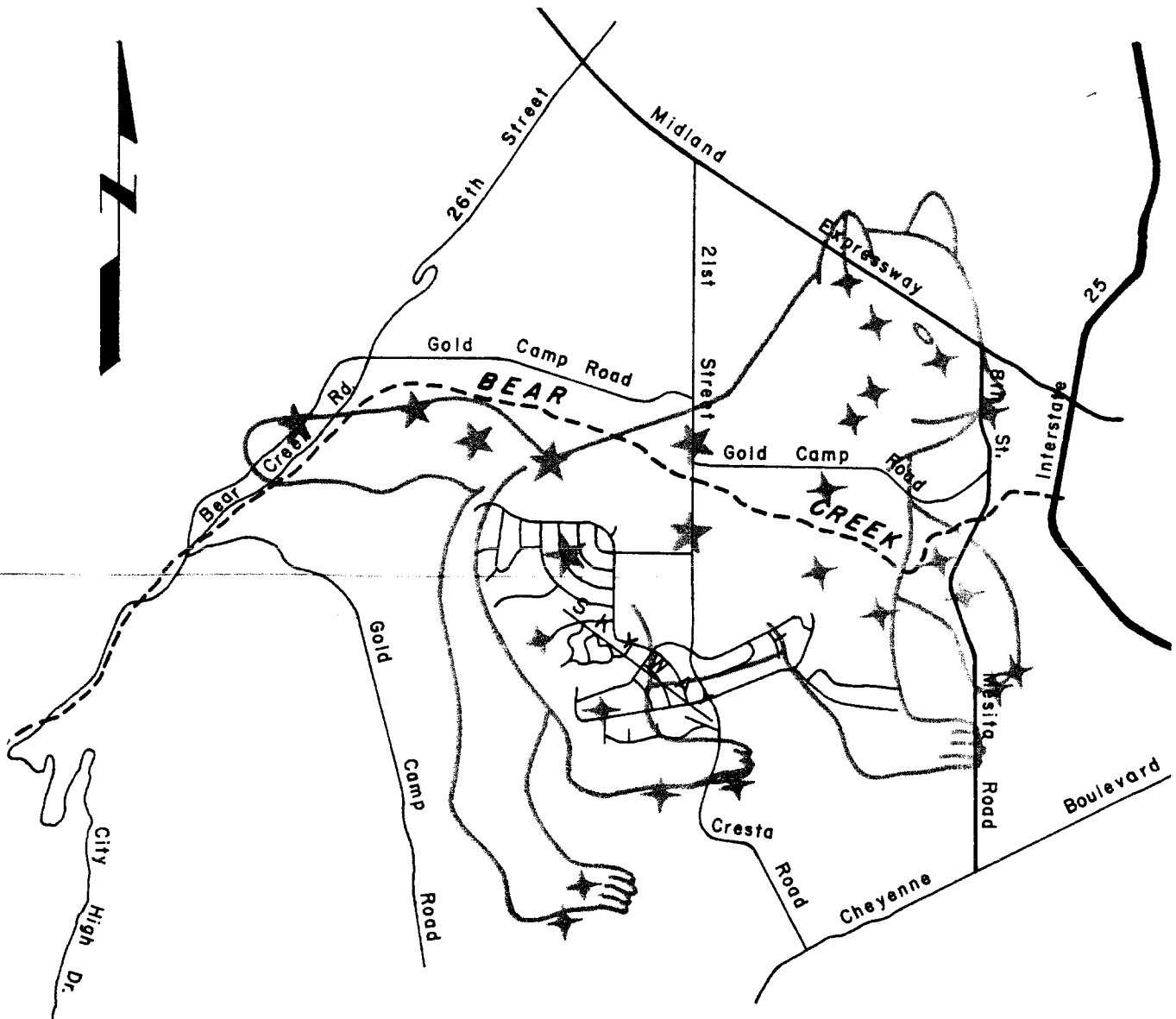


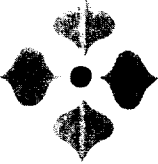
r. keith hook & associates, inc.

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BEAR CREEK drainage basin study

ARCHITECTS
ENGINEERS
PLANNERS
SURVEYORS



Deutera

r. keith hook & associates, inc.

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July 14, 1972

Mr. George Jury
City Engineer
City Hall
Colorado Springs, CO 80902

Dear Sir:

Transmitted herewith is the engineering study of the Bear Creek Drainage Basin System.

It is requested that this report be reviewed by the Drainage Board at their next regular meeting at the end of July. Also, because of the special nature of the recommendations and proposals set forth for Bear Creek, after the Board has reached a decision regarding the approval of the Basin plan, it would be advisable to set a meeting with the appropriate key personnel from the County Planning Commission and Parks and Recreation Department, and City Parks and Recreation and Utilities Departments. These departments represent the controlling interests to a large segment of land along Bear Creek, and can materially aid in establishing a firm and proper program for implementing the recommendations as set forth herein or as modified by the Board.

We have included in the body of our report, an estimated construction cost for the improvements in the Bear Creek Basin, based on our recommendations. The corresponding drainage fees are also shown. At one of our earlier progress meetings with the City's engineering staff, the City proposed consideration be given to establishing a cost estimate for Bear Creek as a fully improved (lined) channel from Gold Camp Road to Interstate Highway 25 at Fountain Creek. This cost estimate, along with the corresponding drainage fee is included at the back of the report.

We wish to thank the City for its cooperation in reviewing and commenting on the various phases and problems involved during the preparation of this report, with special thanks to Mr. Richard Ernster and Robert Martin.

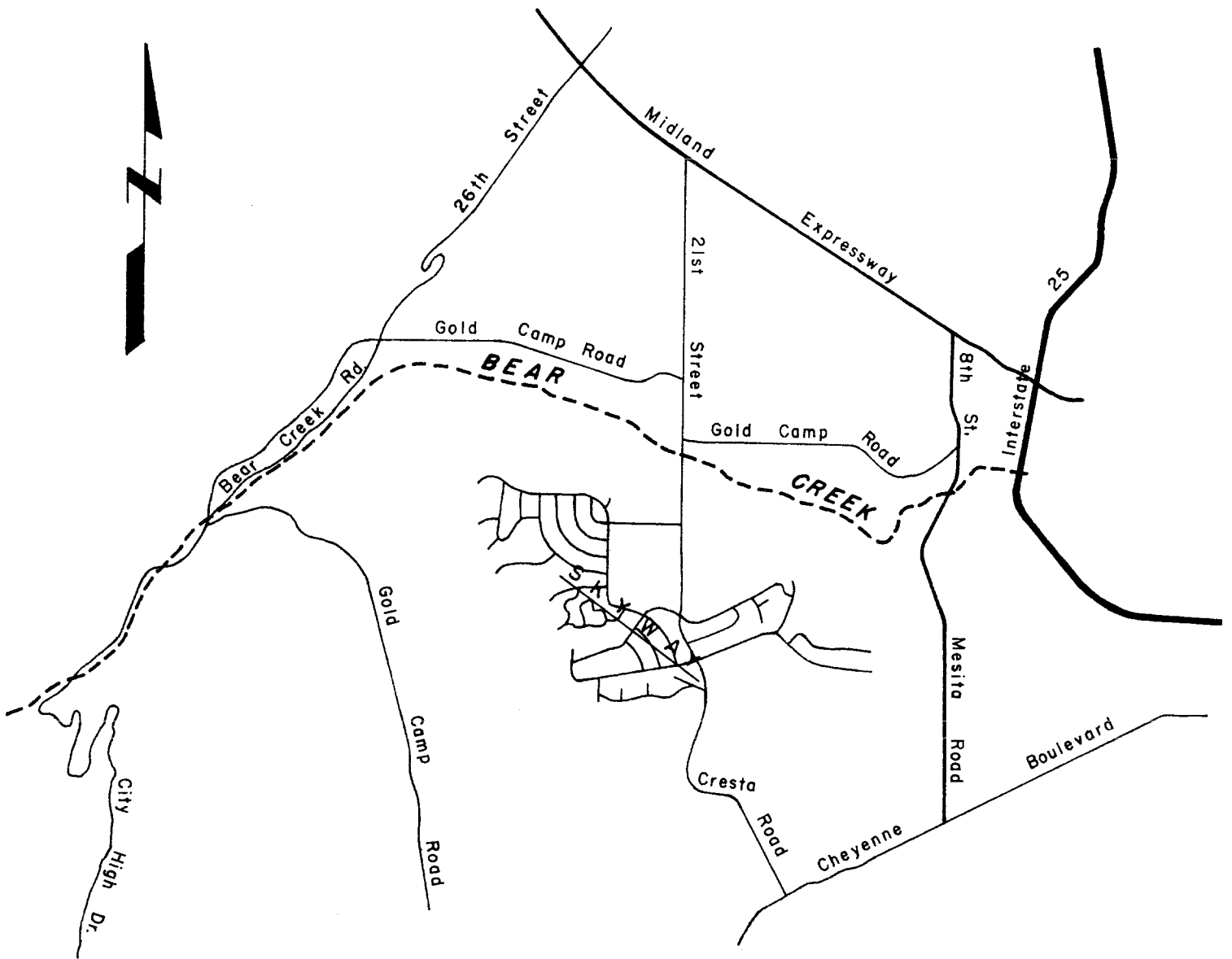
Respectfully submitted,

R. KEITH HOOK & ASSOCIATES

Roy N. Lamar
Roy N. Lamar, P. E.

ARCHITECTS
ENGINEERS
PLANNERS
SURVEYORS

RNL/sj



VICINITY MAP
Scale: None

HYDROLOGIC ENGINEERING STUDY
of the
BEAR CREEK
DRAINAGE BASIN
for
THE DEPARTMENT OF PUBLIC WORKS
COLORADO SPRINGS, COLORADO

JULY, 1972

R. KEITH HOOK & ASSOCIATES, INC.
2545 East Platte Place
Colorado Springs, Colorado 80909

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I. D E S C R I P T I O N

A. Scope and Purpose

This report defines the quantity of storm water runoff in Bear Creek Drainage Basin which will contribute to Fountain Creek at the easterly terminus of Bear Creek. Flows in Bear Creek were computed on the basis of a 100-year return period, 1-hour duration storm, while flows in tributaries to Bear Creek were computed on the basis of a 50-year, 1-hour duration storm.

On the basis of the computed storm water runoff quantities, drainage criteria have been established herein showing all major and minor drainage systems within the Bear Creek Drainage Basin. These systems as described will provide guidance to future land development in the Basin regarding proposed street systems, drainage structures and planned greenbelt systems.

As a direct result of preparing this report, we feel it is of utmost importance to point out that Bear Creek represents a truly valuable natural resource to the community. However, uncontrolled or random attempts to alter this stream's regimen can destroy the natural beauty of the stream or create irreversible changes. Therefore, our recommendations are pointed toward preserving this resource as well as controlling flow and minimizing flood hazard.

B. Basin Description

Bear Creek Drainage Basin is comprised of approximately 6,771 Acres or 10.6 square miles within Township 14 South, Ranges 67 and 68 West of the 6th Principal Meridian. It extends from the steep, mountainous region in Pike National Forest easterly to the relatively level and gentle river plain at the Fountain Creek confluence.

The Basin can be suitably divided into two primary categories: (1) Bear Creek channel proper, including the contiguous sub-basins discharging directly into it; and (2) "Skyway" tributaries, including those sub-basins lying generally easterly of Gold Camp Road, whose cumulative flows are collected by the three minor greenbelt tributaries to Bear Creek: "Argus", Gardiner, and "Parkview" gulches.

1. Bear Creek channel proper extends several thousand feet downstream from its headwaters before reaching a point of convenient access. This first (uppermost) point of access has been designated as hydrograph point "A" and is at the crossing of High Drive Road. The stream continues downstream in a typical steep mountain ravine to the junction of Gold Camp and Bear Creek Canyon Roads. Upstream of this junction, development in the near future is unlikely because of the steep terrain, lack of access, and the fact that the area is in the National Forest. From the junction downstream, development of the mountain-home type increases with the gradual lessening of slope. Further downstream, large parcels of land are owned by El Paso County and the City of Colorado Springs,

so private development is limited in those areas. Presently, the City and County intend to preserve and develop their present downstream holdings along Bear Creek as a wilderness-type park which would limit access to riding and hiking trails. From 8th Street downstream to Fountain Creek, commercial and industrial development is increasing, and major stream improvement is required in this reach to limit erosion and to preserve the efficiency of the present major drainage structures.

2. "Skyway" tributaries include the area of Skyway Park Estates and the primary private, developable land within the Basin. Present development has extended over approximately 305 Acres, leaving 1189 Acres presently undeveloped. The master plan shows proposed roads for a potential development affecting sub-basins 49, 50, 66 and 67, with proposed drainage structures designed to preserve the existing tributaries as the major storm flow carriers. It must be noted that in Skyway Park Estates, natural drainage courses have been (and are continuing to be) obliterated by existing and in progress development, causing the storm flow to be diverted into the street system further and further upstream as the development progresses westerly toward Gold Camp Road. The master plan assumes a continuation of this type development in sub-basins 44 and 56 as the most probable, at least for the present time. Since downstream portions of these tributaries have either been obliterated or severed by streets, the master plan shows a proposed storm drain system required in the existing and proposed streets.

C. Geological Description

The westerly portion of the Basin lies in the uplifted mountainous Pikes Peak granite consisting of exposed bedrock, with a soil profile formed from the weathered granites. This area is resistant to erosion where bedrock is exposed; however, the soil profile infiltration is relatively high.

The easterly portion consists of uplifted sediments with the Pierre Shale outcropping as the uppermost sediment, overlain by Quaternary gravels and alluvium formed from the westerly mountainous granites. Runoff is higher where the Pierre Shale is exposed than in areas overlain by alluvium.

Primary faulting is evidenced along the base of the mountains in the vicinity of the Gold Camp Road where sediments to the east are abruptly terminated by the crystalline mountain mass to the west. Also, there is evidence of primary faulting along Bear Creek in sub-basin 55 where the Creek makes an abrupt $50\pm$ degree meander to the east away from its upstream, northeasterly trend.

Generally, the westerly mountainous area is resistant to erosion with infiltration rates moderately low because of joint seepage. The intermediate foothill region is much less resistant to the erosion as characterized by the numerous gully washes in the relatively weak alluvium with increased infiltration. The easterly portion is again somewhat more erosion resistant, with runoff slightly greater and infiltration lower than the foothill region.

D. Rainfall

The rainfall intensities used in the designs incorporated in this report are as follows:

Major Greenbelt (Bear Creek Proper)

100-Year Return Period
1-Hour Duration
Intensity = 2.35 in./hr.

Minor Greenbelts (Tributaries) and Subdivisions

50-Year Return Period
1-Hour Duration
Intensity = 2.00 in./hr.

The above intensities were obtained from U. S. Department of Commerce, Weather Bureau, Technical Paper No. 40, "Rainfall Frequency Atlas of the United States - For Durations From 30 Minutes to 24 Hours and Return Periods From 1 to 100 Years", Washington, D. C., May, 1961, reprinted January, 1963:

Chart 13 - 50-Year, 1-Hour Rainfall
Chart 14 - 100-Year, 1-Hour Rainfall

These intensities agree with the intensity-duration curves shown on Chart I in the "Comprehensive Drainage Planning" report published by the Pikes Peak Area Council of Governments.

The above durations and return periods are in conformance with the design criteria set forth by the City of Colorado Springs, Department of Public Works, to be used in the calculations for this study.

E. Surface Flow Criteria

Runoff calculations are based on criteria given in the United States Department of the Interior, Bureau of Reclamation, "Design of Small Dams":

Appendix A - Estimating Rainfall Runoff
From Soil and Cover Data
Chapter II - Flood Studies

This criteria is also formulated in the "Hydrology Guide for Use in Watershed Planning" published by the Soil Conservation Service and has been designated for use in preparing this study by the City.

Direct runoff (Q) in inches of water is given in Fig. A-4 of the above reference "Appendix A", and is read directly off the figure based on rainfall in inches (see Section "D" above), and "Curve Number" which is determined from soil type and land use.

The following table sets forth the basic curve numbers, which in turn were prorated on a percent of development and tabulated in the Synthetic Hydrograph Tables in Section II following.

	<u>Curve No.</u>		<u>Q 50 yr. (in.)</u>		<u>Q 100 yr. (in.)</u>	
<u>Hydrologic Soil Group--B</u>	C		B	C	B	C
<u>Land Use</u>						
Woodland	66	77	0.15	0.45	0.25	0.60
Subdivided	94	96	1.40	1.57	1.65	1.78

"Chapter II - Flood Studies" referenced above sets forth the necessary nomographs and formulae for calculating the time of

concentration, time to peak flow, and the peak rate of flow based on area of sub-basin and elevation difference between extreme high and low ground in the sub-basin. Areas were planimetered off photographic blow-ups of the following United States Department of the Interior Geological Survey topographical maps:

- "Colorado Springs Quadrangle, 7.5 Minute Series"
 - "Manitou Springs Quadrangle, 7.5 Minute Series"
- (Both photorevised 1969)

For Bear Creek proper, a 1" = 800' scale blow-up was used; whereas a 1" = 200' blow-up was used for the "Skyway" tributary basins. Elevation differences were taken directly or interpolated from the contours given on these quadrangles.

Peak runoff calculations for each sub-basin and for flow table combinations of sub-basins are tabulated in Section II following. Synthetic hydrographs were computed for each sub-basin and an accumulative synthetic hydrograph was computed for entire Bear Creek based on the calculations given in the "Flood Flow Table" in Section II.

The synthetic hydrographs were constructed on the assumption that in the next 20 years rural development will continue westerly up to the vicinity of Gold Camp Road, and little to no development will take place in the steeper mountainous headwater region to the west in National Forest.

F. Greenbelt System

The greenbelt systems designated on the map are divided into

major and minor greenbelts, the major greenbelt being along Bear Creek proper, and minor greenbelts assigned to the three key tributaries to Bear Creek which drain the "Skyway" area. Right-of-way widths were established on the basis of either: (1) depth of flow, top width of channel, and access for maintenance for channel sections which are to be improved; or (2) a specific greenbelt width consisting of 150 feet plus an additional adjusted width based on the 100-year storm calculated channel top width for channel sections designated to be left unimproved and in their natural state, the minimum major greenbelt width being 200 feet. This second condition applies specifically to that portion of Bear Creek upstream of 8th Street. The portion designated as the adjusted channel top width is intended to contain the natural, undisturbed stream with maintenance consisting only of cleaning accumulated debris and minor brush growth clearance. The remaining or outer 150 feet shall be used exclusively for wilderness park and for encroachment by wheeled vehicles for access to picnic sites, and must be strictly enforced to preserve and protect the natural environment.

1. Major greenbelt is designated along Bear Creek only, with the basic criterion for drainage control being to leave the stream in its natural state everywhere possible, except in those specific locations where improvements are absolutely necessary to protect property and/or minimize erosion, or required because of access crossings.

Three major problem areas exist along the stream, and each is a direct result of man-made attempts at altering either the stream course or the channel configuration. It is these three problem areas that comprise the only locations along the stream for which improvements are recommended other than the several bridge culverts shown on the proposed improvement plan.

(a). The first area is located immediately upstream of 21st Street where the stream was diverted south and straightened by cutting into the hill on the south bank for approximately 500 feet. The cut slope is denuded and is undergoing severe erosion which is contributing considerable turbidity to the stream during heavy rains. It is recommended that the stream be diverted back to its original channel to the north; and that the denuded embankment be planted with vegetation native to the area and be provided with at least two drainage terraces to intercept downslope runoff and minimize further erosion.

(b). The second area is upstream of 8th Street between the confluences with Gardiner and "Parkview" Gulches, near the "gravel pit" where the historic channel was diverted in a cut meander to the south to increase available land space for the past gold processing operations. Erosion both of the channel and embankments is extremely severe, with extensive lengths of vertical or near vertical banks which are progressively being undermined and caused to fall away into the stream bed. This

area alone appears to contribute as much silt (and therefore turbidity) as the entire remaining portion of Bear Creek upstream. It is recommended that the stream be restored back to its original course to eliminate the on-going severe erosion and embankment sloughing, and to shape those portions of "Parkview" Gulch's banks at the confluence, which are nearly vertical, and provide rip-rap stabilization. The present gravel pit acts as an existing retention basin, and may be retained as such.

Both of the above problem areas are now in County and City ownership and are presently earmarked for wilderness park usage; and the recommended action will tend to restore and preserve the natural aesthetics in keeping with the planned park usage.

(c). The third major "problem" area exists along the entire stream channel downstream from 8th Street to the box culverts at Interstate Highway 25. This section of stream has been completely diverted southerly out of its natural drainage course, and the natural course is now completely back-filled to existing surrounding grade. The flood flow velocities are excessively erosive for the channel configuration as presently modified by this random and/or unplanned grading in the vicinity. Any required maintenance at this time would be seriously hampered by the steep "V" configuration formed in the non-resistant embankment soils. It is recommended that

this entire length of channel be reshaped and widened, and lined with grouted rip-rap and boulders. Also, the outlet at the 8th Street culverts impinges on the north slope of the channel because of a change in flow direction. This portion of the channel should be heavily lined (as is presently attempted with loose boulders, trash, and debris) and the change in flow direction transitioned downstream during the channel-shaping construction. It was noted in the field that the material forming the present channel invert is a very resistant, tough, dark gray to black clay. It would warrant soils borings along this reach to verify the depth of this clay as being greater than four feet, thereby requiring side-wall lining only, with the naturally occurring clay forming the invert. The south headwall on the inlet side of the 8th Street culverts is being progressively eroded by runoff that is not reaching the street gutter because of improper grading. Repair by filling and rip-rapping is required, with suitable grading along the west curb line to direct the surface runoff to the street gutter. It is recommended that the right-of-way from 8th Street to Fountain Creek be of sufficient width to accommodate a future planned trail up Bear Creek from Fountain Creek, as outlined in the Regional Open Space Program. It must be pointed out that unless this reach of channel is completely and carefully lined and protected, heavy flows or flows in excess of the design storm would seek out any weak point in the new fill and cause the stream to cut its way back to the original, historic channel.

The stream channel is well defined and established along its entire reach upstream from 8th Street except at the problem areas noted above, and little to no damage appears probable anywhere along this reach except for stream crossings of access roads. These crossings are noted on the improvement plan and call for bridge culverts and headwall rip-rapping up and downstream of the culverts. Downstream from 21st Street, it is also recommended that the north barrel of the 21st Street culvert have its outlet cleared and the embankment rip-rapped to establish full-flow capacity to the existing culvert and protect the County Farm's property.

The parabolic section [Fig. 2] was used in the Bear Creek flood flow analysis because it approximates the form assumed by many natural streams. Also, trapezoidal and triangular sections will generally approach parabolic configuration after a long period of service due to the normal action of channel deposition and erosion and lack of maintenance. The general equation of a parabola in terms of hydraulic dimensions is $(0.5T)^2 = C (D)$, where T is the channel top width, D is the Depth, and C is the parabolic constant. In preparing the flood flow table in Section II, existing top widths were determined from the U.S.G.S. quad sheet, and the depths for the top widths determined were interpolated from the contours shown. These dimensions were then used to establish the actual and required channel section parameter "C" as shown on the flood flow table. Actual flow depths were determined by matching the hydraulic section calculated for

the hydrograph flow with the actual channel constant "C".

2. Minor greenbelts are designated for the three "Skyway" tributaries shown on the plan as draining into Bear Creek downstream of 21st Street: "Argus", Gardiner, and "Parkview" Gulches. Minor greenbelt was also designated for a portion of "Scorpio" Gulch which is a tributary to Gardiner Gulch.

It is recommended that these tributary channels be lined from their confluences with Bear Creek upstream to the locations within Skyway Park Estates as shown on the plan. Flood flow velocities in these channels are well in excess of non-erodible velocities because of the steep slopes involved, and serious scouring and side-wall erosion is certain unless lining is provided. These tributaries drain an area that is presently being developed and that offers the greatest potential for future development, thereby making these tributaries extremely important to present and future drainage planning. (See Figure 1.)

G. Improvements

The proposed improvements included in this report consist of the following:

- a - Greenbelt Channel System, Shaping and Lining
- b - Proposed Roadways, New and Extensions
- c - Drainage Structures and Piping
- d - Drainage Channels

- e - Drainage Outlets and Catch Basins
- f - Miscellaneous Drainage Appurtenances
- g - On-Going Maintenance Program

The location of proposed drainage facilities (including greenbelt systems, minor channels, piping and appurtenances), street extensions and new street systems are shown as a guide in order to establish drainage costs and drainage fees. Actual subdivision development may vary or require a change in street systems as shown herein; however, the basic intent of the drainage requirements shall be maintained.

The required improvements along Bear Creek proper have been discussed above in paragraph F, "Greenbelt System", as have the proposed improvements in the three major tributaries from Skyway Park. Improvements actually within Skyway and upstream of present development are intended to satisfy an existing and increasingly serious drainage deficiency. Presently, natural drainage gullies existing upstream from Skyway contribute their flow to the existing street system because the residential development is obliterating the gullies with building pad and street improvement construction. Downstream from Skyway, this storm flow leaves the street system and re-enters the natural drainage system as concentrated high velocity flow in the three primary tributaries described above. It is evident and probable that this condition will continue to worsen as development increases upstream. The present street system cannot carry the design storm flow (50-year return period) without a storm drain

system. Projected street networks are shown on the plan, and the required storm drain system has been indicated for these streets as well. It is understood that actual development may diverge from the plan shown, but this study indicates that any future development must include a careful analysis of storm flow to insure adequate protection to the surrounding area and downstream improvements.

It is further recommended that the minor tributaries upstream of 21st Street along Bear Creek be left in their natural state with pipe culverts strategically placed to carry flows across intersecting streets. Development must not obliterate the drainage network. Presently, no such interfering development exists in these upstream reaches and an initially wise layout of streets can eliminate the need for costly storm sewers. This is the intent of the projected street system and drainage improvements shown in sub-basins 49 and 50 where future development is certain.

In the table "Inventory Major Drainage Structures - Bear Creek Channel" in Section II, specific sized structures are given under the heading "Required Structures" where the existing structure is inadequate for the required flow. This was considered preferable to giving required areas so as to take into account variables such as depth and friction factor, and to establish a criterion for the required structure should sizing requirements have to be changed because of changed conditions or proposed interfacing improvements such as approach roads.

Two basic deficiencies are noted in the existing drainage facilities serving Bear Creek and its tributaries:

- 1). Property or pasture separating fencing strung across the creek
- 2). Plugged or buried culvert inlets and/or outlets

While it is recognized that property lines must be located, it is anticipated that the present wire fence barriers will be removed or modified so as not to act as randomly placed trash barriers. One example of this is at the County Farm where there is a substantial wire fence barrier strung across the creek immediately downstream from the 21st Street culvert outlets and the access bridge to the farm. It is evident that during flood flows, trash would accumulate rapidly and either jeopardize the upstream structure or eventually fail causing a massive, debris-laden crest to bear down on any near downstream structure. This problem will likely be self-curing after the right-of-way along Bear Creek is legally adopted and becomes a part of a united park-type or other improvement program.

The problem of plugged culverts can be eliminated by initiating a maintenance program to include the Bear Creek area, wherein all culverts would be inspected on a regular basis with provisions established for cleaning and/or flushing the pipes. Again, this problem will probably be either reduced or totally eliminated by a uniform program for Bear Creek's development.

ESTIMATE OF COST

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT COST</u>	<u>AMOUNT</u>
1.	Main greenbelt channel shaping and slope treatment	3,700	L.F.	\$ 17.25	\$ 63,825
2.	Minor drainage channels - grouted rip-rapp or concrete with embedded boulder lining	14,800	L.F.	52.00	769,600
3.	Storm Drain Piping				
	a) Reinforced Concrete Pipe				
	18"	1,730	L.F.	12.50	21,625
	21"	1,450	L.F.	13.50	19,575
	24"	2,100	L.F.	15.00	31,500
	27"	4,500	L.F.	16.00	72,000
	30"	650	L.F.	18.50	12,025
	33"	600	L.F.	19.50	11,700
	36"	1,300	L.F.	22.00	28,600
	39"	600	L.F.	24.50	14,700
	42"	300	L.F.	26.00	7,800
	48"	1,150	L.F.	30.00	34,500
					<u>\$ 254,025</u>
	b) Corrugated Steel Pipe				
	18"	100	L.F.	11.00	1,100
	24"	100	L.F.	13.50	1,350
	30"	400	L.F.	16.00	6,400
	36"	550	L.F.	21.00	11,550
	42"	550	L.F.	24.50	13,475
	48"	250	L.F.	29.50	7,375
					<u>\$ 41,250</u>

ESTIMATE OF COST
(Continued)

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT COST</u>	<u>AMOUNT</u>
4.	Drainage Outlets (4), catch basins and curb openings	86	Ea.	\$ 1,725.00	\$ 148,350
5.	Reinforced concrete culverts	11	Ea.	33,000.00	363,000
6.	Bank protection, including rip-rapp and drainage terraces	16,500	SY	12.60	<u>207,900</u>
GRAND TOTAL -----					\$1,847,950

Total Land Area ----- 6,771 acres

U.S.A. Area (National Forest) ----- 2,424 acres

NET ----- 4,347 acres assessable area

TOTAL COST ----- \$1,847,950
NET ACRES 4,347 = \$425.11/acre

SUMMARY OF AREAS (BY OWNERSHIP)

IN BEAR CREEK BASIN

	<u>Calculated Area (Acres)</u>	x	<u>Proration Factor</u>	=	<u>Adjusted Area (Acres)</u>	<u>% TOTAL</u>
Private	1499	x	6771/6796	=	1494	22.1
El Paso County	446	x	6771/6796	=	444	6.6
State of Colorado	82	x	6771/6796	=	82	1.2
City of Colorado Springs	2345	x	6771/6796	=	2336	34.5
U.S.A.	<u>2424</u>	x	6771/6796	=	<u>2415</u>	<u>35.6</u>
	6796				6771	= 100.0%

BEAR CREEK
FLOOD FLOW TABLE

REACH	SLOPE - FT/FT S	TOP WIDTH - FT T	FLOW - CFS Q	MANNING'S COEFFICIENT n	DEPTH - FT D	HYDRAULIC RADIUS - FT R	VELOCITY - FPS V	AREA - SQ.FT. A	WETTED PERIM. - FT P	PARABOLIC CONSTANT C
A to B	0.073	40 (s) 22	779.1	0.04	10 (i) 3.3	2.08	16.43	47.42	22.80	40 (r) 36.7
B to C	.118	50 (s) 26	883.7	.04	10 (i) 2.6	1.69	18.18	48.61	28.76	62.5 (r) 65
C to D	.043	120 (s) 58	1049	.04	10 (i) 2.5	1.66	10.80	97.13	58.51	360 (r) 337
D to E	.0375	160 (s) 88	1427	.04	7.5 (i) 2.4	1.60	9.83	145.2	90.73	853 (r) 806
E to V	.025	100 (s) 79	1466	.04	5 (i) 3.0	2.0	9.33	157.1	78.56	500 (r) 520
V to V'	.024	120 (s) 97	2214	.04	5 (i) 3.4	2.26	9.93	223.0	98.65	720 (r) 692
V' to R	.022	90 (s) 200 (s)	2530	.04	5 (i) 10 (i)	2.5	10.23	247.3	98.9	405 1000 use 720 (r) 675
R to S	.050	100 (s) 63	2783	.04	10 (i) 4.1	2.7	16.10	172.9	64.0	250 (r) 242
(s) scaled (i) interpolated (r) required										

-20-

RIGHT-OF-WAY CRITERIA

MAJOR GREENBELT

(1) Improved Channel:

$$R/W = \text{Channel Top Width} + 30'$$

(2) Unimproved Natural Channel:

150' + 100-year storm flow channel top width
200' minimum total width

<u>REACH</u>	<u>TOP WIDTH</u>	+	<u>Δ</u>	=	<u>RIGHT-OF-WAY</u>	
					<u>Calc.</u>	<u>Adjusted (Ft.)</u>
Upstream From "A"	-		-	=	-	200
A to B	22	+	150	=	172	200
B to C	26	+	150	=	176	200
C to D	58	+	150	=	208	210
D to E	88	+	150	=	238	240
E to V	79	+	150	=	229	240
V to V'	97	+	150	=	247	250
V' to R	100	+	150	=	250	250
R to S	63*	+	30	=	93	130'

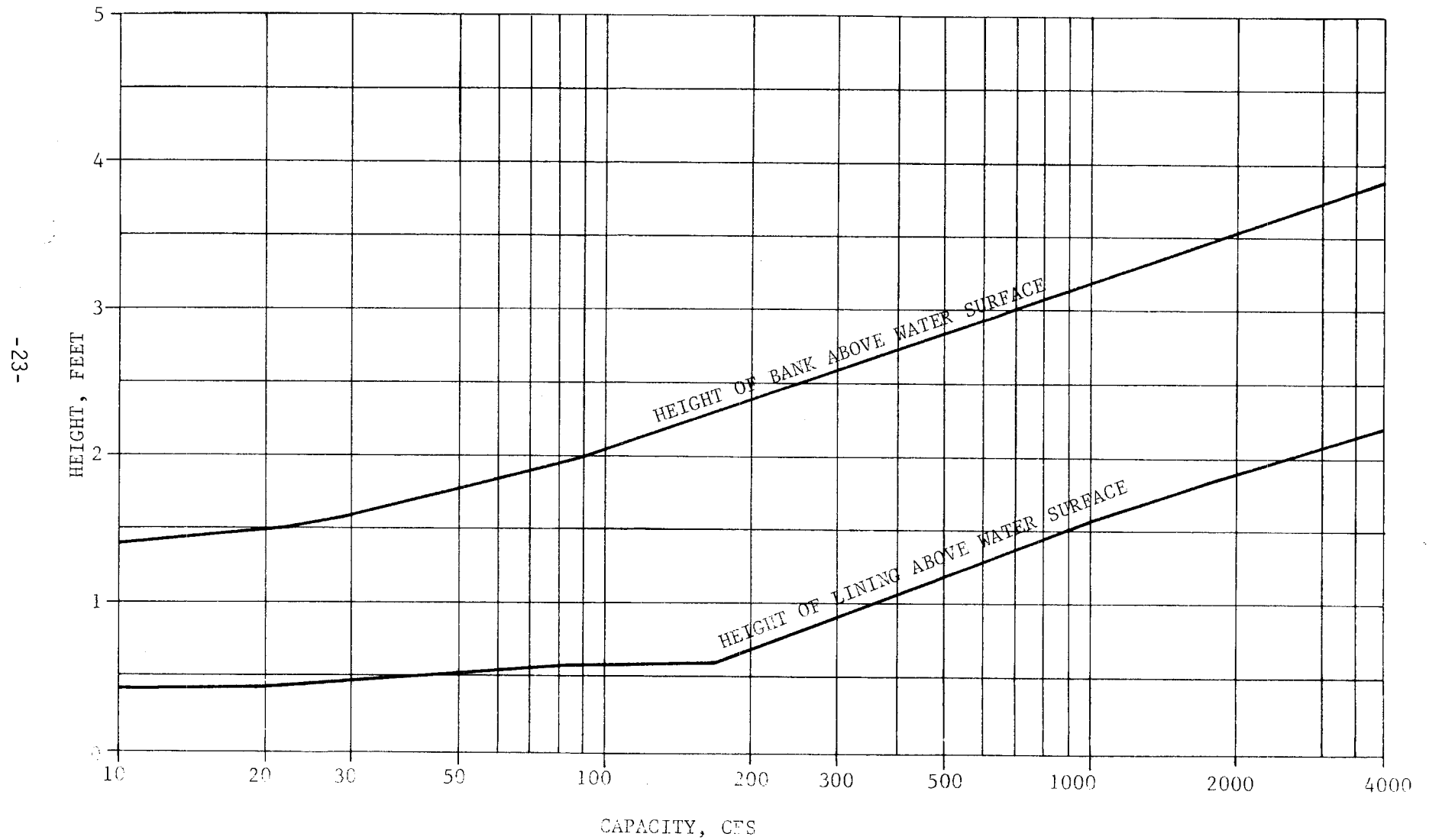
* Channel shaping will enlarge top width.

MINOR GREENBELT

<u>Reach</u>	<u>Bottom Width</u>	<u>Z</u>	<u>Water Depth D</u>	<u>**Ht. of Bank H</u>	<u>D+H</u>	<u>Top Width</u>	<u>RIGHT-OF-WAY</u>	
							<u>Calc.</u>	<u>Adjusted (Ft.)</u>
Gardiner Gulch to 21st	4'	1	1.96	2.3	4.3	12.6	33'	33'
"Scorpio" Gulch to 21st	4'	1	1.48	2.1	3.6	11.2	32'	32'
Parkview Gulch 21st to Parkview Boulevard	4'	3	2.56	2.8	5.4	20.2	40.2'	40'
Argus Gulch to 21st	4'	2	2.16	2.5	4.7	13.4	33.4'	35'
Parkview Gulch D/S from Parkview Boulevard	8'	3	2.80	3.0	6.0	26.0	46.0'	46'
Gardiner Gulch 21st to Bear Creek	8'	2	2.48	2.75	5.23	29	49'	49'
Argus Gulch 21st to Bear Creek	8	1	2.32	2.65	4.97	15	35'	35'

** Chow, Ven Te; page 160, ref. Fig. 7-1 from U. S. Bureau of Reclamation
"Recommended freeboard and height of bank of lined channels".

RECOMMENDED FREEBOARD AND HEIGHT OF
BANK OF LINED CHANNELS (U.S. BUREAU
OF RECLAMATION) - FROM CHOW, V.T.
"OPEN CHANNEL HYDRAULICS", FIGURE 7-1



CRITERIA
HYDRAULIC CALCULATIONS

FOR PARABOLIC CHANNELS:

n = Manning's Coefficient
T = Top width
S = Slope in Ft/Ft
D = Depth of water in feet

Q = AV = $\frac{K}{n} D^{8/3} S^{1/2}$ = Total discharge of channel in CFS

$$K = \frac{1.2}{x \left[\sqrt{16x^2 + 1} + \frac{1}{4x} \log_e (\sqrt{16x^2 + 1} + 4x) \right]^{2/3}}$$

where x = D/T

$$K' = x^{8/3} K$$

Assumed or given T:

$$K' = \frac{Qn}{T^{8/3} S^{1/2}} \longrightarrow D/T$$

Assumed or given D:

$$K = \frac{Qn}{D^{8/3} S^{1/2}} \longrightarrow D/T$$

K' and K are tabled by King¹ to give D/T (Tables 101 and 102)

Given D/T:

R = cD where c is tabled by King (Table 89)

Given R and S:

nV is tabled by King (Table 90), corresponding to

Manning's formula $V = \frac{1.486}{n} R^{2/3} S^{1/2}$

$$V = \frac{nV \text{ (tabled)}}{n}$$

¹ King, H.W., Handbook of Hydraulics, 4th ed.

SUMMARY MANNING'S n VALUES

Concrete Lined	-	n	=	.013
Earth Bottom, Concrete sides	-	n	=	.022
Earth or Rubble bottom, Rubble sides	-	n	=	.033-0.04
Natural Stream	-	n	=	.04 (Bear Creek - Hi Flood Stage)
Natural Stream	-	n	=	.05 (Tributaries, Bear Creek-Lo Stage)
Concrete Pipe or Culvert Box	-	n	=	.013
CMP	-	n	=	.024

CULVERT AT 21st STREET AND BEAR CREEK

$$\text{Pt. E: } Q = 1466 \text{ CFS}$$

$$A_{\text{exist.}} = 2 - 7' \times 10' = 140.0 \text{ SF}$$

$$V = \frac{Q}{A} = \frac{1466}{140} = 10.5 \text{ FPS}$$

$$H = h_e + h_f + h_o$$

$$h_e = 0.44 \left(\frac{V^2}{2g} \right) = 0.44 \times 1.714 = 0.75'$$

$$h_f = sL = \left(\frac{Qn}{KD^{8/3}} \right)^2 L \quad \frac{D}{b} = \frac{7}{20} = 0.35$$

$$K = 2.98 \text{ (King, Table 96)}$$

$$h_f = \left(\frac{1466 \times 0.013}{2.98 \times 179} \right)^2 L = (.03572)^2 L = 0.00128 L$$

for $L = 100$, $h_f = 0.128$

$$h_o = 1.0 (1.714) = 1.71'$$

$$H = 0.75 + 0.13 + 1.71 = \underline{\underline{2.59 \text{ FT}}}$$

CMP CULVERTS @ 8th STREET

$$Q = \frac{K}{\eta} D^{8/3} S^{1/2}$$

$$d = 13' \text{ where } D/d = 1$$

$$S = .05$$

$$\eta = .024$$

$$K = .463$$

$$Q = \frac{.463}{.024} \times 934 \times .2236 = 4029 \text{ cfs each}$$

$$\frac{\times 2}{8058 \text{ cfs maximum capacity without minor losses}}$$

Assume each pipe carries 1/2Q for Q = 2783

$$Q_2 = 2783 \div 2 = 1391.5$$

$$D_2 = \left(\frac{Q_2 D^{8/3}}{Q} \right)^{3/8} = \left(\frac{1391.5 \times 934}{4029} \right)^{3/8} =$$

$$= (322.6)^{3/8} \quad D_2 = 8.73$$

$$h_f = S_L = \left(\frac{Q \eta}{D^{8/3} K} \right)^2 L$$

$$= \left(\frac{1391.5 \times .024}{323 \times 1.064} \right)^2 L$$

$$= (.096)^2 L = .00922L$$

$$D_2/d = \frac{8.73}{13} = .67$$

$$K = 1.064$$

$$L = 100'$$

$$A = cd^2 = .559 (13)^2 = 94.47$$

$$h_f = .92 \text{ feet}$$

$$h_e = K_3 \frac{V^2}{2g} = .44 \frac{(Q/A)^2}{2g} = .44 \frac{(1391.5/94.47)^2}{2g} = .44 \frac{(14.7)^2}{2g} = .44 \times 3.36$$

$$= 1.48 \text{ feet}$$

$$h_o = .86 \times 3.36 = 2.89 \text{ Feet}$$

$$H = .92 + 1.48 + 2.89 = \underline{5.29 \text{ Feet}}$$

CULVERT @ I-25 and FOUNTAIN CREEK

$$Q = 2783 \text{ cfs}$$

$$A = 10 \times 28 = 280 \text{ SF}$$

$$V = \frac{Q}{A} = 9.94 \text{ FPS}$$

$$H = h_e + h_f + h_o$$

$$h_e = k_e \frac{v^2}{2g} = 0.1 (1.536) = 0.15'$$

where $k_e = 0.1$ assumes flush inlet

$$h_o = K_o \frac{v^2}{2g} = 1.0 (1.536) = 1.54'$$

$$h_f = s\ell = \left(\frac{Qn}{K D^{4/3}} \right)^2 \ell$$

$$\frac{D}{b} = \frac{10}{28} = .357$$

$$K = 2.91 \text{ (King, Table 96)}$$

$$h_f = \left(\frac{2783 \times .013}{2.91 \times 464} \right)^2 \ell = .00068\ell$$

$$\text{for } \ell = 200, \quad h_f = .136$$

$$H = .15 + .14 + 1.54 = 1.83'$$

MINOR DRAINAGE CHANNELS

TRAPEZOIDAL SECTIONS

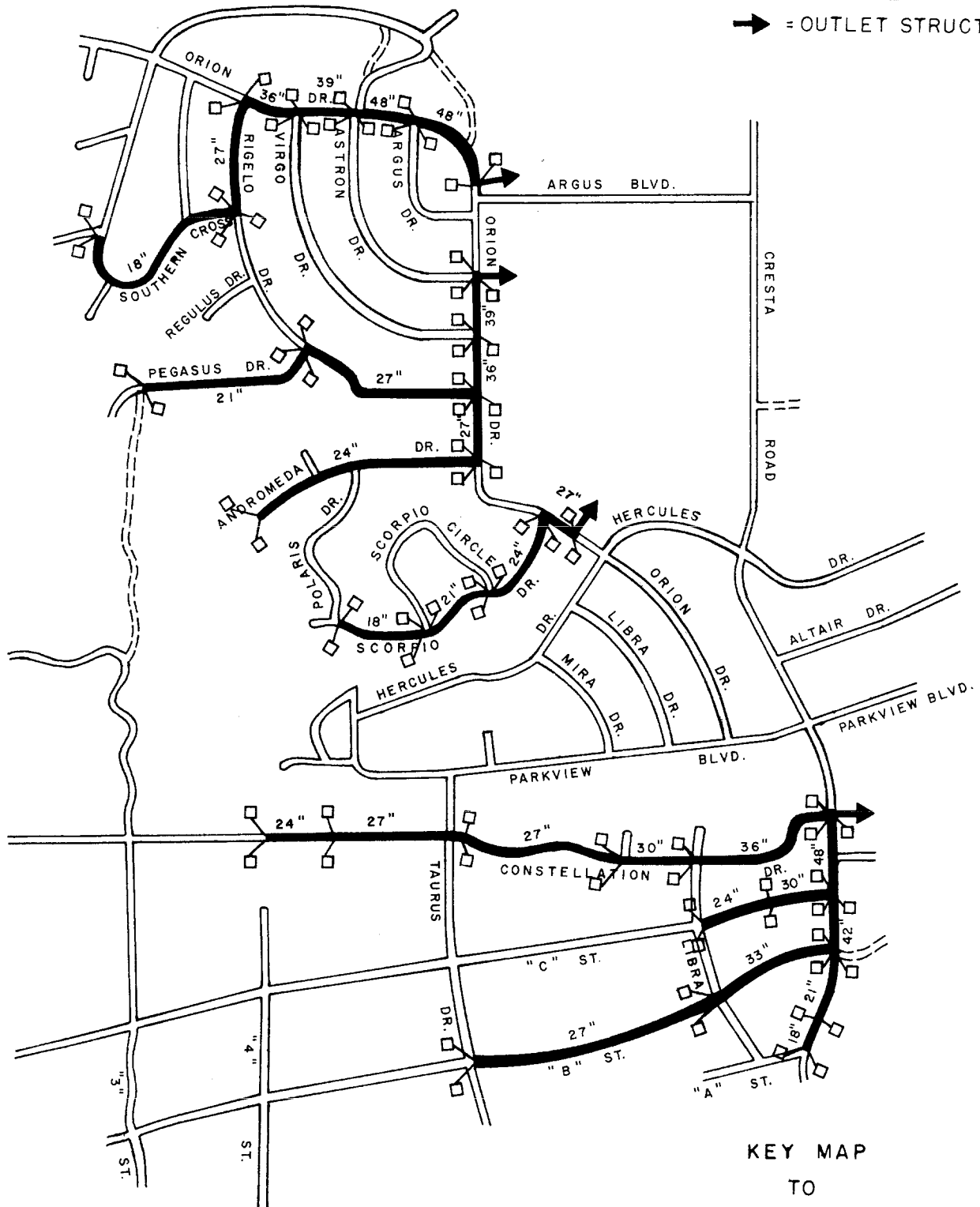
REACH	SLOPE FT/FT S	BOTTOM WIDTH-FT b	SIDE SLOPES HORIZ./VERT. Z	FLOW CFS Q	MANNING'S COEFFICIENT n	DEPTH FEET D	HYDRAULIC RADIUS-FT. R	VELOCITY FPS V	AREA SQ.FT. A	WETTED PER.-FT. P
GARDINER GULCH	.082	4	1	175	.033	1.96	1.23	15.2	11.5	9.4
"SCORPIO" GULCH	.079	4	1	102	.033	1.48	.99	12.7	8.0	8.1
"PARKVIEW GULCH" Downstream from Cresta Road	.075	4	3	474	.033	2.56	1.48	16.2	29.4	19.8
"ARGUS GULCH" D/S from Orion Drive	.060	4	2	236	.033	2.16	1.32	13.2	18.0	13.7
"PARKVIEW GULCH" D/S from Parkview Boulevard	.033	8	3	559	.033	2.80	1.79	11.6	48.4	27.0
GARDINER GULCH D/S from 21st to Bear Creek	.034	8	2	386	.033	2.48	1.68	12.0	32.2	19.1
"ARGUS GULCH" D/S from 21st to Bear Creek	.045	8	1	329	.033	2.32	1.65	13.3	24.7	15.0

LEGEND:

□ — = CATCH BASIN W/CONNECTOR PIPE.

24" = STORM DRAIN RCP W/SIZE DIAMETER

➔ = OUTLET STRUCTURE



KEY MAP
TO

STORM DRAIN SYSTEM
"BEAR CREEK"

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

NORTH ORION DRIVE SYSTEM

BASED ON MANNING'S EQUATION
n = 0.015

Location	(1) Length Ft	(2) Time Min.*	(3) Runoff cfs	(4) Total cfs	(5) Slope %	(6) Street cfs	(7) V-FPS	(8) size	(9) PIPE cfs	(10) V-FPS	REMARKS
Regulus Rigel (No.)	400	32.2	11.6 3.9	11.6 15.5	6.6 6.6	11.6 15.5	10.3 10.3	- -	- -		At Rigel to South. Cross

Stub end w/ So. Cross	250	32.5	41.6	41.6	4.6	21.6	12.7	18"	20	11	To South. Cross
South. Cross	900	33.1	38.4	64.5	8.5	44.5	16.8	18"	20	11	To Rigel
Rigel				64.5							
	400	33.7	15.5 12.8	80.0 92.8	4	33.2 (max)	8.0	27"	59.6	13	(From above) To Orion at Rigel

Orion (Easterly)	250	33.4	45.7	45.7	3	45.7	10.0	-	-		From West
	300	33.8	3.8	49.5	10	49.5	18	-	-		in Proposed Devel.
	150	33.9	6.4	55.9	12.5	55.9	18	-	-		To South. Cross

Southern Cross	650	32.2	1.3	1.3	7.5	1.3	11	-	-		
	150	32.4	11.5	12.8	10	12.8	12.7	-	-		To Orion
		33.9	55.9	68.7	7.1	68.7	15.4				(From above)
Orion (Easterly)	600	34.5	6.4	75.1	7.1	75.1	15.4				To Rigel
			92.8	167.9				27"	59.6		(From above)
	300	34.8	12.5	180.4	10	-	-	36"	180.4		To Virgo

*NOTE: All times shown herein are a guide only, for following the storm flow direction, and are not to be used as T_c in design.

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		Pipe			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Virgo	300	32.9	11.3	11.3	5.2	11.3	9.3	-	-		To Orion

Orion		34.8	11.2								At Virgo (From Above) To Astron
	300	35.1	180.4 5.0	191.6 196.6	5	34.6	8.8	39"	162		

Astron	200	32.3	8.9	8.9	3.3	8.9	7.3	-	-		To Orion

Orion		35.1	8.7								At Astron (From Above) To Argus
	300	35.4	196.6 5.3	205.3 210.6	3.3	-	-	48"	210.6	18	

Argus	150	31.5	5.2	3.7	5.2	7.8					To Orion

Orion		35.4	5.2								At Argus (From Above) To "V" drain No. of Argus Blvd.
			210.6	215.8							
	350	35.7	6.3	222.1	7.4	-	-	48"	222.1		
			2.5	224.6		2.5					

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SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

GARDINER GULCH SYSTEM

Location	Length Ft. (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Andromeda	350	33.9	76.1	76.1	10	13.1	12.7	24"	63	20	To Polaris
	550	34.4	7.6	83.7	10	20.7	12.7	24"	63	20	To Orion
Orion (Northerly)	300	34.4	5.2	88.9	6.7	18.9	10.4	27"	70	17	To Rigel

Pegasus	900	33.7	62.2	62.2	8.9	20.2	12	21"	42	17	To Rigel
Rigel											To "Dog Leg"
(Southeasterly)	300	34.2	10.3	72.5	3.2	23.5	7.2	27"	49	12	In Rigel
Rigel											
(Easterly)	550	34.7	7.5	80.0	10	-		27"	85	20	To Orion
		34.7	86.0	166.0							(From above)
Orion (Northerly)	300	35.0	1.3	167.3		17.3	10	36"	150	20	To Virgo

Virgo	250	32.2	7.6	7.6		7.6	11				To Orion

Orion (Northerly)		35.0	7.5								From Virgo
		35.0	167.3								(From above)
	300	35.3	2.8	177.6	6.7	-	-	39"	177.6	20	To Astron

Astron	200	32.1	3.8		6.6	3.8	10.3				To Orion

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Orion (Northerly)		35.3	3.7								From Astron (From Above) Diverted to Gardiner Gulch through proposed Outlet Structure
		35.3	177.6	181.3		-	-	39"	181.3	20	
<hr style="border-top: 1px dashed black;"/>											
Orion (Northerly)	300	31.6	2.6	2.6	6.7	2.6	10.1	-	-		To Argus Drive
<hr style="border-top: 1px dashed black;"/>											
Argus Drive	100	31.3	2.6	2.6	8.3	2.6	11.6	-	-		To Orion
<hr style="border-top: 1px dashed black;"/>											
Orion	150	31.9		5.2	6.7	5.2	10.1	-	-		To "V" Ditch
<hr style="border-top: 1px dashed black;"/>											

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

SCORPIO DRIVE SYSTEM

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Polaris	300	35.4	3.9	3.9	10	3.9	12.7				To Scorpio

Scorpio	150	32.1	41.8	41.8	10	41.8	12.7				To Polaris (From Above) To Scorpio Circle West
		32.1	3.8	45.6							
	430	32.8	12.5	58.1	8	32.1	11	18"	26	15	

Scorpio Circle West	300	34.4	7.7	7.7	1.6	7.7	1.9	-	-		To Scorpio

Scorpio		32.8	7.5								From Scorpio Circle West (From Above) To Scorpio Circle East
		32.8	58.1	65.6							
	350	33.4	6.1	71.7	10	27.7	12.7	21"	44	18	

Scorpio Circle East	200	33.8	5.2		8	5.2	11.3				To Scorpio

Scorpio		33.4	5.2								From Scorpio Circle East (From Above) To Orion
		33.4	71.7	76.9							
	500	34.3	-	76.9	7	24.9	10.7	24"	52	16	

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

SCORPIO DRIVE SYSTEM (Continued)

Location	Length	Time	Runoff	Total	Slope	Street		PIPE			Remarks
	Ft (1)	Min.* (2)	cfs (3)	cfs (4)	% (5)	cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Orion	200	34.0	5.2	5.2	5.7	5.2	9.6	-	-		To Scorpio To "Texas Crossing"
	100	34.5	76.9	82.1	5.7	20.1	9.6	27"	65	16	
		34.5	7.7	89.8		27.8	9.6				

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

HERCULES DRIVE SYSTEM (SURFACE FLOW)

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks	
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)		
Hercules	650	32.0	0.6	0.6	10	0.6	12.7	-	-		To Mira Drive	
	200	32.4	5.1	5.7	6.7	5.7	10.4	-	-			

Mira Drive	100	32.9	10.1	10.1	1.1	10.4	2.5				To Hercules	

Hercules		32.4	10.1								From Mira Drive (From above) To Libra Drive	
		32.4	5.7	15.8								
	300	33.7	1.3	17.1	9.1	17.1	12.2	-	-			

Libra Drive	150	39.0	1.3	1.3	1.25	1.3	4.5	-	-		To Hercules	

Hercules		33.7	1.2								From Libra Drive (From Above) To Orion	
		33.7	17.1	18.3								
	300	34.9	1.3	19.6	4.5	19.6	8.5	-	-			

Orion (Northwesterly)	150	31.9	1.3	1.3	1.25	1.3	4.5	-	-		To Hercules	
		34.9	1.3	1.3								
	150	35.2	19.6	20.9	6.25	20.9	10	-	-		(From Above) to	
Orion (From NW)		35.2	89.8	110.7	cfs	= Σ Q at "Texas Crossing" - proposed outlet structure						"Texas Crossing"

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

PARKVIEW BOULEVARD SYSTEM (SURFACE FLOW)

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Parkview	450	33.5	14.9	14.9	6.7	14.9	10.4	-	-		To Taurus

Taurus	150	31.3	1.3	7.3	6.6	1.3	10.3	-	-		To Parkview

Parkview	750	33.5	1.3								From Taurus (From above) To Mira Drive
		34.0	14.9	16.2	10	16.2	12.7				
		34.5	0.7	16.9	9	16.9	12.1	-	-		

Mira Drive	250	32.4	2.6	2.6	1.6	2.6	5.1	-	-		To Parkview

Parkview	300	34.5	2.6								From Mira Dr. (From above) To Libra Drive
		34.5	16.9	19.5							
		35.0	0.6	20.1	5.3	20.1	9.3				

Libra	250	32.6	6.3	6.3	4	6.3	8.1	-	-		To Parkview

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

PARVIEW BOULEVARD SYSTEM (CONTINUED)

Location	Length	Time	Runoff	Total	Slope	Street		PIPE		Remarks	
	Ft (1)	Min. (2)	cfs (3)	cfs (4)	% (5)	cfs (6)	V-FPS (7)	size (8)	cfs (9)		V=FPS (10)
Parkview	300	35.0	6.2								From Libra Dr. (From above) To Orion
		35.0	20.1	26.3							
		35.6	0.6	26.9	4.8	26.9	8.8	-	-		

Orion	400	32.9	8.7	8.7	0.5	8.7	2.9	-	-		To Parkview

Parkview	400	35.6	8.5								From Orion (From above) To Cresta Road
		35.6	26.9	35.4							
		36.4	-	35.4	4.8	35.4	8.8	-	-		

Cresta Road (Southerly)	350	32.8	7.4	7.4	0.5	7.4	2.9				To Parkview Boulevard
		36.4	7.2	7.2							
		36.4	35.4	42.6							
	430	37.0	1.2	43.8	10	43.8	12.7				From Parkview To Ditch at Cresta Road ("Parkview Gulch")

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

"PARKVIEW GULCH" SYSTEM

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
Constellation Drive	550	35.4	30.5	30.5	10	30.5	12.7	-	-		To (2) Side Street
(2) Side Street	250	35.0	18.9	18.9	10	18.9	12.7	-	-		To Constellation Drive
Constellation Drive		35.4	18.9								From (2) Side Street (From above)
	450	35.4	30.5	49.4							
	150	35.8	17.5	66.9	9	66.9	17.3	-	-		
		36.0	11.1	78.0	9	78.0	17.3	-	-		To (3) Side Street
(3) Side Street	600	32.2	11.7	11.7	7.3	11.7	10.9	-	-		To Constellation Drive
Constellation Drive		36.0	11.3								From (3) Side Street (From above)
	450	36.6	78.0	89.3	9	89.3	17.3				
	200	36.9	7.4	96.7	9	96.7	17.3				To (4) Side Street

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

"PARKVIEW GULCH" SYSTEM (Continued)

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V=FPS (7)	size (8)	cfs (9)	V=FPS (10)	
(4) Side Street	350	32.0	12.9	12.9	6.1	12.9	6.1				To Constella- tion Drive

Constellation Drive		36.9	12.2								From (4) Side Street
	200	37.2	96.7	108.9	9	48.9	12.7	24"	60	18	(From above)
	650	37.8	4.8	113.7	10	28.7	18.2	27"	85	20	To Taurus

Taurus (No.)	150	32.1	17.9	17.9	4	32.1	8.1				To Constella- tion Drive

Taurus (So.)	50	30.6	0.5	0.5	4	0.5	8.1				To Constella- tion Drive

Constellation Drive		37.8	16.6								To Taurus (No.)
		37.8	0.4	17.0							From Taurus (So)
	250	38.0	113.7	130.7	9.4	45.7	17.3	27"	85	20	(From above)
	450	38.4	4.2	134.9	9.4	49.9	17.3	27"	85	20	
	150	38.5	4.0	138.9	9.4	53.9	17.3	27"	85	20	To Mira Circle
	350	38.9	10.4	149.3	9.4	39.3	17.3	30"	110	22	To Libra Circle
	350	39.2	-	149.3	5.7	9.3	13.8	36"	140	20	
	350	39.5	20.4	169.7	10	-	18.2	36"	169.7	24	To Cresta Road

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

"PARKVIEW GULCH" SYSTEM (Continued)

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
"C" Street	600	32.8	10.2	10.2	10	10.2	12.7				From (1) Side Street to (2) Side Street
	700	33.7	15.6	25.8	10	25.8	12.7				To (3) Side Street
	700	34.3	16.6	42.4	8.7	42.4	11.9				To (4) Side Street
	1000	35.3	12.7	55.1	9	55.1	17.3				To Taurus
	1300	36.5	21.1	76.2	10	76.2	18.2				To Libra
	500	36.5	26.3	102.5	4.2	61.5	11.8	24"	41	13	
	300	36.9	6.3	108.8	4.2	33.8	11.8	30"	75	15	To Cresta Rd.

SUMMARY
STORM DRAIN SYSTEM
FLOW TABLE

"PARKVIEW GULCH" SYSTEM (Continued)

Location	Length Ft (1)	Time Min.* (2)	Runoff cfs (3)	Total cfs (4)	Slope % (5)	Street		PIPE			Remarks
						cfs (6)	V-FPS (7)	size (8)	cfs (9)	V=FPS (10)	
"B" Street	500	32.7	20.4	20.4	10	20.4	12.7	-	-		To (2) Side Street
	800	33.7	20.8	41.2	10	41.2	12.7	-	-		To (3) Side Street
	800	34.5	17.8	59.0	8.7	59.0	17	-	-		To (4) Side Street
	1100	35.5	17.0	76.0	10	76.0	18.2	-	-		To Taurus
	1350	35.5	28.9	104.9	7	32.9	15.3	27"	72	18	To Libra
	600	36.2	28.2	133.1	5	28.1	12.9	33"	105	17	To Cresta Road

"A" Street	600	33.4	8.9	8.9	10	8.9	12.7				To (4) Side Street
	1200	35.0	8.3	17.2	10	17.2	12.7				To Taurus
	1500	37.4	16.6	33.8	6.6	33.8	10.3				To Libra
	200	37.6	11.1	44.9	6.6	44.9	14.8				To Cresta Road

Cresta Road (Northerly)	400	38.1	44.9	44.9	5.5	22.9	13.5	18"	22	12	From "A" Street
	200	38.3	9.6	54.5	5.5	22.5	13.5	21"	32	14	To "B" Street
	300	38.6	136.0	190.5	5.5	--	13.5	42"	190.5	21	"B" Street to "C" Street
	500	39.0	114.1	304.6	8	--	16.1	48"	340.6	24	To Prop. Outlet @ Constellation Drive

Cresta		39.0	304.6			--			304.6		(From South - above)
At Prop. Outlet		39.0	43.4			43.4			-		From Parkview
		39.0	169.7	517.7		--			169.7		From Constellation
				517.7		43.4			474.3		

INVENTORY
MAJOR DRAINAGE STRUCTURES - BEAR CREEK CHANNEL

LOCATION	EXISTING STRUCTURE	Qp - CFS		A _{Exist.} - SF	A _{Flow} - SF	REQUIRED STRUCTURE
		50 YEAR	100 YEAR			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
19, 20	24" CMP 36" RCP in series	21.7 21.7	40.6 40.6	3.14 7.07		30" CMP 36" OK
-44- 20	36" RCP	31.7	59.3	7.07		36" OK
A	3 - 4'x8' in series	-	779.1	32.0 ea	47.4	3 - 6'hx21'w RCB
15	30" CMP	32.6	60.9	4.91		36" CMP
26	18" CMP	16.8	31.4	1.77		27" CMP
B	4'x8'	-	883.7	32	48.6	7'hx19'w RCB
29	3 - 18" CMP 2 - 24" CMP in parallel	16.0	29.9	5.31 6.28 <u>11.59</u>		4 SF
C	144 Ft ²	-	1049	144	97.1	10'hx13'w RCB
31	18" Tile & CMP 36" CMP in parallel	22.5	42.1	1.77 7.07 <u>8.84</u>		5 SF

INVENTORY - MAJOR DRAINAGE STRUCTURES - BEAR CREEK CHANNEL-Cont.

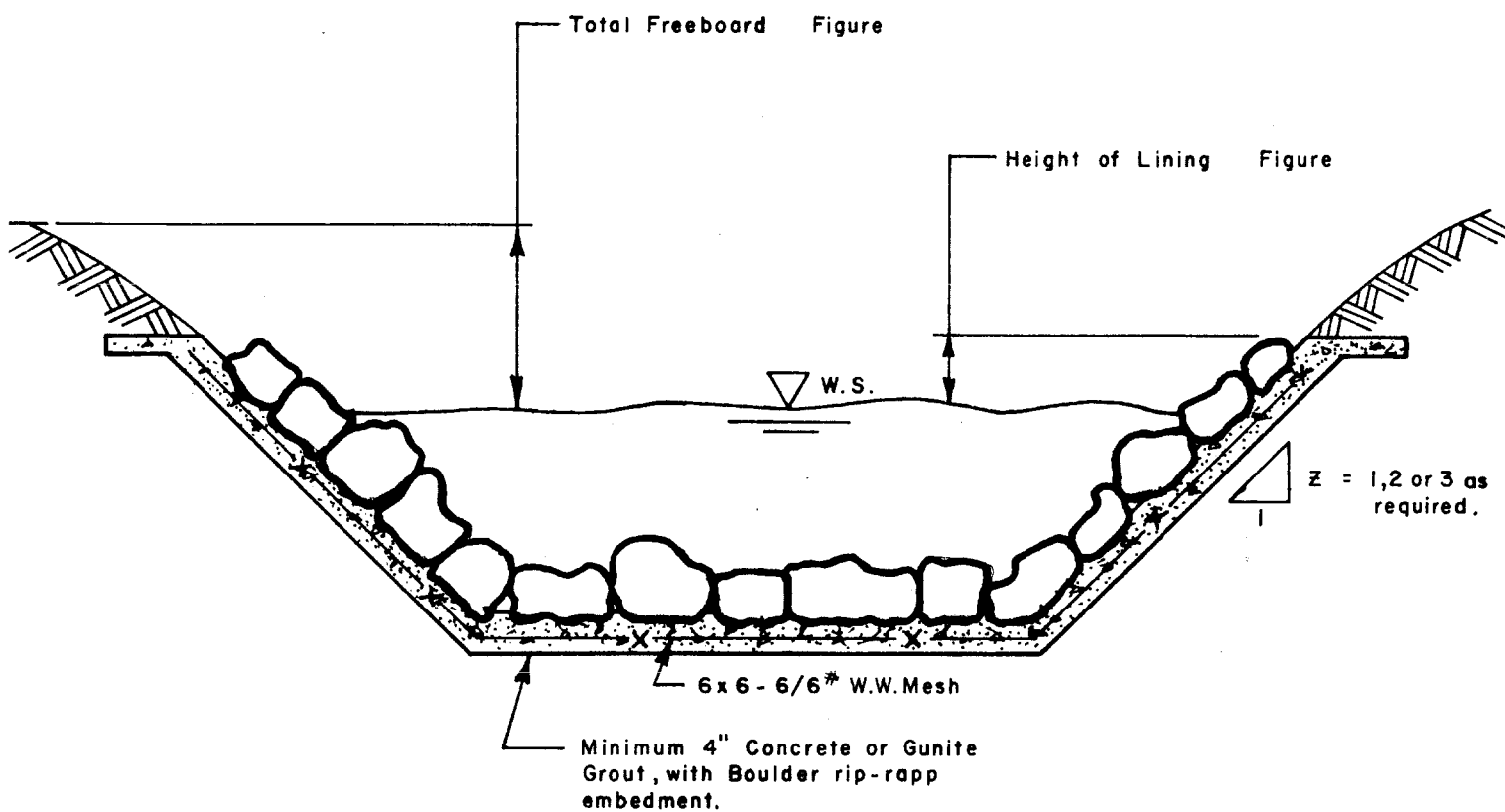
(1)	(2)	(3)	(4)	(5)	(6)	(7)
51	2 - 25"x16" Ellip.CMP in parallel	59.0	73.7	7.0 cfs ea		11 SF 48" CMP
C to D	100 Ft ² Bridge	-	1049	100	97.1	10'hx13'w
53	24" CMP	9.1	11.4	3.14		2.5 SF
54	5'hx2'w RCB	9.1	11.3	10		2.5 SF
D	58"x36" CMP 2 - 24" CMP in series	-	1427	55 cfs 6.28sf	145.2	7'hx26.5'w
E	2 - 7'x10'RCB	-	1466	140	157.1	OK @ 0.9' headwater
68	42" CMP in series with 29"x18" CMP 24" CMP	29.4 72.5 51.5	36.7 90.6 64.4	9.62sf 9.5 cfs 3.14		42" OK 5.9SF 48"CMP 42"CMP
E	Bridge 160 Ft ²	-	1466	160	157.1	10'hx18.5'w
R	2 - 13' dia. CMP	-	2783	266	247.3	2 - 13' dia.CMP OK
S	2 - 10'hx14'w	-	2783	280	172.9	10'x29' w/0' head- water; therefore, 2 - 10'x14' OK w/0.5' submergence

INVENTORY - MINOR DRAINAGE STRUCTURES

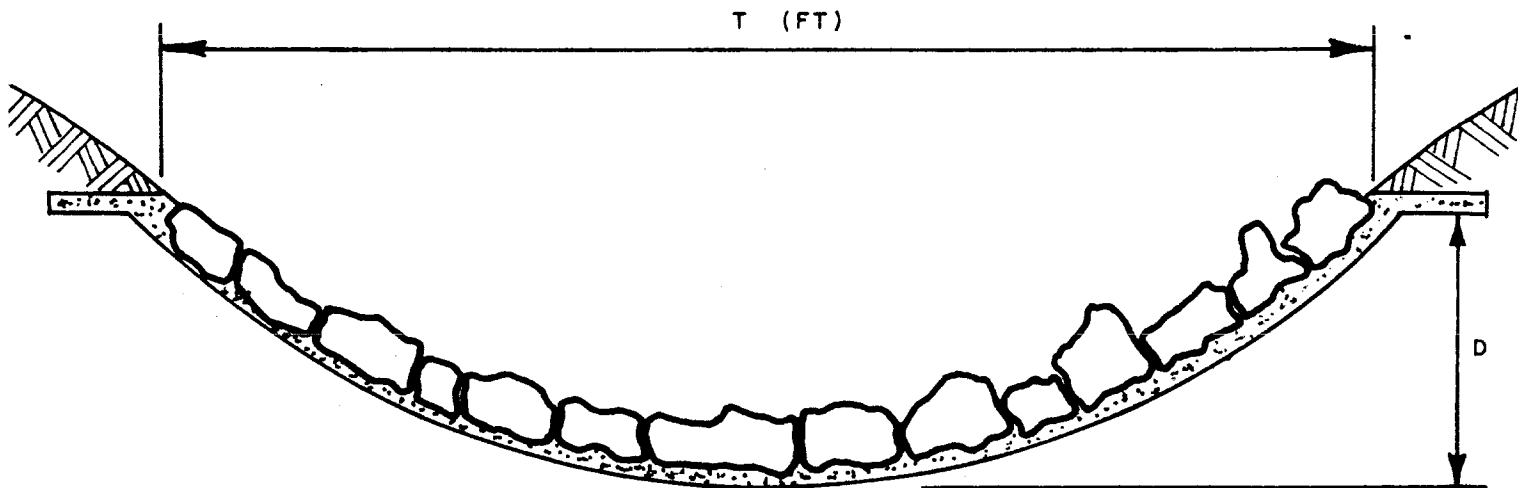
Location	Existing Structure	Qp-CFS		A Exist.	A Required Structure
		50 year	100 year		
40	Gold Camp Road	18" CMP	1.1	1.8	OK
39	None	15.9	---	---	4.0/27" CMP
38	None	6.1	---	---	1.8/18" CMP
37	None	15.5	---	---	4.0/27" CMP
36	None	24.1	---	---	4.9/30" CMP
35	None	78.0	---	(Gardiner Gulch)	12.6/48" CMP
34	None	39.0	---	---	7.1/36" CMP
33	None	41.0	---	---	7.1/36" CMP
32	15" CMP	22.2	---	1.23	4.9/30" CMP
<u>PROPOSED SKYWAY</u>					
50	None	4.0	---	---	18" CMP
50	None	10.0	---	---	24" CMP
50	None	12.0	---	---	24" CMP
50	None	23.0	---	---	30" CMP
50	None	17.0	---	---	30" CMP
50	None	79.0	---	---	2-36" CMP
50	None	93.0	---	---	2-36" CMP
50	None	95.0	---	---	2-36" CMP
50	None	95.0	---	---	2-36" CMP
50	None	42.4	---	---	42" CMP
50	None	112.0	---	---	2-42" CMP
50	None	113.0	---	---	2-42" CMP
50	None	113.0	---	---	2-42" CMP
50	None	254.0	---	---	34SF RCB

INVENTORY
STORM DRAIN PIPING (RCP)
AND IMPROVEMENTS

BASIN	STORM DRAIN PIPE		CATCH BASINS	OUTLET STRUCTURES
	Size in.-dia.	Length feet		
44	24	700	4	
	27	2850	6	
	30	650	4	
	33	600	2	
	36	700	4	
	42	300	4	
	48	500	2	1
45	18	430	5	
	21	350	3	
	24	1000	6	
	27	400	-	
	--	-	-	1
47	18	900	2	
	27	200	3	
	39	300	6	
	48	650	3	
	--	-	-	1
49	27	200	2	
	36	300	3	-
56	18	400	2	
	21	200	3	
61	24	400	2	-
62	21	900	5	
	27	850	3	
	39	300	3	
	--	-	-	1
63	36	300	3	-
			82	4



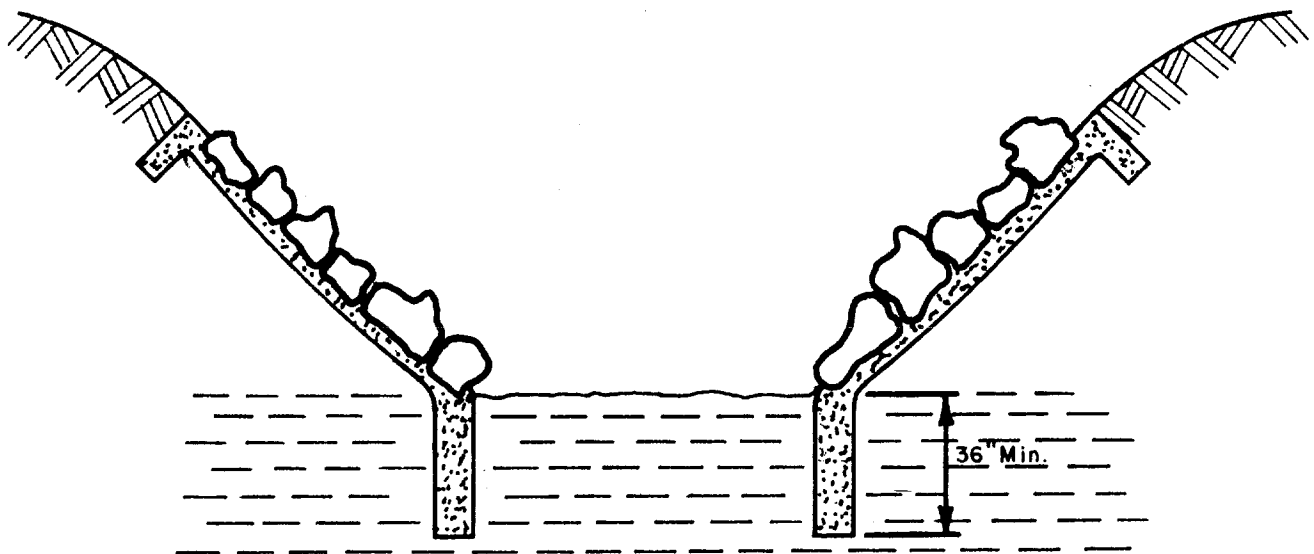
TRAPEZOIDAL CHANNEL



MINIMUM 4" CONCRETE OR GUNITE GROUT,
WITH NATIVE BOULDER RIP-RAPP EMBEDMENT,
6x6 - 6/6* W.W. MESH MINIMUM REINFORCEMENT.

$(0.5T)^2 = C(D)$
WHERE C = PARABOLIC CONSTANT

PARABOLIC SECTION



ALTERNATE SECTION

WHERE FOOTER WALLS ARE SEATED IN DENSE GRAY-BLACK
CLAY. (VERIFY CLAY DEPTH WITH SOIL BORINGS)

FIGURE 2

Point	HYDROGRAPH LOCATION (including contributing sub-basins)
A	Section 21, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-10, 12-14, 16-23; at 4' x 8' bridge crossing on High Drive Road.
B	Section 21, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-10, 12-28; at 4' x 8' bridge crossing on High Drive Road downstream of "A".
C	Section 21, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-30; at bridge crossing at junction of Bear Creek Canyon Road and Gold Camp Road.
D	Section 14, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins in "C" above, 31, 38-43, 50-55; at downstream boundary of Sub-basin 55.
E	Section 14, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins in "D" above and 67; at double 7' x 10' concrete box culverts crossing 21st Street at County Farm.
V	Section 24, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins in "E" above, M, P and 68; at confluence with Gardiner Gulch at approximate location of diversion from historic channel Southerly to gravel pit.
V'	Section 24, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins in "V" above, O, 70 and portion of 71; at point where diverted channel re-enters historic channel, also being point of confluence with tributary.
R	Section 24, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-71; at existing double 13-foot diameter C.M.P.s crossing 8th Street.
S	Section 24, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-72; at existing double 14' x 10' concrete box culverts crossing under Interstate Highway No. 25.
T	Section 24, Township 14 South, Range 67 West of the 6th P.M.; Sub-basins 1-73; at terminal confluence with Fountain Creek.

ACCUMULATIVE HYDROGRAPH

REACH	BASE Qp - CFS	BASE Tp - HRS	LENGTH - FT	SLOPE - FT/FT	TIME - HRS	Tp - HRS	Qp - CFS	VEL - FPS
A to B	779.1	0.836	3000	0.073	0.050	0.886	883.7	16.43
B to C	883.7	.886	1500	.118	.022	.908	1049	18.18
C to D	1049	.908	9200	.043	.236	1.144	1427	10.80
-15- D to E	1427	1.144	1600	.0375	.045	1.189	1466	9.83
E to V	1466	1.189	3200	.025	.095	1.284	2214	9.33
V to V'	2214	1.284	1550	.024	.043	1.327	2530	9.93
V' to R	2530	1.327	1000	.022	.027	1.354	2783	10.23
R to S	2783	1.354	1200	.050	.020	1.374	2783	16.10
* S to T	2783	1.374						

* Flow is through two existing 10' H x 14' W concrete box culverts under Freeway I-25.

SYNTHETIC HYDROGRAPH CALCULATIONS

BASIN (1)	ACRES (2)	SQ.MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)	
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)
1	256.1	0.400	6480	2080	0.160	0.596	0.15	0.28	48.7	91.0
2	223.6	0.349	4800	1800	0.120	0.572	0.15	0.28	44.3	82.7
3	436.4	0.682	6400	1600	0.170	0.602	0.15	0.28	82.2	153.5
4	62.4	0.098	3040	1000	0.091	0.555	0.15	0.28	12.8	23.9
5	138.1	0.216	4000	1600	0.100	0.560	0.15	0.28	28.0	52.3
6	280.6	0.438	5920	1800	0.150	0.590	0.15	0.28	53.9	100.6
7	320.3	0.500	8000	1700	0.220	0.632	0.15	0.28	57.4	107.2
8	266.7	0.417	5280	1700	0.135	0.581	0.15	0.28	52.1	97.3
9	352.6	0.551	7520	2100	0.190	0.614	0.15	0.28	65.2	121.6
10	232.7	0.364	4800	2500	0.100	0.560	0.15	0.28	47.2	88.1
11	642.0	1.003	11600	3300	0.250	0.650	0.15	0.28	112.0	209.1
12	44.8	0.070	2400	1300	0.060	0.536	0.15	0.28	9.5	17.7
13	66.8	0.104	3760	2100	0.083	0.550	0.15	0.28	13.7	25.6
14	88.9	0.139	3440	2000	0.076	0.546	0.15	0.28	18.5	34.5
15	171.2	0.268	6800	2400	0.160	0.596	0.15	0.28	32.6	60.9
16	74.8	0.117	3520	1000	0.102	0.561	0.15	0.28	15.1	28.3
17	11.8	0.018	1200	490	0.039	0.523	0.15	0.28	2.5	4.7
18	14.7	0.023	1200	620	0.036	0.522	0.15	0.28	3.2	6.0

SYNTHETIC HYDROGRAPH CALCULATIONS

BASIN (1)	ACRES (2)	SQ. MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)	
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)
19	102.8	0.161	2320	1050	0.063	0.538	0.15	0.28	21.7	40.6
20	46.1	0.072	1200	520	0.039	0.523	0.15	0.28	10.0	18.7
21	14.0	0.022	1600	600	0.051	0.531	0.15	0.28	3.0	5.6
22	21.1	0.033	1280	400	0.046	0.528	0.15	0.28	4.5	8.5
23	20.3	0.032	2160	800	0.063	0.538	0.15	0.28	4.3	8.1
24	2.9	0.005	560	240	0.025	0.515	0.15	0.28	0.7	1.3
25	36.4	0.057	2080	850	0.059	0.535	0.15	0.28	7.7	14.4
26	83.0	0.130	3360	820	0.101	0.561	0.15	0.28	16.8	31.4
27	206.4	0.323	4680	1200	0.140	0.584	0.15	0.28	40.2	75.0
28	13.5	0.021	1120	600	0.036	0.522	0.15	0.28	2.9	5.5
29	77.0	0.120	2600	960	0.074	0.544	0.15	0.28	16.0	29.9
30	13.1	0.020	1120	560	0.036	0.522	0.15	0.28	2.8	5.2
31	110.3	0.172	3200	1260	0.090	0.554	0.15	0.28	22.5	42.1
32	22.0	0.034	1760	600	0.056	0.534	0.72	0.90	22.2	27.7
33	40.5	0.063	2080	800	0.060	0.536	0.72	0.90	41.0	51.2
34	38.2	0.060	2000	740	0.060	0.536	0.72	0.90	39.0	48.8
35	79.6	0.124	3080	900	0.090	0.554	0.72	0.90	78.0	97.5
36	23.5	0.037	1920	710	0.059	0.535	0.72	0.90	24.1	30.1

SYNTHETIC HYDROGRPH CALCULATIONS

BASIN (1)	ACRES (2)	SQ.MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)	
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)
37	15.6	0.024	1840	500	0.064	0.538	0.72	0.90	15.5	19.4
38	5.7	0.009	400	140	0.019	0.511	0.72	0.90	6.1	7.7
39	77.1	0.120	2880	900	0.081	0.549	0.15	0.28	15.9	29.6
40	5.1	0.008	800	300	0.031	0.519	0.15	0.28	1.1	2.1
41	29.4	0.046	2160	600	0.072	0.543	0.15	0.28	6.2	11.5
42	24.2	0.038	1760	260	0.079	0.547	0.15	0.28	5.0	9.4
43	14.7	0.023	1120	200	0.052	0.531	1.40	1.75	29.3	36.7
44	234.2	0.366	6160	650	0.230	0.638	1.40	1.75	388.7	485.9
45	163.1	0.255	5360	800	0.180	0.608	1.40	1.75	284.2	355.2
46	40.4	0.063	3520	380	0.090	0.554	1.40	1.75	77.1	96.3
47	87.6	0.137	5000	580	0.190	0.614	1.40	1.75	151.2	189.0
48	36.0	0.056	3360	420	0.140	0.584	1.40	1.75	65.0	81.2
49	71.1	0.111	4160	520	0.165	0.599	1.40	1.75	125.6	157.0
50	161.6	0.253	6080	660	0.230	0.638	1.40	1.75	268.7	335.9
51	30.3	0.047	1600	300	0.067	0.540	1.40	1.75	59.0	73.7
52	33.1	0.052	1480	400	0.054	0.532	1.40	1.75	66.2	82.8
53	4.4	0.007	640	100	0.037	0.522	1.40	1.75	9.1	11.4
54	4.4	0.007	640	80	0.040	0.524	1.40	1.75	9.1	11.3
55	207.2	0.324	5360	340	0.260	0.656	1.40	1.75	334.7	418.3

SYNTHETIC HYDROGRAPH CALCULATIONS

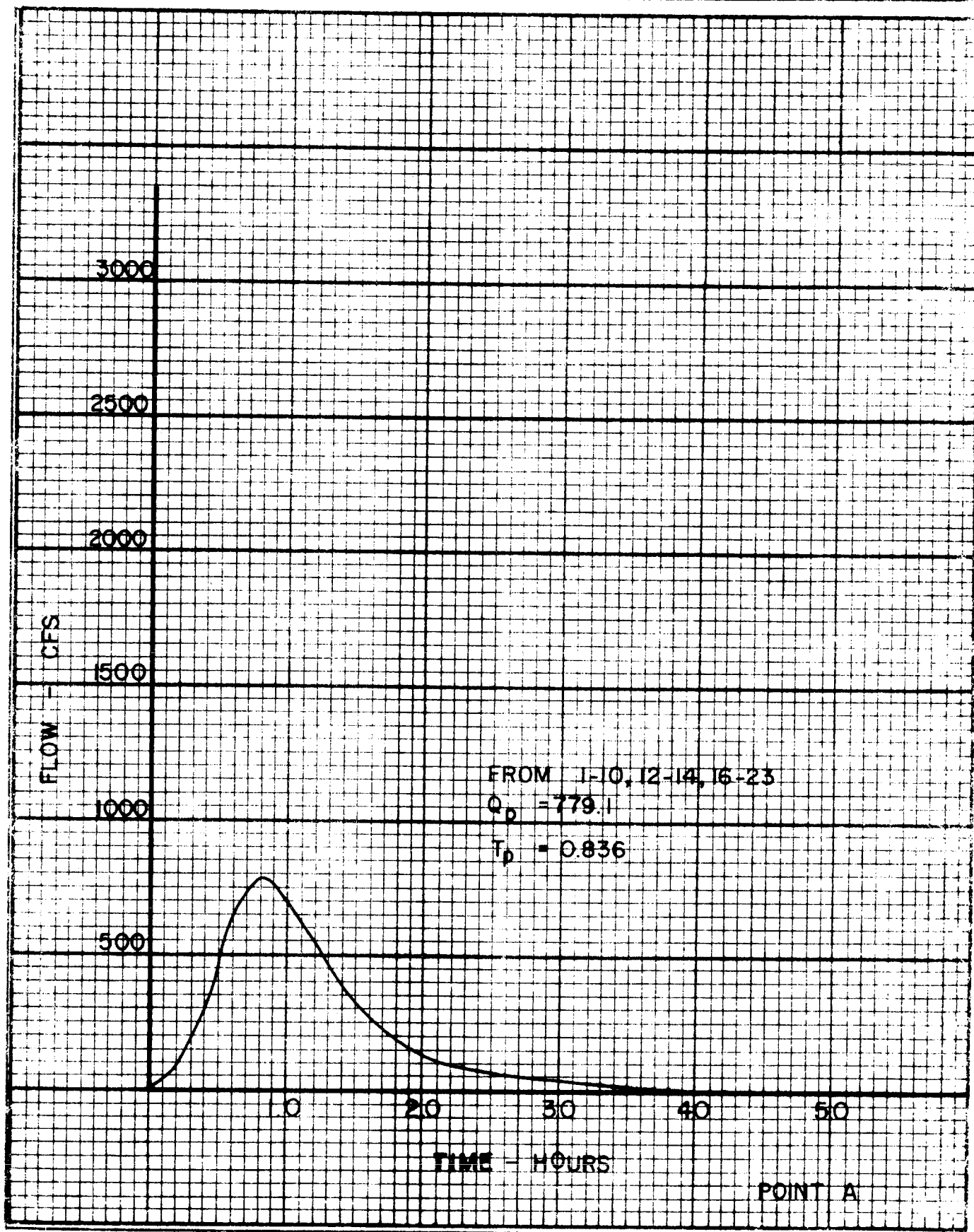
BASIN (1)	ACRES (2)	SQ.MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)	
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)
56	9.0	0.014	1280	80	0.086	0.552	1.40	1.75	17.2	21.5
57	11.9	0.019	1720	120	0.100	0.560	1.40	1.75	23.0	28.7
58	58.5	0.091	1800	180	0.092	0.555	1.40	1.75	111.1	138.9
59	22.8	0.036	2400	160	0.086	0.552	1.40	1.75	44.2	55.2
60	112.2	0.175	4880	300	0.240	0.644	1.40	1.75	184.1	230.2
61	11.8	0.018	2160	240	0.100	0.560	1.40	1.75	21.8	27.23
62	39.1	0.061	3920	500	0.155	0.593	1.40	1.75	69.7	87.13
63	2.4	0.004	800	90	0.051	0.531	1.40	1.75	5.1	6.38
64	24.8	0.038	1760	155	0.096	0.558	1.40	1.75	46.1	57.7
65	33.8	0.053	1600	150	0.170	0.602	1.40	1.75	59.7	74.6
66	57.3	0.090	2640	200	0.140	0.584	1.40	1.75	104.4	130.5
67	63.6	0.099	3080	200	0.160	0.596	1.40	1.75	112.6	140.7
68	170.4	0.266	5280	220	0.300	0.680	1.40	1.75	265.1	331.3
69	76.1	0.119	2800	120	0.180	0.608	1.57	1.90	148.7	180.0
70	13.5	0.021	1600	90	0.110	0.566	1.57	1.90	28.2	34.12
71	131.3	0.205	4060	240	0.220	0.632	1.57	1.90	246.5	298.3
72	46.9	0.073	3200	180	0.180	0.608	1.57	1.90	91.2	110.4
73	4.7	0.007	880	20	0.097	0.558	0.45	0.65	2.7	3.9

SYNTHETIC HYDROGRAPH CALCULATIONS

BASIN (1)	ACRES (2)	SQ.MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)		REMARKS (12)
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)	
A	3075.6	4.806	24,000	4,000	0.560	0.836	0.15	0.28	417.4	779.1	1-10, 12-14, 16-23
B	3589.1	5.608	26,960	4,200	0.600	0.860	0.15	0.28	473.4	883.7	1-10, 12-28
C	4321.2	6.752	28,440	4,400	0.620	0.872	0.15	0.28	562.2	1049.0	1-30
D	5028.8	7.858	37,640	4,800	0.810	0.986	0.26	0.37	1002.9	1427.0	C, 31, 38-43, 50-55
E	5092.4	7.957	39,240	4,860	0.830	0.998	0.28	0.38	1080.5	1466.0	D & 67
F	235.1	0.367	8,400	1,540	0.240	0.644	1.29	1.58	355.8	435.8	34, 45, 65
G	317.8	0.497	8,000	1,450	0.230	0.638	1.27	1.50	478.8	565.6	32, 33, 44, 56, 57
H	167.3	0.261	6,320	800	0.220	0.632	1.38	1.68	275.8	335.8	38, 50
I	86.7	0.135	6,240	1,020	0.190	0.614	1.28	1.58	136.2	168.1	37, 49
J	59.5	0.093	5,120	1,120	0.150	0.590	1.13	1.37	86.2	104.5	36, 48
K	320.3	0.500	7,840	1,480	0.220	0.632	1.18	1.40	451.8	536.1	35, 36, 46-48, 61-63
L	24.8	0.039	1,760	155	0.096	0.558	1.40	1.75	47.4	59.20	64, 65
M	377.6	0.590	9,840	1,650	0.270	0.662	1.21	1.49	521.9	642.7	I-K-66

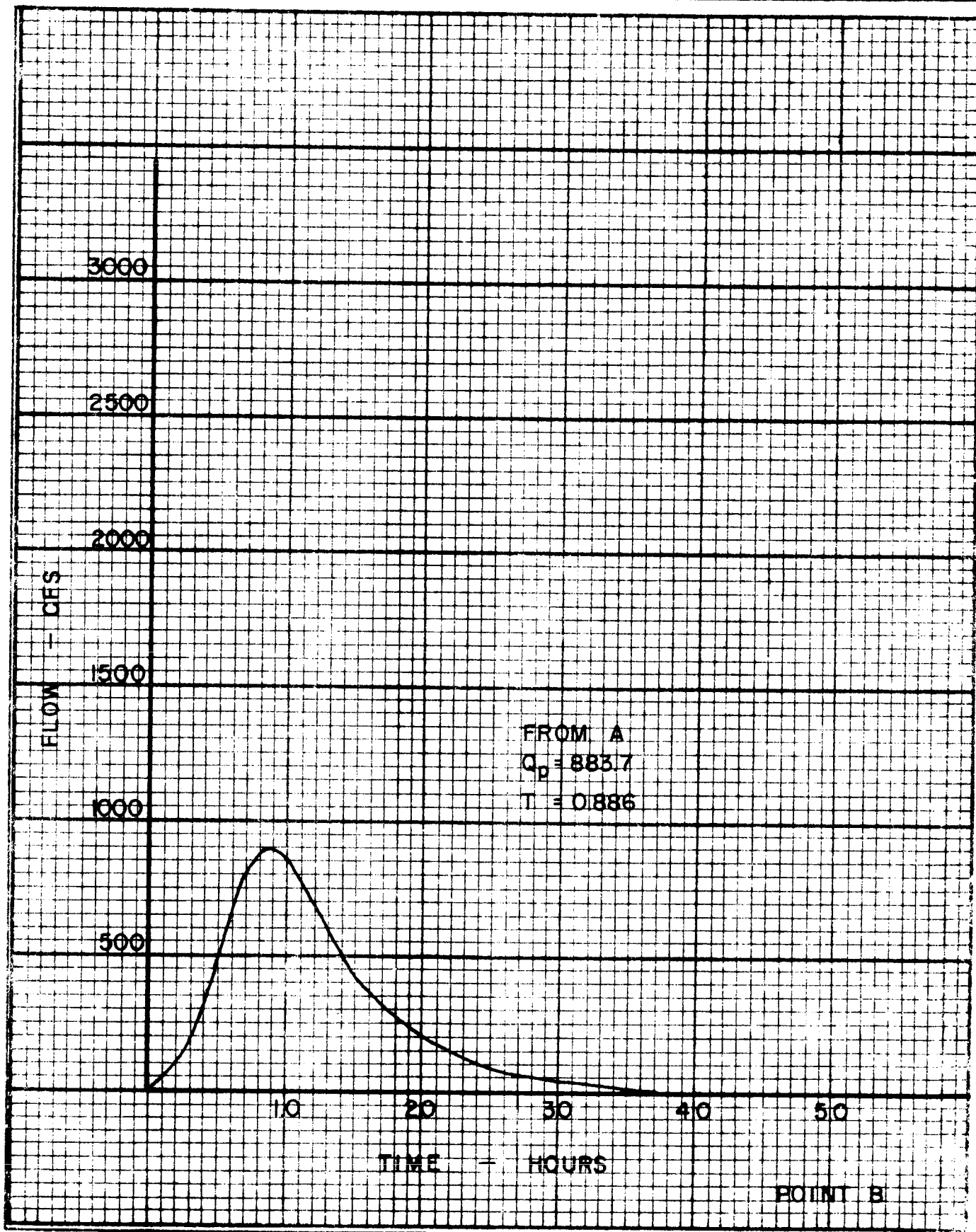
SYNTHETIC HYDROGRAPH CALCULATIONS

BASIN (1)	ACRES (2)	SQ. MI. (3)	L(FT.) (4)	H(FT.) (5)	Tc(HRS) (6)	Tp(HRS) (7)	Q (In.)		Qp (c.f.s.)		REMARKS (12)
							50 yr (8)	100 yr (9)	50 yr (10)	100 yr (11)	
N	376.1	0.588	10,400	1,585	0.300	0.680	1.29	1.53	539.9	640.3	G, 58
O	475.0	0.742	5,160	1,705	0.130	0.578	1.34	1.59	832.6	987.9	N, 59, 69
P	372.1	0.581	12,240	1,840	0.320	0.692	1.27	1.57	516.1	638.0	F, L, 60
Q	6587.7	10.293	43,800	5,300	1.103	1.162	0.51	0.64	2186.5	2744.0	1-70
R	6719.1	10.499	45,560	5,380	1.145	1.187	0.53	0.65	2268.9	2783.0	1-71
S	6766.0	10.572	46,760	5,440	1.175	1.205	0.54	0.65	2293.0	2760.0	1-72
T	6770.7	10.579	47,360	5,460	1.191	1.215	0.54	0.65	2275.7	2739.0	1-73
U	106.5	0.166	4,000	1,200	0.119	0.571	0.15	0.28	21.1	39.40	39 & 40 & 42
F&L	259.9	0.406	8,400	1,540	0.240	0.644	1.30	1.59	396.7	485.2	
D-H	4861.5	7.696	37,640	4,800	0.810	0.986	0.22	0.32	831.1	1209.0	
V		9.394	45,800	5,145	1.17	1.202	0.464	0.585	1771.0	2214.0	E, M, P, 68
W	4583.0	7.16	31,640	4,590	0.798	.979		0.31		1097.0	C, U, 31, 43, 51



POINT HYDROGRAPHS "A"- "S"
ALONG BEAR CREEK



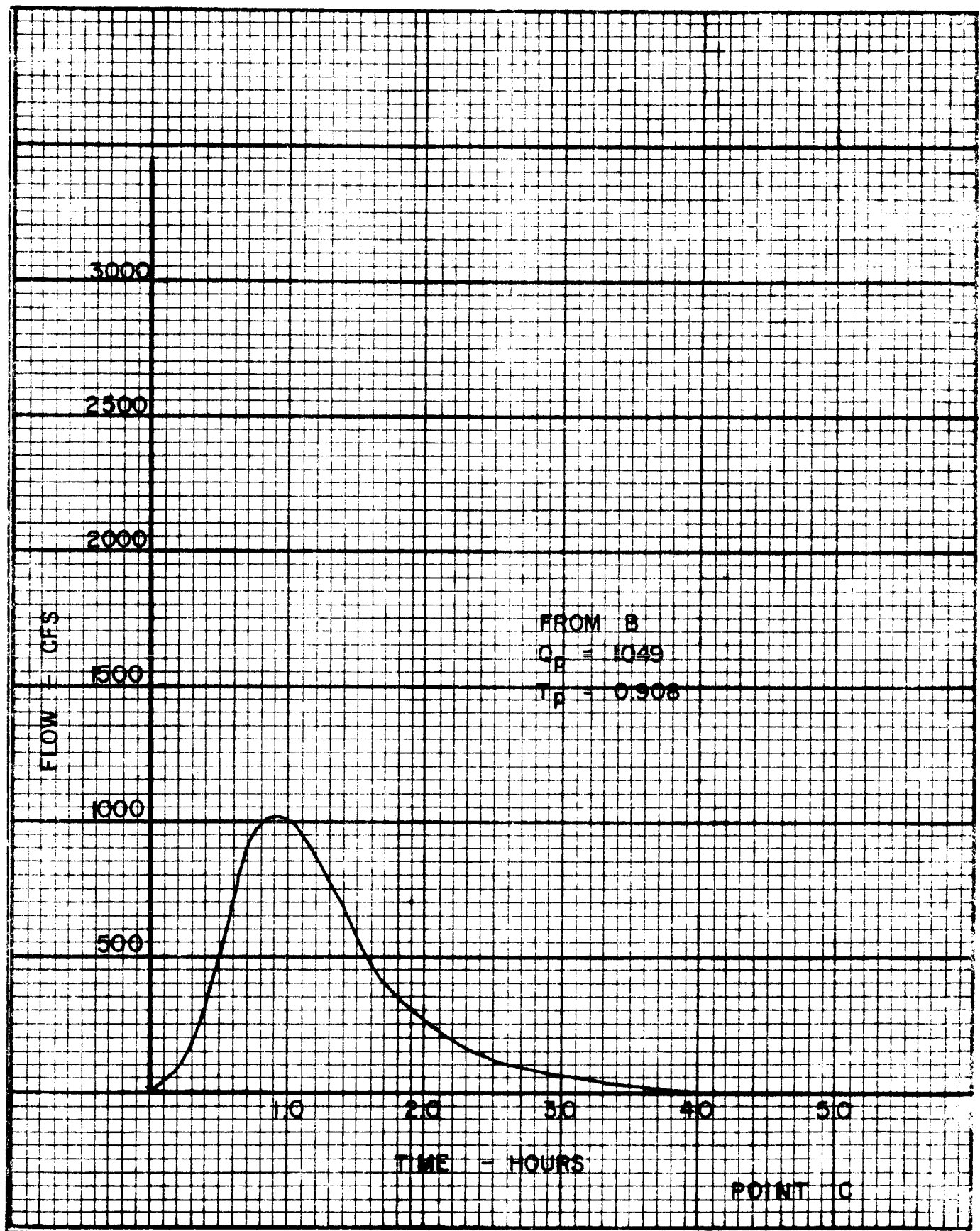


KEITH HOOK & ASSOCIATES, INC.

PHONE (473) 5451

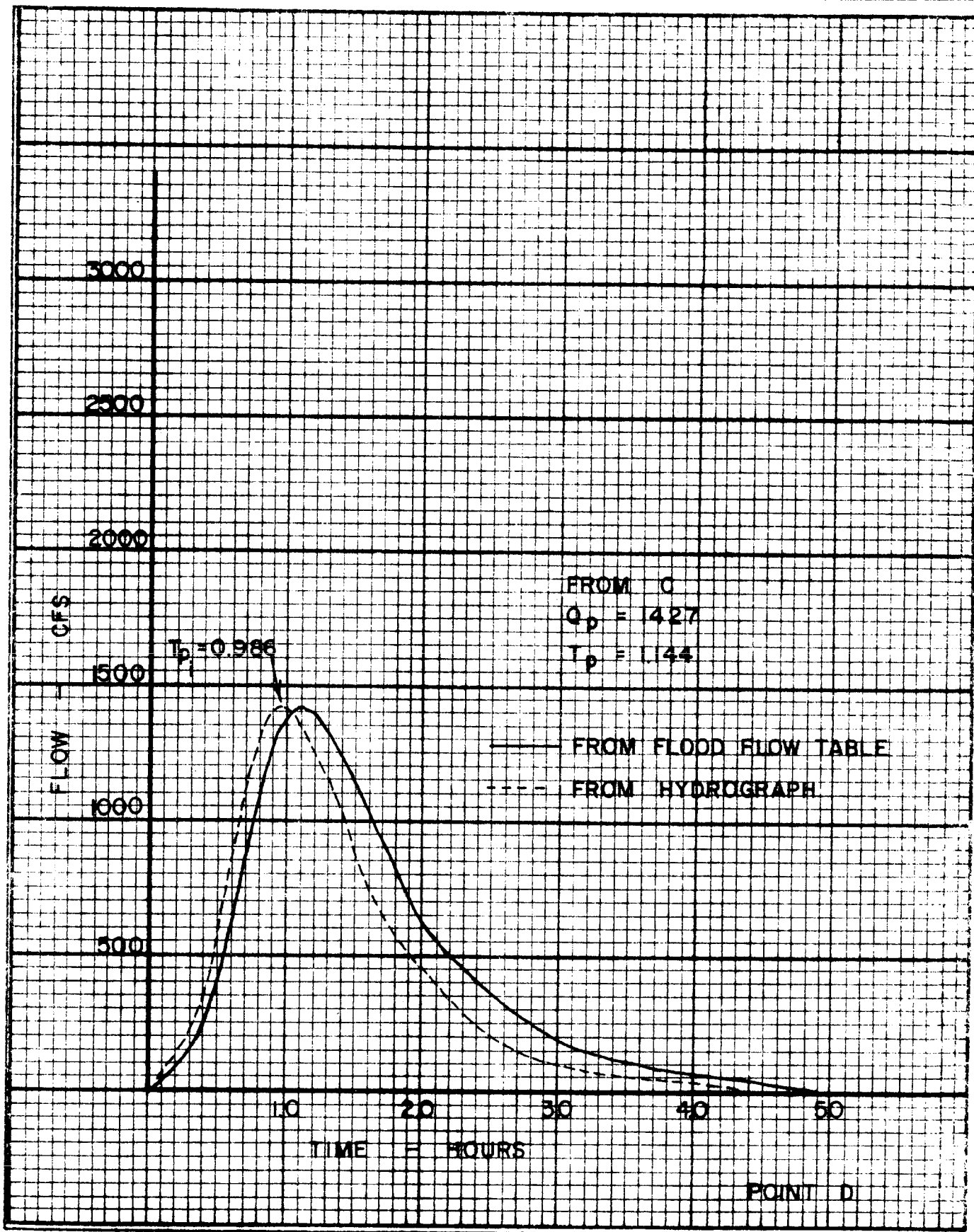
2ND E. PLATTE AVE

WILLOW SPRING, MO. 64080



r. keith hook & associates, inc.



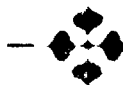
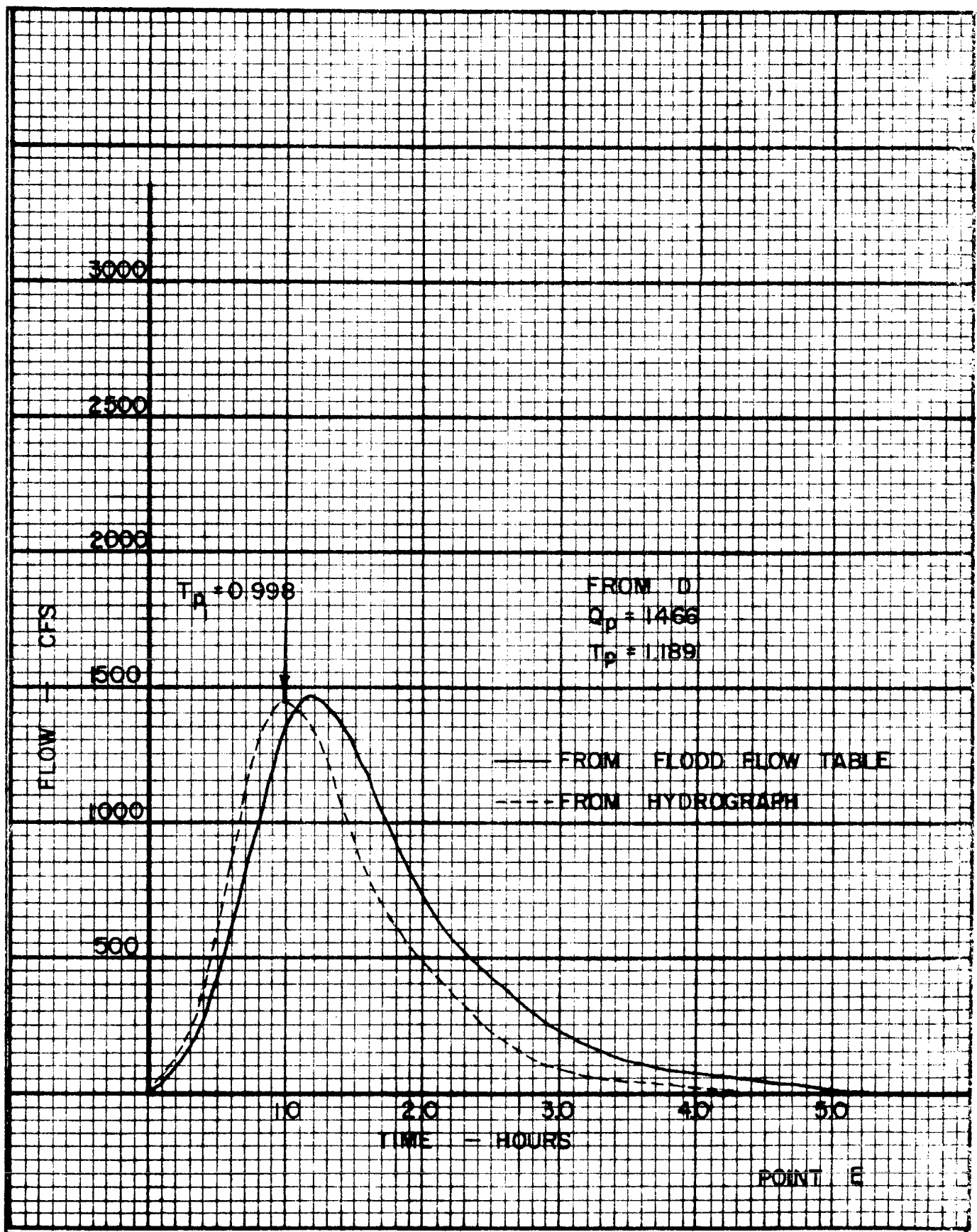


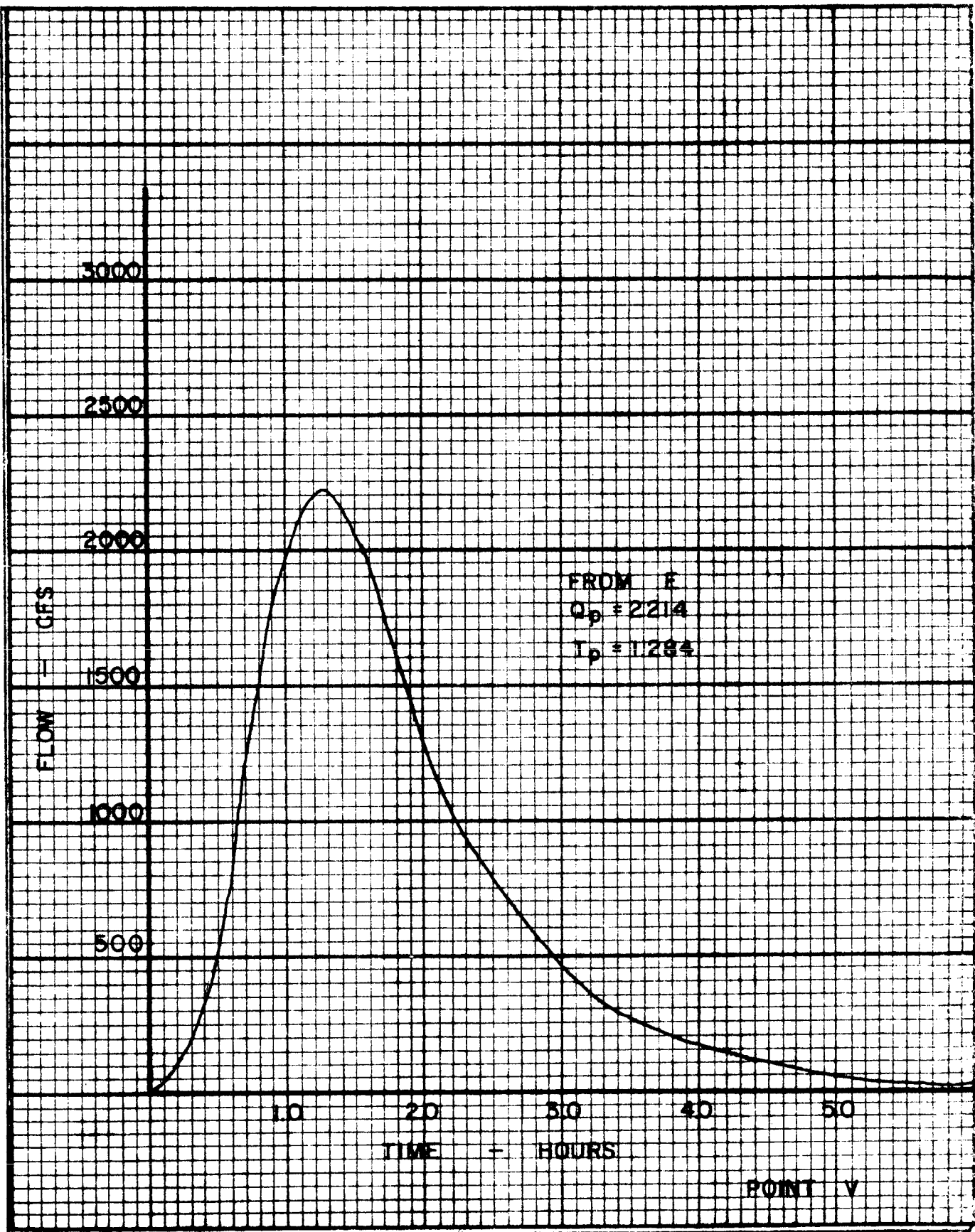
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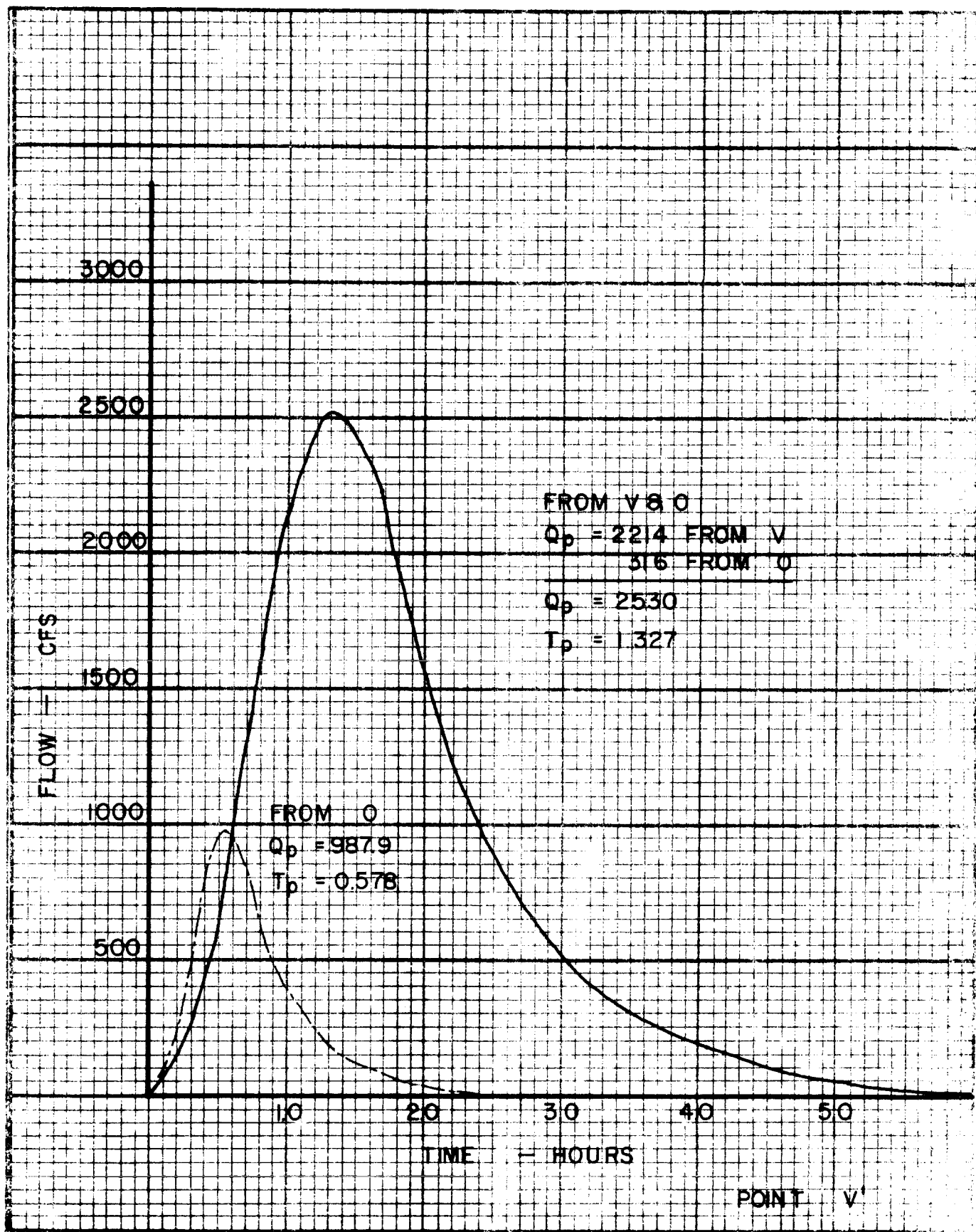
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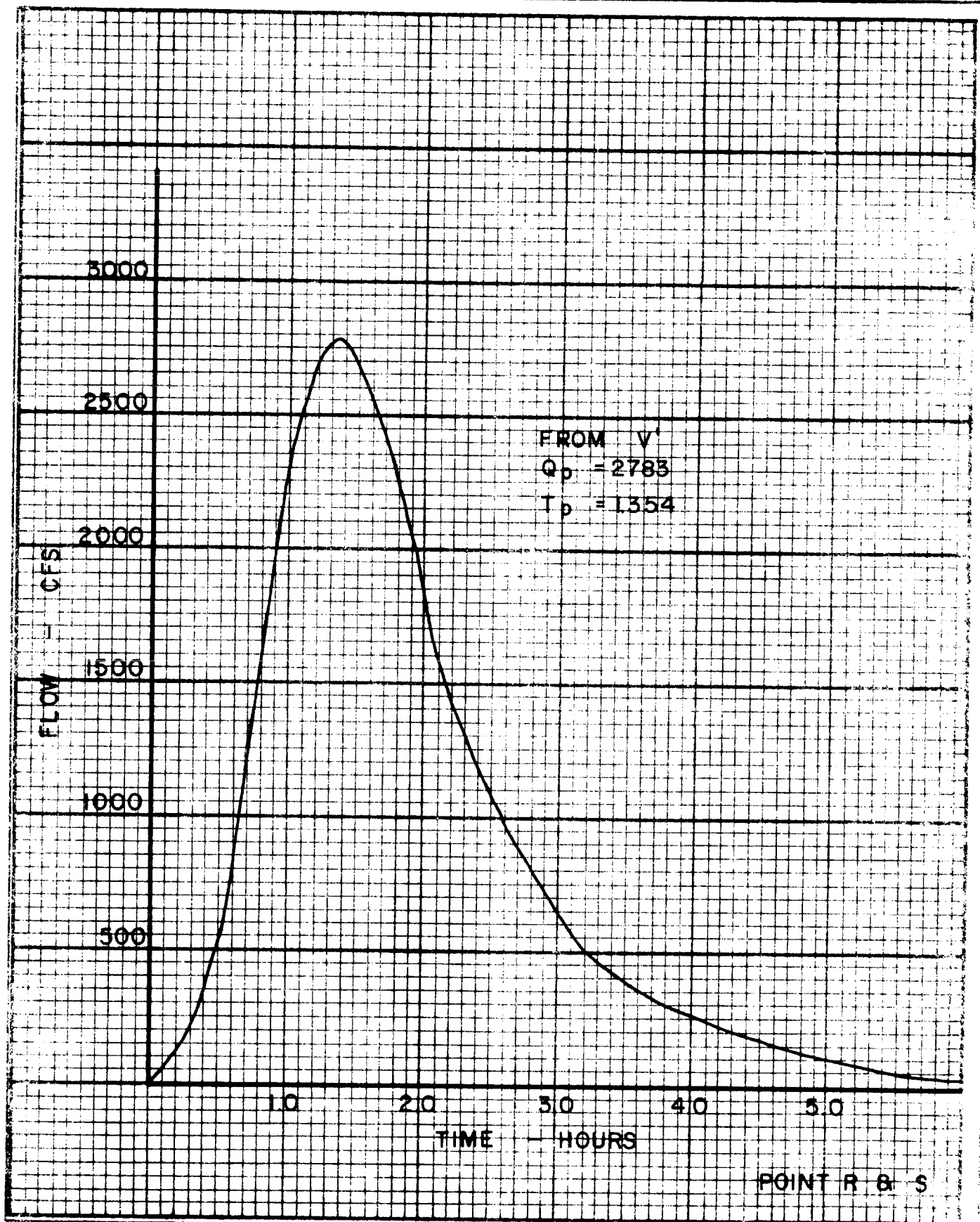
2345 E. PLATTE AVE.

COLORADO SPRINGS, COLORADO 80906









SUB-BASIN DESCRIPTIONS

- Basin 1: Portion of Sections 35 and 36, extending somewhat into Sections 25 and 26, Township 14 South, Range 68 West of the 6th Princ. Merid.; containing 256.1 Acres, 48.7 CFS/91.0 CFS* at Easterly boundary; located in the Easterly portion of Pike National Forest. Relatively steep slope, rugged mountains and sharp, well defined valleys. Area is undeveloped.
- Basin 2: Portion of Sections 25 and 26, Township 14 South, Range 68 West of the 6th Princ. Merid.; containing 223.6 Acres, 44.3 CFS/82.69 CFS at Easterly boundary; location, terrain and development same as 1 above.
- Basin 3: Portion of Sections 25 and 26, extending somewhat into Sections 23 and 24, Township 14 South, Range 68 West of the 6th Princ. Merid.; containing 436.4 Acres, 82.2 CFS/153.5 CFS at Southerly boundary; location, terrain and development are similar to 1 above.
- Basin 4: Portion of Sections 25 and 36, Township 14 South, Range 68 West of the 6th Princ. Merid.; containing 62.4 Acres, 12.8 CFS/23.9 CFS at Easterly boundary; location, terrain and development are similar to 1 above.
- Basin 5: Portion of Section 25 and extending somewhat into Section 36, Township 14 South, Range 68 West of the 6th Princ. Merid.; containing 138.1 Acres, 28.0 CFS/52.3 CFS at Southeasterly boundary; location, terrain and development are similar to 1 above.
- Basin 6: Portion of Sections 25 and 36, Township 14 South, Range 68 West, and extending somewhat into Sections 30 and 31, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 280.6 Acres, 53.9 CFS/100.6 CFS at Southerly boundary; drains Southerly from Mounts Garfield and Arthur to Bear Creek in Pike National Forest; terrain is rugged with steep slope, area is undeveloped.

* 48.7 CFS/91.0 CFS = 50-yr. frequency/100-yr. frequency:
1 hr. duration

- Basin 7: Portion of Section 36, Township 14 South, Range 68 West, and portion of Sections 30 and 31, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 320.3 Acres, 57.4 CFS/107.2 CFS at Easterly boundary; located in portion of Bear Creek known as Jones Park of Pike National Forest, containing Kineo Mountain; terrain is rugged with relatively steep slopes, area is undeveloped.
- Basin 8: Portion of Section 30 and extending into Section 31, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 266.7 Acres, 52.1 CFS/97.3 CFS at Southerly boundary; drains Southerly from Tenney Crags to Bear Creek; area is rugged, steep and undeveloped; located in Pike National Forest.
- Basin 9: Portion of Sections 29, 31 and 32, and a small portion of 30, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 352.6 Acres, 65.2 CFS/121.6 CFS at Northerly boundary; area extends down Bear Creek from Kineo Mountain to Mount Buckhorn, and is steep, rugged and undeveloped; located in Pike National Forest.
- Basin 10: Portion of Section 29 and a small portion of Section 30, Township 14 South, Range 67 West of the 6th Princ. Merid., containing 232.7 Acres, 47.2 CFS/88.1 CFS at Easterly boundary; located in Pike National Forest; terrain is steep, rugged and undeveloped, and drains Easterly from Tenney Crags.
- Basin 11: Portion of Sections 19, 20, 21, 29 and 30 in Pike National Forest, and portions of Sections 16 and 17 outside of the National Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 642.0 Acres, 112.0 CFS/209.1 CFS at Easterly boundary; drains area known as "Hunters Run" tributary to Bear Creek; terrain is rugged and steep, and is relatively undeveloped. Access to Easterly boundary off Bear Creek Canyon Road.
- Basin 12: Portion of Section 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 44.8 Acres in Pike National Forest, 9.5 CFS/17.7 CFS at Northerly boundary; terrain is steep, rugged and undeveloped.

- Basin 13: Portion of Section 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 66.8 Acres, 13.7 CFS/25.6 CFS at Easterly boundary; location and terrain are similar to 12 above.
- Basin 14: Portion of Sections 20 and 29, and extending somewhat into Sections 21 and 28, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 88.9 Acres, and 18.5 CFS/34.5 CFS at the Southeasterly boundary; location and terrain are similar to 12 above.
- Basin 15: Portion of Sections 20 and 21 and a small portion of 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 171.2 Acres, and 32.6 CFS/60.9 CFS at the Easterly boundary; location and terrain are similar to 12 above. Contains area known as "Scout Camp", with access partially up tributary canyon off Bear Creek Canyon Road.
- Basin 16: Portion of Sections 28 and 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 74.8 Acres, and 15.1 CFS/28.3 CFS at Northerly boundary; located in Pike National Forest; draining Northerly off Mount Buckhorn to Bear Creek; terrain steep, rugged and undeveloped.
- Basin 17: Portion of Sections 28 and 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 11.8 Acres, and 2.5 CFS/4.7 CFS at Northerly boundary; location and terrain are similar to 16 above.
- Basin 18: Portion of Section 29, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 14.7 Acres, and 3.2 CFS/6.0 CFS at Easterly boundary; located in Pike National Forest; terrain is steep, rugged and undeveloped.
- Basin 19: Portion of Section 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 102.8 Acres, and 21.7 CFS/40.6 CFS at Northerly boundary; located on West slope of Mays Peak and drains Northwesterly across High Drive Road; terrain is similar to 18 above.

- Basin 20: Portion of Section 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 46.1 Acres, and 10.0 CFS/18.7 CFS at the Northerly boundary; terrain is similar to 18 above.
- Basin 21: Portion of Section 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 14.0 Acres, and 3.0 CFS/5.6 CFS at the Northerly boundary; terrain is similar to 18 above.
- Basin 22: Portion of Section 21, and extending into Sections 20 and 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 21.1 Acres, and 4.5 CFS/8.5 CFS at the Easterly boundary crossing Bear Creek Canyon Road; terrain is similar to 18 above.
- Basin 23: Portion of Section 28, and small portion of Section 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 20.3 Acres, and 4.3 CFS/8.1 CFS at the Northwesterly boundary crossing Bear Creek Canyon Road; drains across High Drive Road; terrain is steep, rugged and undeveloped.
- Basin 24: Portion Section 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 2.9 Acres, and 0.7 CFS/1.3 CFS at Northeasterly boundary.
- Basin 25: Portion of Sections 21 and 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 36.4 Acres, and 7.7 CFS/14.4 CFS at the Northerly boundary.
- Basin 26: Portion of Sections 20 and 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 83.0 Acres, and 16.8 CFS/31.4 CFS at the Northeasterly boundary crossing Bear Creek Canyon Road.
- Basin 27: Portion of Sections 21 and 28, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 206.4 Acres, and 40.2 CFS/75.0 CFS at the Northwesterly boundary, draining the North slope of Mays Peak.

- Basin 28: Portion of Section 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 13.5 Acres, and 2.9 CFS/5.5 CFS at the Northerly boundary, crossing Bear Creek Canyon Road.
- Basin 29: Portion of Section 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 77.0 Acres, and 16.0 CFS/29.9 CFS at the Northerly boundary where Bear Creek Canyon Road and Gold Camp Road intersect.
- Basin 30: Portion of Section 21, Township 14 South, Range 67 West of the 6th Princ. Merid. in Pike National Forest; containing 13.1 Acres, and 2.8 CFS/5.2 CFS at the Northeasterly boundary where Bear Creek Canyon Road and Gold Camp Road intersect.
- Basin 31: Portion of Section 21 in Pike National Forest, and Sections 16 and 22 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 110.3 Acres, and 22.5 CFS/42.1 CFS at the Easterly boundary; terrain is steep and rugged grading to moderately steep in the creek valley; development is minimal and only along the creek.
- Basin 32: Portion of Section 27, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 22.0 Acres, and 22.2 CFS/27.7 CFS at the Easterly boundary; located Westerly of Gold Camp Road in moderately steep, hilly terrain; development is minimal and primarily individual mountain homes.
- Basin 33: Portion of Section 27, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 40.5 Acres, and 41.0 CFS/51.2 CFS at the Easterly boundary; location, terrain and development are similar to 32 above.
- Basin 34: Portion of Sections 22 and 27, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 38.2 Acres, and 39.0 CFS/48.8 CFS at the Easterly boundary; location, terrain and development are similar to 32 above.
- Basin 35: Portion of Sections 21 and 28 in Pike National Forest, and Sections 22 and 27 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 79.6 Acres, and 78.0 CFS/97.5 CFS at the Easterly

- Basin 35: (continued)
boundary; terrain and development are similar to 32 above. This sub-basin contains head of Gardiner Gulch (above Gold Camp Road).
- Basin 36: Portion of Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 23.5 Acres, and 24.1 CFS/30.1 CFS at the Easterly boundary; location, terrain and development are similar to 32 above.
- Basin 37: Portion of Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 15.6 Acres, and 15.5 CFS/19.4 CFS at the Easterly boundary; terrain and location are similar to 32 above; development is lacking at present.
- Basin 38: Portion of Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 5.7 Acres, and 6.1 CFS/7.7 CFS at the Easterly boundary; no development at present; terrain and location are similar to 32 above.
- Basin 39: Portion of Section 21 in Pike National Forest, and portion of Section 22 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 77.1 Acres, and 15.9 CFS/29.6 CFS at the Northerly boundary; no development at present; terrain and location are similar to 32 above.
- Basin 40: Portion of Section 21 in Pike National Forest, and portion of Section 22 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 5.1 Acres, and 1.1 CFS/2.1 CFS at the Easterly boundary; terrain is uniformly steep and there is no development at present. The sub-basin extends Westerly from Gold Camp Road.
- Basin 41: Portion of Section 21 in Pike National Forest, and a small portion in Section 22 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 29.4 Acres, and 6.2 CFS/11.5 CFS at the Northerly boundary at Bear Creek Canyon Road; terrain grades from steep above Gold Camp Road to moderately steep in the creek valley where development is light. There is potential for growth in Bear Creek valley.

- Basin 42: Portion of Section 21 in Pike National Forest, and portion of Section 22 outside the Forest, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 24.2 Acres, and 5.0 CFS/9.4 CFS at the Northerly boundary; terrain is moderately steep, extending downslope from Gold Camp Road; no development at present, but there is potential for light development.
- Basin 43: Portion of Sections 15 and 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 14.7 Acres, and 29.3 CFS/36.7 CFS at the Northerly boundary; light development at present along East bank of Bear Creek; slopes along creek valley and upper section are moderate, with a sharp rise separating creek valley from upper portion.
- Basin 44: Portion of Sections 22, 23, 26 and 27, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 234.2 Acres, and 388.7 CFS/485.9 CFS at the Easterly boundary at Cresta Road in Skyway Park Estates; located in piedmont area adjacent to mountains rising behind Gold Camp Road; slopes are steep to moderately steep, with easily erodible alluviums and top soil; development is moderate at lower portion and light in steeper upper portion, with potential for increased single family development.
- Basin 45: Portion of Sections 22, 23 and 27, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 163.1 Acres, and 284.2 CFS/355.2 CFS at the Easterly boundary at Orion Drive in Skyway Park Estates. Location, terrain and development are similar to 44 above.
- Basin 46: Portion of Sections 22 and 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 40.4 Acres, and 77.1 CFS/96.3 CFS at the Easterly boundary. Terrain is similar to 44 above; present development is light, with potential for increased development.
- Basin 47: Portion of Sections 22 and 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 87.6 Acres, and 151.2 CFS/189.0 CFS at the Easterly boundary at Argus and Orion Drives in Skyway Park Estates. Location, terrain and development are similar to 44 above.

- Basin 48: Portion of Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 36.0 Acres, and 65.0 CFS/81.2 CFS at the Easterly boundary at Southern Cross Drive. Terrain, location and development are similar to 46 above.
- Basin 49: Portion of Sections 22 and 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 71.1 Acres, and 125.6 CFS/157.0 CFS at the Easterly boundary at Virgo and Orion Drives in Skyway Park Estates. Terrain and development are similar to 46 above.
- Basin 50: Portion of Sections 14, 15, 22 and 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 161.6 Acres, and 268.7 CFS/335.9 CFS at the Northeasterly boundary at Bear Creek. Present development is light, but potential is great for increased single family growth, either individual or by subdivision. Terrain is moderately steep and is of less eroded piedmont than sub-basins to the South.
- Basin 51: Portion of Sections 15, 16 and 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 30.3 Acres, and 59.0 CFS/73.7 CFS at the Southeasterly boundary at Bear Creek Canyon Road. This sub-basin is moderately developed with single family mountain homes closely spaced along road. Potential exists for increased growth. Terrain is slightly to moderately steep and similar to 50 above.
- Basin 52: Portion of Section 15, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 33.1 Acres, and 66.2 CFS/82.8 CFS at the Southeasterly boundary crossing Bear Creek Canyon Road. Location, terrain and development are similar to 51 above.
- Basin 53: Portion of Section 15, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 4.4 Acres, and 9.1 CFS/11.4 CFS at the Southerly boundary crossing Bear Creek Canyon Road. Location and terrain are similar to 51 above; development is light.
- Basin 54: Portion of Section 15, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 4.4 Acres, and 9.1 CFS/11.3 CFS at the Southerly boundary. Location, terrain and development are similar to 53 above.

- Basin 55: Portion of Sections 14 and 15, and extending somewhat into Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 207.2 Acres, and 334.7 CFS/418.3 CFS at the Easterly boundary in Bear Creek. Terrain is moderately to slightly steep, some rolling hills, with light erosion. Development is slight, but potential is good for growth.
- Basin 56: Portion of Section 26 and extending slightly into Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 9.0 Acres, and 17.2 CFS/21.5 CFS at the Northerly boundary at Cresta Road and Constellation Drive in Skyway Park Estates. Terrain is moderately steep and hilly. Development is probable.
- Basin 57: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 11.9 Acres, and 23.0 CFS/28.7 CFS at the Easterly boundary at Cresta Road near Parkview Boulevard. Terrain is hilly and development is moderate.
- Basin 58: Portion of Sections 23 and 26, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 58.5 Acres, and 111.1 CFS/138.9 CFS at the Easterly boundary at Parkview Boulevard near Sirius Drive in Skyway Park Estates. Terrain is of hill and gully type with increasing development on the hills, and some development starting in the gullies.
- Basin 59: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 22.8 Acres, and 44.2 CFS/55.2 CFS at the Easterly boundary crossing Sirius Drive in Skyway Park Estates. Terrain is hilly and slightly to moderately steep. Development is moderate and increasing.
- Basin 60: Portion of Sections 23 and 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 112.2 Acres, and 184.1 CFS/230.2 CFS at the Northeasterly boundary at confluence of Gardiner Gulch and Bear Creek. Terrain is hilly to gently rolling with sedimentary and alluvial formations. Development is light because ownership is primarily City and County at present.
- Basin 61: Portion of Sections 22 and 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 11.8 Acres,

and 21.8 CFS/27.2 CFS at the Easterly boundary at Polaris and Andromeda Drives in Skyway Park Estates. Terrain, location and development are similar to 44 above.

Basin 62: Portion of Sections 22 and 23, Township 14 South, Range 67 West of the Princ. Merid.; containing 39.1 Acres, and 69.7 CFS/87.1 CFS at the Easterly boundary at Orion Drive between Virgo and Astron Drives in Skyway Park Estates. Terrain is similar to 44 above, and development is moderate over about fifty percent (50%) and is increasing. The remaining upper portion is moderately steep and lightly developed.

Basin 63: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 2.4 Acres, and 5.1 CFS/6.4 CFS at the Easterly boundary at Orion Drive. The sub-basin is moderately developed throughout, and is on gently sloping hilly terrain.

Basin 64: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 24.8 Acres, and 46.1 CFS/57.7 CFS at the Easterly boundary at 21st Street South of Argus Boulevard. Terrain is gently sloping, undeveloped pasture land with little development except along Orion Drive, because of present County ownership.

Basin 65: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 33.8 Acres, and 59.7 CFS/74.6 CFS at the Northeasterly boundary at 21st Street. Terrain and development are similar to 64 above except that development extends along Hercules Drive as well as Orion Drive in Skyway Park Estates.

Basin 66: Portion of Section 23, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 57.3 Acres, and 104.4 CFS/130.5 CFS at the Easterly boundary at 21st Street just South of the County Farm buildings. Development is primarily on the fringe along Orion Drive extending up from Argus Boulevard to Virgo Drive in Skyway Park Estates. Terrain is hilly and sloping, with the slope steeping from West to East. Development is increasing in the upper portion in private ownership.

Basin 67: Portion of Sections 14 and 23, and extending somewhat into Section 22, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 63.6 Acres, and 112.6 CFS/

140.7 CFS at the Easterly boundary at 21st Street and West Rio Grande. The terrain is moderate to gently sloping, and is undeveloped pasture land in general. Potential for development is good, both as to terrain and access.

Basin 68: Portion of Sections 14, 23 and 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 170.4 Acres, and 265.1 CFS/331.3 CFS at the Easterly boundary at Bear Creek's confluence with Gardiner Gulch. The area is lightly developed (containing the County Farm), but has definite growth potential. Terrain is gently sloping to rolling hills, with open pasture land.

Basin 69: Portion of Sections 23 and 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 76.1 Acres, and 148.7 CFS/180.0 CFS at the Northeasterly boundary near the "Gravel Pit". This area is presently open country with gentle hills and gullies. The soil is easily erodible along the main stream course. Development is minimal except in the upper zone along Parkview Boulevard and Sirius Drive in Skyway Park Estates.

Basin 70: Portion of Section 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 13.5 Acres, and 28.2 CFS/34.1 CFS at the Easterly boundary. Terrain is gently sloping, similar to 69 above. There is no development at present.

Basin 71: Portion of Sections 13, 14 and 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 131.3 Acres, and 246.5 CFS/298.3 CFS at the Easterly boundary at 8th Street just North of Fountain Creek Boulevard. Present development is light and limited to commercial along 8th Street. Potential exists for growth. Terrain is gently rolling open country with moderate to gentle slopes.

Basin 72: Portion of Sections 13 and 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 46.9 Acres, and 91.2 CFS/110.4 CFS at the Southeasterly boundary at Bear Creek and Interstate Highway No. 25. Development is light and primarily commercial. Terrain is relatively flat and gently sloping except along Bear Creek where sharp, steep slopes now form the stream bed. Development potential is very high.

Basin 73: Portion of Section 24, Township 14 South, Range 67 West of the 6th Princ. Merid.; containing 4.7 Acres, and 2.7 CFS/3.9 CFS at the Easterly boundary where Bear Creek has its terminal confluence with Fountain Creek. This sub-basin is entirely within the stream alluvium and development potential is limited.

ESTIMATE OF COST - CITY'S PROPOSAL

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT COST</u>	<u>AMOUNT</u>
1.	Main greenbelt channel shaping, slope treatment, and grouted rip-rapp or concrete with embedded boulder lining	18,000	LF	\$255.50	\$4,599,000
2.	Minor drainage channels, - grouted rip-rapp or concrete with embedded boulder lining	14,800	LF	52.00	769,600
3.	Storm Drain Piping				
	a) Reinforced Concrete Pipe				
	18" -----	1,730	LF	12.50	21,625
	21" -----	1,450	LF	13.50	19,575
	24" -----	2,100	LF	15.00	31,500
	27" -----	4,500	LF	16.00	72,000
	30" -----	650	LF	18.50	12,025
	33" -----	600	LF	19.50	11,700
	36" -----	1,300	LF	22.00	28,600
	39" -----	600	LF	24.50	14,700
	42" -----	300	LF	26.00	7,800
	48" -----	1,150	LF	30.00	34,500
				SUB-TOTAL -----	\$ 254,025
	b) Corrugated Steel Pipe				
	18" -----	100	LF	11.00	1,100
	24" -----	100	LF	13.50	1,350
	30" -----	400	LF	16.00	6,400
	36" -----	550	LF	21.00	11,550
	42" -----	550	LF	24.50	13,475
	48" -----	250	LF	29.50	7,375
					\$ 41,250

ESTIMATE OF COST

<u>ITEM</u>	<u>DESCRIPTION</u>	<u>QUANTITY</u>	<u>UNIT</u>	<u>UNIT COST</u>	<u>AMOUNT</u>
4.	Drainage outlets (4), catch basins, and curb openings	86	EA	\$ 1,725.00	\$ 148,350
5.	Reinforced concrete culverts	11	EA	33,000.00	363,000
6.	Rip-rapp bank protection	13,750	SY	12.60	<u>173,250</u>

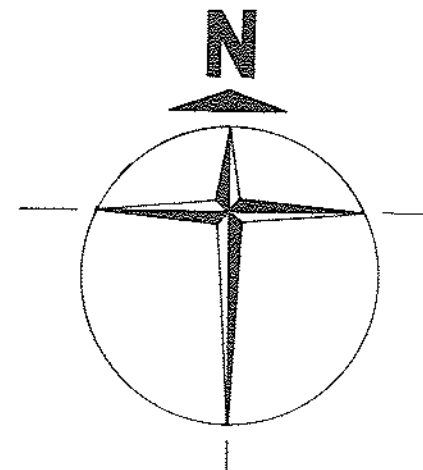
Grand Total ----- \$6,348,475

Total Land Area ----- 6,771 Acres

U.S.A. Area (National Forest)----- 2,424 Acres

Net Acreage ----- 4,347 Acres assessable area

TOTAL COST ----- \$6,348,475
Acres Assessable Area ----- 4347 = \$1,460.43/Acre



LEGEND

- MAJOR BASIN BOUNDARY
- EXISTING ROADWAYS
- PROPOSED ROADWAYS
- OWNERSHIP BOUNDARY (Private or Govt.)
- EXISTING CULVERT & SIZE
- EXISTING BRIDGE
- PROPOSED PIPE OR BRIDGE CULVERT & SIZE
- PROPOSED GREENBELTS
- MINOR DRAINAGE CHANNELS
- PROPOSED STRUCTURE REQUIRED SQ. FT. OPENING
- RIPRAP AREA (Proposed)
- PIPING & SIZE (Proposed)
- HYDROGRAPH POINT - PEAK FLOW IN CFS
- BASIN DIVISION BOUNDARIES
- SUB-BASIN DESIGNATION

BEAR CREEK DRAINAGE BASIN PLAN

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