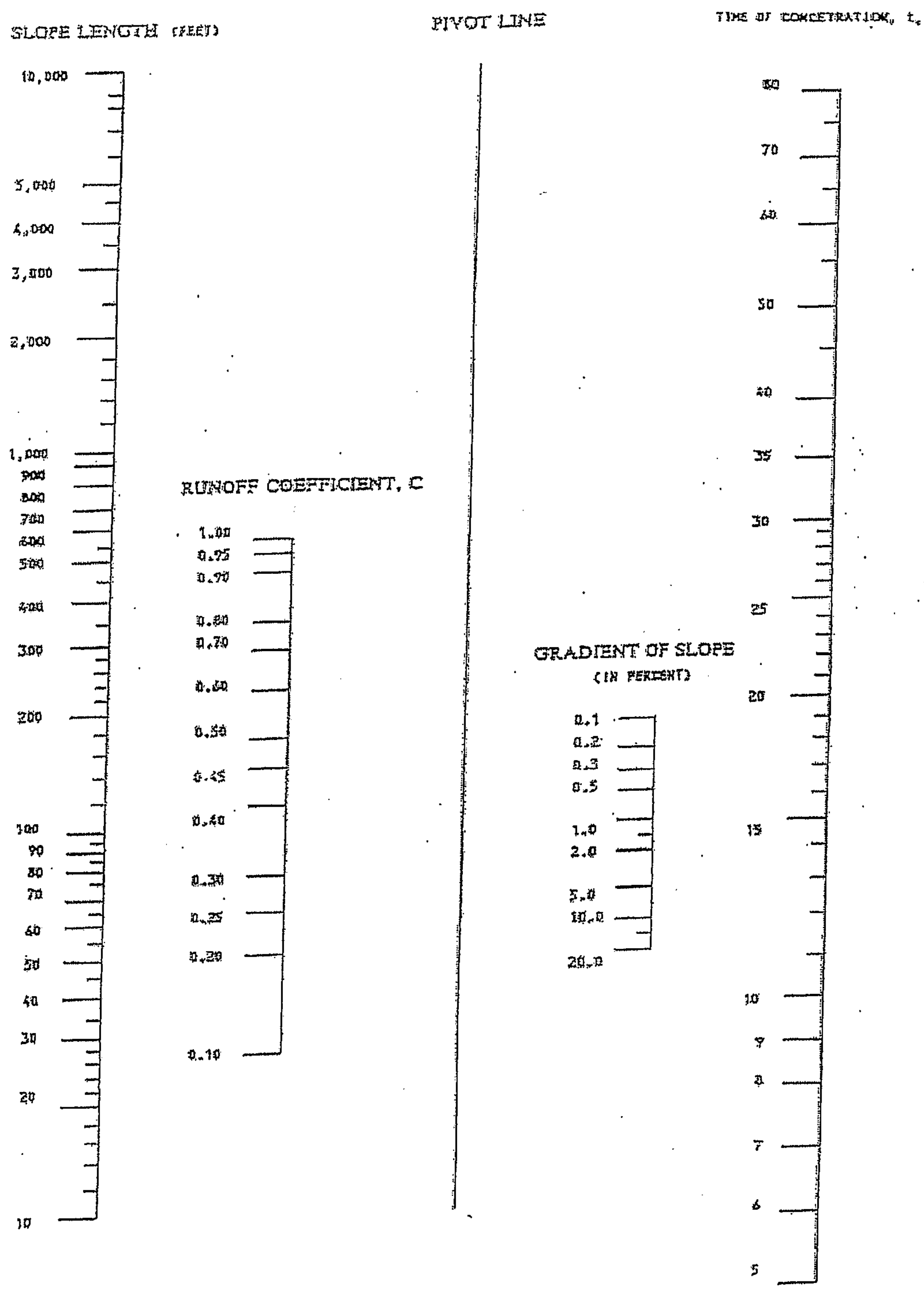
OVERLAND FLOW CHART



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 ☐ acres ☐ mi² ☐ %	Product of CN % area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

1/ Use only one CN source per line

CN (weighted) = total product/total area = ―――― = ______; Use CN = ☐

2. Runoff

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

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 ≤ 300 ft)	ft				
4. Two-yr 24-hr rainfall, P_2	in				
5. Land slope, s	ft/ft				
6. $T_t = 0.007(nL)^{0.8}/P_2^{0.5}s^{0.4}$	Compute T_t ...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. $T_t = L/360V$	Compute T_t.........hr		+	=	
Channel flow	Segment ID				
12. Cross sectional flow area, a	ft^2				
13. Wetter perimeter, P_w	ft				
14. Hydraulic radius, $r = a/P_w$ Compute r	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. $T_t = L/3600V$	Compute T_t .... hr		+	=	
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11 and 19)	.....hr				

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 .... (Use CN with table 4-1.)	in			
5. Compute I_a /P				
6. Unit peak discharge, q_u .... (Use T_c and I_a /P with exhibit 4 - ___)	csm/in			
7. Runoff, Q .... (From worksheet 2).	in			
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 .... (Where $q_p = q_u A_m Q F_p$)	cfs			

Worksheet 5a: Basic watershed data

Project ______________________ Location ______________________ By ______________ Date ______

Circle one: Present Developed ______________________ Frequency (yr) ________ Checked ________ Date ________

Subarea name	Drainage area A_m (mi^2)	Time of concen-tration T_c (hr)	Travel time through subarea T_t (hr)	Downstream subarea names	Travel time summation to outlet $\sum T_t$ (hr)	24 -hr Rain-fall P (in)	Runoff curve number CN	Run-off Q (in)	A_mQ (mi^2 - in)	Initial abstraction I_a (in)	I_a/P

↑↑↑↑↑↑↑↑↑↑↑↑↑ From worksheet 3 (Time of concentration; Travel time through subarea)

↑↑↑↑↑↑↑↑↑↑↑↑ From worksheet 2 (Runoff curve number; Run-off)

↑↑↑↑↑↑↑ From table 5-1 (Initial abstraction)

Worksheet 5b: Tabular hydrograph discharge summary

Project ______________________ Location ______________________ By ____________ Date ______

Circle one: Present Developed ______________________ Frequency (yr) ______ Checked ________ Date ________

Subarea name	Basic watershed data used 1/				Select and enter hydrograph times in hours form exhibit 5- 2/											
	Sub-area T_c (hr)	$\sum T_t$ to outlet (hr)	I_a/P	A_mQ (mi^2-in)												
					Discharges at selected hydrograph times 3/ (cfs)											
Composite hydrograph at outlet																

1/ Worksheet 5a. Rounded as needed for use with exhibit 5.

2/ Enter rainfall distribution type used.

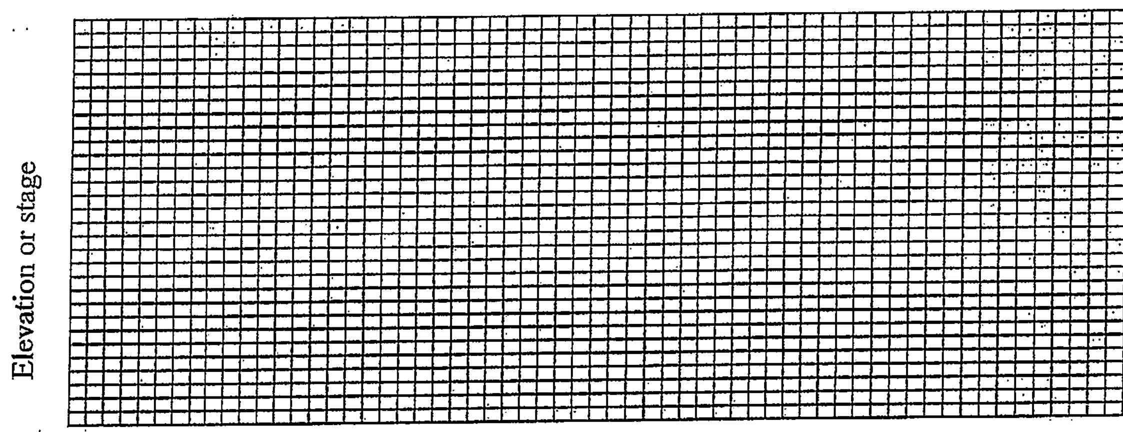
3/ Hydrograph discharge for selected times in A_mQ multiplied by tabular discharge from appropriate exhibit 5.

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) = ________

	1st stage	2nd stage
2. Frequency.................yr		
3. Peak inflow discharge q_i ....cfs (from worksheet 4 or 5b)		
4. Peak outflow discharge, q_o ....cfs 1/		
5. Compute q_o / q_i		

6. V_s/V_r.................................. (Use q_o/q_i with figure 6-1)			
7. Runoff, Q .... (From worksheet 2)	in		
8. Runoff volume, V_r .... ($V_r = QA_m53.33$)	ac-ft		
9. Storage volume, V_s .... ($V_s = V_r(V_s/V_r)$)	ac-ft		
10. Maximum stage, (From plot)	E_{max}		

1/ 2nd stage q_o includes 1st stage q_o

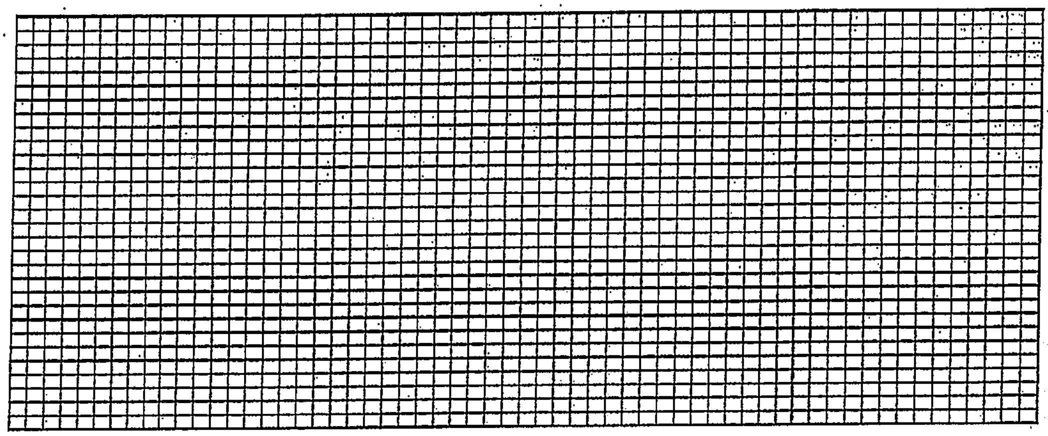
Worksheet 6b: Detention basin, peak outflow, storage volume (V_s) known

Project ______________________ By ______________ Date __________

Location ______________________ Checked ______________ Date __________

Circle one: Present Developed ______________________________

Elevation or stage



Detention basin storage

1. Data:
   - Drainage area .... A_m = ______ mi^2
   - Rainfall distribution type (I, IA, II, III) = ______

		1st stage	2nd stage
2. Frequency	yr		
3. Storage volume, V_s	ac ft		
4. Runoff, Q .... (From worksheet 2)	in		
5. Runoff volume, V_r .... ($V_r = QA_m 53.33$)	ac ft		
6. Compute V_s/V_r			
7. q_o/q_i .... (Use V_s/V_r and figure 6-1)	in		
8. Peak inflow discharge, q_i .... (From worksheet 4 or 5b)	cfs		
9. Peak outflow discharge, q_o .... ($q_o = q_i\ (q_o/q_i)$)	cfs		1/
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 (allowable detention basin outflow release rate – stage one)

Area, "A" = [_______] acres

Runoff Coefficient, "C" = [_______]

Intensity, "i" = a/(t_c+ b) = [_______] in/hr

Where: a = 80 (Table IV)

b = 14 (Table IV)

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

q_1 = A [_____]* C [_____] * i [_____] = [______] cfs

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

Q_1 = A*C*i

Area, "A" = [_______] acres

Runoff Coefficient, "C" = [_______]

Intensity, "i" = a/(t_c+ b) = [_______] in/hr

Where: a = 80

b = 14

t_c = time of concentration (minutes)

Q_1 = A [_____]* C [_____] * i [_____] = [______] cfs

III Critical Storm Calculation.

[(Q_1/q_1) – 1.0]*100 = PC PC = [______] (See Table II on Page 34 for Critical Storm Frequency)

Critical Storm Frequency = [_______]

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

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

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

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

C = the one year <u>post</u>developed weighted runoff coefficient

A = area in acres

T_{ccr} = [______] minutes

V Calculate I_{cr}:

$I_{cr} = [a / (T_{ccr} + b)]$ = [______] in/hr

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

Q_{cr} = A [______]* C [______] * I_{cr} [______] = [______] cfs

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

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

SV_{cr} = [________] ft^3

VIII Calculate the peak flow in cfs due to the one-hundred (100) year frequency storm under <u>pre</u>developed conditions.

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

Area, "A" = [_______] acres

Runoff Coefficient, "C" = [_______]

Intensity, "i" = $a/(t_c + b)$ = [_______] 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 <u>pre</u>developed

q_{100} = A [_____]* C [______] * i [______] = [______] cfs

IX Calculate maximum storm duration T_{c100}, for the one-hundred year frequency (in minutes) storm under <u>post</u>developed conditions.

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

Where: a = 290

b = 31

C = the one-hundred year <u>post</u>developed weighted runoff coefficient

A = area in acres

Tc_{100}=[______] minutes

X Calculate I_{100}:

I_{100} = [a / (Tc_{100}+ b)] = [______] in/hr

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

Q_{100} = A [_____]* C [_____] * I_{100} [_____] = [______] cfs

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

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

SV_{100} = [_________] ft^3

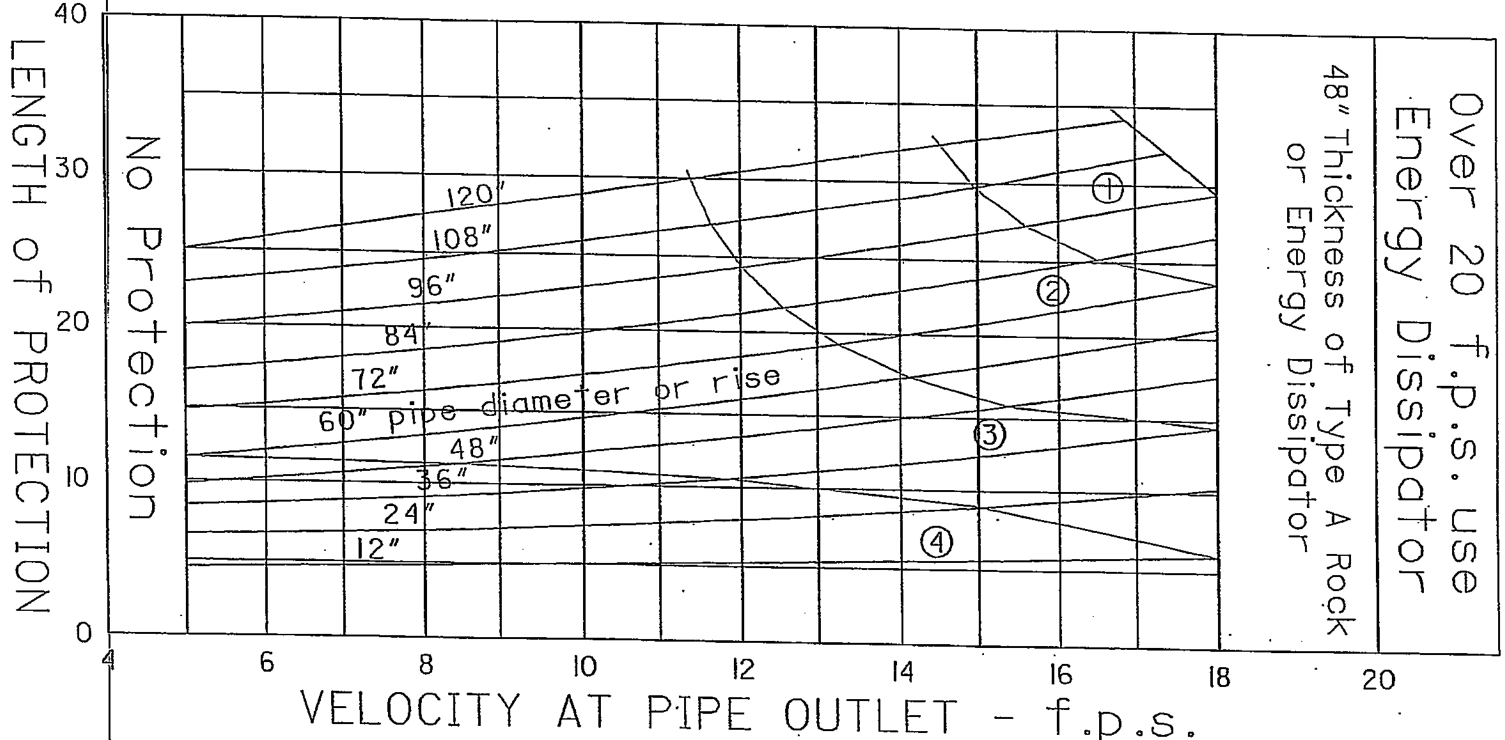
XIII Design Notes:

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, <u>Water and Wastes Engineering</u>, "Estimate Detention and Reservoir Storage". By A.S. Paital, 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	ROCK TYPE
① 48" of 18" rock	A
② 36" of 18" rock	A
③ 30" of 12" rock	B
④ 18" of 6" rock	C

Appendix A – Exhibit IV

CRITICAL AREA PLANTING

1.TEMPORARY AND PERMANENT SEEDING

1.1 SEEDBED PREPARATION

A.**Lime** (in lieu of a soil test recommendation) on acid soil (ph = 5.5 or less) and subsoil at a rate of 100 pounds per 1000 sq. ft. or two (2) tons per acre of agricultural ground limestone.

B.**Fertilizer** (in lieu of soil test recommendation) shall be applied at a rate of 12-15 pounds (25 pounds for permanent seeding) per 1000 sq. ft. of 10-10-10 or 12-12-12 analysis or equivalent.

1.2SEEDING

A.Species Selection

(1)Temporary Seeding Mixture

Seeding Period	Type	Rate (1000 ft^2)
Spring and	1. Oats	3 lbs
Summer	2. Peren. Ryegrass	1 lbs
	3. Tall Fescue	1 lbs
Fall	1. Peren. Ryegrass	1 lbs
	2. Rye	3 lbs
	3. Wheat	3 lbs
	4. Tall Fescue	1 lbs

(2) Permanent Seeding Mixture

Seeding Period	Type	Rate (1000 ft^2)
Spring,	1. Creeping Red Fescue	0.5 lbs
Summer, and	Domestic Ryegrass	0.25 lbs
Fall	Kentucky Bluegrass	0.25 lbs
	2. Tall Fescue	1 lbs
	3. Dwarf Fescue	1 lbs

(2-1) Seedings for Steep Banks or Cuts

Spring, Summer, and Fall	1. Tall Fescue	1 lbs
	2. Crownvetch	0.25 lbs
	Tall Fescue	0.50 lbs
	3. Flatpea	0.50 lbs
	Tall Fescue	0.50 lbs

(2-2) Seedings for Waterways and Road Ditches

Spring, Summer, and Fall	1. Tall Fescue	1 lbs

B. Apply the seed uniformly with a cyclone seeder, drill, cultipacker seeder, or hydroseeder (slurry may include seed and fertilizer) preferably on a firm, moist seedbed. Seed wheat or rye no deeper than one (1) inch. Seed ryegrass no deeper than one quarter (1/4) of an inch.

C. When feasible, except where a cultipacker type seeder is used, the seedbed should be firmed following seeding operations with a cultipacker, roller, or light drag. On sloping land seeding operations should be on the contour wherever possible.

D. Other seed species may be substituted for these mixtures.

E. These seeding rates need to be increased two to three times if they are to be used as a lawn.

2. <u>DORMANT SEEDING</u>

A. Temporary Seeding - After November 1, use mulch only.

B. Permanent Seeding - Seedings should not be planted from October 1 through November 20. The following methods may be used to make a "dormant seeding":

(1) From October 1 through November 20, prepare the seedbed, add the required amounts of lime and fertilizer, then mulch and anchor. After November 20, and before March 15, broadcast the selected seed mixture. Increase the seeding rates by 50 percent for this type of seeding.

(2) From November 20 through March 15, when soil conditions, permit, prepare the seedbed, lime and fertilize, apply the selected seed mixture, and

(3) mulch and anchor. Increase the seeding rates by 50 percent for this type of seeding.

3. <u>MULCHING</u>

A. Mulch shall consist of small grain straw (preferably wheat or rye) and shall be applied at the rate of two tons per acre or 100 pounds per 1000 sq. ft.

B. Spread the mulch uniformly by hand or mechanically so the soil surface is covered.

C. **Mulch Anchoring Methods**

(1) Mechanical - Use a disk, crimper, or similar type tool set straight to punch or anchor the mulch material into the soil.

(2) Asphalt Emulsion - Apply at the rate of 160 gallons per acre into the mulch as it is being applied.

(3) Mulch Netting - Use according to the manufacturer's recommendations.

4. IRRIGATION

Supply new seedlings with adequate water for plant growth until they are firmly established.