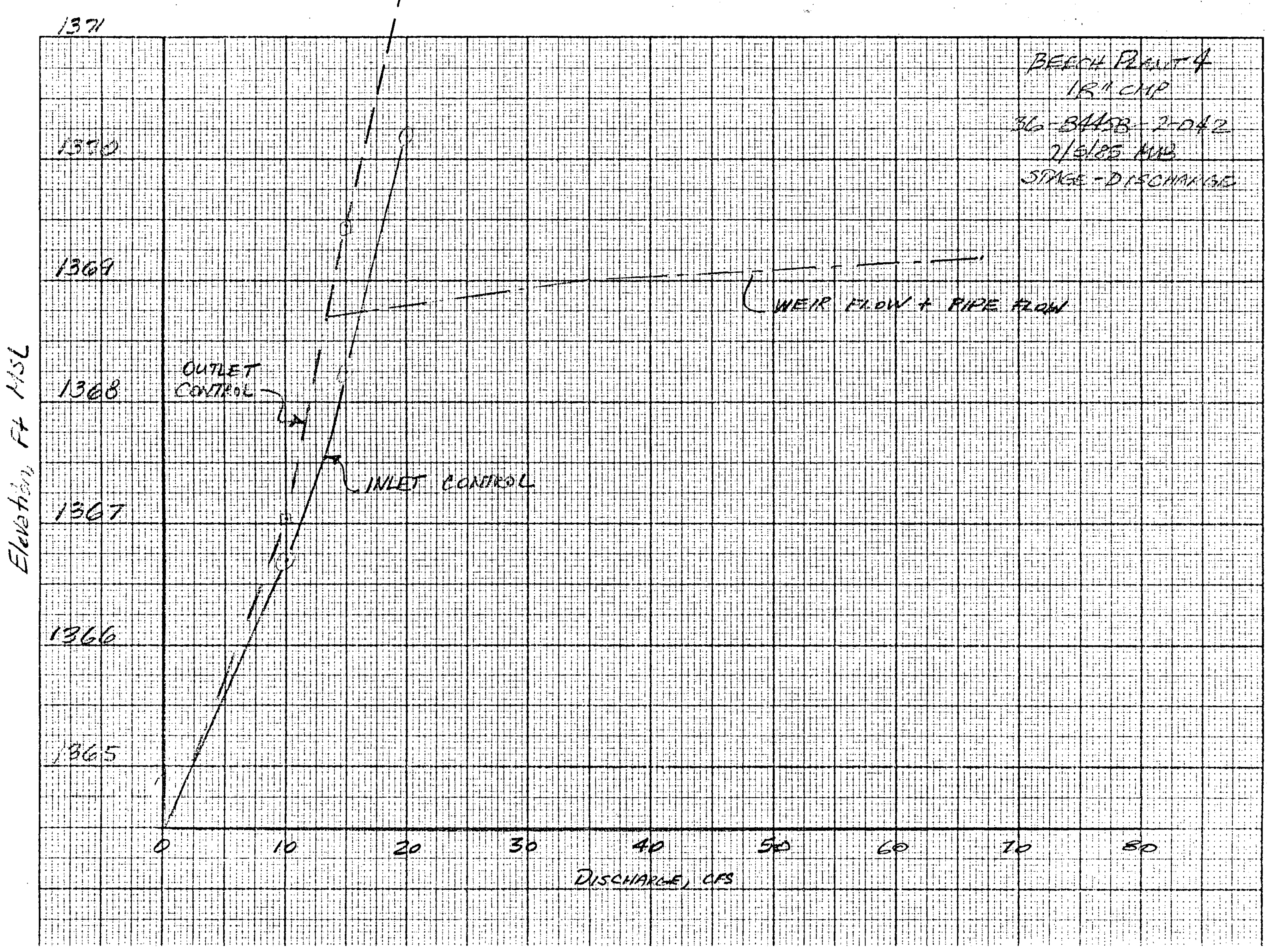
36-84558-2-403
BEECH DRAINAGE
PLANT 4 ENTRANCE
7-5-85 MVB

18" CMP STAGE-DISCHARGE
PLANT 4 ENTRANCE
INLET ℄ = 1364.5 Outlet ℄ = 1364.0 LS_o = 0.5'
ASSUME TW = 0   L = 35'   Pr Gr = 1368.7

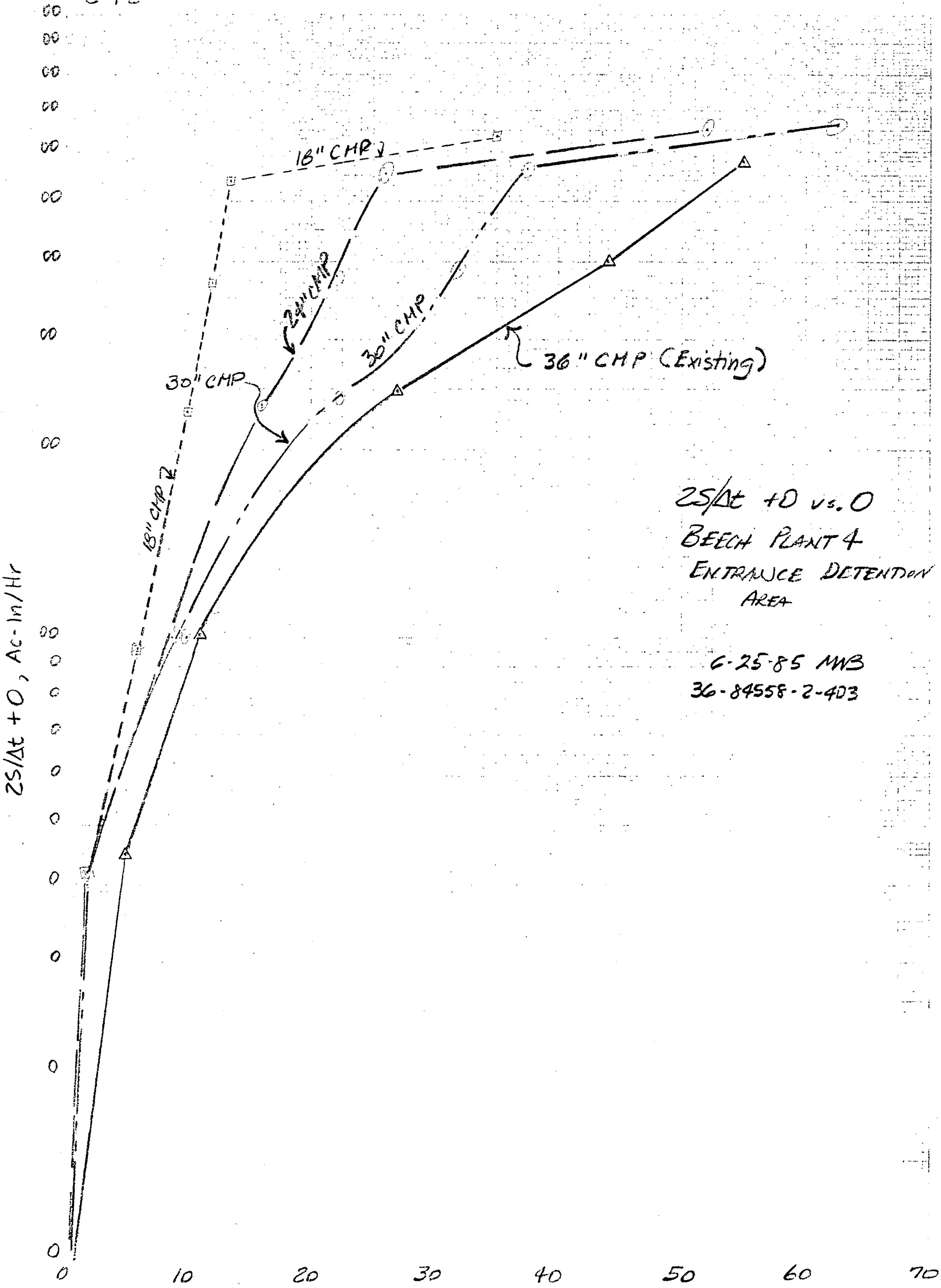
DISCHARGE	INLET CONTROL HW/D	HW	ELEV	H	d_c	$\frac{d_c+D}{2}$	$= h_o$	LS_o	HW	Elev
0	—	—	1364.5	0	0	0	0	-0.5	0	1364.5
10	1.45	2.18	66.68	1.7	1.2	1.35	1.35	-0.5	2.55	1367.05
15	2.5	3.75	68.25	4.0	1.4	1.45	1.45	-0.5	4.95	1369.45
20	3.8	5.70	70.20	6.2	1.5	1.5	1.5	-0.5	7.20	1371.70

18" CMP
2S/Δt+O vs O   Δt = 0.1 Hr

Elev (ft MSL)	S (Ac-In)	2S/Δt (Ac-In/Hr)	2S/Δt+O (Ac-In/Hr)	O (Ac-In/Hr)
1364.5	0	0	0	0
1365	2	40	42	2
1366	4.5	90	96	6
1367	11	220	230	10
1368	17.9	358	370	12
1368.7	26.3	526	540	13.5
1369	30	600	635	35


BEECH PLANT 4
18" CMP
STAGE - DISCHARGE
WEIR FLOW + PIPE FLOW
OUTLET CONTROL
INLET CONTROL
Elevation, Ft MSL
1371
1370
1369
1368
1367
1366
1365
0
10
20
30
40
50
60
70
80
DISCHARGE, CFS

C-12



18" CMP
24" CMP
30" CMP
30" CMP
36" CMP (Existing)
18" CMP
2S/Δt + O, Ac-In/Hr
2S/Δt +O vs. O
BEECH PLANT 4
ENTRANCE DETENTION AREA
6-25-85 MWB
36-84558-2-403
0
10
20
30
40
50
60
70

Project: BEECH DRAINAGE
Job No.: PLANT & DETENTION BASIN
18" CMP
36-84458-Z-403

RESERVOIR ROUTING TABLE

Date: 9/5/85
By: MLB
Page , of

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
11.0	2	4	0	—	0	1364.5	0
11.1	2	4	4	4	0	1364.5	0
11.2	2	4	8	8	0	1364.5	0
11.3	2	5	10	12	1	1364.6	0.6
11.4	3	6	13	15	1	1364.6	0.6
11.5	3	8	17	19	1	1364.6	0.6
11.6	5	12	21	25	2	1365.0	2.0
11.7	7	22	29	33	2	1365.0	2.0
11.8	15	43	45	51	3	1365.1	2.2
11.9	28	68	76	88	6	1366.0	4.6
12.0	40	86	128	144	8	1366.5	7.8
12.1	46	90	194	214	10	1367.0	11.0
12.2	44	81	262	284	11	1367.5	14.4
12.3	37	66	319	343	12	1368.2	20.0
12.4	29	52	361	385	12	1368.2	20.0

$(3)_n + (4)_n = (5)_{n+1}$ $\qquad$ $(5)_n - 2 \times (6)_n = (4)_n$

C-14

Project: Beech Drainage Plat 4 Detention Area 15" CMP
Job No.: 56-84-18-2-403

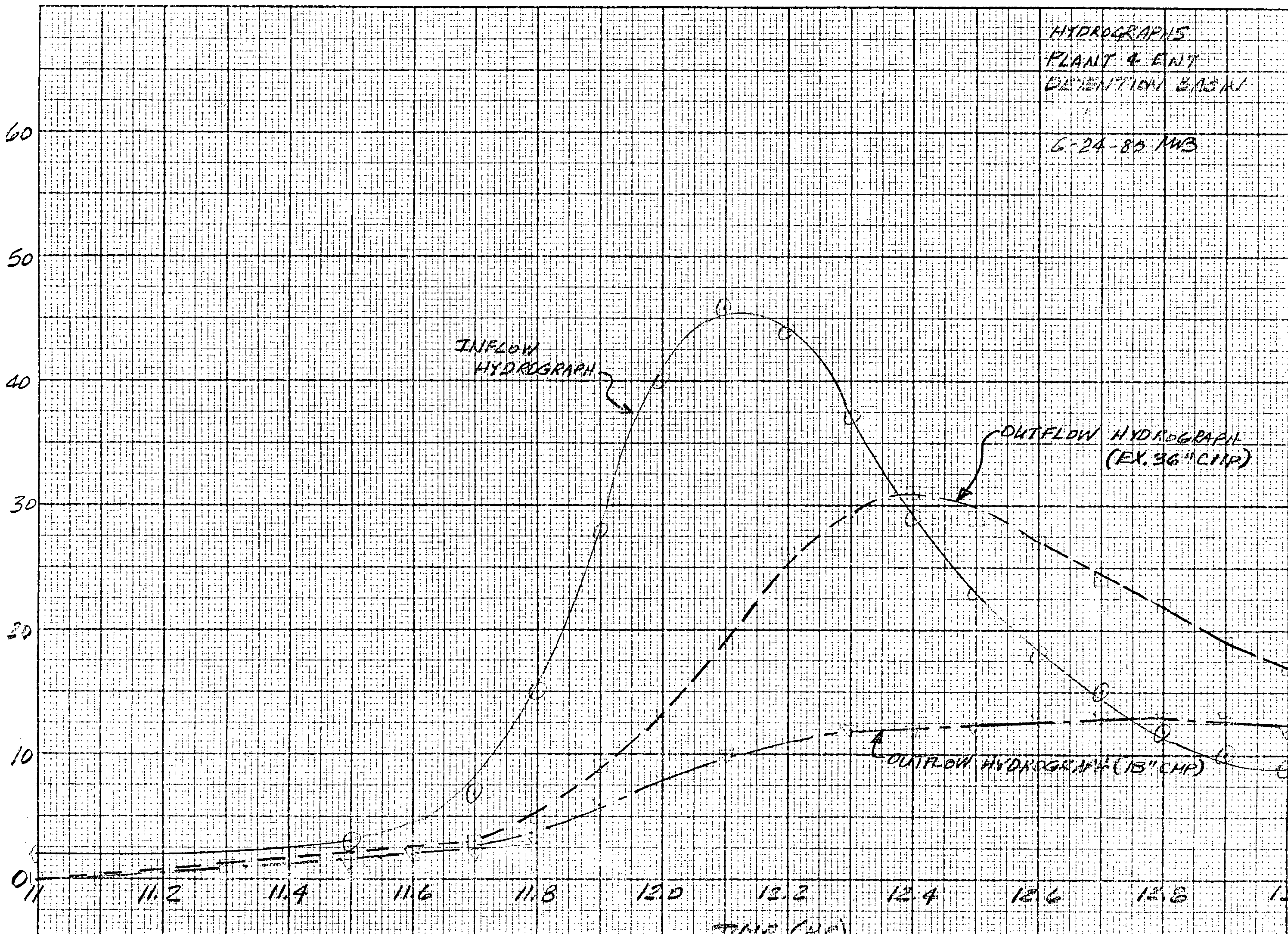
RESERVOIR ROUTING TABLE

Date: 7/5/85
By: [illegible]
Page 2 of

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
12.5	23	41	389	413	12	1368.2	20.0
12.6	18	33	404	430	13	1368.55	24.4
12.7	15	27	411	437	13	1368.55	24.4
12.8	12	22	412	438	13	1368.55	24.4
12.9	10	19	408	434	13	1368.55	24.0
13.0	9	18	403	427	12	1368.2	20
13.1	9	17	397	421	12	1368.2	20
13.2	8	15	390	414	12	1368.2	20
13.3	7	13	381	405	12	1368.2	20
13.4	6	11	370	394	12	1368.2	20
13.5	5	10	357	381	12	1368.2	20
13.6	5						

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$



HYDROGRAPHS
PLANT 4 ENT
DETENTION BASIN
6-24-85 MWB
INFLOW HYDROGRAPH
OUTFLOW HYDROGRAPH (EX. 36" CMP)
OUTFLOW HYDROGRAPH (18" CMP)
0
10
20
30
40
50
60
11
11.2
11.4
11.6
11.8
12.0
12.2
12.4
12.6
12.8
13
TIME (HR)

D-1

DA = 37 Ac
Imp = 3.4 Ac
9%

URBAN HYDROLOGY FOR SMALL WATERSHEDS (TR-55)
PEAK DISCHARGE WORKSHEET
FOR GRAPHICAL (T_c) METHOD (FIGURE 5-2)

Project South Detention Basin Contrib. Basin By MWB Date 6/27/85
Checked ______ Date ______

Steps Peak Discharge Computation for up to 3 storms: Type II, Duration 24 hours.

1. Data: Watershed Condition = 9% Imp (1985 Cond.) (present or future).
   Drainage Area (DA) = 37 acres. Ave. Watershed Slope (S) = 1.5 %.
   Ponding and Swampy areas (PND) = — acres, — % of DA
   Impervious Area (IMP) = ______ acres, 9 % of DA
   Total Hydraulic Length (HL) = 1000 feet
   Hydraulic Length Modified (HLM) = 0 feet, 0 % of HL

	1st Storm	2nd Storm	3rd Storm	
2. Rainfall Frequency (F)	5	50	100	yrs.
3. Rainfall Depth (P)	4.5	7.0	7.8	inches

4. Runoff Curve Number (CN) = 82 S = 2.20
   See other side for computation

	1st Storm	2nd Storm	3rd Storm	
5. Runoff Depth (Q) Use P, CN, and Table 2-1.	2.63	4.91	5.67	inches

6. Time of Concentration (T_c) = 0.39 hrs.
   See other side for computations (check one)
   - [ ] Velocity Method
   - [x] Lag-CN Method
   - [ ] Other ______

x

7. Unit Peak Discharge (q) Use T_c and Figure 5-2: 590 csm/inch of Q

x

8. Drainage Area $\left[\frac{DA(acres)}{640(ac/sm)}\right] = \left[\frac{37}{640}\right] =$ 0.0578 sq. miles

x

	1st Storm	2nd Storm	3rd Storm	
*9. Ponding and Swampy Area Peak Factor. Only use % PND, F and Table E-3; when PND is spreadout in watershed and not related to T_c flow path.	1.0	1.0	1.0	
		=		
10. Peak Discharge Area Factor where q_p = Steps #5 x 7 x 8 x 9	90	167	193	cfs ← For Info. Only

*If the adjustment is not applicable, enter a Factor of 1.0.

Rossmiller Method

i_5 = 4.34	i_{50} = 6.63	i_{100} = 7.48
C_5 = 0.36	C_{50} = 0.44	C_{100} = 0.48
Q_5 = 58 cfs	Q_{50} = 108 cfs	Q_{100} = 133 cfs

↑ USE ↑

(TR NOTICE 55-A, September 1981)

TR-55 GRAPHICAL (T_c) METHOD, PEAK DISCHARGE WORKSHEET (CONT.)

Steps from other side

4. Runoff Curve Number (CN)

Hydrologic Soil Group (Appendix B)	Land Use Description Include Treatment, Practice & Condition (Table 2-2)	CN (Table 2-2) (3)	% or Area (acres) (4)	Product (3)x(4) (5)
D	Pasture	80	91	
D	imp	98	9	
		Totals =		

CN (weighted) = total col. 5 / total col. 4 [ ] = ; use CN = **82**

5. Time of Concentration (T_c) Select computation method, (a) is recommended.

(a) Velocity Method

Reach	Description of Flow 1/	Length (ft.) (3)	Velocity (ft/sec) (4)	Travel Time ~~(sec.)~~ (3) ÷ (4)
1000'	Pasture 1.0%	1000'	0.9	18.5 min
			Totals =	sec.

1/ Use Figure 3.1 for overland flow portion of travel time.

T_c = Total Travel Time (sec.) / 3,600 (sec./hr.) = [/ 3,600] = **0.31** hrs.

(b) Lag-CN Method

S = 2.20

(1) Unadjusted Lag (L) — Use HL, S, CN, and Figure 3-3. **0.24** hrs.
x
*(2) Hydraulic Length Modified Lag Factor — Use % HLM, CN, and Figure 3-4. **1.00**
x
*(3) Impervious Area Lag Factor — Use % IMP, CN, and Figure 3-5. **0.97**
x
(4) Constant (T_c = 1.67L) **1.67**
=
(5) Time of Concentration (T_c) where T_c = (1)x(2)x(3)x(4) **0.39** hrs. = 24 min

Use to be consider[ed]

(TR NOTICE 55-A, September 1981)

MWB 6/27/85

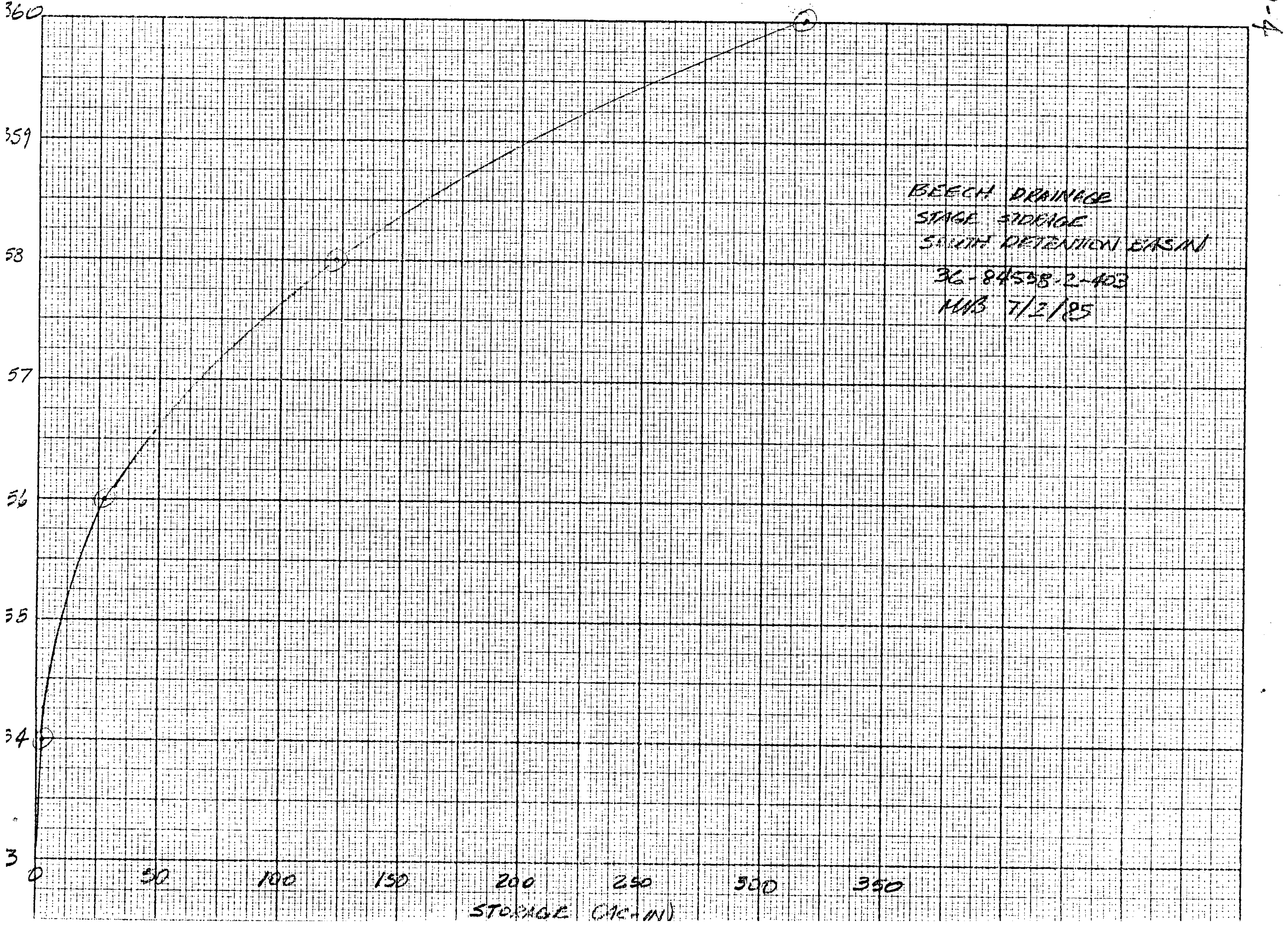
BEECH DRAINAGE
36-84458-1-403
SOUTH DETENTION BASIN

STAGE - STORAGE

AREAS BY PLANIMETER ON 1"=100', 2' CONTOUR MAP

ELEV ft M.S.L.	AREA Ac.	Δh In	ΔVol Ac.'In	ΣVol AC. In	ΣVol Ac.Ft
1353	0	12		0	0
			2.4		
1354	0.4			2.4	0.2
		24	28		
1356	1.95			28	2.3
		24	94		
1358	5.89			122	10.2
		24	195		
1360	10.33			317	26.4

D-4


BEECH DRAINAGE
STAGE STORAGE
SOUTH DETENTION BASIN
36-84538-2-403
MWB 7/2/85
360
359
58
57
56
55
54
3
0
50
100
150
200
250
300
350
STORAGE (AC-IN)

MWB 6/27/85
3C-84458-1-403

SOUTH DETENTION POND
STAGE/DISCHARGE

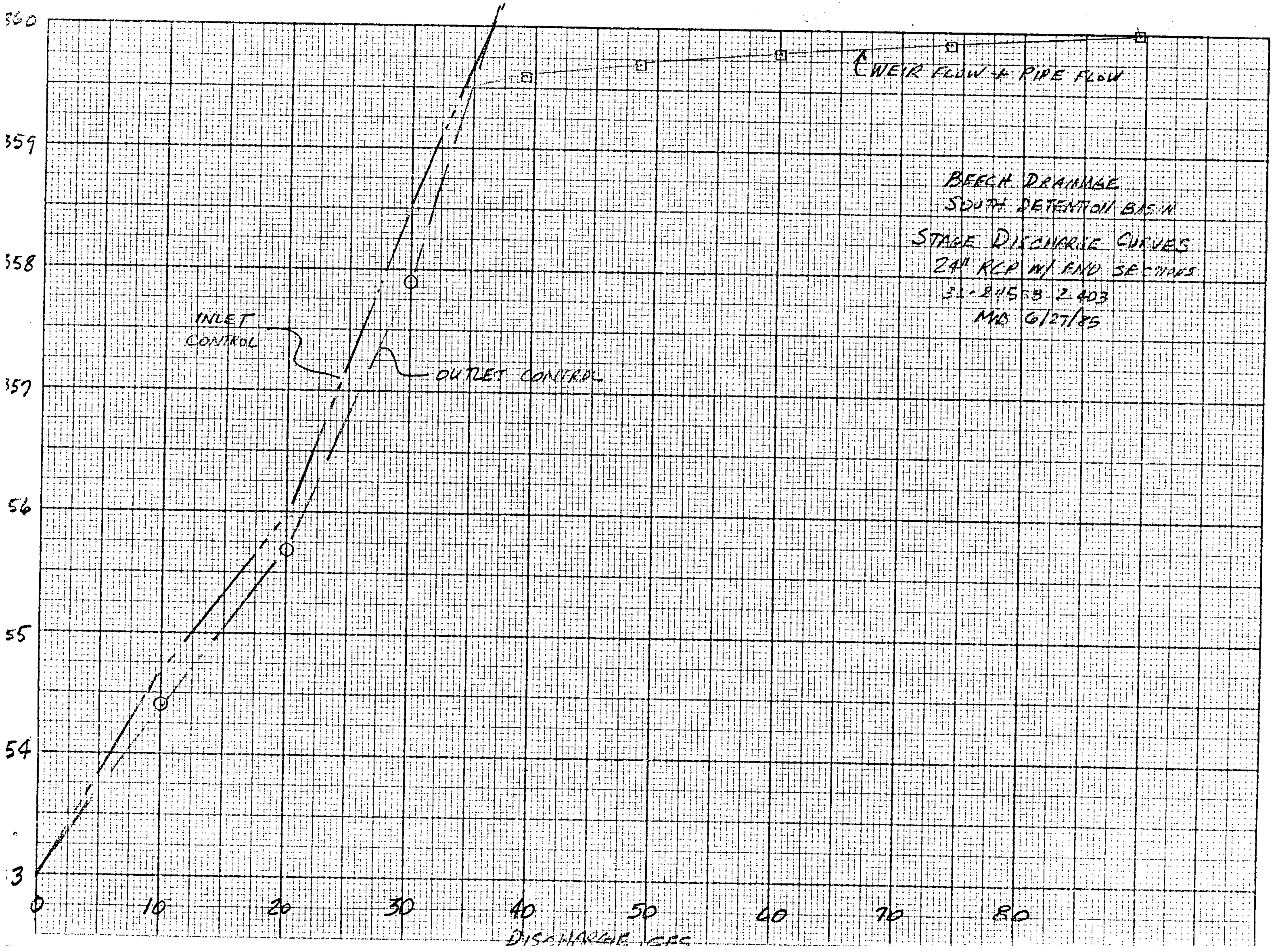
Using HEC-5 charts; 1-24" RCP outfall; L=100'; Type I End Sections
Inlet ℄ = 1353   Outlet ℄ = 1352   Dike Elev = 1360 Max
Assume TW = 2' in 10' FB ditch, on 0.25%, with Q = 36 cfs

DISCHARGE	INLET CONTROL HW/D	HW	ELEV.	OUTLET CONTROL H	d_c	$d_c+D/2$	TW	h_o	LS_o	HW	Elev.
0	–	–	1353	–	–	–	2	–	-1.0	0	1353
10	0.85	1.7	1354.7	0.4	1.2	1.6	2	2	-1.0	1.4	1354.4
20	1.5	3.0	1356	1.7	1.6	1.8	2	2	-1.0	2.7	1355.7
30	2.75	5.5	1358.5	3.9	1.8	1.9	2	2	-1.0	4.9	1357.9
40	3.9	7.8	1360.8	7.1	—	2.0	2	2	-1.0	8.1	1361.1
50	5.7	—	—				2		-1.0		

WEIR FLOW – Crest – El. 1359.5 L = 50' $Q = CLH^{1.5}$ C = 3.0

	H	Q
1359.6	0.1	4.7
1359.7	0.2	13.4
1359.8	0.3	24.6
1359.9	0.4	37.9
1360	0.5	53.0

D-6


WEIR FLOW + PIPE FLOW
BEECH DRAINAGE
SOUTH DETENTION BASIN
STAGE DISCHARGE CURVES
24" RCP W/ END SECTIONS
MHB 6/27/85
INLET CONTROL
OUTLET CONTROL
360
359
358
357
56
55
54
0
10
20
30
40
50
60
70
80
DISCHARGE (CFS

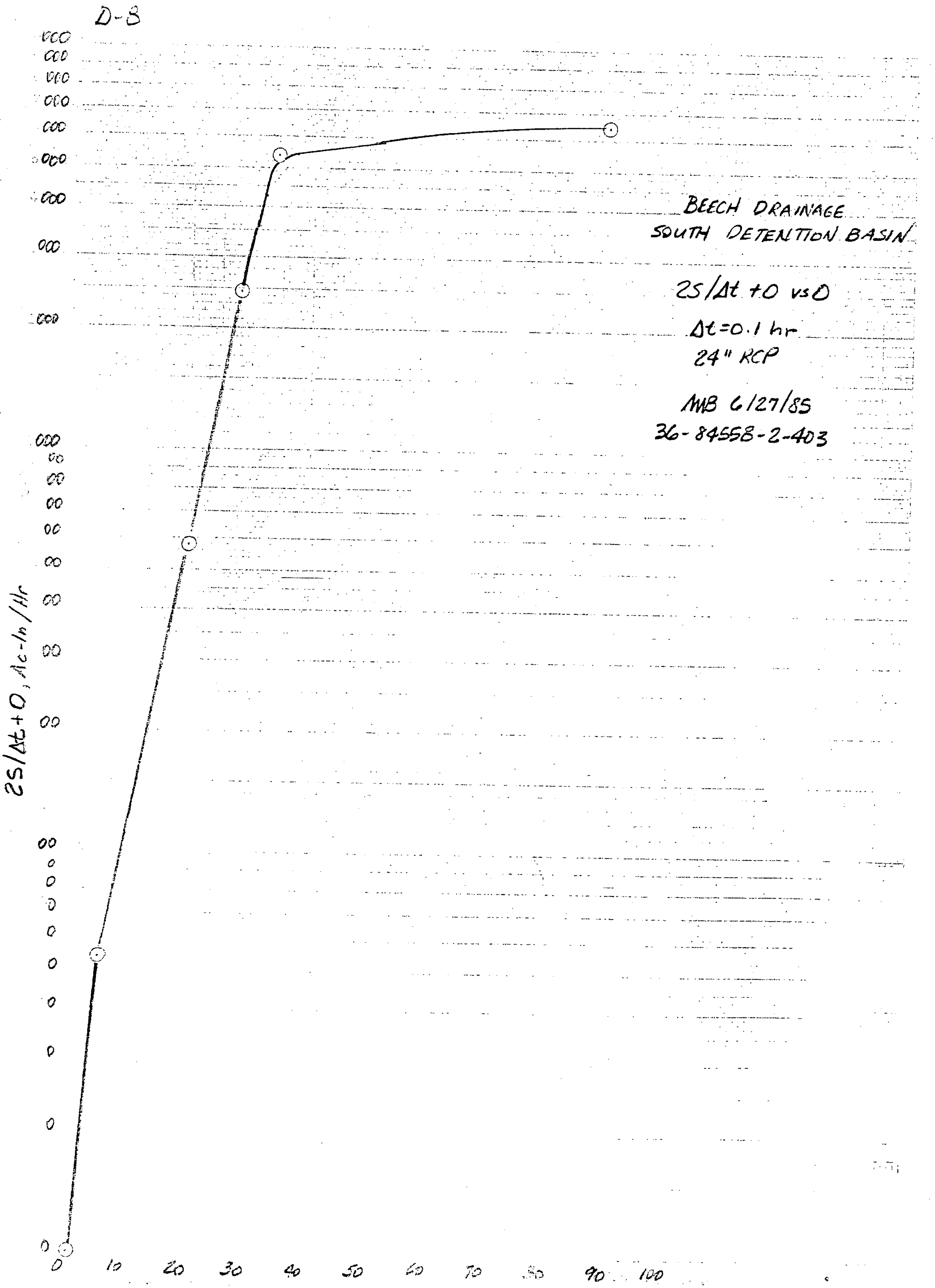
MWB 6/27/85
36-84458-1-403

South Detention Pond

$2S/\Delta t + O$ vs O

$O \rightarrow$ 24" RCP w/ End Section
$\Delta t \rightarrow 0.1$ hr

Elev ft MSL	S Ac In	$\frac{2S}{\Delta t}$ Ac In/Hr	$\frac{2S}{\Delta t} + O$ Ac In/Hr	O Ac In/Hr
1353	0	0	0	0
1354	2.4	48	54	6
1356	28	560	580	20
1358	122	2440	2468	28
1359.5	268	5360	5394	34
1360	317	6340	6429	89


D-8
BEECH DRAINAGE
SOUTH DETENTION BASIN
2S/Δt +O vs O
Δt=0.1 hr
24" RCP
MB 6/27/85
36-84558-2-403
2S/Δt+O, Ac-In/Hr
0
10
20
30
40
50
60
70
80
90
100

Project: BEECH DRAINAGE SOUTH DETENTION BASIN
Job No.: 24" RCP w/ REDUCED PLANT 4
36-84558-2-403

RESERVOIR ROUTING TABLE

Date: 7/3/85
By: MB
Page 1 of

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac-In
11.0	4	9	0	–	0	1352.0	0
11.1	5	11	7	9	1	1353.1	1
11.2	6	14	12	18	3	1353.5	1
11.3	8	19	18	26	4	1353.6	1
11.4	11	26	27	37	5	1353.8	2
11.5	15	32	41	53	6	1354.0	2
11.6	17	37	57	73	8	1354.4	4
11.7	20	49	76	94	9	1354.5	5
11.8	29	85	103	125	11	1354.8	8
11.9	56	156	162	188	13	1355.0	10
12.0	100	244	286	318	16	1355.5	18
12.1	144	331	492	530	19	1355.9	25
12.2	187	388	779	823	22	1356.6	50
12.3	201	393	1119	1167	24	1357.0	67
12.4	192	365	1462	1512	25	1357.3	82

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

D-10

Project: BEECH DRAINAGE SOUTH DETENTION BASIN 24" RCP PLANT 4 REDUCED

Job No.: 36-84458-2-403

RESERVOIR ROUTING TABLE

Date: 7/8/85
By: MB
Page 2 of

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
12.5	173	325	1775	1827	26	1357.5	92
12.6	152	286	2046	2100	27	1357.7	105
12.7	134	254	2278	2332	27	1357.7	105
12.8	120	251	2456	2532	28	1358.0	122
12.9	111	212	2651	2707	28	1358.0	122
13.0	101	195	2805	2863	29	1358.3	142
13.1	94	183	2942	3000	29	1358.3	142
13.2	89	175	3067	3125	29	1358.3	142
13.3	86	169	3182	3242	30	1358.5	160
13.4	83	163	3291	3351	30	1358.5	160
13.5	80	157	3394	3454	30	1358.5	160
13.6	77	151	3485	3545	30	1358.5	160
13.7	74	146	3574	3636	31	1358.75	180
13.8	72	140	3658	3720	31	1358.75	180
13.9	68	134	3736	3798	31	1358.75	180

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

Project: BEECH DRAINAGE SOUTH DETENTION BASIN W/ REDUCED PLANT 4 ENT.
Job No.: 56-84458-2-403

RESERVOIR ROUTING TABLE

Date: 7-8-85
By: MWB
Page 3 of

(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
14.0	66	129	3808	3870	31	1358.75	180
14.1	63	125	3875	3937	31	1358.75	180
14.2	62	122	3938	4000	31	1358.75	180
14.3	60	118	3996	4060	32	1359.0	203
14.4	58	114	4050	4114	32		
14.5	56	110	4100	4164	32		
14.6	54	106	4146	4210	32		
14.7	52	102	4188	4252	32		
14.8	50	98	4226	4290	32		
14.9	48	95	4260	4324	32		
15.0	47	93	4291	4355	32		
15.1	46	90	4320	4384	32		
15.2	44	87	4346	4410	32		
15.3	43	84	4369	4433	32		
15.4	41	80	4389	4453	32	1359.0	203

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

Project: BEECH DRAINAGE SOUTH DETENTION BASIN W/ REDUCED PLANT & ENT.
Job No.: 36-81459-2-403

RESERVOIR ROUTING TABLE

Date: 7-8-85
By: MWB
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(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
15.5	39	77	4405	4469	32	1359.0	203
15.6	38	75	4418	4482	32		
15.7	37	72	4429	4493	32		
15.8	35	69	4437	4501	32		
15.9	34	66	4442	4506	32		
16.0	32	64	4444	4508	32		
16.1	32	63	4444	4508	32		
16.2	31	62	4443	4507	32		
16.3	31	62	4441	4505	32		
16.4	31	61	4439	4503	32		
16.5	30	60	4436	4500	32		
16.6	30	59	4432	4496	32		
16.7	29	58	4427	4491	32		
16.8	29	58	4421	4485	32		
16.9	29	57	4415	4479	32	1359.0	203

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

Project: BEECH DRAINAGE
SOUTH DETENTION POND
24" RCP w/ RED. PLT. 4 OUTFALL
Job No.: 36-84558-2-403

RESERVOIR ROUTING TABLE

Date: 7-8-85
By: MJB
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(1) Time	(2) I_1	(3) I_1+I_2	(4) $\frac{2S_1}{\Delta t} - O_1$	(5) $\frac{2S_2}{\Delta t} + O_2$	(6) Outflow O_2	(7) Elev.	(8) Storage S_2
Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ac In/Hr	Ft MSL	Ac In
17.0	28	56	4408	4472	32	1359.0	203
17.1	28	56	4400	4464	32		
17.2	28	55	4392	4456	32		
17.3	27	54	4383	4447	32		
17.4	27	53	4373	4437	32		
17.5	26	52	4362	4426	32		
17.6	26	52	4350	4414	32		
17.7	26	51	4338	4402	32		
17.8	25	50	4325	4389	32		
17.9	25	50	4311	4375	32		
18.0	25	49	4297	4361	32		
18.1	24	48	4282	4346	32		
18.2	24	47	4266	4330	32		
18.3	23	46	4249	4313	32		
18.4	23		4231	4295	32	1359.0	203

$(3)_n + (4)_n = (5)_{n+1}$

$(5)_n - 2 \times (6)_n = (4)_n$

References

1. PROFESSIONAL ENGINEERING CONSULTANTS, P.A., APRIL 16, 1885. Drainage Plan and Supporting Calculations, Chelsea Brooke Addition, Wichita, Sedgwick County, Kansas.

2. Soil Conservation Service, U.S. Dept. of Agriculture, January 1975. Urban Hydrology for Small Watersheds, Technical Release No. 55.

3. Ring, S.L., Austin, T.A., and Rossmiller, R.L. December, 1981. Urban Stormwater Drainage, course notes presented at Wichita, Kansas.

4. Federal Highway Administration, U.S. Department of Transportation, December 1965. Hydraulic Charts for the Selection of Highway Culverts, Hydraulic Engineering Circular No. 5.

Design Procedure:

Our design procedure uses the linear reservoir flood routing method. We assume that our reservoir can be represented by the simple hydrologic budget equation

$$I\Delta t - O\Delta t = \Delta S \qquad (2)$$

In our design, the reservoir is assumed to be initially empty, with outflow equal to zero. Discharge occurs only thru a principal spillway, which is a pipe through the embankment. Assuming that the rate of inflow is constant and the rate of outflow is constant for a short time increment t

$$I = \frac{1}{2}(I_t + I_{t+\Delta t})$$

$$O = \frac{1}{2}(O_t + O_{t+\Delta t})$$

$$\Delta S = S_{t+\Delta t} - S_t$$

With the above substitutions, equation (2) becomes

$$\frac{1}{2}(I_t + I_{t+\Delta t})\Delta t - \frac{1}{2}(Ot + O_{t+\Delta t})\Delta t = S_{t+\Delta t} - S_t$$

$$(I_t + I_{t+\Delta t}) - O_t - O_{t+\Delta t} = \frac{2}{\Delta t}(S_{t+\Delta t} - S_t)$$

$$(I_t + I_{t+\Delta t}) + \left(\frac{2S_t}{\Delta t} - O_t\right) = \frac{2S_{t+\Delta t}}{\Delta t} + O_{t+\Delta t} \qquad (3)$$

We will use equation (3) in developing our flood routing table.

The inflow hydrograph, stage-storage curve, and stage-discharge curve must be known. From these, a 2S/ t+O vs.O curve is generated. Then, the values for the routing table may be computed as outlined below:

Col. (1): Time, increment, hours
Col. (2): The inflow hydrograph ordinate for time t
Col. (3): The value of I from Col (2) in this row + from Col. (2) of next row
Col. (5): (5) = [(3) from previous row + (4) previous row]
Col. (6): Outflow, O, corresponding to $2S/\Delta t + O$ on this row. The value is read from the $2S/\Delta t + O$ vs. O curve. (This col. is blank in row 1)
Col. (4): (4) = (5) - 2 x (6)
[$2S/\Delta t - O = 2S/\Delta t + O - 2O$]
Col. (7): The stage h corresponding to value of O in Col. (6) is read from the stage-discharge curve.