
HYDROLOGY REPORT

I-25 NORTH DESIGN BUILD

EL PASO COUNTY, COLORADO

prepared by

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prepared for

Colorado Department of Transportation, Region 2
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August 2012



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1.0 INTRODUCTION

The Colorado Department of Transportation (CDOT) has planned a design build improvement project for Interstate 25 (I-25) between the Woodmen Road Interchange (Exit 149) and the Monument Interchange (Exit 161). The report presents the hydrologic analysis and corresponding peak flows for off-site drainage basins tributary to I-25 existing cross drainage facilities within the project limits. These existing cross drainage facilities convey the off-site runoff under I-25 and they include pipe culverts, concrete box culverts, and two bridges (northbound and southbound) at Black Squirrel Creek. The peak flows presented below are to be used by the contractor to complete the hydraulic design and sizing of the project cross drainage facilities.

This report only analyzes runoff accumulation off of the highway (off-site) and does not include runoff accumulation on and between the north and southbound highways (on-site). The on-site drainage basin hydrology analysis be determined by the contractor based on the roadway design. The contractor's on-site hydrologic analysis includes all areas within the CDOT right-of-way or easement. The peak flow resulting from this analysis will be used to complete the hydraulic design of all non I-25 cross drainage facilities including: pavement and area inlets, storm sewers, roadside ditches, culverts, and permanent stormwater quality facilities.

This report describes the off-site storm drainage patterns of the project area, the hydrology calculation methodology used, and the results of the completed analysis.

2.0 GENERAL PROJECT LOCATION AND DESCRIPTION

The purpose of this project is to widen I-25 and add new lanes within the project limits. The project includes complete reconstruction of portions of the highway (including permanent storm drainage facilities) and just widening of the pavement section in other locations. The project begins at the north end of the Woodmen Road interchange and extends to the Monument interchange. The majority of the project is in unincorporated El Paso County, CO within an easement on land owned by the U.S. Air Force Academy (USAFA). A small section of I-25 between the crossing of Pine Creek and Woodman Road is within the CDOT right-of-way within the Colorado Springs, CO city limits. Figure 1, the Vicinity Map, illustrates the general location of the project.

I-25 is a major commercial corridor for interstate commerce among the states of New Mexico, Colorado, and Wyoming, as well as international commerce among the United States, Mexico, and Canada. It connects more than three million residents of Denver, Colorado Springs, Pueblo, and several major cities in northern Colorado. I-25, within the project limits, is currently a four lane facility, with a northbound auxiliary land running between Woodmen to North academy Blvd. and North Academy Blvd. to Briargate

Parkway and a southbound auxiliary from Briargate Parkway and a southbound auxiliary from Briargate Parkway to North Academy Blvd.

The purpose of this project is to – at a minimum – increase capacity by providing one additional through lane in each direction, with auxiliary lanes between interchanges. The basic configuration limits are from the Woodmen Rd. Interchange (Exit 149) to Monument Interchange (Exit 161), with auxiliary lanes between interchanges from the Woodmen Rd Interchange to south of the Interquest Parkway Interchange. Key Elements of the project include: increasing capacity to 6 through-lanes (with auxiliary lanes) on I-25, replacement of the NB and SB Black Squirrel Creek bridges, removal and relocation of the Ackerman Overlook, construction phasing safety improvements, drainage improvements, permanent water quality elements, and temporary erosion control. There will be a temporary configuration on I-25 within the limits of the future Powers Blvd. Interchange.

I-25 shall be widened, milled and overlaid - except on I-25 southbound (SB) between Woodmen Rd and Black Squirrel Creek, and Black Forest Creek and Monument Interchange, where full reconstruction is required to match the northbound (NB) profile. CDOT's Pavement Selection Committee has determined that hot mix asphalt (HMA) is the preferred pavement for use on this project.

3.0 HYDROLOGIC ANALYSIS

3.1 Off-Site Drainage Basin Description

The off-site drainage basins tributary to the project generally slope east to west toward I-25, crossing under the highway through numerous pipe culverts, concrete box culverts and two bridges at Black Squirrel Creek. The flows discharged from the I-25 facilities ultimately outfall into Monument Creek located west of I-25. A very small area of the project, west of I-25 near North Academy Boulevard Interchange slopes west to east beginning around 4000 feet north to 2000 feet south of the interchange.

The existing cross drainage facilities within the project limit were identified using the *Department of Transportation State of Colorado Conceptual Design Project No. C 0252-316 Interstate Highway No. 25 Corridor El Paso County State Highway 83 to State Highway 105* plans last modified on 10/31/02. In addition, site investigations in January and July of 2012 were completed to confirm the location and size of existing cross drainage facilities. There are 39 off-site drainage basins that cross I-25 within the project limits. Note that Kettle Creek is dammed east of I-25 and the outlet pipe crosses the highway, but surface flows from Kettle Creek do not approach the I-25 roadway embankment. Therefore Kettle Creek is not included in this study of off-site drainage basins.

3.2 Existing Hydrologic Information

El Paso County has published numerous Drainage Basin Planning Studies (DBPS) for many of the major watersheds contributing off-site flows to I-25 cross drainage facilities including Pine Creek, Black Squirrel Creek, Middle Tributary, Monument Branch, Smith Creek, and the Black Forest Drainage Basin. Figure 2, Major Subwatershed Map illustrates these major drainageways as defined in the DBPS. The pertinent DBPS are listed in the references at the end of this report. When available, the reports were referenced for master planned peak flows (fully-developed land use condition with master planned infrastructure in place). In most circumstances, the master planned peak flows were equal to or lower than the existing peak flows at the time of that particular DBPS publication. Even though there is a potential for additional development within these major drainageway watersheds, the master plan has provided guidance for the infrastructure that must be constructed to compensate for the added impervious area from development.

The DBPS have published master planned peak flows for 11 of the crossings which are included in Table 1, Roadway Crossing Inventory and Peak Flow Summary, following this discussion. No additional analysis was completed for these locations.

3.3 Off-Site Drainage Basin Analysis

There are 28 drainage crossing structures that did not have published DBPS peak flows. Figures 3a and 3b, the Off-Site Basin Maps, illustrate the location of these off-site subwatersheds. The hydrologic analysis calculated the 10-, 50-, 100-, and 500-year storm events under existing land use conditions to develop design flows for these remaining off-site drainage basins.

3.3.1 Land Use and Soils

The off-site drainage basin areas are partially developed with varying densities of residential, schools and churches, and commercial/industrial land uses. The undeveloped areas are covered with native range grasses and scattered stands of native shrubs and trees. Existing land uses and cover conditions were based on aerial photography and field observation. Figures 4a and 4b, the Land Use Maps, illustrate the existing land uses defined for the project area.

Soils information for the smaller off-site drainage basins was downloaded from the Natural Resources Conservation Service (NRCS) Soil Data Mart for El Paso County. The natural soils are primarily Hydrologic Soils Groups Type A and B with isolated areas of Type C. Figures 5a and 5b, the Soils Maps, illustrate the Hydrologic Soils Groups within the project area.

3.3.2 Hydrologic Analysis Approach

Subwatersheds were delineated for the remaining 28 off-site drainage basins using GIS 2' topography obtained from City of Colorado Springs, CO on January 17, 2012 with in City of Colorado Springs Limits, and a rasterized digital elevation model (DEM) of the remaining areas from the USGS Seamless Data Warehouse online server was obtained to complete the remaining delineations. The DEM is in 1/3 Arc-second resolution. Peak design flows were estimated based on existing land use. The Rational Method was used to estimate peak flows for subwatersheds with area less than 100 acres. The Soil Conservation Service (SCS) Hydrograph Procedure (using HEC-HMS software) was used to estimate peak flows for subwatersheds larger than 100 acres.

For the Rational Method, the time of concentration was estimated by considering overland flow time, shallow concentrated flow time, and open-channel flow time. The one-hour point rainfall for the 10- and 100-year storm events was extracted from *The City of Colorado Springs/El Paso County Drainage Criteria Manual* Figure 5-6 Rainfall Depth-Duration Relationship. The 50- and 500-year one-hour point rainfall depths were derived using a log-normal curve fit equation (see Appendix). Intensity was approximated using the following equation from the Rainfall Chapter of the Urban Drainage and Flood Control District *Urban Storm Drainage Criteria Manual* revised April 2008.

$$I = \frac{28.5 P_1}{(10 + T_c)^{0.786}}$$

I = rainfall intensity (inches per hour)
 P_1 = 1-hour point rainfall depth (inches)
 T_c = time of concentration (minutes)

For the SCS Hydrograph Procedure, lag times were estimated considering overland flow time, shallow concentrated flow time, and open-channel flow time. Curve Numbers were based on SCS criteria included in *The City of Colorado Springs/El Paso County Drainage Criteria Manual*. HEC-HMS software was used to calculate runoff hydrology for five of the off-site subwatersheds.

3.4 Design Peak Flows

Table 1, Roadway Crossing Inventory and Peak Flow Summary, lists peak flows for the off-site basins tributary to existing I-25 cross drainage facilities. Presented in the table are peak flows for the 100-year event. This return period is to be used by the Contractor to analyze and design all I-25 cross drainage facilities.

Excerpts from the DBPS, Rational Method calculations, and the HEC-HMS computations for

the off-site drainage basins are included in the Appendix.

4.0 CONCLUSIONS

The peak flows for the off-site drainage basins have been estimated and are in conformance with CDOT and City and Colorado Springs/El Paso County hydrology methodologies and criteria. The peak flows included in this report are to be used by the contractor to analyze and design I-25 cross drainage facilities within the project limits.

5.0 REFERENCES

CH2MHill, 1985. . *Monument Creek Drainage Basin Planning Study*. PDF

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JR Engineering, 2002. *Smith Creek Drainage Basin Planning Study*. PDF.

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FIGURES

Figure 1. Vicinity Map

Figure 2. Major Subwatershed Map

Figure 3a. Off-Site Basin Map North

Figure 3b. Off-Site Basin Map South

Figure 4a. Land Use Map North

Figure 4b. Land Use Map South

Figure 5a. Soils Map North

Figure 5b. Soils Map South

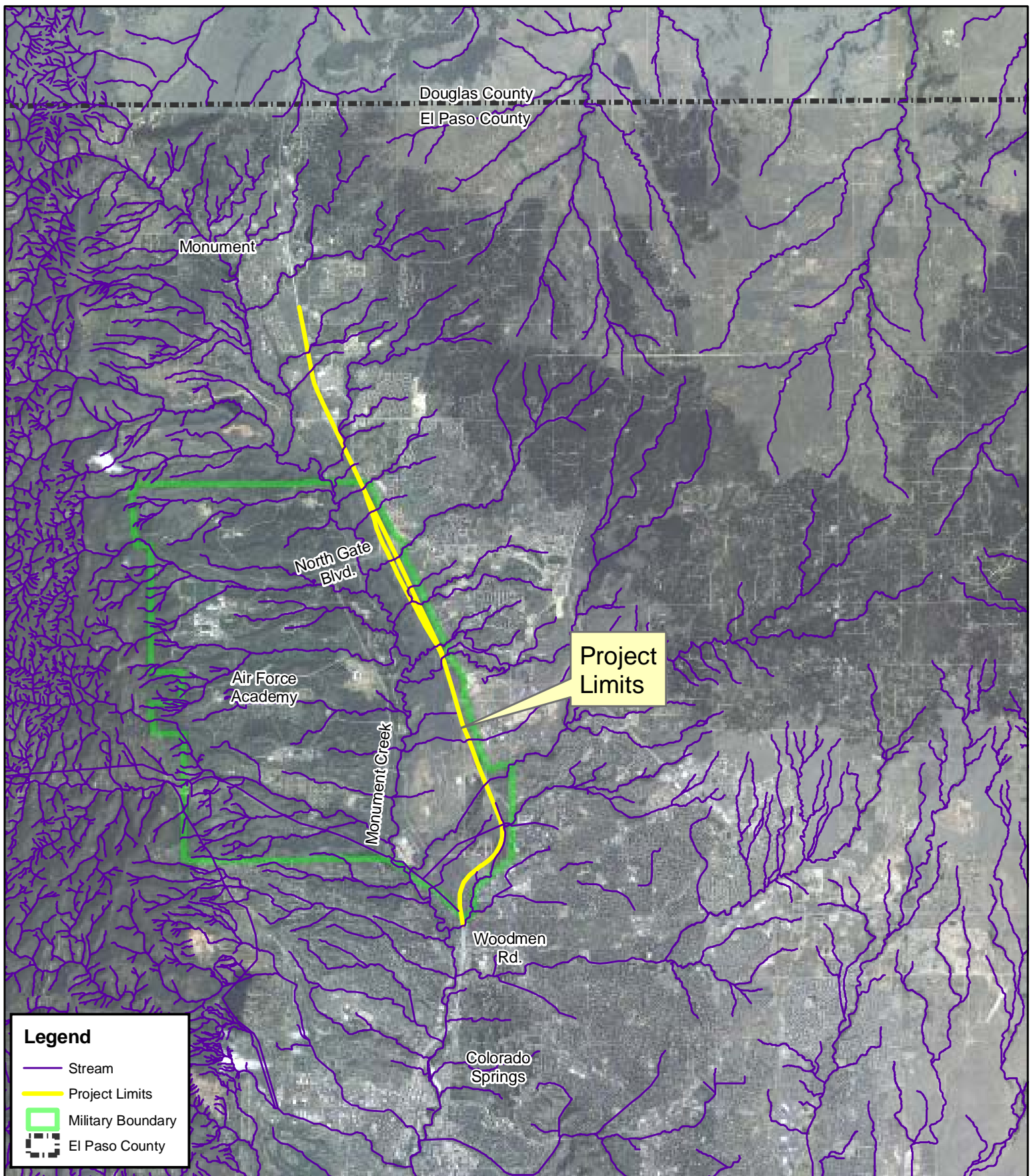


Figure 1 - Vicinity Map
I-25 North Design-Build
 August 2012

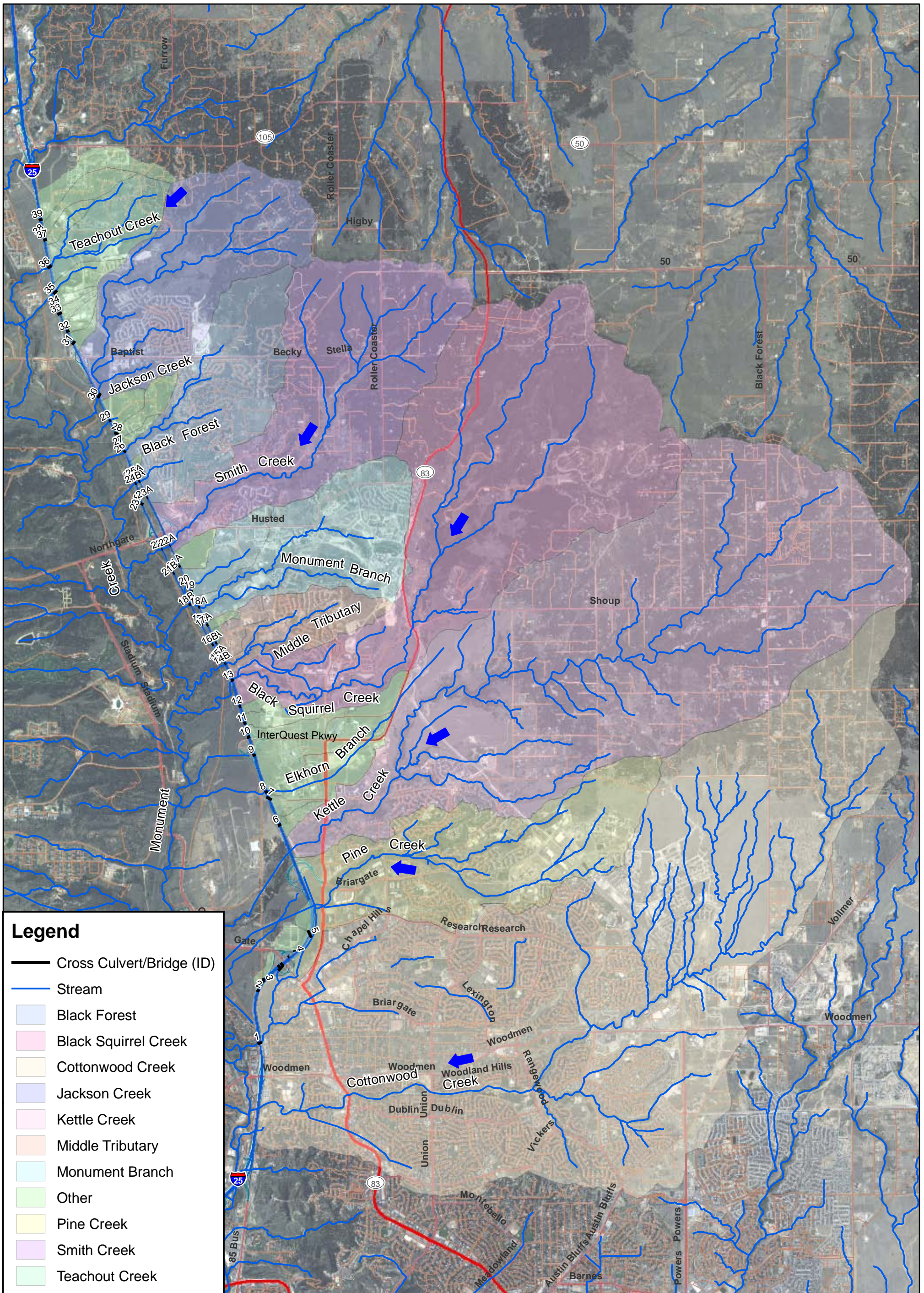


Figure 2 Major Subwatershed Map
I-25 North Design-Build

July 2012



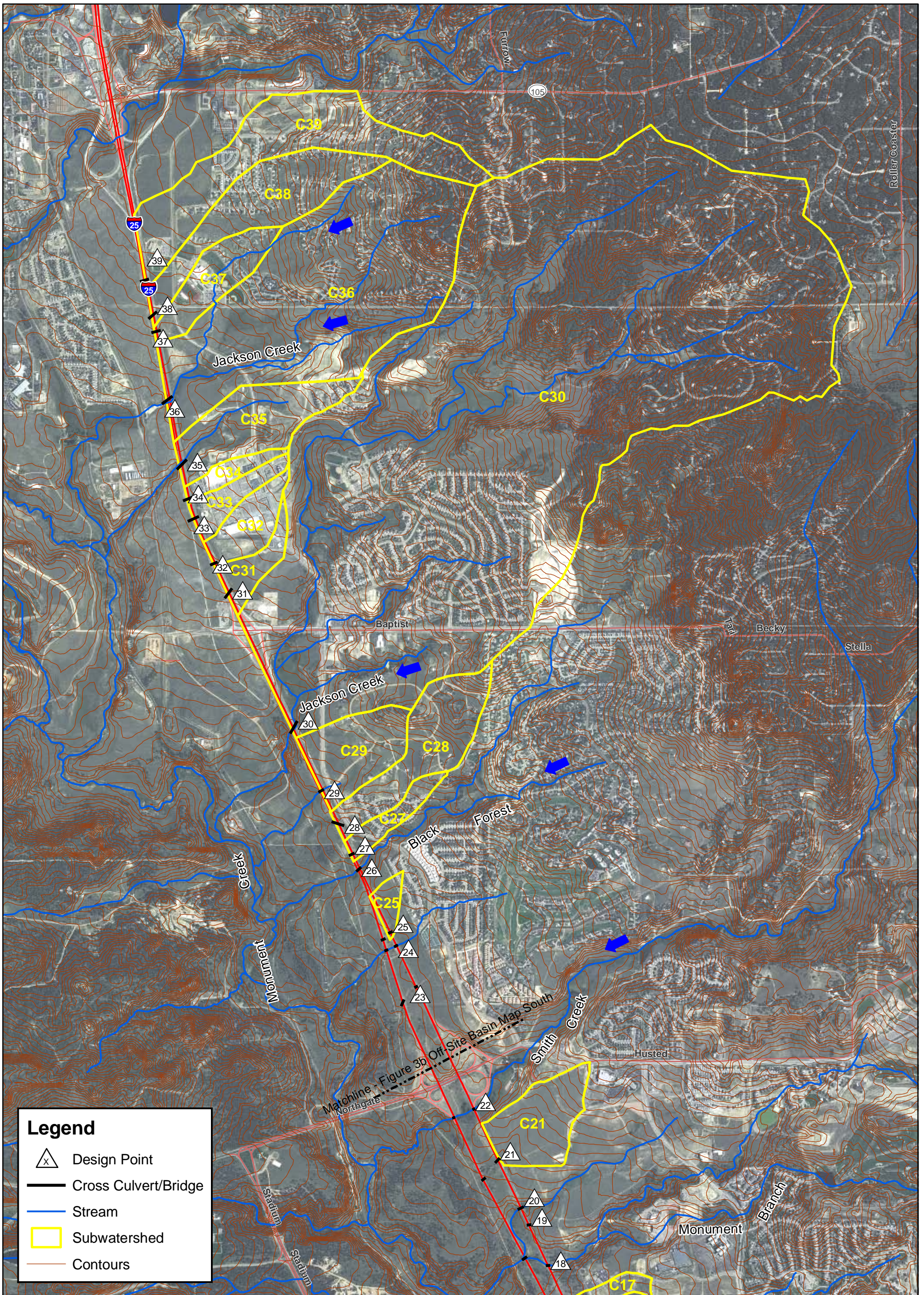


Figure 3a Off-Site Basin Map North
I-25 North Design-Build

July 2012

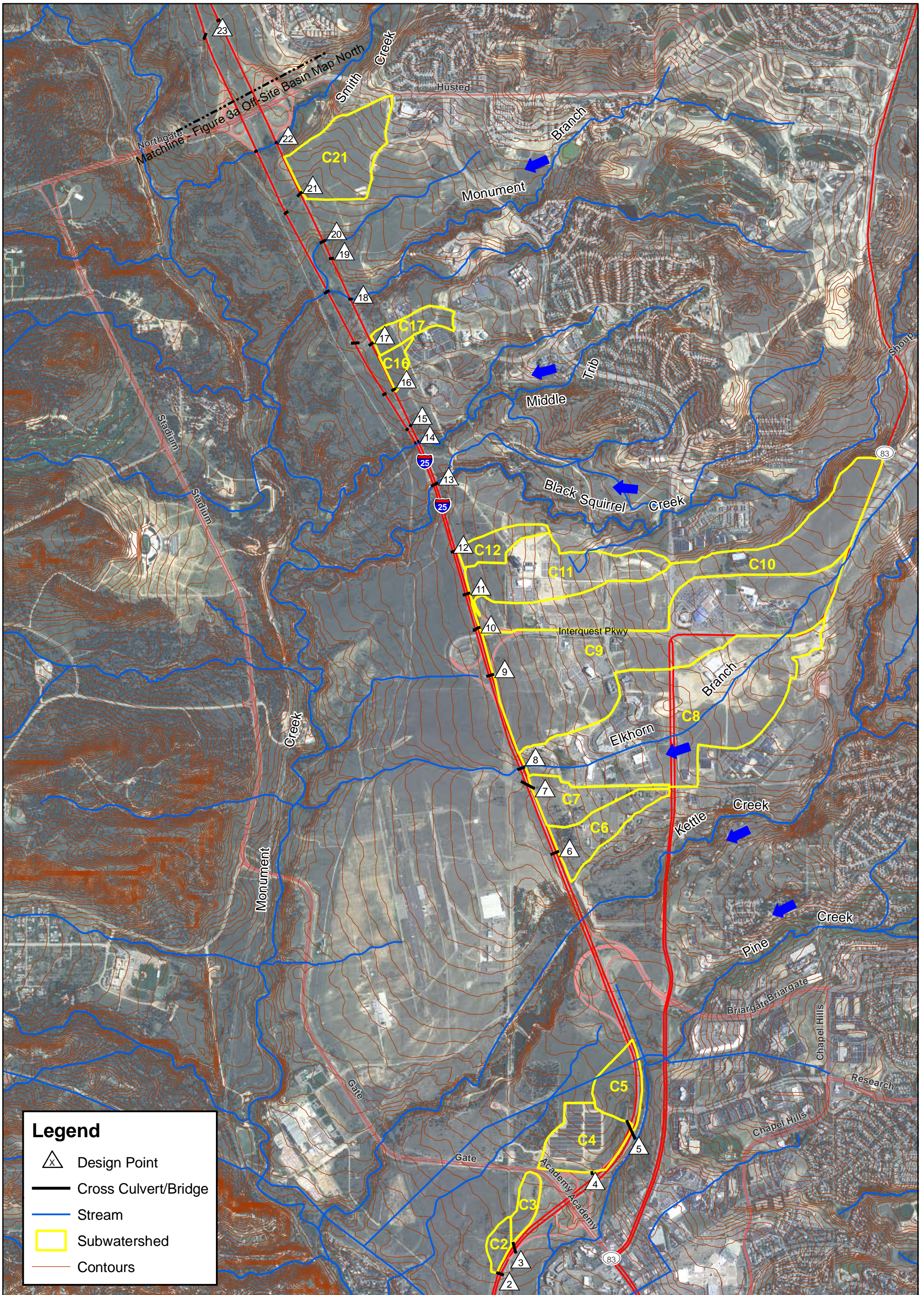


Figure 3b Off-Site Basin Map South
I-25 North Design-Build

July 2012

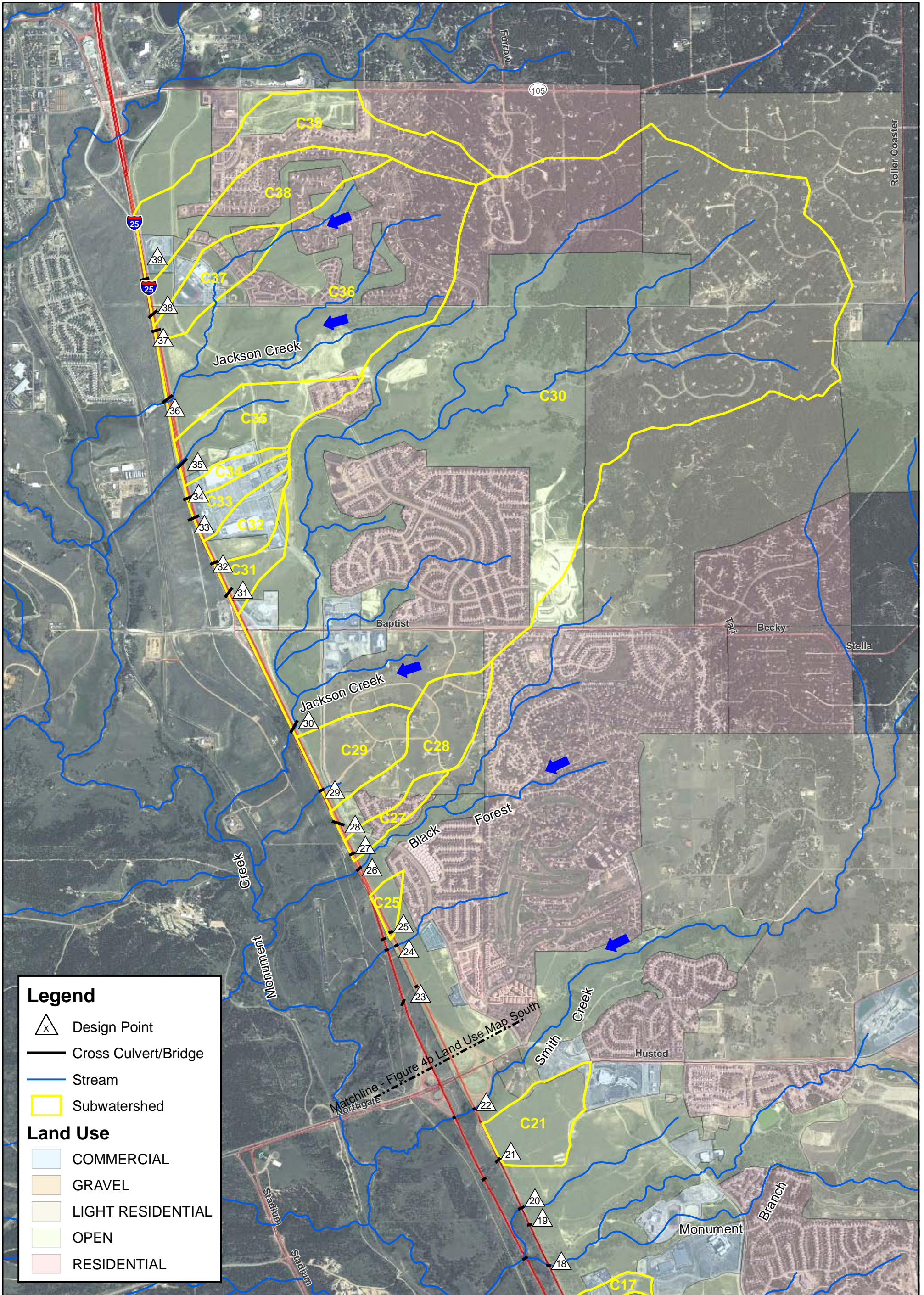


Figure 4a Land Use Map North

I-25 North Design-Build

July 2012

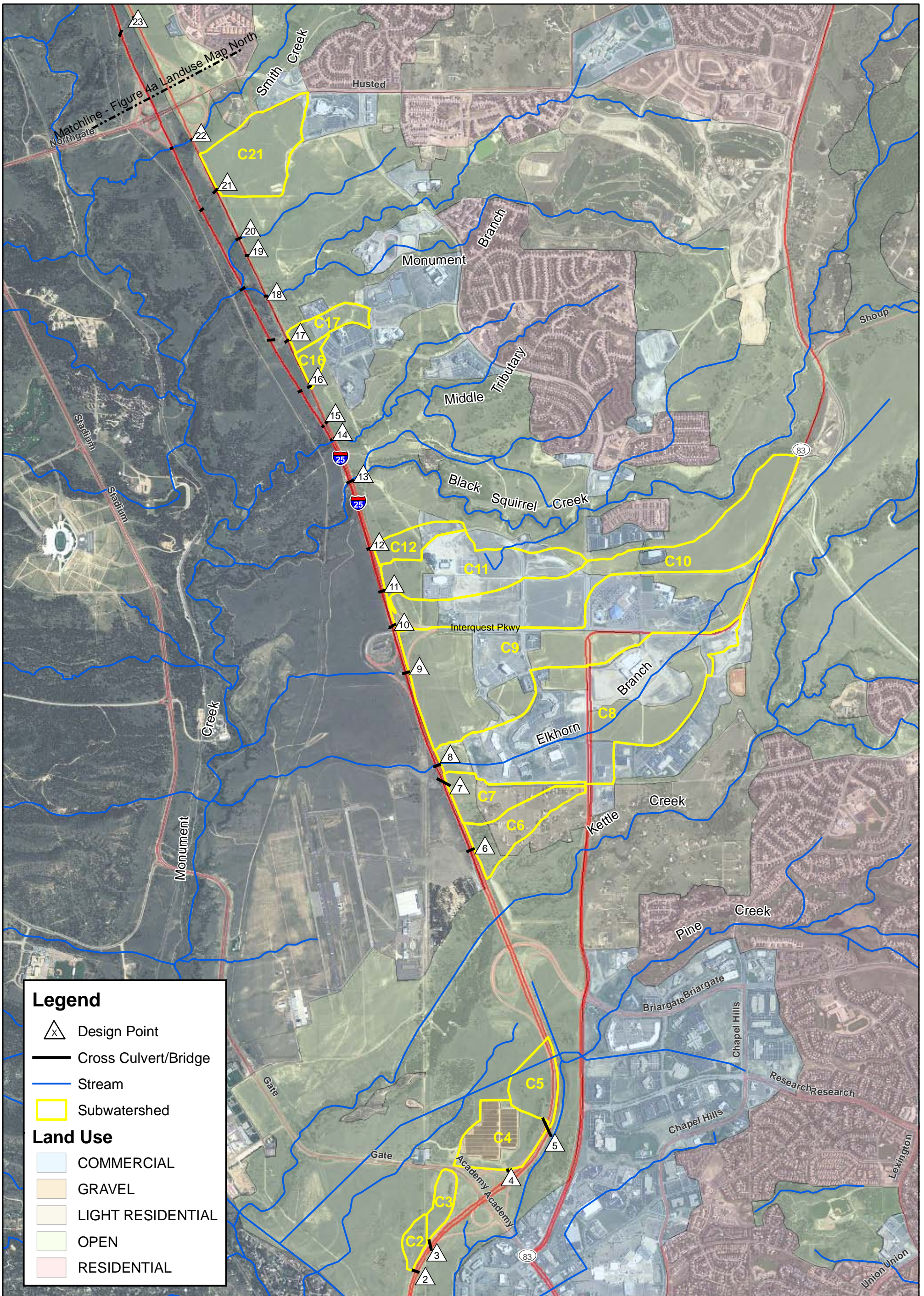
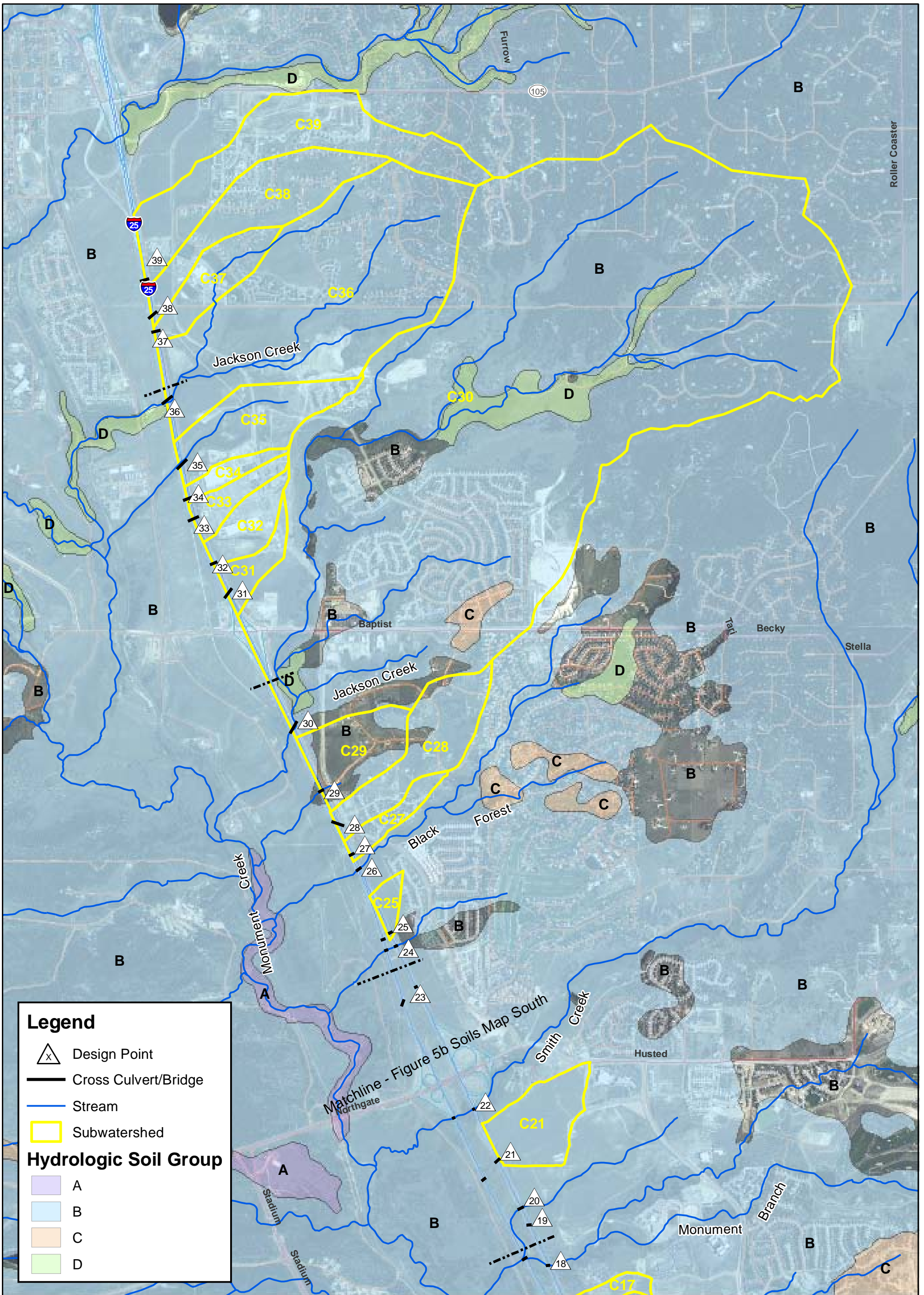


Figure 4b Land Use Map South
I-25 North Design-Build

July 2012



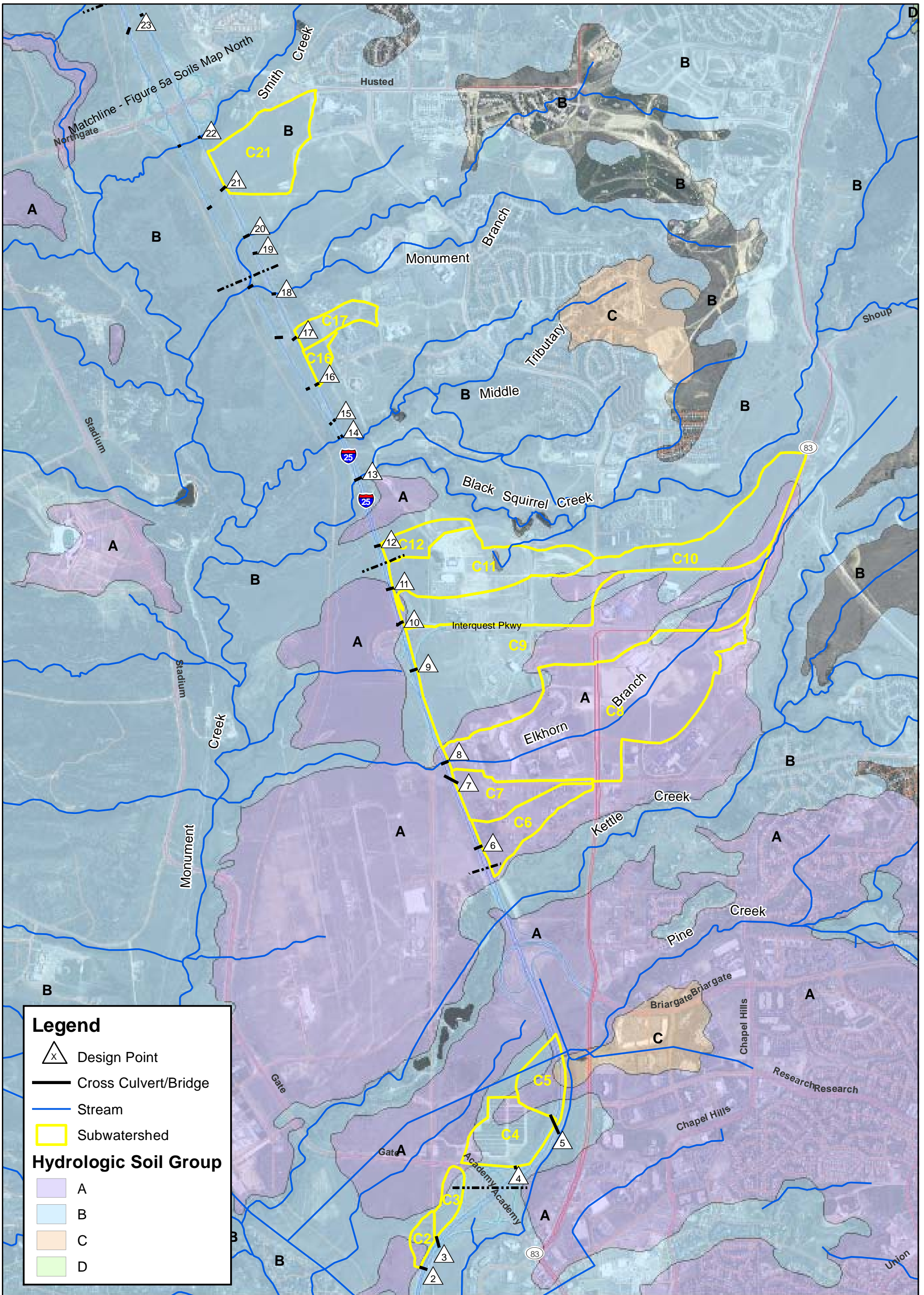


Figure 5b Soils Map South
I-25 North Design-Build

July 2012

TABLES

Table 1. Roadway Crossing Inventory and Peak Flow Summary

**Table 1. Roadway Crossing Inventory and Peak Flow Summary
I-25 North Design-Build**

DESIGN POINT	ID	MILE POST	DIRECTION	DRAINAGEWAY	DRAINAGE AREA (acres)	CROSSING	PEAK FLOW (cfs)			
							Q10	Q50	Q100**	Q500
1	1	149.27		Pine Creek	6,182	BRIDGE			5,613*	
2	2	149.9		Unnamed	12	24" RCP	6	16	21	38
3	3	150.03		Unnamed	17	24" HDPE	8	22	29	51
4	4	150.53		Unnamed	61	18" HDPE	51	100	123	193
5	5	150.8		Unnamed	39	54" RCP	17	47	61	107
6	6	152.2		Unnamed	50	24" RCP	17	43	56	104
7	7	152.48		Unnamed	44	48" RCP	19	42	54	96
8	8	152.58		Elkhorn Branch	329	60" RCP	364	484	545	576
9	9	153.07		Unnamed	354	24" RCP	229	323	372	498
10	10	153.31		Unnamed	222	24" RCP	148	206	235	311
11	11	153.48		Unnamed	113	24" RCP	171	222	248	313
12	12	153.68		Unnamed	26	30" RCP	29	52	62	93
13	13	154.01		Black Squirrel Creek	6,890	2-BRIDGES	1,104		3,953	
14	14A	154.17	NB	Middle Tributary	595	12'X8' CBC	238		782	
	14B	154.17	SB	Middle Tributary	595	12'X8' CBC	238		782	
15	15A	154.31	NB	Middle Tributary	132	48" CMP	29		167	
	15B	154.29	SB	Middle Tributary	132	48" CMP	29		167	
16	16A	154.49	NB	Unnamed	12	24" RCP	9	20	25	40
	16B	154.49	SB	Unnamed	12	24" RCP	9	20	25	40
17	17A	154.74	NB	Unnamed	25	24" RCP	24	46	56	87
	17B	154.77	SB	Unnamed	25	24" RCP	24	46	56	87
18	18A	154.96	NB	Monument Branch	1,772	2-12'X10' CBC	722		2,285	
	18B	155.03	SB	Monument Branch	1,772	2-12'X10' CBC	722		2,439	
19	19	155.12	NB	Monument Branch	357	6'X7' CBC	136		390	
20	20	155.26	NB	Monument Branch	48	48" RCP	102		135	
21	21A	155.51	NB	Unnamed	92	48" RCP	65	105	127	183
	21B	155.44	SB	Unnamed	92	48" RCP	65	105	127	183
22	22A	155.77	NB	Smith Creek	3,449	2-10'X10' CBC	540	1,376	2,055	
	22B	155.76	SB	Smith Creek	3,449	2-10'X10' CBC	540	1,376	2,055	
23	23A	156.41	NB	Unnamed	361	6'X7' CBC	165		350	
	23B	156.35	SB	Unnamed	361	6'X6' CBC	165		350	
24	24A	156.62	NB	Unnamed	205	6'X7' CBC	135		300	
	24B	156.61	SB	Unnamed	205	8'X6' CBC	135		300	
25	25A	156.68	NB	Unnamed	17	36" RCP	11	27	34	57
26	26	157.01		Black Forest	1,318	10'X10' CBC	360		1,900	
27	27	157.09		Unnamed	32	48" CMP	24	49	60	93
28	28	157.25		Unnamed	128	4'X4' CBC	61	105	128	193
29	29	157.42		Unnamed	96	4'X4' CBC	60	135	169	276
30	30	157.74		Jackson Creek	2,573	30'X17' CBC	837	1,296	1,542	2,194
31	31	158.45		Unnamed	37	36" RCP	27	57	70	113
32	32	158.59		Unnamed	54	30" RCP	76	121	141	196
33	33	158.83		Unnamed	38	30" RCP	77	112	127	164
34	34	158.92		Unnamed	25	24" RCP	46	69	79	104
35	35	159.09		Unnamed	126	6'X6' CBC	89	138	164	232
36	36	159.4		Teachout Creek	595	2-10'X10' CBC	378	583	693	980
37	37	159.72		Unnamed	76	24" RCP	74	129	154	224
38	38	159.79		Unnamed	154	36" RCP	115	169	197	271
39	39	159.96		Unnamed	250	24" RCP	193	284	332	457



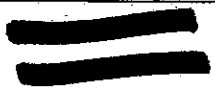
Peak Flows obtained from published Master Plan
 Calculated using Rational Method
 Calculated using HEC-HMS (SCS Method)

* For informational purposes only, crossing just outside project limits.
 ** Cross culverts to be hydraulically designed for Q100.

APPENDIX A

DRAINAGE BASIN PLANNING STUDY EXCERPTS

Do Not Check out



CITY OF COLORADO SPRINGS
PLANNING, DEVELOPMENT AND FINANCE DEPARTMENT

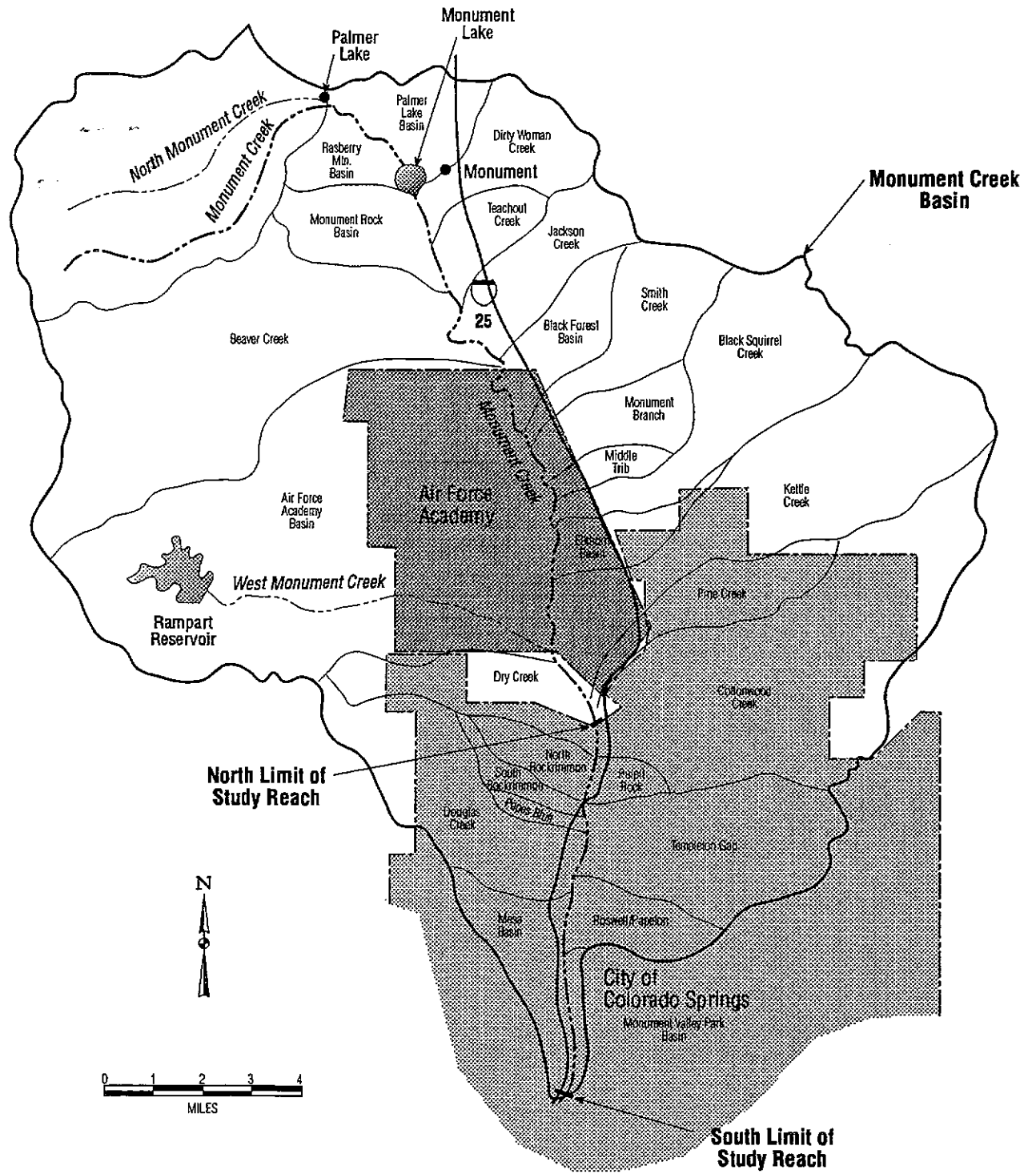
Monument Creek Drainage Basin Planning Study

Volume I
Report

Prepared by
CHM HILL

in association with
Kiowa Engineering Corporation
Thomas & Thomas
Urban Edges

SCANNED



**Figure 2-3
MAJOR DRAINAGE
BASINS**

Library Copy - Do Not Remove

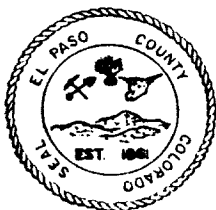
PINE CREEK DRAINAGE BASIN

DRAINAGE BASIN PLANNING STUDY

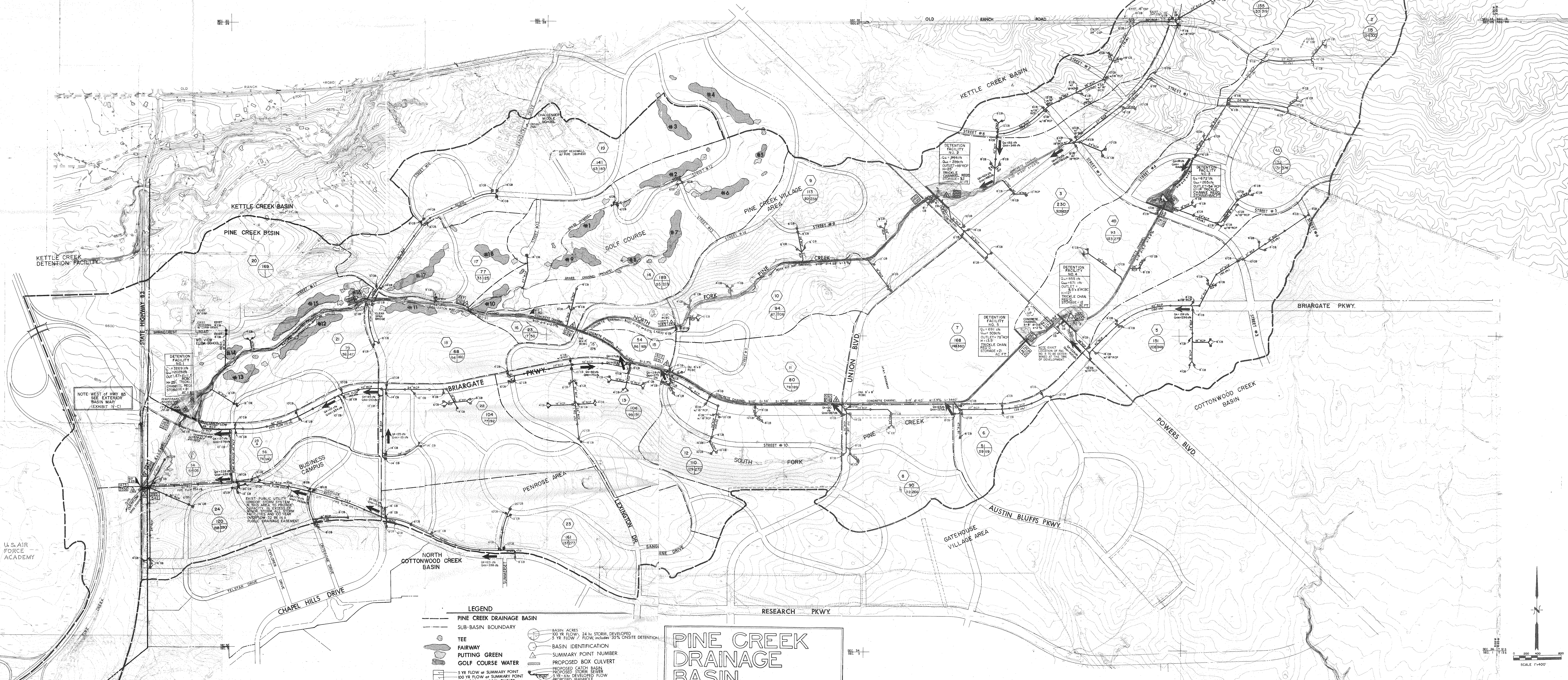
JUNE, 1988

REVISED OCTOBER, 1988

CITY OF COLORADO SPRINGS
AND
EL PASO COUNTY



Obering, Wurth & Associates
Consulting Civil Engineers



NOTE WEST OF HWY 83
SEE EXTERIOR
BASIN MAP
(EXHIBIT IV-C)

DETENTION FACILITY
NO. 1
CAP. 300,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

EXIST. PUBLIC UTILITY
CONDUIT FROM SYSTEM
IN THIS AREA TO PROVIDE
DRAINAGE TO EXISTING
FACILITIES AND TO REAR
IMPROVEMENT TO 60 IN. DIA.
PUBLIC CHARGE EASEMENT

DETENTION FACILITY
NO. 2
CAP. 200,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 3
CAP. 230,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 4
CAP. 180,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 5
CAP. 150,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 6
CAP. 120,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 7
CAP. 100,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 8
CAP. 80,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 9
CAP. 60,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 10
CAP. 40,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 11
CAP. 20,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 12
CAP. 10,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

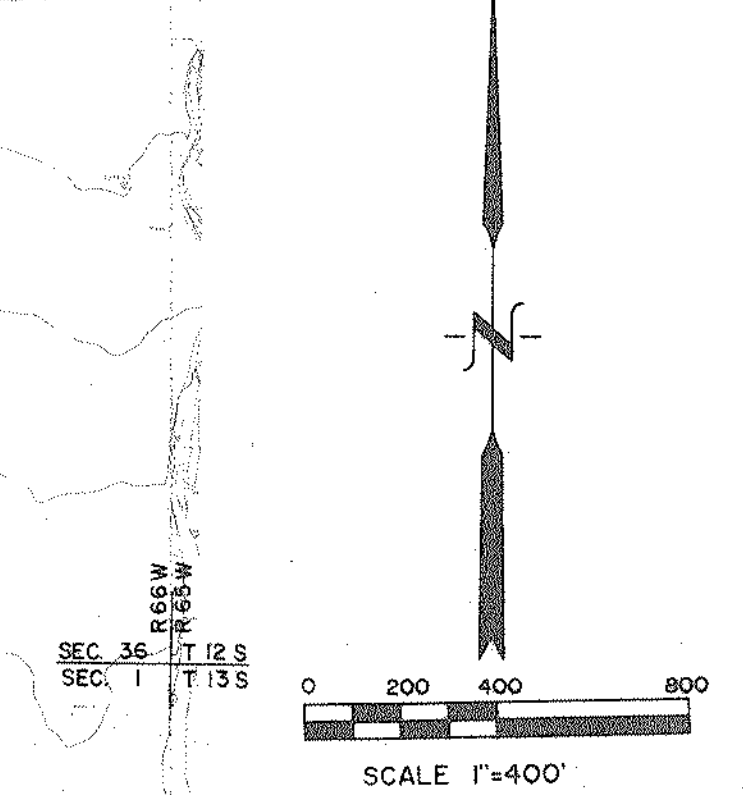
DETENTION FACILITY
NO. 13
CAP. 5,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 14
CAP. 2,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

DETENTION FACILITY
NO. 15
CAP. 1,000 GALS
OUTLET 48" DIA.
TRUCK CHANNEL
STORAGE 25' DIA.

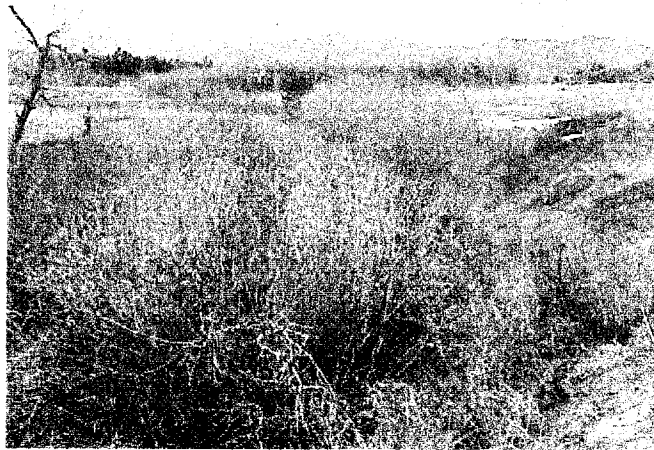
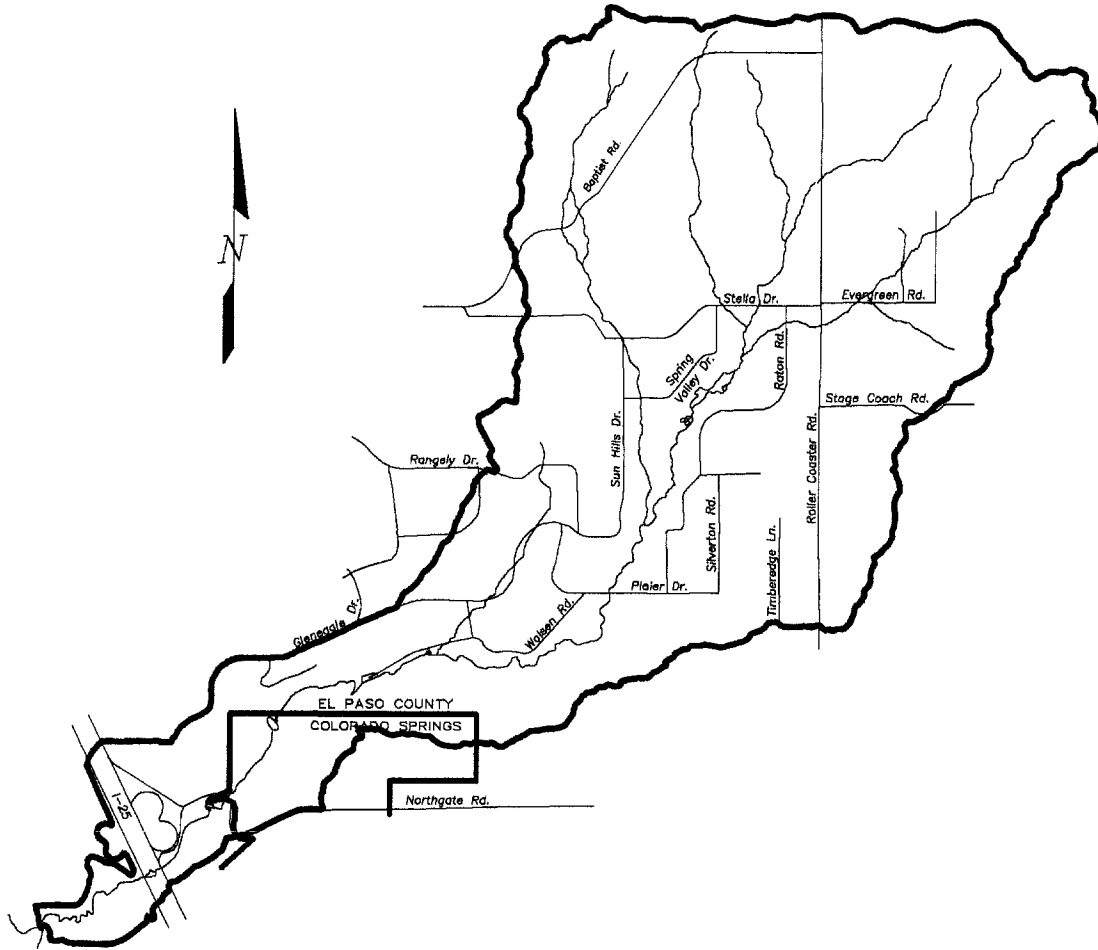
- LEGEND**
- PINE CREEK DRAINAGE BASIN
 - - - SUB-BASIN BOUNDARY
 - TEE
 - FAIRWAY
 - PUTTING GREEN
 - GOLF COURSE WATER
 - 5 YR FLOW @ SUMMARY POINT
 - 100 YR FLOW @ SUMMARY POINT
 - INTERMEDIATE SUMMARY FLOWS (6 hr.) USED TO SIZE MINOR FACILITIES
 - BASIN ACRES
 - 24 hr. FLOW
 - 5 YR FLOW / FLOW, includes 35% ONSITE DETENTION
 - BASIN IDENTIFICATION
 - SUMMARY POINT NUMBER
 - PROPOSED BOX CULVERT
 - PROPOSED CATCH BASIN
 - PROPOSED STORM SEWER
 - 5 YR - CAP. DEVELOPED FLOW
 - PROPOSED MANHOLE
 - SUBBASIN ADDED SPECIFICALLY FOR THE HEC 1 COMPUTER RUNS

**PINE CREEK
DRAINAGE
BASIN
MASTER PLAN
BASIN MAP**



PREPARED BY:
OBERING, WURTH & ASSOC.
1015 ELKTON DR.
CO. SPRINGS, CO. 80907
PROJ. NO. 10-286
DEC. 1988
REV. OCT. 1988
EXHIBIT IV-D

SMITH CREEK DRAINAGE BASIN PLANNING STUDY CITY OF COLORADO SPRINGS COUNTY OF ELPASO, STATE OF COLORADO AUGUST 2002



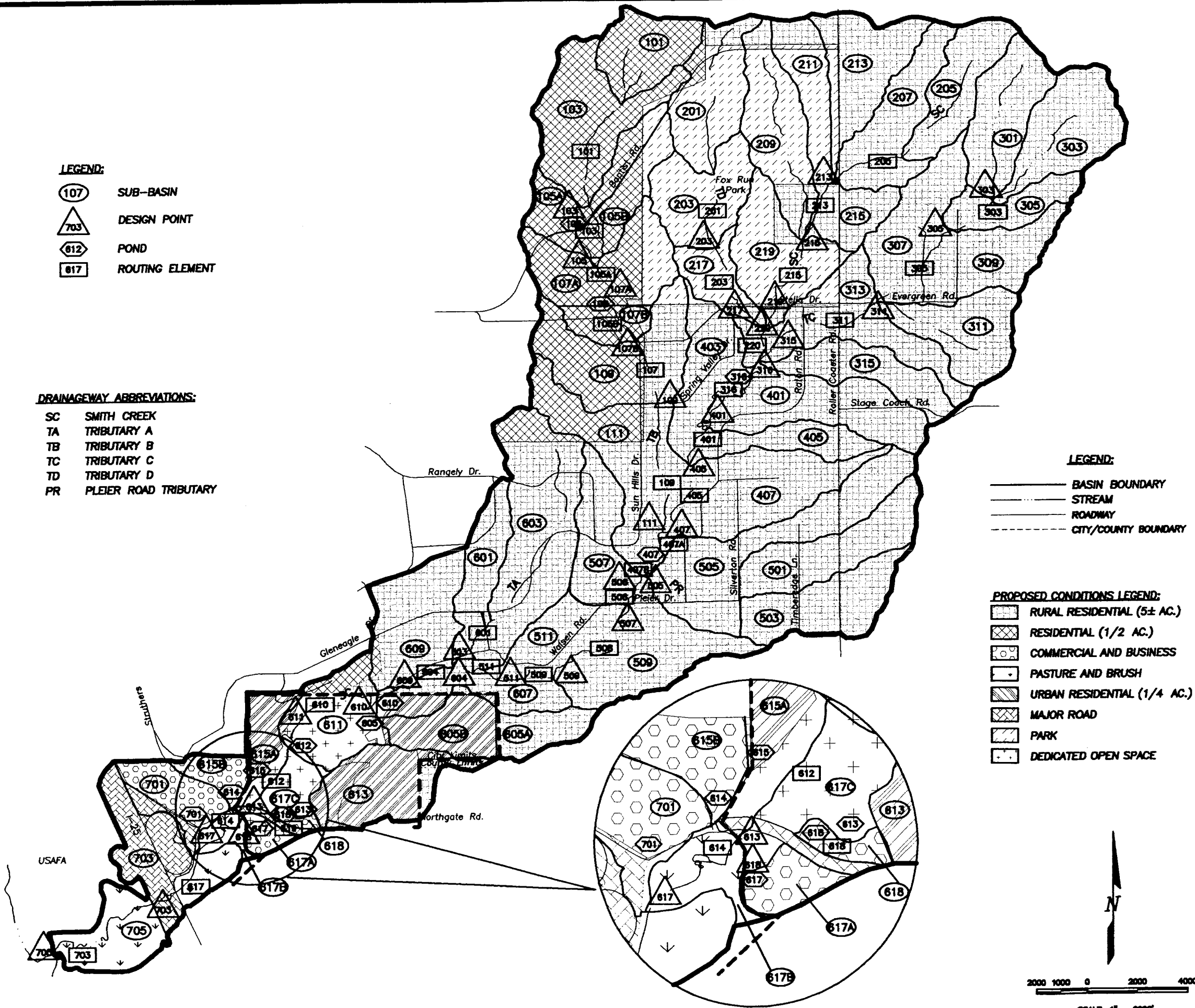
J-R ENGINEERING

A Subsidiary of Westrian

4310 ArrowsWest Drive • Colorado Springs, CO 80907

719-593-2593 • Fax: 719-528-6613

www.jrengineering.com



LEGEND:
 (107) SUB-BASIN
 (703) DESIGN POINT
 (612) POND
 (617) ROUTING ELEMENT

DRAINAGEWAY ABBREVIATIONS:
 SC SMITH CREEK
 TA TRIBUTARY A
 TB TRIBUTARY B
 TC TRIBUTARY C
 TD TRIBUTARY D
 PR PLEIER ROAD TRIBUTARY

LEGEND:
 — BASIN BOUNDARY
 — STREAM
 — ROADWAY
 - - - - CITY/COUNTY BOUNDARY

PROPOSED CONDITIONS LEGEND:
 [diagonal lines] RURAL RESIDENTIAL (5± AC.)
 [cross-hatch] RESIDENTIAL (1/2 AC.)
 [stippled] COMMERCIAL AND BUSINESS
 [dots] PASTURE AND BRUSH
 [diagonal lines] URBAN RESIDENTIAL (1/4 AC.)
 [thick line] MAJOR ROAD
 [dotted] PARK
 [white] DEDICATED OPEN SPACE

UNTIL SUCH TIME AS THESE DRAWINGS ARE APPROVED BY AN APPROPRIATE ENGINEERING AGENCIES, JR ENGINEERING APPROVES THEIR USE ONLY FOR THE PURPOSES DESIGNATED BY WRITTEN AUTHORIZATION.

PREPARED FOR
MOJAVE, INC.
ALVIN STEVE SHARKEY
 90 S. CASCADE AVE., STE. #1300
 COLORADO SPRINGS, CO 80903
 (719) 381-8441

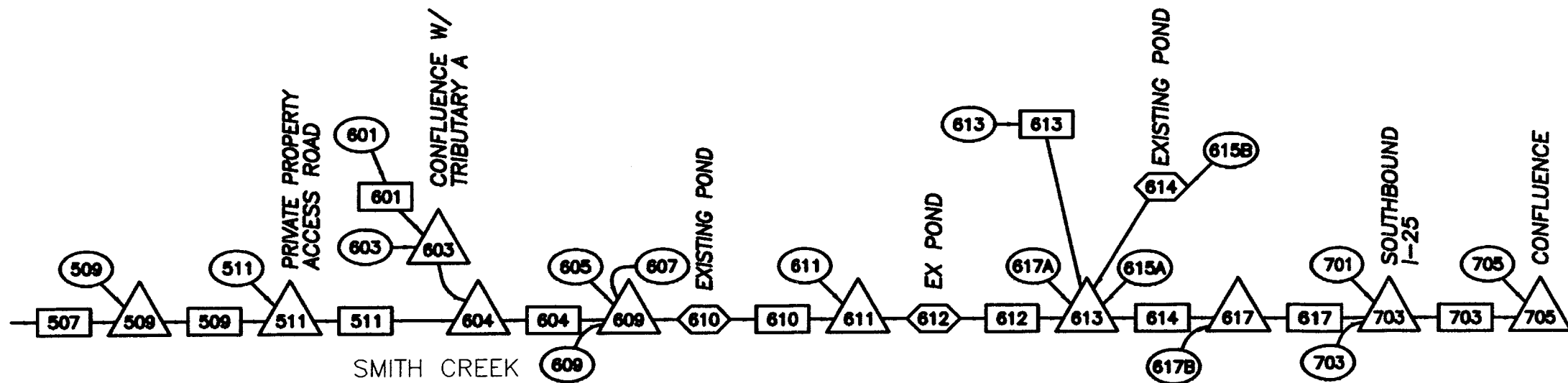
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1	03/20/02	ACS	REVISED PER AGENCY COMMENTS

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	MSD	

SMITH CREEK DRAINAGE BASIN PLANNING STUDY
 FG II-1B
 BASIN MAP
 LAND USE PROPOSED

SHEET 1 OF 1
 JOB NO. 0006.00



DISCHARGE TABLE

DESIGN POINT	AREA OF DRAINAGE (sq. mi.)	2-YR Q EXISTING (cfs)	5-YR Q EXISTING (cfs)	10-YR Q EXISTING (cfs)	50-YR Q EXISTING (cfs)	100-YR Q EXISTING (cfs)
103	0.33	9	35	61	144	205
105	0.40	10	35	59	113	164
107A	0.53	15	52	86	171	248
107B	0.57	16	55	91	184	267
109	0.74	22	73	119	246	353
111	0.93	28	91	149	324	451
203	0.23	2	12	26	75	112
213	0.34	7	34	60	145	206
215	0.62	9	46	86	226	330
217	0.29	2	14	30	88	133
219	0.75	9	48	89	248	368
220	1.03	11	61	119	336	501
303	0.25	4	23	42	105	150
305	0.31	5	28	51	129	185
311	0.65	10	51	96	247	359
315	0.89	13	65	115	309	457
316	1.92	25	125	228	636	947
401	2.08	27	133	249	628	922
405	2.25	29	142	267	677	1000
407	3.34	56	233	426	1054	1507
505	0.43	8	40	73	178	255
506	3.77	62	252	463	1168	1679
507	3.87	63	257	460	1181	1704
509	4.02	66	268	464	1219	1770
511	4.11	67	264	473	1188	1754
603	0.31	16	50	80	173	238
604	4.43	72	284	504	1283	1886
609	4.78	79	306	543	1386	2036
611	4.89	84	303	536	1337	1976
613	5.17	80	307	550	1402	2016
617	5.19	79	308	547	1396	2016
703	5.39	81	312	545	1388	2035
705	5.48	82	310	535	1366	2032

LEGEND:

- 703 DESIGN POINT
- 703 SUB-BASIN
- 612 POND
- 617 ROUTING ELEMENT

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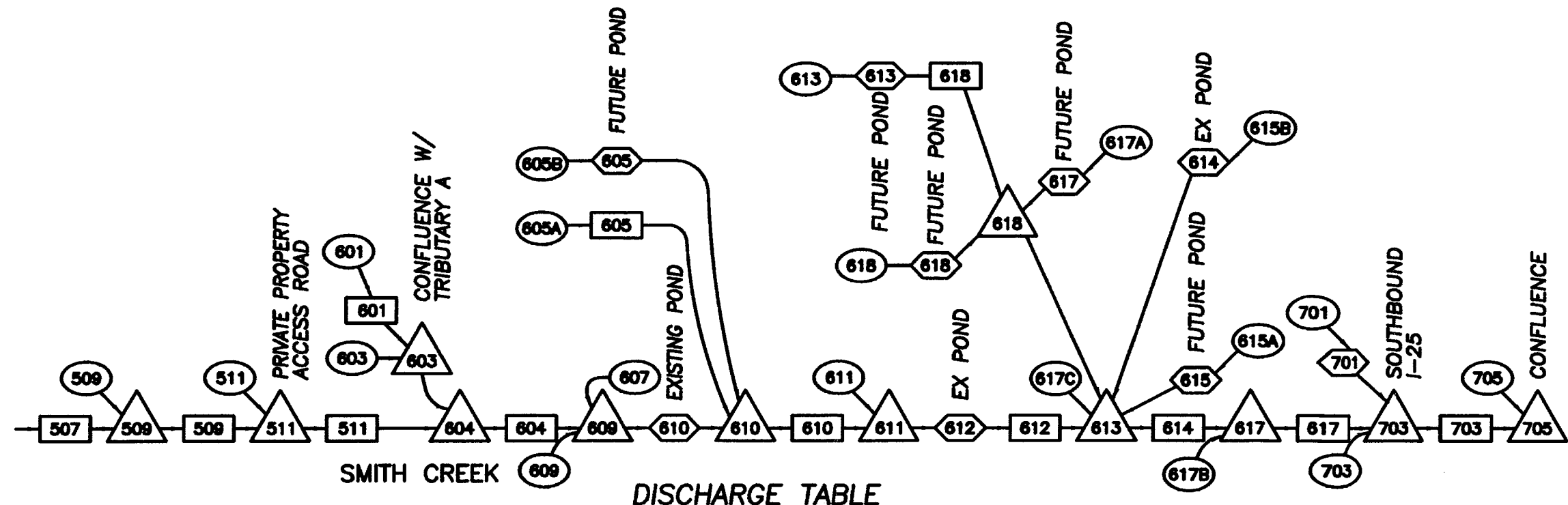
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SMITH CREEK
DRAINAGE BASIN PLANNING STUDY
 EXISTING CONDITIONS
 FLOW CHART
 FIG II-4B



DISCHARGE TABLE

DESIGN POINT	AREA OF DRAINAGE (sq. mi.)	2-YR Q FUTURE (cfs)			5-YR Q FUTURE (cfs)			10-YR Q FUTURE (cfs)			50-YR Q FUTURE (cfs)			100-YR Q FUTURE (cfs)		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
103	0.33	9	9	9	36	36	36	62	62	62	147	147	147	208	208	208
105	0.40	10	10	10	36	36	36	61	61	61	114	114	114	167	167	167
107A	0.53	17	17	17	56	56	56	90	90	90	184	184	184	263	263	263
107B	0.57	18	18	18	59	59	59	94	94	94	197	197	197	281	281	281
109	0.74	24	24	24	77	77	77	123	123	123	268	268	268	382	382	382
111	0.93	30	30	30	98	98	98	157	157	157	335	335	335	463	463	463
203	0.23	2	2	2	14	14	14	28	28	28	78	78	78	116	116	116
213	0.34	14	14	14	49	49	49	79	79	79	175	175	175	243	243	243
215	0.62	18	18	18	69	69	69	118	118	118	275	275	275	389	389	389
217	0.29	3	3	3	16	16	16	32	32	32	93	93	93	139	139	139
219	0.75	18	18	18	69	69	69	122	122	122	301	301	301	432	432	432
220	1.03	21	21	21	84	84	84	154	154	154	394	394	394	570	570	570
303	0.25	13	13	13	40	40	40	65	65	65	138	138	138	190	190	190
305	0.31	15	15	15	49	49	49	79	79	79	171	171	171	235	235	235
311	0.65	28	28	28	93	93	93	150	150	150	330	330	330	458	458	458
315	0.89	35	35	35	112	112	112	187	187	187	427	427	427	599	599	599
316	1.92	55	55	55	192	192	192	335	335	335	811	811	811	1158	1158	1158
401	2.08	56	56	45	206	206	148	340	340	294	799	799	789	1162	1162	1095
405	2.25	60	60	48	220	220	156	365	365	310	868	868	837	1260	1260	1177
407	3.34	95	95	76	329	329	248	548	548	466	1226	1226	1221	1713	1713	1718
505	0.43	20	20	20	65	65	65	105	105	105	229	229	229	317	317	317
506	3.77	105	105	62	361	361	265	608	608	522	1375	1375	1239	1926	1926	2065
507	3.87	105	105	63	356	356	265	607	607	513	1393	1393	1219	1948	1948	2036
509	4.02	105	105	65	355	355	270	612	612	504	1439	1439	1240	2026	2026	2019
511	4.11	107	107	66	360	360	260	590	590	495	1423	1423	1250	2031	2031	1891
603	0.31	17	17	17	52	52	52	83	83	83	176	176	176	241	241	241
604	4.43	112	112	70	377	377	270	619	619	514	1506	1506	1301	2149	2149	1989
609	4.65	115	115	72	388	388	278	642	642	526	1556	1556	1335	2227	2227	2025
610	4.78	131	132	74	383	387	284	656	658	543	1583	1594	1367	2248	2264	2028
611	4.89	121	122	75	384	387	284	659	662	526	1549	1559	1352	2240	2254	2040
613	5.17	115	119	81	399	403	296	662	665	540	1589	1592	1357	2248	2232	2084
617	5.19	113	118	81	395	400	296	662	665	539	1587	1589	1359	2230	2233	2073
618	0.15	9	7	6	26	11	9	41	14	10	84	25	21	113	35	27
703	5.39	120	124	83	401	406	299	682	684	540	1622	1622	1376	2298	2298	2055
705	5.48	119	124	83	404	409	297	678	679	535	1614	1610	1376	2312	2308	2022

LEGEND:

- 703** DESIGN POINT
- 703** SUB-BASIN
- 612** POND
- 617** ROUTING ELEMENT

- ALTERNATIVE 1. NO PROPOSED DETENTION
 2. CITY OF COLORADO SPRINGS ONSITE DETENTION
 3. REGIONAL DETENTION WITH ONSITE DETENTION USING PRUDENT LINE SETBACKS AND LIMITED CHANNEL STABILIZATION

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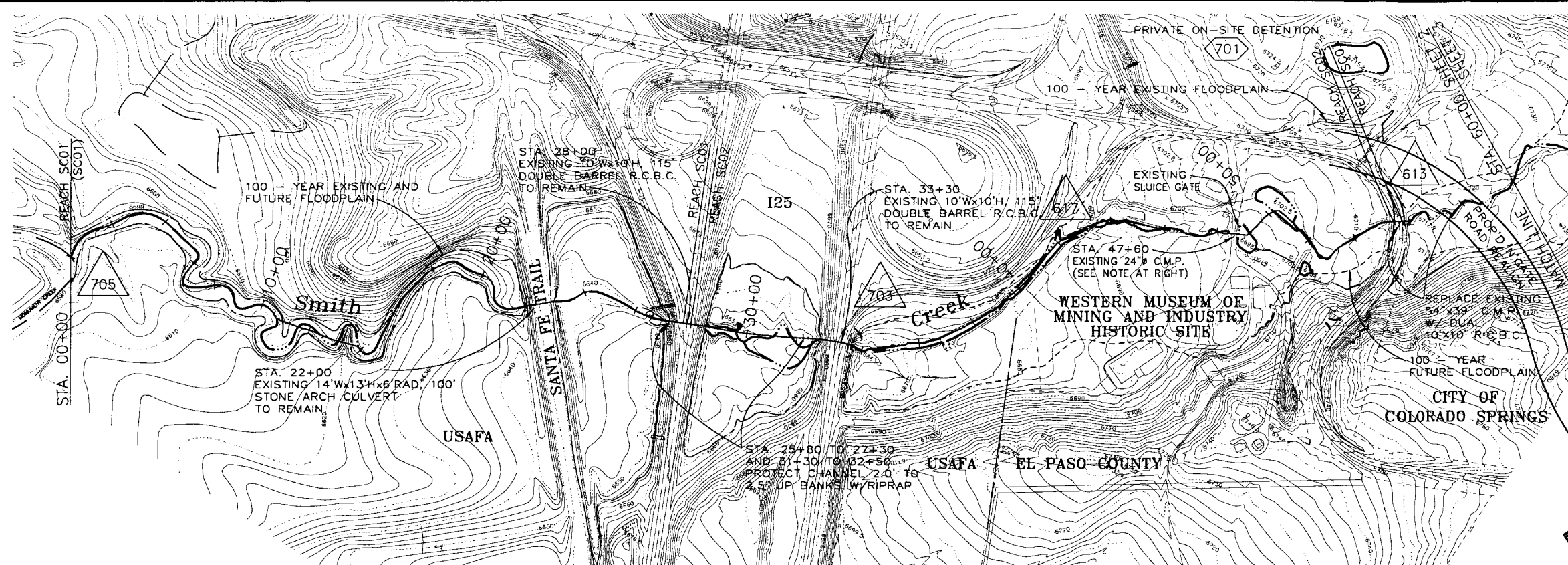
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SMITH CREEK
DRAINAGE BASIN PLANNING STUDY
FUTURE CONDITIONS
FLOW CHART
 FIG II-88



NOTE: THE EXISTING 24" DIAMETER CULVERT UNDER THE ACCESS ROAD TO THE MINING MUSEUM IS GROSSLY UNDERSIZED PER COUNTY CRITERIA. THERE IS NO APPARENT PROPERTY DAMAGE AT THIS LOCATION. DUE TO THE HISTORIC NATURE OF THIS SITE, AND THE HISTORIC USE OF THIS ROAD, AND AFTER SPEAKING WITH THE MUSEUM DIRECTOR, IT IS RECOMMENDED THAT THE CULVERT REMAIN WITH THE UNDERSTANDING THAT PERIODIC FLOODING OF THIS LOCATION MAY OCCUR. AT SUCH TIME THAT IT IS DEEMED FEASIBLE OR NECESSARY, GRADING OPERATIONS ARE RECOMMENDED IN THIS AREA TO MODIFY THE FLOODPLAIN AND REMOVE EXISTING STRUCTURES FROM INUNDATION HAZARD. A NEW CULVERT SIZED PER COUNTY CRITERIA IS ALSO SUGGESTED.

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DP 705 FUTURE FLOWS

Q ₂	=	83 cfs
Q ₅	=	297 cfs
Q ₁₀	=	535 cfs
Q ₅₀	=	1376 cfs
Q ₁₀₀	=	2022 cfs

DP 703 FUTURE FLOWS

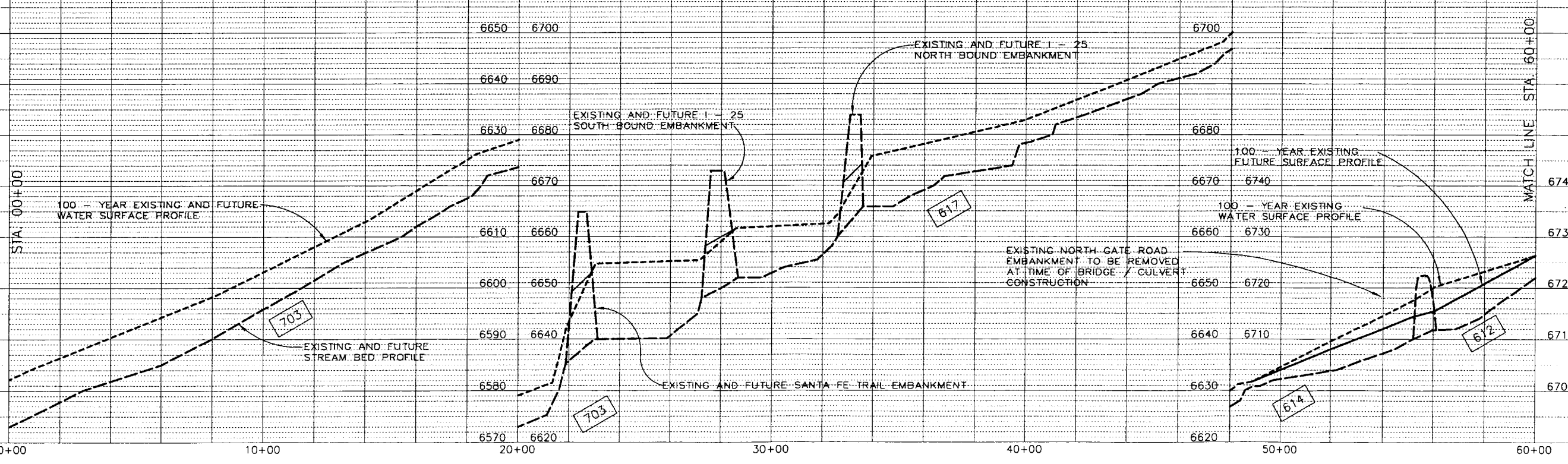
Q ₂	=	83 cfs
Q ₅	=	299 cfs
Q ₁₀	=	540 cfs
Q ₅₀	=	1376 cfs
Q ₁₀₀	=	2055 cfs

DP 617 FUTURE FLOWS

Q ₂	=	81 cfs
Q ₅	=	296 cfs
Q ₁₀	=	539 cfs
Q ₅₀	=	1359 cfs
Q ₁₀₀	=	2073 cfs

DP 613 FUTURE FLOWS

Q ₂	=	81 cfs
Q ₅	=	296 cfs
Q ₁₀	=	540 cfs
Q ₅₀	=	1357 cfs
Q ₁₀₀	=	2084 cfs



NOTE:
 CREEK BOTTOM PROFILE PER MULLER ENGINEERING STUDY.

PREPARED UNDER MY DIRECT SUPERVISION FOR AND ON BEHALF OF JR ENGINEERING

LUANNE O. RUBEY, COLORADO P.E. # 32339 DATE _____

SMITH CREEK DRAINAGE BASIN PLANNING STUDY PRELIMINARY PLAN AND PROFILE STA 00+00 TO STA 60+00	BY	DATE	
	AGS 03/20/02	MFS 07/16/02	
REVISION	No.	DATE	BY
	1	6/29/01	MSD
H-SCALE	V-SCALE	DATE	DESIGNED BY
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SHEET 2 OF 13		JOB NO. 8896.90	

Vol. I

BLACK FOREST DRAINAGE BASIN PLANNING STUDY

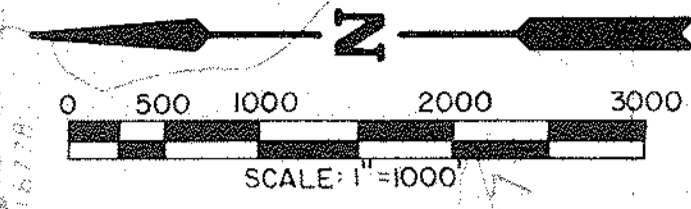
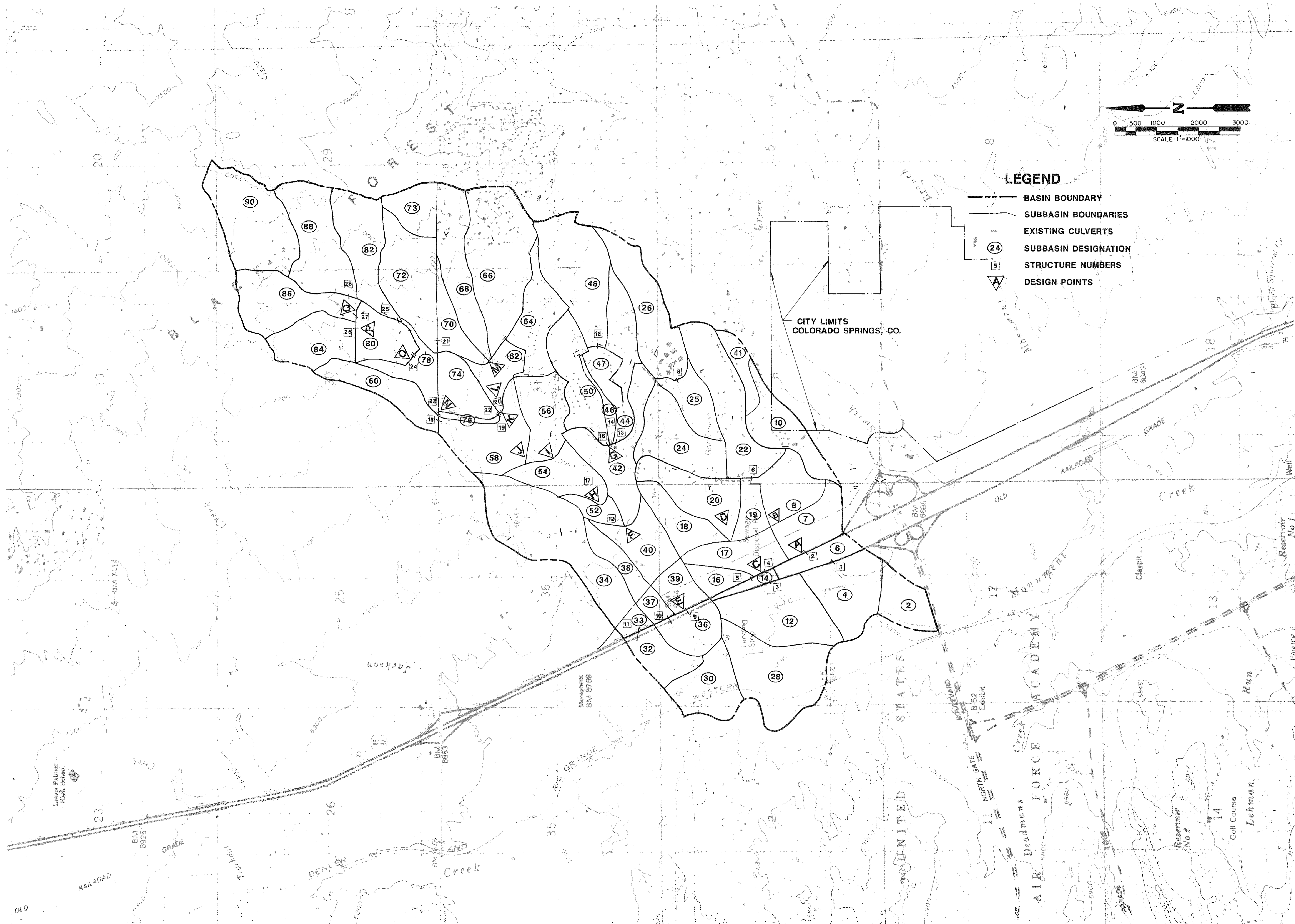


Prepared for:

El Paso County
Department of Public Works

May 1989

**WILSON
& COMPANY**



LEGEND

- BASIN BOUNDARY
- SUBBASIN BOUNDARIES
- - - EXISTING CULVERTS
- (24) SUBBASIN DESIGNATION
- (5) STRUCTURE NUMBERS
- ▲ DESIGN POINTS

CITY LIMITS
COLORADO SPRINGS, CO.

REVISION	DATE	BY

WILSON & COMPANY
ENGINEERS & ARCHITECTS
COLORADO SPRINGS, COLORADO

**BLACK FOREST
DRAINAGE BASIN PLANNING STUDY
BASIN DISCHARGE MAP**

DESIGN	MAB
DRAWN	W&C
DATE	
FILE NO.	88-809
SHEET NO.	

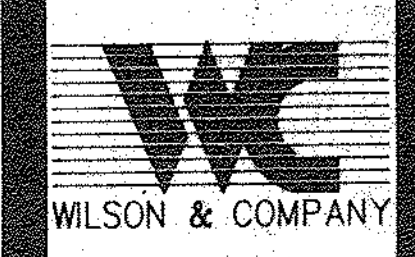


TABLE 6
SUMMARY OF DISCHARGES

Design Point	Existing Conditions Peak Flows (CFS)				Future Conditions Peak Flows (CFS)			
	24-Hour		2-Hour		24-Hour		2-Hour	
	100-Yr	10-Yr	100-Yr	10-Yr	100-Yr	10-Yr	100-Yr	10-Yr
A	315	85	250	125	350	165	290	150
B	240	70	200	100	265	115	195	100
C	290	65	280	120	300	135	135	80
D	260	55	240	105	365	155	290	160
E	2090	620	1355	645	1900	360	1455	610
F	1990	610	1320	650	1825	355	1345	565
G	390	155	325	160	435	165	320	145
H	1510	490	930	455	1655	790	1225	740
I	1445	470	880	435	1540	740	1135	690
J	1350	430	805	395	1410	685	1035	570
K	1235	395	690	340	1135	580	900	540
L	630	225	535	260	860	385	690	375
M	455	155	400	195	665	290	53	285
N	625	170	530	245	815	280	705	330
O	590	150	500	230	590	150	530	240
P	510	135	435	190	520	135	425	190
Q	390	115	340	160	390	116	330	160
R	2140	655	1460	710	2010	960	1600	715

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**Black Squirrel Creek Drainage Basin
Planning Study**

City of Colorado Springs
and El Paso County

January, 1989

LEGEND

- MAJOR ROADWAYS
- BLACK SQUIRREL BASIN BOUNDARY
- MINOR BASIN BOUNDARY
- URBAN PLANNING BOUNDARY
- CITY LIMITS
- NORTHGATE BOUNDARY
- FOREST AREA
- MINOR BASIN ACREAGE
- DESIGN POINT
- 100-YEAR FLOODPLAIN
- EXISTING STOCK POND

DESIGN POINT	10-YEAR* (cfs)	100-YEAR* (cfs)	COMMENT
	86	307	A
	182	773	A,B
	194	686	C
	405	1825	A,B,C,D,E
	496	1832	F
	1118	4158	A thru H
	1154	4389	A thru I
	1129	4051	A thru J
	1104	3956	A thru K
	1098	3950	A thru L

* 24-HOUR STORM

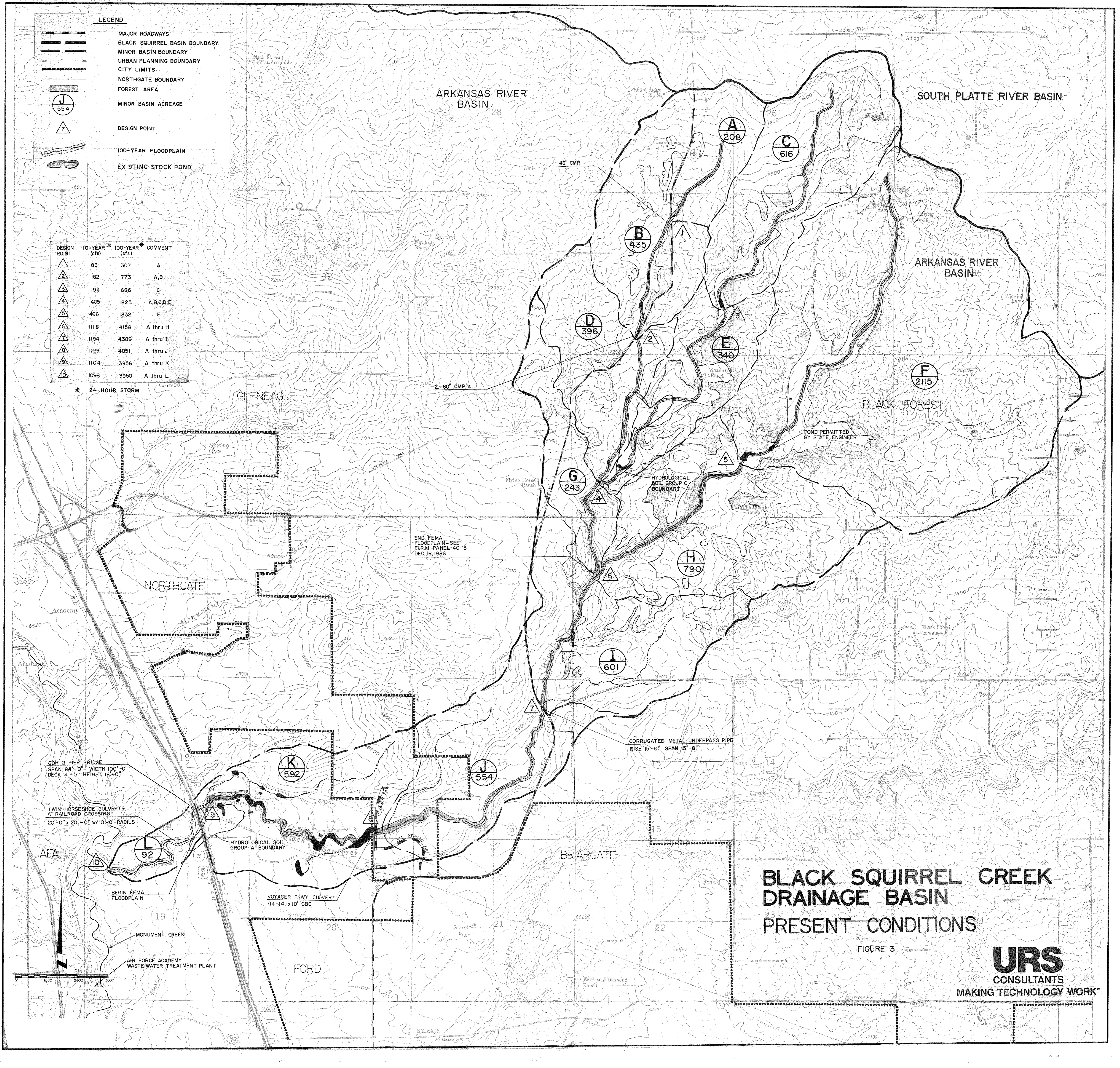


FIGURE 3

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TABLE 5

BLACK SQUIRREL CREEK DRAINAGE BASIN
 DESIGN PEAK FLOWS FOR
 PRESENT AND RECOMMEND CONDITIONS
 24-HOUR STORM

DESIGN POINT	CONTRIBUTING SUBBASINS	PRESENT CONDITIONS		RECOMMENDED CONDITIONS	
		10-YR (cfs)	100-YR (cfs)	10-YR (cfs)	100-YR (cfs)
1A	A5	106	307	201	563
1B	A4-A5	182	773	288	848
1	A	213	922	213 out	906 out
2	B	165	746	165 out	740 out
3	A,B,D	405	1825	405	1476
4E	C2-C4	174	645	343	1029
4W	C1,C5-C10	276	1019	276 out	1085 out
4	C	450	1661	450	1641
5E	C,F	651	2188	651	2202
5W	A,B,D,E	467	1974	467	1450
5	A-F	1118	4158	1118	3328
6	A-G	1154	4389	1154	3536
7	A-H	1387	4432	1387	3577
8	A-I	1142	4220	1142	3597
9	A-J	1129	4051	1129	3779
10	A-K	1117	4004	1117	3803
11	A-L	1104	3956	1104	3953
12	A-M	1098	3950	1098	3931

Notes: 1) Design points are taken from Figure 4.

2) Present conditions include routed flows without existing "stockponds". Present conditions are assumed to represent historic conditions.

3) Recommended conditions include routed flows through proposed detention facilities.

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Cottonwood Creek
Drainage Basin Planning Study

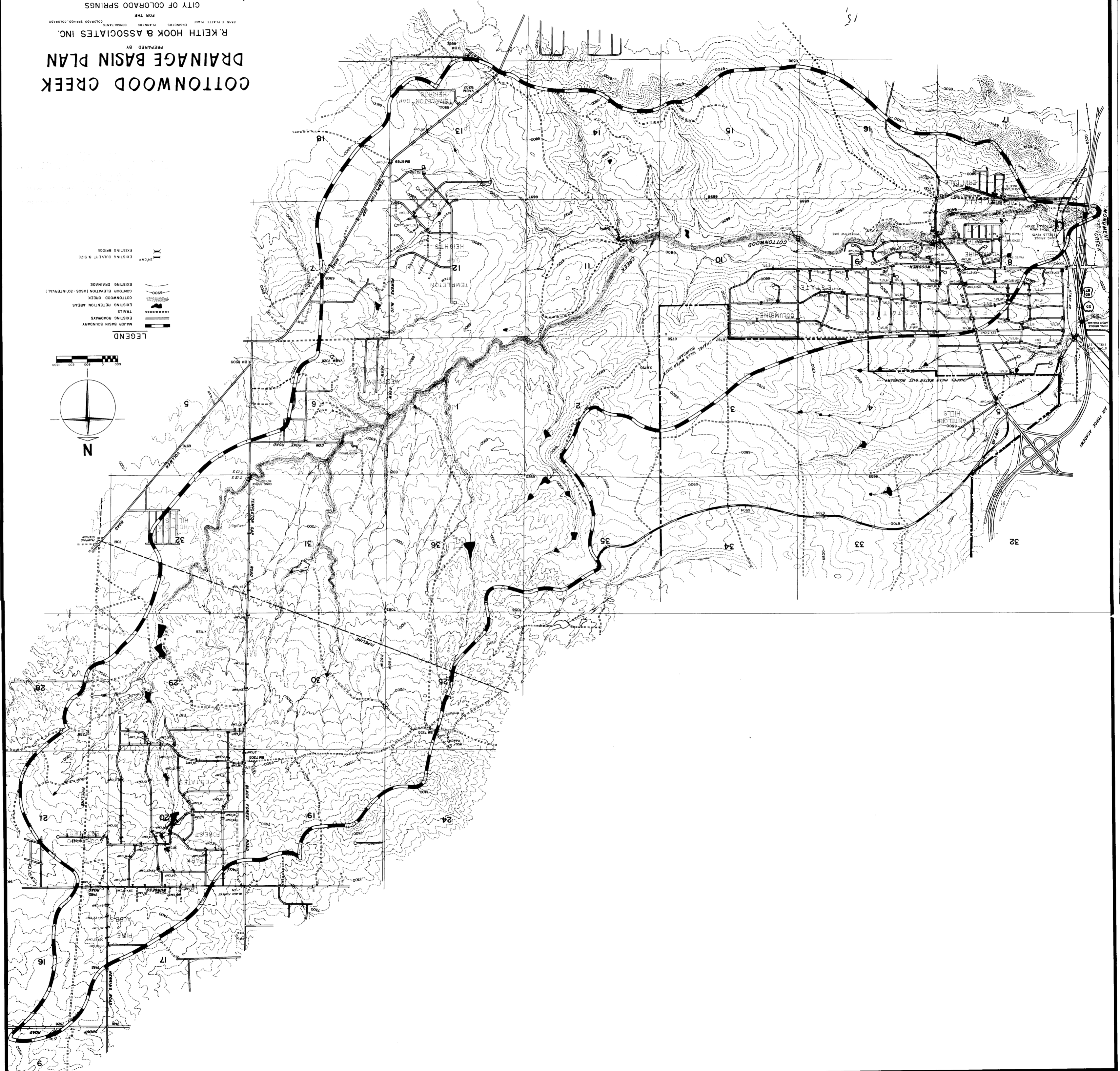
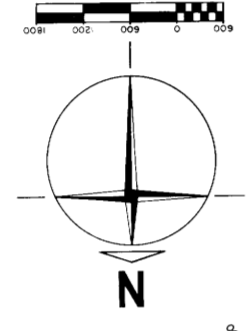
City of Colorado Springs and El Paso County

JUNE 9, 1994

**COTTONWOOD CREEK
DRAINAGE BASIN PLAN**
PREPARED BY
R. KEITH HOOK & ASSOCIATES INC.
FOR THE
CITY OF COLORADO SPRINGS
AUGUST 1969

LEGEND

- MAJOR BASIN BOUNDARY
- EXISTING ROADWAYS
- TRAILS
- EXISTING RETENTION AREAS
- COTTONWOOD CREEK
- CONTINUOUS ELEVATION (100' INTERVAL)
- EXISTING DRAINAGE
- EXISTING BRIDGE
- EXISTING CULVERT & SILE

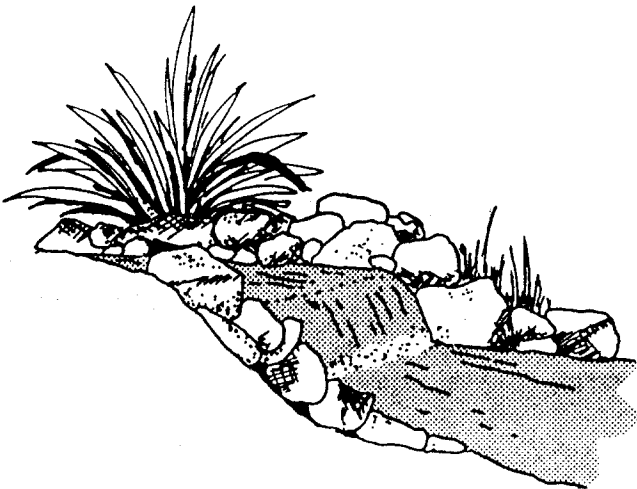


COTTONWOOD CREEK DBPS - TABLE 1			
BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS			
100-YEAR STORM			
DESIGN POINT	TRIBUTARY AREA (ACRES)	* DETAINED RUNOFF Q(CFS)	* FLOW THRU RUNOFF Q(CFS)
6A	186	417	417
5A	179	101	101
32	6,259	5,674	11,505
31	6,182	5,613	11,267
30	5,805	4,981	10,669
29	5,638	4,589	10,422
OFF-29	3,194	2,583	5,634
28	2,317	2,770	5,600
27	1,472	518	3,213
26	1,344	253	2,970
25	1,024	118	2,201
24	915	1,999	1,999
23	819	1,807	1,807
22	282	578	578
U4B+X4	218	538	538
28H	2,067	2,344	4,980
28G	1,581	794	3,487
28F	493	1,563	1,563
28E	365	1,120	1,120
28D	128	356	356
28C	237	775	775
28B	243	430	651
28A	179	256	426
26B	320	138	797
26A	154	454	454
23A	269	511	511
22A	147	300	300
* INCLUDES PRECIPITATION AREA REDUCTION FACTOR FOR COTTONWOOD CREEK BASIN			

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**Middle Tributary Drainage Basin
Planning Study**

**City of Colorado Springs
and El Paso County**



April, 1987

NORTHGATE

USAFA BOUNDARY

USAFA

- LEGEND**
- MAJOR ROADWAY
 - CITY LIMITS
 - NORTHGATE BOUNDARY
 - STREAM
 - DRAINAGE BASIN BOUNDARY
 - MINOR BASIN BOUNDARY
 - MINOR BASIN DESIGNATION /ACREAGE
 - DESIGN POINT
 - PARTIALLY LINED CHANNEL
 - PROPOSED SUB-REGIONAL DETENTION FACILITY

MIDDLE TRIBUTARY DRAINAGE BASIN
PROPOSED MAJOR DRAINAGE FACILITIES

DESIGN POINT	REACH	FACILITY (w x d x l)	DESIGN FLOW (cfs)
1	1A	100 YR OVERFLOW PROVISION	786
1B	25' x 4.0' x 1800' PLC, 8 drops	42" RCP	50
2	2	100 YR OVERFLOW PROVISION	50
3A	5' x 5' CBC		179
3B	54" RCP		104
3C	25' x 4.0' x 1400' PLC, 8 drops		445
4	100 YR OVERFLOW PROVISION		179
5	25' x 4.0' x 2600' PLC, 8 drops		512
6	8' x 8' CBC		560
7	9' x 9' CBC		770
8	100 YR OVERFLOW PROVISION		323
9	DETENTION FACILITY		35 (out)
6A	100 YR OVERFLOW PROVISION		375
6B	48" RCP		223
7A	DETENTION FACILITY		27 (out)
7B	25' x 4.0' x 1400' PLC, 1 drop		779
8A	NATURAL CHANNEL		782
8B	100 YR OVERFLOW PROVISION		161
9A	60" RCP		461
9B	NATURAL CHANNEL		167
10	DETENTION FACILITY		223 (out)
11	NATURAL CHANNEL		893
12	9' x 9' CBC (EXIST.)		779
13	5' x 5' CBC		904
14	12' x 8' CBC (EXIST.)		702
15	DETENTION FACILITY		199
16	48" CMP (EXIST.)		123 (out)
17	EXIST. HORSESHOE CULV. CONFLUENCE MON. CK.		147
			895
			904

* Calculated by the Rational Method.

SCALE 1"=500'

MIDDLE TRIBUTARY DRAINAGE BASIN
PRESENT & DEVELOPED CONDITIONS
FIGURE 3

PREPARED BY:

URS CORPORATION
MAKING TECHNOLOGY WORK
COLORADO SPRINGS, COLORADO

TABLE 6

MIDDLE TRIBUTARY DRAINAGE BASIN
DESIGN PEAK FLOWS FOR
PRESENT AND RECOMMENDED CONDITIONS
24-HOUR STORM

DESIGN POINT	CONTRIBUTING BASINS	PRESENT CONDITIONS		RECOMMENDED CONDITIONS	
		10-YR (cfs)	100-YR (cfs)	10-YR (cfs)	100-YR (cfs)
1	A	84 +	158 +	104 +	190 +
2	C	28 +	50 +	28 +	50 +
3A	D	97 +	179 +	97 +	179 +
3B	H	30 +	55 +	56 +	104 +
4	A-D	142	441	142	445
5	A-E	177	546	177	560
6	A-I, K	234	792	234	770
7	G1	12	45	12	35
8	G2	9	39	9	28
9	G-I	40	161	40	161
10	G-I, K	41	202	41	223
11	A-I, K, L1	237	800	237	779
12	A-I, K, L	238	803	238	782
13	M	37 +	68 +	108 +	199 +
14	J, M, N1	28	129	28	123
15	J, M, N	29	141	29	167
16	A-N	254	881	254	893
17	A-O	259	905	259	904

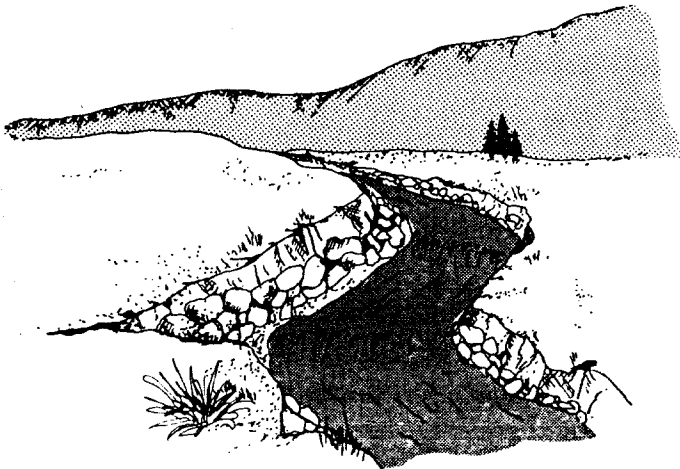
+ Calculated by the Rational Method.

Check out copy #1

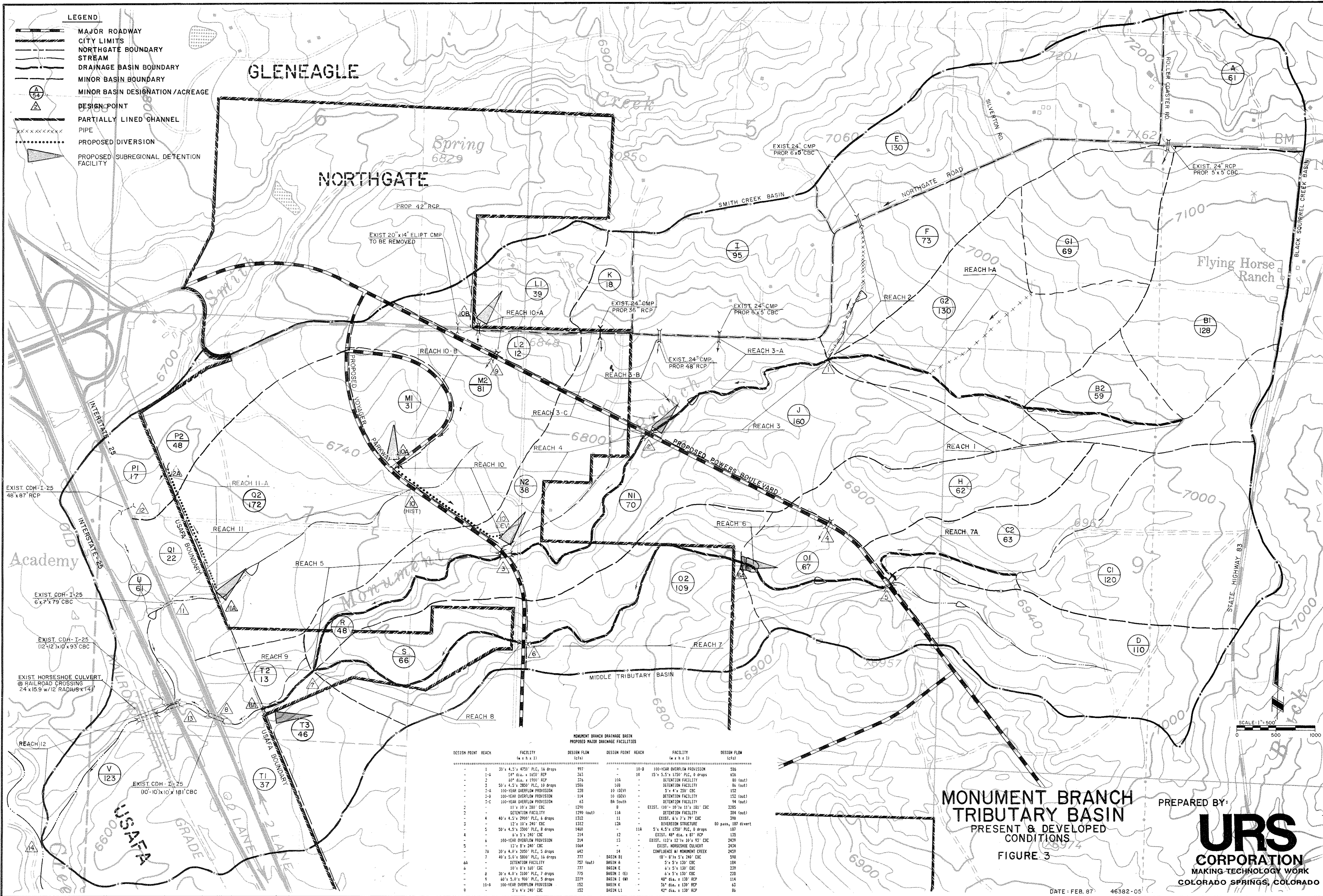
URS
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WORK™

**Monument Branch Drainage Basin
Planning Study**

**City of Colorado Springs
and El Paso County**



April, 1987



- LEGEND**
- MAJOR ROADWAY
 - CITY LIMITS
 - NORTHGATE BOUNDARY
 - STREAM
 - DRAINAGE BASIN BOUNDARY
 - MINOR BASIN BOUNDARY
 - MINOR BASIN DESIGNATION /ACREAGE
 - DESIGN POINT
 - PARTIALLY LINED CHANNEL
 - PIPE
 - PROPOSED DIVERSION
 - PROPOSED SUBREGIONAL DETENTION FACILITY

MONUMENT BRANCH DRAINAGE BASIN
PROPOSED MAJOR DRAINAGE FACILITIES

DESIGN POINT	REACH	FACILITY (w x h x l)	DESIGN FLOW (cfs)	DESIGN POINT	REACH	FACILITY (w x h x l)	DESIGN FLOW (cfs)
1	10-A	30" x 4.5' x 450' PFC, 14 drops	997	10-B	100-YEAR OVERFLOW PROVISION	504	504
1-A	10-A	30" dia. x 1850' RCP	343	10	15" x 5.5' x 1750' PFC, 0 drops	858	858
2	10-A	60" dia. x 1900' RCP	376	10A	DETENTION FACILITY	80	80
3	10-A	50" x 4.5' x 2000' PFC, 10 drops	1556	10B	DETENTION FACILITY	80	80
3-A	10-A	100-YEAR OVERFLOW PROVISION	228	10	5' x 4' x 250' CBC	152	152
3-B	10-A	100-YEAR OVERFLOW PROVISION	114	10 (DEV)	DETENTION FACILITY	152	152
3-C	10-A	100-YEAR OVERFLOW PROVISION	63	10A South	DETENTION FACILITY	94	94
2	10-A	11" x 10" x 280' CBC	1290	8	EXIST. 10" x 10" x 181' CBC	2285	2285
2	10-A	DETENTION FACILITY	118	10A	DETENTION FACILITY	304	304
4	10-A	40" x 4.5' x 2000' PFC, 6 drops	1312	11	EXIST. 6" x 7" x 79' CBC	390	390
3	10-A	12" x 10" x 240' CBC	1312	12A	DIVERSION STRUCTURE	80 pass, 187 divert	
5	10-A	50" x 4.5' x 3000' PFC, 8 drops	1460	11A	5' x 4.5' x 1750' PFC, 0 drops	187	187
4	10-A	6" x 5' x 240' CBC	214	112	EXIST. 48" dia. x 87' RCP	125	125
4	10-A	100-YEAR OVERFLOW PROVISION	214	11	EXIST. 12" x 12" x 10' x 93' CBC	2439	2439
5	10-A	13" x 8" x 240' CBC	1064	11	EXIST. HORSESHOE CULVERT	2434	2434
7A	10-A	30" x 4.0' x 2000' PFC, 5 drops	642	14	CONFLUENCE W/ MONUMENT CREEK	2459	2459
7	10-A	40" x 5.0' x 2000' PFC, 16 drops	777	10A	18" x 5.0' x 240' CBC	398	398
6A	10-A	10" x 8" x 180' CBC	757	10A	5' x 5' x 120' CBC	184	184
6	10-A	10" x 8" x 180' CBC	777	10A	6" x 5' x 130' CBC	239	239
8	10-A	30" x 4.0' x 3100' PFC, 7 drops	775	10A	6" x 5' x 130' CBC	220	220
9	10-A	60" x 5.0' x 900' PFC, 5 drops	2279	10A	48" dia. x 120' RCP	114	114
10-A	10-A	100-YEAR OVERFLOW PROVISION	152	10A	54" dia. x 120' RCP	63	63
9	10-A	5" x 4' x 240' CBC	152	10A	42" dia. x 120' RCP	63	63

**MONUMENT BRANCH
TRIBUTARY BASIN**
PRESENT & DEVELOPED
CONDITIONS
FIGURE 3

PREPARED BY:
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COLORADO SPRINGS, COLORADO

TABLE 6

MONUMENT BRANCH DRAINAGE BASIN
DESIGN PEAK FLOWS FOR
PRESENT AND RECOMMENDED CONDITIONS
24-HOUR STORM

DESIGN POINT	CONTRIBUTING BASINS	PRESENT CONDITIONS		RECOMMENDED CONDITIONS	
		10-YR (cfs)	100-YR (cfs)	10-YR (cfs)	100-YR (cfs)
1	A, B, E-G	386	1124	521	1305
2	A, B, E-G, I-K	453	1391	453	1290
3	A, B, E-G, I-K, N1	469	1448	469	1312
4	H	68 +	124 +	111 +	214 +
5	C, D	195	580	444	1064
6A	C, D, H, O1	252	755	252	757
6	C, D, H, O	254	797	265	777
7	A-K, N, O, R, S (L, M) *	717	2265	717	2235
8A	A-K, N, O, R, S, T2&3 (L, M) *	719	2280	719	2279
8	A-K, N, O, R-T (L, M) *	722	2289	722	2285
10B	L1	43	106	43	86
9	L	58	143	85	152
10A	M1	33	85	33	80
10	L, M	141	378	141	152
11A	(L, M) Q2 **	261	730	261	384
11	(L, M) Q **	264	737	136	390
12A	P2	42	115	80	267 ++
12	P	45	136	102	135
13	A-U	772	2439	772	2439
14	A-V	778	2459	778	2459

NOTES:

- 1) Present conditions include routed flows without existing "stockponds" or proposed detention facilities. Present conditions are assumed to represent historic conditions.
 - 2) Recommended conditions include routed flows through proposed detention facilities.
- * Present conditions do not include basins L & M; recommended conditions include basins L & M due to proposed diversion.
- ** Present conditions include basins L & M; recommended conditions do not include basins L & M due to proposed diversion.
- + These hydrologic calculations are based on the Rational Method.
- ++ Flows in excess of 80 cfs are diverted to DP 11-A.

APPENDIX B
HYDROLOGIC CALCULATIONS

CHAPTER 5 STORM RUNOFF METHODS OF ANALYSIS

5.1 General Statement

This section presents three methodologies for computing storm water runoff in the City/County. These include the Rational Method, the Soil Conservation Service (SCS) Hydrograph procedure and statistical methods. The statistical methods include the Log-pearson Type III frequency distribution and multiple regression analyses. The Rational Method will be used for the determination of runoff from areas of approximately 100 acres or less, and is especially useful for the design of storm sewer systems. The SCS procedure is used to quantify the effects of urbanization to determine peak flows for large drainage areas, and to design storm water storage facilities.

The various runoff models selected for use in evaluating drainage in the City/County are broken down by basin area restrictions as listed below:

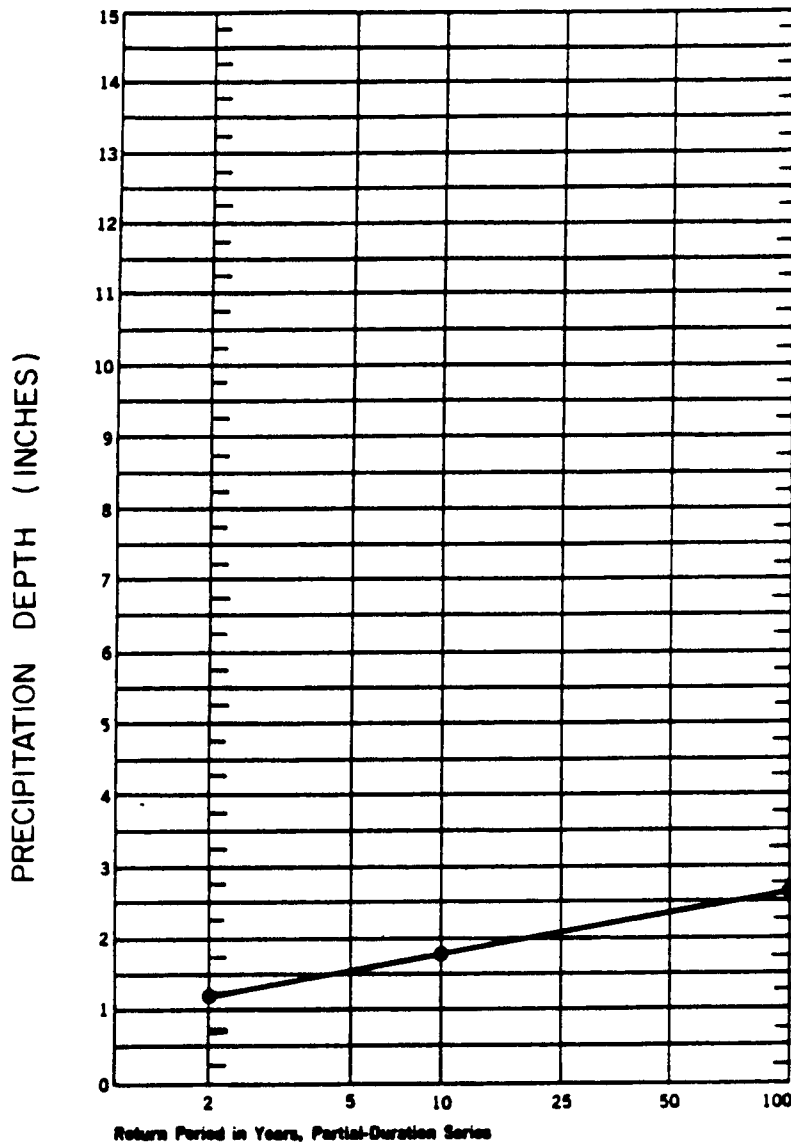
<u>Drainage Basin Size</u>	<u>Runoff Methodology</u>
100 acres or less	Rational Method
Greater than 100 acres	SCS Hydrograph Procedure
Major Basins (greater than 10 sq. miles)	Statistical or Computer Models

The engineer must secure approval from the appropriate design review agencies before utilizing different methods.

Acceptable computer simulation models used in hydrologic evaluation are listed in the following Table. These computer models, designed for general use, should be calibrated for local use, and based on locally available data. Updated versions and variations of the models are available, but any model used for storm water design in the City/County should be carefully calibrated with local data and methods to ensure consistent results for all basin studies in the City/County. Several of these models listed are available in IBM PC compatible forms. Many of the storm sewer routing programs which utilize the Rational Method of analysis to develop basin hydrology are excellent analytical tools. Use of a computer modeling tool must be approved by the City/County engineering staff.

It should be recognized that the engineer must compute storm water runoff for at least the 10-year and 100-year storms at all design points to conform to the City/County design criteria. The design of initial and major storm drainage systems will require checking both runoff events to ensure all drainage criteria are met. The fully developed, ultimate condition storm water runoff for the Basins is to be analyzed unless otherwise determined by the City/County.

9/30/90



EXAMPLE

2 yr. 1 hr rainfall (calculated) = 1.19"
 100 yr. 1 hr rainfall (calculated) = 2.64"
 10 yr. 1 hr rainfall (interpolated) = 1.78"

REFERENCE : NOAA Atlas 2, Volume 3 - Colorado

NOTE: This example is for Colorado Springs as indicated on the Isopluvials.



HDR Infrastructure, Inc.
 A Centerra Company

The City of Colorado Springs / El Paso County
 Drainage Criteria Manual

RAINFALL DEPTH - DURATION RELATIONSHIP

Date
 OCT. 1987

Figure
 5 - 6

TABLE 5-4
RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL
COVER COMPLEXES - RURAL CONDITIONS
(Antecedent Moisture Condition II, and Ia = 0.2 S)
 (From: U.S. Dept. of Agriculture,
 Soil Conservation Service, 1977)

<u>Land Use</u>	<u>Cover Treatment or Practice</u>	<u>Hydrologic Condition</u>	<u>Runoff Curve Number by Hydrologic Soil Group</u>			
			<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
Fallow	Straight Row	----	77	86	91	94
Row Crops	Straight Row	Poor	72	81	88	91
	Straight Row	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	Contoured	Good	65	75	82	86
	Cont. & Terraced	Poor	66	74	80	82
	Cont. & Terraced	Good	62	71	78	81
Small Grain	Straight Row	Poor	65	76	84	88
	Straight Row	Good	63	75	83	87
	Contoured	Poor	63	74	82	85
	Contoured	Good	61	73	81	84
	Cont. & Terraced	Poor	61	72	79	82
	Cont. & Terraced	Good	59	70	78	81
Close-seeded legumes <u>1/</u> or rotation meadow	Straight Row	Poor	66	77	85	89
	Straight Row	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	Contoured	Good	55	69	78	83
	Cont. & Terraced	Poor	63	73	80	83
	Cont. & Terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	Contoured	Fair	25	59	75	83
	Contoured	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) <u>2/</u> (hard surface) <u>2/</u>		----	72	82	87	89
		----	74	84	90	92

1/ Close-drilled or broadcast
2/ Including right-of-way

TABLE 5-5
RUNOFF CURVE NUMBERS FOR HYDROLOGIC SOIL
COVER COMPLEXES - URBAN AND SUBURBAN CONDITIONS 1/
(Antecedent Moisture Condition II)
(From: U.S. Dept. of Agriculture,
Soil Conservation Service, 1977)

<u>Land Use</u>	<u>Hydrologic Soil Group</u>			
	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>
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: <u>2/</u>				
<u>Acres per Dwelling Unit</u>	<u>Average %</u>			
	<u>Impervious</u>	<u>3/</u>		
1/8 acre or less	65	77*	85	90
1/4 acre	38	61*	75	83
1/3 acre	30	57*	72	81
1/2 acre	25	54*	70	80
1 acre	20	51*	68	79
Paved parking lots, roofs, driveways, etc.	98	98	98	98
Streets and Roads:				
paved with curbs and storm sewers	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 the National Engineering Handbook (U.S. Dept. of Agriculture, Soil Conservation Service, 1972).

2/ 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.

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

* Not to be used wherever overlot grading or filling is to occur.

One-Hour Point Rainfall

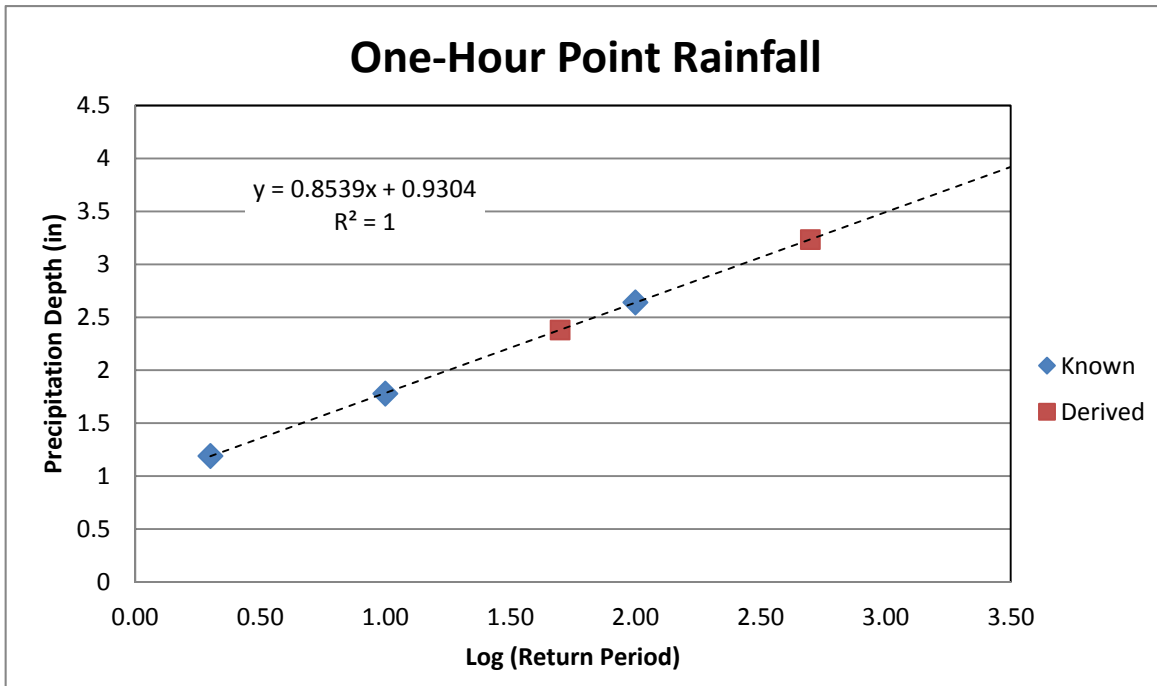
2/16/2012

Known One-Hour Point Rainfall from Co. Springs Drainage Manual Figure 5-6

Return Period	Log RP	1-Hr Pt Rainfall
2	0.30	1.19
10	1.00	1.78
100	2.00	2.64

Derived One-Hour Point Rainfall

Return Period	Log RP	1-Hr Pt Rainfall
50	1.70	2.38
500	2.70	3.24



Runoff and Peak Flow Calculations

I-25 North Design Build
(Rational Method Procedure)

Basin ID	Area (ac)	Imperv. (%)	T _c (min)	Q ₁₀ (cfs)	Q ₅₀ (cfs)	Q ₁₀₀ (cfs)	Q ₅₀₀ (cfs)
2	12.1	2.00	17.90	6.2	16.4	21.2	37.9
3	16.7	2.00	20.26	8.5	22.2	28.7	50.5
5	38.5	2.00	19.92	17.3	47.0	61.2	107.1
6	49.7	7.63	27.64	17.0	42.9	55.8	103.8
7	44.2	11.81	28.03	18.6	42.1	53.7	96.0
12	26.0	29.99	22.90	28.9	51.7	62.0	92.7
16	11.6	10.86	19.43	9.1	19.7	24.6	40.2
17	24.8	20.97	21.38	23.8	46.0	56.0	87.0
25	16.7	5.85	18.53	11.3	26.7	33.8	56.9
27	31.9	19.21	27.19	24.3	48.7	59.8	93.4
29	96.4	8.55	26.74	60.3	134.6	169.0	276.1
31	36.7	14.41	25.49	27.4	56.7	70.2	112.5
32	53.5	51.71	26.77	76.3	121.4	141.0	195.9
33	38.2	81.91	25.94	77.4	112.1	126.6	163.6
34	24.6	70.56	24.34	46.2	68.8	78.5	103.9
37	75.6	35.53	32.01	74.4	129.1	153.5	224.4

C-Factors
I-25 North Design Build
(Rational Method Procedure)

BASIN ID / DESIGN POINT	% IMP	5 YEAR	10 YEAR	50 YEAR	100 YEAR	500 YEAR
2	0.02	0.08	0.14	0.27	0.32	0.47
3	0.02	0.09	0.15	0.29	0.33	0.48
4	0.22	0.19	0.25	0.37	0.41	0.52
5	0.02	0.08	0.13	0.26	0.31	0.44
6	0.08	0.06	0.12	0.22	0.26	0.39
7	0.12	0.09	0.14	0.25	0.28	0.41
12	0.30	0.29	0.34	0.46	0.49	0.60
16	0.11	0.16	0.22	0.36	0.40	0.54
17	0.21	0.23	0.28	0.41	0.45	0.57
25	0.06	0.12	0.19	0.33	0.38	0.52
27	0.19	0.19	0.26	0.39	0.43	0.54
29	0.09	0.13	0.21	0.35	0.40	0.53
31	0.14	0.18	0.24	0.38	0.42	0.55
32	0.52	0.43	0.48	0.57	0.60	0.67
33	0.82	0.64	0.67	0.72	0.74	0.78
34	0.71	0.56	0.60	0.67	0.68	0.74
37	0.36	0.31	0.37	0.48	0.51	0.61

Time of Concentration
I-25 North Design Build
(Rational Method Procedure)

BASIN DATA			INIT. OVERLAND TIME (Ti)			TRAVEL TIME (Tt)					TOTAL	Max Tc	FINAL Tc
BASIN ID	C5	AREA (ACRES)	LENGTH (FT)	SLOPE (FT/FT)	Ti (Min.)	LENGTH (FT)	SLOPE (FT/FT)	VEL. (FPS)	Convey Coef. Cv	Tt (Min.)**	Ti+Tt (Min.)	(Minutes)	(Minutes)
2	0.08	12.05	300	0.032	21.6	1123	0.013	0.81	7	23.2	44.8	17.9	17.9
3	0.09	16.68	300	0.017	26.3	1547	0.015	0.85	7	30.4	56.7	20.3	20.3
4	0.19	61.40	300	0.033	19.1	1943	0.031	1.41	8	23.0	42.1	22.5	22.5
5	0.13	38.50	500	0.019	31.9	1285	0.024	1.08	7	19.8	51.6	19.9	19.9
6	0.12	49.74	500	0.026	28.9	2676	0.022	1.49	10	30.0	58.9	27.6	27.6
7	0.14	44.24	300	0.020	23.9	2945	0.019	1.39	10	35.2	59.1	28.0	28.0
8	Elkhorn - Flows computed using HEC-HMS												
9	Flows computed using HEC-HMS												
10	Flows computed using HEC-HMS												
11	Flows computed using HEC-HMS												
12	0.34	26.01	500	0.032	20.8	1821	0.026	3.23	20	9.4	30.3	22.9	22.9
13	Black Squirrel - Flow information from Planning Study												
14	Middle Trib - Flow information from Planning Study												
15	Flow information from Planning Study												
16	0.22	11.56	300	0.032	18.6	1397	0.023	3.02	20	7.7	26.4	19.4	19.4
17	0.28	24.78	200	0.017	17.6	1848	0.021	2.92	20	10.5	28.2	21.4	21.4
18	Monument Branch - Flow information from Planning Study												
19	Flow information from Planning Study												
20	Flow information from Planning Study												
21	Flows computed using HEC-HMS												
22													
23	Black Forest Drainage Basin - Flow information from Planning Study.												
24	Black Forest Drainage Basin - Flow information from Planning Study.												
25	0.12	16.65	300.00	0.03	20.57	1234.94	0.12	6.97	20	2.95	23.52	18.53	18.53
26	Black Forest Drainage Basin - Flow information from Planning Study.												
27	0.19	31.89	500.00	0.03	24.72	2594.32	0.04	3.83	20	11.30	36.02	27.19	27.19
28	Flows computed using HEC-HMS												
29	0.18	96.40	500.00	0.03	24.68	2513.39	0.05	2.32	10	18.07	42.75	26.74	26.74
30	Jackson Creek - Flows computed using HEC-HMS												
31	0.18	36.70	500.00	0.02	27.69	2288.57	0.03	3.18	20	11.98	39.67	25.49	25.49
32	0.43	53.53	300.00	0.03	14.00	2719.02	0.03	3.21	20	14.12	28.12	26.77	26.77
33	0.64	38.16	300.00	0.01	16.60	2568.56	0.03	3.42	20	12.53	29.12	25.94	25.94
34	0.56	24.59	300.00	0.03	11.35	2372.78	0.02	3.04	20	12.99	24.34	24.85	24.34
35	Flows computed using HEC-HMS												
36	Teachout Creek - Flows computed using HEC-HMS												
37	0.31	75.58	300.00	0.02	20.90	3662.29	0.03	3.62	20	16.86	37.76	32.01	32.01
38	Flows computed using HEC-HMS												
39	Flows computed using HEC-HMS												

Intensity and Flow Calculations
I-25 North Design Build
(Rational Method Procedure)

Basin Data			Return Period											
			10-Year			50-Year			100-Year			500-Year		
Basin ID	Area (acres)	Tc (min)	C10	I10 (in/hr)	Q10 (cfs)	C50	I50 (in/hr)	Q50 (cfs)	C100	I100 (in/hr)	Q100 (cfs)	C500	I500 (in/hr)	Q500 (cfs)
2	12.1	17.9	0.14	3.71	6.16	0.27	4.96	16.38	0.32	5.50	21.24	0.47	6.75	37.87
3	16.7	20.3	0.15	3.48	8.49	0.29	4.65	22.21	0.33	5.16	28.70	0.48	6.33	50.54
4	61.4	22.5	0.25	3.29	51.07	0.37	4.40	100.15	0.41	4.88	122.71	0.52	5.99	192.78
5	38.5	19.9	0.13	3.51	17.28	0.26	4.69	47.02	0.31	5.20	61.23	0.44	6.39	107.06
6	49.7	27.6	0.12	2.93	16.98	0.22	3.92	42.94	0.26	4.34	55.79	0.39	5.33	103.76
7	44.2	28.0	0.14	2.91	18.59	0.25	3.89	42.14	0.28	4.31	53.70	0.41	5.29	95.99
12	26.0	22.9	0.34	3.26	28.91	0.46	4.35	51.74	0.49	4.83	61.98	0.60	5.93	92.69
16	11.6	19.4	0.22	3.55	9.09	0.36	4.75	19.71	0.40	5.27	24.62	0.54	6.47	40.19
17	24.8	21.4	0.28	3.38	23.84	0.41	4.52	45.97	0.45	5.01	56.03	0.57	6.15	87.04
25	16.7	18.5	0.19	3.64	11.25	0.33	4.87	26.66	0.38	5.40	33.84	0.52	6.63	56.88
27	31.9	27.2	0.26	2.96	24.33	0.39	3.95	48.66	0.43	4.39	59.76	0.54	5.38	93.42
29	96.4	26.7	0.21	2.99	60.33	0.35	3.99	134.62	0.40	4.43	169.03	0.53	5.43	276.13
31	36.7	25.5	0.24	3.07	27.41	0.38	4.10	56.74	0.42	4.55	70.21	0.55	5.58	112.52
32	53.5	26.8	0.48	2.98	76.31	0.57	3.99	121.37	0.60	4.43	140.96	0.67	5.43	195.93
33	38.2	25.9	0.67	3.04	77.38	0.72	4.06	112.12	0.74	4.51	126.63	0.78	5.53	163.57
34	24.6	24.3	0.60	3.15	46.16	0.67	4.21	68.84	0.68	4.67	78.46	0.74	5.73	103.87
37	75.6	32.0	0.37	2.69	74.41	0.48	3.59	129.13	0.51	3.99	153.49	0.61	4.89	224.36

One-Hour Point Rainfall

Return Period	1-Hr Point Rainfall (in)
10	1.78
50	2.38
100	2.64
500	3.24

HEC-HMS Input Information

I-25 North Design-Build

Basin Models

Basin: I25 Crossings

Last Modified Date: 19 July 2012

Last Modified Time: 21:54:27

Version: 3.5

Filepath Separator: \

Unit System: English

Missing Flow To Zero: No

Enable Flow Ratio: No

Allow Blending: No

Compute Local Flow At Junctions: No

Enable Sediment Routing: No

Enable Quality Routing: No

End:

Subbasin: C8

Canvas X: 3199565.6092636483

Canvas Y: 1420536.6221667805

Area: 0.5137

Canopy: None

Surface: None

LossRate: SCS

Percent Impervious Area: 61.2

Curve Number: 80.44

Transform: SCS

Lag: 40.0

Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C9

Canvas X: 3196755.913011347

Canvas Y: 1421283.88180835

Area: 0.5526

Canopy: None

Surface: None

LossRate: SCS

Percent Impervious Area: 35.6

Curve Number: 76.40

Transform: SCS

Lag: 55.6

Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: C10
Canvas X: 3197712.405352556
Canvas Y: 1423137.0857194425
Area: 0.3473

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 37.3
Curve Number: 79.64

Transform: SCS
Lag: 61.4
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: C11
Canvas X: 3196038.54375544
Canvas Y: 1423764.783818361
Area: 0.1768

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 65.6
Curve Number: 87.69

Transform: SCS
Lag: 30.4
Unitgraph Type: STANDARD

Baseflow: None
End:

Subbasin: C21
Canvas X: 3191166.410892407
Canvas Y: 1434011.9491912588
Area: 0.1434

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 4.9
Curve Number: 74.57

Transform: SCS
Lag: 24.3
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C28

Description: Basins 33 & 34 of the Black Forest Drainage Basin
Planmning Study

Canvas X: 3186738.913045646
Canvas Y: 1441693.1415800515
Area: 0.2

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 8.5
Curve Number: 69.04

Transform: SCS
Lag: 28.8
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C30

Description: Jackson Creek main drainage basin.

Canvas X: 3185508.8659240287
Canvas Y: 1444446.104185576
Area: 4.02

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 15.7
Curve Number: 72.61

Transform: SCS
Lag: 80.2
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C35

Description: Subwatershed of the Teachout Creek Drainage Basin

Canvas X: 3182814.476990962
Canvas Y: 1450420.6187762893
Area: 0.197

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 11.6
Curve Number: 74.97

Transform: SCS
Lag: 29.9
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C36

Description: Teachout Creek Main Drainage basin
Canvas X: 3182638.755973588
Canvas Y: 1451884.9605877385
Area: 0.93

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 16.1
Curve Number: 73.17

Transform: SCS
Lag: 33.9
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C38

Description: Subwatershed of the Teachout Creek Drainage Basin.
Canvas X: 3181994.4455765504
Canvas Y: 1454462.2021758894
Area: 0.24

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 27.0
Curve Number: 73.60

Transform: SCS
Lag: 35.0
Unitgraph Type: STANDARD

Baseflow: None

End:

Subbasin: C39

Description: Subwatershed of the Teachout Creek Drainage Basin
Canvas X: 3181935.8719040924
Canvas Y: 1455867.9703148808
Area: 0.39

Canopy: None

Surface: None

LossRate: SCS
Percent Impervious Area: 25.4
Curve Number: 74.04

Transform: SCS
Lag: 33.2
Unitgraph Type: STANDARD

Baseflow: None

End:

Basin Schematic Properties:

Last View N: 1459324.8234103902
Last View S: 1425820.68276443
Last View W: 3163343.058506789
Last View E: 3197653.140680315
Maximum View N: 1459439.9579143282
Maximum View S: 1393583.0216617882
Maximum View W: 3181438.7685181946
Maximum View E: 3236203.606606409
Extent Method: Elements Maps
Buffer: 0
Draw Icons: Yes
Draw Icon Labels: Yes
Draw Map Objects: No
Draw Gridlines: Yes
Draw Flow Direction: No
Fix Element Locations: No
Fix Hydrologic Order: No
Map: hec.map.aishape.AiShapeMap
Map File Name: maps\subwatershed_clean.shp
Minimum Scale: -2147483648
Maximum Scale: 2147483647
Map Shown: Yes

End:

Meteorologic Models

Meteorology: 10 Year

Last Modified Date: 11 July 2012
Last Modified Time: 18:30:36
Version: 3.5
Unit System: English
Precipitation Method: SCS Storm
Short-Wave Radiation Method: None
Long-Wave Radiation Method: None
Snowmelt Method: None
Evapotranspiration Method: No Evapotranspiration
Use Basin Model: I25 Crossings

End:

Precip Method Parameters: SCS Storm
Storm Depth: 3.0
Storm Type: Type II

End:

Meteorology: 50 Year
Last Modified Date: 11 July 2012
Last Modified Time: 18:30:37
Version: 3.5
Unit System: English
Precipitation Method: SCS Storm
Short-Wave Radiation Method: None
Long-Wave Radiation Method: None
Snowmelt Method: None
Evapotranspiration Method: No Evapotranspiration
Use Basin Model: I25 Crossings

End:

Precip Method Parameters: SCS Storm
Storm Depth: 3.8
Storm Type: Type II

End:

Meteorology: 100 Year
Last Modified Date: 11 July 2012
Last Modified Time: 18:30:35
Version: 3.5
Unit System: English
Precipitation Method: SCS Storm
Short-Wave Radiation Method: None
Long-Wave Radiation Method: None
Snowmelt Method: None
Evapotranspiration Method: No Evapotranspiration
Use Basin Model: I25 Crossings

End:

Precip Method Parameters: SCS Storm
Storm Depth: 4.2
Storm Type: Type II

End:

Meteorology: 500 Year
Last Modified Date: 11 July 2012
Last Modified Time: 18:30:36
Version: 3.5
Unit System: English
Precipitation Method: SCS Storm
Short-Wave Radiation Method: None
Long-Wave Radiation Method: None
Snowmelt Method: None
Evapotranspiration Method: No Evapotranspiration
Use Basin Model: I25 Crossings

End:

Precip Method Parameters: SCS Storm

Storm Depth: 5.2
Storm Type: Type II

End:

HEC-HMS Peak Flow Calculations
I-25 North Design Build
(SCS Procedure)

Basin ID	Area (ac)	Peak Flow (cfs)			
		10 YR	50 YR	100 YR	500 YR
C8	328.768	364.4	483.8	544.5	576.4
C9	353.664	229.1	323.0	371.9	497.8
C10	222.272	148.1	205.5	235.1	310.6
C11	113.152	170.6	222.2	248.1	313.0
C21	91.776	65.2	105.3	126.7	183.1
C28	128	61.3	104.6	128.4	192.5
C30	2572.8	837.0	1295.5	1542.3	2194.4
C35	126.08	88.7	137.6	163.6	231.6
C36	595.2	377.7	582.8	692.5	980.4
C38	153.6	115.0	168.7	197.0	270.8
C39	249.6	192.6	283.6	331.6	456.5