HAYNES

SHOOK'S RUN

MASTER DRAINAGE BASIN STUDY

COLORADO SPRINGS, COLORADO

DECEMBER, 1972

KARCICH & WEBER INC.

ENGINEERS · SURVEYORS · PLANNERS · CONSULTANTS

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COLORADO SPRINGS, COLORADO 80930

November 30, 1972

Mr. Robert Martin
City Engineer
City Hall-Kiowa & Nevada
Colorado Springs, Colorado 80902

Dear Mr. Martin:

Transmitted herewith is the Master Drainage Study of the Shooks Run Drainage Basin in Metropolitan Colorado Springs, as authorized by the City of Colorado Springs, Colorado.

Our study includes a hydrologic study of the entire Shooks Run Drainage Basin. Included are rainfall - runoff characteristics of the basin, geologic data and soils survey information, synthetic unit hydrographs for peak flows in the channel, and recommendations for street paving and utility relocations. Existing storm sewer systems were analyzed and recommendations made for system improvements. Recommendations are made for design alternatives along with associated costs for all major drainage facilities within Shooks Run channel. Schematic drawings and design criteria are specified for all design alternatives.

We wish to thank the City for their cooperation in reviewing and commenting on the various phases and problems involved during the preparation of this report. We are available for any questions that you might have.

Very truly yours,
Karcich & Weber, Inc.

Matthew F. Karcich

Matthew F. Karcich

Prepared by: Dennis A. Maroney
Tom R. Perkins

Master Basin Drainage Study

of the

Shook's Run

Drainage Basin

for the

City of Colorado Springs

Karcich & Weber, Inc.
3010 Mallard Drive
Colorado Springs, Colorado

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SCOPE AND PURPOSE

This master drainage plan study of the Shook's Run drainage basin defines an overall plan for handling storm water runoff by means of increased and larger capacity storm sewers, culverts, and lined drainage channels. A preliminary cost estimate for construction, engineering and land acquisition for these drainage improvements is also included in this study. Flows in the Shook's Run drainage basin were computed on the basis of a 50 year return period, 1 hour duration storm for subdivisions and tributaries to Shook's Run and on the basis of a 100 year return period, 1 hour duration storm in Shook's Run proper.

Storm drainage is a recurring problem in the Colorado Springs metropolitan area. This area is classified as semi-arid with low average annual rainfall. It is, however, subject to intense thunder storms, some of which can cause rather extreme local damage. The lack of proper drainage and the rapid accumulation of extremely large amounts of runoff water would further contribute to the gradual decline in the condition of some of the residential housing in the area. From a health standpoint, the storm drainage project is necessary for the elimination of a demonstrated health hazard. Without the proposed drainage improvements, periodic inundation of service areas would overload present sewer facilities, making Shook's Run, in effect, an open sewer at times. Also, severe erosion along the banks is causing imminent danger to houses along Shook's Run. Trash, overlaid with dirt, has been dumped off the banks as an interim measure to deter erosion, consequently, trash then floats in the water causing blockage problems as well as being an eyesore. With the completion of the entire drainage system, the physical problem of collecting water will be solved and the equally important goals of increased land values, improvement of the general business climate and a needed open space park link throughout the entire basin will be realized.

SHOOKS RUN DEVELOPMENT PLAN AND DRAINAGE PROJECT OBJECTIVES

Overall Objectives:

The two primary objectives of the Shook's Run Development Plan and Drainage Project are: (1) to alleviate, over a 10 year period, a serious storm drainage problem in the almost completely urbanized central portion of the City of Colorado Springs and (2) to upgrade the neighborhoods paralleling Shooks Run by the development and implementation of a long range comprehensive master plan for the area which will entail the coordination and programming of engineering, physical planning and open space and park design elements.

Functional Objectives:

In this complex study area, which is characterized by poor drainage, mixed land uses, minority concentrations, poor access, low to middle income families, pockets of deteriorating housing, inadequate parks and some poor land use relationships, there are several functional elements which must be improved in order to upgrade and/or stabilize this portion of the community. These elements, which will be a part of the comprehensive plan, are: Transportation, Open Space and Drainage. The basic objectives relative to these elements follow:

Transportation:

1. Improve access ability into and through the study area for the automobile, pedestrian, service vehicle, and mass transportation modes.
2. Coordinate the implementation of the City's Major Thoroughfare Plan with the development of the proposed Shooks Run drainage facilities. It should be noted that the drainage course crosses at least six arterials and generally parallels two other thoroughfares.
3. Coordinate the proposed transportation and open space networks.
4. Utilize, where possible, the arterial thoroughfares as neighborhood boundaries.

Open Space:

1. Implement the Regional Open Space Plan which calls for a connecting open space link from the Fountain Creek floodway near Interstate 25 up Shooks Run to the existing Santa Fe railroad tracks, which is in the process of abandonment. This link, which will utilize the existing physical features, will provide unimpeded access for pedestrians, bicyclists and perhaps horseback riders.
2. Provide predetermined nodes of active parks and recreational development which might include playfields, playgrounds and totlots to serve park deficient neighborhoods and/or the community in general.
3. Act as an open space buffer between Shooks Run residential areas and the unsightly mixed, railroad, commercial and industrial uses.
4. Maintain and upgrade the character and image of the entire community.
5. Act as a deterent to community air pollution by encouraging more plant cover in low lying areas.

Drainage:

1. Assess storm drainage deficiencies in the study area and engineer, program and construct all necessary street, minor channels, and major course facilities to adequately accommodate a 100 year storm frequency runoff.
2. Construct necessary improvements which are compatabile with and complement the objectives of the comprehensive plan.

Overall Land Use Objectives:

The comprehensive plan of the Shooks Run area will contain a land use plan which will be designed to accommodate the following objectives:

1. Provide for a better overall relationship between housing, open space, transportation, community facilities, commercial and industrial uses.
2. Complement the City's downtown comprehensive plan and the development objectives of the remainder of the community.
3. Upgrade existing neighborhoods and encourage proper redevelopment, rehabilitation or conservation without major disruptions.
4. Identify specific areas in which the neighborhoods are deficient, - parks,

housing and neighborhood shopping; and provide the guidelines for the alleviation of these identified deficiencies.

Environmental Assessment for Shook's Run Drainage Basin Study

1. Shook's Run Drainage Basin Project Description for the City of Colorado Springs, Colorado.

The Master Basin Drainage Study of the Shook's Run Drainage Basin provides an over all plan for adequately handling storm water runoff. Various means of handling this runoff include the construction of larger capacity storm sewers, new culverts, lined drainage channels, sewers and associated structures.

Colorado Springs has a recurring storm drainage problem, since this area is subject to intense thunder storms, some of which have been known to cause rather extreme local damage. Without the proposed drainage improvements, periodic inundation of basin areas would overload existing facilities, making Shook's Run drainage basin a health hazard to the local community.

With the completion of the Shook's Run Drainage Basin Project, the entire drainage system will be improved and the physical problem of collecting and disposing of storm water will be provided thus improving environmental considerations and increase property values.

2. The Probable Environmental Impact of the Proposed Action.

The City of Colorado Springs, Colorado, is considered to be one of the fastest growing communities in the United States. With this rapid expansion, it is considered imperative that action be taken to adequately handle the storm runoff which invariably is increased with rapid expansion. This is realized by observing that construction reduces infiltration into the soil and thus increases the speed of runoff into the various storm water courses.

Possible adverse effects may include; property condemnation, inconvenience to local residents during construction and relocation of existing utility mains and services.

It is imperative that adequate provision be made for proper storm water handling.

It is concluded that the beneficial effects of the Shook's Run Drainage Basin Project far out weigh the adverse effects that could be encountered and that the City of Colorado Springs should proceed with the proposed plan.

The above evaluation of the expected environmental effect is submitted in conjunction with the intent of the National Environmental Policy Act as implemented by the Council of Environmental Quality.

3. Factors Considered:

a. Effects on Storm Water Drainage: The current impounding storm water areas are to be eliminated thus reducing stagnant water, and holding lagoons, which could provide facilities for mosquito breeding.

Sediment in the distribution system and effluent channel will be reduced due to improved facilities.

Storm water temperatures will not be altered.

b. Effects on Atmosphere: There will be a definite beneficial environmental effect from the elimination of stagnant pools by providing improved storm water course discharge channels/conduits.

c. Effects on Natural Resources: No significant destruction of vegetation, wild life or marine life will be experienced.

d. Other Effects: The proposed action will not significantly affect, benefically or adversely, other forms of life or ecosystems.

4. <u>Type of Action - Requiring Submittal of Written Environmental Assessments.</u>
There are potential real estate actions contemplated, by purchase, negotiation and/or condemnation which may require written environmental assessments. They are:

Land acquisition by purchase from various property owners located in the Shook's Run Drainage Basin.

Land acquisition by lease from various property owners located in the Shook's Run Drainage Basin.

Land acquisition by condemnation proceedings from various property owners located in the Shook's Run Drainage Basin.

5. <u>Environmental Assessments/Statements Submittals.</u>
Preparation and submittal of written environmental assessments/statements will be subsequently accomplished as appropriate in conjunction with the intent of the National Environmental Policy Act as implemented by the Council of Environmental Policy.

Environmental Assessment - Loy E. Callen, P.E.

BASIN DESCRIPTION

Shooks Run Drainage Basin is comprised of approximately 7.4 square miles within Townships 13 and 14 South, Range 66 West of the 6th Principal Meridian. It extends from the Foxhills Sandstone topography in Palmer Park to the level river plain at the Fountain Creek confluence. The area is bounded by Summit Drive, Palmer Park, and the Chicago, Rock Island and Pacific Railroad on the north, Cascade Avenue on the west, Academy Boulevard and North Circle Drive on the east, and finally by Fountain Creek on the south.

Shooks Run channel extends approximately 22,500 feet (4.25 miles) downstream from the Chicago, Rock Island and Pacific railroad to its Fountain Creek confluence. The portion of Shooks Run above the Chicago, Rock Island, and Pacific Railroad is diverted into Monument Creek via the Templeton Gap and Van Buren storm drain facilities. Thus, all overland flow that drains into Shooks Run proper comes from the Palmer Park area and the area south of the railroad tracks. Portions of the channel are an open ditch approximately 75-100 feet wide and 20-30 feet deep.

Two sub-basins within the Shooks Run drainage basin have already been studied and have had drainage improvements installed or proposed improvements in the process of being installed: these are (1) The Palmer Park area; and (2) Little Shooks Run sub-basin.

The Palmer Park sub-basin was incorporated into Palmer Park Area Master Drainage Report by Karcich & Weber, Inc., Colorado Springs. All information for this area was taken from this report. The area is located in the north-central portion of Metropolitan Colorado Springs. It is bounded by Summit Drive and Palmer Park on the north, Union Boulevard on the west, Uintah Street on the south, and near Academy Boulevard on the east. All runoff from the area eventually drains into Shooks Run inside the Patty Jewett Golf Course west of Union Boulevard.

The Palmer Park Drainage Basin is approximately 15,500 feet in length comprising 1.85 square miles (1185 acres). The peak storm flow emanating from two elliptical concrete pipes just west of Union Boulevard is 1646 cfs.

The Little Shooks Run Drainage Basin plan was previously prepared by R. Keith Hook & Associates, Inc., of Colorado Springs, but their report could not be obtained. Consequently, the area was restudied and the proposed and existing drainage facilities were found to be more than adequate, for the most part, for a 50 year return storm. The area is located in the east-central portion of Metropolitan Colorado Springs. It is bounded by El Paso Street on the west, diagonally, from St. Vrain to Uintah Street on the north, North Circle Drive on the east, and Pikes Peak Avenue on the south.

Little Shooks Run drains approximately 1.4 square miles, with the main portion of the peak storm flow entering Shooks Run at Kiowa Street. At this point, a peak flow of 1045 cfs drains through an 8' x 14' pipe arch into the main Shooks Run channel.

GEOLOGICAL DESCRIPTION

Palmer Park, in the northeastern part of the basin, consists of highly erodible Foxhills Sandstone, with a soil profile formed from the weathered sandstone. The area is characterized by numerous gully washes and the soil profile infiltration is relatively high, as would be expected from a sandy soil.

The majority of the rest of the drainage basin consists of uplifted sediments with Pierre Shale being the uppermost sediment. Water racing down Shook's Run from intense storms has cut down through and exposed the Pierre Shale in numerous sections of the main channel. This sediment is overlain by terrace deposits and alluvium formed from the westerly mountainous granites. (see Soil Survey Map (Figure 6) in Appendix).

RAINFALL

It was found that the 1 hour, 2 inch, 50 year frequency storm for Shooks Run tributaries and 1 hour, 2.30 inch 100 year frequency storm for Shooks Run proper with a saturated soil condition produced the highest reasonable design peak flow. This information was taken from U.S. Weather Bureau Technical Paper No. 40 - Rainfall Frequency Atlas of the United States (1961).

Rainfall intensities used in this report are as follows:

Shooks Run Channel (Proper)
100 year return period
1 hour duration
Intensity = 2.30 in/hr

Tributaries and Subdivision
50 year return period
1 hour duration
Intensity = 2.00 in/hr

The above durations and return periods are in conformance with the design criteria set forth in the scope of work agreement between Karcich & Weber, Inc., and the City of Colorado Springs.

CLIMATIC INFORMATION

The Colorado Springs area is classified as semi-arid with low average annual rainfall. The major portions of this rainfall occur during the months of May, June, July, and August. The storms in the vicinity generally fall into two patterns:

1. Short, intense storms lasting up to 2 hrs., and usually local in nature

2. Long term storms lasting six hours or more, and being spread over a large area

The long term storms last a relatively long period of time, allow high infiltration, produce a great volume of runoff, but have a relatively low flood peak.

The short duration storm produces less runoff water, but being more intense, has a very high flood peak.

The amount of actual moisture from snowfall is usually not high enough to lead to excessive runoff.

STUDY CRITERIA

Actual measured runoff data does not exist for this drainage. This data would be desirable in order to calculate the peak runoff exactly. The following procedure for computing a design flood from an ungaged watershed is based on criteria given in the U.S. Department of the Interior, Bureau of Reclamation, "Design of Small Dams," and also in the SCS "Hydrology Guide for Use in Watershed Planning". Using this method, runoff is empirically correlated with basin characteristics, resulting in a design flood hydrograph that represents direct runoff from precipitation in the form of rain over a watershed having no unusual runoff characteristics.

General Peak Equation:

$$Qp = \frac{484\ A\ Q}{Tp}$$

$$Tp = D/2 + 0.6\ Tc$$

Q = Total runoff in inches

Tp = Time in hours from start of rise to peak rate

Qp = Peak rate in cubic feet per second

D = Rainfall excess period, hours (in this case, 1 hour)

Tc = Time of concentration - travel time of water from hydraulically most distant point to point of interest

Direct runoff (Q) in inches of water is given in Figure A-4 of the "Design of Small Dams" Appendix A, and is read directly off the curve based on rainfall in inches, and curve number, which is determined from soil type and land use.

The following table sets forth the runoff curve numbers for hydrologic soil-cover complexes which were used to tabulate the synthetic hydrographs for Shooks Run Drainage Basin.

Land Use	Weighted Curve No.	Q 50 yr (in)	Q 100 yr (in)
Subdivided	94	1.40	1.60
Business District	99	1.90	2.15
Park Areas	81	.60	.75
Total Basin	94	1.40	1.60

Areas used to calculate peak storm flow for the various sub-basins were planimetered off of a photographically enlarged scale of a U.S.G.S. topographical map, (scale: 1" = 400') Colorado Springs Quadrangle. Elevation differences were also excerpted directly or interpolated from the contours given on the topographical map to determine time of concentration for the main basin and the sub-basins.

The storm runoff peak, volume, and timing provide the basis for all planning, design and construction of drainage facilities. An error in hydrologic interpretation will create facility errors in undersizing, oversizing, or a hydraulic imbalance in drainage facilities. On the other hand, it must be kept in mind that the result of the runoff analysis is an approximation. Very little is known of the factors influencing urban rainfall runoff and statistical data for this area is unavailable. The intent of this drainage report is to provide a reasonable but dependable method of approximating the characteristics of urban rainfall runoff from Shooks Run Drainage Basin.

HYDRAULIC CAPACITY OF STORM SEWERS

The most widely accepted formula for evaluating the hydraulic capacity of nonpressure sewers is the Manning formula. After the design flows were calculated, pipe or culvert size was obtained by selecting a pipe roughness coefficient and using the natural slope of the land.

Mannings formula:

$$Q = VA = \frac{1.486}{n} AR^{2/3} S^{1/2} \quad \text{or}$$

$$Q/S^{1/2} = \frac{1.486}{n} AR^{2/3}$$

Q = Maximum discharge of conduit in CFS

A = Area of flow in conduit in square feet

V = Velocity of flow

n = Manning's roughness coefficient for conduit lining

$R = \text{Hydraulic radius} = \frac{\text{Area}}{\text{Wetted Perimeter}}$

S = Slope of conduit in ft/ft

By evaluating the values of $1.486/n\ AR^{2/3}$ for various types and shapes of pipes available, a pipe size can be selected for any $Q/S^{1/2}$ value. Under any given flow condition, the area A and hydraulic radius R are constant for a particular size and shape of pipe. Therefore, the hydraulic capacity of a pipe is primarily dependent on n, the roughness coefficient.

However, this trial and error method of calculating pipe sizes is not necessary, since nomographs, tables, graphs and computer programs provide a direct solution.

Results of numerous test programs conducted by the U.S. government, have established values for the roughness coefficient of concrete pipe from 0.009 to 0.014. An n value of 0.014 was used for this report to comply with City standards and also to account for the possibility of slime or grease build-up in the storm sewers. Table 2 in the appendix lists values for roughness coefficients of smooth walled pipe and corrugated metal pipe as well as various types of channel sections.

In terms of velocity, concrete pipe can carry water at extremely high velocities without eroding. This would indicate that erosion is seldom a problem with concrete pipe.

DESIGN OF OPEN CHANNELS

Manning's equation was used to determine trapezoidal channel sections for the major greenbelt area of Shook's Run basin:

$$Q = \frac{KD^{8/3} S^{1/2}}{n}$$

n = Manning's coefficient

D = Depth of water in channel

S = Slope in ft/ft

K = Discharge factor

K is found in table 7-11 of "Handbook of Hydraulics," by King.

Here again, trial and error can be avoided by using tables, graphs, and computer programs to obtain a direct solution.

Also by Manning's formula:

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

R = Hydraulic radius

Free Board (in feet) = $2.0 + 0.025\ V \sqrt[3]{D}$

DRAINAGE IMPROVEMENTS AND RECOMMENDATIONS

The results of the drainage study and analysis of the Shooks Run Drainage Basin are presented on the Master Drainage Plan map following the bibliography of this report. This plan shows the locations and sizes of all existing and proposed drainage facilities within the basin, with the exception of the Palmer Park Drainage, which can be found in the previously mentioned master drainage plan. Also shown on the drainage plan are sub-basins within the drainage basin and yearly construction phases.

The most economical and feasible method of removing flood runoff from a developed area is to utilize existing ditches and drainage channels However, at peak storm flows the existing channel would undergo severe channel scour and erosion due to the steepness of side slopes and fall within the channel reach. In addition, the channel is heavily congested with trees and debris. At many points channel erosion has severely undercut adjacent houses making some unsafe for habitation. Embankment protection has been attempted in several reaches of the channel but, in general, this attempted protection has not checked the erosive tendencies of the channel. In many cases existing structures under street crossings are not adequate to handle peak design flows. At low flows the natural channel does not provide adequate drainage for all reaches of the channel. Therefore, ponding occurs at many points along the channel creating health hazards and aesthetic problems.

Because of the above reasons, three alternatives were analyzed in regards to channel improvement: (1) a completely gabion lined channel, (2) a completely concrete lined channel, and (3) a low flow pipe designed to carry the peak load from a 50 year storm and a grass lined channel above the pipe to carry the excess runoff that would occur during a 100 year storm (see figures 3 & 4 of the Appendix). Because of high peak flows for a 50 year storm in the lower reaches of Shooks Run, alternative 3 was not considered due to extremely large pipe sizes and associated high costs.

Only alternatives 1 and 2 were considered downstream of Kiowa Street, however, use of the low flow pipe and grass lined channel alternative might still be considered in future proposed park areas in lower channel reaches.

Because business and residential build-up along Shooks Run is very dense throughout most of channel reach, space to include a lined channel, maintenance roads, and parks, is limited. It is anticipated that there will be considerable expense involved in obtaining the necessary right of way for these facilities. Because of existing conditions throughout the channel reach, it is felt that a gabion lined channel would be the best alternative to improve the existing channel - both in terms of maximizing space and hydraulic efficiency. The channel sections for this type of channel were calculated and are shown in Table H entitled "Major Drainage Channels". The friction factor of gabions is such that it would keep the storm flow velocities from being excessive (under 20 FPS) on the existing drainage slopes. In addition, the side slopes can be steeper and the flows deeper than in a concrete lined channel, thereby reducing the top width of the channel. In summary, the gabion lined channel would maximize the existing right of way space while carrying the design flows at acceptable velocities.

There are a few drawbacks or problems associated with this type of channel. However, most of these problems are also reflected in the use of other types of channel sections. The design flow in the gabion lined channel is supercritical the entire length of Shook's Run, necessitating expertise in design and maintenance. Because of supercritical flow, channel free board is as much as three feet in the downstream areas, and a grassed bank above the free board should also be utilized as protection against oscillatory wave action that is common with supercritical flow. Curves in the stream channel should be kept at a minimum and design characteristics incorporated that will not cause adverse wave action creating an overflow of the channel banks. It would be advisable to straighten the channel wherever possible and install rectangular sections or embankment protection, such as riprap, at curves in the channel. Finally, because debris frequently collects in channels and causes the flow to decelerate, there should be positive and frequent maintenance to keep the channels clear. This reduction in velocity during supercritical flow could cause a hydraulic jump in the channel, with ultimate overtopping of the banks.

The second alternative to improve the channel is to line it completely with concrete. More space is needed for a concrete lined channel as opposed to the gabion lined channel or low flow pipe-excess runoff channel. A concrete lined channel must be made wider and shallower than a gabion lined channel to control velocities. The use of energy dissipators will have to be incorporated to change the existing friction slope to allow for the lower velocities. There would be no energy dissipating structures required for the entire channel if the other two alternative sections are employed. Again, in the concrete lined channel, there will be supercritical flow and the problems associated with this type of flow.

The third alternative, a low flow pipe that will handle a 50 year storm with a channel above, to drain excessive runoff, would eliminate the need for a lined channel since the pipe will handle most of the flow. Residents in the area have expressed a desire for this type of channel when used in combination with a park-type greenway system. This drainage structure would be more aesthetically pleasing combined with grass or tree plantings that blend with future parks. The problem of unsightly debris would be partly eliminated since most of the time the flow will be restricted to the pipe under the channel. The major objection to this alternative is the cost. It exceeds the other two alternatives. A cost comparison table has been prepared to show the difference between the various channel sections. This is incorporated in the report after the preliminary detailed cost estimates (see Table A).

In analyzing the drainage basin, it was found that the existing storm sewer systems and natural drainage systems are adequate in only a few of the sub-basins. These sub-basins are designated on the master drainage plan map: sub-basin #2 (Patty Jewett Golf Course), sub-basin #6, most of Little Shooks Run drainage basin, that portion of sub-basin #9 west of the railroad tracks, and of course, Palmer Park drainage. It was found that the remainder of the area within the basin was inadequately serviced. However, larger storm sewers would not be feasible for many of these areas because of economics and the enormous problem created when major traffic thoroughfares are closed for extended periods of time. These areas will be discussed, along with the proposed facilities that are considered to be necessary and feasible. It should be pointed out that even though larger storm sewers were not proposed for inadequately serviced areas, recommended storm sewer sizes were calculated and are shown in the storm drain system flow tables in the event that future funds and drainage problems warrant their installation. (see Table D)

Sub-basins 4 and 5 were found to be the biggest problem areas in terms of inadequate existing storm sewer systems. The inadequate sections are as follows: (1) the system on Nevada Avenue from Monroe Street south to Dale Street and east along Dale Street to Shooks Run, (2) the section along Boulder Street from Tejon Street easterly to Shooks Run and from Custer Street westerly to Shooks Run and (3) the storm sewer section on Uintah Street from Weber Street easterly to Shooks Run. It should be pointed out that although the storm sewers in these sections can not handle a 50 year design storm, they are adequate for a 10 year design storm. In all probability occassional street flooding can be sustained without major damage or severe inconvenience in these areas. For this reason and because of the trouble and expense of installing larger storm sewers, no new systems were proposed for these areas. As was mentioned earlier, the size of storm sewers needed are given in the storm drain system flow tables in this report (see Table D).

The new proposed drainage facilities along with their lengths, size, number of catch basins and outlet structures, are shown on the table of proposed storm sewers for Shooks Run Drainage Basin (see Table E).

It should be noted that if the storm sewer section along the railroad tracks in sub-basin #4 is installed, including the lined ditch from Jackson Street to Fontanero Street, the drainage in sub-basin #5 will be adequate to handle a 50 year storm. This addition will alleviate the hydraulic load on the now inadequate Uintah Street storm drain system. Calculations for the lined, open ditch are shown in the table for minor drainage channels (see Table G).

Construction of new and larger arches under many of the streets crossing Shooks Run have been proposed because many of the existing structures are deteriorating and are hydraulically and structurally inadequate. In addition, some of the existing streets are to be enlarged to provide for major and minor arterial thoroughfares in the future. These streets are Fountain Boulevard, Pikes Peak Avenue, Cache La Poudre Street, and Uintah Street. In order to provide an open space link along Shooks Run, areas under these arches will be paved with a concrete low flow and pedestrian and equestrian access provided through these arches to link up with the greenway continuing on either side of the arches (see figure 5 of the Appendix). Low profile arches are proposed because of limited space above the channel. However, high profile arches can be substituted to create more space for traffic through the arch system. Walkways will also be provided to gain access to the arches from the maintenance road adjacent to the channel. It should be understood that these arches can not be used for through access during peak storm flow periods.

Because existing sewer lines criss-cross the channel in many areas and may cause construction problems, it will be necessary to relocate the sewer main from Vermijo Avenue to Las Vegas Street along the east side of Shooks Run channel. A 30 inch sewer main is proposed and is compatible with the City of Colorado Springs Sewer Department's plans to put in a new main in 1976. A new sewer should be installed at the time of construction on Shooks Run channel in order to eliminate possible sewage problems that may arise during or after construction (see Appendix for summary on sanitary sewers).

Hydrographs at selected points down Shooks Run channel have been prepared for a gabion lined channel only. However, the peak storm flows for a concrete lined channel are only slightly larger, because of increased velocities and faster time of concentration. The gabion lined channel hydrographs will show the nature and characteristics of the 100 year design peak flow throughout the reaches of Shooks Run channel. The hydrograph points are lettered consecutively down the channel lengths and the calculations for these synthetic hydrographs are found in the table titled "Synthetic Hydrograph Calculations" (Table I)

Cost estimates have been prepared and are included immediately following the recommendations section. It should be noted that an estimated cost for land acquisition and land condemnation have been shown for Phase I only. Cost estimates for the other phases do not include land acquisition costs. An estimate for land acquisition and housing relocation has been included for the remaining channel run above Phase I, but is, at best, an educated estimate only.

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE I

Description	Quantity	Unit Price	Cost
Storm Sewer			
18" RCP	60 LF	13.80	828
Bituminous Paving &			
Base Course	4101 SY	4.00	16,404
Concrete Curb & Gutter	2100 LF	3.50	7,350
Sanitary Sewer			
30"	2360 LF	40.00	94,400
MH's	4	530.00	2,120
			96,520
Multi-Plate Span			
Las Vegas	1	70,000	70,000
Fountain	1	90,000	90,000
			160,000
Lined Channel			
concrete(40'bottom width)	2480 LF	150.00	372,000
Excavation & Grading			
unclassified	70800 CY	1.00	70,800
		Sub-Total	723,902
	Land Acquisition		40,000
	Construction Contingency 5%		38,195
	Estimated Construction Cost		802,097
	Engineering Fees 10%		80,210
		Total Cost	$882,307

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE II

Description	Quantity	Unit Price	Cost
Storm Sewer			
15" RCP	905 LF	13.25	11,991
18" RCP	700 LF	13.80	9,660
21" RCP	960 LF	14.30	13,728
24" RCP	700 LF	15.10	10,570
30" RCP	990 LF	17.90	17,721
36" RCP	50 LF	21.25	1,063
MH's	7	500.00	3,500
			68,233
Catch Basins			
4' x 8"	10	850.00	8,500
6' x 8"	11	1060.00	11,660
8' x 8"	1	1300.00	1,300
			21,460
Bituminous Paving &			
Base Course	11,778 SY	4.00	47,112
Concrete Curb & Gutter	4,700 LF	3.50	16,450
Sanitary Sewer			
30"	2,500 LF	40.00	100,000
MH's	7	530.00	3,710
			103,710
Multi-Plate Span			
Costilla	1	104,000.00	104,000

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE II

Description	Quantity	Unit Price	Cost
Lined Channel			
concrete(40'bottom width)	2620 LF	150.00	393,000
concrete(35'bottom width)	300 LF	140.00	42,000
			435,000
Excavation & Grading			
unclassified	75000 CY	1.00	75,000
		Sub-Total	870,965
	Construction Contingency 5%		43,548
	(x inflation factor 0.06)		54,871
	Estimated construction cost		969,384
	Engineering Fees 10%		96,938
		Total Cost	$1,066,322

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE III

Description	Quantity	Unit Price	Cost
Storm Sewer			
18" RCP	435 LF	13.80	6,003
21" RCP	250 LF	14.30	3,575
24" RCP	2200 LF	15.10	33,220
30" RCP	375 LF	17.90	6,712
MH's	5	500.00	2,500
			52,010
Catch Basins			
4' x 8"	3	850.00	2,550
6' x 8"	8	1060.00	8,480
8' x 8"	1	1300.00	1,300
			12,330
Drop Inlets	2	530.00	1,060
Bituminous Paving &			
Base Course	5559 SY	4.00	22,236
Concrete Curb &			
Gutter	1960 LF	3.50	6,860
Sanitary Sewer			
30"	960 LF	40.00	38,400
MH's	2	530.00	1,060
			39,460
Multi-Plate Span			
Colorado & El Paso	1	70,000.00	70,000
Pikes Peak	1	87,000.00	87,000
			157,000

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE III

Description	Quantity	Unit Price	Cost
Lined Channel			
concrete (35'bottom width)	2620 LF	140.00	366,800
concrete (25'bottom width)	500 LF	117.00	58,500
grass sod	1750 LF	11.00	19,250
			444,550
Excavation & Grading			
unclassified	104,400 CY	1.00	104,400
		Sub-Total	839,906
	Consturction Contingency 5%		41,995
	(x inflation factor 0.1236)		109,003
	Estimated Construction Cost		990,904
	Engineering Fees 10%		99,090
		Total Cost	$1,089,994

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE IV

Description	Quantity	Unit Price	Cost
Multi-Plate Span			
Kiowa	1	65,000.00	65,000
Bijou	1	100,000.00	100,000
			165,000
Lined Channel			
concrete(25'bottom width)	3960	117.00	463,320
Excavation & Grading			
unclassified	114,000 CY	1.00	114,000
		Sub-Total	742,320
	Construction Contingencies 5%		37,116
	(x inflation factor 0.1910)		148,872
	Estimated Construction Cost		928,300
	Engineering Fees 10%		92,830
		Total Cost	$1,021,128

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE V

Description	Quantity	Unit Price	Cost
Storm Sewer			
21" RCP	250 LF	14.30	3,575
30" RCP	1700 LF	17.90	30,430
36" RCP	1780 LF	21.25	37,825
42" RCP	890 LF	24.40	21,716
48" RCP	3180 LF	31.80	101,124
54" RCP	2530 LF	37.10	93,863
60" RCP	2230 LF	48.80	108,824
MH's	19	500.00	9,500
			406,857
Catch Basins			
4' x 8"	6	850.00	5,100
6' x 8"	39	1060.00	41,340
8' x 8"	7	1300.00	9,100
10' x 8"	1	1500.00	1,500
			57,040
Multi-Plate Span			
Cache La Poudre	1	55,000.00	55,000
Lined Channel			
concrete (20'bottom width)	1200 LF	104.00	124,800
concrete (minor channel)	2300 LF	25.00	57,500
			182,300
Excavation & Grading			
Unclassified	36000 CY	1.00	36,000
		Sub-Total	737,197
	Construction Contingency 5%		36,860

PRELIMINARY

ESTIMATED CONSTRUCTION COST

PHASE V

Description	Quantity	Unit Price	Cost
	(x inflation factor 0.2625)		203,190
	Estimated Construction Cost		977,247
	Engineering Fees 10%		97,724
		Total Cost	$1,074,971

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE VI

Description	Quantity	Unit Price	Cost
Storm Sewer			
12" RCP	825 LF	10.60	8,745
24" RCP	1000 LF	15.10	15,100
30" RCP	2425 LF	17.90	43,855
36" RCP	3605 LF	21.25	76,606
42" RCP	1000 LF	24.40	24,400
48" RCP	2920 LF	31.80	92,856
MH's	24	500.00	12,000
			273,562
Catch Basins			
4' x 8"	4	850.00	3,400
6' x 8"	54	1060.00	57,240
10' x 8"	1	1500.00	1,500
			62,140
Multi-Plate Span			
Uintah	1	55,000.00	55,000
Lined Channel			
concrete (15' bottom width)	2240	100.00	224,000
Excavation & Grading			
unclassified	67200 CY	1.00	67,200
		Sub-Total	681,902
	Consturction Contingency 5%		34,095
	(x inflation factor 0.3382)		242,150
	Estimated Construction Cost		958,150
	Engineering Fees 10%		95,815
		Total Cost	$1,053,965

PRELIMINARY

ESTIMATED CONSTRUCTION COSTS

PHASE VII

Description	Quantity	Unit Price	Cost
Storm Sewer			
21" RCP	900 LF	14.30	12,870
MH's	1	500.00	500
			13,370
Catch Basins			
6' x 8"	4	1060.00	4,240
Lined Channel			
concrete(10'bottom width)	2900	90.00	261,000
Low Flow Pipe With			
Overflow Channel	3560 LF	34.40	122,464
Excavation & Grading			
unclassified	87000 CY	1.00	87,000
		Sub-Total	488,074
	Construction Contingencies 5%		24,404
	(x inflation factor 0.4185)		214,472
	Estimated Construction Cost		726,950
	Engineering Fees 10%		72,695
		Total Cost	$799,645

Estimated R.O.W. Costs	
Phase I	40,000
Remaining Phases	1,720,000
Sub-Total	1,760,000
Contingency 5%	88,000
Total	$1,848,000

TABLES

Table A
Comparative Channel Section Costs
(Cost/Lineal Foot)

Reach	Concrete Channel	Gabion Channel	Low Flow Pipe & Grass Lined Channel
A-B			34.40
B-C	90.00	59.63	160.00
C-D	90.00	59.63	175.00
D-E	100.00	64.40	225.00
E-F	104.00	70.53	230.00
F-G	117.00	74.96	270.00
G-H	117.00	74.28	270.00
H-I	117.00	75.30	270.00
I-J	140.00	83.14	415.00 *
J-K	140.00	88.25	415.00 *
K-L	150.00	89.27	415.00 *
L-M	150.00	90.30	465.00 *

* 2 pipes required

Table B

SHOOK'S RUN CHANNEL
MINIMUM RIGHT OF WAY WIDTHS

Reach	Concrete Channel (Ft)	Gabion Channel (Ft)	Low Flow Pipe & Grass Lined Channel (Ft)
A-B			19.0 *
B-C	54.56	43.4	48.6
C-D	55.32	43.4	48.6
D-E	59.68	45.4	51.0
E-F	64.24	47.9	53.6
F-G	70.76	50.6	58.6
G-H	70.96	50.4	58.0
H-I	71.16	50.8	58.6
I-J	82.28	54.0	64.2
J-K	84.16	56.2	68.0
K-L	88.40	56.6	68.6
L-M	88.48	57.0	68.6

* Reach A-B does not include 16' maintenance road

Table C
MAJOR DRAINAGE CHANNEL
ROADWAY ARCHES
LOW PROFILE & STANDARD DESIGN

Location	Peak Flow CFS	Size Ft.	Length Ft.	Area Sq. Ft.
Las Vegas St.	4674	34'-5" x 13'-3"	100	371
Fountain Blvd.	4693	34'-5" x 13'-3"	150	371
Costilla St.	4598	34'-5" x 13'-3"	220	371
Colorado Ave.	4407	34'-5" x 13'-3"	120	371
Pikes Peak Ave.	4407	34'-5" x 13'-3"	160	371
Kiowa St.	2995	26'-0" x 12'-8"	120	256
Cache La Poudre St.	2237	23'-0" x 11'-6"	100	208
Uintah St.	1835	23'-0" x 11'-1"	100	198

Shook's Run
Drainage Basin

Sub-Drainage Basin 1

Table D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
La Salle	920	.35	14.1	0.80				14.1	At Shook's Run No pipe required
Monroe & Custer	2510	.49	23.2	1.10				23.2	No pipe required
Monroe & Paseo	2810	.51	44.3	1.30	21	14.3	5.95	30.0	
Paseo	3450	.56	71.1						At Shook's Run

Shook's Run
Drainage Basin
Sub-Drainage Basin 3

Table D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Monroe & Franklin	1550	.21	22.6	1.30				22.6	No pipe required
Monroe & Magellan	2150	.24	46.6	1.00	24	16.6	5.28	30.0	
Madison & El Paso	920	.19	11.3	1.80				11.3	No pipe required
Madison & Royer	2700	.28	67.8	0.70	36	37.8	5.35	30.0	
Jefferson & Royer	3150	.30	66.8	0.70	36	36.8	5.21	30.0	
Washington & Royer	3630	.33	71.6	0.90	36	41.6	5.89	30.0	
Templeton Gap & El Paso	2060	.35	15.3	0.90				15.3	No pipe required
Fontanero & El Paso	2850	.39	125.3	1.13	42	95.3	9.91	30.0	
Del Norte & El Paso	3770	.42	143.6	1.25	48	113.6	9.04	30.0	
Columbia & Prospect	5910	.50	187.2	2.08	48	157.2	12.50	30.0	
Uintah & San Miguel	1435	.24	26.5	5.30				26.5	No pipe required
Palmer Park & Farragut	1590	.38	17.6	2.20				17.6	No pipe required

Shook's Run
Drainage Basin
Sub-Drainage Basin 3

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required: size (5)	Pipe Required: cfs (6)	Pipe Required: V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Uintah & San Miguel	1435	.24	26.5	5.30				26.5	No pipe required
Palmer Park & Farragut	1590	.38	17.6	2.20				17.6	No pipe required
San Miguel & Foote	2290	.41	68.7	2.30	30	38.7	7.88	30.0	
San Miguel & Hancock	3220	.46	95.6	2.56	36	65.6	9.28	30.0	
San Miguel & Custer	4140	.49	112.4	3.56	36	92.4	13.07	30.0	

Shook's Run
Drainage Basin
Sub-Drainage Basin 4

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft	Time of Concentration hrs	Peak Storm Flow cfs	Slope %	Pipe Required size	Pipe Required cfs	Pipe Required V=FPS	Peak Street Flow cfs	Remarks
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Jackson	4660	.62	55.3	0.86	36	55.3	7.82		At R.R. Tracks
Weber & Fontanero	2290	.30	13.0	0.88	21	13.0	5.40		
Fontanero & Wahsatch	2875	.55	60.4	1.00	36	40.0	5.66	20.4	
Fontanero	6900	.68	125.8	1.18	48	125.8	10.01		At R.R. Tracks
Espanola	7450	.69	138.5	1.00	48	138.5	11.02		At R.R. Tracks
Caramillo	8450	.71	163.2	1.40	54	163.2	10.26		At R.R.Tracks
Columbia	9450	.74	188.1	1.00	54	188.1	11.83		At R.R. Tracks
San Miguel	10300	.75	191.9	1.07	60	191.9	9.77		At R.R. Tracks
Uintah	10900	.77	311.3	1.07	66	311.3	13.10		At R.R. Tracks to Shook's Run
Yampa & Foote	2080	.35	34.4	3.20	12	4.4	5.6	30.0	
Yampa & Hancock	2970	.38	59.4	2.90	24	29.4	9.36	30.0	
Yampa & Cedar	3410	.39	70.5	2.65	30	40.5	8.25	30.0	
Yampa & Prospect	5010	.47	96.4	4.34	36	96.4	13.64		
San Rafael	2360	.40	19.2	6.45	18	19.2	10.87	19.2	At Shook's Run
Cach La Poudre	2100	.40	14.6	4.10				14.6	At Shook's Run Existing OK

Shook's Run
Drainage Basin

Sub-Drainage Basin 5

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Mannings n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Jackson & Nevada	1450	.26	27.7	1.10				27.7	Existing OK
Monroe & Nevada	2315	.47	57.3	1.06	30	27.3	5.56	30.0	
Madison & Nevada	2775	.49	70.3	1.06	30	40.3	8.21	30.0	
Jefferson & Nevada	3245	.51	82.0	.95	36	52.0	7.36	30.0	
Washington & Nevada	3705	.53	95.9	.95	42	65.9	6.85	30.0	
Fontanero & Nevada	4185	.55	108.6	.95	42	78.6	8.17	30.0	
Madison & Tejon	2130	.39	22.3	.90				22.3	No pipe required
Jefferson & Tejon	2580	.42	38.8	1.00	18	8.8	4.98	30.0	
Espanola & Tejon	4000	.51	59.3	.50	42	59.3	6.16		
Espanola & Nevada	4685	.57	171.0	.95	54	141.0	8.87	30.0	
Caramillo & Nevada	5675	.60	178.1	.75	54	148.1	9.31	30.0	
Columbia & Nevada	6675	.63	186.3	.75	54	166.3	10.46	30.0	

Shook's Run
Drainage Basin

Sub-Drainage Basin 5

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Uintah & Nevada	7825	.66	200.3	.82	54	170.3	10.71	30.0	
Caramillo & Tejon	1800	.34	28.0	.70				28.0	No pipe required
Columbia & Tejon	1920	.41	44.3	.82	24	14.3	4.55	30.0	
Tejon	3260	.52	56.9	.50	42	56.9	5.91		At Colorado College
San Rafel & Nevada	8285	.67	265.0	.82	60	235.0	10.43	30.0	
Cache La Poudre & Nevada	9305	.70	277.7	.82	66	247.7	10.43	30.0	
Dale & Nevada	9815	.71	281.2	.82	66	251.2	10.57	30.0	
Cache La Poudre & Weber	1570	.38	24.1	.80				24.1	Existing OK
Dale & Weber	10365	.73	303.5	1.14	66	273.5	11.51	30.0	
Cache La Poudre & Wahsatch	1585	.35	24.8	.80				24.8	No Pipe required
Dale & Wahsatch	10940	.74	329.4	1.14	66	299.4	12.60	30.0	
Dale & Corona	11360	.75	347.4	1.14	66	317.4	13.36	30.0	
Dale & El Paso	12260	.77	356.4	1.14	66	326.4	13.74	30.0	

Shook's Run
Drainage Basin

Sub-Drainage Basin 5

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Maple	12510	.77	357.1	2.60					At Shook's Run
Cache La Poudre & Tejon	1835	.51	30.5	1.53	30	30.5	6.21		
Monument & Tejon	1960	.53	20.1	0.90				20.1	Existing OK
Boulder & Tejon	3510	.62	49.8	0.50	30	21.4	4.34	28.4	
St. Vrain & Nevada	1620	.38	26.0	1.00				26.0	Existing OK
Boulder & Nevada	2170	.66	53.5	0.50	30	25.1	5.11	28.4	
Boulder & Wahsatch	3220	.72	64.1	3.77	24	34.1	10.85	30.0	
Boulder	3840	.74	69.2	4.20					At Shook's Run
St. Vrain & Weber	1540	.36	25.4	1.10				25.4	Existing OK
St. Vrain & Wahsatch	2060	.39	50.1	1.00	21	20.1	8.36	30.0	Existing OK
St. Vrain & Royer	2760	.41	61.4	2.80	24	31.4	9.99	30.00	At Shook's Run
Boulder	3210	.42	64.1	1.80					
Willamette	560	.24	1.8	2.20	10	1.8	3.33		At R.R. tracks

Shook's Run
Drainage Basin

Sub-Drainage Basin 5

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Franklin	2190	.27	3.5	0.60	15	3.5	2.85		Existing OK
Royer & Willamette	1660	.31	46.1	1.90	21	16.1	6.69	30.0	
Willamette & El Paso	2300	.33	46.5	1.90	30	46.5	9.47		
Cache La Poudre & Union	2480	.31	49.1	4.00	30	49.1	10.00		
Faragut & Cache La Poudre	3280	.33	67.8	3.00	30	37.8	7.70	30.0	
Foot & Cache La Poudre	4155	.36	87.5	1.26	36	57.5	8.13	30.00	
Dale & Sheridan	2310	.33	28.1	2.90				28.1	No pipe required
Dale & Hancock	5475	.41	139.1	2.38	42	109.1	11.34	30.0	
Dale & Custer	6305	.43	156.0	1.44	48	126.0	10.03	30.0	
Mounument & Hancock	2690	.39	26.0	2.20				26.0	No pipe required
Monument & Custer	6755	.45	194.5	1.83	48	164.5	13.09	30.0	

Shook's Run
Drainage Basin

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Sub-Drainage Basin 5

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Monument & Prospect	7856	.47	217.2	2.63	48	217.2	17.28		
Dale & Prospect	1445	.34	18.4	1.50				18.4	No pipe required
Prospect	1795	.35	26.7	0.78	30	26.7	5.44		Existing OK
IX	8035	.47	241.5	2.63	54	241.5	15.18		At R.R. Right of Way
Willamette	1410	.42	19.0	3.12	21	19.0	7.90		At R.R. tracks

Shook's Run
Drainage Basin
Sub Drainage Basin 6

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Platte & Tejon	890	.11	10.7	0.50				30.0	Existing OK
Platte & Wahsatch	2490	.17	42.9	1.40	21	12.9	5.36	30.0	Existing OK
Platte	2990	.20	56.8	0.80	36	56.8	8.04		Existing OK At Shook's Run
Bijou & Wahsatch	2740	.14	45.6	1.00	21	15.6	6.49	30.0	Existing OK
Bijou	3290	.16	59.9						At Shook's Run
Kiowa & Wahsatch	2690	.17	50.3	0.60	24	20.3	6.46	30.0	Existing OK
Pikes Peak & Wahsatch	2560	.19	43.2	0.50	24	14.8	4.71	28.4	Existing OK
Kiowa & Corona	3760	.23	116.2	1.30	42	86.2	8.96	30.0	Existing OK
Kiowa	4290	.24	123.4						At Shook's Run

Shook's Run
Drainage Basin
Little Shook's Run
Sub-Drainage Basin

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Bennett	2700	.29	38.4	2.00					Existing OK
Bennett & Willamette	4380	.33	155.8	1.80	42	97.6	10.2	58.2	Existing OK
Monument & East Hills	1980	.36	40.5	3.30				40.5	Existing OK
Willamette & East Hills	2430	.39	200.5	2.10	54	142.3	9.1	58.2	Existing OK
Alexander & Monument	3092	.42	78.6	4.10				78.6	Existing OK
Willamette & Alexander	3492	.43	306.7	1.20	72	262.7	9.2	44.0	Existing OK
Sunset & Willamette	4212	.45	344.1	0.50	72	315.7	11.0	28.4	Existing OK
St Vrain	4762	.46	369.2	0.90	78	331.1	10.1	38.1	Existing OK
Boulder	5202	.47	405.7	0.70	78	372.1	11.5	33.6	Existing OK
Willamette & Swope	2550	.26	54.4	3.90				79.3	Existing OK
Boulder & Swope	5822	.48	510.3	0.80	78	474.4	14.1	35.9	Existing OK
Balfour & Bijou	3200	.39	71.5	1.50	24	22.3	7.1	49.2	Existing OK
Bijou	5100	.51	139.7	1.30	42	93.9	9.8	45.8	Existing OK
Bijou & Iowa	5830	.53	195.8	1.20	48	151.8	12.0	44.0	Existing OK
Bijou & Swope	6230	.54	711.5	1.50	84	662.3	8.8	49.2	Existing OK

Shook's Run
Drainage Basin
Little Shook's Run
Sub-Drainage Basin

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Union & Bijou	70301	.57	784.1	1.00	90	743.9	18.0	40.2	Existing OK
Logan	8730	.60	847.8	0.60	72x115	847.8	22.0		Existing Pipe Arch OK
Foote	9130	.60	947.8	1.70	72x115	947.8	23.0		Pipe Arch OK
Kiowa	13450	.56	1045.3	1.60	72¼x122	1045.3	22.0		Pipe arch OK At Shook's Run
Hancock & St.Vrain	1050	.41	31.6	1.40				31.6	Existing OK
Boulder & Custer	2360	.48	66.9	1.04	30	36.9	7.52	30.0	
Institute & Boulder	2810	.49	82.3	1.04	36	52.3	7.40	30.0	
Prospect & Boulder	3460	.52	93.7	1.04	36	63.7	9.01	30.0	
Boulder & El Paso	4200	.54	102.5	2.76	36	72.5	10.26	30.0	
Boulder	4900	.56	104.9	3.30					At Shook's Run

Shook's Run
Drainage Basin

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Sub-Drainage Basin 8

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Union & Printers Rd.	1748	.48	22.7	1.80	24	22.7	7.23		30" CMP
I	2198	.54	19.8	2.90	21	19.8	8.23		24" CMP
II	2598	.61	17.4	1.50	21	17.4	7.23		24" CMP
III	3478	.75	29.7	1.50	30	29.7	6.05		30" CMP
IV	300	.25	1.2	2.05	10	1.2	2.20		10" CMP
V	4188	.78	32.3	2.99	24	32.3	10.28		30" CMP
VI	4368	.79	33.8	2.99	24	33.8	10.76		30" CMP
VII	5028	.82	33.1						
VIII	1890	.48	15.1	2.44	18	15.1	8.54		Existing OK
Pikes Peak & Hancock	2640	.55	118.0	1.86	36	65.3	9.24		Existing OK
Pikes Peak	6748	1.03	123.2	4.55	42	123.2	13.10		At Canal OK
Pikes Peak & Institute	1960	.38	17.6	8.00	18	17.6	9.96		
Institute	7068	1.06	139.3	4.76	42	139.3	14.48		At Canal OK
Prospect	7748	1.14	141.9	2.44	42	141.9	14.75		At Canal OK

Shook's Run
Drainage Basin
Sub-Drainage Basin 9

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Colorado & Wahsatch	2510	.17	47.8	0.50	30	19.4	3.95	28.4	Existing OK
Cucharras & Wahsatch	3010	.19	95.2	1.23	36	65.2	9.22	30.0	Existing OK
Vermijo & Wahsatch	3530	.21	137.7	0.80	48	107.7	8.57	30.0	Existing OK
Costilla & Wahsatch	4070	.23	162.1	0.90	48	132.1	10.51	30.0	Existing OK
Costilla	4670	.25	166.8						At Shook's Run
Pikes Peak & El Paso	859	.25	19.8	4.00	24	19.8	6.30		
Prospect & Pikes Peak	750	.10	15.2	5.00	18	15.2	8.60		
Cucharras & Institute	1540	.27	30.6	4.17	24	20.0	6.37	10.6	
Cucharras & El Paso	2980	.32	55.0	4.35	30	55.0	11.20		
Vermijo & El Paso	1560	.23	28.6	4.54	21	28.6	11.89		
Costilla & El Paso	1630	.24	30.7	5.90				30.7	No Pipe required
Costilla	2400	.26	33.9						At Shook's Run

Shook's Run
Drainage Basin

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Sub-Drainage Basin 10

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Cimarron & Institute	1670	.33	39.7	2.40	18	9.7	5.49	30.0	
Prospect & Cimarron	2370	.35	62.0	4.00	24	32.0	10.19	30.0	
Cimarron & El Paso	3050	.72	64.9	4.00		34.9		30.0	
Cimarron	3970	.73	76.1	5.55	30	76.1	15.50		At Shook's Run
Rio Grande & Prospect	2030	.34	36.8	2.70	15	6.8	5.54	30.0	
Rio Grande & El Paso	2780	.36	56.5	5.90	21	26.5	11.02	30.0	
Rio Grande & Corona	3780	.38	82.6	4.35	36	82.6	11.69		
Moreno & Corona	1780	.37	20.7	5.26	18	20.7	11.71		21" CMP Existing OK
Las Animas & Corona	1770	.39	12.1	4.88	15	12.1	9.86	12.1	18" CMP
Corona	2280	.24	23.3	Corona Street below Fountain, should be paved to move water and prevent erosio					
Royer	1050	.23	14.5	6.67	15	14.5	11.82		Existing OK
Fort Worth	1900	.32	16.6	6.67	18	16.6	9.39		At Shook's Run

Shook's Run
Drainage Basin
Sub-Drainage Basin 10

TABLE D
STORM DRAIN SYSTEM
FLOW TABLE

Manning's n = .014

Location	Length ft (1)	Time of Concentration hrs (2)	Peak Storm Flow cfs (3)	Slope % (4)	Pipe Required size (5)	Pipe Required cfs (6)	Pipe Required V=FPS (7)	Peak Street Flow cfs (8)	Remarks
Moreno & Weber	1280	.18	33.0	0.90	30	33.0	6.72		
Wahsatch	1615	.24	65.3	2.46	36	65.3	9.24		Between Rio Grande & Los Anim
Fountain & Corona	2560	.49	22.5	3.33					Existing OK
Las Vegas	1760	.22	15.1	0.90	24	15.1	4.81		Existing OK

TABLE E

Shook's Run Drainage Basin

Proposed Storm Sewers

Basin	Location	Size in. dia.	Type	Length Ft.	No. of Inlets	Inlet Throat Openings	No. of Outlet Structures
1	Monroe & Paseo	21	RCP	450	4	6' x 8"	
	Madison & Paseo	21	RCP	450	2	6' x 8"	1
3	Monroe & Magellan	24	RCP	550	3	6' x 8"	
	Madison & Royer	36	RCP	450	3	6' x 8"	
	Jefferson & Royer	36	RCP	450	2	6' x 8"	
	Washington & Royer	36	RCP	500	2	6' x 8"	
	Fontanero & Royer	36	RCP	400	2	6' x 8"	
	Fontanero & El Paso	42	RCP	500	4	6' x 8"	
	Espanola & El Paso	42	RCP	500	2	6' x 8"	
	Del Norte & El Paso	48	RCP	400	2	6' x 8"	
	Del Norte & Franklin	48	RCP	500	3	6' x 8"	
	Caramillo & Franklin	48	RCP	850	3	6' x 8"	
	Franklin & Columbia	48	RCP	350	2	6' x 8"	

TABLE E

Basin	Location	Size in.dia.	Type	Length Ft.	No. of Inlet	Inlet Throat Openings	No. of Outlet Structures
3	Prospect & Columbia to Shook's Run	48	RCP	820	3	6' x 8"	1
	San Miguel & Foote	30	RCP	850	3	6' x 8"	
	San Miguel & Hancock	36	RCP	900	2	6' x 8"	
	San Miguel & Custer	36	RCP	430	2	6' x 8"	
	San Miguel & Columbia	36	RCP	325	2	6' x 8"	1
4	Jackson & RR Tracks	36	RCP	80	2	10' x 8"	1
	Fontanero & Weber	21	RCP	250	4	4' x 8"	
	Wahsatch & Fontanero	36	RCP	300	3	8' x 8"	
	Fontanero & RR. Tracks	48	RCP	500	2	6' x 8"	
	Espanola & RR Tracks	48	RCP	1050	2	6' x 8"	
	Wahsatch & Caramillo @ RR Tracks	54	RCP	1050	6	6' x 8"	
	Columbia & Corona @ RR Tracks	54	RCP	800	3	6' x 8"	
	San Miguel @ RR Tracks	60	RCP	560	1	6' x 8"	

TABLE E

Basin	Location	Size in.dia.	Type	Length Ft.	No. of Inlet	Inlet Throat Openings	No. of Outlet Structures
4	Uintah @ RR Tracks	60	RCP	1670	2	6' x 8"	1
	Yampa & Foote	12	RCP	400	2	4' x 8"	
	Yampa & Sheridan	12	RCP	425	2	4' x 8"	
	Yampa & Hancock	24	RCP	450	3	6' x 8"	
	Yampa & Cedar	30	RCP	450	4	6' x 8"	
	Yampa & Custer	30	RCP	450	2	6' x 8"	
	Yampa & Institute	30	RCP	700	3	6' x 8"	
	Yampa & Prospect	36	RCP	175	3	(2) 6 x 8" (2) 8' x 8"	1
5	Union & Cache La Poudre	30	RCP	350	4	(1) 8' x 8" (1) 12' x 8" (2) 4' x 8"	
	Meade & Cache La Poudre	30	RCP	450	2	6' x 8"	
	Farragut & Cache La Poudre	30	RCP	450	2	6' x 8"	
	Logan & Cache La Poudre	30	RCP	450	2	6' x 8"	
	Foote & Cache La Poudre	36	RCP	425	2	6' x 8"	

TABLE E

Basin	Location	Size in.dia.	Type	Length Ft.	No. of Inlet	Inlet Throat Openings	No. of Outlet Structures
5	Sheridan & Cache La Poudre	36	RCP	450	1	6' x 8"	
	Hancock & Cache La Poudre	36	RCP	500	4	6' x 8"	
	Hancock & Dale	42	RCP	450	4	6' x 8"	
	Cedar & Dale	42	RCP	440	2	6' x 8"	
	Dale & Custer	48	RCP	500	4	6' x 8"	
	Monument & Custer	48	RCP	430	3	6' x 8"	
	Monument & Institute	48	RCP	700	3	6' x 8"	
	Monument & Prospect to Shook's Run	54	RCP	680	3	(2) 6' x 8" (1) 8' x 8"	1
8	V in. Memorial Park	24 30	RCP CMP	800	(2) drop inlets		1
9	Prospect & Pikes Peak	18	RCP	435	3	4' x 8"	1
	Cucharras & Institute	24	RCP	700	2	6' x 8"	
	Cucharras & Prospect	24	RCP	700	2	6' x 8"	
	El Paso to Shook's Run	30	RCP	375	3	(2) 6'x8" (1) 8' x 8"	1

TABLE E

Basin	Location	Size in.dia.	Type	Length Ft.	No. of Inlet	Inlet Throat Openings	No. of Outlet Structures
9	Vermijo & El Paso to Shook's Run	21	RCP	250			1
10	Institute & Cimarron	18	RCP	700	3	4' x 8"	
	Prospect & Cimarron	24	RCP	700	2	6' x 8"	
	El Paso & Cimmarron to Shook's Run	30	RCP	990	4	6' x 8"	1
	Rio Grande & Prospect	15	RCP	730	4	4' x 8"	
	Rio Grande & El Paso	21	RCP	960	5	(2) 6' x 8" (3) 4' x 8"	
	Rio Grande & Corona	36	RCP	50	3	(2) 6' x 8" (1) 8' x 8"	1
	Corona & Las Animas to Shook's Run	15	RCP	175			1
	Fort Worth (?) Shook's Run	18	RCP	60	1	6' x 8"	1

TABLE F

INVENTORY

STORM DRAIN PIPING (RCP)

AND IMPROVEMENTS

Basin	Storm Drain Pipe Size in. dia.	Storm Drain Pipe Length feet	Catch Basins Ea	Outlet Structures Ea
1	21	900	4	1
3	24	550	3	
	30	850	3	
	36	3455	15	1
	42	1000	6	
	48	2920	13	1
4	12	825	4	
	21	250	4	
	24	450	3	
	30	1600	9	
	36	555	8	2
	48	1550	4	
	54	1850	9	
	60	2230	3	1
5	30	1700	10	
	36	1375	7	
	42	890	6	
	48	1630	10	
	54	680	3	1

TABLE F

INVENTORY

STORM DRAIN PIPING (RCP)

AND IMPROVEMENTS

Basin	Storm Drain Pipe Size in.dia.	Storm Drain Pipe Length feet	Catch Basins Ea	Outlet Structures Ea
8	24	800	(2) drop inlets	1
9	18	435	3	1
	21	250		1
	24	1400	4	
	30	375	3	1
10	15	905	4	1
	18	760	4	1
	21	960	5	
	24	700	2	
	30	990	4	1
	36	50	3	1

Shook's Run Drainage Basin

TABLE G

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	Free Board Ft	Velocity FPS V	Area Sq. Ft. A
Jackson to Fontanero along RR Tracks	.01	1.77	2	70.7	.016	1.62	2.3	8.67	8.15
Canal along Hancock to Pikes Peak	.005	2.00	3	33.1	.035	1.66	1.0	2.85	11.59
Canal along Pikes Peak to CMP culvert	.027	3.0	3	70.7	.035	1.48	2.0	6.45	10.96

Gabion Lined
Open Channel

TABLE H
MAJOR 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	Free Board Ft.	Velocity FPS V	Area Sq. Ft. A
A-B	.0088			79.3	.045			3.40	
B-C	.0133	9.00	1	1493.2	.027	6.50	2.7	14.96	99.79
C-D	.0133	9.00	1	1505.0	.027	6.50	2.7	15.08	99.82
D-E	.0105	9.00	1	1801.2	.027	7.50	2.7	14.47	124.50
E-F	.0089	9.00	1	2196.5	.027	8.70	2.75	14.31	153.51
F-G	.0099	12.00	1	2690.0	.027	8.50	2.80	15.60	172.43
G-H	.0116	12.00	1	2803.3	.027	8.30	2.90	16.72	167.66
H-I	.0116	12.00	1	2892.4	.027	8.50	2.90	16.86	171.58
I-J	.0111	12.00	1	3945.5	.027	10.00	3.00	17.97	219.57
J-K	.0086	12.00	1	4293.6	.027	11.10	3.00	16.70	257.14
K-L	.0086	12.00	1	4444.4	.027	11.3	3.00	16.84	263.85
L-M	.0083	12.00	1	4539.1	.027	11.5	3.00	16.71	271.61

Concrete lined
Open Trapezoidal Channel

TABLE H
MAJOR 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	Free Board Ft.	Velocity FPS V	Area Sq. Ft. A
A-B	.0088			79.3	.045			3.40	
B-C	.0093	10.0	2	1493.2	.016	4.44	2.7	17.82	83.79
C-D	.0081	10.0	2	1519.3	.016	4.63	2.7	17.02	89.27
D-E	.0077	15.0	2	1835.2	.016	4.47	2.7	17.16	106.93
E-F	.0083	20.0	2	2237.2	.016	4.31	2.75	18.14	123.34
F-G	.0064	25.0	2	2816.1	.016	4.74	2.7	17.24	163.36
G-H	.0068	25.0	2	2904.3	.016	4.74	2.75	17.77	163.42
H-I	.0067	25.0	2	2994.8	.016	4.84	2.7	17.84	167.85
I-J	.0059	35.0	2	4085.1	.016	5.07	2.75	17.86	228.74
J-K	.0050	35.0	2	4406.6	.016	5.54	2.75	17.27	255.17
K-L	.0056	40.0	2	4597.7	.016	5.30	2.8	18.09	267.97
L-M	.0050	40.0	2	4693.0	.016	5.37	2.75	17.23	272.42

Low Flow Pipe & Flood Control Channel

TABLE H
MAJOR DRAINAGE CHANNELS
TRAPEZOIDAL SECTIONS

Reach	Slope Ft/Ft S	Bottom Width-Ft b	Side Slopes Horiz/Vert. Z	Flow CFS Q	Manning's Coeficient n	Depth Feet D	Free Board Ft	Velocity FPS V	Pipe Size In.
A-B	.0088	1	3	9.9	.035	1.0	2	2.61	42
B-C	.0100	5	3	186.7	.035	2.6	2	5.67	87 x 136
C-D	.0100	5	3	189.9	.035	2.6	2	5.70	92 x 143
D-E	.0100	8	3	229.4	.035	2.5	2	5.89	106 x 166
E-F	.0100	10	3	279.7	.035	2.6	2	6.13	106 x 166
F-G	.0100	15	3	397.3	.035	2.6	2	6.54	116 x 180
G-H	.0100	15	3	363.0	.035	2.5	2	6.37	116 x 180
H-I	.0100	15	3	374.3	.035	2.6	2	6.43	116 x 180
I-J	.0100	20	3	510.6	.035	2.7	2	6.81	(2) 106 x 166
J-K	.0100	25	3	550.8	.035	2.5	2	6.73	(2) 106 x 166
K-L	.0100	25	3	574.7	.035	2.6	2	6.82	(2) 106 x 166
L-M	.0100	25	3	586.6	.035	2.6	2	6.87	(2) 116 x 180

Gabion Lined
Open Trapezoidal Channel

TABLE I
SYNTHETIC HYDROGRAPH CALCULATIONS

Shook's Run
Drainage Basin

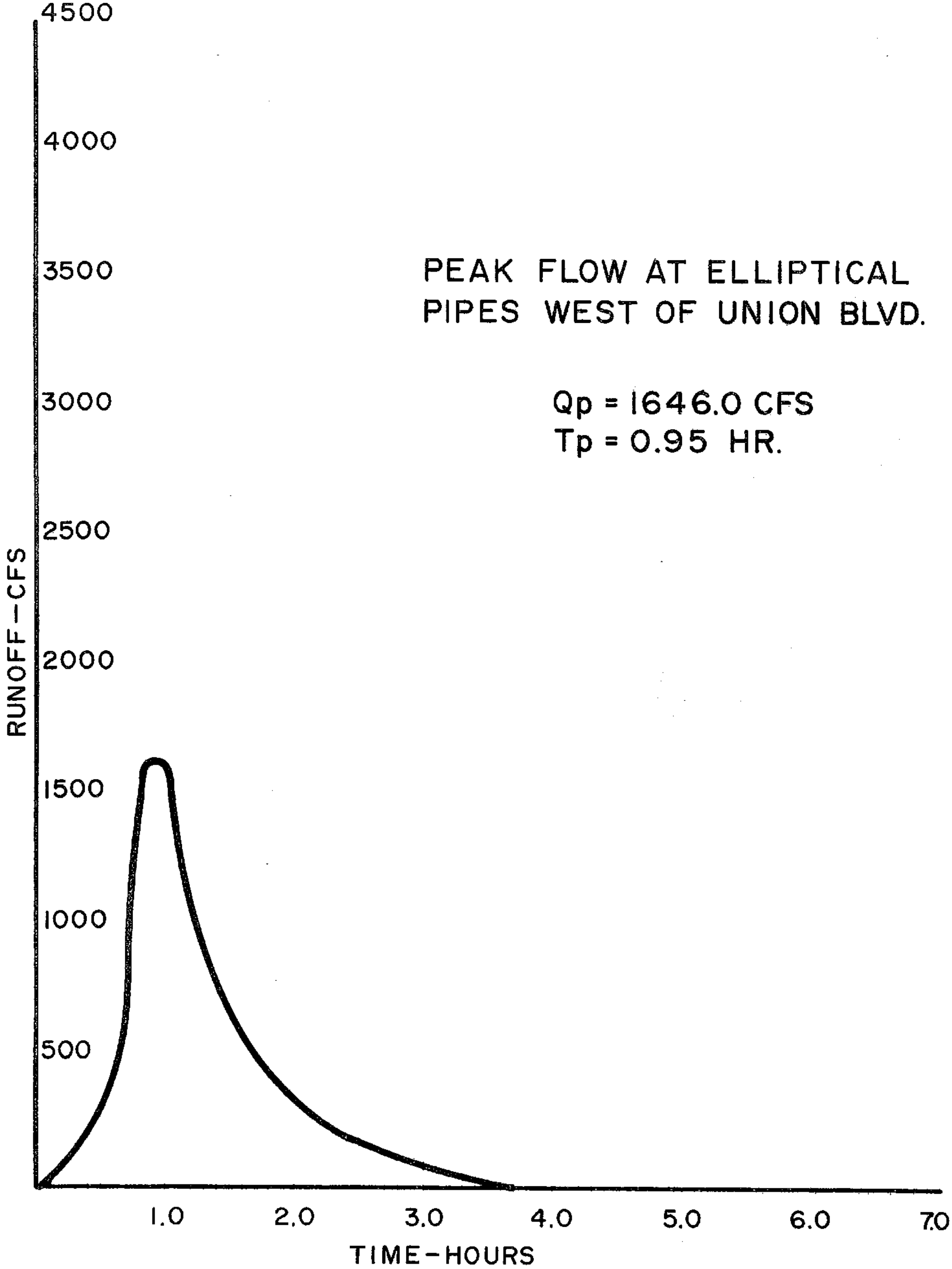
Hydrograph Location (1)	Acres (2)	Sq. Miles (3)	L(ft) (4)	H(ft) (5)	Tc(hrs) (6)	Tp(hrs) (7)	Q (In) / 100 yr (8)	Qp (cfs) / 100 yr (9)
A	55.0	.086	3440	20	.56	.84	1.60	79.3
B	1271.0	1.986	18980	237	.89	1.03	1.60	1493.2
C	1318.4	2.060	21360	270	.93	1.06	1.60	1505.0
D	1607.7	2.512	23020	292	.96	1.08	1.60	1801.2
E	1996.8	3.120	25260	314	1.00	1.10	1.60	2196.5
F	2490.2	3.891	26180	322	1.04	1.12	1.60	2690.0
G	2664.3	4.163	28220	342	1.08	1.15	1.60	2803.3
H	2796.8	4.370	30240	364	1.11	1.17	1.60	2892.4
I	3815.0	5.961	30700	371	1.12	1.17	1.60	3945.5
J	4151.7	6.487	30820	372	1.12	1.17	1.60	4293.6
K	4407.7	6.887	33720	397	1.17	1.20	1.60	4444.4
L	4576.6	7.151	35480	410	1.20	1.22	1.60	4539.1
M	4673.9	7.303	38720	435	1.25	1.25	1.60	4524.4

TABLE I
SYNTHETIC HYDROGRAPH CALCULATIONS

Concrete lined
Open Trapezoidal Channel

Shooks Run
Drainage Basin

Hydrograph Location (1)	Acres (2)	Sq. Miles (3)	L(ft.) (4)	H(ft.) (5)	Tc(hrs.) (6)	Tp (hrs.) (7)	Q (In.) 100 yr. (8)	Qp (cfs) 100 yr. (9)
A	55.0	.086	3440	20	.56	.84	1.60	79.3
B	1271.0	1.986	18980	237	.89	1.03	1.60	1493.2
C	1318.4	2.060	21360	270	.92	1.05	1.60	1519.3
D	1607.7	2.512	23020	292	.94	1.06	1.60	1835.2
E	1996.8	3.120	25260	314	.97	1.08	1.60	2237.2
F	2490.2	3.891	26180	322	.99	1.09	1.60	2816.1
G	2664.3	4.163	28220	342	1.02	1.11	1.60	2904.3
H	2796.8	4.370	30240	364	1.05	1.13	1.60	2994.8
I	3815.0	5.961	30700	371	1.05	1.13	1.60	4085.1
J	4151.7	6.487	30820	372	1.06	1.14	1.60	4406.6
K	4407.7	6.887	33720	397	1.10	1.16	1.60	4597.7
L	4576.6	7.151	35480	410	1.13	1.18	1.60	4693.0
M	4673.9	7.303	38720	435	1.18	1.21	1.60	4673.9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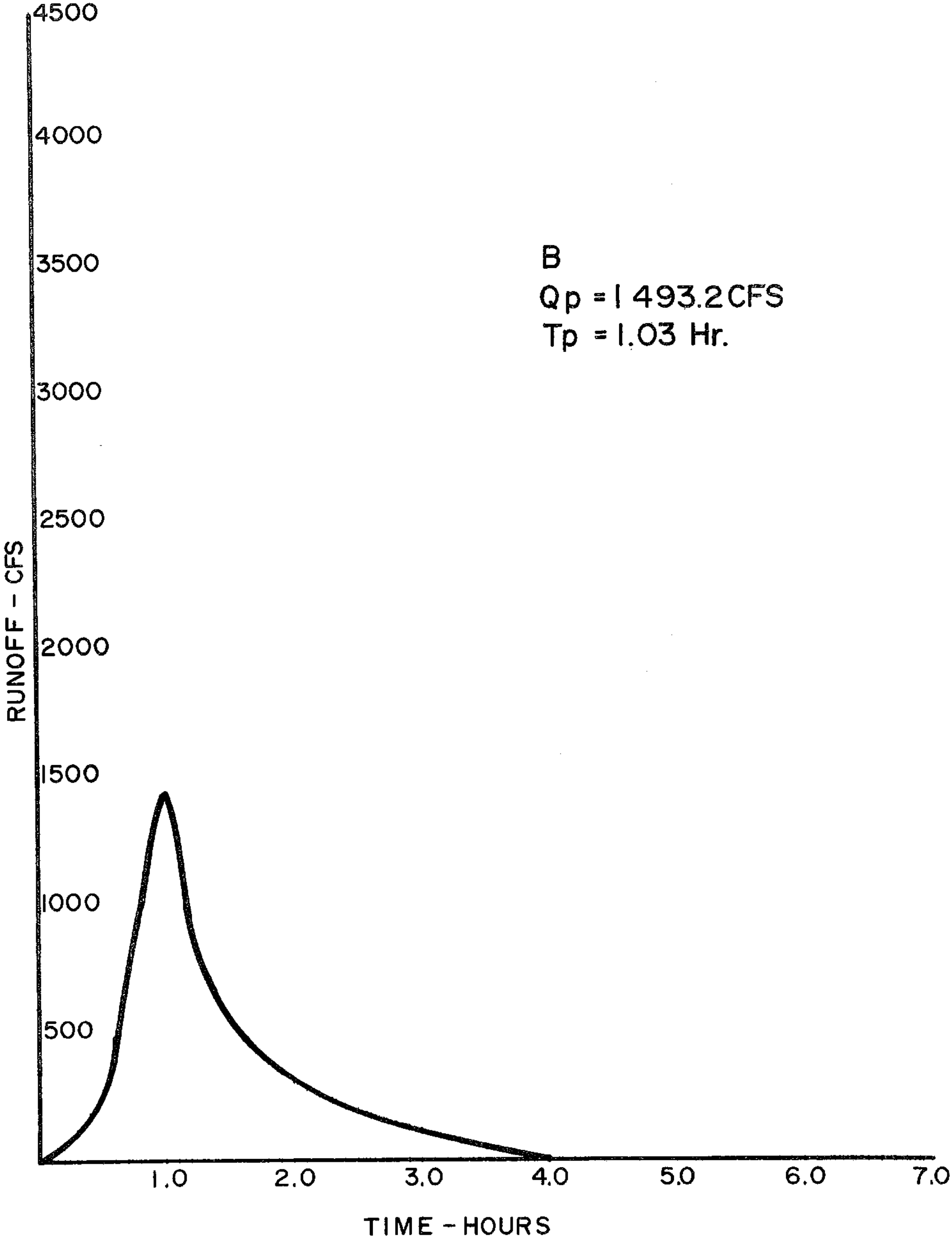
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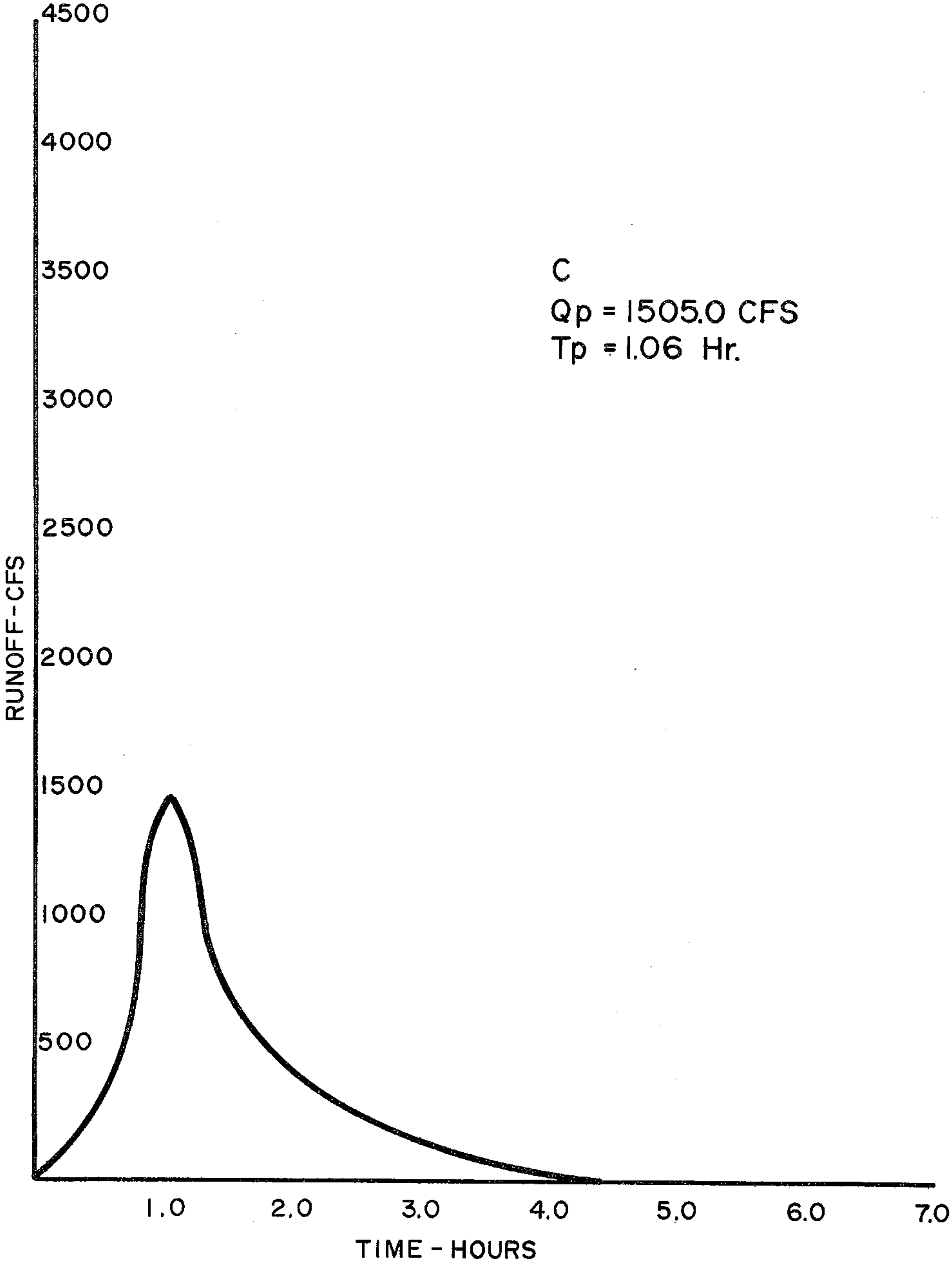
TIME - HOURS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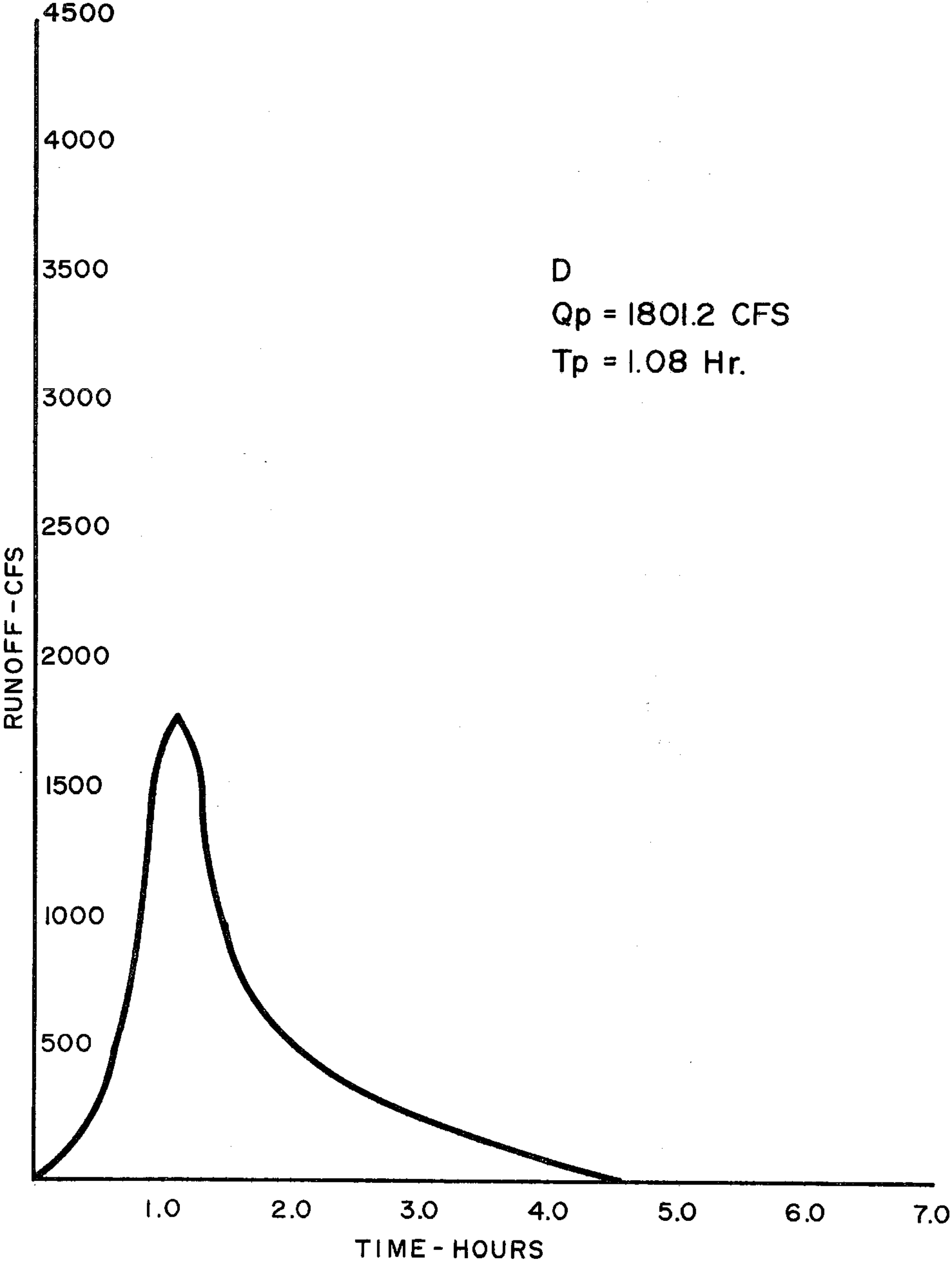
6.0
7.0
TIME - HOURS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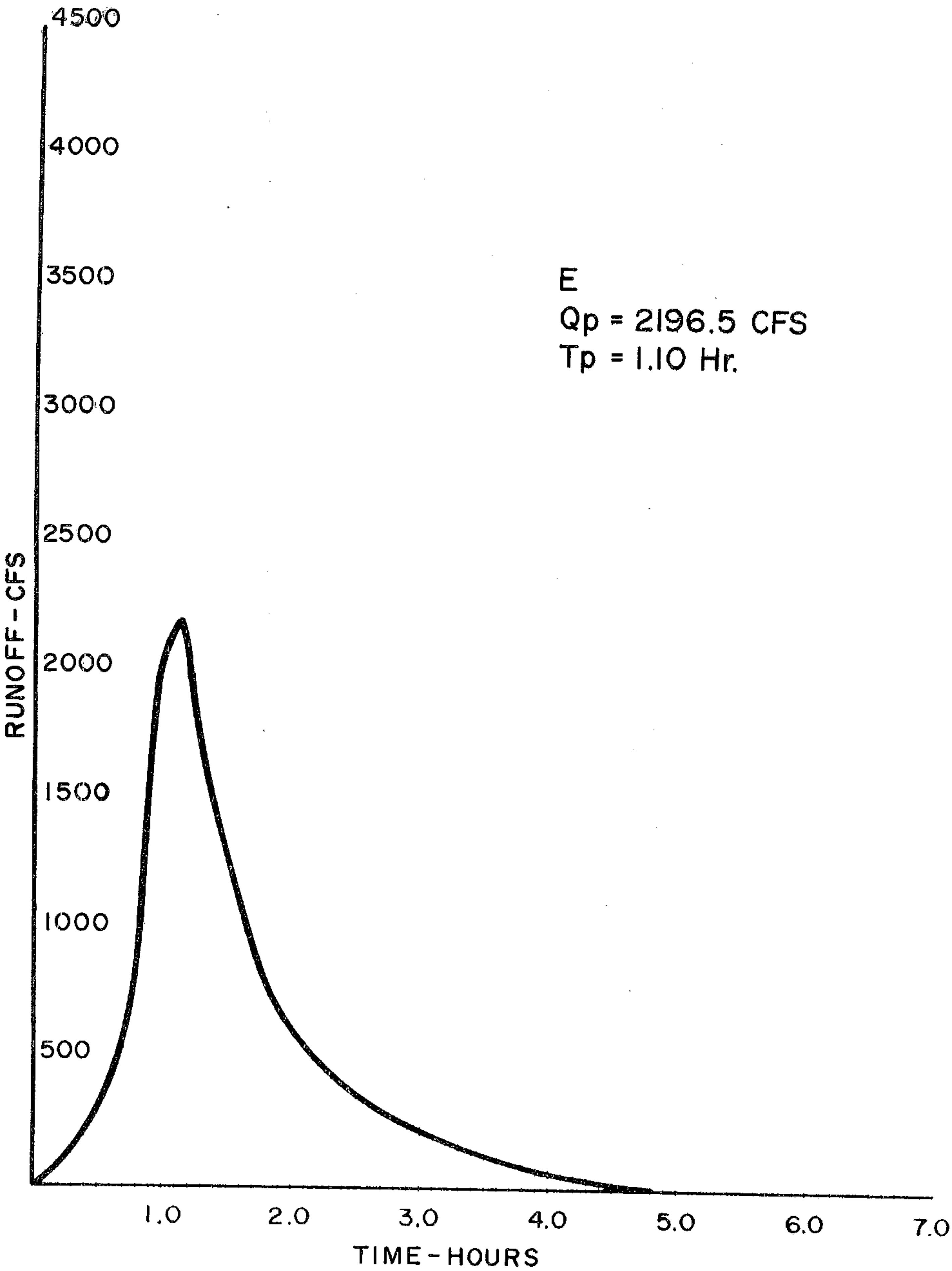
TIME - HOURS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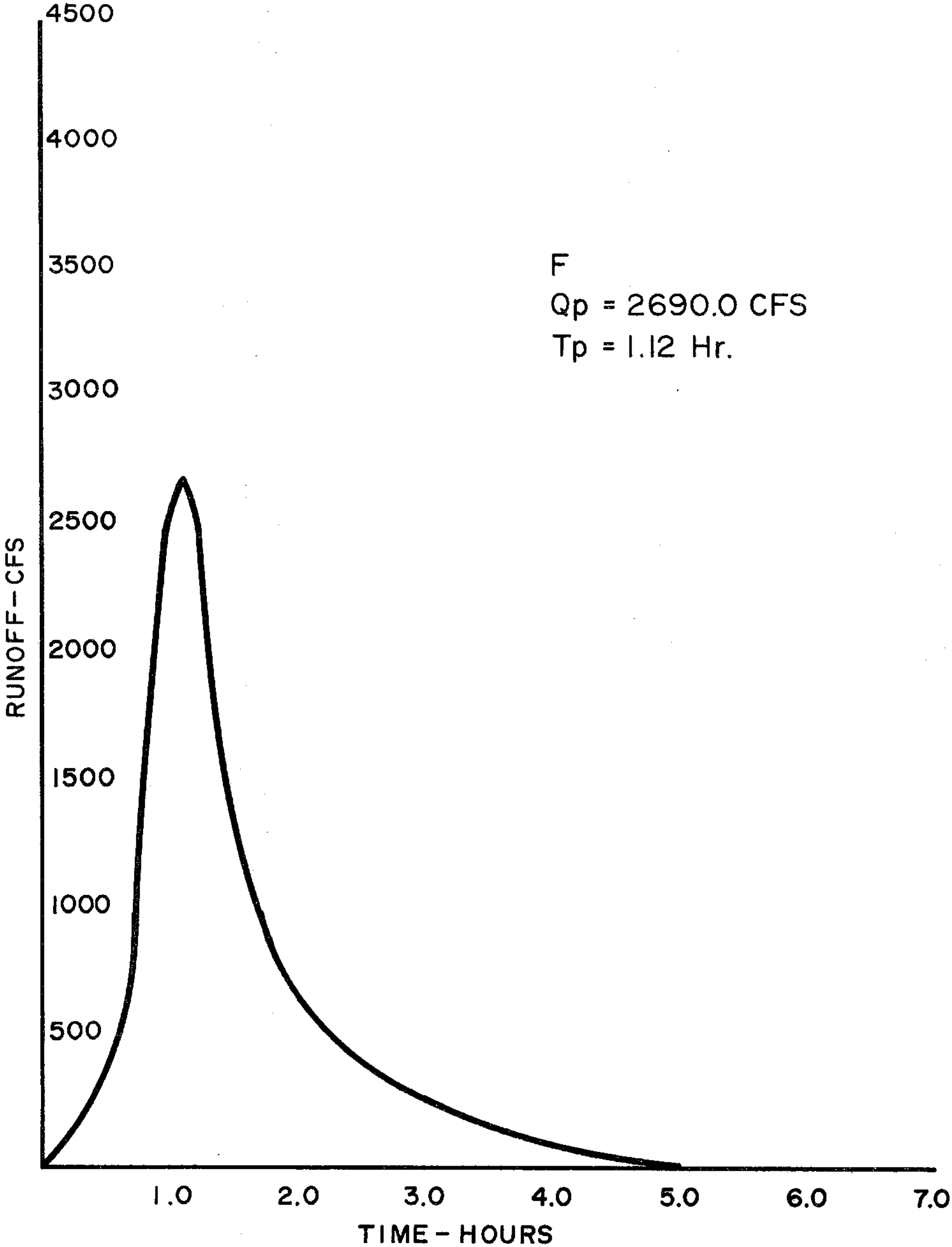
7.0
TIME - HOURS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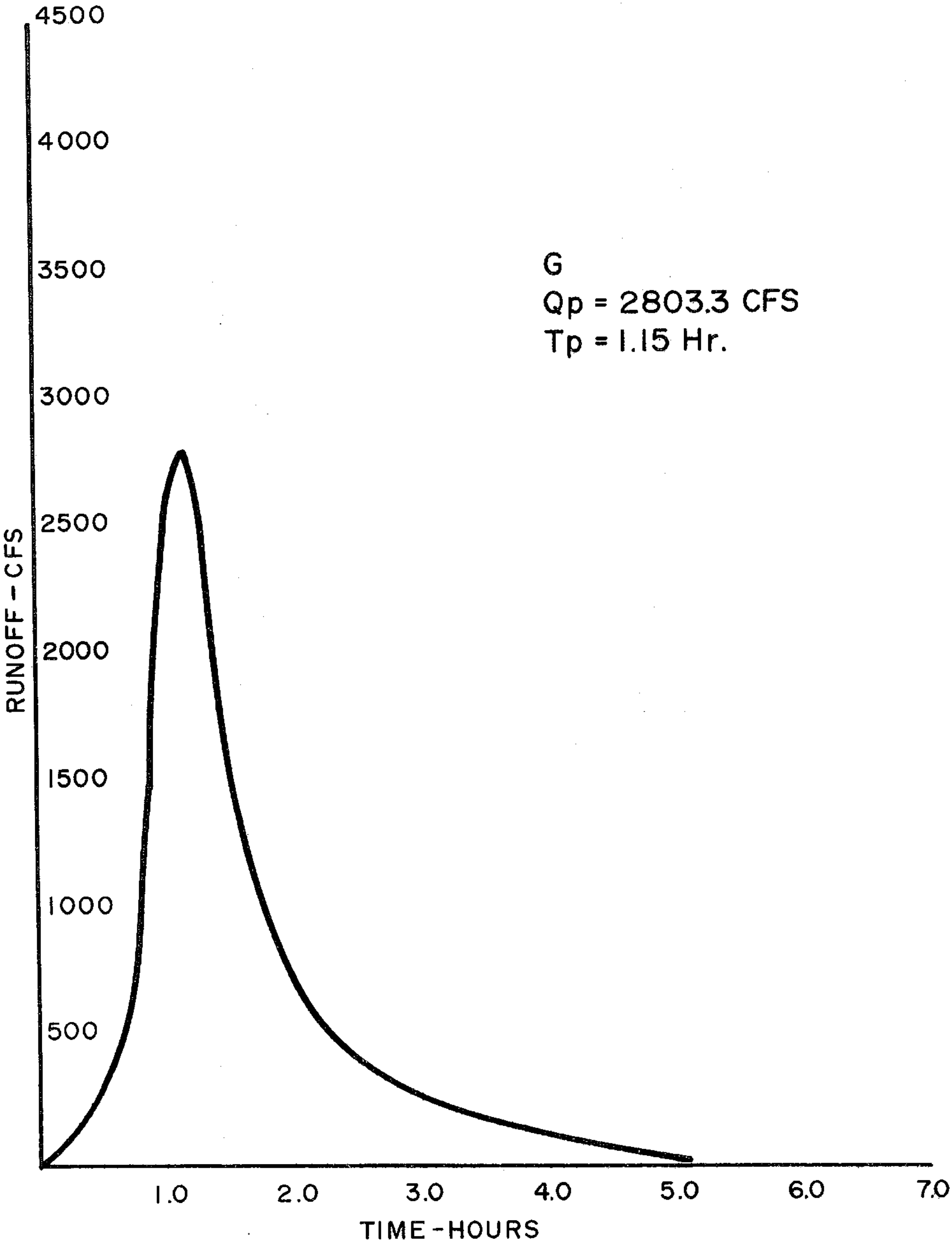
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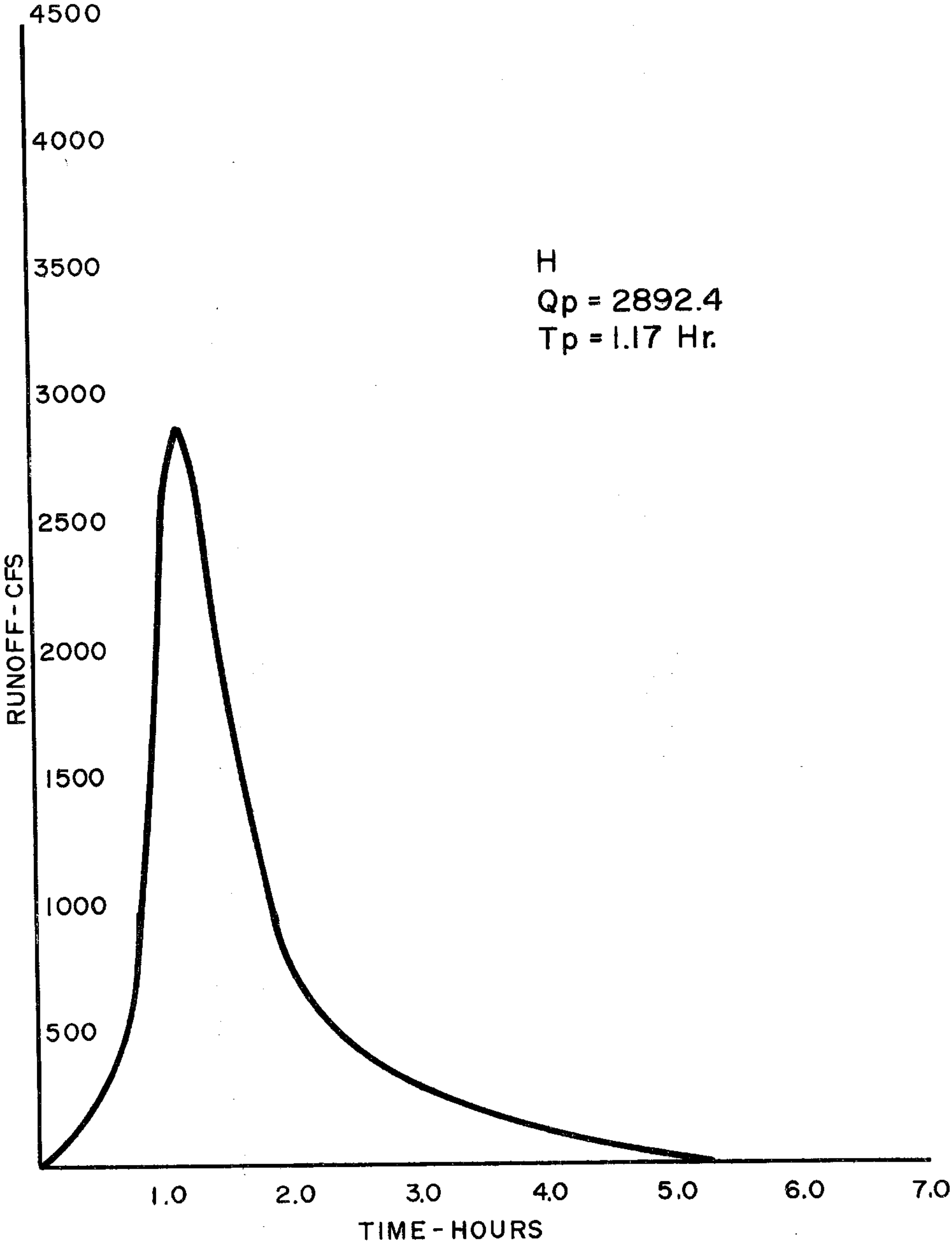
7.0
TIME-HOURS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RUNOFF - CFS
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4.0
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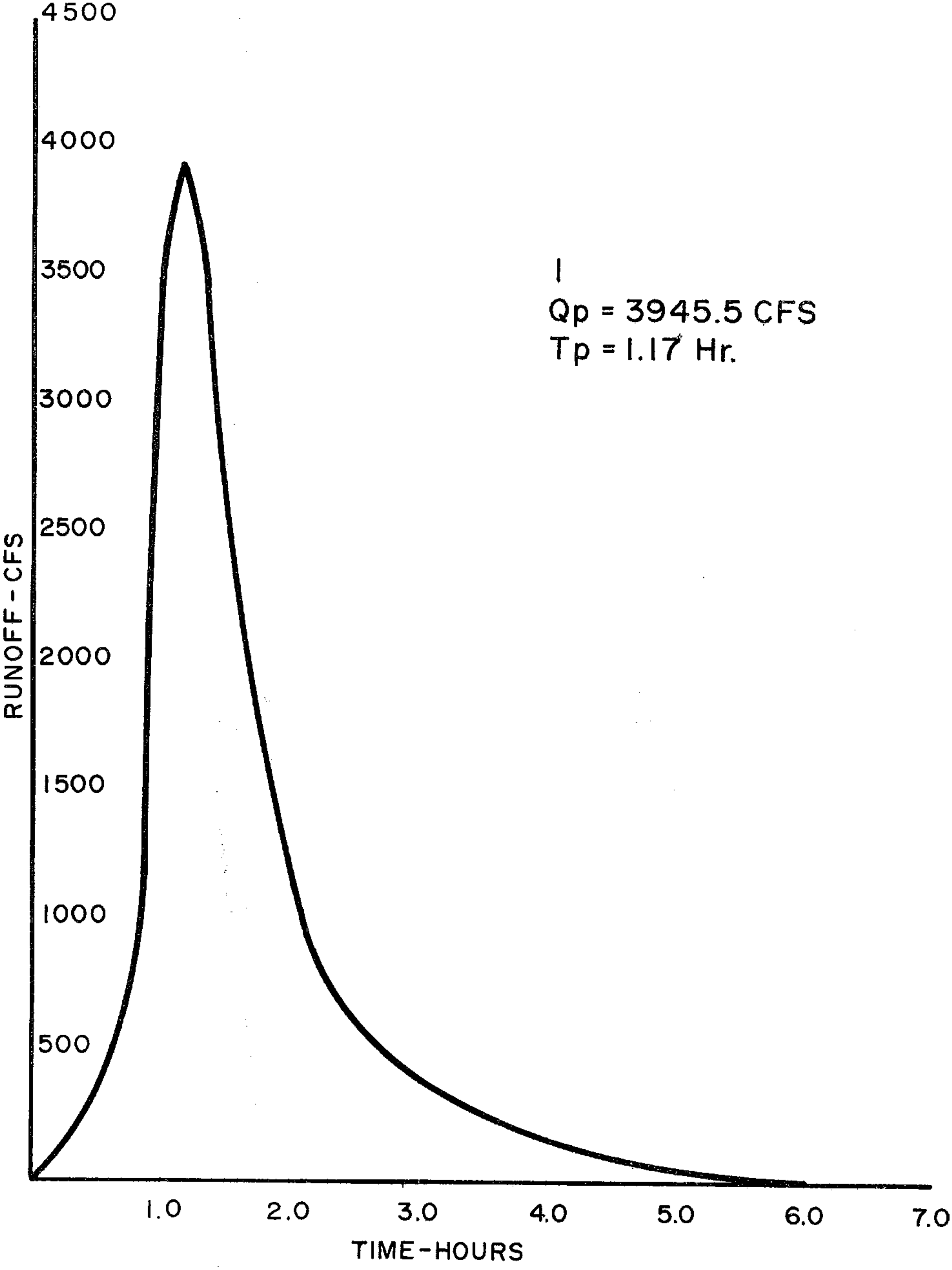
7.0
TIME - HOURS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RUNOFF - CFS
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7.0
TIME-HOURS
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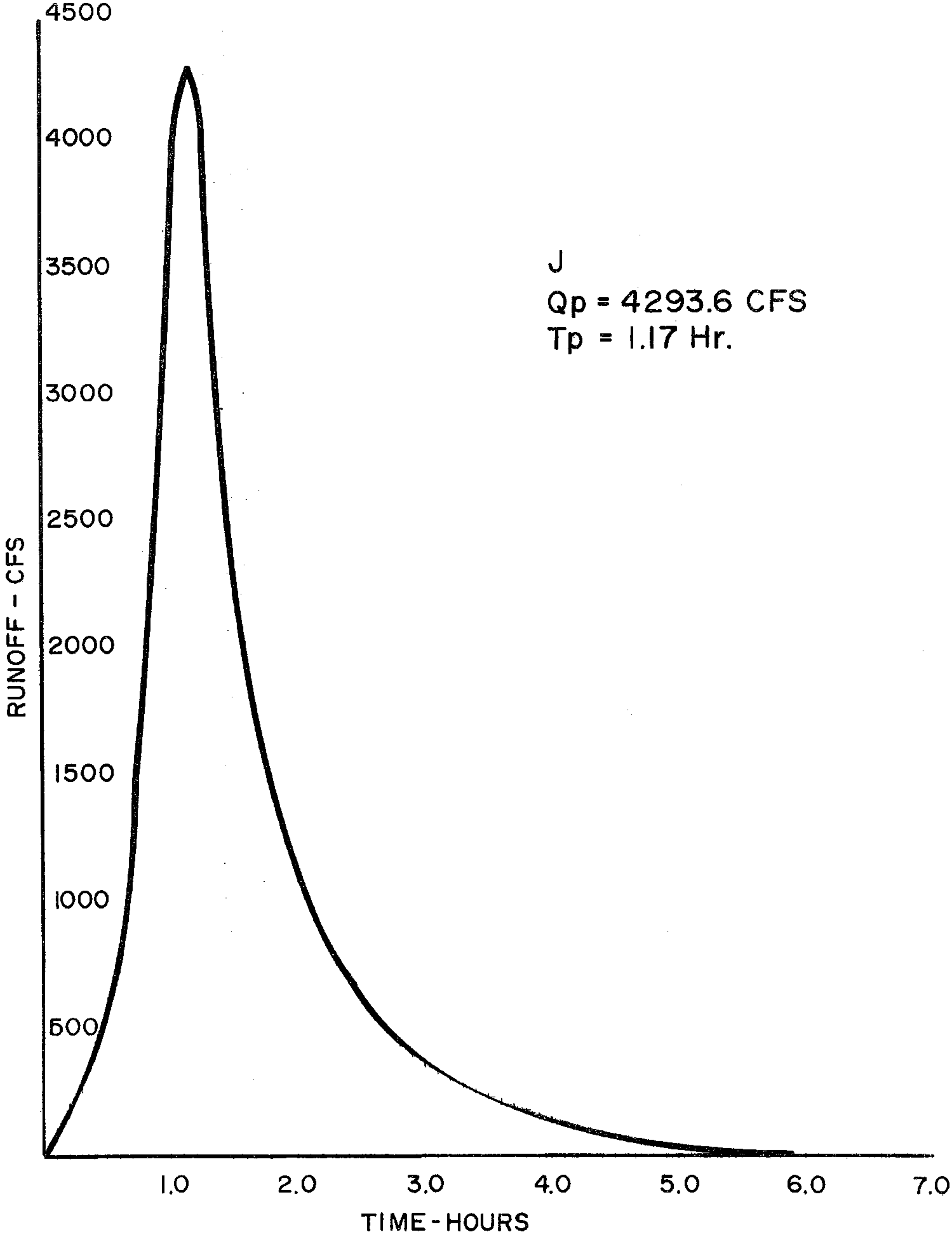
Tp = 1.17 Hr.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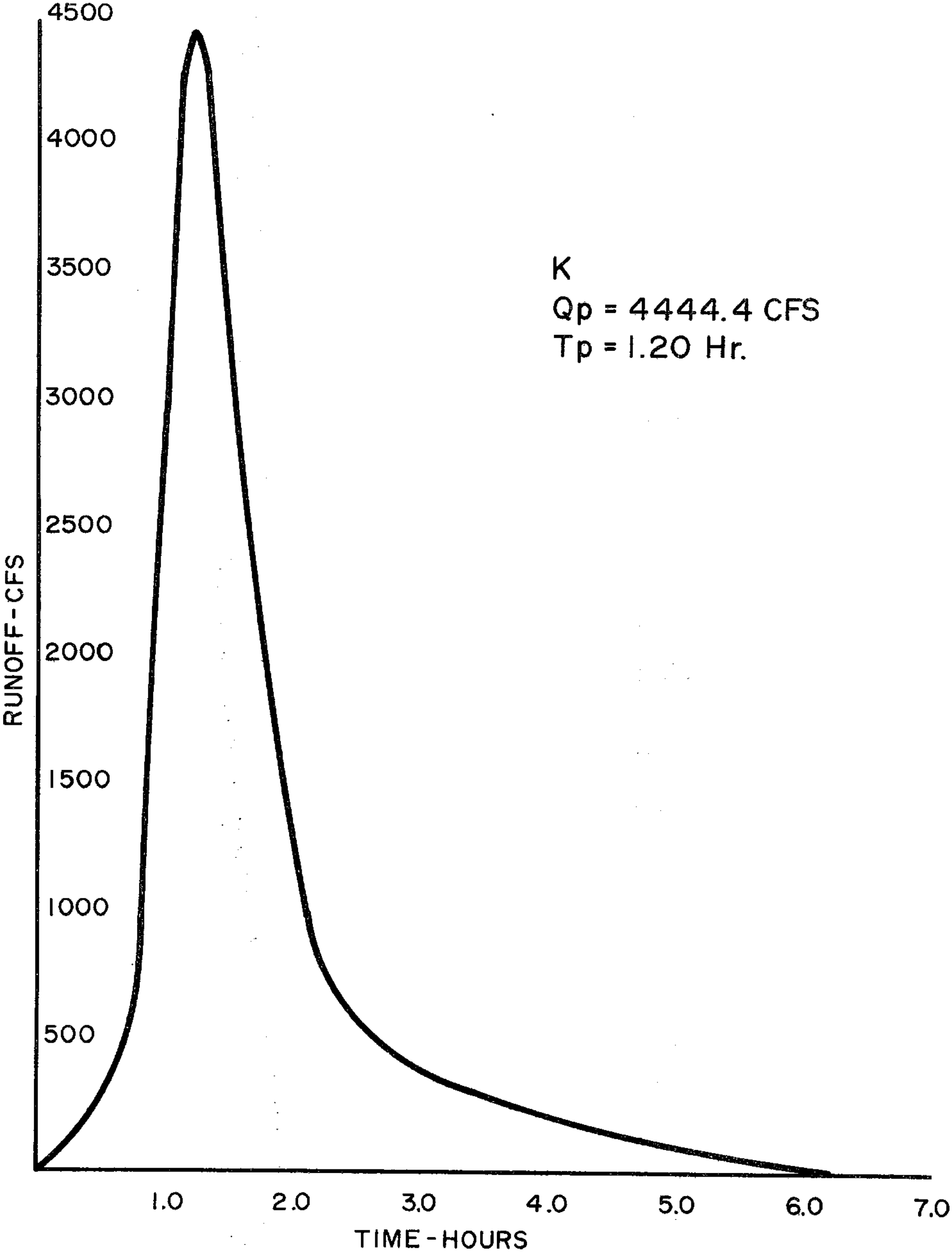
6.0
7.0
TIME - HOURS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1500
1000
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RUNOFF-CFS
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5.0
6.0
7.0
TIME-HOURS
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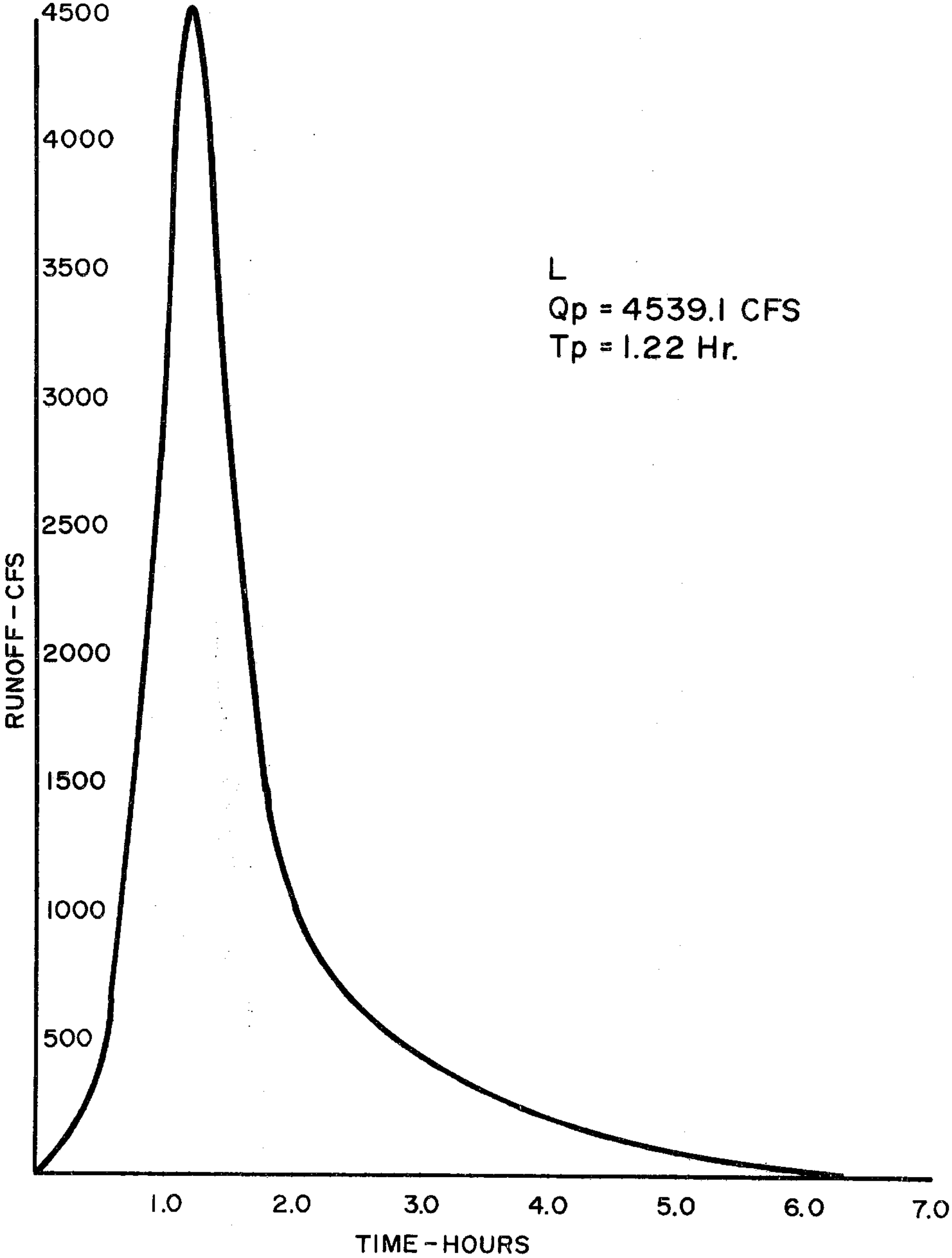
Tp = 1.20 Hr.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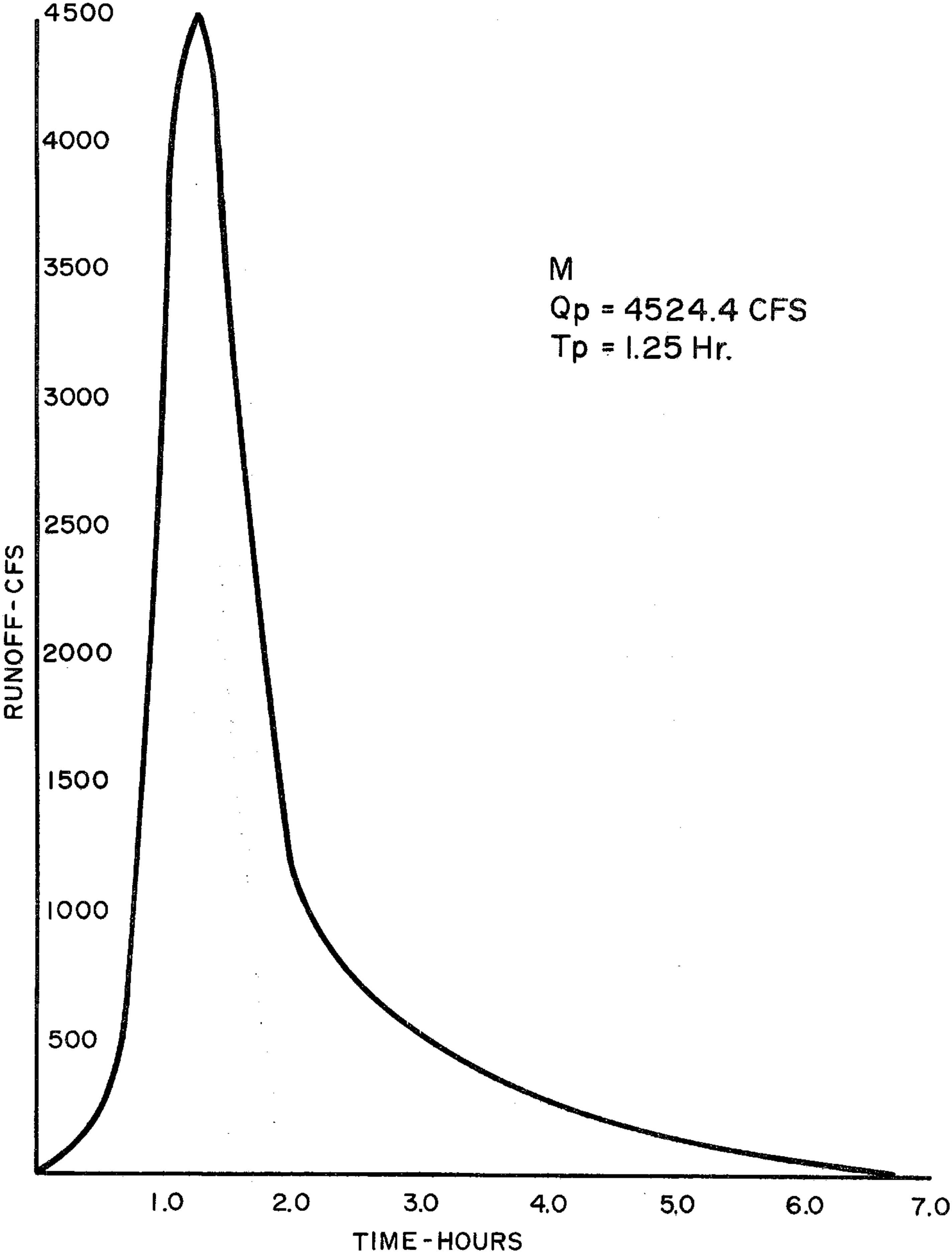
6.0
7.0
TIME - HOURS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7.0
TIME - HOURS

APPENDIX

OVERLAND FLOW TIME

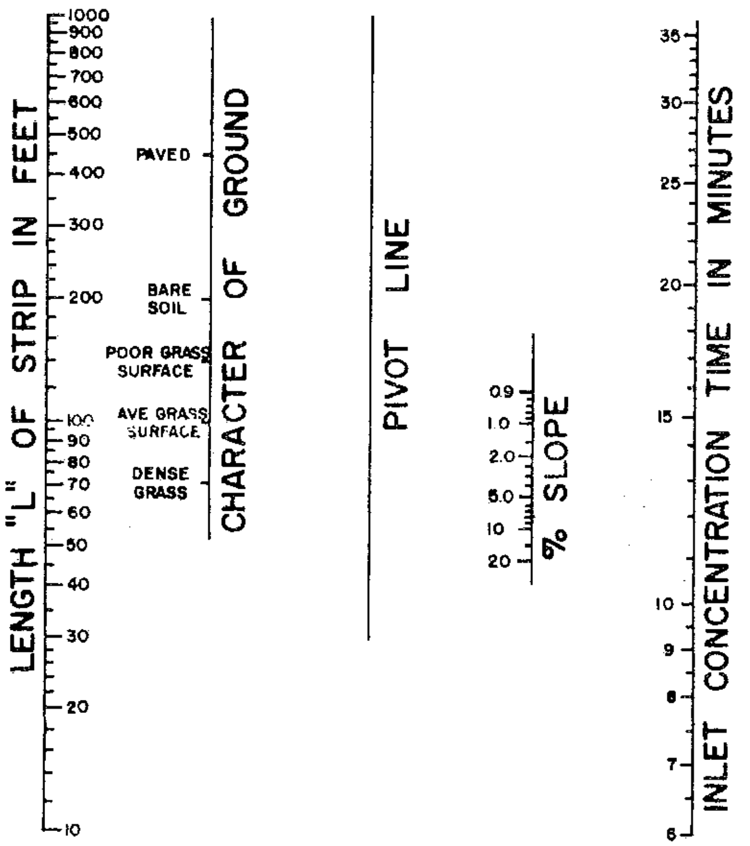


FIGURE I

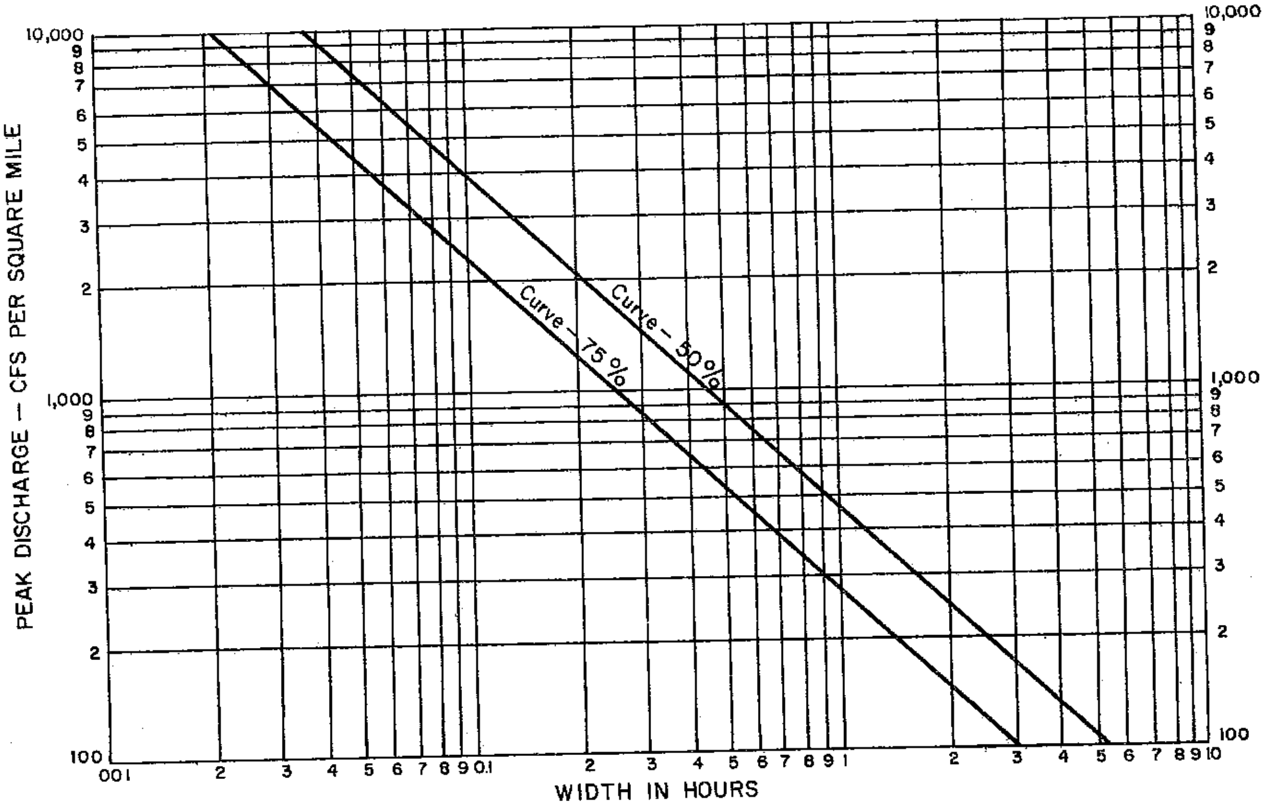
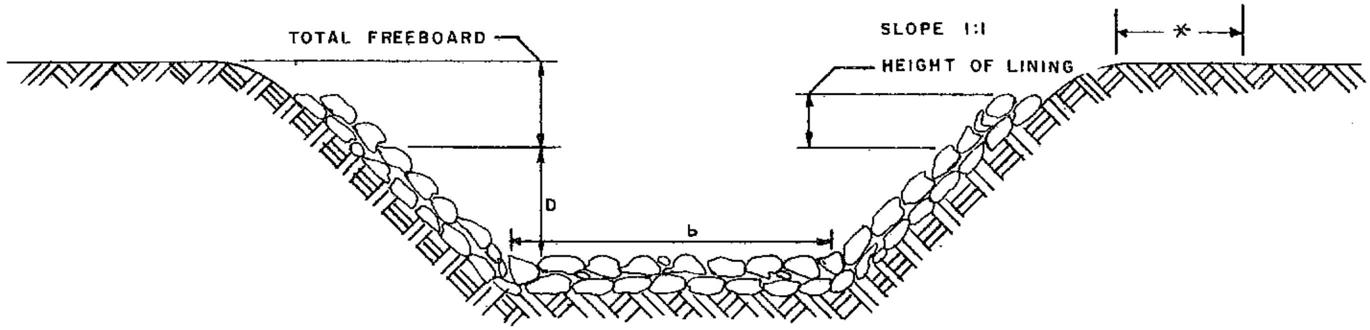
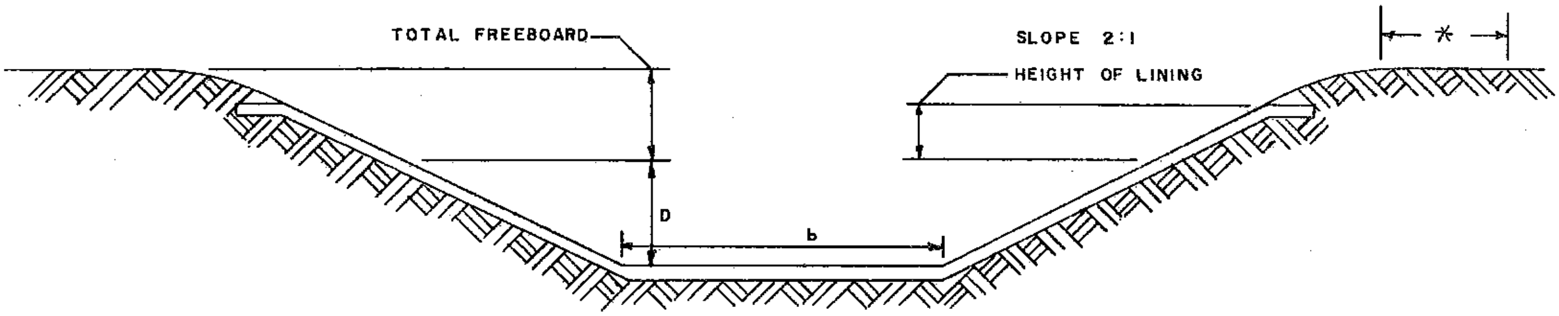


FIGURE 2 UNIT HYDROGRAPH WIDTHS AT 50% AND 75% OF PEAK FLOW

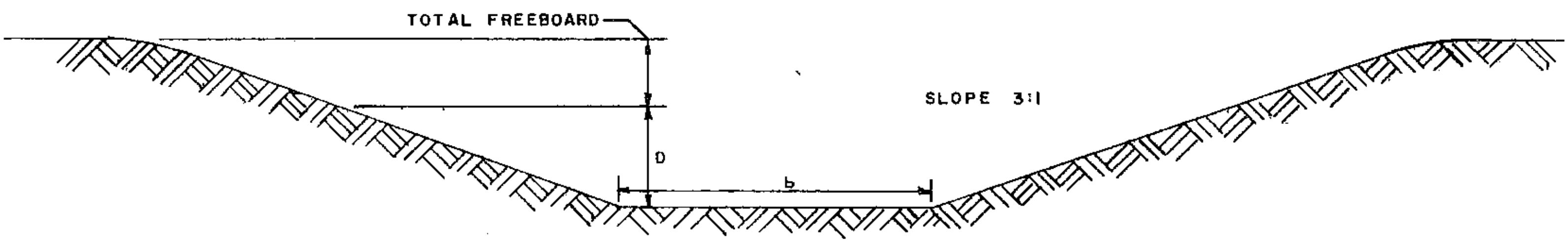
TYPICAL TRAPEZOIDAL CHANNELS



GABION LINED
TYPE I



CONCRETE LINED
TYPE II

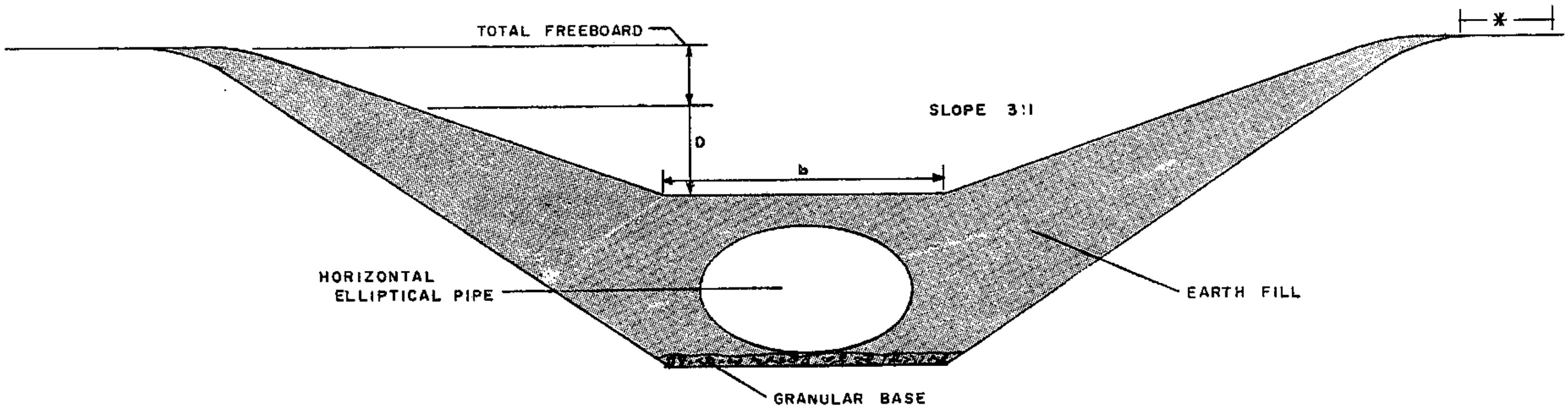


GRASS LINED
TYPE III

FIGURE 3

(* 16' ROADWAY FOR MAINTENANCE)

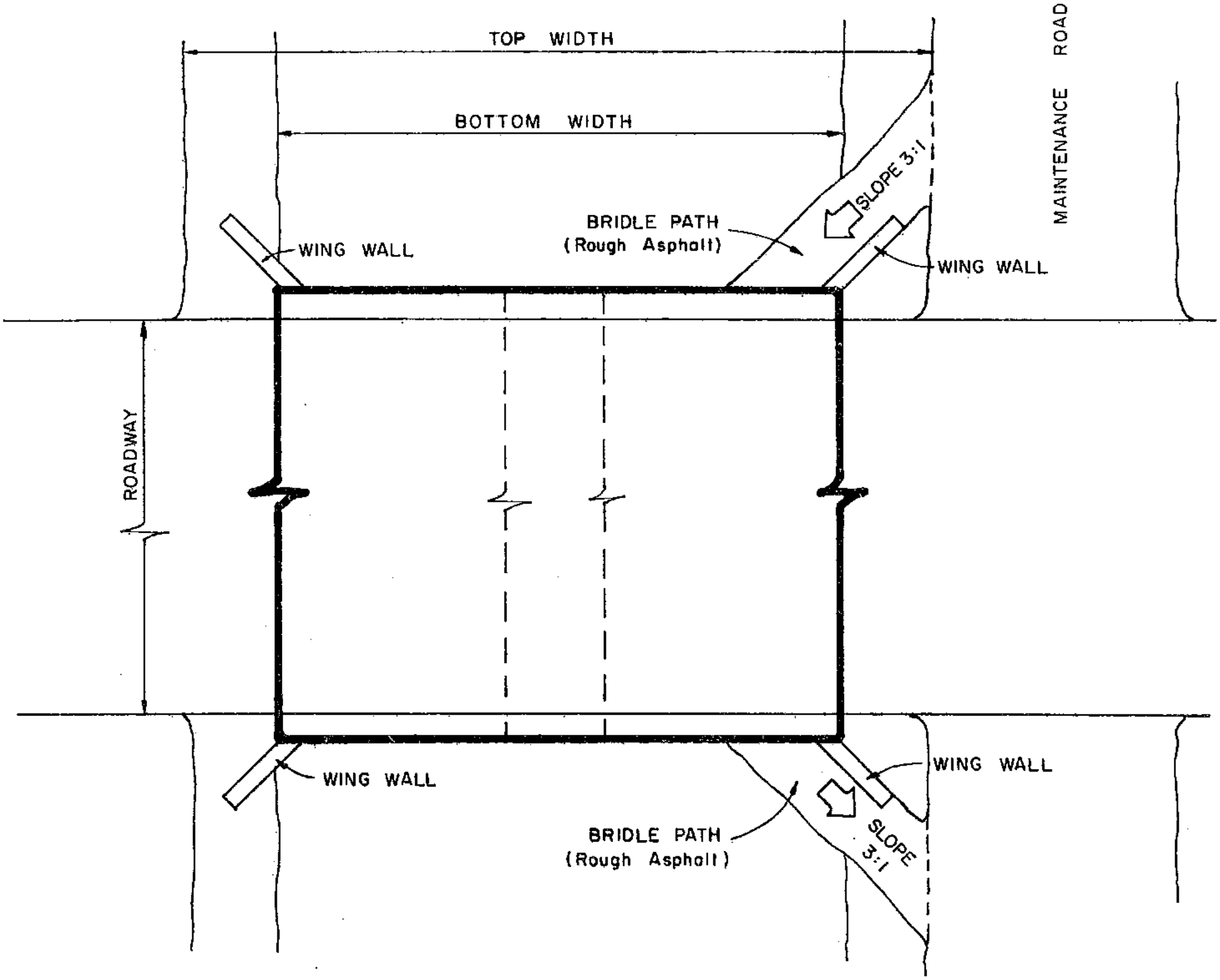
LOW FLOW PIPE
&
FLOOD CONTROL CHANNEL



(* 16' ROAD FOR MAINTENANCE)

FIGURE 4

TYPICAL OPEN SPACE LINK



TYPICAL ROADWAY ARCH

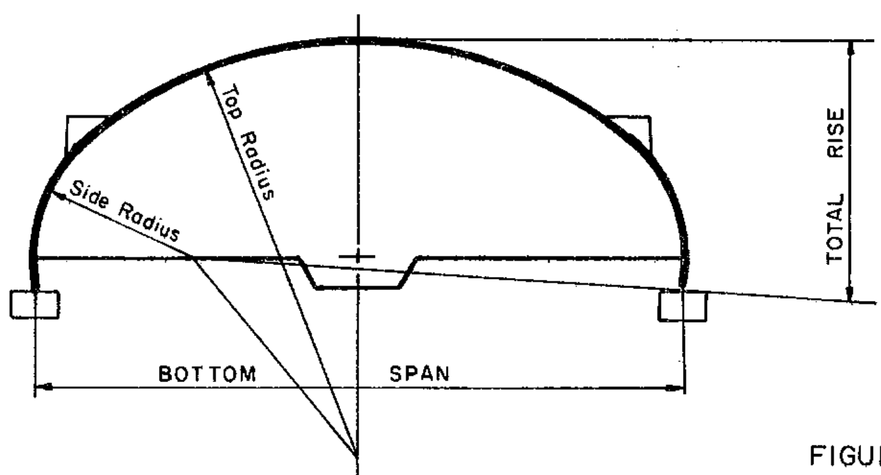
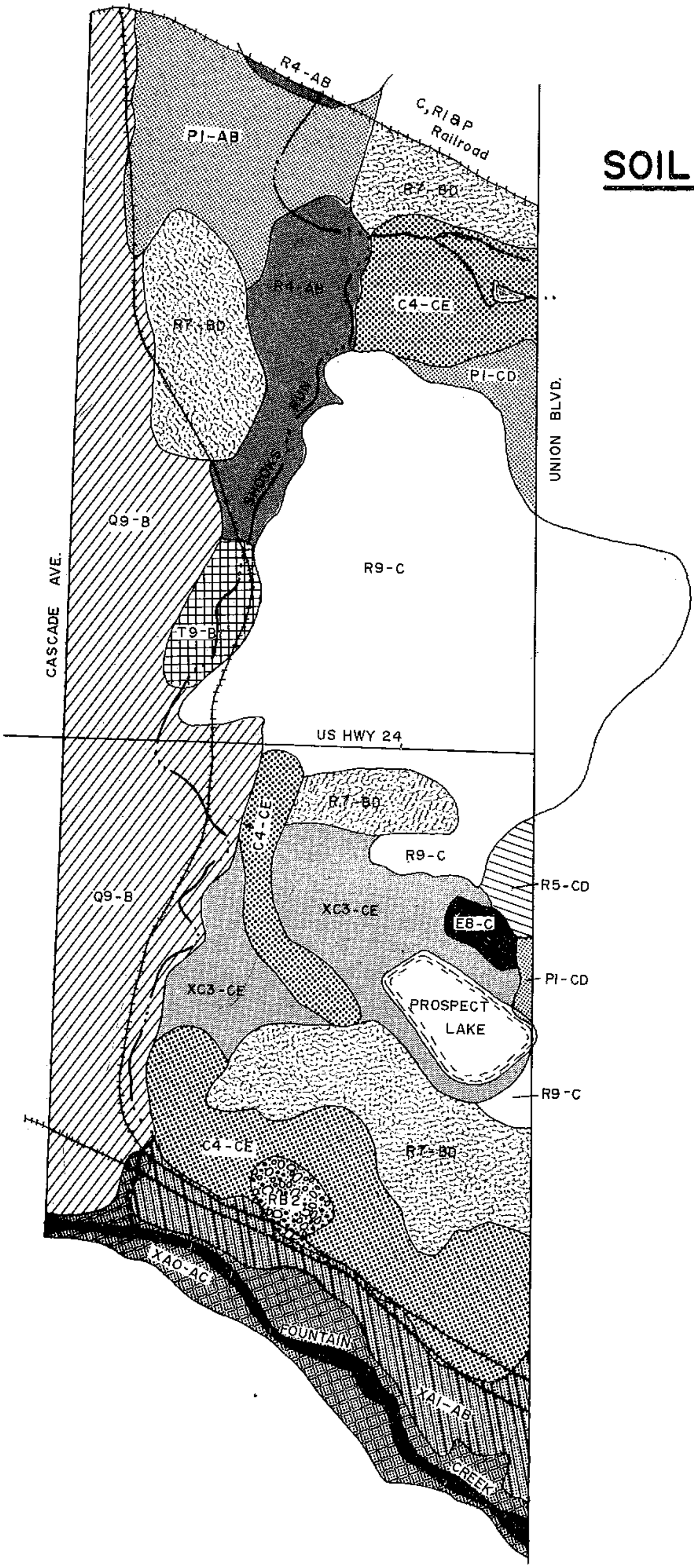


FIGURE 5

SOIL SURVEY MAP



LEGEND:

RB-2
SOIL SERIES DESIGNATION

FIGURE 6

SOIL SURVEY TABLE

Series	Hydrologic Soil Group	Texture	Unified	Permeability (in/hr)	Available water capacity (in/hr)	Shrink-swell potential	Degree of Use Limitation: streets	excavations	recreation	Erodibility	Description
P1 Ascalon	B	SL	SC	2.0-6.0	.11-.13	Low	Slight	Slight	Moderate	Moderate (slope limitations)	Deep, dark, Medium textured soils
R7 Blakeland	B	LS	SP	6.0-20.0	.06-.08	Low	Slight	Severe	Severe on Steep slopes	High	Deep, dark, coarse textured soils hazard of ground water pollution
R9 Bresser	B	SL	SM	.6-6.0	.11-.13	Low	Slight	Slight	Moderate on steeper slopes	Moderate	Deep, dark, moderately coarse textured soils
Q9 Chaseveille	B	qls	SP-SM	6.0-20.0	.04-.09	Low	Slight	Severe	Slight	High	Sandy alluvial materials hazard of ground water pollution
R4 Eastonville	B	SL	SM	2.0-6.0	.11-.13	Low	Slight	Slight	Moderate	Moderate	Deep, dark colored, coarse textured soils usually on stream terraces
E8 Kutch	C	CL	CL	.2-.6	.19-.21	Moderate	Severe	Severe	Severe	High	Fine textured, dark colored soils, over shale
A1 Loamy Alluvial	A	SL	SM	.6-6.0	.11-.21	Low	Severe	Severe	Severe	Moderate	Loamy alluvium on raised flood plains
C4 Nelson	B	FSL	SM	2.0-6.0	.13-.15	Low	Severe	Severe	Severe on steep slopes	High	Light colored, calcareous soils
C4 Tassel	B	FSL	SM	6.0-20.0	.13-.15	Low	Severe	Severe	Moderate	High	Shallow, light colored calcareous soils
T9 Nunn	C	CL	CL	.2-.6	.19-.21	Moderate	Severe	Moderate	Moderate	Moderate	Deep, dark, clayey soils on alluvial terraces or fans
C3 Razor	C	C	CH	.06-.2	.14-.16	High	Severe	Severe	Severe	Hight	Well drained, light colored, clayey soils
C1 Samsil	C	C	CH	.06-.6	.14-.16	High	Severe	Severe	Severe	High	Very shallow, clayey soils of the upland slopes & breaks
XA0 Sandy Alluvial	A	gSL	SP	.6-20.0	.05-.12	Low	Severe	Severe	Severe	High	Coarse textured, stratified soil on slightly raised flood plains
stony, steep land							Severe	Severe	Variable		Steep, rough areas
R5 Truckton	A	SL	SM	2.0-6.0	.11-.13	Low	Slight	Slight	Slight	Moderate	Deep, dark soils-sandy loam in texture

Manning's n Values

Concrete lined channel	=	.016
Gabion lined channel	=	.027
Concrete pipe or culvert	=	.014
CMP or culvert	=	.024-.033
Grass Lined Channel	=	.035
Natural Channel	=	.045 (Flood Stage)

Table 2

TABLE 3

Street Improvements

Street	Pavement S.Y.	Curb & Gutter L. F.
Corona	500	300
Las Animos	5389	1900
Royer	5389	1900
Fort Worth	3601	1800
Vermijo	5559	1960
Rio Grande	1000	900

SUMMARY OF SANITARY SEWER RELOCATIONS AND CROSSINGS

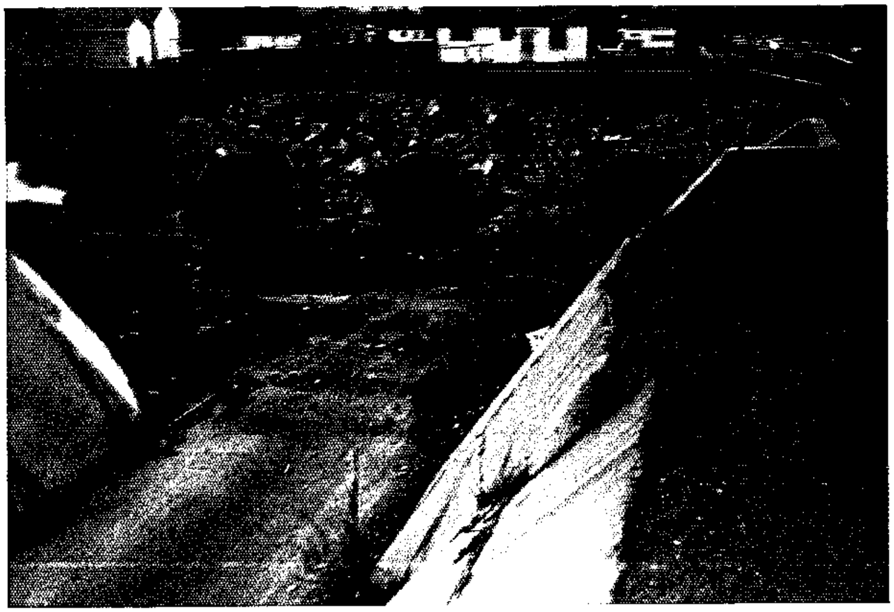
Included in this summary is the proposed sewer main running south on the east side of Shook's Run and all crossings of the existing storm sewer that interfere with construction of the proposed improved channel and therefore must be removed. The proposed sewer main relocation is needed not only to facilitate the construction of the lined channel, but also the existing sewer is flowing at full capacity and future loading requirements warrant an increase in sewer capacity in the near future.

Locations where the existing sanitary sewer crosses Shook's Run and interferes with future construction are:

1. Las Vegas Street
2. Corona Street
3. Costilla Street
4. Vermijo Avenue
5. El Paso-(3)
6. Pikes Peak Avenue
7. Kiowa Street
8. Cache La Poudre
9. Uintah Street
10. Channel behind the Taylor School

The proposed sewer main included in the drainage study will be installed on the east side of the proposed improved channel from Vermijo Avenue to Las Vegas Street. This proposed 30" sewer main will tie into the existing 18" main at Vermijo and the sewage load will eventually be collected by the existing 48" main that runs underneath Las Vegas to the sewage disposal plant.

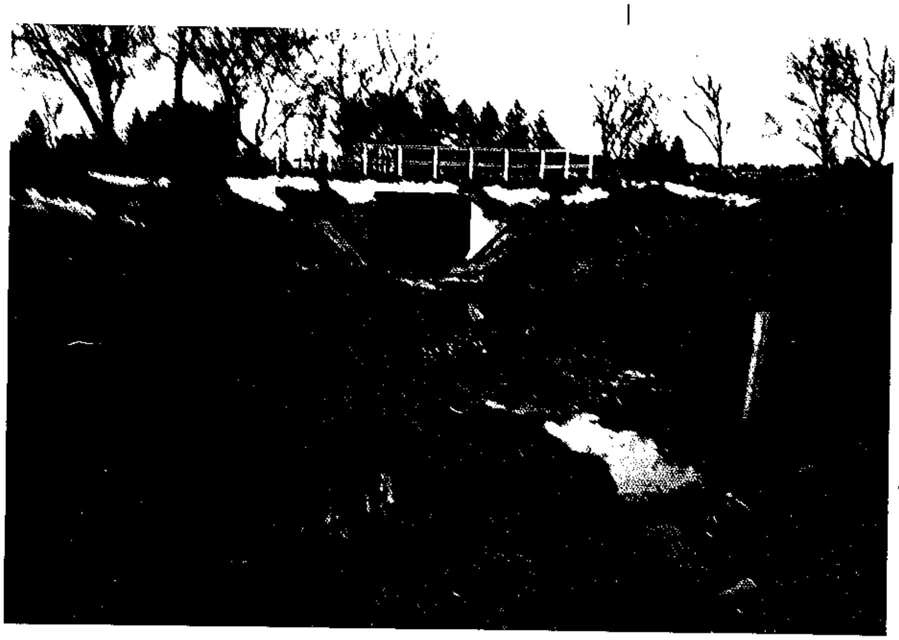
All sewer relocation costs above Vermijo Avenue have been included in the roadway arch construction costs and in the construction contingencies.



No. 1 This photo, looking south at the Chicago, Rock Island, and Pacific Railroad, shows that virtually all water up to this point is diverted down the Van Buren Floodway and does not enter Shook's Run.

No. 2 Shown here are newly installed elliptical pipes just west of Union Boulevard. These pipes are designed to carry a peak design flow of 1646.0 CFS.

No. 3 This small detention reservoir in Patty Jewett Golf Course and a larger one just above it, are too small to have much effect on the flood peak caused by severe storms.



No. 4 The proposed improved channel starts inside the golf course at this point – just south of the main road leading to the club house: Note water pipe which will have to be relocated to prevent possible blockage during peak flows.

No. 5 This photo shows a typical portion of the upper Shook's Run Channel looking north at San Miguel Street.

No. 6 This picture, taken just north of Bijou Street, shows typical problem conditions that are encountered throughout the entire Shook's Run Channel by encroachment of ramshackle or slum housing, debris and sewer and water pipes.

No. 7 This shows a typical standard arch (20'x11') in Shook's Run: Note house located above the arch.

No. 8 Many slipshod attempts to prevent erosion by bank protection structures have resulted in eyesores like this channel reach north of Kiowa Street.

No. 9 The pipe arch on the right was just recently installed to drain water and alleviate flood problems in the Little Shook's Run Basin. The standard arch on the left (at Kiowa Street) is undersized and will have to be replaced.

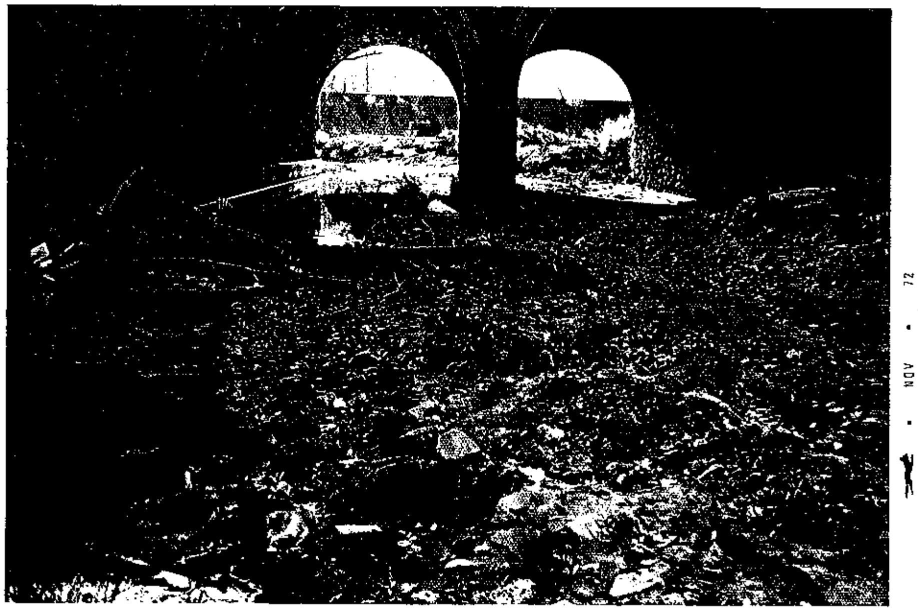
No. 10 This photo shows the railroad tunnel just north of Pikes Peak Avenue: Note the sewer main going through the arch.

No. 11 Although it is huge, this 14' vertical, elliptical pipe at Pikes Peak Avenue is not large enough to handle peak flows: Note the debris that has collected above the pipe from past flood flows.

No. 12 This photo is looking north at the concrete arch going under Pikes Peak Avenue: Note the attempt at bank stabilization and cluttered condition of the channel.

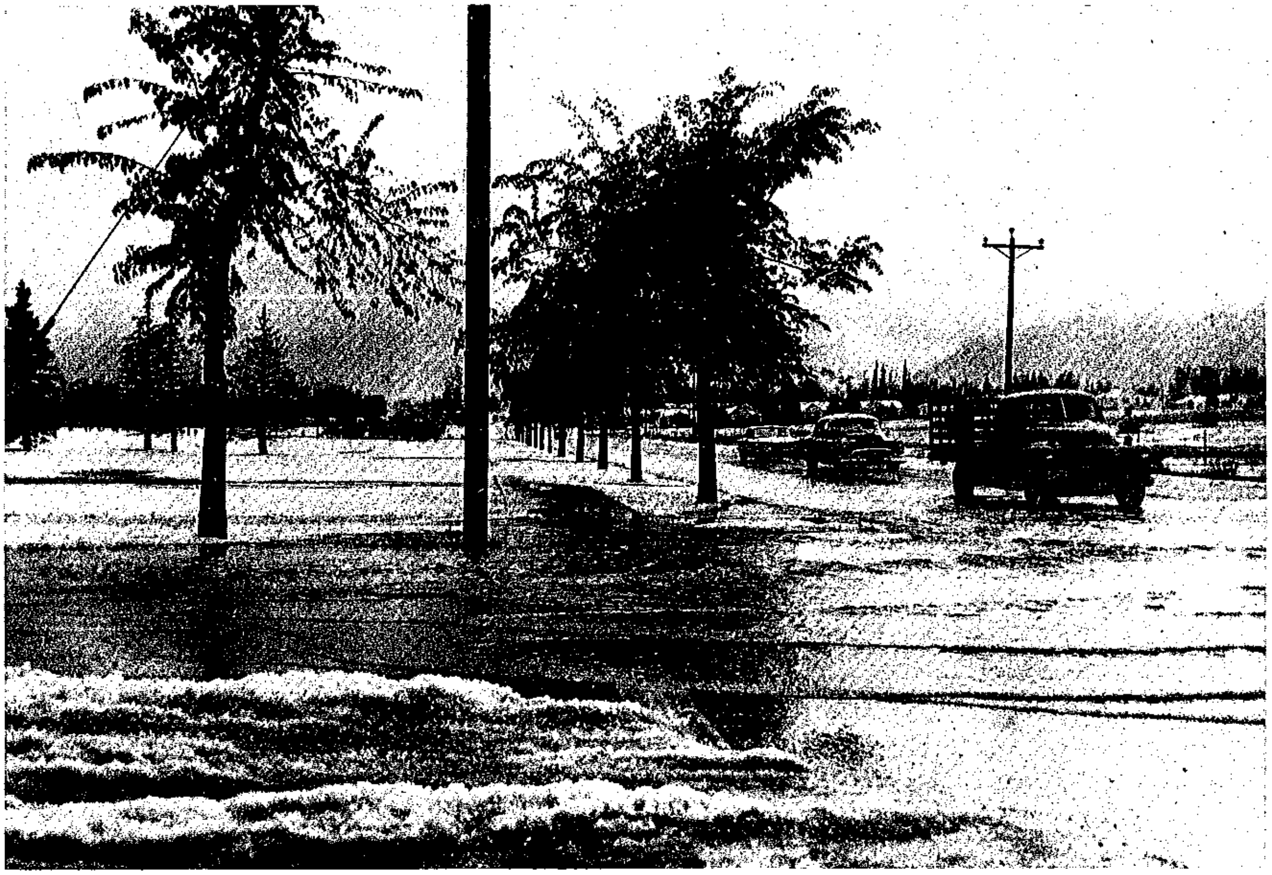
No. 13 This encased sewer main at Vermijo will have to be relocated when the channel is lined to prevent blockage of flood waters when debris piles upstream from it.

No. 14 This photo was taken inside the arch under Costilla Street: Note that the top and sides are deteriorating, allowing groundwater to seep into the cracks that have formed.



No. 15 Shown here are the large railroad arches downstream from Fountain Boulevard: Note debris and trash that collects in the channel after storm flows have subsided.

No. 16 This photo shows the lower portion of Shook's Run at its confluence with Fountain Creek: Note debris caught by trees growing along the banks.



Too small or not enough drop inlets can severely restrict the effectiveness of the storm sewer system. This picture is looking south at the intersection of Pikes Peak and Hancock. (1961)

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