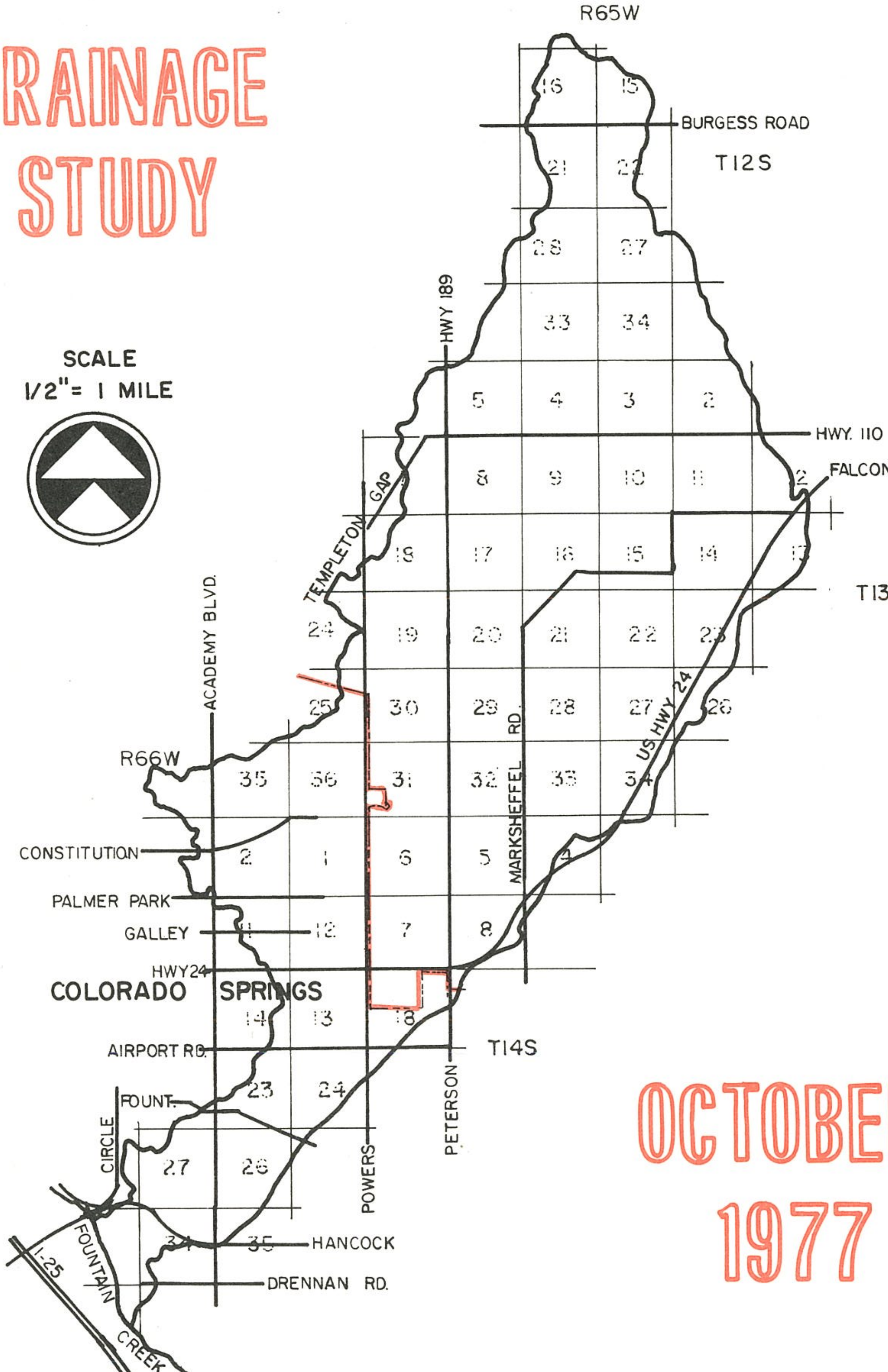
SAND CREEK DRAINAGE BASIN

DRAINAGE STUDY



OCTOBER 1977

UNITED PLANNING AND ENGINEERING COMPANY

planners · consultants · engineers

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October 11, 1977

Mr. Dewitt Miller
Director of Public Works
City of Colorado Springs
P. O. Box 1575
Colorado Springs, CO 80901

SUBJECT: Sand Creek Drainage Basin
Master Drainage Study

Dear Deke:

Transmitted herewith is the master drainage study for the Sand Creek Drainage Basin in Colorado Springs.

The study was prepared by me and under my direct supervision and complies with all applicable criteria and ordinances of the City of Colorado Springs.

Please do not hesitate to call on me if I may answer any questions concerning the study.

OLIVER E. WATTS
REGISTERED
9853
P. E. & L. S.
STATE OF COLORADO

Respectfully submitted,

UNITED PLANNING & ENGINEERING CO.

Oliver E. Watts
PE-LS 9853
Partner

OEW:pq
Enclosure

MASTER DRAINAGE STUDY

SAND CREEK DRAINAGE BASIN

PREPARED FOR

THE CITY OF COLORADO SPRINGS, COLORADO

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Lawrence B. Ochs	Mayor
Richard E. Dodge	Vice Mayor
Michael Bird	
Mary Kyer	
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CITY ADMINISTRATION

George Fellows	Manager
Dewitt Miller	Public Works Director
Donnel Jeffries	City Engineer

OCTOBER, 1977

CONTENTS

MASTER DRAINAGE STUDY

SAND CREEK DRAINAGE BASIN

SECTION I - INTRODUCTION

A. Purpose and Scope

The purpose of this study is to provide a master plan that will best protect the developments and people within the basin from the runoff of severe storms and to provide a legal means of enforcement to the City of Colorado Springs as required by ordinance.

This study prescribes the design values to be used for the structures on the various greenbelts, the general type of structures to be used and their location. A collection system of minor structures is specified to serve undeveloped ground, based on anticipated future development. All computations are based on the assumed ultimate developed state of the basin. Costs are assigned to the various structures and a drainage fee computed, based on the acreage of unplatted ground likely to occur within the future City limits.

B. Description of Basin

The approximate limits of the basin are shown on the cover sheet--more detailed limits can be found on the various plates in the appendix.

The Sand Creek Drainage Basin is the largest designated basin within the City of Colorado Springs, containing 48.74 square miles--nearly three times the size of the next largest basin. It originates eleven miles east of the Air Force Academy and flows southerly along the eastern limits of the City to its confluence with Fountain Creek at the southern limits. Elevations in the basin range from 7600 mean sea level (msl) near the community of Black Forest to an elevation of 5780 msl at its confluence. The total length of the main drainage course is 103,000 feet (19.5 miles).

The headwaters of Sand Creek are in the conifer covered Black Forest, but most of the basin is typlified as a semi-arid high plain that is common near the foothills of the Rocky Mountains. Sand Creek is an ephemeral stream except near the confluence where the Pierre Shale outcroppings force ground water to the surface.

Soil mapping of the basin has been prepared by the local office of the USDA - Soil Conservation Service. This mapping is simplified into their four major hydrologic groupings and is shown on plate number one in the appendix. These four soils groupings are as follows:

Group A: (Low Runoff Potential): Soils that have high infiltration rates even when wetted, consisting of deep, well to excessively well drained sands and gravel.

Group B: Soils having moderate infiltration rates when thoroughly wetted, consisting of moderately fine to moderately coarse textures soils.

Group C: Soils having slow infiltration rates when thoroughly wetted, consisting of moderately fine to fine textures soils or soils having a layer that impedes downward movement of water.

Group D: (High Runoff Potential): Soils having very slow infiltration rates when thoroughly wetted, consisting chiefly of high plasticity clays, a high groundwater table, a shallow clay or clay pan layer or shallow soils over nearly impervious bedrock.

It should be noted from plate number one that Sand Creek has an abnormally high percentage of Group A soils--so that its name is no accident, and that relatively low percentage of C and D soils exist. As might be expected, the runoff per square mile is correspondingly lower than normally encountered elsewhere in the region.

Sand Creek is bounded by the west by several previously studied basins; Spring Creek, Palmer Park, Templeton Gap and Cottonwood Creek, and the south by the Peterson Field Basin.

C. Proposed Development

All computations are based on the basin being in its ultimate state of development, which is projected to be as shown on plate number two in the appendix. By this means, all structures built to contain storm runoff should not require replacement due to some future development upstream. Furthermore, the City has a legal right to insure that some future, unforeseen developer employ such flood control techniques necessary to protect downstream areas.

The Cities and the Counties land use plans and policies were compiled and all known existing and proposed developments are considered. These developments are categorized into general zoning types as shown on plate number two, but may be broken into two main categories; Urban and Rural. Plate number 2 shows our anticipated ultimate development condition.

The urban developments are those within an area serviced by normal urban utility services. In this case water supply (not necessarily the City's) is the major limiting factor in population densities. The following urban classifications were used, as shown on plate number two:

Urban Land Use Classifications

Residential: Includes single and multiple family dwellings, mobile homes, and normal neighborhood support elements such as schools and small shopping areas.

Commercial: All commercial zonings of more than a neighborhood impact, to include those "special" zonings designated in the City land use plans.

Industrial: Light industrial uses common to those now found in industrial parks within the City.

Open: Golf courses and regional parks, both fully landscaped and left in a "natural" state, to include large areas of flood plain near the confluence.

The development that will occur outside the "limit of urban services" will be limited by water supply. In this case the water supply is from individual wells drilled into the Dawson Arkose formation, about which much information has been compiled and published. The development is assumed to be limited by the recharge by precipitation to this aquifer as published by the Colorado Water Conservation Board and the US Geological Survey. Near the headwaters, the aquifer can supply as many as three dwelling units per acre, but near the urban limits in the south, one dwelling unit per 23 acres is the maximum.

Only one county development is planned that will not satisfy the above--being the "Latigo" development, occupying 2 sections in the northwest portion. In August, 1976, the developers provided the County Commissioners with an issue statement that stated:

"Latigo plans the extensive use of retention facilities along with wide natural drainage channels. This will hold the amount of development related runoff to an amount no greater than the natural drainage occurring prior to any development."

For this reason the Latigo area is treated the same as the surrounding areas.

MASTER DRAINAGE STUDY

SAND CREEK DRAINAGE BASIN

SECTION II - HYDROLOGY

A. Description

The mean annual precipitation in the Sand Creek Basin is fifteen inches per year and has ranged from less than 12 to over 30 inches in the period of record since 1931.

The Sand Creek Basin is in the zone of prevailing westerlies. The source of moist air in the winter is from the Pacific Ocean. Since most of the precipitation is on the western slopes of the Continental Divide, winter is the driest season of the year.

April through September is the wet season in the Sand Creek Basin. Precipitation is caused by frontal action and air mass thunderstorms that frequently occur during April and May, and less frequently from June through August. During October and November there is an increase in frontal activity, but a decrease in moisture from the Gulf of Mexico, which serves as a principal source of moisture during the flood season.

The floods are characterized by high peak flows, moderate volumes and short durations.

B. Design Parameters

1. Design Storms: As required by City criteria the following design floods were used: Minor Structures: 5 year, 6 hour precipitation (2.1 inches); Greenbelt Structures: 100 year, 24 hour precipitation (4.6 inches).

2. Rainfall Distribution: Type IIA storm distribution, typical of the eastern slope, was used, which is as follows for the 100 year storm:

TIME-HOURS	IIA DISTRIBUTION	100 YEAR RAINFALL-INCHES
00.00	0.000	0.000
2.00	0.010	0.045
4.00	0.030	0.138
4.50	0.050	0.230
5.00	0.060	0.276
5.50	0.100	0.460
6.00	0.700	3.220
6.50	0.750	3.450
7.00	0.780	3.590
8.00	0.820	3.770
9.00	0.840	3.860
9.50	0.850	3.910
10.00	0.860	3.960
10.50	0.865	3.980
11.00	0.870	4.000
11.50	0.885	4.070

TIME-HOURS	IIA DISTRIBUTION	100 YEAR RAINFALL-INCHES
11.75	0.888	4.080
12.00	0.890	4.090
12.50	0.900	4.140
13.00	0.905	4.160
13.50	0.910	4.190
14.00	0.915	4.210
16.00	0.940	4.320
20.00	0.980	4.510
24.00	1.000	4.600

3. Curve Numbers

The following curve numbers were used in hydrologic computations.

DEVELOPMENT TYPES	SOIL GROUPS A	B	C	D
Residential - less than 1 DU/acre	51	68	79	84
Residential - 2.1 DU/acre	54	70	80	85
Residential - 3.0 DU/acre	57	72	81	86
Urban Residential, Plus Support Facilities	63	75	82	86
Commercial & Special	89	92	94	95
Industrial	81	88	91	93
Parks: Natural Ground	49	69	79	84
Golf Course	39	61	74	80

4. Time of Concentration

For overland flow the California formula was used:

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

To the first inlet.

For structural flow, the full barrel velocity was used to the first hydrograph point.

For all greenbelt routings, the actual design velocity for the 100 year runoff was used.

5. Flow Routings (100 year storm)

Design discharges were computed for each basin shown in plate number three in the appendix. These individual runoffs were then routed down respective greenbelts, using travel times corresponding to the actual design velocities. Peak flow attenuations were used using a parabolic channel storage routine.

An excellent example of the method used is presented as the tabular example in Chapter 5 of the SCS publication "Urban Hydrology for Small Watersheds", January, 1975, except that type IIA Tabular Discharges were developed and used.

6. Basic Hydrologic Data

The following is the basic hydrologic input data for the various basins shown on plate number three.

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
West Fork West Fork:			
IA	1.380	75	0.286
IB	0.321	69	0.369
IC	0.616	77	0.281
ID	0.251	74	0.242
IE	0.359	79	0.610
IF	0.316	82	0.306
IG1	0.481	76	0.236
IG2	0.522	75	0.177
IG3	0.182	82	0.180
IG4	0.234	84	0.163
IH1	0.352	81	0.236
IH2	0.237	85	0.286
II	0.360	86	0.480
I TOTAL	4.934	77	0.557

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
West Fork:			
IIA	3.220	70	0.805
IIB	0.445	62	0.704
IIC	1.616	59	0.910
IID1	0.484	51	0.638
IID2	0.706	51	0.299
IIE1	0.968	57	0.687
IIE2	0.709	53	0.485
IIF1	0.199	58	0.291
IIF2	0.674	64	0.359

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
West Fork:			
IIG1	0.435	51	0.534
IIG2	0.459	62	0.488
IIH1	0.630	68	0.477
IIH2	1.844	63	0.651
III1	0.154	86	0.176
III2	0.098	86	0.144
III3	1.456	74	0.596
III4	0.166	80	0.162
III5	0.189	85	0.431
III6	0.237	75	0.138
III7	0.835	72	0.564
IIJ	0.412	74	0.212
IIK	0.644	69	0.436
IIL	0.372	69	0.533
IIM	0.319	90	0.377
IIN	0.053	88	0.172
II TOTAL	16.843	66	2.970

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
Center Tributary:			
IIIA	0.106	63	0.215
IIIB	0.294	57	0.387
IIIC	0.402	72	0.440
IIID	0.330	79	0.389
IIIE	0.242	69	0.320
IIIF	0.473	85	0.505
III TOTAL	1.848	73	0.463

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
East Fork:			
IVA	0.782	61	0.834
IVB1	0.608	51	0.674
IVB2	1.065	53	0.763
IVC1	1.080	51	1.002
IVC2	1.293	53	0.805
IVD1	1.683	56	0.915
IVD2	1.710	56	1.124
IVD3	0.722	51	0.742
IVD4	0.709	51	0.929

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
East Fork:			
IVD5	0.927	51	0.795
IVD6	1.290	56	0.847
IVE	1.397	59	0.732
IVF	1.360	58	0.772
IVG1	0.650	51	0.393
IVG2	1.469	51	0.812
IVG3	0.980	57	0.733
IVG4	0.872	56	0.600
IVG5	0.208	68	0.273
IVG6	0.442	68	0.420
IVG7	0.762	59	0.604
IVG8	0.928	81	0.945
IVH1	0.745	71	0.667
IVH2	0.571	81	0.647
IVI	1.700	69	1.030
IVJ	0.204	77	0.350
IVK	0.824	78	0.938
IV TOTAL	20.578	57	4.254

BASIN DESIGNATION	AREA -SM-	CURVE NO.	Tc -HRS-
Main Stem:			
VIA	0.521	77	0.590
VIB	0.316	75	0.247
VIC	0.677	76	0.416
VID	0.123	78	0.277
VIE	0.558	84	0.380
VIF	0.331	65	0.521
VIG	0.181	82	0.181
VIH	0.548	76	0.256
VII	0.770	78	0.604
VIJ	0.505	76	0.597
VI TOTAL	4.531	77	---
VII	0.188	79	0.194

C. Design Flows

The following are the design flows to be used:

1. Main Greenbelt--100 year flows

GREENBELT	LOCATION	TIME TO PEAK -HRS-	PEAK RUNOFF -CFS-
Main Stem	Junction w/ Fountain Creek	6.4	11,865
	Hancock Expressway	6.3	11,987
	Academy Boulevard	6.3	11,043
	Fountain Boulevard	6.2	10,515
East Fork	Junction w/ Main Stem	9.0	3,353
	Junction w/ Center Tributary	9.0	3,312
	Aviation Way	9.0	3,247
	Highway 24	8.5	3.398
	Peterson Road	9.0	3,040
	Mark Sheffel Road	9.0	2,575
Center Tributary	Junction w/ East Fork	---	2,148
	Powers Boulevard	---	1,481
	Highway 24	---	1,257
	Galley Road	---	780
	Palmer Park Boulevard	---	291
	C R I & P R R	---	107
West Fork	Junction w/ Main Stem	6.2	7,210
	Below Junction w/ West Fork West Fork	6.1	7,157
	Above Junction w/ West Fork West Fork	8.0	4,067
	Highway 24	6.8	4,321
	Galley Road	6.5	4,333
	Palmer Park Boulevard	7.2	4,211
	C R I & P R R	7.0	4,230
	Barnes Road Extension	7.0	3,400
West Fork West Fork	Junction w/ West Fork	6.2	6,895
	Below "H" Tributary	6.1	5,806
	Above "H" Tributary	6.1	5,370
	"H" Tributary	5.9	586
	Galley Road	6.2	3,709
	Palmer Park Boulevard	5.9	3,341
	C R I & P R R	5.9	3,522
	Constitution Avenue	5.9	3,136
	Maizeland Road	5.9	2,403
IG Tributary	Tributary w/ West Fork West Fork	5.9	3,031
	Palmer Park	5.9	2,062
	G1 - G2 Junction	5.9	1,674

2. Minor Flows

BASIN	LOCATION OF OUTFALL	CRITERIA	PEAK RUNOFF -CFS-
IB	Maizeland Road Storm Sewer	5 yr.	67.4
IID1	Highway 110	100 yr.	195
IIE1	Highway 110	100 yr.	427
IIF1	Peterson Road	100 yr.	137
IIG1	Peterson Road	100 yr.	192
IIH1	Peterson Road	100 yr.	590
III1	Barnes Road	5 yr.	156
III1+I2	Powers Boulevard	5 yr.	247
III4	Powers Boulevard	5 yr.	116
III6	Powers Boulevard	5 yr.	120
IVB1	Mark Sheffel Road	100 yr.	238
IVC1	Mark Sheffel Road	100 yr.	337
IVD1	Highway 110	100 yr.	587
IVD2	Highway 110	100 yr.	524
IVD1-D3	Mark Sheffel Road	100 yr.	835
IVD4	Highway 110	100 yr.	232
IVD4+D5	Mark Sheffel Road	100 yr.	352
IVD	East Fork	100 yr.	1062
IVG1	Highway 110	100 yr.	326
IVG1+G2	Mark Sheffel Road	100 yr.	586
IVG3	Mark Sheffel Road	100 yr.	419
IVG5	Mark Sheffel Road	100 yr.	246
IVG5+G6	Mark Sheffel Road	100 yr.	510
IVG1-G7	C R I & P R R	100 yr.	950
IVG1-G8	East Fork	100 yr.	1081
IVH1	C R I & P R R	100 yr.	671
IVH1+H2	East Fork	100 yr.	497

MASTER DRAINAGE STUDY

SAND CREEK DRAINAGE BASIN

SECTION III - HYDRAULICS

A. Criteria

All hydraulics are computed from the Mannings Formula using the following "n" values:

Concrete Pipe or Boxes	0.013
Concrete Channel Lining	0.015
Natural, Clean Channel Inverts	0.020
Riprapped Channel Banks	0.030

Major consideration was given to the type of channels chosen. Ordinarily the most economical is a fully concrete lined section with 1:1 side slopes, where the bottom width is roughly equal to the depth. This type of channel is shown on plate number five and is usable in the tributaries to Sand Creek, however, the natural channel shapes are not usable in larger channels.

As the natural channels become progressively wide and shallow, the Type II channel (see plate number six) is recommended. A major limiting factor is the velocities created by the natural slopes. The majority of the channel is highly erosive in velocities exceeding 5 feet per second. In any case, grade stabilization structures are required.

In the larger channels on moderate slopes, the Type III channel is recommended (see plate number seven). Drop structures are provided so that the resulting slopes are as flat as possible--thereby limited the excessive erosive effect due to velocity.

In both the Type II and III channels, the channel lining must be continued to well below the channel grade, so that the lining will not be undercut by the natural turbulence. Generally the depth of cutoff should not be less than the depth of flow.

Bridge structures are preliminarily sized so as to minimize severe transitional effects. The effects of piers are considered in accordance with USACE and USDOT criteria.

B. Flood Plain Levels

Those channels lying above the limits of urban development are proposed to remain in their natural state. The following is a tabulation of the flood plain information, based on the SCS data. The USDA-SCS conveyance factors used in the formulation of their 1973 Flood Hazard Analysis for Sand Creek were used in routing the flood to the limits of channelization. Also, the main stem below the Santa Fe Railroad is proposed to be left natural.

SECTION NUMBER	STATION FROM FOUNTAIN CREEK	REFERENCE LOCATION	RUNOFF -CFS-	FLOOD PLAIN ELEVATION	AREA -SF-	VELOCITY -FPS-
West Fork:						
W010	874 + 40		2536	7055.82	283.17	8.96
W020	857 + 40		2536	7036.46	449.42	5.64
W030	810 + 40		2536	6958.73	349.80	7.25
W040	780 + 00		2536	6912.76	285.60	8.88
W049	757 + 20	Highway 110	2574	6880.42	387.97	6.63
W051	754 + 60		2574	6876.92	339.81	7.57
W060	738 + 40		2572	6853.60	427.21	6.02
W070	716 + 00		2486	6814.15	297.58	8.35
W080	697 + 00		2521	6789.25	326.05	7.73
W090	675 + 40		2557	6761.17	366.07	6.98
W100	649 + 80		2592	6723.53	494.59	5.24
W110	636 + 20		2825	6706.21	308.36	9.16
W120	620 + 20		3059	6680.30	515.33	5.94
W130	599 + 80	Peterson Road	3292	6650.85	368.40	8.94
W140	582 + 80		3307	6625.83	345.65	9.57
W150	559 + 40		3376	6587.23	348.84	9.68
W160	549 + 00		3396	6573.92	325.45	10.43
W170	527 + 80	Barnes Road	3400	6540.10	403.65	8.42
W180	507 + 70		3692	6512.41	671.16	5.50
W190	492 + 90		3802	6494.87	832.47	4.57
W200	467 + 90		3818	6465.00	576.27	6.63
W210	454 + 30		3850	6446.29	598.71	6.43
W220	440 + 30		3882	6431.01	731.29	5.31
W230	427 + 10		4119	6415.18	764.31	5.39
W239	409 + 70	CRI & PRR	4230	6393.68	1224.84	3.45
East Fork:						
E010	570 + 60		392	6715.90	76.97	5.09
E020	556 + 30		507	6698.00	154.87	3.27

SECTION NUMBER	STATION FROM FOUNTAIN CREEK	REFERENCE LOCATION	RUNOFF -CFS-	FLOOD PLAIN ELEVATION	AREA -SF-	VELOCITY -FPS-
East Fork:						
E030	535 + 90		542	6678.24	177.53	3.05
E040	516 + 90		646	6651.20	107.92	5.99
E050	504 + 10		738	6629.82	123.08	6.00
E060	490 + 50	B-L Reservoir	842	6613.99	328.09	2.57
E070	468 + 30		1650	6591.02	359.25	4.59
E080	448 + 40	B-L Reservoir	1652	6568.27	255.18	6.47
E090	433 + 40		1575	6548.90	368.75	4.27
E100	412 + 20		1498	6526.64	620.57	2.41
E110	393 + 80		1421	6504.58	345.81	4.11
E120	378 + 80		1421	6490.86	191.06	7.44
E130	359 + 40		1260	6469.05	300.55	4.22
E140	341 + 90		1267	6451.01	312.32	4.06
E150	317 + 10		2498	6422.97	567.65	4.40
E160	303 + 10		2421	6411.28	482.83	5.01
E170	287.+ 40		2421	6394.49	684.80	3.54
E174	277 + 60		2575	6382.08	419.04	6.14
E175	276 + 10	Marksheffel Road	2575	---	---	---
Main Stem:						
M150	3 + 00		11865	5792.05	1022.28	11.61
M140	11 + 80		11865	5803.93	Unk.	Unk.
M131	23 + 20		11865	5814.49	1263.58	9.39
M130	26 + 30	D&RGW RR	11865	5827.64	Unk.	Unk.
M129	29 + 90		11865	5829.90	5389.06	2.20
M120	37 + 50	AT&SF RR	11865	5838.53	Unk.	Unk.

C. Summary of Structures

The following is a summary of the structures recommended -- refer to plate numbers five, six and seven for channel types.

1. Primary Greenbelts

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
West Fork of West Fork:							
Maizeland Road		Exist RCB					
	3136	II concrete	50X4.2	1.38%	3.2	169.5	18.5
Constitution(0+00)	3136	Exist RCB	4-8x5.7	---	3.9	124.8	25.1
	3522	IG. Riprap	20x8.0	2.25%	6.7	200.9	17.5
Station 5 + 00							
	3341	II concrete	50x4.6	1.04%	3.6	192.3	17.4
Palmer Park Blvd.	3341	Exist RCB	5-11x3.2	---	3.1	170.5	19.6
	3341	II concrete	70x4.5	0.74%	3.2	240.5	13.9
Station 35 + 00							
	3341	II concrete	50x5.0	0.74%	3.9	215.8	15.5
Murray Blvd.	3341	Add 3 cells	3-9x4.5	---	3.9	---	---
	3709	II concrete	70x5.5	0.41%	4.1	310.6	11.9
Galley Road	3709	Add 3 cells	3-8x4.8	---	4.1	---	---
	3709	II concrete	70x5.0	0.64%	3.6	268.1	13.8
Station 67 + 82							
	5370	II concrete	70x6.0	0.53%	4.7	359.6	14.9
Highway 24	5370	Exist RCB	27x30x27x6	---	3.7	347.8	15.4
	5370	II concrete	50x6.5	0.71%	5.4	289.2	18.6
East Tributary							
	6900	II concrete	50x7.2	0.71%	6.2	342.1	20.2
Mouth/Wooten	6900	RCB	4-13x9	---	7.8	407.7	16.8
East Tributary to West Fork West Fork:							
Roubidoux							
	2062	I concrete	7x7	1.74%	6.0	73.2	28.2
Palmer Park							

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
Wooten							
	2031	II concrete	50x3.5	1.14%	2.5	136.7	14.8
Station 67 + 82							
Highway 24							
Borrow Ditch	586	I concrete	6x5.5	0.68%	4.5	40.5	14.5
West Fork:							
Barnes Road							
See flod plain - stabilize West Bank Only							
CRI & PRR, Constitution		Bridge	4 @ 41x4				
	4211	Unlined,Z=5	160x4	1.66%	1.83	310.1	13.6
Powers Blvd.	-------	Bridge	4@46'x4'	---	2.0	---	---
	4211	II concrete	100x4.5	1.66%	2.4	245.1	17.2
Palmer Park Blvd.	---	Exist Bridge					
	4333	II concrete	100x4.5	1.66%	2.4	249.4	17.4
Galley Road	-------	Bridge	4@41'x4'	---	2.6	---	---
	4324	II concrete	100x4.5	1.66%	2.4	249.1	17.4
US 24		Exist Bridge					
	4373	II concrete	200x4.5	1.74%	2.3	473.8	9.2
Junction W. Fork							
	5830	II Riprap	90x6	1.10%	4.2	412.1	17.5
Mouth/Airport		Exist Bridge					
Center Tributary:							
CRI & PRR							
	107	RCP	42"RCP	2.25%	---	9.6	11.1
Palmer Park Blvd.							
	291	I concrete	4'x4'	2.28%	2.8	15.2	19.1
Omaha Blvd.	291	RCB	8'x4'		2.8	22.4	13.0
	780	Exist Ditch	6.5'x4'	1.93%min.	3.2	35.7	21.8
Galley	780	RCB	2.9x5		3.8	68.4	11.4
	1257	I concrete	6x6	1.62%	5.0	51.9	24.2
Highway 24	1257	Exist Bridge					

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
	1481	I concrete	7x7	1.09%	5.8	68.0	21.8
Powers Blvd.	1481	RCB	4-9'x8', skewed		6.8		
	2148	I concrete	8x7	1.32%	6.5	83.7	25.7
Pikes Peak		RCB	2-10'x8'		7.0		
	2148	I concrete	8x7.5	1.08%	6.7	90.1	23.8
Airport		RCB	2-10'x9'		7.4		
	2148	I concrete	9x8.5	0.53%	7.7	118.2	18.2
East Fork							
East Fork:							
Marksheffel Road	3040	Bridge	3@100'x4'		1.9		
	3040	II concrete	150x4.0	1.25%	1.7	257.0	11.8
Peterson Road	3040	Bridge	4@40'x4'		1.9		
	3398	II concrete	150x4.0	1.25%	1.8	275.1	12.4
Highway 24		Exist Bridge					
	3247	III concrete	150x4.0	0.50%	2.3	351.2	9.2
Aviation Way		Exist Bridge					
	3312	III concrete	150x4.0	0.50%	2.3	351.2	9.4
Powers Blvd.		Bridge	4@40'x4'		2.3		
	3312	II Riprap	70x5.0	1.10%	3.0	232.3	14.3
Center Tributary							
	3350	III Riprap	70x5	1.06%	3.1	236.7	14.2
West Fork							
Mainstem:							
Junction + W. Forks							
	10515	III Riprap	150x5	1.10%	3.8	601.1	17.5
Fountain Blvd.		Exist Bridge					
	11043	III concrete	150x6	0.50%	4.8	749.9	14.7
Academy Blvd.		Exist Bridge					
	11987	III concrete	150x7	0.50%	5.0	790.6	15.2
Hancock Blvd.		Bridge	3@50x6		5.0		
	11865	III concrete	150x7	0.50%	5.0	785.7	15.1
AT & SF RR		Exist Bridge					
	Flood Plain - See SCS Report						
Mouth							
Chelton	11043	Bridge	4@41x6, skewed		4.8		

2. Collection Ditches & Minor Storm Sewers

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
Basin III1:							
Barnes Road	247		54"RCP				
	247	I concrete	4x3.1	2.67%	2.1	12.69	19.5
Powers Blvd.	247		54"RCP				
	391	I concrete	4x4	2.04%	2.9	19.82	19.7
Greenbelt							
Basin III4:							
Powers Blvd.							
	262	RCP	60"RCP	1.43%	---	19.64	13.3
Greenbelt							
Basin III6:							
Powers							
	184	RCP	54"RCP	1.58%		15.90	11.6
Greenbelt							
Basin IIJ2:							
Top							
	19	I concrete	2x2	0.74%	1.0	3.00	6.3
Greenbelt							
Basin IIIC:							
Top							
	37.8	I concrete	Exist 4x3	1.17%	0.9	4.23	8.9
Greenbelt							
Basin IVH1:							
Limit Service							
	671	I concrete	5x5	1.79%	3.7	31.20	21.5
CRI & P		Exist Culvert					
	874	I concrete	6x5.2	1.32%	4.2	42.64	20.5
Greenbelt	Culvert	RCB	8x6				

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
Cimarron Hills Elementary School Ditch:							
CRI & P		Exist Culvert					
	26.9	I concrete	2x2	3.33%	0.7	1.99	13.5
Palmer Park		Exist Culvert					
	43.5	I concrete	3x2.5	0.81%	1.3	5.40	8.0
Ditch "A"		Exist Culvert					
	99.1	I concrete	4x3	0.60%	1.9	11.23	8.8
Greenbelt							
Cimarron Pipe "A":							
Top							
	56.1	RCP	30"RCP	2.38%		4.91	11.4
School Ditch							
Cimarron MHP Ditch:							
Begin							
	26.0	I concrete	2x2	1.39%	1.0	3.00	8.7
Mescalero		Exist RCB					
	32.4	I concrete	2x2.1	1.35%	1.1	3.57	9.1
Greenbelt		Exist RC					
Area IVG8:							
CRI & PRR	950	Exist Bridge					
	1081	To be left natural, flood plan limits to be delineated at time of platting					
Greenbelt			Private Bridges as required			225.0	
Airport Outfall:							
Boundary							
	34.3	RCP	27"	1.82%	---	3.98	8.6
Street							
	34.3	RCP	30"	1.07%	---	4.91	7.0
Junction							
	45.1	RCP	27"	2.22%	---	3.98	11.3
Powers Blvd.							
	59.1	RCP	36"	1.36%	---	7.07	8.4
PP Panorama							
	82.1	I Ditch	3x3	1.40%	1.5	7.08	11.6
Existing Ditch							

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
North Panorama:							
Road							
	25.6	I concrete	2x2	1.33%	1.0	3.01	8.5
Greenbelt							
South Panorama:							
Begin							
	28.9	I concrete	Exist				
Raton Drive	28.9	Exist RCP					
	48.8	I concrete	Exist				
Greenbelt							
Newport Outfall:							
Begin							
	23.4	RCP	24"	1.30%	---	3.14	7.4
Powers Blvd.							
	35.4	RCP	30"	1.23%	--	4.91	7.2
Junction							
	40.0	RCP	27"	1.67%	---	3.98	10.1
PP Panorama							
	41.0	I concrete	3x2	1.64%	1.0	3.96	10.3
Jet Wing	41.0	RCP	30"				
	55.8	I concrete	3x2.3	1.29%	1.3	5.46	10.2
Greenbelt							
Astrozon Outfall:							
Academy							
	21.8	RCP	24"	1.75"	---	3.14	6.9
Greenbelt							

LOCATION	DESIGN FLOW -CFS-	TYPE STRUCTURE	SIZE b x d	SLOPE	DEPTH -FT-	AREA -SF-	VELOCITY -FPS-
Morley Outfall:							
Academy							
	40.2	RCP	30"	1.35%	---	4.91	8.2
Greenbelt							
Hancock Outfall:							
Academy	93.2	RCP	48"				
	93.2	I Concrete	4x3	0.48%	1.9	11.64	8.0
Greenbelt							
Basin IG1 (Villa Loma) Outfall:							
Constitution							
	109	I Concrete	6x2	See Villa Loma Master			
CRI & PRR		Exist Bridge					
	268	I Concrete	4x4	1.27%	3.0	17.85	15.0
Ditch Intersection							
	609	I Concrete	5x5	1.11%	4.0	34.69	17.6
Van Diest		Exist RCB					
	805	I Concrete	5x4.5	3.22%	3.5	28.68	28.1
Darley		Exist RCB					
Basin IG2 (Rustic Hills) Outfall:							
Brady Road							
	869	I Concrete	5x4	1.84%	3.0	37.50	23.2
CRI & PRR		Exist Culvert to be replaced by others					

SECTION IV

COST ESTIMATE

A. Unit Prices & Acreage

1. Unit Prices

The following unit prices were used in the cost estimating for this study. All costs include a 10% contingency and engineering factor:

Type I Channel lining and shaping:	$1.30 per SY
Type II Channel lining and shaping:	1.90 per SY
Type III Channel lining and shaping:	2.00 per SY
Structural Excavation:	3.00 per CY
Structural Backfill:	3.50 per CY
Structural Concrete:	150.00 per CY
Structural Steel:	0.40 per LB
Bridge Structures (Girder Type):	25.00 per SF

2. Acreage

A complete review of that portion of the Sand Creek Basin within the "limit of urban services" was made using the maps of the El Paso County Assessor. The total acreage within this area that is available for platting was computed, and the unplatted area within Cimarron Hills and the Smartt Industrial Park was broken out. The total area is as follows:

City of Colorado Springs	4,166.17 acres
Cimarron Hills Oriented	1,796.58 acres
Total area available for development	5,962.75 acres

B. Collection System

SYSTEM	LOCATION	STRUCTURE	Cost Breakdown DEVELOPER	OTHER	TOTAL
Basin III1	Barnes	54"RCP	$ 3,400		$ 3,400
		I 4x3	19,100		19,100
	Powers	54"RCP	8,400		8,400
		I 4x4	56,500		56,500
	Greenbelt				
Basin III4	Powers	60"RCP	173,600		173,600
	Greenbelt				
Basin III6	Powers	I 4x3	121,800		121,800
	Greenbelt				

			Cost Breakdown		
SYSTEM	LOCATION	STRUCTURE	DEVELOPER	OTHER	TOTAL
Basin IIJ East	Top				
		I 2x2	31,300*		31,300
	Greenbelt				
Basin IVH1	Top				
		I 5x5	71,000*		71,000
	CRI & PRR	Exist Bridge			
		I 6x5.2	207,100*		207,100
	Greenbelt	8x6 RCBs	117,800*		117,800
Basin IVI	CRI & PRR	Exist Bridge			
		I 2x2		$13,900*	13,900
	Palmer Park	Exist RCP			
		I 3x2.5		35,900*	35,900
	Ditch A				
		I 4x3	29,200*		29,200
	Greenbelt				
Basin IVI	Ditch A	30"RCP	74,400*		74,400
Basin IVI	Ditch				
		I 2x2		25,000*	25,000
	Mescalero	Exist RCB			
		I 2x2		22,300*	22,300
	Greenbelt				
Airport Outfall:					
	Airport				
		27" RCP	11,600		11,600
	Interior				
		30" RCP	20,200		20,200
	Street				
		27" RCP	11,300		11,300
	Powers				
		36" RCP	6,600		6,600
	PP Panorama				
		I 3x3	13,600		13,600
	Greenbelt	42" RCPs	5,800		5,800
PP Panorama	Road				
		I 2x2	13,900		13,900
	Greenbelt				
PP Panorama	Top				
		I 3x2	10,000		10,000
	Road	27" RCP	2,500		2,500
Newport Outfall:					
	ID				
		24" RCP	9,700		9,700
	Powers				
		30" RCP	15,600		15,600
	Outfall				
		27" RCP	2,500		2,500
	PP Panorama				
		I 3x2	24,800		24,800
	Jet Wing	30" RCP	1,400		1,400
		I 3x2.3	23,500		23,500
	Greenbelt				

(* Cimarron Hills Item)

SYSTEM	LOCATION	STRUCTURE	Cost Breakdown DEVELOPER	OTHER	TOTAL
Astrozon Outfall:	Academy – Greenbelt	24" RCP	28,800		28,800
Molley Outfall:	Academy – Greenbelt	30" RCP	58,600		58,600
Hancock Outfall:	Academy – Greenbelt	48" RCP	4,100		4,100
		I 4x3	83,400		83,400
Basin IG1 Outfall:	CRI & PRR – Ditch Intersection	I 4x4	34,700		34,700
	Ditch Intersection – Van Diest	I 5x5	53,300		53,300
	Van Diest – Darley	I 5x4.5		12,300	12,300
Basin IG2 Outfall:	Brady Road – CRI & PRR	I 5x4		31,000	31,000

Minor Collection Systems:

STRUCTURE		Developer Costs CIMARRON HILLS	OTHER DEVELOPER
Catch Basins		$63,000	$123,000
18-inch RCP		60,700	32,300
24-inch RCP		89,800	133,800
30-inch RCP		8,700	166,000
36-inch RCP		26,700	137,200
42-inch RCP		30,600	27,400
48-inch RCP		17,100	17,700
I Channel, 2x2		84,100	-0-
I Channel, 2x2.5		-0-	12,100
I Channel, 3x3		10,500	-0-
I Channel, 4x3	R&R	21,000	16,900
I Channel, 4x4 (val)		-0-	10,400
I Channel, 6x2		-0-	27,300
Dike		-0-	5,000

Total Costs, Collection System	Developer	OTHER	Total
Cimarron Hills Items	$ 943,000	$97,100	$1,040,100
City Items	1,527,800	43,300	1,571,100
TOTAL	$2,470,800	$140,400	$2,611,200

C. GREENBELTS

LOCATION	STRUCTURE	COST BREAKDOWN DEVELOPER	BRIDGE	OTHER	TOTAL
West Fork of the West Fork:					
Maizeland	Exist Bridge				
	II 50x4.2	$41,000		$94,600	$135,600
Constitution	Exist Bridge				
	I 20x8.06 R.R.	8,000		18,800	26,800
Sta 5 + 00					
	II 50x4.6	24,400		66,000	90,400
Palmer Park	Exist Bridge				
	II 70x4.5			45,300	45,300
Sta 35 + 00					
	II 50x5.0			28,600	28,600
Murray	Add 3-9x4.5 RCB			29,300	29,300
	II 70x5.5			109,900	109,900
Galley	Add 3-8x4.8 RCB			30,000	30,000
	II 70x5.0			33,800	33,800
Sta 67 + 82					
	II 70x6.0	36,600		85,500	122,100
Highway 24	Exist Bridge				
	II 50x6.5	49,900			49,900
Junction					
	II 50x7.2	106,900			106,900
Wooten	4-13x9 RCB	90,800			90,800
	II 50x7.2	106,900			106,900
Pikes Peak	4-13x9 RCB	54,500	36,300		90,800
	II 50x7.2	57,000			57,000
Mouth					
Roubidoux					
	I 7x7			43,900	43,900
Palmer Park					
Borrow Ditch	I 6x5.5			51,400	51,400
Wooten	10x6 RCB			18,800	18,800
	II 50x3.5	55,700			55,700
Junction					
Subtotal, West Fork West Fork		$631,700	$36,300	$655,900	$1,323,900
West Fork:					
Constitution	Bridge 4@45'	$216,000	$144,000		$360,000
CRI & PRR	Exist Bridge				
	Exist Channel				
Waynoka	Bridge 4@45'			360,000	360,000
	Exist Channel				
Powers	Bridge 2x4@46'	220,800	220,800		441,600
	II 100x4.5	125,300			125,300
Palmer Park	Exist Bridge				
	II 100x4.5	58,600		137,900	196,500

LOCATION	STRUCTURE	COST BREAKDOWN DEVELOPER	BRIDGE	OTHER	TOTAL
Galley	Bridge 4@41'	$196,800	$131,200		$328,000
	II 100x4.5	137,000			137,000
Highway 24	Exist Bridge				
	II 200x4.5	146,500			146,500
Junction					
Subtotal, West Fork		$1,101,000	$496,000	$496,900	$2,094,900
Center Tributary:					
CRI & PRR					
	42" RCP			$51,200*	$51,200
Palmer Park					
	I 4x4			47,400*	47,400
Omaha	8x4 RCB			13,600*	13,600
	I 6-5x4	30,900*			30,900
Galley	2-9x5 RCB			28,700*	28,700
	I 6x6			82,100*	82,100
Highway 24	Exist Bridge				
	I 7x7	74,600			74,600
Powers	4-9x8 RCB	37,400	56,200		93,600
	I 8x7	57,900			57,900
Bijou	2-10x8 RCB	20,400	22,000		42,400
	I 8x7.5	165,600			165,600
Airport	2-10x9 RCB	20,400	30,500		50,900
	I 9x8.5	40,000			40,000
Mouth					
Subtotal Center Tributary		$447,200	$108,700	$223,000	$778,900
East Fork:					
Mark Sheffel	Bridge 3@100'	$360,000*	90,000*		$450,000
	II 150x4	259,200*			259,200
Peterson	Bridge 4@40'	192,000*	48,000*		240,000
	II 150x4	104,100*			104,100
Highway 24	Exist Bridge				
	II 150x4	176,600			176,600
Aviation Way	Exist Bridge				
	II 150x4	89,100		174,300	263,400
Powers	Bridge 4@40'	192,000	192,000		384,000
	II 70x5	38,700			38,700
Junction					
Subtotal East Fork		$1,411,700	$330,000	$174,300	$1,916,000
Main Stem:					
Junction W+W					
	III 90x6	$287,400			$287,400
Existing					
	III 150x5	26,100			26,100
Fountain	Exist Bridge				
	III 150x6	195,400			195,400
Chelton	Bridge 4@41'	196,800	$131,200		328,000
	III 150x6	156,400			156,400
Academy	Exist Bridge				

(* Cimarron Hills Item)

LOCATION	STRUCTURE	DEVELOPER	BRIDGE	OTHER	TOTAL
		COST BREAKDOWN			
	III 150x7	$125,600		$125,700	$251,300
Hancock	Bridge 3@50'			410,000	410,000
	III 150x7	36,000		49,900	85,900
AT & SF	Exist Bridge				
	Natural Flood Plain				
Mouth					
Subtotal Main Stem		$1,023,700	$131,200	$585,600	$1,740,500
Total Greenbelts		$4,615,300	$1,102,200	$2,136,700	$7,854,200
Cimarron Hills Items		$946,200	$138,000	$223,000	$1,307,200
City Items		$3,669,100	$964,200	$1,913,700	$6,547,000

D. RECOMMENDED FEES

1. Bridge Fee:

	TOTAL COST	ACRES	FEE
City Items	$964,200	4,166.17	$231.44 per acre
Cimarron Hills	138,000	1,796.58	76.81 per acre
Total Basin	$1,102,200	5,962.75	$184.85 per acre

2. Drainage Fee:

	TOTAL COST	ACRES	FEE
City Items:			
Collection System	$1,527,800		
Greenbelts	3,669,100		
Subtotal	$5,196,900		
Cash in Fund (-)	369,700		
Potential Credits (+)	127,000		
Total Cost	$4,954,200	4,166.17	$1,189.15 per acre
Cimarron Hills:			
Collection System	$943,000		
Greenbelts	946,200		
Total Cost	$1,889,200	1,796.58	$1,051.55 per acre
TOTAL BASIN	$6,843,400	5,962.75	$1,147.69 per acre

MASTER DRAINAGE STUDY

SAND CREEK DRAINAGE BASIN

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

The Sand Creek Drainage Basin is by far the largest in the City of Colorado Springs, occupying a total of nearly 49 square miles. It originates eleven (11) miles east of the Air Force Academy on the Black Forest Divide and runs 19.5 miles to its confluence with Fountain Creek just above Stratmoor Valley. The soils within the basin have been mapped and compiled by the USDA-SCS, and this mapping is summarized on Plate Number 1.

The basin is analyzed as being in its ultimate state of development, shown on Plate Number 2. The area within the "limits of urban development" is that anticipated to eventually be served by urban utilities. This acreage is used to compute the drainage fees as follows:

Area served by the City:	4,166.17 acres
Area served by Cimarron:	1,796.58 acres
Total:	5,962.75 acres

Outside this area, the basin is assumed to develop to the limit of its water resources capacity, which would be similar to the existing county developments in the Black Forest.

The technical details related to hydrologic and hydraulic computations are presented in Sections II and III, and the related cost estimates of recommended facilities are found in Section IV. As requested by the City Engineer, total cost estimates and associated drainage fees were computed including and excluding the Cimarron Hills area, as follows:

	TOTAL COST	PER ACRE FEE
Bridge Fee:		
City Costs:	$964,200	$231.44
Cimarron Hills Costs:	138,000	76.81
Total	$1,102,200	$184,85
Drainage Fee:		
City Costs:	$4,954,200	$1,189.15
Cimarron Hills Costs:	1,889,200	1,051.55
Total	$6,843,400	$1,147.69

A complete drainage plan is included as Plate Number 4, and the major types of channels recommended are shown on Plates No. 5, 6 and 7. A larger (scale 1"=800') drainage plan is available from this firm or the City Engineer for individuals needing more detail than available herein.

MASTER DRAINAGE STUDY

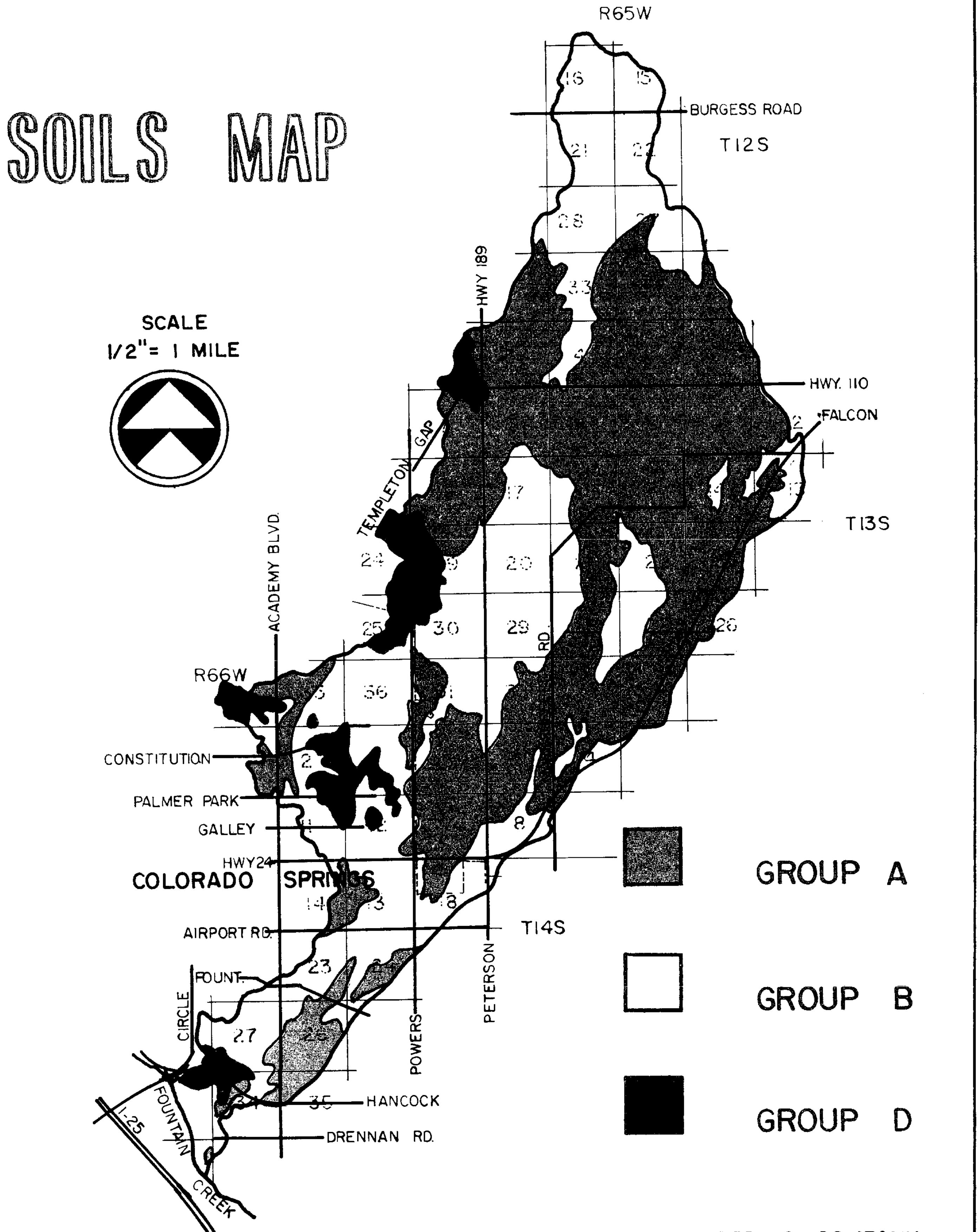
SAND CREEK DRAINAGE BASIN

SECTION VI

APPENDIX

SAND CREEK DRAINAGE BASIN

SOILS MAP



UNITED PLANNING AND ENGINEERING COMPANY

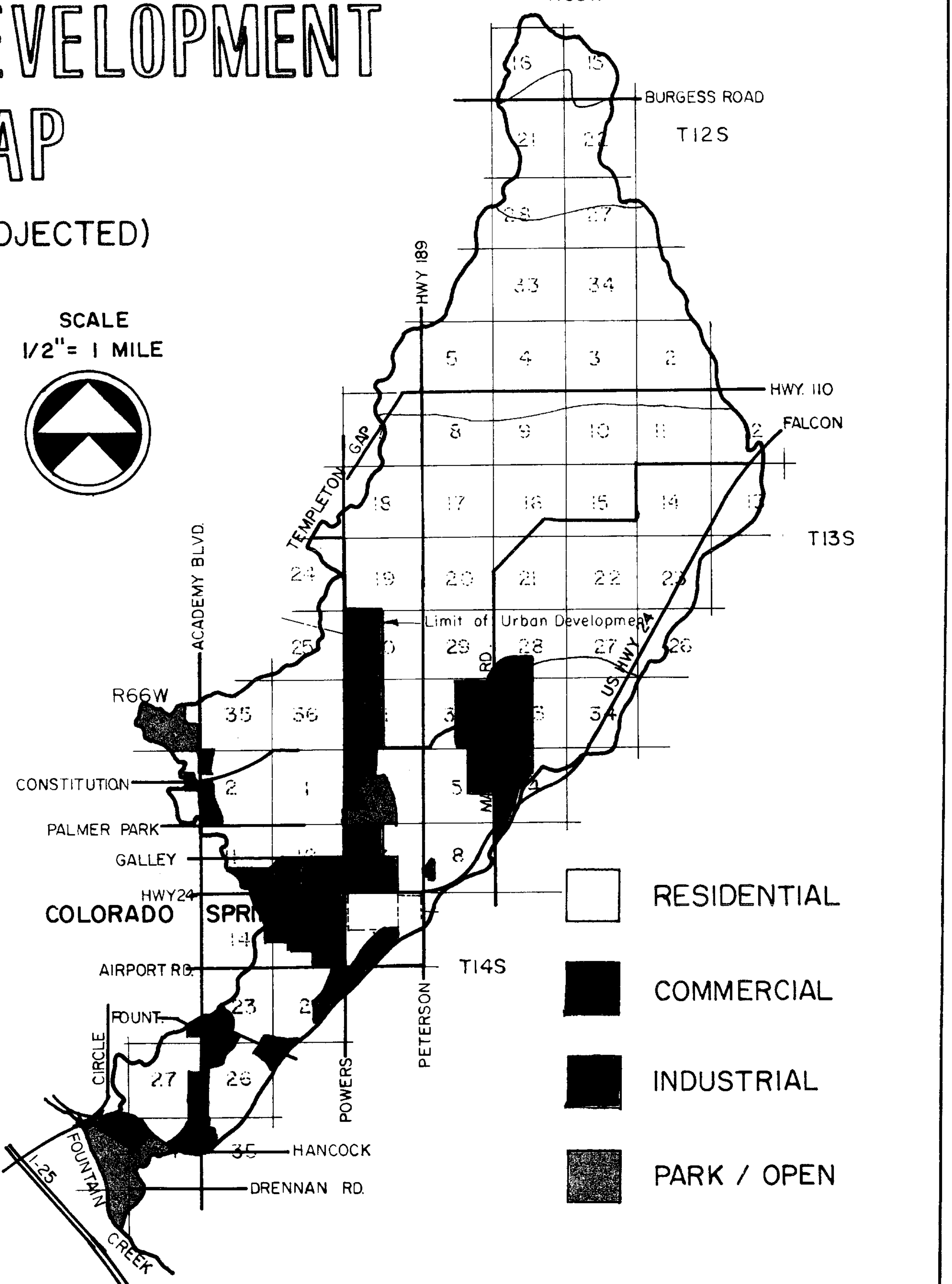
PLATE I

SAND CREEK DRAINAGE BASIN

DEVELOPMENT MAP

(PROJECTED)

SCALE
1/2" = 1 MILE



UNITED PLANNING AND ENGINEERING COMPANY

PLATE 2

SAND CREEK DRAINAGE BASIN

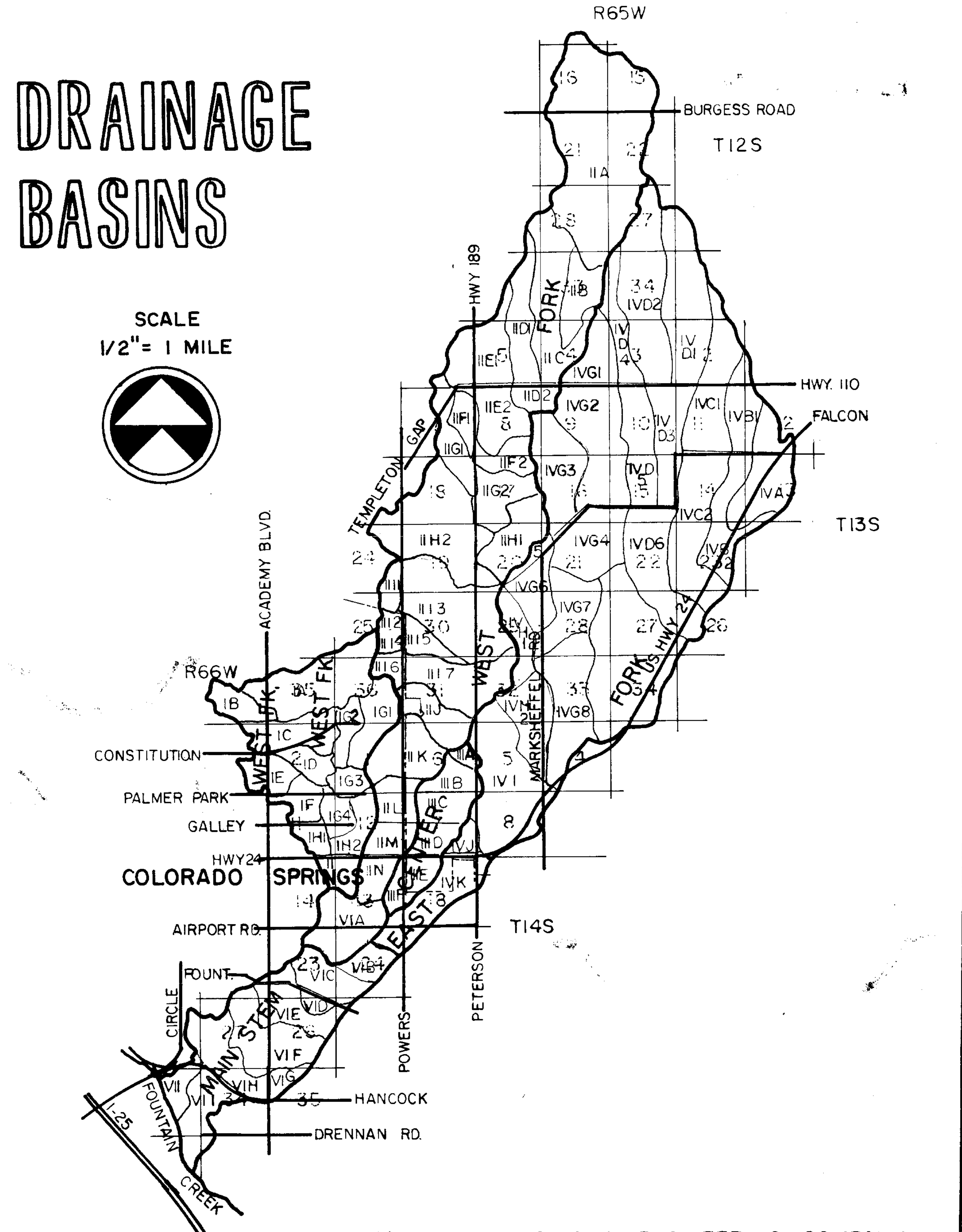


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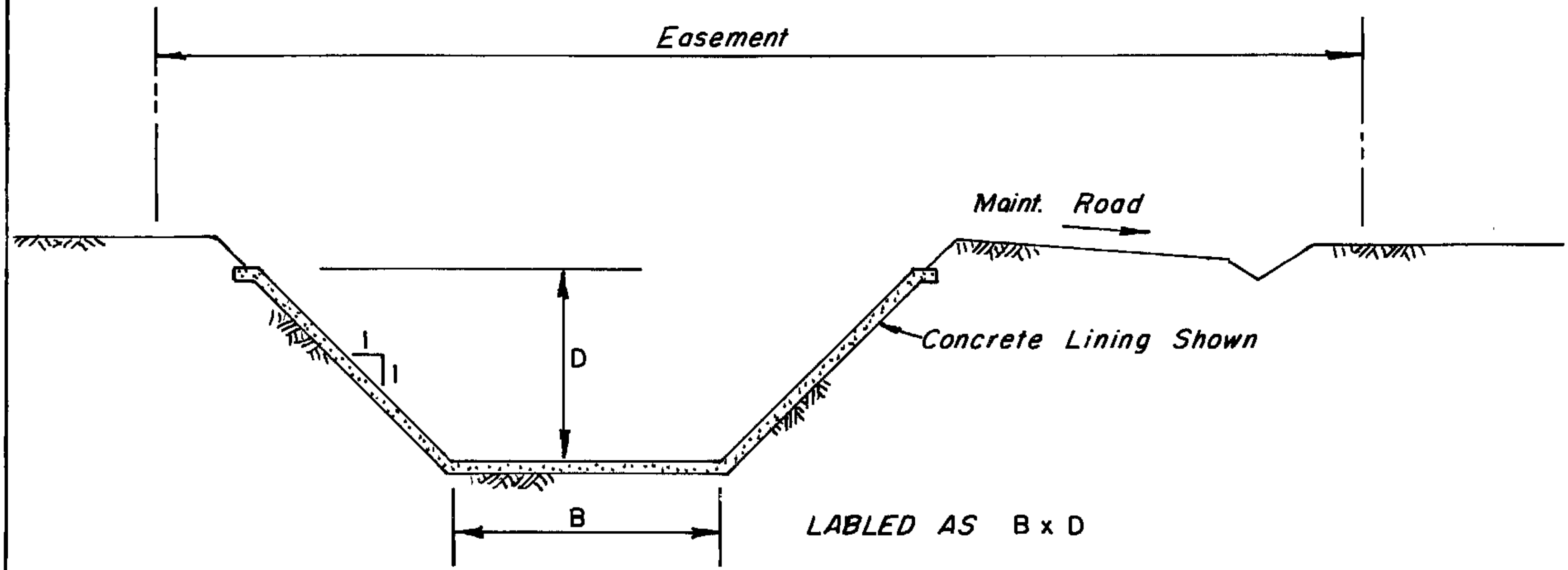
PLATE 3



TYPICAL DRAINAGE CHANNEL

TYPE I

PLATE 5

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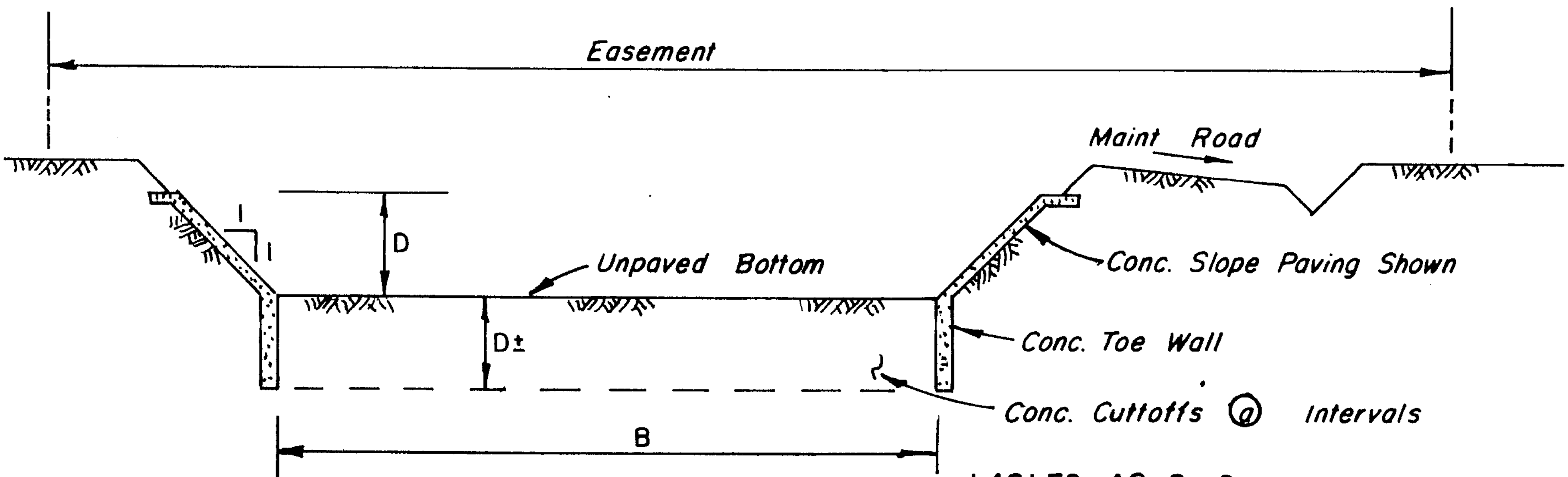
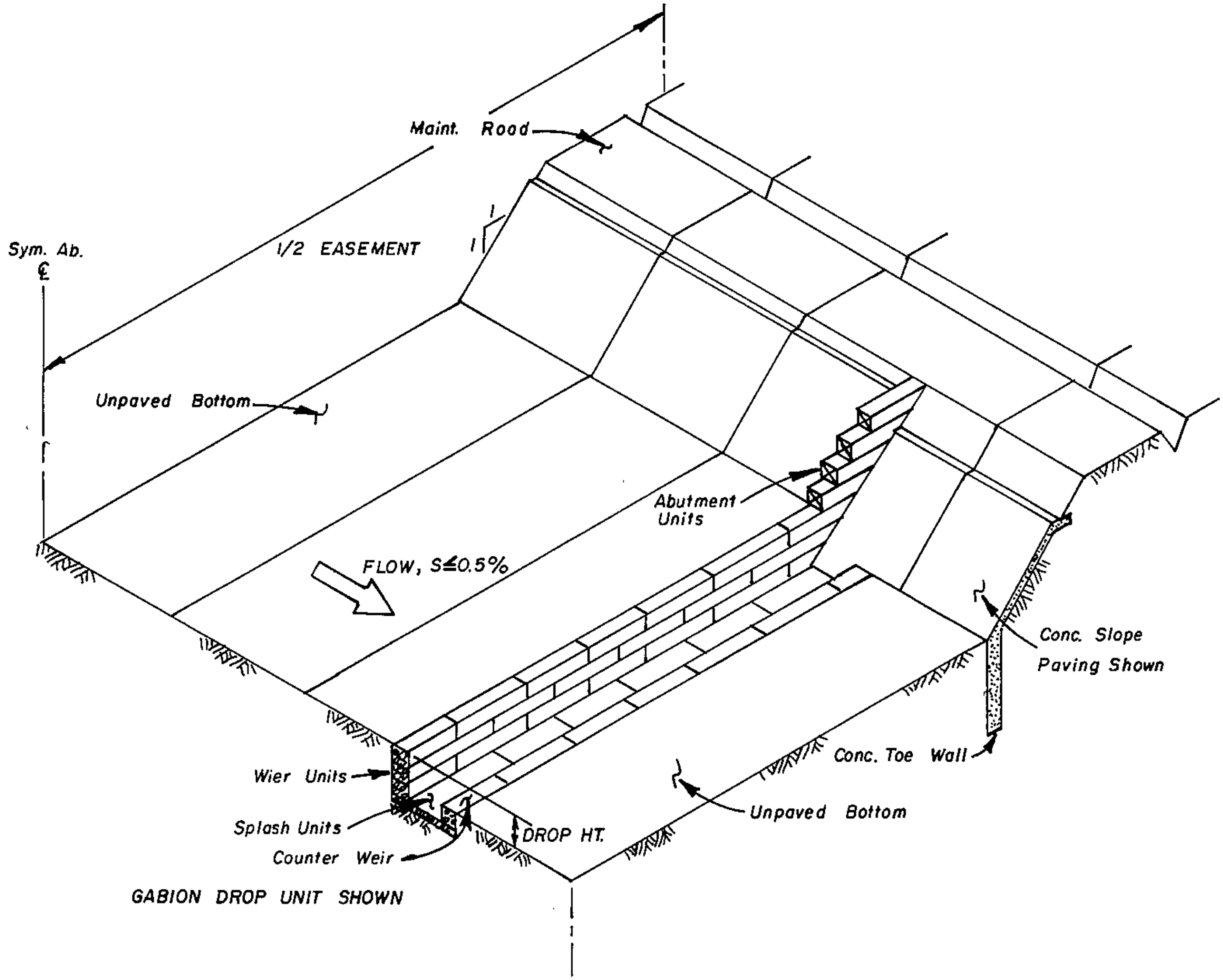


TYPICAL DRAINAGE CHANNEL
TYPE II

PLATE 6

UNITED PLANNING & ENGINEERING CO.



TYPICAL DRAINAGE CHANNEL
TYPE III

UNITED PLANNING & ENGINEERING CO.

PLATE 7