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DMJM Phillips·Reister·Haley,Inc.

Planning
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PRELIMINARY DRAINAGE REPORT

FOR

COTTONWOOD CREEK BASIN

TABLE OF CONTENTS

I. SUMMARY

This report is the preliminary draft of a supplemental report to the previous drainage study of Cottonwood Creek (Lincoln DeVore, 1979). Detailed study is provided for that part of the basin falling within the May 1, 1983 city limits. A main channel assessment is included. Drainage fees will be calculated upon approval by the City of Colorado Springs of this preliminary report.

II. INTRODUCTION

Scope and Intent

The Cottonwood Creek Drainage Basin has been analyzed for planning purposes three times previously. These previous planning efforts are listed below:

- o 1969 Study completed by City of Colorado Springs (Keith Hook & Associates, Inc.)
- o 1976 Flood Plain Study conducted by the Army Corps of Engineers
- o 1979 Drainage Master Plan completed by Lincoln DeVore

Approximately sixty percent of the drainage basin lies within the existing city limits of Colorado Springs. Areas within the city limits have developed rapidly and considerably more development is expected as a result of the recently approved Briargate Master Plan (a large scale residential and recreational development). Due to the rapid pace of development and defined future land uses it is necessary to update the previous drainage plans.

This report is a supplement to the 1979 study listed above. This supplemental report uses Colorado Springs city limits in effect on May 1, 1983. That portion of the basin within the city limits having newly defined land uses is fully analyzed for storm drainage. Older areas of full development whose flow contributions have not changed since the 1979 study are not re-evaluated. Previously developed run-off is used. That portion of the basin outside the city limits is only analyzed to the extent necessary to determine the channel flows and detention capability.

The Briargate Master Plan is used as a guide for determining proposed land use and location of major roadways. Site specific information (street profiles, roadway widths, lot grading, etc.) is approximated using the Master Plan, existing topography and physical features of the basin. The intent of this study is not to establish precise locations, sizes or design for storm sewers, ditches or other facilities but to establish basin-wide drainage criteria to be used as development progresses within the basin.

Assessment of existing drainage structures is included in the report. Structures that are inadequate to accommodate storm flows are identified along with proposed solutions.

Costs for the drainage improvements are based on estimated sizes and quantities. These are incorporated into a fee schedule in accordance with Colorado Springs procedures.

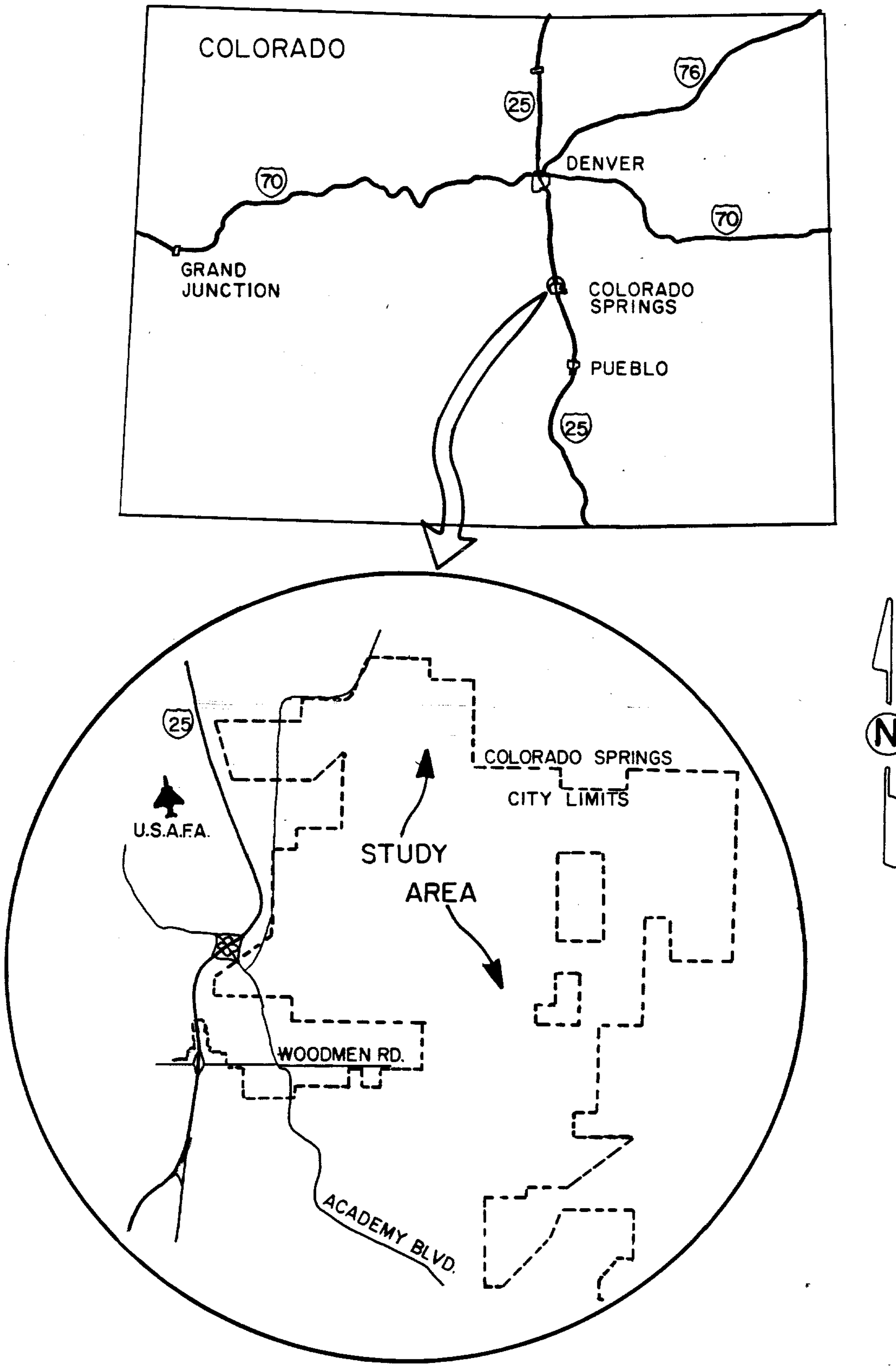
Mapping is provided in the Appendix for identification of basin and sub-basin boundaries, soil classifications, projected land use classifications, and existing and proposed drainage structures.

III. BASIN DESCRIPTION

The Cottonwood Creek Drainage Basin is located northeast of downtown Colorado Springs as indicated in the vicinity map of Figure 1. The basin encompasses 24.44 square miles of which 14.70 square miles lie within the May 1, 1983 Corporate City Limits. Areas external to the City lie on El Paso County land (to the northeast, east and west - 9.00 square miles), State land (north central - 0.47 square miles), Interstate 25 right-of-way (west - 0.16 square miles), and United States Air Force Academy property (west - 0.11 square miles). The Cottonwood Creek Basin boundary and topography are presented in the Appendix, Sheet A-1.

The Cottonwood Creek Drainage Basin consists of three major basins: Basin "A" is the main channel of Cottonwood Creek extending from the Black Forest in the northeast to the outfall at Monument Creek near Interstate 25. Basin "B" is the North Cottonwood Creek Drainage Basin. Although this basin is tributary to Pine Creek from Academy Boulevard to Interstate 25 it has been treated historically as a portion of the Cottonwood Creek watershed. Accordingly, Pine Creek is considered to be tributary to the North Cottonwood Creek Basin. Basin "C" is part of the Pulpit Rock Drainage Basin. In a recent study by the Army Corps of Engineers this area was treated as a part of the South Cottonwood Creek Drainage Basin due to the fact that prior to the construction of the 12' X 10' concrete box culvert at Interstate 25 runoff from Basin "C" emptied into Cottonwood Creek.

The upper reaches of the basin are characterized by rolling hills which are dissected by numerous gullies. The streambed is well defined in this area as it emerges from the southern edge of the Black Forest, and it continues to be dominant throughout the basin. Smaller tributaries add to the flow in the upper two thirds of the channel reach. Downstream of this point water from the basin enters the streambed by overland flow, street flow, storm drains, or man-made channels.



Vicinity Map

Fig. 1

Undeveloped areas of the basin are primarily rangeland. Ground cover consists of native grasses, shrubs, and some deciduous trees (in areas of permanent water). A small part of the Black Forest extends into the extreme northeast end of the watershed. This forest is characterized by large stands of ponderosa pine trees. In developed areas natural ground cover has been replaced with lawns, planted trees, paved surfaces, and buildings.

The soils of the Cottonwood Creek Basin were obtained from the El Paso County Area Soil Survey (Soil Conservation Service, Department of Agriculture). (See Appendix, Sheet A-1). These are categorized, for hydrologic purposes, into four classes;

A. (Low runoff potential). These soils have high infiltration rates even when throughly wetted. They consist chiefly of deep, well to excessively drained sands or gravel. These soils have a high rate of water transmission in that water readily passes through them.

B. These soils have moderate infiltration rates when thoroughly wetted. They consist chiefly of moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.

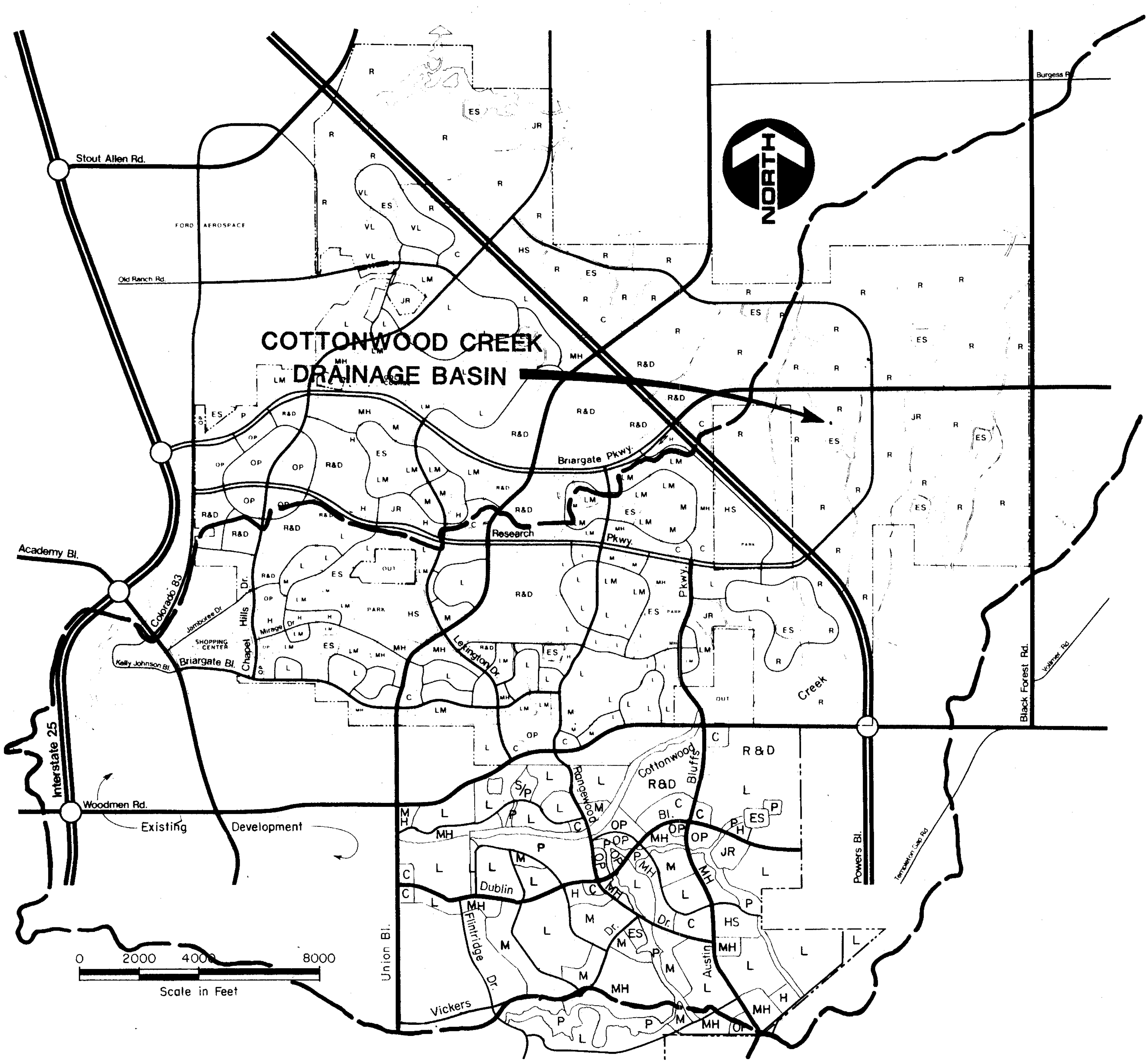
C. These soils have slow infiltration rates when thoroughly wetted. They consist chiefly of soils with a layer that impedes downward movement of water or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

D. (High runoff potential). These soils have very slow infiltration rates when thoroughly wetted. They 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 slow rate of water transmission.

For the most part, the native soil composition of the Cottonwood Creek Drainage Basin is made up of sandy loams that formed in materials weathered from arkosic sedimentary rock. These soils are well drained, moderately permeable, and are quite susceptible to erosion in disturbed areas. Erosion of the stream bed is apparent in the lower reaches of the basin. Much of the basin to the northeast is composed of Kettle Gravelly Loam, while the central portion of the basin consists of Blakeland Loamy Sand. Because these soils are well drained and have moderate to low surface run-off, they are classified as Hydrologic Soil Groups A and B. The western portion of the basin is well mixed and is composed of Hydrologic Soil Groups A, B, C, and D.

Most of the development to date has occurred to the west of Union Boulevard and to the east of Interstate 25. (See Figure 2). Construction of the Air Force Academy brought sparse development to the southwest portion of the basin in the mid-1960s. Medium to high density residential development increased steadily from the early 1970s as the city grew. Continuous replatting and relocation of city limits is occurring today as Colorado Springs establishes itself as a leader in high technology industry. The Briargate Development, which lies to the east of Academy Boulevard and incorporates a wide variety of land use, is growing at a rapid rate. The Norwood Development, to the south of Woodmen Road, is developing in a like manner. Existing development in the eastern portion of the basin is limited to small ranches and farmland. The Black Forest area outside the city limits is partially developed as very low density residential (one to five acre lots).

The major north-south roadways in the Cottonwood Basin are Interstate 25 to the west, Academy Boulevard and Union Boulevard. Vickers Drive, Dublin Boulevard, and Woodmen Road run east-west and are to be expanded in the future. Some of the roadways in the Briargate Master Plan have already been partially constructed (e.g., Briargate Boulevard and Chapel Hills Drive). County roads, such as Templeton Gap Road or Burgess Road, provide access in the less densely populated areas of the basin.



LEGEND

——— ———	Drainage Basin Boundary
	LAND USE
VL	Residential Very Low (1-2 DU/acre)
L	Residential Low (3-5 DU/acre)
LM	Residential Low-Medium (5-8 DU/acre)
M	Residential Medium (8-12 DU/acre)
MH	Residential Medium-High (12-20 DU/acre)
H	Residential High (20-25 DU/acre)
R	Residential Holding Zone
C	Commercial/Village Center
OP	Office Park/Industrial
R&D	Campus Research & Development
ES	Elementary School
JR	Junior High School
HS	High School
P	Parks/Open Space

PROPOSED LAND USE

COTTONWOOD CREEK DRAINAGE BASIN

Fig. 2

IV. HYDROLOGY

The annual average precipitation in the Colorado Springs region is about 15 inches per year. This precipitation occurs in three general forms; 1) snowfall (accounting for 40 to 50 percent of the total); 2) upslope storm conditions producing high amounts of precipitation over a relatively long period of time (2 to 4 days); and 3) intense thunderstorms of short duration. This third type of storm produces the greatest concentrated amount of runoff and is potentially the most hazardous. It is the storm for which all drainage facilities in this study are designed.

Three generally accepted storm types; Type I, Type II, and Type II-A, have been developed from the U.S. National Oceanic and Atmospheric Administration (Weather Bureau) data. The Type II-A storm corresponds to the intense thunderstorm described above and is used as a basis for hydrologic studies in this report. This type of storm is characterized by intense cloudbursts which produce higher peak runoff rates than Type I or Type II storms. The Type II-A storm is used, in conjunction with precipitation values for the 100 year frequency (i.e. 1% change occurrence in any year) - 6 hour, and the 5 year frequency - 6 hour rainfall events, to compute peak runoff rates. Total precipitation values for the 100 year and 5 year storms are 3.5 inches, and 2.1 inches, respectively (Colorado Springs Drainage Criteria Manual).

Criteria stipulated in the City of Colorado Springs Determination of Storm Runoff Criteria manual and in Technical Release No. 55 (U.S. Soil Conservation Service) are used as a guide throughout this report for all hydrologic and hydraulic computations.

Historic and developed peak flows are computed for some sub-basins within the Cottonwood Creek watershed. Most of the soils in the Cottonwood Creek Basin are moderately pervious. Runoff on such soil is relatively low due to losses from infiltration. When an area is developed the percent of impervious area increases due to paving, soil compaction, and building construction. Runoff from such developed areas will be considerably higher and potentially more destructive than historic flows.

Although not stated in the current drainage manual a recently developed policy within the City of Colorado Springs is to require stormwater detention on developed land rather than permit release of the increased flows that result from development. Toward this end it is necessary to calculate historic and developed flood flow rates in order that provision may be made to temporarily detain the difference between them. Stormwater detention generally has the effect of reducing downstream structure costs and keeping floodwaters at historic levels.

Basins "A" and "B" have been further sub-divided into 69 and 22 sub-basins respectively, ranging in size from 24 to 1,078 acres. (See Appendix, Sheets A-2 through A-8). Major streets and arterials (proposed and existing), locations of major existing drainage structures, and topographic features of the basin are used to define sub-basin boundaries. The historical and natural basin boundary of the Cottonwood Creek watershed is adjusted slightly to reflect the proposed street pattern and land use. With the exception of the basin boundary shift at proposed Research Parkway, these minor adjustments will have no affect on the overall hydrology of the basin. The change in basin boundary at proposed Research Parkway was first introduced in the drainage study prepared for Briargate Sub-Division Filing No. 17. (Donell Jeffries, September 1982). Storm water intercepted at Research Parkway is diverted from the North Cottonwood Creek Drainage Basin to an existing natural sump in the Pine Creek Drainage Basin. This boundary shift accounts for approximately 150 acres in the North Cottonwood Creek Basin.

Much of the western Cottonwood Creek Drainage Basin has achieved its full potential for development. Most of the remainder of the basin is presently undergoing development or is being platted by the Briargate Development (comprising most of the North Cottonwood Basin to the northeast of Academy Boulevard) and the Norwood Development (to the south of Woodmen Road). "The Engineering Study of Cottonwood Creek Drainage Basin" produced by Lincoln DeVore in 1979, provides the background for this supplemental report of these areas. Many of these areas have been studied independently. Recommendations for drainage improvements have been submitted and approved and in some cases have already been constructed. It is redundant to further study such areas in this report. However, these drainage studies are reviewed and all drainage improvements are incorporated in the master plan.

The Modified Soil Conservation Service Method, as presented in the criteria manual, is used to compute peak flows for both the 5 year and the 100 year storms for each of those sub-basins which have not yet been studied in detail. The method involves computation of a peak runoff rate, a time of concentration for runoff flows, and a triangular storm hydrograph which is constructed using those two parameters.

Peak runoff rates are determined by the following equation:

$$q = q_p \, Q \, A$$

where:

q = peak runoff rate (CFS)

q_p = runoff rate per square mile per inch of runoff (csm/in)

Q = runoff (in.)

A = area (sq. mi.)

The variable q_p is a function of the time of concentration (t_c) which is defined as the time it takes for runoff to travel from the hydraulically most distant part of the watershed to the point of reference. The time of concentration can be made up of any combination of overland, channel, gutter, or storm sewer flow. The graph in Figure 3 is used to compute the velocity of flow for both overland and gutter flow. Design charts for open channel flow using Manning's equation are used to compute t_c for improved channels and storm sewers. The following equation is used to calculate time of concentration for unimproved channels and streams;

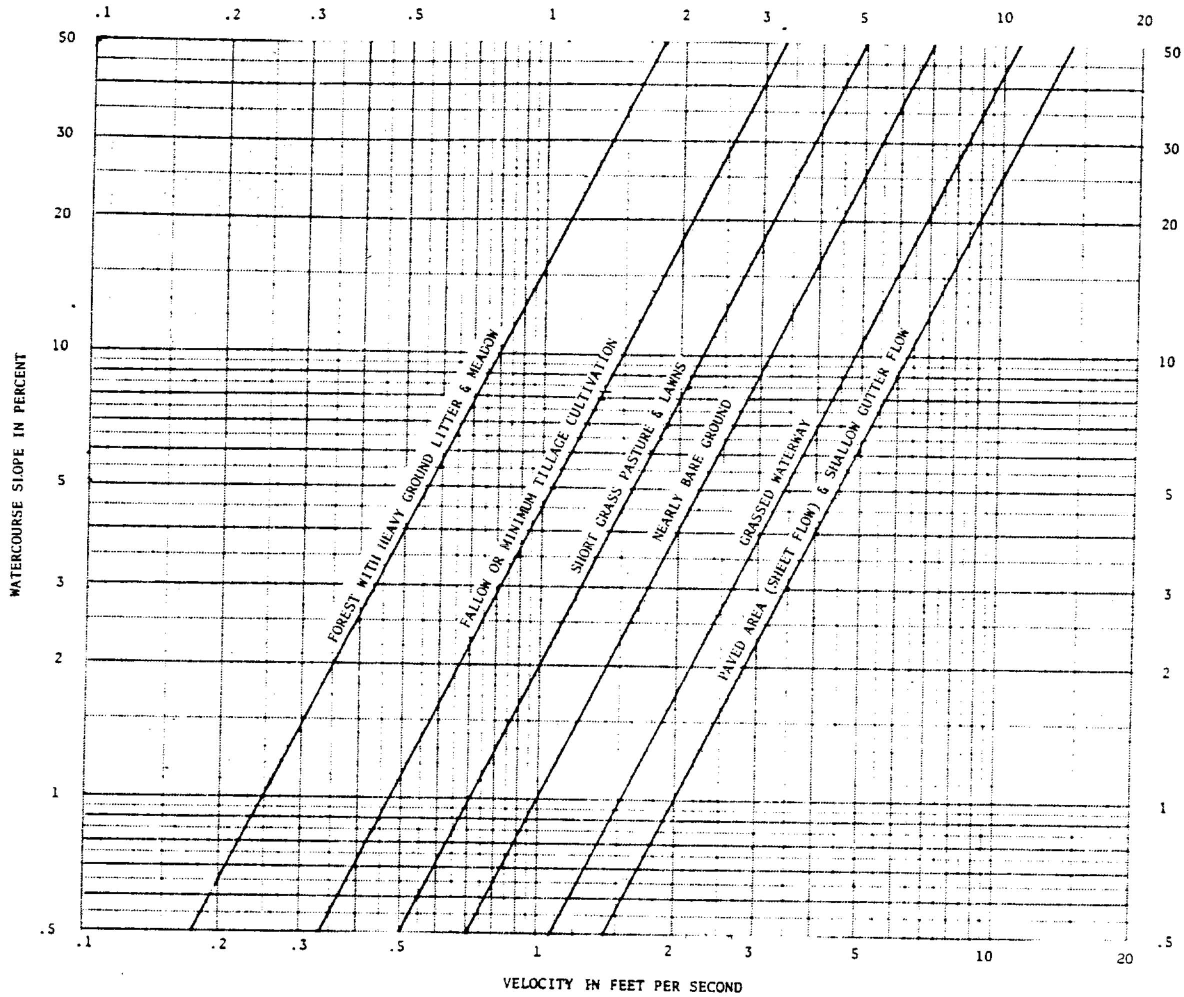
$$t_c = \left(\frac{11.9L^3}{H}\right)^{0.385}$$

where:

t_c = time of concentration (hr.)

L = length of streambed (mi.)

H = elevation drop (ft.)



Average velocities for estimating travel time for overland flow.

Fig. 3

The time of concentration for a given sub-basin is the summation of the individually calculated times.

A development factor is determined for each land use group by taking the average for a series of developed/historic t_c ratios from previously developed areas in the basin with similar soil types. Undeveloped times of concentration are multiplied by the appropriate factor to find the corresponding t_c for developed conditions. A table listing the sub-basins and associated times of concentration is presented in Figure 4.

The graph of Figure 5 indicates the relationship between t_c and q_p for a Type II-A storm.

Runoff (Q) is a function of precipitation and the runoff curve number (CN);

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

where:

Q = runoff (in.)

P = precipitation (in.)

$S = \frac{1000}{CN} - 10$

CN = runoff curve number

P (100 year storm) = 3.5 in., P (5 year storm) = 2.1 in.

The curve number is an areal weighted average of soil type/land use factors from the table in Figure 6. For historic conditions land use is primarily rangeland in fair condition or low density residential. Development of the basin has the effect of decreasing the amount of pervious ground cover and thus increasing the curve number.

The triangular storm hydrograph is constructed from the peak runoff rate (q) and the developed time of concentration (t_c). The time span from the onset of runoff to the peak flow is called the time to peak (t_p);

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COTTONWOOD CREEK

SUBJECT: HYDROLOGIC SUMMARY - BASIN A

JOB No. 5096-01-01 SHEET No. 1 OF 3
BY SJMc DATE 5-13-83

SUB-BASIN	AREA (ACRES)	HYDR. SOILS GR.	CN	t_c (HR.)	t_t (HR.)	$Q_{2.1}$ (IN.)	$Q_{3.5}$ (IN	q_p (CSM/IN.)	$q_{2.1}$ (CFS)	$q_{3.5}$ (CFS)	t_p (HR.)	t_b (HR.)
1*	1078	B	64	0.90	-				135	686	2.10	5.61
2*	365	B	62	0.53	-				49	277	1.82	4.86
3	741	B,BD	69	2.16	0.85	0.26	0.96	270	81	300	4.30	11.47
4	422	B	70	0.93	-	0.28	1.01	520	96	346	3.56	9.50
5	138	B	70	0.54	-	0.28	1.01	710	43	155	3.32	8.88
6	177	B	69	0.57	-	0.26	0.96	690	50	183	3.34	8.92
7	357	B	72	0.52	0.37	0.34	1.12	720	137	450	3.31	8.84
8	267	B	72	0.85	-	0.34	1.12	550	78	257	3.51	9.37
9	103	B	71	0.48	-	0.31	1.06	740	37	126	3.29	8.78
10	53	B	70	0.28	-	0.28	1.01	960	22	80	3.17	8.46
11	94	B	70	0.55	0.36	0.28	1.01	700	29	104	3.33	8.89
12	74	B	73	0.50	0.32	0.37	1.18	730	31	100	3.30	8.81
13	321	B,BD	72	1.52	0.53,0.45	0.34	1.12	360	61	202	3.91	10.45
14	101	A,BD	72	0.68	0.44	0.34	1.12	620	33	110	3.41	9.10
15	291	A,B,BD	73	1.36	-	0.37	1.18	400	67	215	3.82	1.19
16	116	A,B	74	0.69	0.33	0.40	1.24	610	44	137	3.41	9.12
17	265	B,BD	74	0.71	0.41	0.40	1.24	605	100	311	3.43	9.15
18	45	BD	78	0.24	—	0.54	1.50	1000	38	105	3.14	8.39
19	246	A,BD	76	0.60	-	0.47	1.36	670	121	471	3.36	8.97
20	105	B	69	0.47	0.33	0.26	0.96	750	32	118	3.28	8.76
21	78	B	69	0.57	-	0.26	0.96	690	22	81	3.34	8.92
22	94	A,BD	65	0.40	-	0.16	0.76	820	19	92	3.24	8.65
23	79	A,B	68	0.37	0.31	0.23	0.90	840	24	93	3.22	8.60
24	109	A,B,BD	72	0.31	0.24	0.34	1.12	910	53	174	3.19	8.51
25	71	A,B,BD	61	0.33	0.16	0.10	0.58	890	10	57	3.20	8.54
26	96	A,BD	72	0.37	—	0.34	1.12	850	43	143	3.22	8.60

* FROM PREVIOUS STUDY

Fig. 4

SUB-BASIN	AREA (ACRES)	HYDR. SOILS GR.	CN	t_c (HR.)	t_t (HR.)	$Q_{2.1}$ (IN.)	$Q_{3.5}$ (IN.)	q_p (CSM/IN.)	$q_{2.1}$ (CFS)	$q_{3.5}$ (CFS)	t_p (HR.)	t_b (HR.)
27	182	A,B,BD	82	0.42	0.38	0.71	1.78	790	159	400	3.25	8.68
28	119	A,B	65	0.89	0.48	0.16	0.755	540	16	76	3.53	9.44
29	282	A,B	60	0.58	0.48	0.08	0.53	680	24	159	3.35	8.94
30	135	A	58	0.37	0.28	0.05	0.48	850	9	81	3.22	8.60
31	409	A,B	57	1.80	-	0.04	0.42	310	8	83	4.08	10.89
32*	390	A,B	59	1.08	-	0.06	0.49	470	17	140	3.65	9.74
33	189	A	62	0.99	0.39	0.11	0.62	500	16	92	3.59	9.60
34	66	A	67	0.53	-	0.205	0.85	700	15	61	3.32	8.86
35	356	A	58	1.43	0.61	0.05	0.45	370	10	93	3.86	10.30
36	60	A,B	66	0.57	-	0.18	0.80	690	12	52	3.34	8.92
37	105	A,B	66	0.30	0.24	0.18	0.80	910	27	119	3.18	8.49
38	69	A,B	60	0.22	-	0.08	0.53	1050	9	60	3.13	8.36
39	209	A,B	74	0.88	0.27	0.40	1.24	540	71	219	3.53	9.42
40	115	B,BD	80	0.24	-	0.62	1.64	1025	114	302	3.14	8.39
41	83	A,AB	72	0.38	0.18	0.34	1.12	840	37	122	3.23	8.62
42	52	A,BD	74	0.26	0.15	0.40	1.24	970	32	98	3.16	8.43
43	120	B,D,BD	87	0.32	0.21	0.98	2.18	900	165	368	3.19	8.52
44	36	A,AB,D	74	0.26	0.18	0.40	1.24	980	22	68	3.16	8.43
45	184	VARIES	64	0.39	0.39	0.14	0.71	810	33	165	3.23	8.63
46	59	A,D	71	0.35	0.16	0.31	1.06	860	25	84	3.21	8.57
47	141	B	60	0.58	-	0.08	0.53	680	112	79	3.35	8.94
48	106	B,BD	87	0.35	-	0.98	2.18	830	135	300	3.21	8.57
49	51	B,D	72	0.34	-	0.34	1.12	870	24	78	3.20	8.55
50	57	A,B,D	76	0.28	0.13	0.47	1.36	950	40	115	3.17	8.46
51	85	A,B	69	0.30	-	0.26	0.96	920	32	117	3.18	8.49
52	42	A	54	0.24	0.24	0.02	0.31	1000	2	20	3.14	8.39

* FROM PREVIOUS STUDY

Fig. 4

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COTTONWOOD CREEK

SUBJECT: HYDROLOGIC SUMMARY BASIN A

JOB No. 5096·01·01
SHEET No. 2 OF 3
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DATE 5·13·83

SUB-BASIN	AREA (ACRES)	HYDR. SOILS GR.	CN	t_c (HR.)	t_t (HR.)	$Q_{2.1}$ (IN.)	$Q_{3.5}$ (IN)	q_p (CSM/IN.)	$q_{2.1}$ (CFS)	$q_{3.5}$ (CFS)	t_p (HR.)	t_b (HR.)
53*	132								207	471		
54*	159								292	588		
55*	94								188	413		
56	99	VARIES	74	0.44	-	0.40	1.24	780	48	150	3.26	8.71
57	82	A, B	77	0.46	-	0.50	1.43	760	49	139	3.28	8.75
58*	24								26	72		
59*	186	A	62	0.62	-	0.11	0.62	660	21	118		
60*	231		86	0.25					335	764	1.65	4.41
61*	163		84	0.193					216	512	1.62	4.33
62*	392		86	0.50					457	1043	1.80	4.81
63*	386		84	0.51					386	936	1.80	4.82
64	118	A	75	0.49	-	0.44	1.30	7.30	59	175	3.29	8.79
65*	154		84	0.33					190	449	1.70	4.54
66*	143		83	0.20					170	414	1.62	4.33
67*	417		87	0.54					498	1109	1.82	4.86
68	236	A, B, D	75	0.79	-	0.44	1.30	580	94	278	3.26	8.71
69	61	AB, B	68	0.55	-	0.23	0.90	700	15	60	3.33	8.89

* FROM PREVIOUS STUDY

Fig. 4

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SUBJECT: HYDROLOGIC SUMMARY - BASIN A

COTTONWOOD CREEK

JOB No. 5096-01-01
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SHEET No. 3 OF 3
DATE 5-13-83

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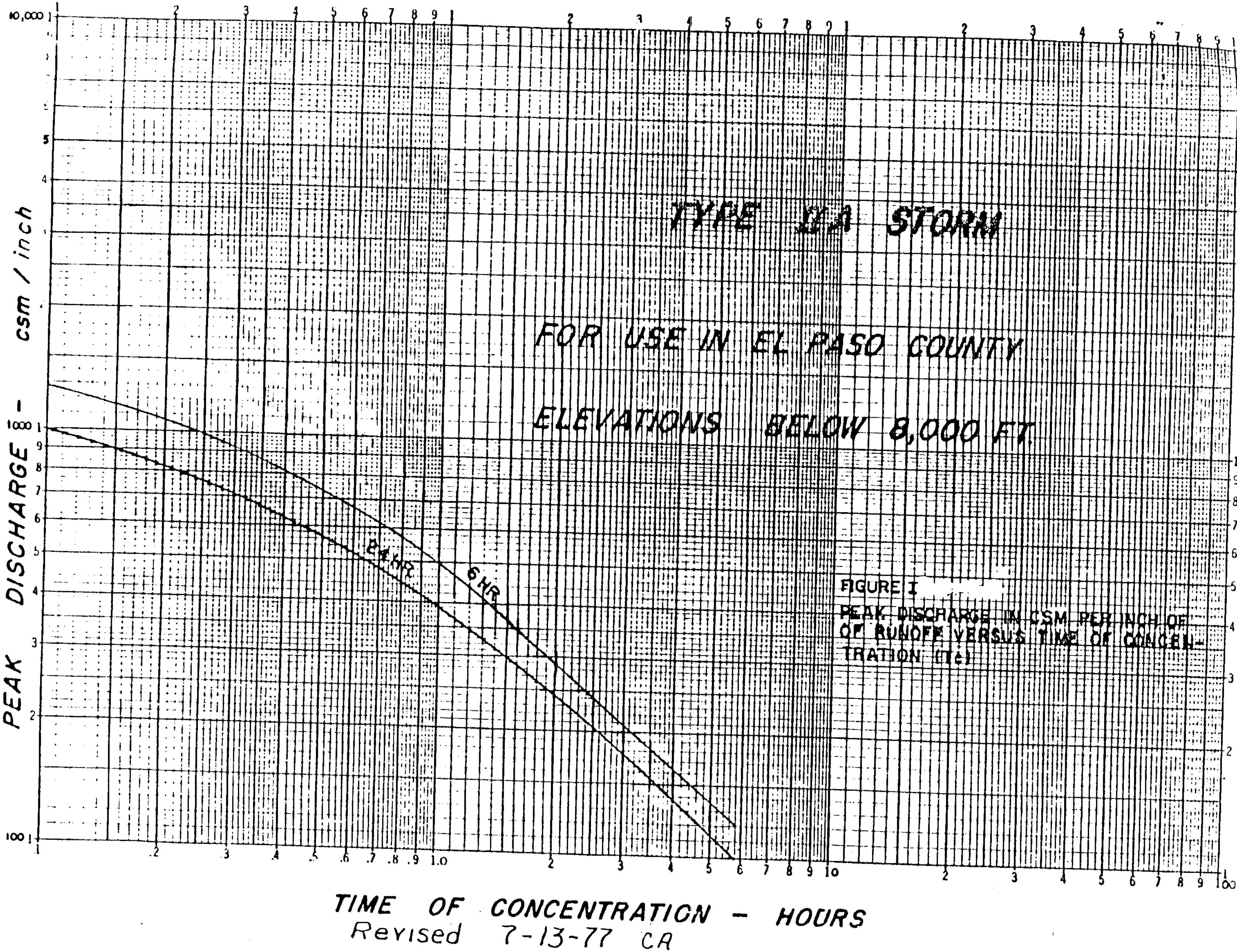
SUBJECT: HYDROLOGIC SUMMARY - BASINS B & C

COTTONWOOD CREEK

JOB No. 5096.01.01 | SHEET No. 1 OF 1
BY SJMc | DATE 5.13.83

SUB-BASIN	AREA (ACRES)	HYDR. SOILS GR.	CN	t_c (HR)	t_t (HR)	$Q_{2.1}$ (IN.)	$Q_{3.5}$ (IN.)	q_p (CSM/IN.)	$q_{2.1}$ (CFS)	$q_{3.5}$ (CFS)	t_p (HR.)	t_b (HR.)
BASIN B												
1*	180								156	468		
2*	160								123	398		
3*	130								74	244		
4*	86	A	86	0.13	-	0.92	2.10	1230	152	347		
5*	69	A	81	0.13	-	0.66	1.71	1260	90	232		
6*	135	A	81	0.37	0.09				120	330	3.22	8.60
7*	207	A	71	0.59	0.11				70	235	3.35	8.96
8*	51	A	70	0.15	0.04	0.05	0.45	1160	5	42		
9*	50	A	70			0.05	0.45		31	232		
10*	71	A	75	0.22	0.04	0.44	1.30	1040	51	150		
11*	112								56	201		
12*	103	A	69	0.30	0.25	0.26	0.96	920	38	142		
13*	104	A	69	0.28	0.16	0.26	0.96	950	40	148		
14*	83	A	81	0.21	0.04	0.66	1.71	1050	90	233		
15*	165								116	294		
16*	110	A,B	71	0.22	0.10	0.31	1.06	1040	127	433		
17	292	A	68	0.85	-	0.23	0.90	550	58	226	3.51	9.37
18	116	A	65	0.54	-	0.16	0.76	700	20	96	3.32	8.88
19*	202	A	83	0.45	0.24	0.76	1.86	760	182	446		
20*	109	A,B	89	0.26	0.09,0.10	1.11	2.36	980	185	394		
21	338	A,B	72	0.66	-	0.34	1.12	640	115	379	3.40	9.07
22	61	B	72	0.42	0.16	0.34	1.12	800	26	85	3.25	8.68
BASIN C												
1	157	VARIES	73	0.22	-	0.37	1.18	1040	94	301	3.13	8.36
2	44	AD	50	0.16	0.16	0	0.20	1140	0	16	3.10	8.27

Fig. 4



TYPE IIA STORM
FOR USE IN EL PASO COUNTY
ELEVATIONS BELOW 8,000 FT
24 HR
6 HR
FIGURE I
PEAK DISCHARGE IN CSM PER INCH OF OF RUNOFF VERSUS TIME OF CONCEN- TRATION (Tc)
PEAK DISCHARGE - csm / inch
TIME OF CONCENTRATION - HOURS
Revised 7-13-77 CA

Fig. 5

Table 2-2.--Runoff curve numbers for selected agricultural, suburban, and urban land use. (Antecedent moisture condition II, and $I_a = 0.2S$)

LAND USE DESCRIPTION	HYDROLOGIC SOIL GROUP			
	A	B	C	D
Cultivated land[1/]: without conservation treatment	72	81	88	91
: with conservation treatment	62	71	78	81
Pasture or range land: poor condition	68	79	86	89
good condition	39	61	74	80
Meadow: good condition	30	58	71	78
Wood or Forest land: thin stand, poor cover, no mulch	45	66	77	83
good cover[2/]	25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.				
good condition: grass cover on 75% or more of the area	39	61	74	80
fair condition: grass cover on 50% to 75% of the area	49	69	79	84
Commercial and business areas (85% impervious)	89	92	94	95
Industrial districts (72% impervious).	81	88	91	93
Residential:[3/]				
Average lot size — Average % Impervious[4/]				
1/8 acre or less — 65	77	85	90	92
1/4 acre — 38	61	75	83	87
1/3 acre — 30	57	72	81	86
1/2 acre — 25	54	70	80	85
1 acre — 20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5/]	98	98	98	98
Streets and roads:				
paved with curbs and storm sewers[5/]	98	98	98	98
gravel	76	85	89	91
dirt	72	82	87	89

[1/] For a more detailed description of agricultural land use curve numbers refer to National Engineering Handbook, Section 4, Hydrology, Chapter 9, Aug. 1972.

[2/] Good cover is protected from grazing and litter and brush cover soil.

[3/] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4/] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5/] In some warmer climates of the country a curve number of 95 may be used.

Fig.6

$$t_p = \frac{D}{2} + 0.6t_c$$

where: t_p = time to peak (hr.)
D = total period of excess rainfall (6 hr.)
t_c = time of concentration (hr.)

The total length of time during which runoff occurs is the base time (t_b);

$$t_b = 2.67\ t_p$$

Using q, t_p, and t_b the hydrograph is plotted on a graph as CFS vs. time.

In order to determine the peak flow at the outfall of a series of sub-basins the individual hydrographs must be routed through the sub-basins to the outfall. This is accomplished by calculating the travel time (t_t) for each hydrograph through the downstream sub-basins and using that time to offset the zero point of the routed hydrograph from the zero point of the hydrograph at the outfall point. Travel time is computed in the same manner as is t_c. The contributing hydrographs are summed to yield the composite hydrograph. Generally, $t_p + t_t$ will be unique for each routed hydrograph (t_t for the hydrograph of the outfall sub-basin equals zero). It is, therefore, expected that the composite peak flow will be less than the sum of the individual peak flows of the contributing sub-basins, since the peak flows will not arrive at the outfall point simultaneously.

A flow chart indicating direction of flood flow and contributing sub-basins is presented in Figure 7. The table in Figure 4 lists travel time (where applicable) through sub-basins, q (100 year), q (5 year), and accumulative flood flows (for 100 year and 5 year floods) at each sub-basin outfall.

DMJM DENVER, COLORADO	COTTONWOOD CREEK	JOB No. 5096-01-01	SHEET No.
		BY SJMc	DATE 5-2-83

SUBJECT: Hydrograph Routing Flowchart - A

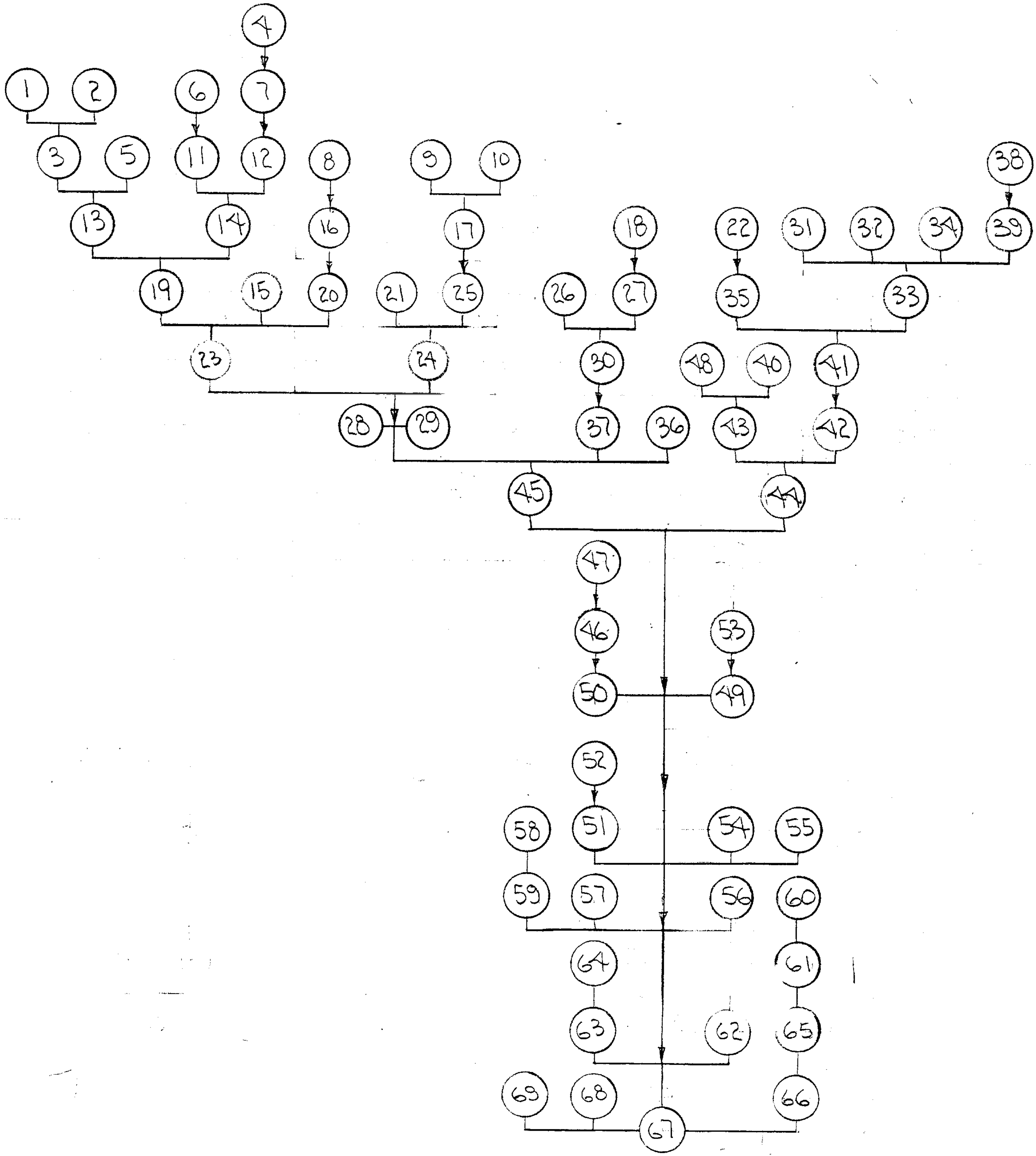


Fig. 7

DMJM DENVER, COLORADO	COTTONWOOD CREEK	JOB No. 5096-01-01	SHEET No.
		BY SJMc	DATE 5-2-83

SUBJECT: HYDROGRAPH ROUTING FLOWCHART B.

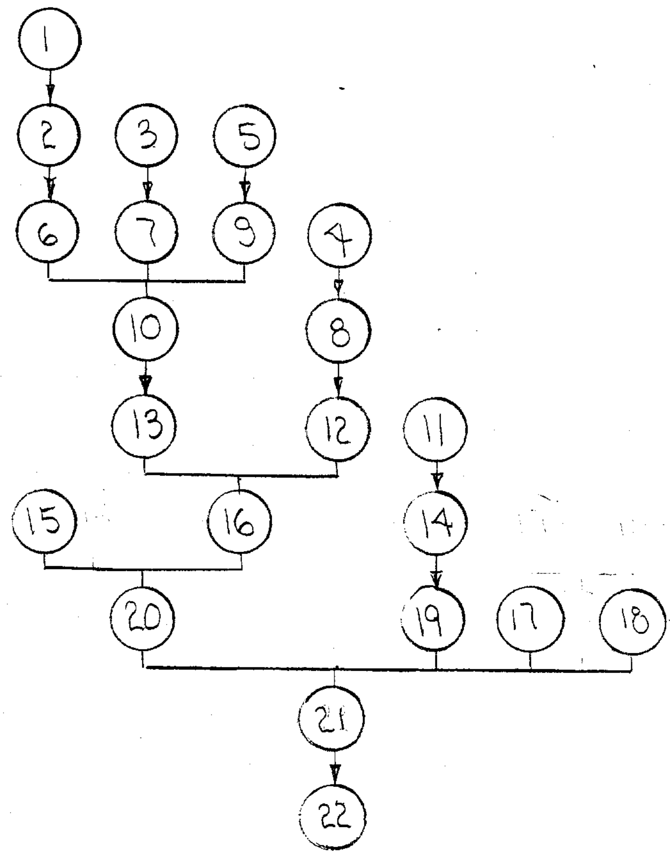


Fig. 7

V. HYDRAULICS

The western portion of the Cottonwood Creek Basin has been previously studied and partially developed. Drainage facilities which have been proposed and constructed in these areas are shown as existing on the master plan and do not affect the proposed improvements in the eastern portion of the basin. This report deals with that portion of Basin "A", the Cottonwood Creek Basin, in the eastern (and currently undeveloped) portion of the City.

No drainage improvements are proposed for any part of the basin falling into one or more of the following catagories; 1) The area is assumed to be developed to its full potential and no further development is foreseen. In these areas a workable drainage system is already in existence and drainage fees have already been assessed. 2) The area is presently being developed or at least has already been platted. Drainage studies have been completed, drainage facilities have been planned or are being constructed, and drainage fees have already been computed. 3) The area is outside the Corporate City Limits and is governed by El Paso County. These areas are not subject to the city's drainage fees and are outside of the scope of the detailed portion of this report.

The 100 year developed flow in Cottonwood Creek (without stormwater detention) has been calculated previously (Engineering Study of Cottonwood Creek Drainage Basin, Lincoln Devore, 1979) and is not amended here. The proposed development assumed in the previous study reasonably reflects current and proposed land use. The channel flows presented in Figure 8 represent the 100 year storm flows assuming development throughout the basin. These are used for assessing structures and capacities along the main channel. Flows generated by sub-basins within the city limits that are currently undeveloped but are slated for future development are calculated separately.

The developed flow for the Cottonwood Creek Basin is handled in several ways. Stormwater is transported through the basin by means of natural channels, lined ditches, storm sewers, culverts, and, where appropriate, roadways. Culverts are sized using the nomographs for inlet control from Hydraulic Engineering Circular

No. 5 (Bureau of Public Roads, U.S. Department of Commerce). Hydraulic Design Series No. 3 (U.S. Department of Transportation, Federal Highway Administration) is used in the design of storm sewers. Gutter flow and inlet capacity are calculated using the Determination of Storm Runoff Criteria (City of Colorado Springs, 1977). All detention ponds are sized by the Modified Puls method of flood routing through reservoirs (Bureau of Reclamation, U.S. Department of the Interior). Lined ditches are designed using the charts for open channel flow of Hydraulic Engineering Circular No. 5. As stipulated in the criteria manual of Colorado Springs these channels are fully lined with either concrete or grouted riprap.

According to the Colorado Springs criteria manual, the 100-year storm shall be used as a basis for design of all major channels having a 100-year peak flow greater than or equal to 500 CFS. Should the 100-year peak flow be less than 500 CFS, the 5-year storm shall be used as a basis for design. Both 100 year and 5 year storm data are presented in this report.

All detention ponds (with the exception of Pond No. 2 and No. 19) are designed to detain the 100 year developed flow. Detention Ponds No. 2 and No. 19 are situated on minor channels and detain only the 5 year excess runoff. The exact locations and sizes of the detention ponds are approximate and may be adjusted, relocated, or combined, should a more efficient and advantageous arrangement be determined as the area is developed. The scheme presented here serves to indicate the magnitude of ponding required and a reasonable placement with the given land use and street layout.

In addition to detention ponds, the use of on-site detention is also proposed where feasible. Areas designated as commercial or research and development, where large parking lots or landscape grounds often exist, can be graded or depressed to accommodate the storage of excess runoff for a brief period of time. It will be the responsibility of the developer to integrate this on-site detention with the design of a given site such that only the historic runoff will be released from the site. The values for 100 year and 5 year flow as well as accumulative flow, as given in Figure 4 and as shown on the 1 inch = 400 feet scale plans (See Appendix, Sheets A-2 through A-8) reflect historic runoff only where applicable.

Storm runoff within a given sub-basin flows over lawns and landscaped areas to the local streets. It is then conveyed by gutters and valley pans to the collector streets. The concentrated flows in the collector streets necessitate the establishment of a storm sewer system to ensure that the runoff reaches the appropriate channel and/or detention pond. Inlets are used when the capacity of the street to carry this runoff is exceeded, to drain low points in the roadway, or to pick-up nuisance water at intersections. Storm drains located in the middle of a sub-basin, where no street network is currently planned, are situated so as to drain areas of high runoff or to help route the stormwater toward a channel or pond more effectively. It is assumed that the grade of the existing terrain approximates the street profile. Inlet sizing and spacing is based on the most efficient size and combination for a given street profile and cross-section. Upon final design, the size and location of inlets may be adjusted to yield a more economical design.

Proposed channels are located, where possible, in existing streambeds or swales. All channels are lined with either concrete or grouted rip rap. Grouted rip-rap channels are proposed for steeper channels where velocity of flow and the erosive forces need to be controlled. Along major existing streambeds a riprap lining is required on the sideslopes only.

Cross culverts and concrete box culverts are designed assuming inlet control. Standard sizes are used wherever possible and it is assumed that adequate cover is available at roadway crossings. Preliminary and final design at the time of site development may dictate the use of non-standard sizes or elliptical culvert pipe.

PEAK FLOWS FOR THE 100-YEAR FLOOD ALONG COTTONWOOD CREEK

APPROXIMATE LOCATION	FLOW (CFS)
Monument Creek	10,000
Academy Boulevard	9,400
Union Boulevard	9,200
Woodmen Road	7,300
Cowpoke Road	4,900
Azore Road (Black Forest Road)	3,000

Fig. 8

VI. MAIN CHANNEL ASSESSMENT

Because of the large area of the Cottonwood Creek watershed (24 square miles), extremely large flows must be conveyed along the main channel of Cottonwood Creek during periods of high precipitation. Due to the sandy soil composition of the basin erosion of the streambed has become a great problem which will only worsen as greater developed flows are introduced to the channel without any form of detention.

The upper reaches of the channel are fairly narrow and brush filled. The surrounding terrain is rolling with good ground cover (native grasses and shrubs) providing good stability for the channel side slopes. There are no signs of excessive erosion in the channel.

Further downstream the streambed becomes deeper and wider. Underground springs feed into the channel providing a minimal base flow during the dry season. The steel H-pile bridge at Woodmen Road is adequate to pass the 100 year design flow. This bridge appears to be structurally sound, however, about 5 feet of the concrete caissons, supporting the steel H-piles, are exposed due to the deep channel cut. Regular maintenance should be provided to assure that the bridge opening is left clear from trash, tree limbs, and brush which often collect on the center supports and clog the channel.

Between proposed Rangewood Road and Union Boulevard the channel is wider and has a shallower slope. Rip-rap has been dumped on both banks to prevent erosion of the side slopes. In all but one 5 foot section this riprap is well stabilized and is adequately protecting the banks. Woodland Hills subdivision, to the north, is separated from the main channel by an access road which also serves as a levee. As constructed, the levee is not sufficient to contain the flood waters of a 100-year storm, therefore the lower portions of this development lie within the floodplain.

The proposed Rangewood Drive crossing over Cottonwood Creek will require a 7' x 400' bridge, or equivalent structure, to span the creek bed, and to permit passage of the 100-year flood. A narrower bridge will create a constriction that will increase flooding upstream.

An additional complication is the intersection, at the south end of the bridge, with a roadway which connects Rangewood Drive and Dublin Road. The intersection occurs at the approximate abutment location and spans a tributary entering Cottonwood Creek from the south. A bridge and a large culvert are required to accommodate the tributary flow during low flows, and the extension of the flood plain (see Sheet A-7) during a 100-year flood.

According to the Norwood Master Plan this road will serve as an access to an office park complex. It is not a major roadway. The alignment could be shifted such that it forms a loop, connecting at both ends to Dublin Road, and still serve the same purpose as it does with the present alignment. Alternatively, to avoid complications at the Rangewood Drive structure, the roadway intersection could be shifted south. This alignment requires two culverts as the tributary splits close to the Cottonwood Creek channel.

The (7) 6' X 12' concrete box culvert structure at Union Boulevard is adequate to transport the 5 year design flow, but is too small to handle the 100 year design flow. Storm runoff will overtop the roadway and back up onto the floodplain. An existing gas line passing through the upper portion of the culvert further reduces the capacity of this structure as well as posing a potentially dangerous situation. The downstream invert of this structure is about 6' to 8' above the natural channel. The grouted riprap at the outlet does not appear to have been extended below the channel invert and consequently is being badly under cut. In places the sandy soil beneath the riprap has been scoured out to the extent that the grout is failing. Some groundwater flow emerges at the toe of the riprap. It is not clear how much of the scour is due to groundwater flows and how much is caused by channel flow during rainstorms.

This problem should be redressed before the structural integrity of culvert is jeopardized. The culvert is, in effect, a 6 foot - 8 foot drop structure. To halt further scour an adequate stilling basin is required to dissipate energy as the water flows over the drop. Both the drop and the channel downstream of the culvert require protection. Subsurface flows below the culvert and into the stilling basin must be provided for in the final design to avoid failure of the stilling basin due to piping.

To upgrade this structure, in order that it will pass the 100-year peak flow of 9,200 CFS, will require major alterations. The problem is twofold. Both the channel immediately upstream and the structure are inadequate to accommodate a 100 year flood. The existing structure requires seven additional boxes of the same dimensions (6' x 12') in order to pass the flow. The channel is not wide enough to excavate another eighty-four (+) feet for the additional boxes. The Union Boulevard requires a bridge crossing with an associated drop structure for the eight foot drop. The drop structure is best positioned upstream of the bridge for the following reasons; 1) Positioning the drop above the bridge will lower the invert of the channel. Sufficient height will be obtained for the top of the water surface plus freeboard, and the existing vertical profile of the roadway need not be raised significantly. 2) The size of the drop and the quantity of water passing through will necessitate the installment of a long stilling basin. There is more room in the channel upstream of the existing culvert for such an installment than there is downstream and there is no additional complication of flow around bends that is found downstream. 3) Should the drop structure sustain damage and partial failure erosion, due to headwall cutting, will not affect the bridge.

Downstream of Union Boulevard the channel is narrow and has a steeper gradient. Erosion of the streambed and side slopes is apparent throughout. Some of the streambed cutting in the upper reaches may be due to the accelerated velocities which occur, without energy dissipation, at the Union Boulevard box culvert structure. Correcting the problem at Union Boulevard will have a beneficial effect on downstream reaches. The (5) 7' X 20' concrete box culvert structure at Academy Boulevard is inadequate to carry the 100 year design flow. The sandy soil which has been eroded upstream is being deposited inside the boxes (1' - 1.5' deep) further reducing the capacity of this structure. The 1979, Lincoln DeVore Drainage Report called for an additional 7'x 20' box to be added to the structure. This report reaffirms the need for that addition.

The detailed portion of this report addresses problems along the main channel of Cottonwood Creek within the May 1, 1983 city limits. Included herein is a brief summary of the channel as it passes thru El Paso County and Interstate 25 right-of-way. Downstream of Academy Boulevard considerable development and construction is taking place. Properties adjacent to the channel on both sides are expanding their parking and other facilities by backfilling into the channel. The streambed is being constricted to a width as narrow as 40 feet in some areas. A standard channel cross section and right-of-way should be defined in this area and enforced. The 100 year design flow is between 9,400 and 10,000 CFS in this reach and a hazardous situation could develop should these fill areas be washed away. There are presently five bridges located between Academy Boulevard and Monument Creek crossing Cottonwood Creek. These are the double masonry arch bridge at the old A.T. & S.F. Railroad, the reinforced concrete bridge at Vincent Drive, the two steel girder bridges at Interstate 25 and the new concrete I-beam bridge adjacent to Interstate 25. All of these bridges are adequate to convey the 100 year runoff. Some structural problems are evident at the old railroad bridge. Masonry blocks have been displaced and portions of the foundation have been eroded and undercut. This bridge is no longer in use and could be removed. Some lateral movement is apparent at the bridge abutments at Interstate 25 bridges - large cracks are visible at abutment/wingwall corners. There are no evident erosion problems, however.

APPENDIX