DRAINAGE REPORT

FOR

BENSON ESTATES

Prepared For:
City of Fruita Review

Prepared By:
Williams Engineering
1231 19 Road
Fruita, CO 81521
(970) 858-1014

May, 2000

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COLORADO REGISTERED
GERALD R. WILLIAMS
GRW
26431
5/15/00
PROFESSIONAL ENGINEER

NARRATIVE

General Location and Drainage Patterns The site is located north of and adjacent to K.4 Road between 18 Road and 18.5 Road (see the Watershed Map). Just north of the site is a divide that results in very little area that drains towards the site from the north. An elevated concrete ditch along the north side of the site will intercept the minimal runoff generated, thus effectively preventing inflow along the northern boundary. From the east, the contributing area that could reach the east site boundary were there no obstacles is also not very large. Runoff generated east of 18.5 Road will be diverted south, not likely overtopping 18.5 Road until a point south of K.4 Road (see discussion and review comments on Monument Glen Filing 3 Drainage Report). Of the 10 acres west of 18.5 Road and east of the site, runoff from 9.9 acres will be intercepted and taken south by a berm between the two properties that is above and in addition to the tailwater ditch, which was assumed to be full in our channel analysis. Only approximately 0.1 acres east of the site will drain across the eastern boundary. Runoff from the balance of the site will be conveyed south to K.4 Road. Existing there is a tailwater ditch with limited capacity, but roadway improvements to K.4 Road soon to be constructed as part of Monument Glen Filing 3 should result in an adequate borrow ditch. However, any crossings must be adequate to convey flow.

Site runoff flows southwest because of topography and multiple tailwater ditches. By plan or by default, the water will end up at the southwest corner of the site. Runoff to that point joins flow from the east. Flow amounts at this point of discharge to offsite should not increase due to development.

Proposed Drainage Pattern Changes

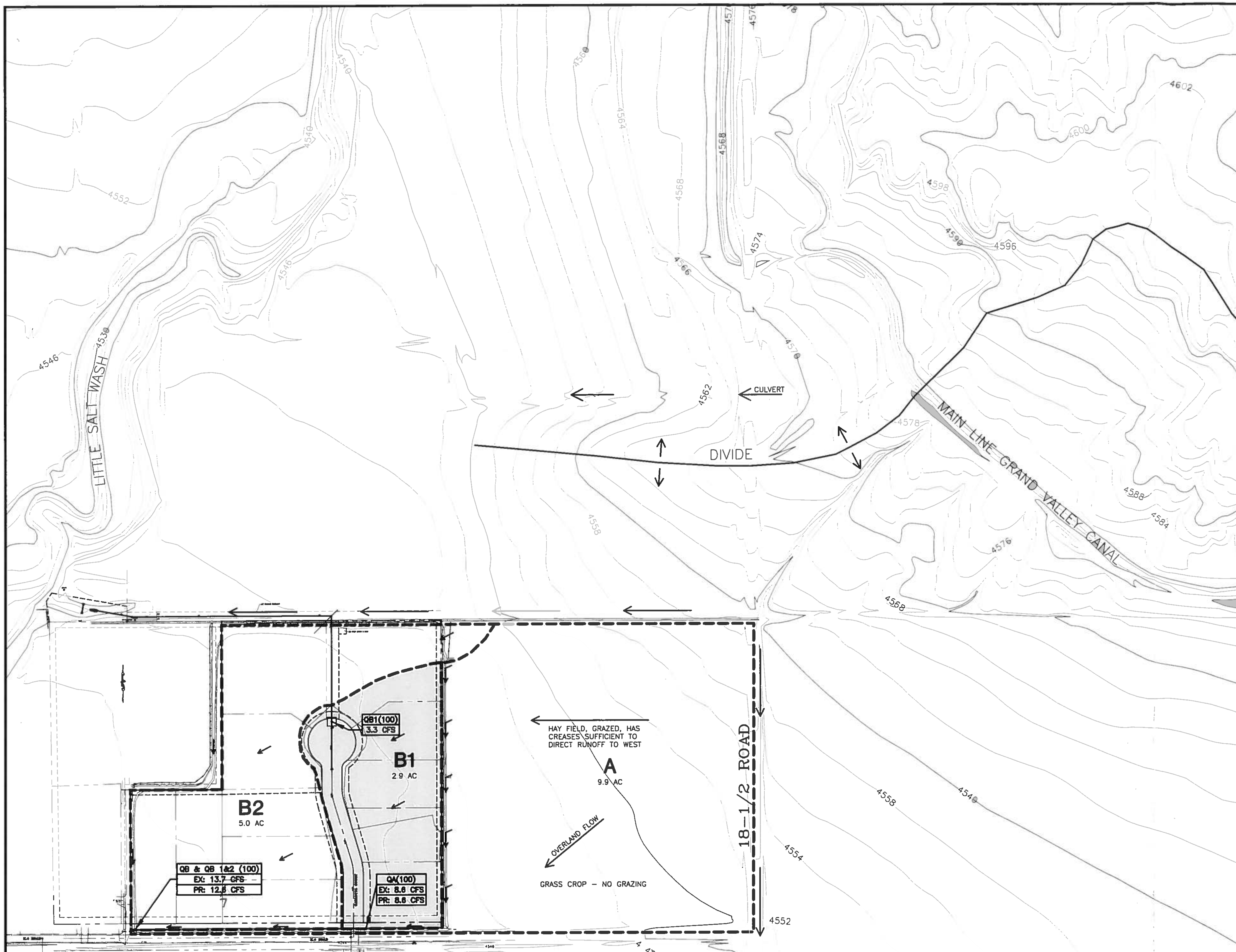
Rather than provide a small nuisance detention basin to prevent an increase in runoff, we propose to divert runoff from the natural flow pattern and take it to Little Salt Wash. This is in accordance with the Fruita Stormwater Management Master Plan, which is to quickly discharge local runoff to the wash before the peak from upland areas arrive. The wash has adequate capacity for both the local and upland peak separately, but not if the two peaks are overlapping.

Results and Conclusions

Project drainage is quite simple. Nonetheless, calculations are provided in the appendicies according to the Stormwater Management Manual to determine peak flows at key locations. Peaks are shown on the Watershed Map at various locations for existing and proposed conditions. The diversion is sufficient to prevent an increase in runoff to the southwest corner of the site. The street, inlet, and storm drain have adequate capacity to convey the 100 year runoff that they receive to the wash without flooding. Furthermore, as is shown on the construction plans, the drainage system should still function during Little Salt Wash flooding, the 100 year flood level being 4.1' lower than the inlet grate and the 500 year 1.6' lower. These flood levels are also below the irrigation pump pit that has a floor drain connected to the storm drain.

Proposed culvert crossings also have capacity to convey estimated runoffs. An existing 12" CMP will be replaced with a double 15" culvert at an existing driveway, and the same will be used "upstream" at the Carlotta Court crossing.

Appendicies are provided which document parameter value selection and also calculations.



DRAINAGE SUMMARY
(FOR ADDITIONAL INFORMATION, REFER TO THE DRAINAGE REPORT)

APPROXIMATELY 0.1 ACRES OF OFFSITE AREA CONTRIBUTES TO THE SITE AT THE NORTHEAST CORNER, AND 0.9 ACRES TO THE SOUTHEAST CORNER AT A DRAIN DITCH.

BASIN A: AREA = 9.9 AC
QA(100) = 8.6 CFS

BASIN B: EXISTING CONDITION
AREA = 7.9 ACRES
QB(100) = 13.7 CFS

PROPOSED CONDITION
AREA B1 = 2.9 ACRES
QB1(100) = 3.3 CFS
AREA B2 = 5.0 ACRES
QB2(100) = 4.1 CFS

COMPARE PRE & POST DEVELOPMENT
AT THE SOUTHWEST CORNER OF THE SITE, 100 YEAR FLOWS:

EXISTING Q100 = QA + QB
= 8.6 + 5.1
= 13.7 CFS

PROPOSED Q100 = QA + QB2
= 8.6 + 4.1
= 12.7 CFS

WITH THE DIVERSION OF AREA B1 RUNOFF TO LITTLE SALT WASH, RUNOFF OFFSITE TO THE SOUTHWEST CORNER IS DECREASED WITH PROPOSED DEVELOPMENT.

DESCRIPTION	DATE
REVISION △	
REVISION △	
REVISION △	

SCALE	PLAN	PROFILE	SECTIONS
HORIZONTAL	0 50 100 200		
VERTICAL			

WILLIAMS ENGINEERING
1231 19 ROAD, FRUITA, COLORADO 81521-9689
(970) 858-1014 PHONE (970) 858-1007 FAX

BENSON ESTATES
WATERSHED MAP

SHEET 1
FILENAME
WSHED.DWG

Appendicies

3. **Basin Average Total Storm Precipitation** When using SCS rainfall distributions which are based upon a percent of rainfall, a basin average total precipitation depth is required. These same depths may also be used to calculate volume of runoff for total retention (see Section VIII and Appendix "N"). Depths at various storm durations for various frequencies (known as Depth-Duration-Frequency, or DDF) are provided in Table "A-2" for the Grand Valley. For outside the Grand Valley, use information provided in Figure "A-1".

TABLE "A-2"
DEPTH-DURATION-FREQUENCY (DDF)
FOR THE GRAND VALLEY

Storm Duration (Hours)	Precipitation Depth (inches)	
	2-Year Storm	100-Year Storm
2	0.42	1.40
6	0.55	1.56
24	0.70	2.01

Source: Mesa County 1992

4. **Area Rainfall Depth Reduction Curves** The larger the watershed area, the less likely that the same level of intensity will be constant spatially. Curves have been provided which allow reduction of the values provided in Table "A-2" and Figure "A-1" for larger watersheds. These have been reproduced and are provided in Figure "A-2".

5. **SCS Rainfall Distribution** Rainfall distributions have been developed by the SCS for several storm durations. The information is usually provided in "S" curve form, showing the percent of total precipitation depth at a given time. In HEC-1, data is entered either on PI or PC records; that is, incremental precipitation or cumulative precipitation. The data are based on increments of time which are specified on the "IN" record "JXMIN" parameter. Since the rainfall distribution data will most likely be used as tabular input into a computer file, information from curves has been converted to a tabular cumulative precipitation versus time format. Additionally, it is presented in a way that may be directly inserted into a HEC-1 free format input file. The SCS rainfall distribution data is provided in Table "A-3".

TABLE "A-1a"
IDF DATA FOR USE IN THE GRAND VALLEY

Time (min)	2-Year Intensity (in/hr)	100-Year Intensity (in/hr)	Time (min)	2-Year Intensity (in/hr)	100-Year Intensity (in/hr)
5	1.11	4.41	33	0.51	2.03
6	1.07	4.23	34	0.50	1.99
7	1.03	4.07	35	0.49	1.95
8	0.99	3.92	36	0.49	1.91
9	0.95	3.78	37	0.48	1.88
10	0.92	3.64	38	0.47	1.85
11	0.89	3.52	39	0.46	1.82
12	0.86	3.41	40	0.45	1.79
13	0.83	3.30	41	0.45	1.76
14	0.81	3.20	42	0.44	1.73
15	0.79	3.11	43	0.43	1.70
16	0.76	3.02	44	0.42	1.67
17	0.74	2.93	45	0.42	1.64
18	0.72	2.85	46	0.41	1.61
19	0.70	2.77	47	0.40	1.59
20	0.68	2.70	48	0.40	1.57
21	0.67	2.63	49	0.39	1.55
22	0.65	2.57 B1	50	0.39	1.53
23	0.64	2.51	51	0.38	1.50
24	0.62	2.45	52	0.38	1.48
25	0.61	2.39	53	0.37	1.46
26	0.59	2.34	54	0.37	1.44
27	0.58	A, B 2.29 B2	55	0.36	1.42
28	0.57	2.24	56	0.36	1.40
29	0.56	2.19	57	0.35	1.38
30	0.54	2.15	58	0.35	1.37
31	0.53	2.11	59	0.34	1.35
32	0.52	2.07	60	0.34	1.33

Source: Mesa County 1992 (Modified) $I_2 = \frac{26.71}{Tc + 19.01}$ $I_{100} = \frac{104.94}{Tc + 18.80}$

SUBBASIN I.D.	LAND USE OR SURFACE CHARAC-TERISTICS	STORM FREQ.	SCS HYDROLOGIC SOIL GROUP AND NAME (eg - "B:ABERT")								COMPOSITE C VALUE $\Sigma\left(\frac{C \times \%}{100}\right)$
			A:		B:		C:		D:		
			% OF SUBBASIN	"C" VALUE	% OF SUBBASIN	"C" VALUE	% OF SUBBASIN	"C" VALUE	% OF SUBBASIN	"C" VALUE	
A	-House & Traffic Areas	100			BE = HSG A,		5	0.80			
					RA = HSG B.						
	-Pvmt				BUT, FOR HIGH		4	0.95			
	- PASTURE (GRAZED)				INTENSITY		45	0.38			
	-CULT/AG (NOT GRAZED)				STORMS, THEY		46	0.28			0.38
					ACT MORE LIKE						
					A TIGHTER SOIL.						
					I WILL USE						
					TYPE C.						
B	GRASS CROP						100	0.28			0.28
B1	1/2 AC LOT, BUT LITTLE LOT ON ONE SIDE OF STREET - USE 1/3 AC LOT						100	0.44			0.44
B2	1/2 AC LOT, BUT NO ROW. USE 1 AC LOT VALUE						100	0.36			0.36
ZZ	EXAMPLE		10	.60	40	.70	40	.80	10	.90	.75

SEE APPENDIX "C" FOR SOIL DESCRIPTIONS. SEE TABLE "B-1" FOR APPROXIMATE "C" VALUES

COMPOSITE RUNOFF COEFFICIENTS WORKSHEET — **TABLE "B-2"**

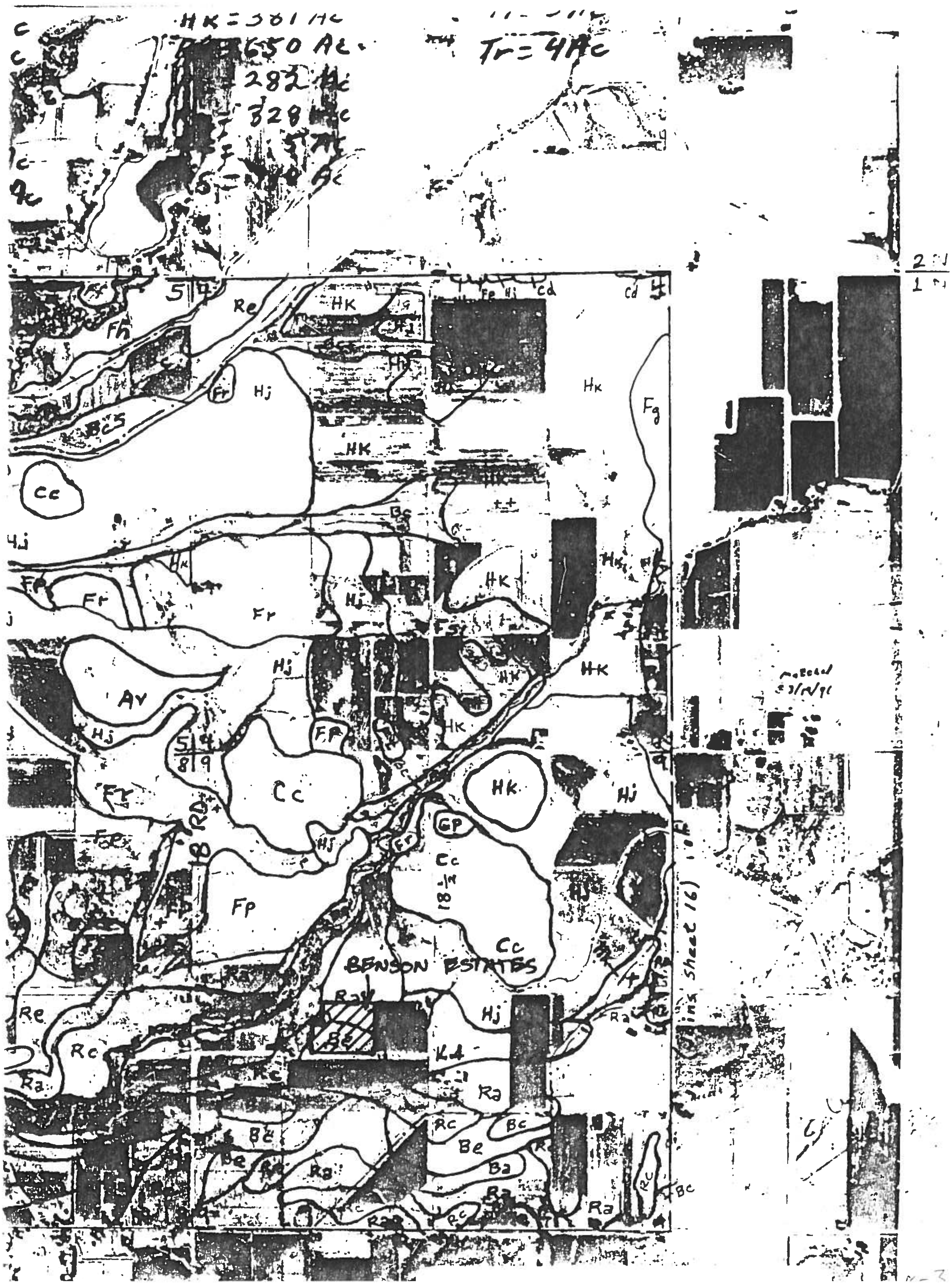
LAND USE OR SURFACE CHARACTERISTICS	SCS HYDROLOGIC SOIL GROUP (SEE APPENDIX "C" FOR DESCRIPTIONS)											
	A			B			C			D		
	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
UNDEVELOPED AREAS Bare ground	.10 - .20 .14 - .24	.16 - .26 .22 - .32	.25 - .35 .30 - .40	.14 - .22 .20 - .28	.22 - .30 .28 - .36	.30 - .38 .37 - .45	.20 - .28 .26 - .34	.28 - .36 .35 - .43	.36 - .44 .40 - .48	.24 - .32 .30 - .38	.30 - .38 .40 - .48	.40 - .48 .50 - .58
Cultivated/Agricultural NOT COMPACTED BY GRAZING	.08 - .18 .14 - .24	.13 - .23 .18 - .28	.16 - .26 .22 - .32	.11 - .19 .16 - .24	.15 - .23 .21 - .29	.21 - .29 .28 - .36	.14 - .22 .20 - .28	.19 - .27 .25 - .33	.26 - .34 .34 - .42	.18 - .26 .24 - .32	.23 - .31 .29 - .37	.31 - .39 .41 - .49
Pasture COMPACTED WITH GRAZING	.12 - .22 .15 - .25	.20 - .30 .25 - .35	.30 - .40 .37 - .47	.18 - .26 .23 - .31	.28 - .36 .34 - .42	.37 - .45 .45 - .53	.24 - .32 .30 - .38	.34 - .42 .42 - .50	.44 - .52 .52 - .60	.30 - .38 .37 - .45	.40 - .48 .50 - .58	.50 - .58 .62 - .70
Meadow	.10 - .20 .14 - .24	.16 - .26 .22 - .32	.25 - .35 .30 - .40	.14 - .22 .20 - .28	.22 - .30 .28 - .36	.30 - .38 .37 - .45	.20 - .28 .26 - .34	.28 - .36 .35 - .43	.36 - .44 .44 - .52	.24 - .32 .30 - .38	.30 - .38 .40 - .48	.40 - .48 .50 - .58
Forest	.05 - .15 .08 - .18	.08 - .18 .11 - .21	.11 - .21 .14 - .24	.08 - .16 .10 - .18	.11 - .19 .14 - .22	.14 - .22 .18 - .26	.10 - .18 .12 - .20	.13 - .21 .16 - .24	.16 - .24 .20 - .28	.12 - .20 .15 - .23	.16 - .24 .20 - .28	.20 - .28 .25 - .33
RESIDENTIAL AREAS 1/8 acre per unit	.40 - .50 .48 - .58	.43 - .53 .52 - .62	.46 - .56 .55 - .65	.42 - .50 .50 - .58	.45 - .53 .54 - .62	.50 - .58 .59 - .67	.45 - .53 .53 - .61	.48 - .56 .57 - .65	.53 - .61 .64 - .72	.48 - .56 .56 - .64	.51 - .59 .60 - .68	.57 - .65 .69 - .77
1/4 acre per unit	.27 - .37 .35 - .45	.31 - .41 .39 - .49	.34 - .44 .42 - .52	.29 - .37 .38 - .46	.34 - .42 .42 - .50	.38 - .46 .47 - .55	.32 - .40 .41 - .49	.36 - .44 .45 - .53	.41 - .49 .52 - .60	.35 - .43 .43 - .51	.39 - .47 .47 - .55	.45 - .53 .57 - .65
1/3 acre per unit	.22 - .32 .31 - .41	.26 - .36 .35 - .45	.29 - .39 .38 - .48	.25 - .33 .33 - .41	.29 - .37 .38 - .46	.33 - .41 .42 - .50	.28 - .36 .36 - .44	.32 - .40 .41 - .49	.37 - .45 .48 - .56	.31 - .39 .39 - .47	.35 - .43 .43 - .51	.42 - .50 .53 - .61
1/2 acre per unit	.16 - .26 .25 - .35	.20 - .30 .29 - .39	.24 - .34 .32 - .42	.19 - .27 .28 - .36	.23 - .31 .32 - .40	.28 - .36 .36 - .44	.22 - .30 .31 - .39	.27 - .35 .35 - .43	.32 - .40 .42 - .50	.26 - .34 .34 - .42	.30 - .38 .38 - .46	.37 - .45 .48 - .56
1 acre per unit	.14 - .24 .22 - .32	.19 - .29 .26 - .36	.22 - .32 .29 - .39	.17 - .25 .24 - .32	.21 - .29 .28 - .36	.26 - .34 .34 - .42	.20 - .28 .28 - .36	.25 - .33 .32 - .40	.31 - .39 .40 - .48	.24 - .32 .31 - .39	.29 - .37 .35 - .43	.35 - .43 .46 - .54
MISC. SURFACES Pavement and roofs	.93 .95	.94 .96	.95 .97	.93 .95	.94 .96	.95 .97	.93 .95	.94 .96	.95 .97	.93 .95	.94 .96	.95 .97
Traffic areas (soil and gravel)	.55 - .65 .65 - .70	.60 - .70 .70 - .75	.64 - .74 .74 - .79	.60 - .68 .68 - .76	.64 - .72 .72 - .80	.67 - .75 .75 - .83	.64 - .72 .72 - .80	.67 - .75 .75 - .83	.69 - .77 .77 - .85	.72 - .80 .79 - .87	.75 - .83 .82 - .90	.77 - .85 .84 - .92
Green landscaping (lawns, parks)	.10 - .20 .14 - .24	.16 - .26 .22 - .32	.25 - .35 .30 - .40	.14 - .22 .20 - .28	.22 - .30 .28 - .36	.30 - .38 .37 - .45	.20 - .28 .26 - .34	.28 - .36 .35 - .43	.36 - .44 .42 - .52	.24 - .32 .30 - .38	.30 - .38 .40 - .48	.40 - .48 .50 - .58
Non-green and gravel landscaping	.30 - .40 .34 - .44	.36 - .46 .42 - .52	.45 - .55 .50 - .60	.45 - .55 .50 - .60	.42 - .50 .48 - .56	.50 - .58 .57 - .65	.40 - .48 .46 - .54	.48 - .56 .55 - .63	.56 - .64 .64 - .72	.44 - .52 .50 - .58	.50 - .58 .60 - .68	.60 - .68 .70 - .78
Cemeteries, playgrounds	.20 - .30 .24 - .34	.26 - .36 .32 - .42	.35 - .45 .40 - .50	.35 - .45 .40 - .50	.32 - .40 .38 - .46	.40 - .48 .47 - .55	.30 - .38 .36 - .44	.38 - .44 .45 - .53	.46 - .54 .54 - .62	.34 - .42 .40 - .48	.40 - .48 .50 - .58	.50 - .58 .60 - .68

NOTES:

1. Values above and below pertain to the 2-year and 100-year storms, respectively.
2. The range of values provided allows for engineering judgement of site conditions such as basic shape, homogeneity of surface type, surface depression storage, and storm duration. In general, during shorter duration storms ($Tc \leq 10$ minutes), infiltration capacity is higher, allowing use of a "C" value in the low range. Conversely, for longer duration storms ($Tc > 30$ minutes), use a ""C value in the higher range.
3. For residential development at less than 1/8 acre per unit or greater than 1 acre per unit, and also for commercial and industrial areas, use values under MISC SURFACES to estimate "C" value ranges for use.

RATIONAL METHOD RUNOFF COEFFICIENTS
(Modified from Table 4, UC-Davis, which appears to be a modification of work done by Rawls)

TABLE "B-1"


650 Ac
282 Ac
Tr = 4Ac
Re
HK
Hj
Fh
Fr
Fg
Cc
Fp
Av
GP
BENSON ESTATES
Sheet 16
Kd
Ra
Rc
Be
Bc
Ba

PRIME FARMLAND

all

Map symbol	Soil name
39	Eghelm silt loam, Slightly Wet, 0 to 2 percent slopes (where irrigated)
5	Battlement loam, 1 to 8 percent slopes (where irrigated)
6	Battlement loam, Saline, 1 to 8 percent slopes (where irrigated)
8	Billings silty clay loam, 1 to 6 percent slopes (where irrigated)
15	Cameo fine sandy loam, 1 to 6 percent slopes (where irrigated)
18	Cerro silty clay loam, 2 to 6 percent slopes (where irrigated)
25	Cowestglen sandy loam, 1 to 8 percent slopes (where irrigated)
28	Cumulic Haploborolls, 1 to 3 percent slopes (where irrigated and protected from flooding or not frequently flooded during the growing season)
31	Dominguez clay loam, 1 to 3 percent slopes (where irrigated)
32	Dominguez clay loam, 3 to 8 percent slopes (where irrigated)
37	Fughes clay loam, 2 to 6 percent slopes (where irrigated)
38	Fughes clay loam, 3 to 9 percent slopes, stony (where irrigated)
54	Panitchen loam, 1 to 6 percent slopes (where irrigated)
58	Peninsula loam, 3 to 9 percent slopes (where irrigated)
78	Youngston loam, 1 to 6 percent slopes (where irrigated)
Av	Avalon sandy loam, 2 to 5 percent slopes (where irrigated)
Bc	Sagers silty clay loam, 0 to 2 percent slopes (where irrigated)
Bd	Sagers silty clay loam, 2 to 5 percent slopes (where irrigated)
Be	Unnamed silty clay loam, 0 to 2 percent slopes (where irrigated)
Bk	Blackston gravelly loam, 0 to 2 percent slopes (where irrigated)
Fe	Fruita clay loam, 0 to 2 percent slopes (where irrigated)
Ff	Fruita clay loam, 2 to 5 percent slopes (where irrigated)
Fg	Fruitvale clay loam, 0 to 2 percent slopes (where irrigated)
Fh	Fruitvale clay loam, 2 to 5 percent slopes (where irrigated)
Fp	Fruitland fine sandy loam, 0 to 2 percent slopes (where irrigated)
Fr	Fruitland fine sandy loam, 2 to 5 percent slopes (where irrigated)
Fs	Turley fine sandy loam, 0 to 2 percent slopes (where irrigated)
Ft	Turley fine sandy loam, 2 to 5 percent slopes (where irrigated)
Ga	Turley clay loam, Warm, 0 to 2 percent slopes (where irrigated)
Gc	Turley loam, Wet, 0 to 2 percent slopes (where irrigated)
Gf	Turley loam, 2 to 5 percent slopes (where irrigated)
Gt	Glenton very fine sandy loam, 0 to 2 percent slopes (where irrigated)
GtW	Glenton sandy loam, Wet, 0 to 2 percent slopes (where irrigated and drained)
Gy	Unnamed clay loam, 0 to 2 percent slopes (where irrigated)
Hb	Fruitvale clay loam, 0 to 2 percent slopes (where irrigated)
Ma	Mack loam, 0 to 2 percent slopes (where irrigated)
Mc	Mesa clay loam, 0 to 2 percent slopes (where irrigated)
Me	Mesa clay loam, 2 to 5 percent slopes (where irrigated)
Mg	Mesa Gravelly clay loam, Warm, 2 to 5 percent slopes (where irrigated)
Mv	Mack clay loam, Gypsum Substratum, Warm, 0 to 2 percent slopes (where irrigated)
My	Mack clay loam, Gypsum Substratum, Warm 2 to 5 percent slopes (where irrigated)
Ra	Turley clay loam, 0 to 2 percent slopes (where irrigated) — HSG B
Rc	Fruitland sandy clay loam, 0 to 2 percent slopes (where irrigated)
Re	Sagrlite loam, 0 to 2 percent slopes (where irrigated)

R-4

Exhibit A-1, continued: Hydrologic soil groups for United States soils

TREMBLES	B	TRUSCREEK	B	TURSON	C	UHLAND	B	UTABA	A
TREMBLES,	C	TRUSSEL	C	TURTON	D	UHLIG	B	UTALINE	B
MODERATELY WET		TRUVAR	D	TUSAYAN	C	UHLORN	C	UTE	D
TREMONA	C	TRYON	D	TUSCAN	D	UINTA	B	UTICA	B
TREMPE	A	TSALI	C	TUSCARAWAS	C	UKIAH	D	UTLEY	B
TREMPEALEAU	B	TSCHICOMA	B	TUSCAWILLA	C	ULA	C	UTSO	B
TRENARY	B	TSIRKU	C	TUSCOLA	B	ULEN	B	UTUADO	B
TRENHOLM	D	TSOSIE	B	TUSCOSSO	B	ULIDA	D	UVADA	D
TRENT	B	TUB	C	TUSCUMBIA	D	ULLOA	B	UVALDE	B
TRENTON	D	TUBAC	C	TUSEL	B	ULM	C	UVI	B
TREON	D	TUBERET	C	TUSIP	B	ULRANT	B	UWALA	B
TREP	B	TUCANNON	C	TUSK	B	ULRIC	C	UWHARRIE	B
TRES HERMANOS	B	TUCKAHOE	B	TUSKAHOMA	D	ULRICHER	B	UZONA	D
TRESANO	B	TUCKER	C	TUSKEEGO	C/D	ULTRA	D	VABEM	D
TRESED	C	TUCKERMAN	D	TUSLER	B	ULUPALAKUA	B	VABUS	C
TRESTLE	B	TUCSON	B	TUSQUITEE	B	ULY	B	VACHERIE	C
TRETTEN	B	TUCUMCARI	B	TUSSY	D	ULYSSES	B	VADAMO	D
TREVINO	D	TUFFIT	C	TUSTELL	C	UMA	A	VADER	B
TREVLAC	B	TUFFO	D	TUSTIN	B	UMAPINE	D	VAONAIS	C
TREY	A	TUGHILL	D	TUSTUMENA	B	UMAPINE, DRAINED	C	VADO	B
TRIANGLE	D	TUJUNGA	A	TUTE	B	UMATILLA	B	VAEDA	D
TRIBBEY	C	TUKEY	C	TUTHILL	B	UMBARG	C	VAIDEN	D
TRICON	C	TUKUHNIK	C	TUTNI	B	UMBERLAND	D	VAILTON	B
TRID	C	TUKWILA	D	TUTTLE	C	UMIAT	D	VAIVA	D
TRID, NONSTONY	B	TUKWILA, DRAINED	C	TUTUILLA	C	UMIKOA	B	VALBY	C
TRIDELL	B	TULA	C	TUTWILER	B	UMIL	D	VALCO	C
TRIGGER	D	TULANA, DRAINED	B	TUWEEP	B	UMPA	B	VALCREEK	B
TRIGO	D	TULANA, NONFLOODED	C	TUXEKAN	B	UMPCOOS	D	VALCREST	C
TRIMAD	B	TULARE	D	TWEBA	D	UMPUMP	B	VALDEZ, CLAYEY	D
TRIMBLE	B	TULARGO	B	TWEBA, MODERATELY	B	UNA	D	SUBSTRATUM	
TRIMMER	C	TULAROSA	B	WET		UNADILLA	B	VALDEZ, SALINE	D
TRINIDAD	D	TULASE	B	TWEBA, DRAINED	C	UNAKA	B	VALDEZ, CLAYEY	C
TRINITY	D	TULCH	B	TWEEDY	C	UNAKWIK	D	SUBSTRATUM,	
TRIO	D	TULECAN	C	TWEENER	D	UNAWEEP	B	SALINE	
TRIOMAS	B	TULELAKE	D	TWICK	D	UNCAS	D	VALDEZ, DRAINED	C
TRIPIT	C	TULIA	B	TWIG	D	UNCOMPAHGRE	D	VALDOSTA	A
TRIPLEN	B	TULIK	B	TWILIGHT	B	UNDERWOOD	B	VALE	B
TRIPOLI	B/D	TULLAHASSEE	C	TWIN CREEK	B	UNDUSK	B	VALENCIA	B
TRIPP	B	TULLER	D	TWINING	C	UNGERS	B	VALENT	A
TRISTAN	B	TULLOCK	C	TWINSI	C	UNICOI	B	VALENTINE	A
TRITON	D	TULLY	C	TWISSELMAN	C	UNION	C	VALERA	C
TRIX	B	TULOSO	D	TWISSELMAN,	D	UNIONTOWN	B	VALHALLA	A
TROCKEN	B	TUMAC	B	SALINE-ALKALI,		UNIONVILLE	B	VALKARIA	B/D
TROJAN	B	TUMALO	C	WET		UNISON	B	VALKARIA,	D
TROMP	C	TUMARION	D	TWISSELMAN,	D	UNIUS	D	DEPRESSIONAL	
TRONSEN	B	TUMBLETON	C	SALINE-ALKALI		UNIVEGA	D	VALLAN	D
TROOK	B	TUNTUM	D	TWOMILE	C/D	UNLIC	B	VALLE	B
TROOK, SALINE	C	TUNBRIDGE	C	TWOTOP	C	UNSEL	B	VALLECITOS	D
TROPAL	D	TUNEHILL	D	TYBO	D	UNSON	B	VALLEONO	B
TROPIC	B	TUNICA	D	TYEE	D	UPDEGRAFF	B	VALLERS	C
TROSI	D	TUNIS	D	TYGART	D	UPDIKE	D	VALLEYCITY	D
TROSKY	B/D	TUNITAS	C	TYGH	C	UPSATA	B	VALMAR	C
TROUGHS	D	TUNK	A	TYLER	D	UPSHUR	D	VALMONT	C
TROUP	A	TUNKHANNOCK	A	TYNDALL	C	UPSON	B	VALMY	B
TROUT CREEK	C	TUNNEL	B	TYNDALL, DRAINED	B	UPSON, STONY	C	VALNOR	C
TROUT RIVER	A	TUNNISON	D	TYNER	A	UPSPRING	D	VALOIS	B
TROUTDALE	C	TUOMI	B	TYONEK	D	UPSTEER	B	VALPAC	C
TROUTER	C	TUPELO	D	TYRE	A/D	UPTMOR	C	VALSETZ	C
TROUTVILLE	B	TUPUKNUK	D	TYRONE	C	UPTON	C	VALTO	D
TROVE	B	TUQUE	B	TYSON	B	UPVILLE	B	VALTON	B
TROXEL	B	TURBEVILLE	C	TYZAK	D	URACCA	B	VALVERDE	B
TRUAX	B	TURBOTVILLE	C	UANA	D	URBANA	C	VANER	D
TRUBLE	C	TURBYFILL	B	UBANK	B	URBO	D	VAMONT	D
TRUCE	C	TURK	C	UBAR	D	UREAL	D	VAMP	C
TRUCHOT	C	TURKEYSPRINGS	B	UBEHEBE	C	URICH	C/D	VAN DUSEN	B
TRUCKEE	C	TURLEY	B	UBIK	B	URIPNES	D	VAN HORN	B
TRUCKEE, DRAINED	B	TURLIN	B	UBLY	B	URIPNES, GRAVELLY	C	VAN NOSTERN	C
TRUCKTON	B	TURLOCK	D	UCHEE	A	URLAND	C	VAN WAGONER	D
TRUDAU	B	TURMOUND	D	UCOLO	D	URNE	B	VANAJO	D
TRUDE	A	TURNBACK	C	UCOPIA	B	URNESS	B/D	VANANDA	D
TRUEFISSURE	B	TURNBULL	D	UDAHO	B	URSA	C	VANBRUNT	C
TRUESDALE	C	TURNER	B	UDEL	D	URSINE	D	VANCE	C
TRUMOY	D	TURNERCREST	C	UDELOPE	D	URTAH	C	VANDA	D
TRULAE	D	TURNERVILLE	B	UDOLPHO	B/D	URWIL	C	VANDALIA	D
TRULON	C	TURNEY	B	UFFENS	B	USAL	C	VANDAMME	B
TRUMAN	B	TURRAH	C	UFFENS, FLOODED	C	USAL, GRAVELLY	B	VANDAMORE	B
TRUMBULL	D	TURRET	B	UGAK	D	USHAR	B	VANDERGRIFT	C
TRUMP	D	TURRIA	B	UHALDE	B	USINE	A	VANDERHOFF	C
TRUNK	D	TURRIA, WET	C	UHL	B	USK	C	VANDERLIP	A

NOTES: TWO HYDROLOGIC SOIL GROUPS SUCH AS B/C INDICATES THE DRAINED/UNDRAINED SITUATION.
MODIFIERS SHOWN, E.G., BEDROCK SUBSTRATUM, REFER TO A SPECIFIC SOIL SERIES PHASE FOUND IN SOIL MAP LEGEND.

PHYSICAL PROPERTIES OF SOILS--Continued

all

Map symbol and soil name	Depth	Clay	Moist bulk density	Permea-bility	Available water capacity	Shrink-swell potential	Organic matter	Erosion factors K	Erosion factors Kf	Erosion factors T	Wind erodi-bility group	Wind erodi-bility index
	In	Pct	g/cc	In/hr	In/in		Pct					
Bc:												
Sagers----------	0-12	27-34	1.15-1.25	0.20-0.60	0.17-0.20	Moderate	0.5-1.0	0.32	0.32	5	4L	86
	12-60	27-34	1.15-1.25	0.20-0.60	0.17-0.20	Moderate	0.0-0.5	0.37	0.37			
BcA:												
Skumpah---------	0-2	12-20	1.15-1.30	0.20-0.60	0.12-0.15	Low	0.0-1.0	0.43	0.43	5	4L	86
	2-9	27-34	1.15-1.25	0.06-0.60	0.14-0.17	Moderate	0.0-0.5	0.37	0.37			
	9-16	27-34	1.15-1.25	0.06-0.60	0.09-0.12	Moderate	0.0-0.5	0.37	0.37			
	16-48	15-19	1.15-1.25	0.20-2.00	0.06-0.08	Low	0.0-0.5	0.49	0.49			
	48-60	18-34	1.30-1.45	0.06-2.00	0.06-0.08	Low	0.0-0.5	0.37	0.37			
BcS:												
Sagers, Saline--	0-12	27-34	1.15-1.25	0.20-0.60	0.08-0.10	Moderate	0.5-1.0	0.32	0.32	5	4L	86
	12-25	27-34	1.15-1.25	0.20-0.60	0.02-0.05	Moderate	0.5-1.0	0.32	0.32			
	25-60	27-34	1.15-1.25	0.20-0.60	0.02-0.05	Moderate	0.0-0.5	0.37	0.37			
BcW:												
Sagers, Wet.												
Bd:												
Sagers----------	0-12	27-34	1.15-1.25	0.20-0.60	0.17-0.20	Moderate	0.5-1.0	0.32	0.32	5	4L	86
	12-60	27-34	1.15-1.25	0.20-0.60	0.17-0.20	Moderate	0.0-0.5	0.37	0.37			
Be:				HSG A								
Unnamed---------	0-6	27-35	1.15-1.25	0.60-2.00	0.19-0.21	Moderate	0.5-1.0	0.43	0.43	5	4L	86
	6-60	18-35	1.30-1.40	0.60-2.00	0.16-0.18	Moderate	---	0.43	0.43			
Bk:												
Blackston-------	0-3	14-25	1.25-1.40	0.60-2.00	0.10-0.12	Low	0.5-1.0	0.20	0.37	3	4L	86
	3-14	23-32	1.25-1.40	0.20-2.00	0.15-0.18	Low	0.0-0.5	0.32	0.32			
	14-35	10-26	1.25-1.50	0.60-6.00	0.05-0.09	Low	0.0-0.5	0.15	0.43			
	35-55	5-15	1.35-1.50	2.00-6.00	0.03-0.04	Low	0.0-0.5	0.05	0.32			
	55-70	2-12	1.45-1.60	6.00-20.00	0.03-0.04	Low	0.0-0.5	0.05	0.15			
BkD:												
Blackston-------	0-3	14-25	1.25-1.40	0.60-2.00	0.07-0.09	Low	0.5-1.0	0.15	0.37	3	8	---
	3-14	23-32	1.25-1.40	0.20-2.00	0.15-0.18	Low	0.0-0.5	0.32	0.32			
	14-35	10-26	1.25-1.50	0.60-6.00	0.05-0.09	Low	0.0-0.5	0.15	0.43			
	35-55	5-15	1.35-1.50	2.00-6.00	0.03-0.04	Low	0.0-0.5	0.05	0.32			
	55-70	2-12	1.45-1.60	6.00-20.00	0.03-0.04	Low	0.0-0.5	0.05	0.15			

Appendix A: Hydrologic soil groups

Soils are classified into hydrologic soil groups (HSG's) to indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting. The HSG's, which are A, B, C, and D, are one element used in determining runoff curve numbers (see chapter 2). For the convenience of TR-55 users, exhibit A-1 lists the HSG classification of United States soils.

The infiltration rate is the rate at which water enters the soil at the soil surface. It is controlled by surface conditions. HSG also indicates the transmission rate—the rate at which the water moves within the soil. This rate is controlled by the soil profile. Approximate numerical ranges for transmission rates shown in the HSG definitions were first published by Musgrave (USDA 1955). The four groups are defined by SCS soil scientists as follows:

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr).

Group B soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

In exhibit A-1, some of the listed soils have an added modifier; for example, "Abrazo, gravelly." This refers to a gravelly phase of the Abrazo series that is found in SCS soil map legends.

Disturbed soil profiles

As a result of urbanization, the soil profile may be considerably altered and the listed group classification may no longer apply. In these circumstances, use the following to determine HSG according to the texture of the new surface soil, provided that significant compaction has not occurred (Brakensiek and Rawls 1983):

HSG	*Soil textures*
A	Sand, loamy sand, or sandy loam
B	Silt loam or loam
C	Sandy clay loam
D	Clay loam, silty clay loam, sandy clay, silty clay, or clay

Drainage and group D soils

Some soils in the list are in group D because of a high water table that creates a drainage problem. Once these soils are effectively drained, they are placed in a different group. For example, Ackerman soil is classified as A/D. This indicates that the drained Ackerman soil is in group A and the undrained soil is in group D.

PROJECT: ________ JOB NO. ________ CALCULATED BY: ________ DATE: ________

CHECKED BY: ________ DATE: ________

(THE TABLE BELOW IS AN ADAPTATION OF A WORKSHEET PROVIDED IN THE SCS TR-55)
1) THIS TABLE MAY BE USED IN SUBBASIN Tc CALCULATION, OR FOR TRAVEL TIME OF SUBBASIN RUNOFF THROUGH A LOWER SUBBASIN REACH (Tr).
2) USE ONLY CHANNEL FLOW FOR Tr CALCULATIONS. NOTE THAT THE FLOW PATH AND CHANNEL FLOW LENGTH MAY NOT BE THE SAME FOR BOTH Tc AND Tr CALCULATIONS.

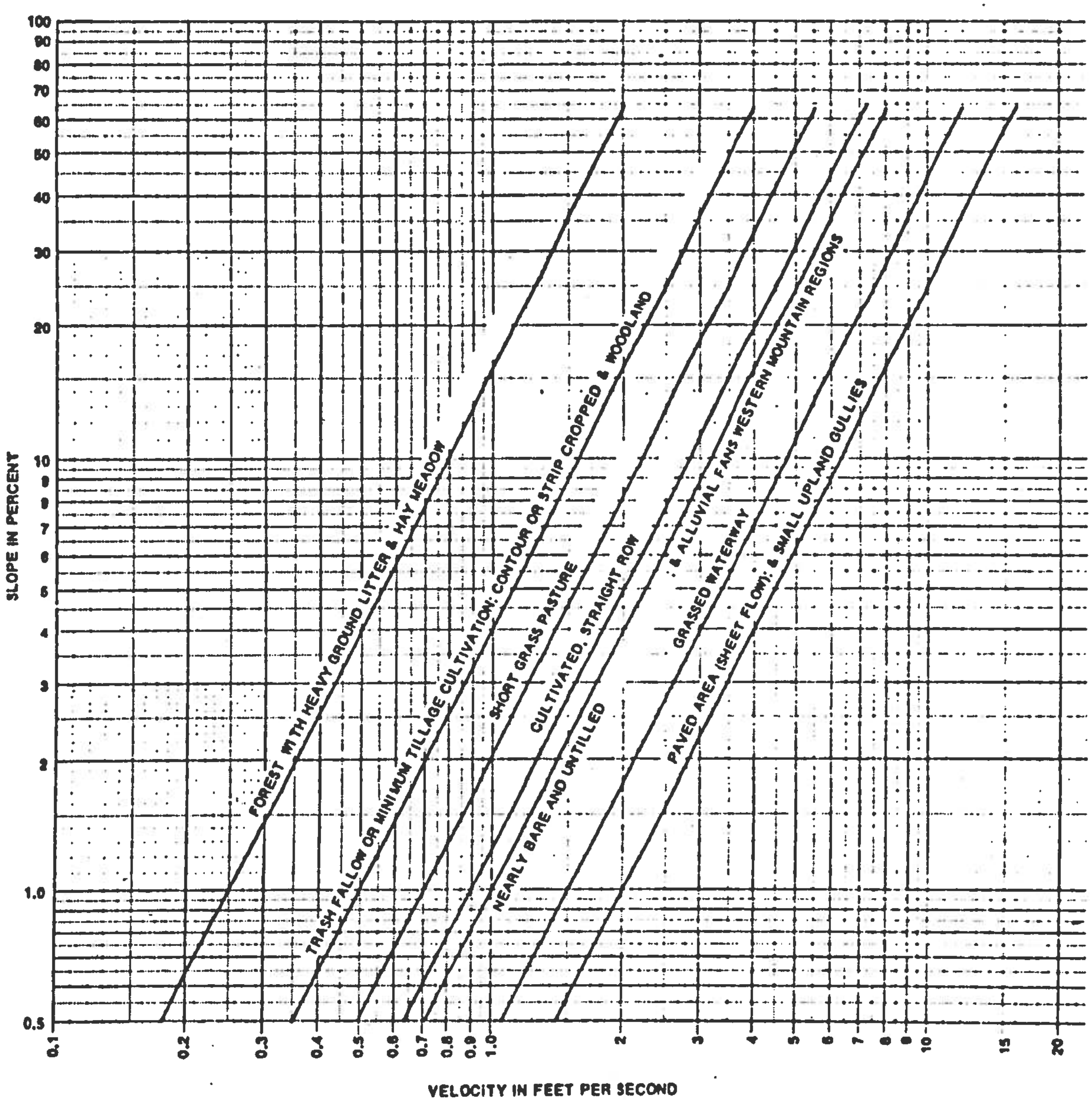
ALT. ROUTE (B1 / B1)

Section	Item	Period	Units							
REACH	AREA IDENTIFIER			A	B	B1	B1	B2		
REACH	SEGEMENT IDENTIFICATION			EX & PR	EX	PR	PR	PR		
REACH	Tc OR Tr THROUGH BASIN REACH					LOT 8	LOT 12			
OVERLAND FLOW	SURFACE DESCRIPTION (TABLE "E-1")			GRAVEL DWY	BARE DIRT	LAWN	LAWN	LAWN		
OVERLAND FLOW	"N" VALUE (TABLE "E-1")			0.10	0.10	0.20	0.20	0.20		
OVERLAND FLOW	FLOW LENGTH, L (TOTAL ≤ 300 FT.)		(ft.)	100	130	100	100	100		
OVERLAND FLOW	LAND SLOPE, S		(ft./ft.)	2%	2.35%	1.25%	1.67%	1.5%		
OVERLAND FLOW	$To_2 = 0.42(NL)^{0.8}/(P_2^{0.5}S^{0.4})$		(min.)							
OVERLAND FLOW	$To_{100} = 0.42(NL)^{0.8}/(P_{100}^{0.5}S^{0.4})$		(min.)	9	10	19	17	17		
SHALLOW CONCENTRATED FLOW	SURFACE DESCRIPTION (FIGURE "E-3")			CULTIVATED STRAIGHT ROW	SHORT GRASS PASTURE	LAWN	LAWN	LAWN		
SHALLOW CONCENTRATED FLOW	FLOW LENGTH, L		(ft.)	520	460	150	65	120		
SHALLOW CONCENTRATED FLOW	FLOW SLOPE, S		(ft./ft.)	1.6%	0.87%	1.0%	0.57%	0.67%		
SHALLOW CONCENTRATED FLOW	FLOW VELOCITY, V (FIGURE "E-3")		(fps.)	1.1	0.66	1.5	1.1	1.2		
SHALLOW CONCENTRATED FLOW	TRAVEL TIME = L/(60V)		(min.)	8	9	2	1	2		
CHANNEL FLOW	CROSS-SECTIONAL FLOW AREA, a		($ft.^2$)							
CHANNEL FLOW	WETTED PERIMETER, Pw		(ft.)							
CHANNEL FLOW	HYDRAULIC RADIUS, r = a/Pw		(ft.)							
CHANNEL FLOW	CHANNEL SLOPE, S		(ft./ft.)							
CHANNEL FLOW	MANNING'S COEFFICIENT, n (APPENDIX F)									
CHANNEL FLOW	$V = 1.49r^{.67}S^{.5}/n$		(fps.)							
CHANNEL FLOW	ASSUMED VELOCITY		(fps.)	2	1.75		2	1.75		
CHANNEL FLOW	FLOW LENGTH, L		(ft.)	1200	800		450	800		
CHANNEL FLOW	TRAVEL TIME L/(60V)		(min.)	10	8		4	8		
Tc&Tr	Tc = To + Ts + Tch	2 YEAR	(min.)							
Tc&Tr	Tr = Tch (See note (2) above)	100 YEAR	(min.)	27	27	21	22 (GOVERNS)	27		
TL	TL = 0.6Tc or	2 YEAR	(min.)							
TL	FROM FIGURE "E-4"	100 YEAR	(min.)							

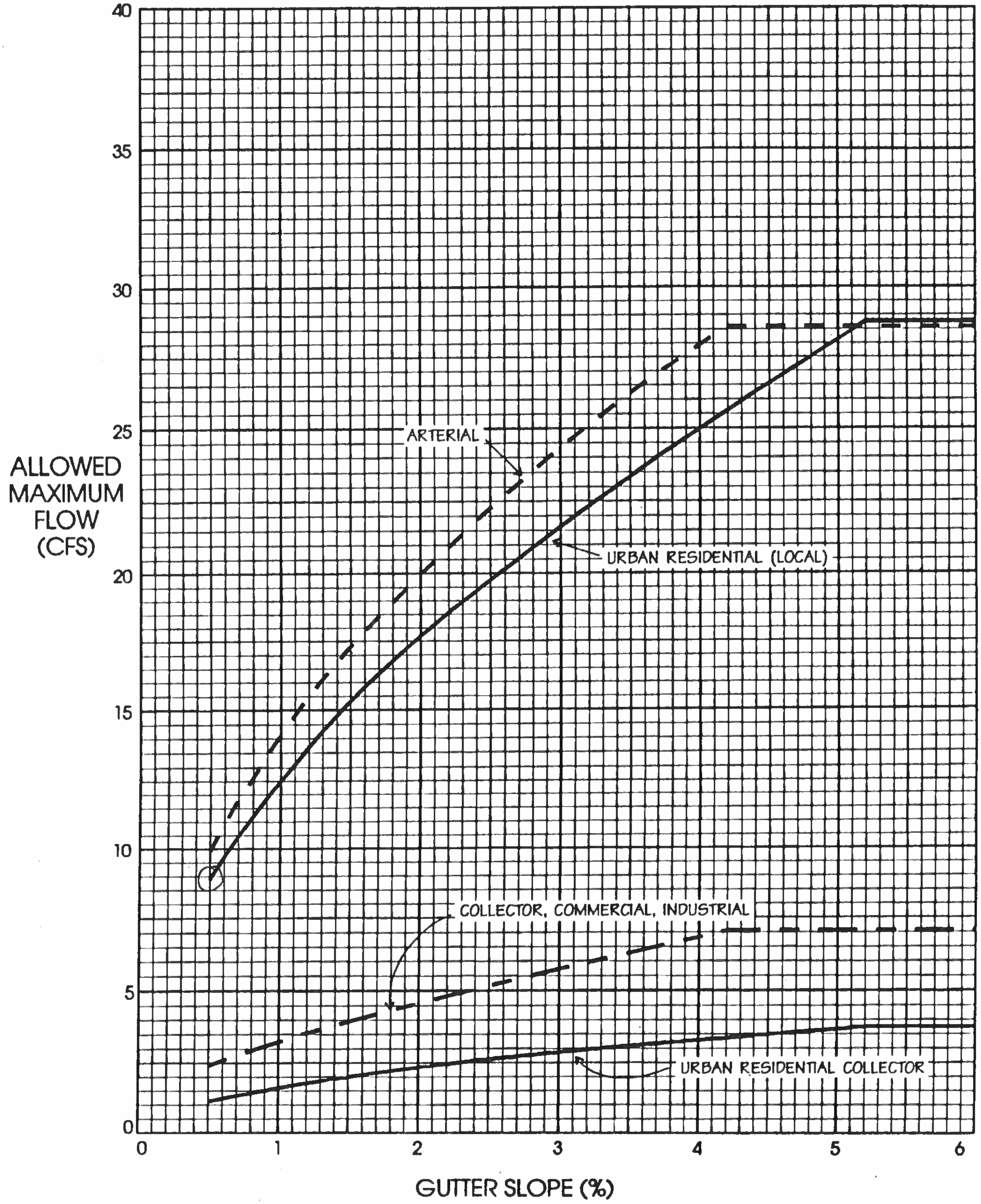
TRAVEL TIME WORKSHEET: TR-55 METHOD

TABLE "E-3"

REPRODUCED FROM FIGURE 15.2, SCS 1972



DETERMINATION OF "Ts"	FIGURE "E-3"



MAXIMUM HALF STREET FLOWS (Sx=2%, n=0.016)
(Based upon Figures G-3 and G-4)

FIGURE "G-5"

ROAD TYPE	COMBINATION INLET CAPACITY (CFS)					
	SINGLE		DOUBLE		TRIPLE	
	2-YR	100-YR	2-YR	100-YR	2-YR	100-YR
Urban Residential (local)	6.4	13	9.5	22	12.7	31
Residential Collector, Commercial and Industrial Streets	3.2	13	4.9	22	6.5	31
Collector Streets (3000 - 8000 ADT)	2.7	13	4.0	22	5.3	31
Principal and Minor Arterials	6.0	13	9.0	22	12.0	31

Inlet capacities shown above are based upon: 1) use of non-curved vane grates (similar to HEC-12 P-1⅞-4 grates; 2) HEC-12 procedures; 3) clogging factors per Section VI, and 4) City/County standard inlets with 2-inch radius on curb face and type C grates. Capacities shown for 2-year storms are based upon depths allowed by maximum street inundation per Figure "G-3". The 100-year capacities are based upon a ponded depth of 1.0 foot. Note that only combination inlets are allowed in sag or sump conditions.

MAXIMUM INLET CAPACITIES: SUMP OR SAG CONDITION — **TABLE "G-1"**

Flow Capacity Above Tailwater Ditch
Cross Section for Triangular Channel

Project Description	
Project File	e:\fmw\benson.fm2
Worksheet	Tailwater Ditch East of Site
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Discharge

Section Data		
Mannings Coefficient	0.050	
Channel Slope	0.006670	ft/ft
Depth	0.50	ft
Left Side Slope	8.00	H : V
Right Side Slope	100.00	H : V
Discharge	13.00	ft³/s

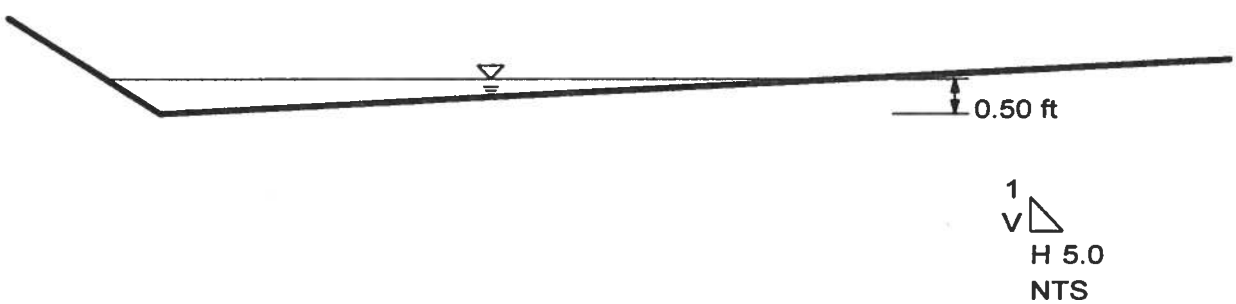
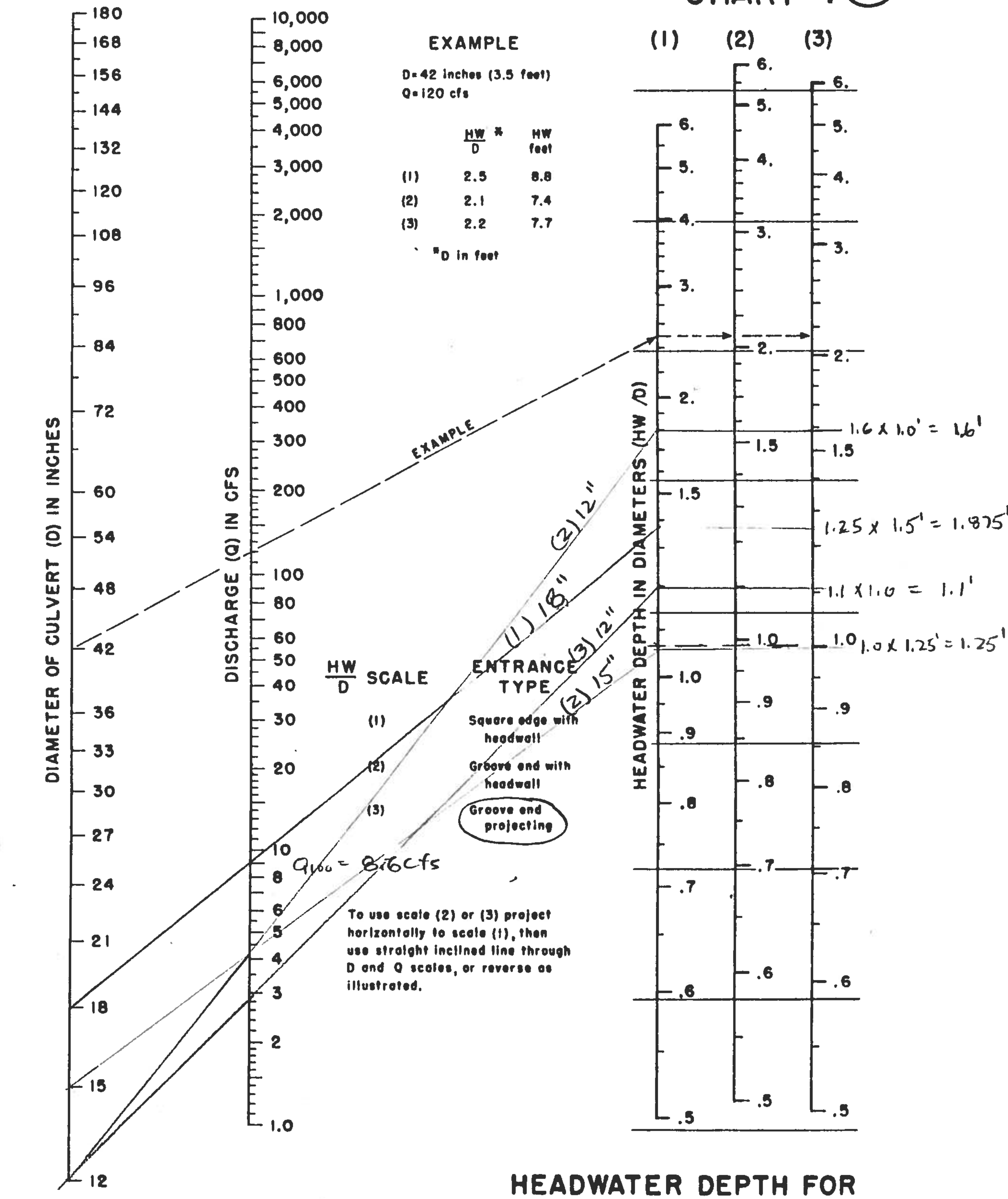


CHART 1



HEADWATER SCALES 2&3
REVISED MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

RATIONAL METHOD CALCULATIONS
(100 YEAR FLOWS)

PREDEVELOPED FLOWS TO THE SOUTHWEST CORNER OF THE SITE

$Q_{TOTAL} = Q_A + Q_B$ (AREA B CONSISTS OF AREAS B1 & B2)

$= (CIA)_A + (CIA)_B$

$= (0.38)(2.29)(9.9) + (0.28)(2.29)(7.9)$ ← SEE PREVIOUS APPENDICIES FOR VALUES

$= 8.6$ CFS $+ 5.1$ CFS

$= 13.7$ CFS

POST-DEVELOPMENT FLOWS TO THE SOUTHWEST CORNER OF THE SITE

$Q_{TOTAL} = Q_A + Q_{B2}$

$= 8.6$ CFS $+ (CIA)_{B2}$

$= 8.6$ CFS $+ (0.36)(2.29)(5.0)$ ← SEE PREVIOUS APPENDICIES FOR VALUES

$= 8.6$ CFS $+ 4.1$ CFS

$= 12.7$ CFS

COMPARISON OF PRE & POST DEVELOPED FLOWS TO SW. CORNER

PRE-DEVELOPMENT : 13.7 CFS
POST-DEVELOPMENT : 12.7 CFS

BY DIVERSION AND CONVEYANCE TO LITTLE SALT WASH, WE HAVE AVOIDED AN INCREASE IN RUNOFF TO DOWNSTREAM PROPERTY DUE TO RUNOFF.

DIVERTED FLOW GOES DIRECTLY TO THE LITTLE SALT WASH PER RECOMMENDATIONS IN THE FRUITA SWMMP.

Q_{100} TO THE PROPOSED STORM DRAIN SYSTEM.

$Q = (CIA)_{B1} = (0.44)(2.57)(2.9) = 3.3$ CFS ← SEE PREVIOUS APPENDICIES FOR VALUES.

STREET FLOW CAPACITY

PER FIGURE G-5, URBAN LOCAL RESIDENTIAL, THE HALF STREET IS ALLOWED TO CONVEY 9 CFS IN THE 2 YEAR EVENT. WE HAVE 3.3 CFS IN THE 100 YEAR EVENT. THE STREET HAS ADEQUATE CAPACITY.

INLET CAPACITY

PER TABLE "G-1", WHICH INCORPORATES HEC-12 CLOGGING FACTORS, A SINGLE COMBINATION INLET HAS CAPACITY FOR 13 CFS. WE HAVE 3.3 CFS. THE INLET SHOULD BE ADEQUATE.

PIPE CAPACITY

AT 0.35% SLOPE AND AN N VALUE OF 0.013, HDPE SMOOTH BORE 15" PIPE HAS A CAPACITY OF 3.8 CFS. HOWEVER, THE ACTUAL CAPACITY IS DETERMINED NOT BY PIPE SLOPE BUT BY THE HYDRAULIC GRADIENT, WHICH IS, FROM CROWN OF PIPE AT SD. MH-1 TO THE GRATE ELEVATION (PONDING OF 1.0' IS ALLOWED IN THE 100 YEAR EVENT, BUT I USED THE GRATE TO ACCOUNT FOR SYSTEM LOSSES AT MANHOLES AND THE GRATE AND INLET CONTROL):

$$H_g = 4.35' / (181.37' + 417.81') = 0.726\%$$

Q_{pipe} @ 0.726% ≅ 5.5 CFS, OR 67% OVER.

THE 15" PIPE SHOULD BE ADEQUATE.

CULVERT CAPACITY

FOR THE 100 YEAR RUNOFF, EITHER AN 18", (2) 15", OR (3) 12" CULVERTS ARE NEED. WE HAVE DESIGNED USING (2) 15" CULVERTS.

EAST BOUNDARY "DITCH"

THE EASTERN BOUNDARY HAS A TAILWATER DITCH WHERE SEDIMENT HAS FOR YEARS BEEN PILED ON THE WEST SIDE BORDERING THE SITE. THE 100 YEAR RUNOFF FROM THE 9.9 ACRES EAST OF THE SITE WILL NOT SHEET FLOW ONTO THE SITE.