ALABAMA SUPPLEMENTS TO THE

NATIONAL ENGINEERING FIELD HANDBOOK

CHAPTER 9. DIVERSIONS

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Design of Diversions

Velocities

The choice of retardance will depend on the vegetation and maintenance planned for the diversion (Table AL9-1).

Table AL9-1. Guide to selection of vegetal retardance.		
Stand	**Average Length of vegetation**	**Degree of retardance**
Good	6 to 10”	C
	2 to 6”	D
Fair	11 to 24”	C
	2 to 10”	D

Diversion Design and Design Procedure

The following example demonstrates how to design a diversion using the tables and exhibits in Chapter 2 and Chapter 9.

Problem:

Determine the safe velocity of flow and dimensions for a stable parabolic channel diversion given the following data:

Location: Lee County, Alabama
Drainage Area: 35 acres
Soils: Ruston Sandy Loam
Conservation Practice: 18 acres of woods and 17 acres of pasture
Hydrologic Condition: Fair (woods), Good (pasture)
Watershed Length: 1300 feet
Watershed Slope: 6%
Grade of diversion to protect row crop field: 0.5 foot/100 feet
Vegetation: Bermuda and bahia grassed, Good stand mowed to 2 to 10 inches

Solution:

Step 1: Establish background data using appropriate tables and exhibits and record on form AL-ENG-9, Diversion Design, or appropriate form:

a. Hydrologic soil group: Ruston Soil is “B”.
b. Curve number: (Fair Woods - 60 and Good Pastures -61) weighted CN = 60.
c. The 10-year, 24-hour storm for Lee County is 6.3 inches.
d. Peak runoff is 45 cfs.
e. Vegetal retardance, Good Stand (Table AL9-1) is “D” and “C”.

Step 2: Use background data to evaluate velocity of flow and size of diversions:

a. Determine permissible velocity V_2 for a sandy loam soil with vegetative retardance “C” and a good stand of grass; therefore, from Table 9-1 for a sandy loam soil with good vegetation and “C” retardance, V_2 = 3.5 feet/sec.

b. Check velocity V1 for stability assuming the “D” retardance for the expected stand of vegetation and future maintenance. For this example, use a high level of management and a good stand of grass; therefore, from Table 9-1 for sandy loam soil with good vegetation and “D” retardance, V_1 = 3.0 feet/sec.

c. Size the channel based on V_1 = 3.0 ft/sec, V_2 = 3.5 ft/sec with “D” “C” retardance, grade = 0.50% and Flow (Q) = 45 cfs (Exhibit 9-2 - Sheet 2 of 14) Top width (T) = 12.5 feet. Depth (D) = 2.0 feet and Velocity (V_2) = 2.7 feet/sec.

The dimensions are for the design flow conditions. Additional fill must be added for settlement (5% for pan and 10% for plow and bulldozer construction) and for freeboard (use 0.25 foot). Where the ridge crosses deep depressions or gullies, the design height or shrinkage should be increased to 10%

depending on construction equipment used. The dimensions for the diversion above using bulldozer construction settlement of 10% and freeboard of 0.25 foot is d = 2.0 x 1.10 + 0.25 = 2.45 feet.

From Figure 9-8 find formula to compute new constructed top width depth and area for the parabolic channel.

Constructed depth (d) = [DX 1.10 (Settlement) + 0.25 (freeboard)] = 2.0 ft. x 1.10 + 0.25 ft. = 2.45 feet.

Constructed top width (t) = $\frac{1.5A}{D} = \frac{1.5 \times 2/3\ Td}{D} = \frac{1.5 \times 2/3 \times 12.5\ ft. \times 2.45\ ft.}{2.0}$ = 15.3 feet

Use t = 15.3 feet Depth (d) = 2.45 feet to determine constructed area.

Constructed area (a) = 2/3 td = 2/3 x 15.3 x 2.45 = 25.00 sq.ft.

Record the Design Data on Form AL-ENG-9, or other appropriate form.

d = 0.7'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =				0.3	0.4	0.5	0.7	0.9	1.1	1.2
LS	**T**	**A**		**Q in cfs**						
5	16	6		2	2	3	4	5	7	7
3	24	8		2	3	4	6	7	9	10
2	32	11		3	4	6	8	10	12	13
1	40	14		4	6	7	10	13	15	17
1	48	17		5	7	9	12	15	19	20
1	56	20		6	8	10	14	18	22	24
1	64	22		7	9	11	15	20	24	26
1	72	25		8	10	13	18	23	28	30
0.9	80	28		8	11	14	20	25	31	34
0.8	88	31		9	12	16	22	28	34	37
0.7	96	34		10	14	17	24	31	37	41
0.6	104	36		11	15	18	25	32	40	43
0.6	112	39		12	16	20	27	35	43	47
0.5	120	42		13	17	21	29	38	46	50
0.5	128	45		14	18	23	32	41	50	54

LS=Maximum land slope
T =Top width at design flow depth
d =Design flow depth
V_2 =Velocity, retardance "D" calculated from Manning's Formula using "n" values from Figure 13 of SCS-TP-61.
A =Cross sectional area of channel at design flow depth (Formula - A = ½Td)

Note: Add freeboard and settlement to "d" values to determine construction height. Value for max. land slope calculated on 4:1 terrace front slopes.

Find "Q" in selected grade column compatible with depth, top width, and land slope at the diversion site.

Example:

Given: Q_{10} = 120 cfs, Grade = 0.75%, Land Slope = 4%, V_1 and 3 ft/sec
Answer: Sheet 3 of 5, d = 1.9', Capacity = 138 cfs, T = 48,
V_2 = 3 ft/sec, A = 46.

Check top width for ground conditions using a 4:1 terrace front slope.
T = 1.9/4 (100) + (4)(1.9) = 47.5 + 7.6 + 55' This design is satisfactory.

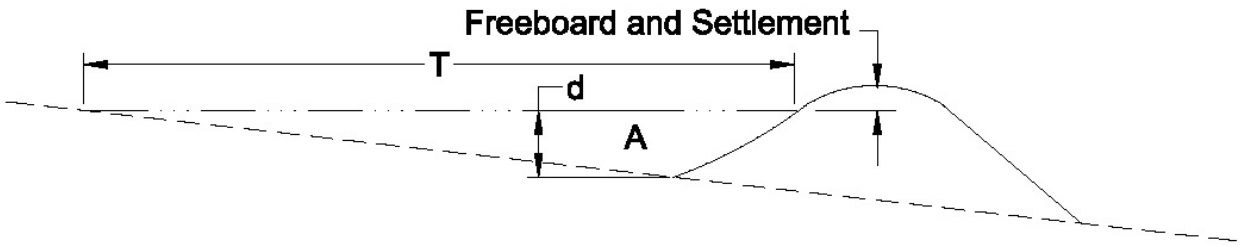

Exhibit AL9-1. Diversion design table for use with standard terrace type construction. (Sheet 1 of 5)

d = 1.0'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			0.4	0.7	1.0	1.3	1.6	1.9	2.2	2.4
LS	T	A	Q in cfs							
12	12	6	2	4	6	8	10	11	13	14
6	20	10	4	7	10	13	16	19	22	24
4	28	14	6	10	14	18	22	27	31	34
3	36	18	7	13	18	23	29	34	40	43
2	44	22	9	15	22	29	35	42	48	53
2	52	26	10	18	26	34	42	49	57	62
1	60	30	12	21	30	39	48	57	66	72
1	68	34	14	24	34	44	54	65	75	82
1	76	38	15	27	38	49	61	72	84	91
1	84	42	17	29	42	55	67	80	92	101
1	92	46	18	32	46	60	74	87	101	110
1	100	50	20	35	50	65	80	95	110	120
0.9	108	54	22	38	54	70	86	103	119	130
0.8	116	58	23	41	58	75	93	110	128	139
0.8	124	62	25	43	62	81	99	118	136	149
0.7	132	66	26	46	66	86	106	125	145	158
0.7	140	70	28	49	70	91	112	133	154	168
0.6	148	74	30	52	74	96	118	141	163	178
0.6	156	78	31	55	78	101	125	148	172	187

d = 1.3'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			0.6	1.1	1.6	2.1	2.6	3.0	3.3	3.6
LS	T	A	Q in cfs							
12	16	10	6	11	16	21	26	30	33	36
6	24	16	10	18	26	34	42	48	53	58
4	32	21	13	23	34	44	55	63	69	76
3	40	26	16	29	42	55	68	78	86	94
3	48	31	19	34	50	65	81	93	102	112
2	56	36	22	40	58	76	94	108	119	130
2	64	42	25	46	67	88	109	126	139	151
1	72	47	28	52	75	99	122	141	155	169
1	80	52	31	57	83	109	135	156	172	187
1	88	57	34	63	91	120	148	171	188	205
1	96	62	37	68	99	130	161	186	205	223
1	104	68	41	75	109	143	177	204	224	245
1	112	73	44	80	117	153	190	219	241	263
1	120	78	47	86	125	164	203	234	257	281
1	128	83	50	91	133	174	216	249	274	299
0.9	136	88	53	97	141	185	229	264	290	317
0.9	144	94	56	103	150	197	244	282	310	338
0.8	152	99	59	109	158	208	257	297	327	356
0.8	160	104	62	114	166	218	270	312	343	
0.7	168	109	65	120	174	229	283	327	360	
0.7	176	114	68	125	182	239	296	342		
0.7	184	120	72	132	294	252	312	360		

Exhibit AL9-1. Diversion design table for use with standard terrace type construction. (Sheet 2 of 5)

d = 1.6'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			1.0	1.7	2.4	3.0	3.4	3.9	4.3	4.7
LS	T	A	Q in cfs							
16	16	13	13	22	31	39	44	51	56	
9	24	19	19	32	46	57	65	74	82	
6	32	26	26	44	62	78	88	101	112	
4	40	32	32	54	77	96	109	125	138	
3	48	38	38	65	91	114	129	148	163	
3	56	45	45	77	108	135	153	176	194	
2	64	51	51	87	122	153	173	199	219	
2	72	58	58	99	139	174	197	226	249	
2	80	64	64	109	154	192	218	250	275	
1	88	70	70	119	168	210	238	273	301	
1	96	77	77	131	185	231	262	300	331	
1	104	83	83	141	199	249	283	324	357	
1	112	90	90	153	216	270	306	351	387	
1	120	96	96	163	230	288	326	374	413	
1	128	102	102	173	245	306	347	398	439	
1	136	109	109	185	262	327	371	425	469	
1	144	115	115	196	276	345	391	449	495	
1	152	122	122	207	293	366	415	476	525	
1	160	128	128	218	307	384	435	499	550	
0.9	168	134	134	228	322	402	456	523		
0.9	176	141	141	240	338	423	479	550		
0.9	184	147	147	250	353	441	500	573		

d = 1.9

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			1.3	2.3	3.0	3.7	4.2	4.7	5.3	5.8
LS	T	A	Q in cfs							
22	16	15	20	35	45	59	63			
11	24	23	30	53	69	89	97			
7	32	30	39	69	90	118	126			
5	40	38	49	87	114	148	160			
4	48	46	60	106	138	170	193			
3	56	53	69	122	159	196	222			
3	64	61	79	140	183	226	256			
2	72	68	88	156	204	251	286			
2	80	76	99	175	228	281	319			
2	88	84	109	193	252	311	353			
2	96	91	118	209	273	337				
1	104	99	129	228	297	366				
1	112	106	138	244	318					
1	120	114	148	262	342					
1	128	122	159	281	366					
1	136	129	168	297						
1	144	137	178	315						
1	152	144	187	331						
1	160	152	198	350						
1	168	160	208	368						

Exhibit AL9-1 - Diversion design table for use with standard terrace type construction. (Sheet 3 of 5)

d = 2.2'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			1.5	2.4	3.3	4.3	5.1			
LS	T	A	Q in cfs							
30	16	18	27	43	59	77				
14	24	26	39	62	86	112				
9	32	35	53	84	116	151				
7	40	44	66	106	145	189				
5	48	53	80	127	175	228				
4	56	62	93	149	205	267				
3	64	70	105	168	231	301				
3	72	79	119	190	261	340				
3	80	88	132	211	290					
2	88	97	146	233	320					
2	96	106	159	254	350					
2	104	114	171	274						
2	112	123	185	295						
1	120	132	198	317						
1	128	141	212	338						
1	136	150	225	360						

d = 2.5'

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			2.0	3.2	4.2	5.1	5.7			
LS	T	A	Q in cfs							
41	16	20	40	64	84					
17	24	30	60	96	126					
11	32	40	80	128	168					
8	40	50	100	160	210					
6	48	60	120	192	252					
5	56	70	140	224	294					
4	64	80	160	256	336					
4	72	90	180	288	378					
3	80	100	200	320						
3	88	110	220	352						
2	96	120	240	384						
2	104	130	260							

Exhibit AL9-1 Diversion design table for use with standard terrace type construction. (Sheet 4 of 5)

d = 2.8’

Grade in % =			0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Velocity - V_2 =			2.3	3.6	4.6	5.6				
LS	**T**	**A**	**Q in cfs**							
21	24	34	78	122	156					
13	32	45	104	162	207					
9	40	56	129	202	258					
7	48	67	154	241	308					
6	56	78	179	281	359					
5	64	90	207	324						
4	72	101	232	364						
4	80	112	258							
3	88	123	283							
3	96	134	308							
3	104	146	336							
2	112	157	361							

Exhibit AL9-1. Diversion design table for use with standard terrace type construction. (Sheet 5 of 5)

DIVERSIONS

A. Engineering Surveys for Design and Construction Layout
(SCS-ENG-191, Field Book)

1. Complete title page with sketch of practice location.
2. Show at beginning of survey: farmer's name, purpose of survey, name of practice, party members, duties, and dates.
3. Profile notes of channel showing grade, outlet elevation, and condition in accordance with recommended format.
4. Diversion design using Form AL-ENG-9.

B. Construction and Performance Check
(SCS-ENG-191, Field Book)

1. Profile notes of channel and ridge.
2. Cross section of channel and ridge for each design section.
3. Length of completed diversion.
4. Vegetative measures.
5. Certification that practice meets construction plans and specifications.

SCD *Lee County* Date *9/10/00*
Field Office *Opelika*
Farmer: *Harry A. Smith*
Location: 5 mi. west of Opelika

Job: *Diversion no.1*
Design Survey: *9/10/86* Const. Layout: *9/10/86*
Constr. Check: *9/27/86* Other:
Dist. Agr. No. 481 Field No.: *4*
AOP No.: 6-62

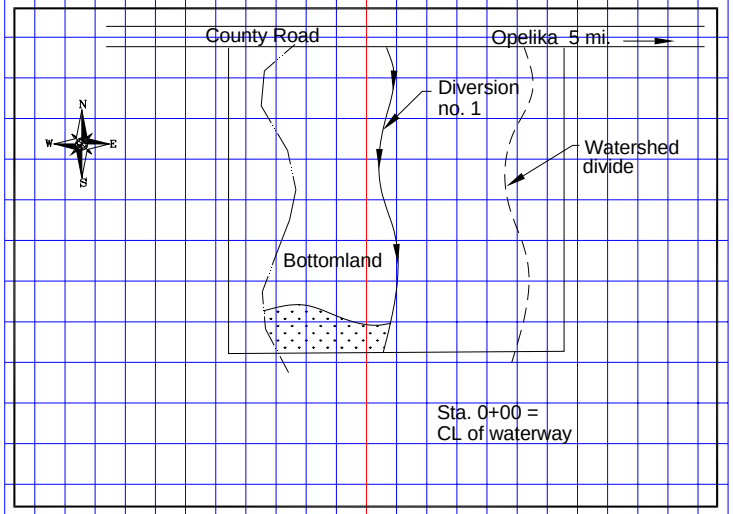

Figure AL9-1. Sample field notes (title page). (Sheet 1 of 3)

U.S. Dept. of Agriculture
Natural Resources Conservation Service

AL-ENG-9
Rev. 2/04

DIVERSION DESIGN

DIV. NO. 1

DIVERSION TYPE: TRAPEZOID _____ TERRACE _____ PARABOLIC X

JOB CLASS I SOILS Rushton HYD. GROUP B

LAND USE OR PRACTICE Woods HYD. COND. Fair

RAINFALL DIST. TYPE II OR III (circled) D.A. 35 AC. CN 60

W/S SLOPE 6 % FLOW LENGTH 1300 FT. Tc 0.46 HRS.

RAINFALL(10 yrs) 6.3 IN. Ia --- IN. Ia/P ------

RUNOFF 2.12 IN. Qu ------- CFS/AC/IN Q 10 YRS. 45(EFH2) CFS

VEG. COVER Bahia/Bermuda STAND Fair HGT. 2" - 10"

SOIL TEXTURE Sandy Loam PERM. VEL (V_1) = 3.0 FT./SEC.

RETARDANCE D-C, Tw = 12.5 or Bw = ------ DEPTH 2.0

V_2 = 2.7 FT./SEC. CONST. Tw = 15.3 GRADE 0.5 FT./100 FT.

DEPTH = 2.0 + 0.2 + 0.25 = 2.45 FT. A = 25.0 $FT.^2$

OTHER Tw = (1.5 x 2/3 x 12.5 x 2.45) / 12 = 15.3' A = 2/3 x 15/3 x 2.45

VEG. TREAT. Bahia & Bermudagrass - Seed & Mulch

COND. OF OUTLET Good Grassed Waterway

DESIGNED J.D. Jones CHECKED J. P. Pool

Station	Rod		Station	Rod
Outlet 0+00	10.9		11+00	4.6
1+00	10.0		12+00	4.0
2+00	9.0		13+00	3.4
3+00	8.6			
4+00	8.1			
5+00	7.5			
6+00	7.0			
7+00	6.5			
8+00	6.0			
9+00	5.4			
10+00	5.1			

Harry A. Smith & - J.D. Jones
Diversion no. 1 - J.P. Poole 9/10/00
Design Construction Layout

Outlets into sod disposal area.

Figure AL9-1. Sample field notes (design). (Sheet 2 of 3)

	Cross Section - Diversion no. 1				
Distance	Rod	Rod diff.	Distance	Rod	Rod diff.
0	5.0	0	18		
2	5.8	0.8	20		
4	6.9	1.9	22		
6	7.4	2.4	20		
8	7.6	2.6	24		
10	7.4	2.4	Note: For cross section,		
12	6.9	1.9	multiply by distance		
14	5.7	0.7	between stations.		
16	5.0	0			
		X-Section = 12.7 x 2 = 25.4 sq. ft.			
		Profile - Diversion no. 1			
Station	Chan. rod	Ridge rod	Station	Chan. rod	Ridge rod
Bot. outlet	12.1				
0+00	11.8	9.3	8+00	7.8	5.2
1+00	11.3	8.7	9+00	7.3	4.7
2+00	10.9	8.4	10+00	6.7	4.2
3+00	10.3	7.7	11+00	6.3	3.8
4+00	9.7	7.2	12+00	5.8	3.2
5+00	9.3	6.8	13+00	5.3	2.7
6+00	8.8	6.2			
7+00	8.3	5.8			
SCS-ENG-29 (2-80)					

Harry A. Smith & - J. Poole
Diversion no. 1 - D. Jones
Construction check 9/27/00

Construction meets plans and specifications as checked.
Diversion has been plowed, fertilized and seeded to bermuda grass.

J. P. Poole
Conservation Technician
9/27/00

Figure AL9-1. Sample field notes (construction). (Sheet 3 of 3)