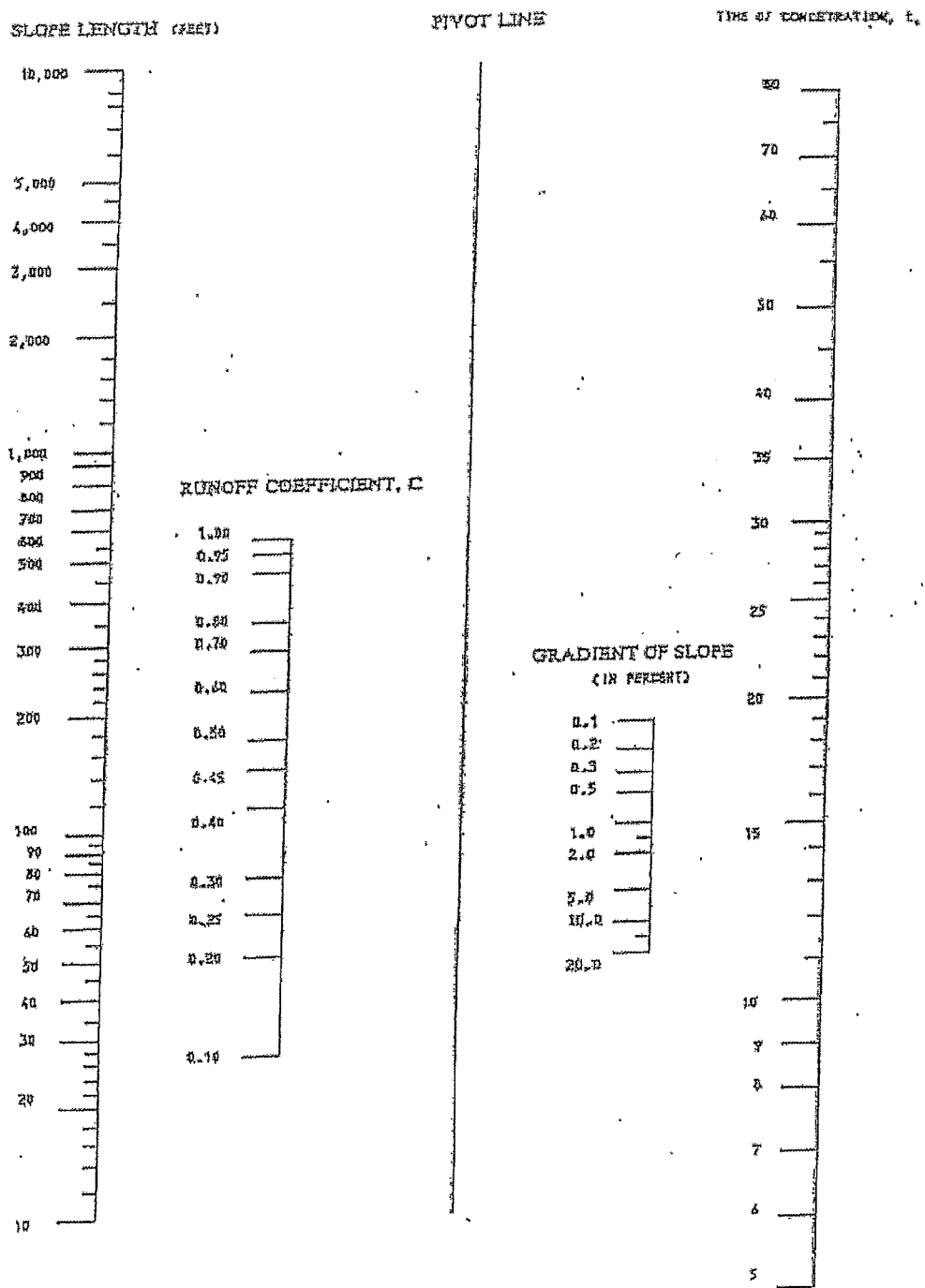


OVERLAND FLOW CHART



Worksheet 2: Runoff curve number and runoff

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

1. Runoff curve number (CN)

Soil name and hydrologic group (Appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area <input type="checkbox"/> acres <input type="checkbox"/> mi ² <input type="checkbox"/> %	Product of CN % area
		Table 2-2	Fig. 2-3	Fig. 2-4		
1/ Use only one CN source per line		Totals =				

CN (weighted) = total product/total area = _____ = _____; Use CN =

2. Runoff

Frequency.....yr
 Rainfall, P (24-hour)in
 Runoff, Qin
 (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)

Storm #1	Storm #2	Storm #3

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed _____

Circle one: T_c T_t _____

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (applicable to T_c only)

	Segment ID		
1. Surface description (table 3-1)			
2. Manning's roughness coeff, n (table 3-1).....			
3. Flow length, L (total L \leq 300 ft).....	ft		
4. Two-yr 24-hr rainfall, P_2	in		
5. Land slope, s	ft/ft		
6. $T_1 = 0.007(nL)^{0.8}/P_2^{0.5}s^{0.4}$	Compute T_1 ..hr		
		+	=

Shallow concentrated flow

	Segment ID		
7. Surface description. (paved or unpaved)			
8. Flow length, L	ft		
9. Watercourse slope, s	ft/ft		
10. Average velocity V (figure 3-1)	ft/s		
11. $T_1 = L/360V$	Compute T_1 ..hr		
		+	=

Channel flow

	Segment ID		
12. Cross sectional flow area, a	ft ²		
13. Wetted perimeter, P_w	ft		
14. Hydraulic radius, $r = a/P_w$	ft		
15. Channel slope, s	ft/ft		
16. Manning's roughness coeff, n			
17. $V = 1.49 r^{2/3} s^{1/2} / n$	Compute V ..ft/s		
18. Flow length, L	ft		
19. $T_1 = L/3600V$	Compute T_1 ..hr		
		+	=
20. Watershed or subarea T_c or T_t (add T_1 in steps 6, 11 and 19)			

Worksheet 4: Graphical Peak Discharge method

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present . Developed _____

1. Data:

Drainage area $A_m =$ _____ mi^2 (acres/640)

Runoff curve number CN = _____ (From worksheet 2)

Time of concentration $T_c =$ _____ hr (From worksheet 3)

Rainfall distribution type = _____ (I, II, III)

Pond and swamp areas spread throughout watershed..... = _____ percent of A_m (_____ acres or mi^2 covered)

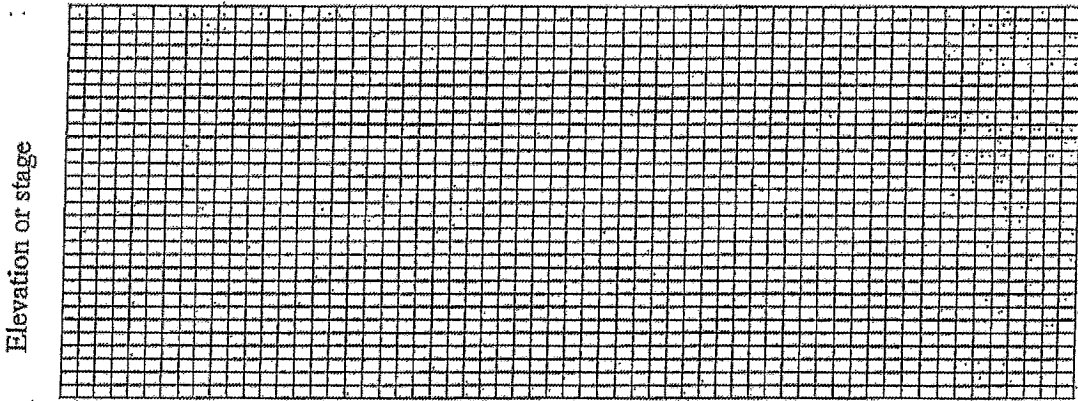
	Storm #1	Storm #2	Storm #3
2. Frequency yr			
3. Rainfall, P (24-hour) in			
4. Initial abstraction, I_a in (Use CN with table 4-1.)			
5. Compute I_a/P			
6. Unit peak discharge, q_u csm/in (Use T_c and I_a/P with exhibit 4 - ____)			
7. Runoff, Q in (From worksheet 2).			
8. Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)			
9. Peak discharge, q_p cfs (Where $q_p = q_u A_m Q F_p$)			

Worksheet 6a: Detention basin storage,
peak outflow discharge (q_o) known

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed



Detention basin storage

1. Data: Drainage area $A_m =$ _____ mi^2 Rainfall distribution Type (I, IA, II, III) <table border="1" style="display: inline-table; margin-left: 20px;"><tr><td>1st stage</td><td>2nd stage</td></tr></table>	1 st stage	2 nd stage	6. V_s/V_r (Use q_o/q_f with figure 6-1)	<table border="1" style="display: inline-table;"><tr><td> </td><td> </td></tr></table>		
1 st stage	2 nd stage					
2. Frequency yr <table border="1" style="display: inline-table; margin-left: 20px;"><tr><td> </td><td> </td></tr></table>			7. Runoff, Q in (From worksheet 2)	<table border="1" style="display: inline-table;"><tr><td> </td><td> </td></tr></table>		
3. Peak inflow discharge q_f cfs (from worksheet 4 or 5b) <table border="1" style="display: inline-table; margin-left: 20px;"><tr><td> </td><td> </td></tr></table>			8. Runoff volume, V_r ac-ft ($V_r = QA_m/33.33$)	<table border="1" style="display: inline-table;"><tr><td> </td><td> </td></tr></table>		
4. Peak outflow discharge, q_o cfs <table border="1" style="display: inline-table; margin-left: 20px;"><tr><td> </td><td> </td></tr></table>			9. Storage volume, V_s ac-ft ($V_s = V_r(V_s/V_r)$)	<table border="1" style="display: inline-table;"><tr><td> </td><td> </td></tr></table>		
5. Compute q_o / q_f <table border="1" style="display: inline-table; margin-left: 20px;"><tr><td> </td><td> </td></tr></table>			10. Maximum stage, (From plot)	E_{max} <table border="1" style="display: inline-table;"><tr><td> </td><td> </td></tr></table>		

1/ 2nd stage q_o includes 1st stage q_o .

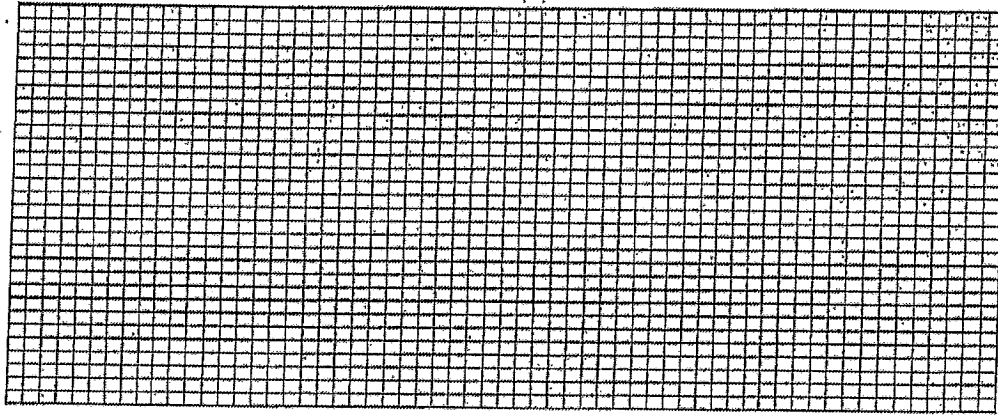
Appendix A - Exhibit II (8 of 8)
Worksheet 6b: Detention basin, peak outflow,
storage volume (V_s) known

Project _____ By _____ Date _____

Location _____ Checked _____ Date _____

Circle one: Present Developed

Elevation or stage



Detention basin storage

1. Data:

Drainage area
Rainfall distribution
type (I, IA, II, III)

$A_m =$ _____ mi^2

$=$ _____

1 st stage	2 nd stage
--------------------------	--------------------------

2. Frequency.....

yr

--	--

3. Storage volume,

V_s ac ft

--	--

4. Runoff, Q

in

(From worksheet 2)

--	--

5. Runoff volume,

V_r ac ft

($V_r = QA_m 53.33$)

--	--

6. Compute V_s/V_r

--	--

7. q_o/q_i in

(Use V_s/V_r and figure 6-1)

--	--

8. Peak inflow discharge,

q_i cfs

(From worksheet 4 or 5b)

--	--

9. Peak outflow discharge,

q_o cfs

($q_o = q_i (q_o/q_i)$)

--	--

10. Maximum stage,
(From plot)

E_{max}

--	--

1/ 2nd stage q_o includes 1st stage q_o .

DETENTION BASIN STORAGE DESIGN

I Calculate the peak flow in cfs due to the one (1) year frequency storm under predeveloped conditions.

$$q_1 = A * C * i \quad (\text{allowable detention basin outflow release rate – stage one})$$

$$\text{Area, "A"} = [\quad] \text{ acres}$$

$$\text{Runoff Coefficient, "C"} = [\quad]$$

$$\text{Intensity, "i"} = a / (t_c + b) = [\quad] \text{ in/hr}$$

Where: a = 80 (Table IV)

$$b = 14 \text{ (Table IV)}$$

t_c = time of concentration (minutes) as determined from Appendix C – Exhibit 1

$$q_1 = A [\quad] * C [\quad] * i [\quad] = [\quad] \text{ cfs}$$

II Calculation for the one (1) year frequency storm under postdevelopment conditions.

$$Q_1 = A * C * i$$

$$\text{Area, "A"} = [\quad] \text{ acres}$$

$$\text{Runoff Coefficient, "C"} = [\quad]$$

$$\text{Intensity, "i"} = a / (t_c + b) = [\quad] \text{ in/hr}$$

Where: a = 80

$$b = 14$$

t_c = time of concentration (minutes)

$$Q_1 = A [\quad] * C [\quad] * i [\quad] = [\quad] \text{ cfs}$$

III Critical Storm Calculation.

$$[(Q_1/q_1) - 1.0] * 100 = PC \quad PC = [\quad] \text{ (See Table II on Page 34 for Critical Storm Frequency)}$$

$$\text{Critical Storm Frequency} = [\quad]$$

IV Calculate maximum storm duration, T_{ccr} , for the critical storm frequency (in minutes).

$$T_{ccr} = \left[\frac{(A * C * a * b)}{(2 * q_1 / 3) - [(q_1^2 * t_c) / (6 * C * A * a)]} \right]^{1/2} - b$$

Appendix A – Exhibit III (2 of 4)

Where: a = determined from Table IV (for critical storm frequency)

b = determined from Table IV (for critical storm frequency)

C = the one year postdeveloped weighted runoff coefficient

A = area in acres

$$T_{cr} = [\text{_____}] \text{ minutes}$$

V Calculate I_{cr} :

$$I_{cr} = [a / (T_{cr} + b)] = [\text{_____}] \text{ in/hr}$$

VI Calculate Q_{cr} , flow at maximum duration for the critical storm frequency:

$$Q_{cr} = A [\text{_____}] * C [\text{_____}] * I_{cr} [\text{_____}] = [\text{_____}] \text{ cfs}$$

VII Calculate the required storage volume due to critical storm criteria, SV_{cr} :

$$SV_{cr} = [(60 * Q_{cr} * T_{cr})] - \{ [2 * q_1 * (T_{cr} + t_o) * 60] / 3 \} \\ + [(q_1^2 * t_o * 60) / (6 * Q_{cr})]$$

$$SV_{cr} = [\text{_____}] \text{ ft}^3$$

VIII Calculate the peak flow in cfs due to the one-hundred (100) year frequency storm under predeveloped conditions.

$$q_{100} = A * C * i \quad (\text{allowable detention basin outflow release rate – stages one + two})$$

$$\text{Area, "A"} = [\text{_____}] \text{ acres}$$

$$\text{Runoff Coefficient, "C"} = [\text{_____}]$$

$$\text{Intensity, "i"} = a / (t_c + b) = [\text{_____}] \text{ in/hr}$$

Where: $a = 290$ (Table IV)

$$b = 31$$
 (Table IV)

t_c = time of concentration (minutes) as determined from Appendix C – Exhibit 1, for predeveloped

$$q_{100} = A [\text{_____}] * C [\text{_____}] * i [\text{_____}] = [\text{_____}] \text{ cfs}$$

IX Calculate maximum storm duration T_{c100} , for the one-hundred year frequency (in minutes) storm under postdeveloped conditions.

Appendix A – Exhibit III (3 of 4)

$$T_{ccr} = \left[\frac{(A * C * a * b)}{(2 * q_{100}/3) - [(q_{100}^2 * t_c) / (6 * C * A * a)]} \right]^{1/2} - b$$

Where: a = 290

b = 31

C = the one-hundred year postdeveloped weighted runoff coefficient

A = area in acres

T_{C100} = [_____] minutes

X Calculate I_{100} :

$$I_{100} = [a / (T_{C100} + b)] = [_____] \text{ in/hr}$$

XI Calculate Q_{100} , flow at maximum duration for the critical storm frequency:

$$Q_{100} = A [_____] * C [_____] * I_{100} [_____] = [_____] \text{ cfs}$$

XII Calculate the required storage volume due to critical storm criteria, SV_{cr} :

$$SV_{100} = [(60 * Q_{100} * T_{C100})] - \{ [2 * q_1 * (T_{C100} + t_c) * 60] / 3 \} \\ + [(q_{100}^2 * t_c * 60) / (6 * Q_{100})]$$

$$SV_{100} = [_____] \text{ ft}^3$$

XIII Design Notes:

1. Design as a two stage outlet

a. An iterative process is required since the change in elevation head will cause an increase in the outflow of the stage one opening.

b. Two detention areas can be used to eliminate the iterative two stage outlet design process.

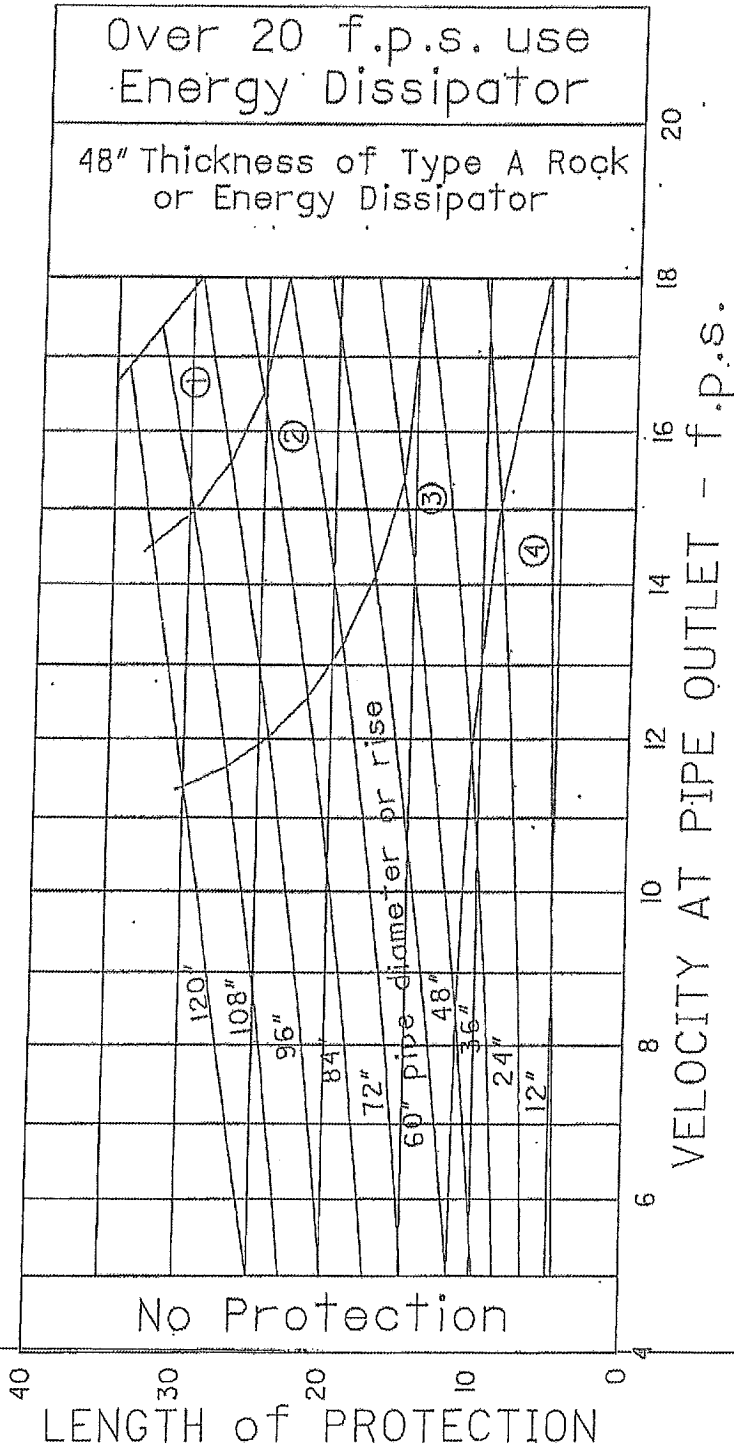
2. Emergency overflow must be accounted for via a spillway or other means.

General Notes:

1. The formulas used in calculations III through VII assume an orifice controlled outflow.

2. Reference pages 98 and 99, Water and Wastes Engineering, "Estimate Detention and Reservoir Storage". By A.S. Patal, P.E., Ph.D.

ROCK CHANNEL PROTECTION
AT CULVERT AND STORM
SEWER OUTLETS



NOTES

Rock size (6", 12", 18") indicates the square opening on which 85% of the material, by weight, will be retained.
The width of protection shall be the width of the headwall, with 4' being the minimum.
(Where a stream bed will withstand the calculated velocity without erosion, no rock channel protection will be required.)

- LEGEND
- ① 48" of 18" rock
 - ② 36" of 18" rock
 - ③ 30" of 12" rock
 - ④ 18" of 6" rock
- ROCK TYPE
- A
 - A
 - B
 - C