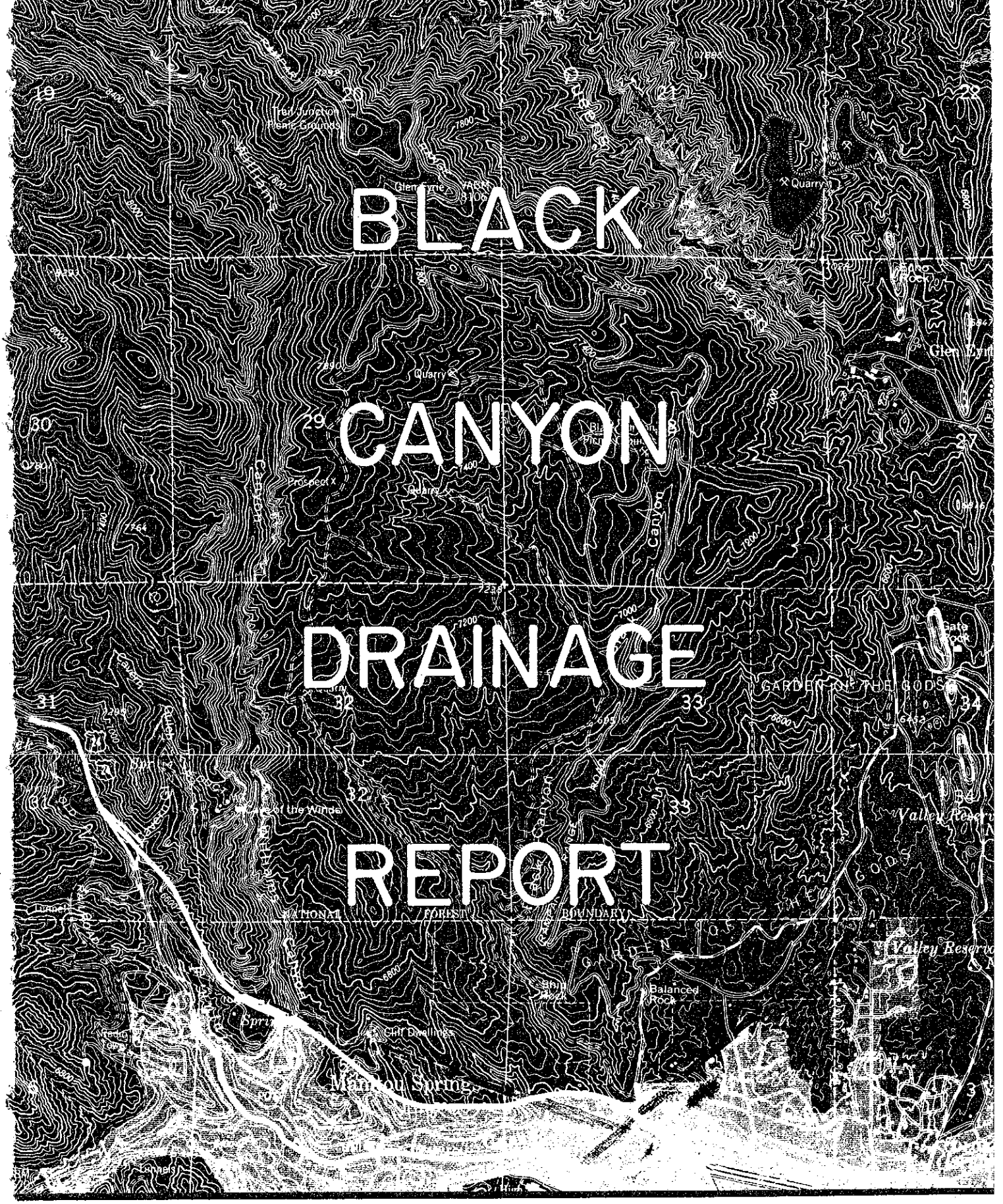


Prepared By:

LEIGH WHITEHEAD & ASSOCIATES
324 Cucharras
Colorado Springs, Colorado

LEIGH WHITEHEAD & ASSOCIATES

CONSULTING ENGINEERS AND SURVEYORS
324 EAST CUCHARRAS • PHONE 636-5179
COLORADO SPRINGS, COLORADO 80903

January 7, 1972

Director of Public Works
City Hall
Colorado Springs, Colorado

Re: Black Canyon and Garden of the Gods Drainage Fees

Dear Mr. Miller:

Since B & H Development Company owns all privately owned property within the Black Canyon Basin and the upper reaches of the Garden of the Gods Basin, we propose that the drainage fees be covered by actual construction of approved drainage facilities and/or letter of credit as the acreage is developed.

We believe the drainage fees should be assumed to be the same per acre in both basins, until such time as the Garden of the Gods Basin is studied and fees established by the major owner. B & H Development owns only about 28% of this basin.

Very truly yours,

LEIGH WHITEHEAD & ASSOCIATES

Gary W. Albertson

Gary W. Albertson

GWA:nam

BLACK CANYON

DRAINAGE REPORT

Project Number 71018

Prepared For:

B & H Development Company
Colorado Springs, Colorado

Prepared By:

LEIGH WHITEHEAD & ASSOCIATES
Consulting Engineers
324 East Cucharras Street
Colorado Springs, Colorado

January 1972

LEIGH WHITEHEAD & ASSOCIATES

CONSULTING ENGINEERS AND SURVEYORS
324 EAST CUCHARRAS • PHONE 636-5179
COLORADO SPRINGS, COLORADO 80903

January 7, 1972

Director of Public Works
City of Colorado Springs
Colorado Springs, Colorado

Dear Sir:

Enclosed herewith is the engineering study of the drainage for Black Canyon.

This report describes precipitation runoff as affected by proposed planned development and the proposed method of conveying subject runoff.

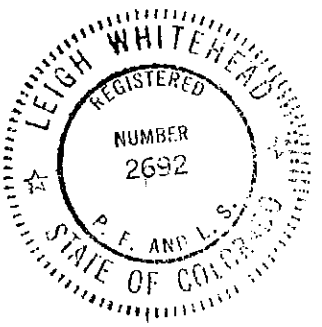
Very truly yours,

LEIGH WHITEHEAD & ASSOCIATES

Gary W. Albertson

Gary W. Albertson

GWA/nam



Leigh Whitehead

Leigh Whitehead, P.E., R.L.S. Colo. 2692

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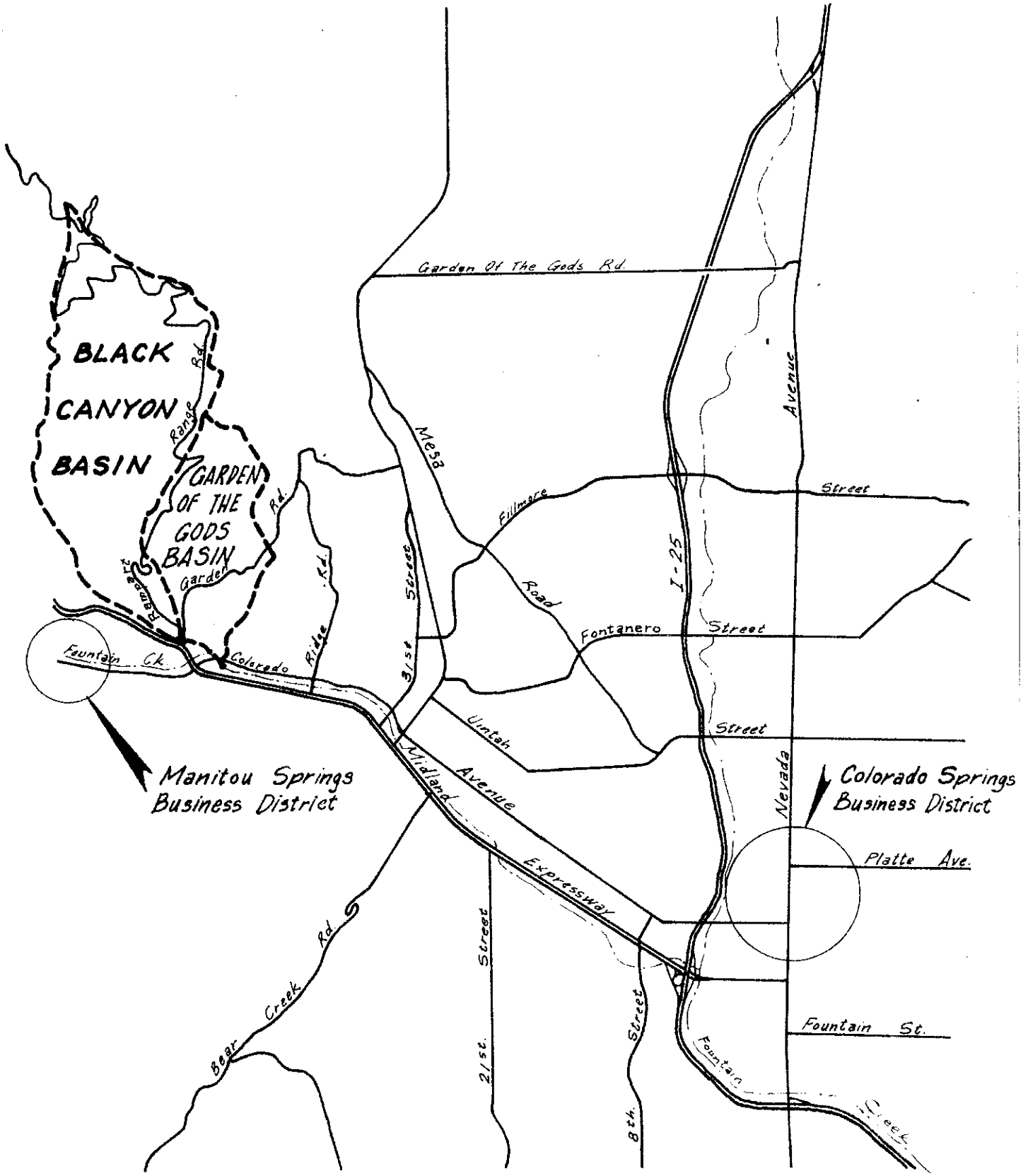
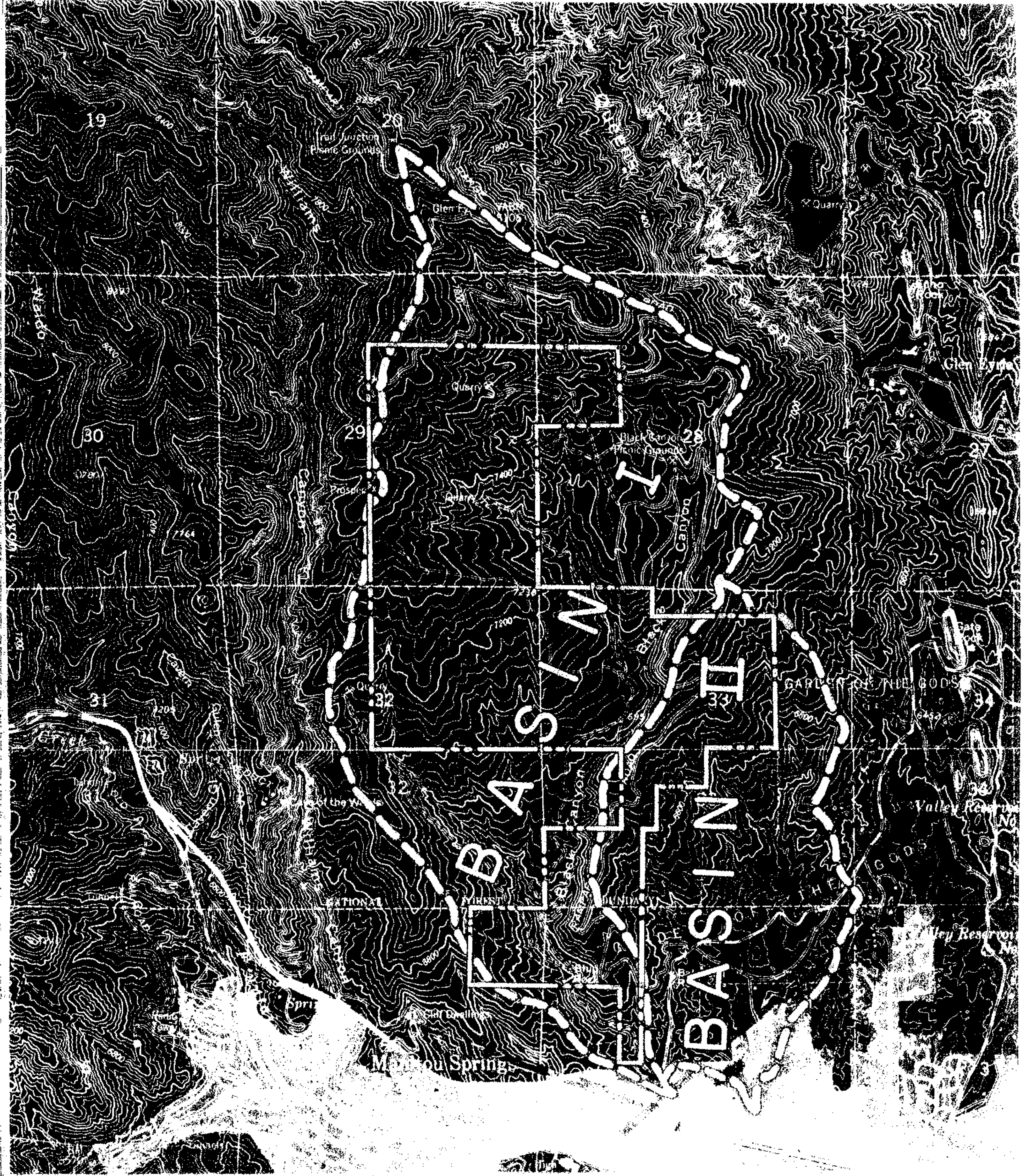


Vicinity Map



LEGEND

RIDGE LINE

PROPERTY LINE

0 1000' 2000'

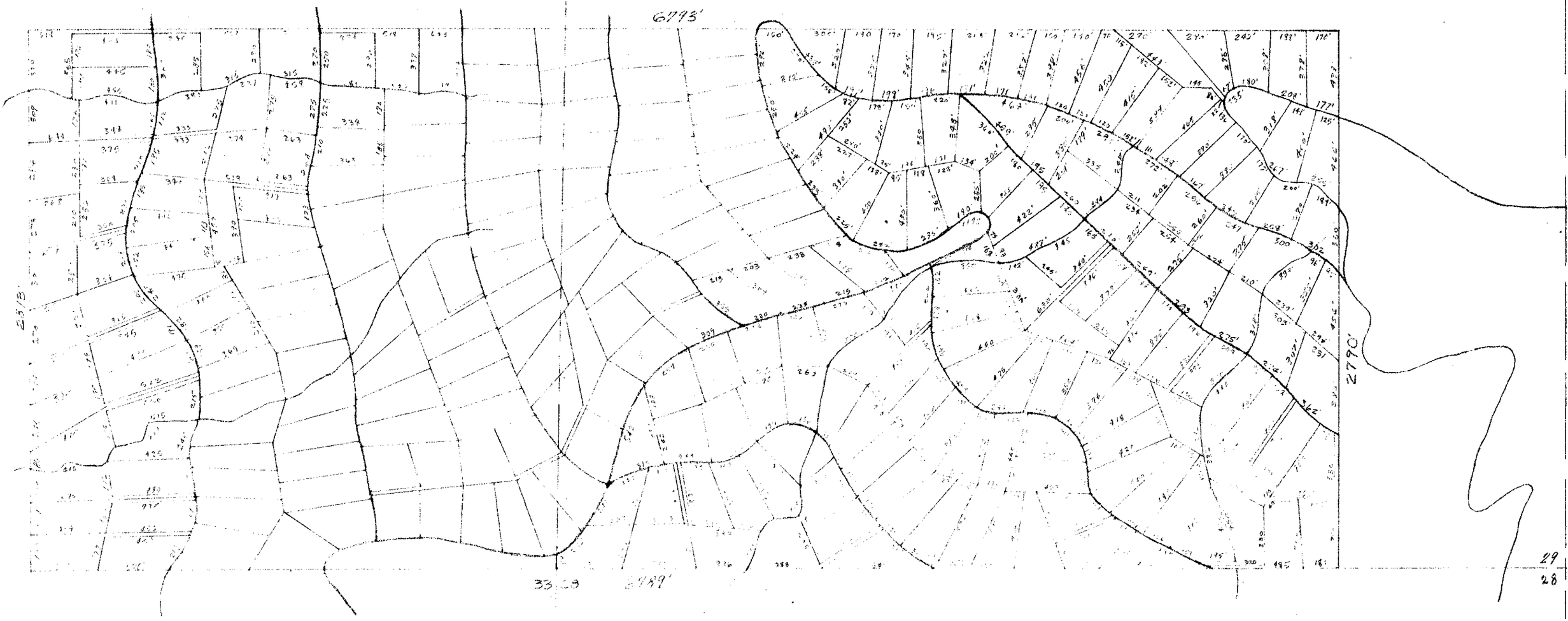
CONTOUR INTERVAL = 40'
FROM U.S.G.S. MAP DATED 1961.

AREA CONTOURS BLACK CANYON & GARDEN OF THE GODS	
DATE: 12-6-71	PROJ. NO. 71018

GENERAL DESCRIPTION

Black Canyon Drainage Basin lies in the West portion of Colorado Springs and empties directly into Fountain Creek at Manitou Springs. Black Canyon is located generally West of the Garden of the Gods, East of Williams Canyon and North of U. S. Highway 24. Black Canyon is normally dry.

The drainage area considered contains 1380 acres and slopes toward the South at 9 percent. This property will be subdivided into approximately one and one-half acre tracts.



Housing Density For Area
436.75 Acres ~ 1771 Lots in
East half Sectio. 29 North
East Quarter Section 32
1.01 Ac/Unit 12/71

SCALE: 1" = 500'

DETAILED REPORT

This report is based on the following:

Rainfall: Since Black Canyon is a major drainage green belt collection system, the major channel flows were calculated using 3.5 inch intensity in one hour, and 100 year frequency. See major channel flow characteristics. Each subbasin was calculated using 2 inch intensity for one hour duration and 50 year frequency. See calculations for 2" in 1 hour storm.

Soils: Weird earth and rock forms caused by water and wind erosion. The soil is composed of up to two feet of decomposed granite, limestone and red sandstone deposit on larger rocks. There are many areas of exposed rocks - especially in and along the drainage courses. Some granite rock is exposed in the lower reaches. At the top of the drainage basins, a red colored topsoil is prominent.

Method: Synthetic Hydrograph routing using $Q_p = \frac{484xAxQ}{T_p}$ where "A" = area in square miles, "T_p" = time of peak in hours = T_c x 0.6 + 0.5. "T_c" is by nomograph by U.S. Soil Conservation Service Method. "i" is taken at a theoretical 2.0 inches of rainfall and "c" is used as 0.6 in the calculation of Q in each subbasin. See Calculation Sheet. Since time of peak (T_p) is essentially the same for each subbasin, accumulative totalling of the flow peak (Q_p) increments would yield data to construct a conservative synthetic Hydrograph at any point of interest. These totals assume perfect peak time matching, and are higher than true maximum probable flows for a 2 inch - one hour - 50 year storm.

Criteria - Major Channel Flow:

Since Black Canyon is a major drainage basin, the major channel flow characteristics were recalculated using Synthetic Hydrograph routing where $Q_p = \frac{484xAxQ}{T_p}$ as before. Letting Q = 3.5 inches in one hour x 0.6 runoff factor = 2.1 inches and T_p equal the time required for the flow peak to reach each point of interest.

Velocity must be estimated or calculated from a calculated hydraulic radius (which comes from an estimated cross-sectional flow area and wetted perimeter). From pictures of the area, memory and a few trial calculations of Manning Formula for V and Q, (assuming n=0.04) V is assumed at 25 f.p.s. (17 mph) to shorten the time of peak (T_p) and thereby yield a conservatively high Q_p. See Major Channel Flow Characteristics.

External Drainage:

There is no external drainage entering the area of this study.

Internal Drainage:

After a field trip walk through the area, the natural unworked channel bed was determined to be the most practical and least ecologically disturbing channel.

Street design planning in this drainage basin indicates the streets will be paved but there will be no curb and gutter; therefore, there will be no street drainage capacities with which to be concerned, no storm drainage piping nor storm inlets, per se.

Reference is made to the drainage plan included in this report for further explanation of the proposed method of handling storm runoff.

Structure Sizing: After calculating the runoff (Q_p) for an entire sub-basin, scaling the distances down the drainage courses to or planimetering drainage area above each road crossing point, proportion calculated and multiplied by sub-basin runoff or major channel flow to get flow at each crossing, the structures were sized using 5 f.p.s. velocity. In the main channel, the structures were sized using a conservative 15 to 20 f.p.s.

Structures are denoted by sub-basin designation and number on the drainage plan.

Structure Costs: Sized structure material, fabrication and delivery costs were priced (from local sales engineers) per lineal foot for pipe-arch corrugated metal pipe. This choice was made to maintain the flow profile as shallow as practical to take advantage of natural channel conditions. Lengths of pipe were determined on the basis of proposed shoulder-to-shoulder width of 36 feet and 2:1 roadway embankment slopes 10 feet high above channel pipe and continued through pipe to channel bed.

Rip-rap or wing-and-head wall, road traffic barriers and bedding costs were not individually priced; however, a multiplier of 2 was used to approximate the labor and material costs of each completely installed culvert pipe.

Outfall Point:

Black Canyon accumulates 2774 c.f.s. discharge during the 100 year storm. See Major Channel Flow Characteristics and synthetic hydrograph for Point 1.

Just above Point 1 (Black Canyon outfall to Fountain Creek), East of U.S. Highway 24, under El Paso Boulevard, there is an existing 6 foot x 12 foot concrete box culvert that was reliably reported to be flowing at full capacity during a summer storm in 1969. This structure appears to be too small for the 100-year storm.

Structures I-A-1 and I-A-2 will be installed by the U.S. Forest Service under the realligned Rampart Range Road. See Drainage Plan. At this time these two structures are planned to be 6 x 12 foot concrete box culverts. These structures appear to be too small for the 100-year storm. See Drainage Structures and Costs, Structures I-A-1 and I-A-2.

RECOMMENDATIONS AND CONCLUSIONS

We have found from our analysis of the storm drainage in this study that the drainage facilities as shown on the Drainage Plan will provide proper drainage of the area.

Since the Black Canyon Drainage Basin is relatively "virgin" country with many trees, boulders and brush in the normally dry channel bottom and proximity, it abounds in natural beauty. It is strongly recommended that it be thus preserved and maintained wherever possible throughout the development stage and thusly conveyed to all future owners and visitors. We suggest a minimum 50 foot drainage easement in all sub-basins(centered on all existing channel beds) so that no fences, buildings or encroachments whatsoever (except necessary utilities) could be built therein or over or disturb in any way the existing beauty of the area; thus preserving stream flow as is. Utilities should cross the channels only within street rights-of-way or parallel the channels other than in the stream flow area.

BLACK CANYON DRAINAGE REPORT

SUBBASIN - CALCULATIONS FOR 2" IN 1 HOUR STORM

SUB-BASIN	Ac.	SQUARE MILE	LENGTH IN FEET	HEIGHT IN FEET	T_c HOURS	T_p HOURS	Q_p c.f.s.	ACCUM. TOTAL
						$.6 \times T_c + .5 =$	$Q_p = \frac{484 \times A \times Q}{T_p}$	c.f.s.
I-K	132.71	0.207	5500	980	0.175	0.605	198.72	198.72
I-J	72.39	0.113	4200	680	0.150	0.590	111.24	309.96
I-I	39.74	0.062	2800	250	0.140	0.584	61.66	371.62
I-H	82.32	0.129	5000	700	0.180	0.608	123.23	494.85
I-G	290.26	0.454	7300	1060	0.235	0.641	411.36	906.21
I-F	126.32	0.197	4300	190	0.255	0.653	175.22	1081.43
I-E	169.60	0.265	6700	1030	0.220	0.632	243.53	1324.96
I-D	156.12	0.244	5600	970	0.180	0.608	233.08	1558.04
I-C	152.67	0.239	5200	460	0.220	0.632	219.64	1777.68
I-B	35.48	0.055	1300	150	0.070	0.542	58.94	1836.62
I-A	122.06	0.191	4600	170	0.285	0.671	165.32	2001.94
TOTALS	1379.67	2.156						

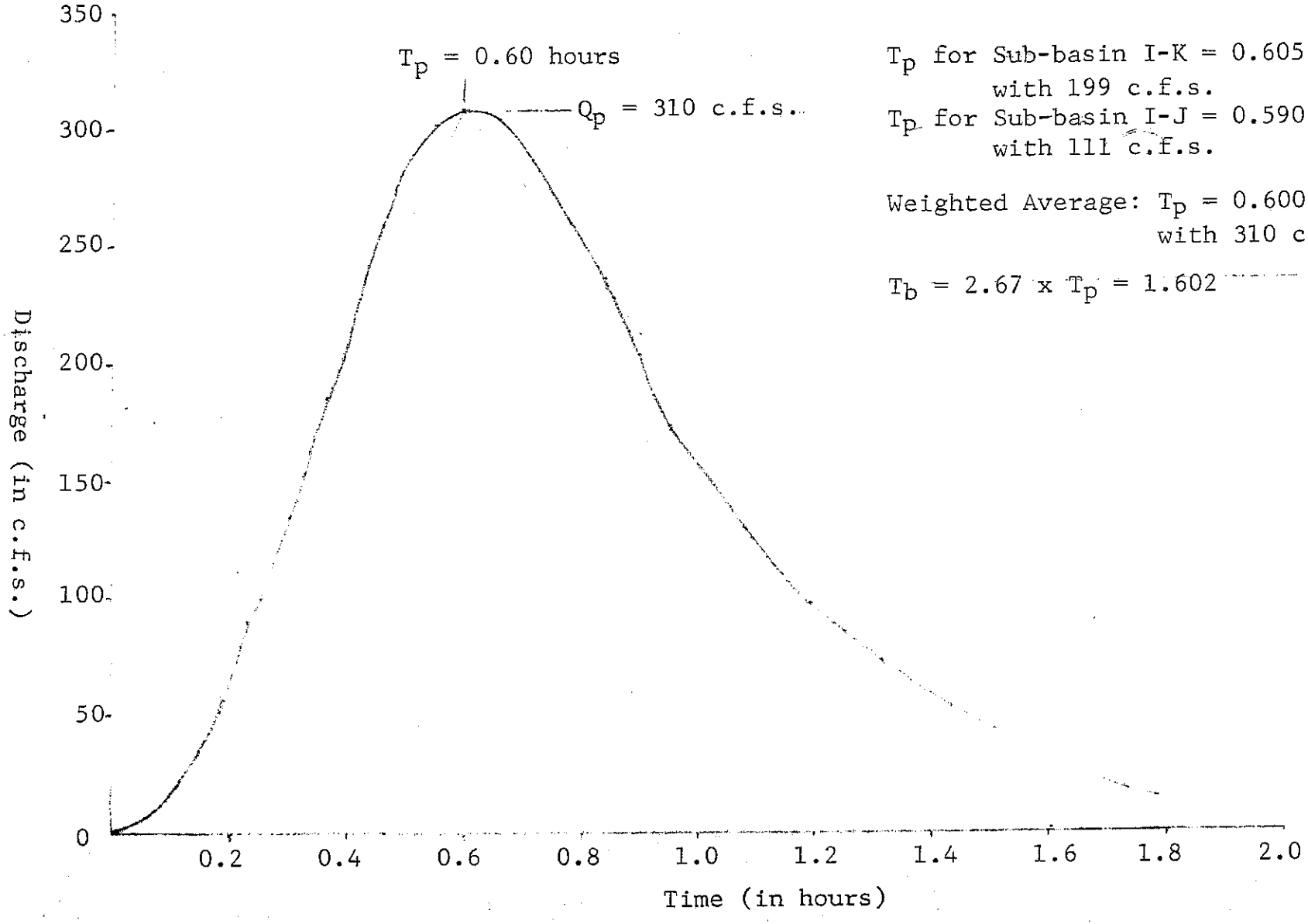
BLACK CANYON DRAINAGE REPORT
MAJOR CHANNEL FLOW CHARACTERISTICS

Point of Interest	Area Above (Sq.Miles)	Time After Rain Started T_p (Hours)	Length to Next Point L (Feet)	Time Required to flow to Next Point where V=25 f.p.s. L/V/60 (Minutes)	L/V/3600 (Hours)	$Q_p = \frac{484xAxQ}{T_p}$ (c.f.s.)
6	0.320	0.60				542
(thru I)			2800	2	0.03	
5	0.511	0.63				824
(thru F)			4300	3	0.05	
4	1.162	0.68				1737
(thru C)			5200	3.5	0.06	
3	0.509	(0.74-0.01) 0.73				709
(thru B)			1300	0.8	0.01	
2	1.965	0.74				2699
(thru A)			4600	3	0.05	
1	2.156	0.79				2744

POINT 6 - 2" Rain for 1 hour

CURVED SYNTHETIC HYDROGRAPH

BLACK CANYON DRAINAGE REPORT



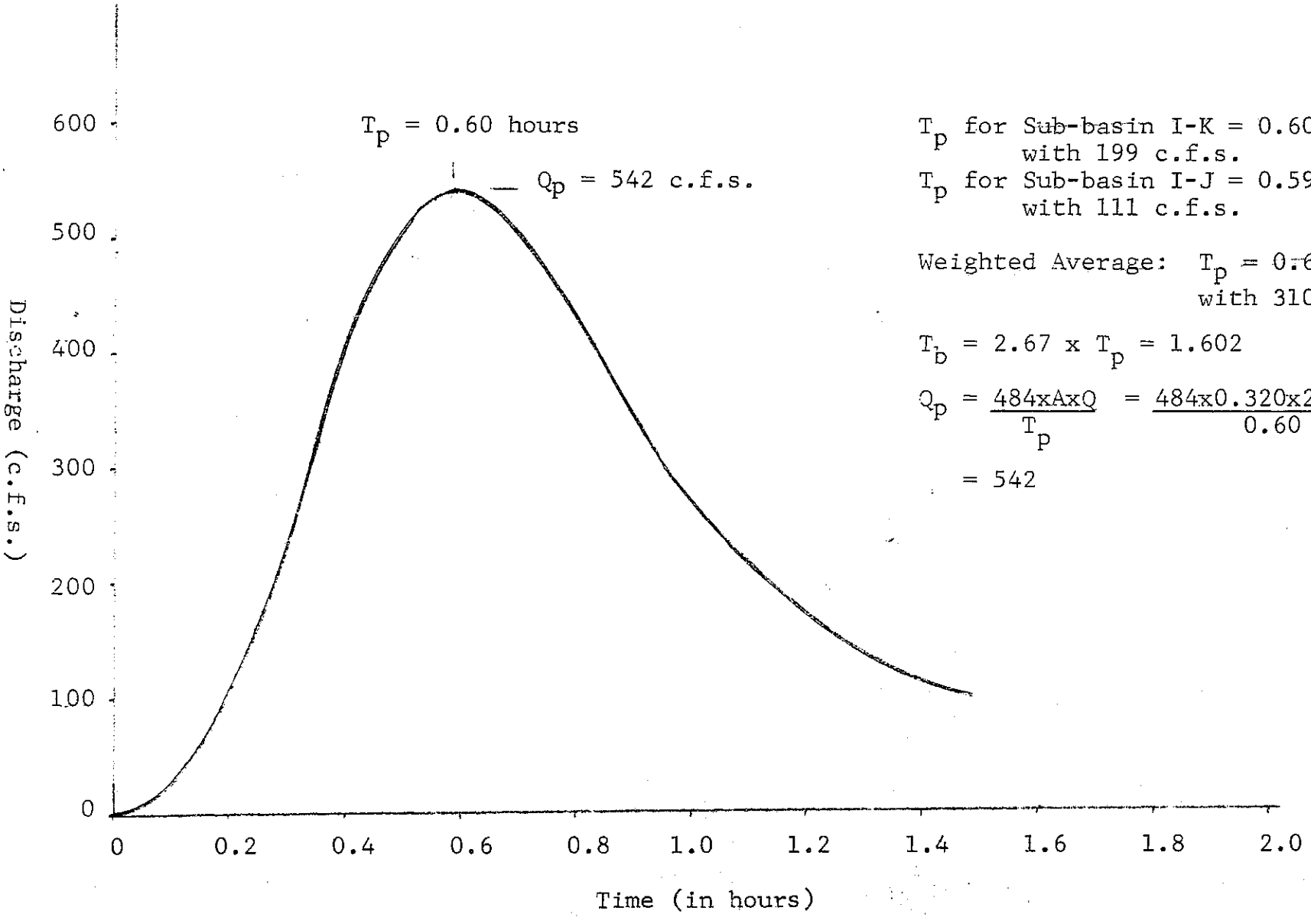
T_p for Sub-basin I-K = 0.605 hours with 199 c.f.s.

T_p for Sub-basin I-J = 0.590 hours with 111 c.f.s.

Weighted Average: T_p = 0.600 hours with 310 c.f.s.

$T_b = 2.67 \times T_p = 1.602$

POINT 6 - 3.5" Rain for 1 hour
CURVED SYNTHETIC HYDROGRAPH
BLACK CANYON DRAINAGE REPORT



T_p for Sub-basin I-K = 0.605 hours with 199 c.f.s.

T_p for Sub-basin I-J = 0.590 hours with 111 c.f.s.

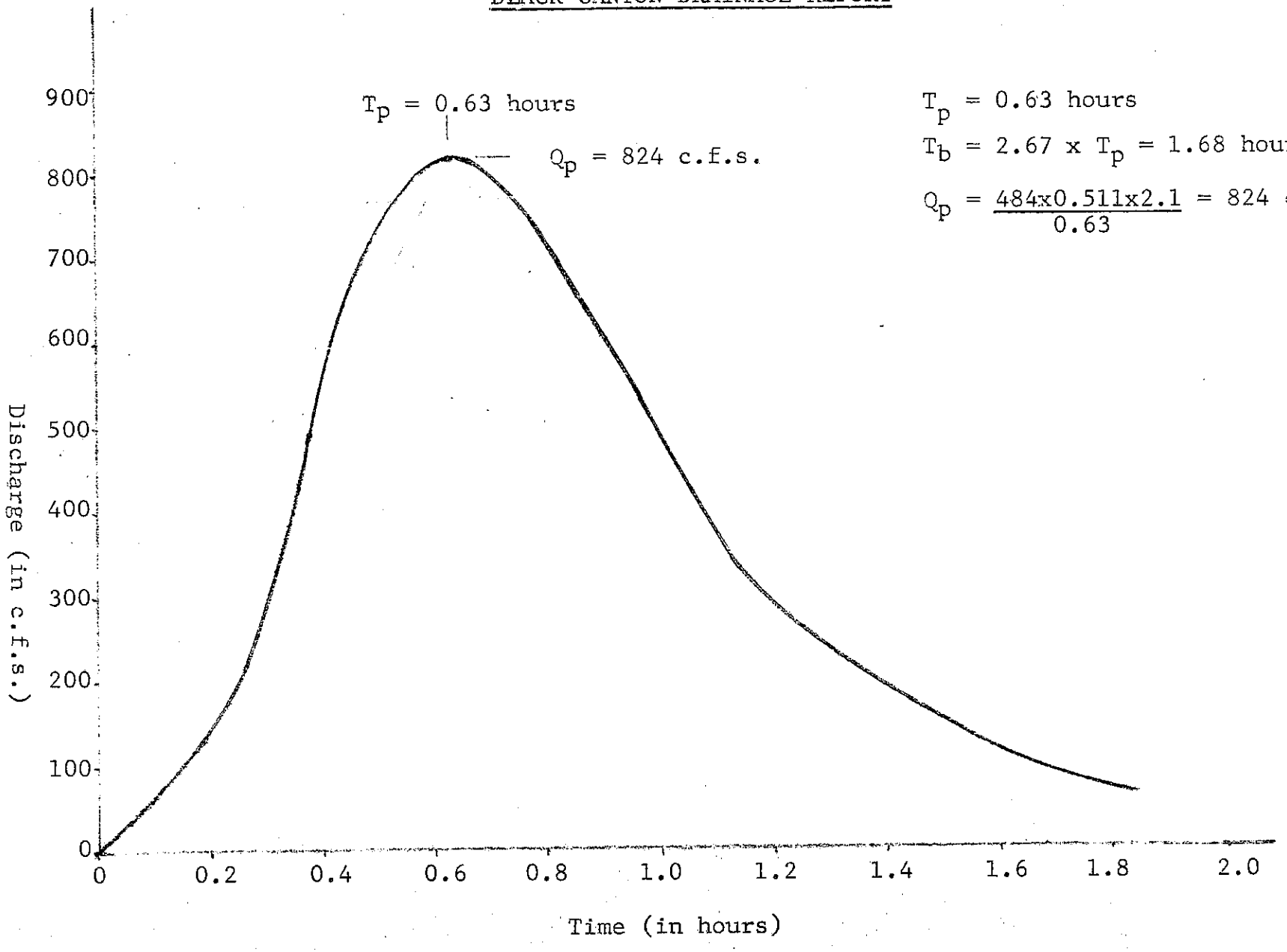
Weighted Average: T_p = 0.600 hours with 310 c.f.s.

$T_b = 2.67 \times T_p = 1.602$

$$Q_p = \frac{484 \times A \times Q}{T_p} = \frac{484 \times 0.320 \times 2.1}{0.60}$$

$$= 542$$

POINT 5
CURVED SYNTHETIC HYDROGRAPH
BLACK CANYON DRAINAGE REPORT

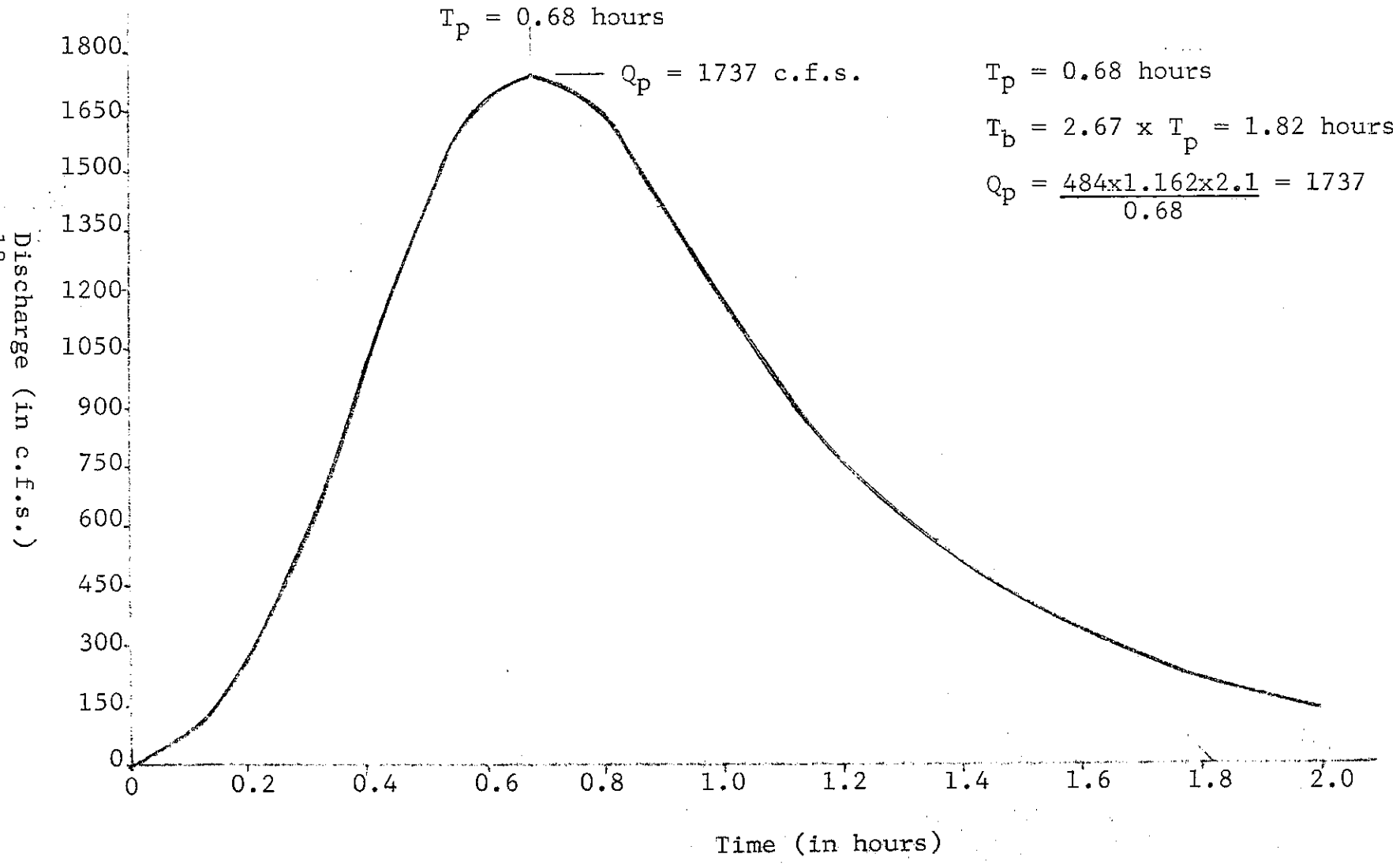


T_p = 0.63 hours

$T_b = 2.67 \times T_p = 1.68$ hours

$$Q_p = \frac{484 \times 0.511 \times 2.1}{0.63} = 824 \text{ c.f.s.}$$

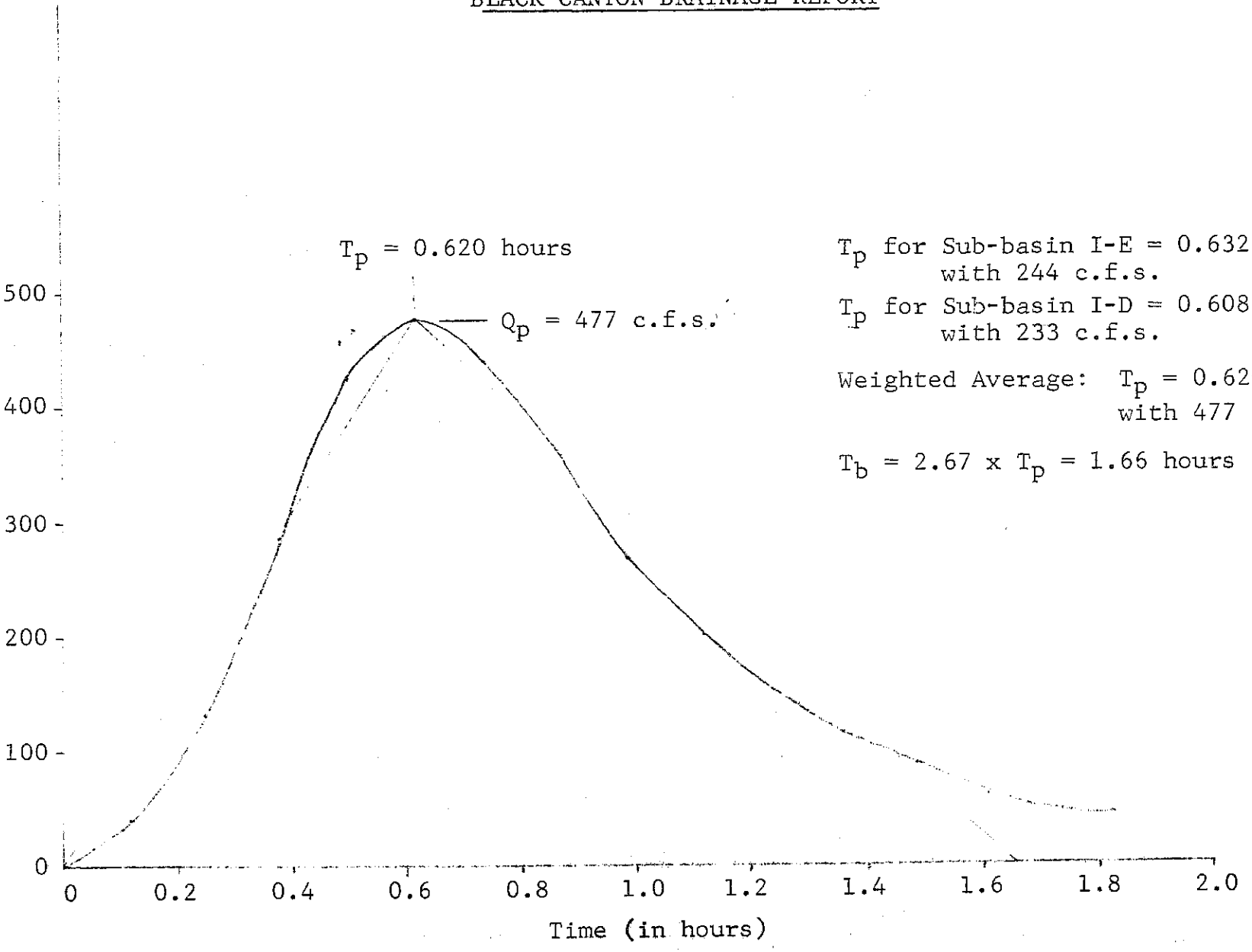
POINT 4
CURVED SYNTHETIC HYDROGRAPH
BLACK CANYON DRAINAGE REPORT



POINT 3 - 2" Rain for 1 hour

CURVED SYNTHETIC HYDROGRAPH

BLACK CANYON DRAINAGE REPORT



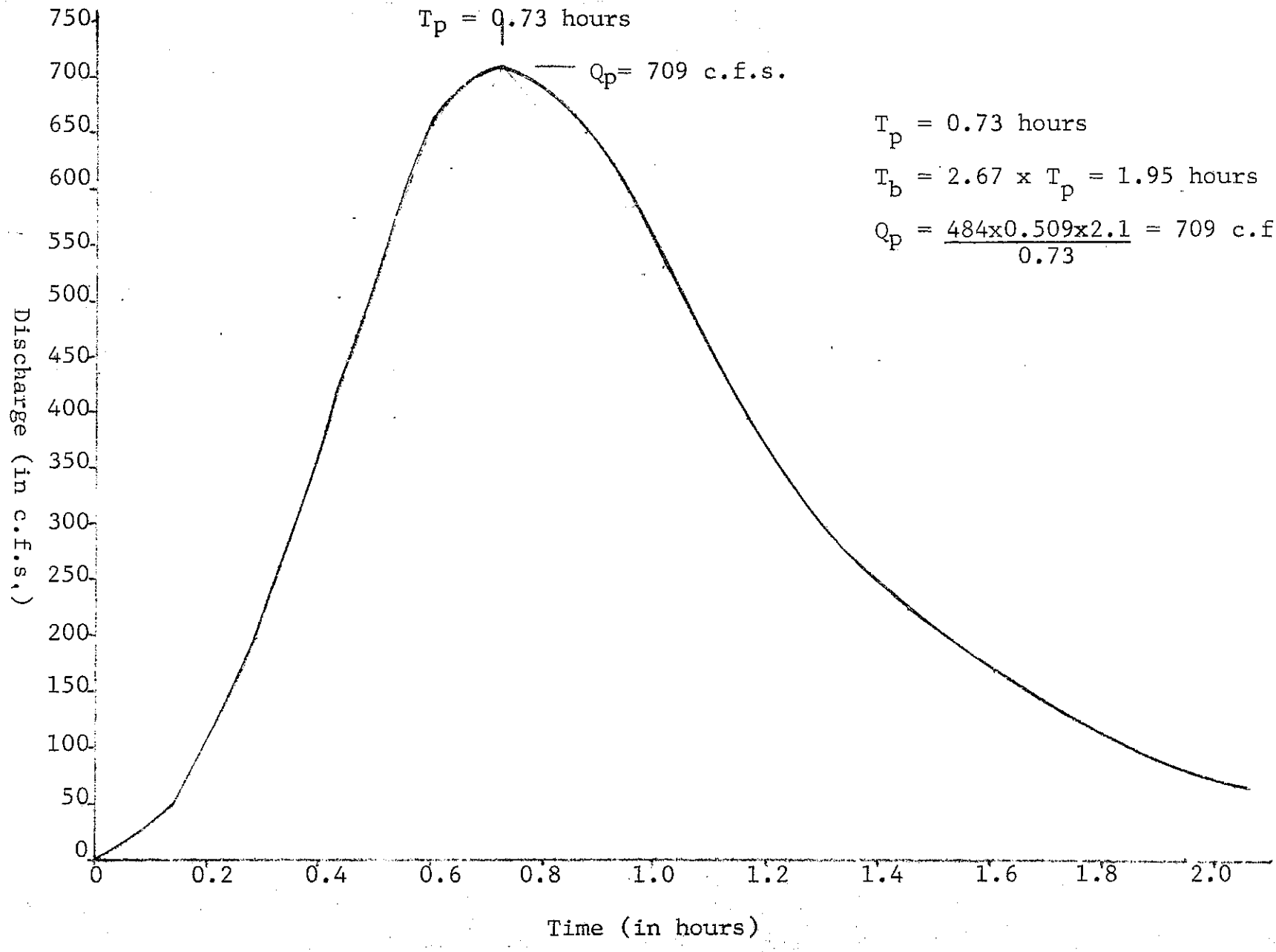
T_p for Sub-basin I-E = 0.632 hours with 244 c.f.s.

T_p for Sub-basin I-D = 0.608 hours with 233 c.f.s.

Weighted Average: T_p = 0.620 hours with 477 c.f.s.

$T_b = 2.67 \times T_p = 1.66$ hours

POINT 3 - 3.5 " Rain in 1 hour
CURVED SYNTHETIC HYDROGRAPH
BLACK CANYON DRAINAGE REPORT



T_p = 0.73 hours

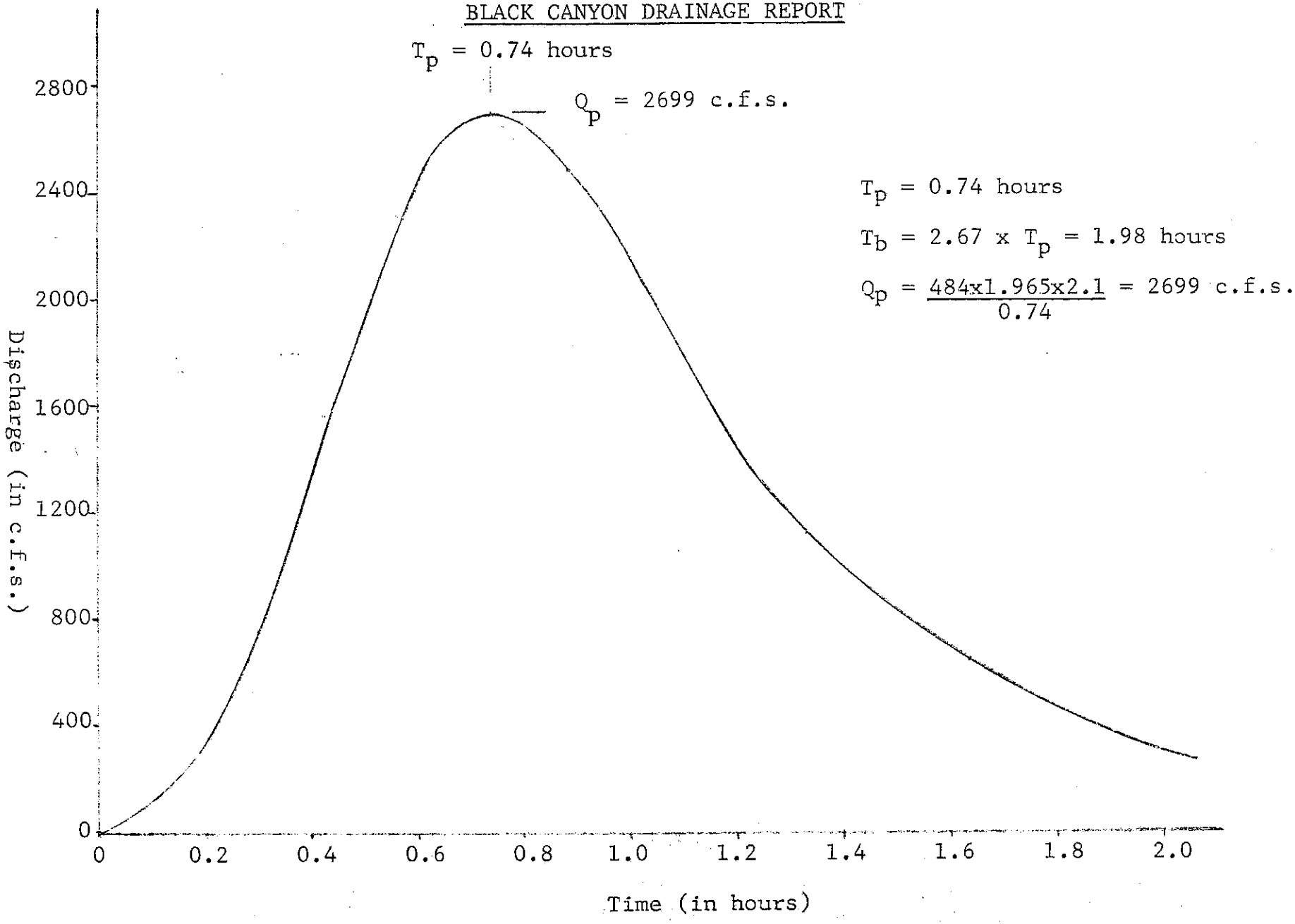
T_b = 2.67 x T_p = 1.95 hours

$Q_p = \frac{484 \times 0.509 \times 2.1}{0.73}$ = 709 c.f.s.

POINT 2

CURVED SYNTHETIC HYDROGRAPH

BLACK CANYON DRAINAGE REPORT



T_p = 0.74 hours

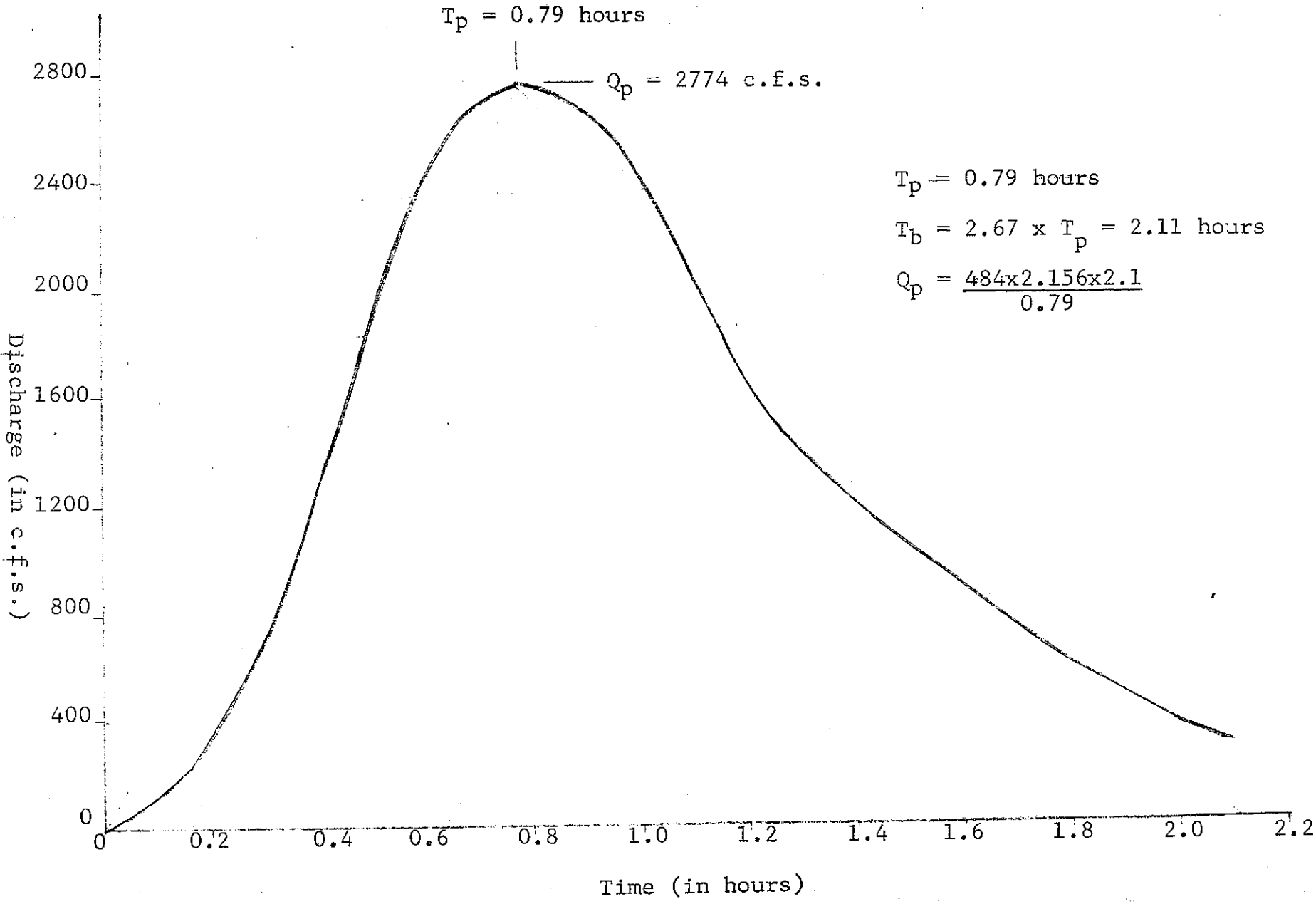
T_b = 2.67 x T_p = 1.98 hours

$Q_p = \frac{484 \times 1.965 \times 2.1}{0.74}$ = 2699 c.f.s.

POINT 1

CURVED SYNTHETIC HYDROGRAPH

BLACK CANYON DRAINAGE REPORT



T_p = 0.79 hours

$T_b = 2.67 \times T_p = 2.11$ hours

$Q_p = \frac{484 \times 2.156 \times 2.1}{0.79}$

71016 - Drainage
Black Canyon
11/17/71
G W A

Drainage Structures & Costs

Structure	Subbasin Property	Decim. Property	Q C.F.S.	a Sq. Ft. @ 5 F.P.S.	C.M.P. inches	C.M.P. Sq. Ft.	Capac. @ 5 F.P.S.	C.M.P. Lin. Ft.	Material Cost $/Lin. Ft.	Installed Cost $ (Matrl x 2)	Subbasin Totals & Comments
I-K-2	12/55	.22	44	8.7	50-31	8.7	44	89	10.98 Extrol.	2022	
I-K-1	29/55	.53	105	21.1	79-49	21.3	107	92	30.17	5551	/ 7,573
I-J-4	7.5/42	.18	20	4.1	36-22	4.4	22	85	6.44	1134	
I-J-3	10/42	.24	27	5.3	43-27	6.4	32	88	8.59	1564	
I-J-2	17.5/42	.42	47	9.4	58-36	11.4	57	92	15.94	3124	
I-J-1	30/42	.71	79	16.3	72-44	17.6	88	94	20.0	4000	/ 9,832
I-I-2	16/28	.57	345	70.4	Two 95-67	70	350	190	45.0	8550	#12 Gauge w/ 3"x1" Corrug.
					95-67	35		95	45.0	8550	
I-I-1	20.5/28	.73	355	72.5	103-71	40	375	95	50.0	9500	/ 26,600
I-H-4	10/50	.20	25	5.0	43-27	6.4	32	88	8.59	1564	
I-H-3	13/50	.26	32	6.5	50-31	8.7	44	89	10.98	2022	
I-H-2	29/50	.58	71	14.5	72-44	17.6	88	94	20.0	4000	
I-H-1	45/50	.90	111	22.5	Two 58-36	22.8	114	184	15.94	6248	/ 13,834

Drainage Structures & Costs

Structure	Subbasin Propr'tn	Decim. Propr'tn	Q C.F.S. @ 5 F.P.S.	a Sq. Ft.	C.M.P. inches	C.M.P. Sq. Ft.	Carols @ 5 C.F.S.	C.M.P. Lin. Ft.	Matrl Cost $/Lin. Ft.	Installed Cost $ (Matrl x 2)	Subbasin Totals $ & Comments
I-G-9	22.9 ac.	.08	33	6.6	50-31	8.7	44	89	10.98	2022	
I-G-8	32.8 ac.	.11	45	9.0	58-36	11.4	57	92	15.94	3124	
I-G-7	10.1 acr.	.03	14	2.9	36-22	4.4	22	85	6.44	1134	
I-G-6	25.6 acr.	.09	37	7.4	50-31	8.7	44	89	10.98	2022	
I-G-5	21.6 acr.	.07	29	5.8	43-27	6.4	32	88	8.59	1564	
I-G-4	3.6 acr.	.01	4	0.8	18-11	1.1	6	82	4.5	740	
I-G-3	6.6 acr.	.02	9	1.9	25-16	2.2	11	84	5.0	840	
I-G-2	31.4 ac.	.11	45	9.0	58-36	11.4	57	92	15.94	3124	
I-G-1	58.1 ac.	.20	82	16.4	72-44	17.6	88	94	240	4000	/18,570
I-F-4	28.4 ac.	.22	39	7.8	50-31	8.7	44	89	10.98	2022	
I-F-3	9.8 ac.	.08	14	2.8	29-18	2.8	14	84	5.25	914	
I-F-2	28.0 ac.	.22	39	7.8	50-31	8.7	44	89	10.98	2022	
I-F-1	39.1 ac.	.31	54	10.8	58-36	11.4	57	92	15.94	3124	/8,082
I-E-4	4/67	.06	15	3.0	36-22	4.4	22	85	6.44	1134	
I-E-3	13.5/67	.20	49	9.8	58-36	11.4	57	92	15.94	3124	
I-E-2	21.5/67	.32	78	15.6	72-44	17.6	88	94	20.0	4000	
I-E-1	30/67	.45	109	21.8	73-55	22	110	95	Extrpld 25.5	4845	/13,103

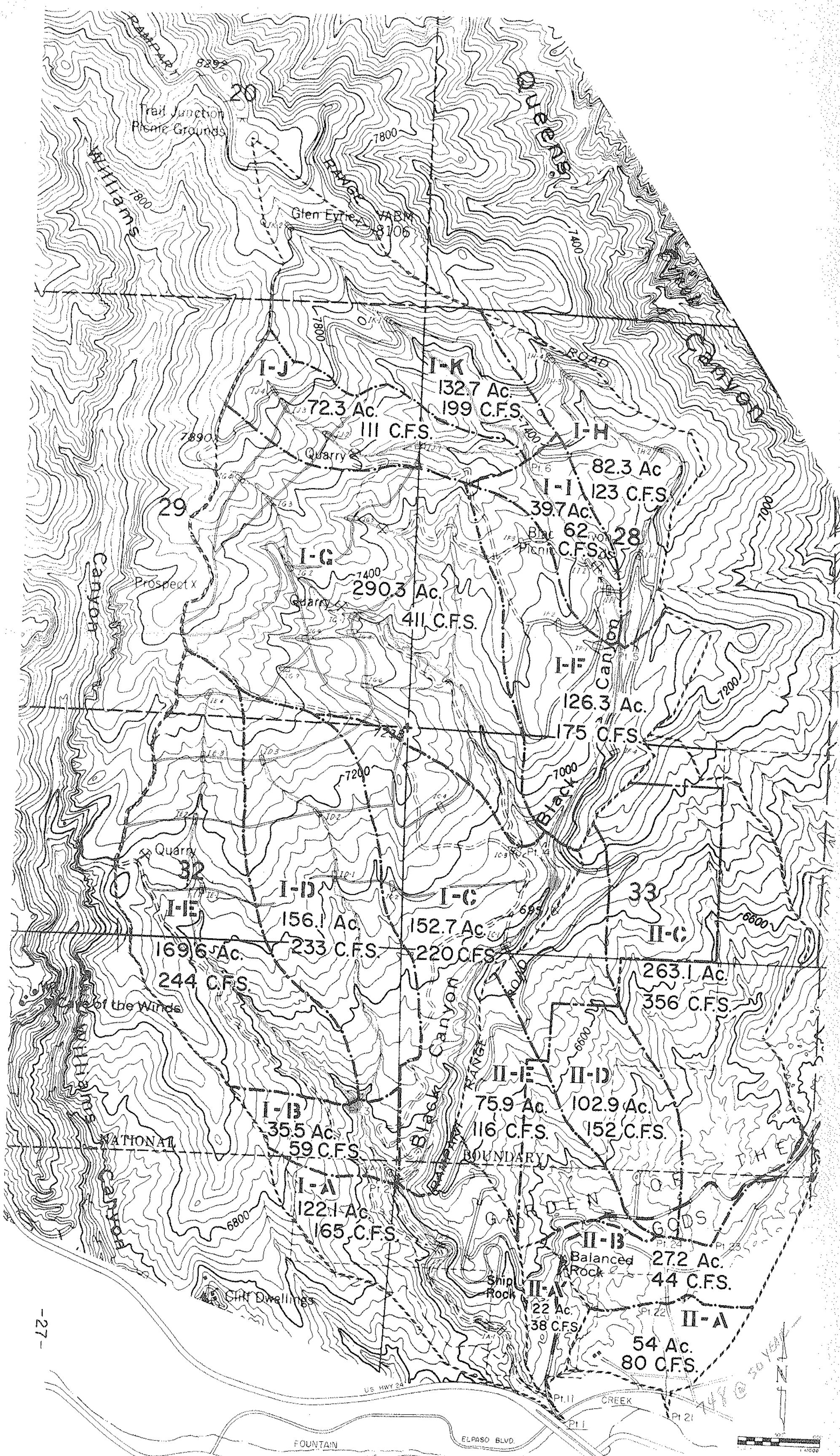
Drainage Structures & Costs

Structure	Subbasin Reports	Decim. Propert.	Q C.F.S.	a Sq. Ft. @5 F.P.S.	C.M.P. inches	C.M.P. Sq. Ft.	Capety Q C.F.S. @5 F.P.S.	C.M.P. Lin. Ft.	Matrl Cost $/Lin. Ft.	Installed Cost $ (Matrl x 2)	Subbasin Totals $ & Comments
I-D-3	9.5/56	.17	40	8.0	50-31	8.7	44	89	10.98	2022	
I-D-2	19/56	.34	79	15.9	72-44	17.6	88	94	20.0	4000	
I-D-1	27.5/56	.49	114	23.1	85-54	25.3	127	96	31.0	6000	/12,022
I-C-4	13.3 ac.	.09	19	3.8	36-22	4.4	22	85	6.44	1134	
I-C-3	34.1 ac.	.22	48	9.6	58-36	11.4	57	92	15.94	3124	
I-C-2	16.8 ac.	.11	24	4.8	43-27	6.4	32	88	8.59	1564	
I-C-1	16/52	.40 ~~.31~~	1812	109	22.0x6'11"	109	1254	95	193.	18,500	@ 16.6 f.p.s. w/10' cover #3 gauge Structural Plate Steel Arch w/concrete /24,322
I-B-1	All	1.00	775	52	Two 81x59	52	780	190	38.00	7,220	@ 15 F.P.S.
Subtotal, Costs Subbasins I-B thru K								3719		141,148	
I-A-2	10/46	.22	2716	136	22.0x6'11"	136	2716	95	193.	18,500	Same as I-C-1
I-A-1	28/46	.61	2745	137	22.0x6'11"	137	2745	95	193.	18,500	Same as I-C-1 @ 20 F.P.S. w/higher cover support walls
Subtotal, Costs Subbasin I-A								190		37,000	
Subtotal, Cost Subbasins I-A thru K								3909		178,148	

COST ESTIMATE

The costs of each structure is today's price estimate. Since these pipe-arch structures are more or less pre-engineered, five percent is added for appurtenant engineering and structural arch footing design.

Subtotal - Costs Sub-basins I-A through K	$178,148
Price Increases, Discount Loss and Contingencies @ 10%	17,815
Subtotal - Material and Installation Cost	$195,963
Taxes (Sales and Employers) @ 5%	9,798
Contractor's Profit and Overhead @ 15%	29,394
Total Installed Cost	$235,155
Drainage Study & Engineering Design @ 5%	11,758
Total Drainage Costs	$246,913
Area (Basin I Total)	1380 Acres
Cost Per Acre	$178.92



CONTOUR INTERVAL = 40' FROM U.S.G.S. MAP DATED 1961.

LEGEND

- RIDGE LINE
- SUBBASIN LINE
- PROPERTY LINE
- DRAINAGE STRUCTURE
- PROPOSED STREETS

CITY APPROVAL _____ DATE _____

DRAINAGE PLAN	
BLACK CANYON GARDEN OF THE GODS	
B & H DEVELOPMENT CO	
LEIGH WHITEHEAD & ASSOCIATES COLORADO SPRINGS, COLO.	
F W B	
G W A	12-6-71