Lincoln DeVore
1000 West Fillmore St.
Colorado Springs, Colorado 80907
(303) 632-3593
Home Office

August 7, 1979

Director of Public Works and
Drainage Board of the City of Colorado Springs
101 West Costilla Street
Colorado Springs, Colorado

Re: ENGINEERING STUDY
of
COTTONWOOD CREEK DRAINAGE BASIN
COLORADO SPRINGS, COLORADO

Gentlemen:

Enclosed herewith is the report concerning the engineering study of the Cottonwood Creek Drainage Basin, authorized by the City Council of the City of Colorado Springs, the Colorado Springs Drainage Board, and the Public Works Department of the City of Colorado Springs.

This study includes an overview of basin geology, rainfall/runoff characteristics, hydrologic history and of the channel improvements existing in the basin. Additions to existing drainage improvements are recommended in this study, together with rating and some upgrading of the existing structures.

The study may be used as a master guide for drainage improvements within the basin. The included recommendations should be used as a guide, not as an inflexible design.

Respectfully submitted,
LINCOLN-DeVORE TESTING LAB., INC.

By: George D. Morris, P. E.

GDM/heh/jah

602 East 8th Street
Pueblo, Colo 81001
(303) 546-1150

P.O. Box 1427
Glenwood Springs, Colo 81601
(303) 945-6020

109 Rosemont Plaza
Montrose, Colo 81401
(303) 249-7838

P.O. Box 1882
Grand Junction, Colo 81501
(303) 242-8968

P.O. Box 1643
Rock Springs, Wyo 82901
(307) 382-2649

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Scope and Requirements of the Study

The total Cottonwood Creek Drainage Basin has been studied at two previous times, although for different purposes. The first basin study was prepared for the City of Colorado Springs in 1969, for use as a drainage planning guide. The U. S. Corps of Engineers, Albuquerque office, studied the basin in 1976 to define the then existing probable flood plain. This study was completed for the Pikes Peak Council of Governments, for use in determining areas available for Federal Flood Insurance.

The 1969 City of Colorado Springs study was completed prior to any large scale urban development in the basin, and under the City of Colorado Springs rainfall criteria of that time. It is desirable to update Basin Studies to correct for differences in actual development from those planned at one time, and to implement newly developed criteria. The flood plain study is precisely that; a defined area which would be flooded if certain conditions prevail and no changes in drainage are considered. Studies of this type also require periodic review to take into consideration changes made in the topography by development and in site drainage structures.

The total basin has, until recently, developed in a random manner. The upper basin has developed slowly south of the Black Forest line, with most existing development being of the 1 to 5 acre site type. An area of approximately 2 square miles within the Black Forest was developed nearly 15 years ago, but has grown slowly. The middle basin contains some development of the 1/2 to 2-1/2-acre, semi-urban type. This area has also developed slowly, with most being found along the line of Templeton Gap Road (Black Forest Road) and Vollmer Road.

The western half of the basin was first developed in the mid-1960's as 1/2 acre to 2-1/2 acre residential tracts a short distance north of Cottonwood Creek. The development was influenced by construction of the Air Force Academy with the size of the tracts set by County Health rules for use of on-site disposal of sewage. True urban type development tentatively entered the basin in 1972 and, after a two-year delay, this development has been quite rapid.

The urban development in the western half of the basin has nearly filled the area south of Cottonwood Creek from Monument Creek to a point about a mile east of Union Boulevard. Due to the presence of the 1/2 acre to 2-1/2 acre tract development, development has leapfrogged this area and is now commencing in the northern part of this portion of the basin. This urban area development, under the control of the City of Colorado Springs, has been developed with storm drainage facilities. With a few exceptions, pre-urban developments have no coherent drainage system. The drainage in these areas consists primarily of roadside ditches and culvert crossings.

The first purpose of this study was to determine the probable runoff flow throughout the basin as determined by existing City rainfall/runoff criteria. The second purpose of this study was to survey the existing drainage structures in the basin and to recommend changes or the placing of new structures if this should be required. The study was to be conducted in two separate portions. The upper and middle basin was to be studied only to the extent of determining the major stream flow and constrictions on the flow, if any. The western portion of the basin was to be studied in detail. This western portion was defined as the extension of the north-south section line between Sections 2 and 3, Township 13 south, Range 67 west of the 6th Principal Meridian. In fact, it was found that detailed study was required for a distance of approximately 1-1/2 miles east of this line.

To accomplish this study, the total area was divided into three portions, labeled Basin A, Basin B and Basin A, Sub-basin 23. Basin A is the primary basin of Cottonwood Creek, extending from Burgess Road at the northeast, to Monument Creek at the western outfall. Sub-basin 23 was considered by the Corps of Engineers as "Cottonwood Creek South". Basically, it is indeed a direct tributary of Cottonwood Creek, and is so considered in this study. Historically, however, this Sub-basin 23 has been considered by the City as a portion of the Pulpit Rock Drainage Basin, for reasons which are obscure. Basin B is an area in the northwest portion of the total which is separate from, but closely related to, the overall Cottonwood Creek drainage system.

Due to the stage of development, areas within the basin were treated in different ways. The major drainageways have been defined by previous development. This development has also fixed the most probable location of other drainage facilities. In these developed areas, no new streets were assumed, although it was assumed that each development was fully built. In open areas, some street and ditch locations were assumed. The probable location of cross streets was also assumed so that drainage lines and major culverts could be estimated. For the purposes of this study, these areas were assumed to be fully developed.

The intent of this study is to determine the adequacy of the existing drainage structures and drainageways and to recommend general improvements and changes required for reasonably safe disposal of runoff. The concept of paving all ditches, used by the City of Colorado Springs for a number of years, increases the required structures by moving water more rapidly, causing higher peak flows. The presence of some unusual problems in the earlier developments has led to recommendation of retention structures by this study.

The intent of this study is not to establish precise locations, sizes or design for storm sewers, ditches or other appurtenances, except where main drainageways or streams already exist. It is intended to establish the general location and size of required systems. The structure and channel sizes shown in this study have been calculated from flows resulting from the City of Colorado Springs rainfall/runoff criteria. In open areas, a reasonable street system was assumed, to fit the topography.

The northeastern and middle portion of the basin were assumed to be as fully developed as possible, primarily with residential tracts ranging from 1/2 to 5 acres. One of the attached maps indicates the assumed population density. This is believed to be a reasonable projection, considering topography and available water.

Basin Description

The Cottonwood Creek Drainage Basin as herein defined, consists of three sub-basins. Two of these are collected directly into the stream known as Cottonwood Creek while the third collects at a separate channel to Monument Creek. The boundary between these basins is not clearly defined at all points and the boundary is crossed by culverts at a number of points.

The upper and middle basin is entirely in El Paso County. The western, closely studied portion of the basin lies partly in the City of Colorado Springs and partly in the County. The total area of the Cottonwood Creek basin as defined herein, is approximately 24-1/4 square miles.

The southern basin boundary is defined by the ridges separating it from the North Shook's Run and Pulpit Rock basins. This ridge line is relatively steep, formed by portions of the Cragmor Bluff and by the erosion ridge caused by basin piracy. The easterly basin boundary is defined by the relatively low, rolling ridge separating it from the Sand Creek Basin. The northerly basin boundary is generally defined by the low, rolling ridge separating it from the Pine Creek Basin. In the Black Forest area, the ridges become rougher and the basin boundaries less well defined. The western boundary is, of course, Monument Creek, which serves as the outfall.

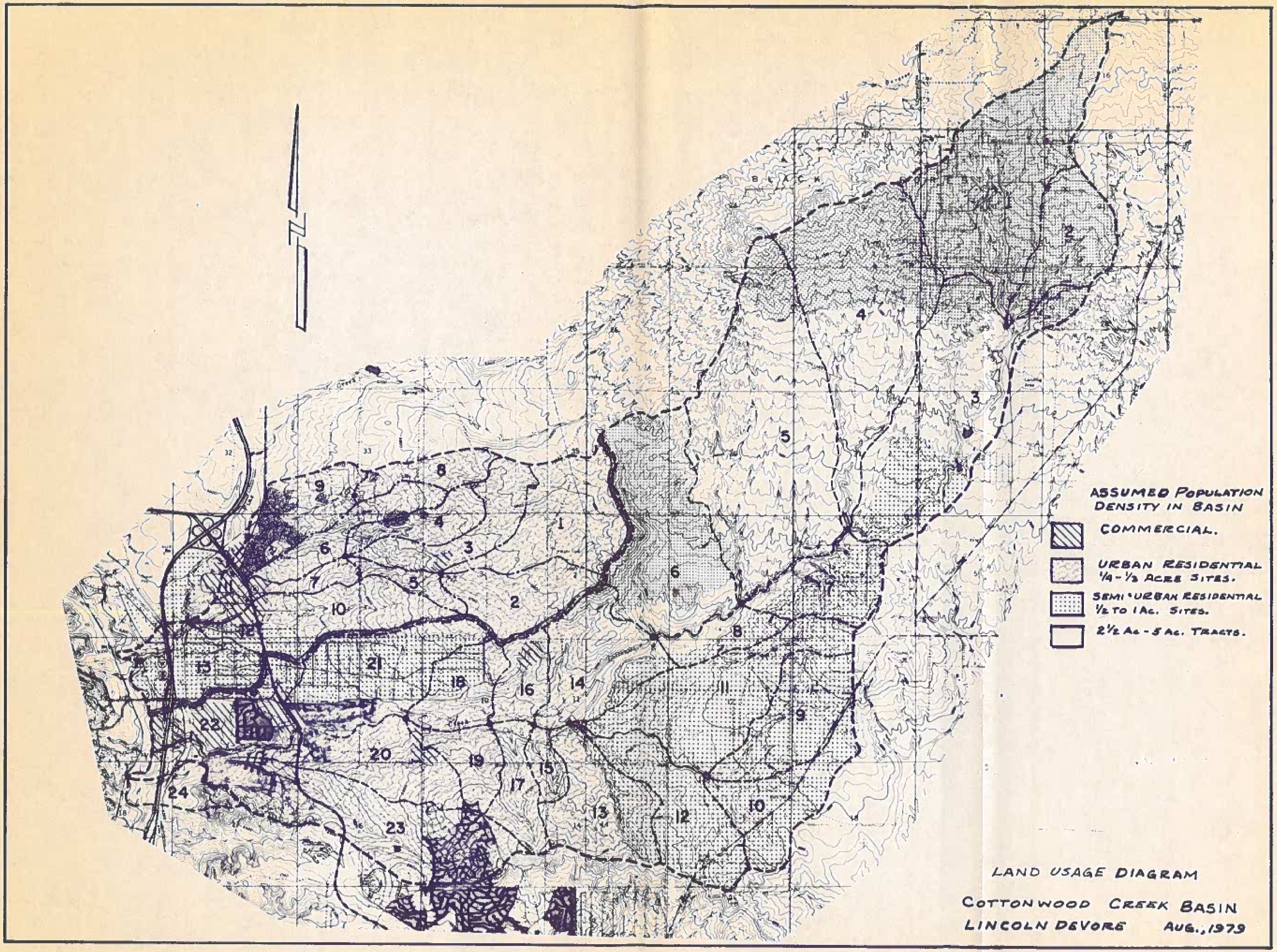
Although quite hilly, the basin is not a "foothills" type basin as normally defined. Its upper reaches lie on a portion of the high ground immediately east of the City of Colorado Springs. Its location and topography prevent it from being classified as a plains type basin. In this intermediate position, rainfall and runoff patterns fit the Type II A storm well. In addition, the upper half of the basin lies under the historic "storm line" east of the mountains. Heavy rainfall in this area is common.

The soils within the basin are primarily sandy, allowing relatively high infiltration rates. Areas of clays and sandstones with low infiltration rates exist, but are more prominent in the southern portion of the basin. Bed and bank storage is relatively high due to the type of soil and the grades typical along the major streams.

The topography of the basin is steep and rough in the upper portions and more rolling in the west. The upper basin is relatively narrow, with relatively steep side drainage to the creek. The lower (western) portion of the basin is also relatively narrow but the side drainage is less steep. The western, more closely studied area can only be described as a series of low, rolling hills with relatively narrow valleys between. These valleys are commonly quite swampy as a result of the confined drainage system and of the soil strata.

Development in the studied portion of the basin has not changed the overall direction of drainage flow in any significant way. Some culverts have acted to change the direction of street flows at specific points, but this is relatively minor. The hills around the major streams are sufficiently steep that flow direction can be altered only with the greatest difficulty. The only major directional change of flow was found in Sub-basin 23 on Dublin Drive. At this point, the primary channel has been partially blocked and the flow follows an ancient bed of Cottonwood Creek to the southwest.

Drainage throughout the basin is basically dendritic and uncomplicated, except in the older developments around Academy Boulevard. The flow is generally collected in the main stream via a number of small tributaries and flows almost directly to Monument Creek. Nearly all of the tributaries are normally "intermittant" streams and do not carry water except after storms or during the snowmelt period. Erosion has cut much of the Cottonwood Creek deeply, but has deposited considerable amounts of bed sand at points of low grade. Deep erosion of this type is normal to the Dawson Formation, and is not necessarily a result of large amounts of water.



LAND USAGE DIAGRAM

COTTONWOOD CREEK BASIN

LINCOLN DEVORE AUG., 1979

Basin Geology, Soils, and Water Table

Basin Geology of the Cottonwood Creek basin is not complicated. Except for a few areas in the incised Monument Creek, the entire basin is underlain by members of the Tertiary Dawson Formation. A small exposure of the Laramie Formation was noted in the southwest corner of the basin, low in Monument Creek. This is so small as to be unimportant from the hydrologic point of view. The Front Range Fault is located west of the site and far enough away that it has no structural control over the basin.

The Dawson group is a rather erratic formation from the standpoint of soils produced. In general, it is a series of weakly cemented sandstones, most of which are Arkosic. Some units of sandstones are relatively competent, do not erode easily and tend to form cliffs. This can be seen at a number of creek incisions and in the erosion pattern along the south basin line. Most units of the sandstone are easily eroded and broken down into their component soil types. Erosion in some of the formation can take place very rapidly. Several wagon roads in the area which existed prior to 1940 as roads, are now fairly deep gullies.

The basic sandstones of the formation are composed of varying percentages of sands, gravels, silts and clay. The rate of erosion is generally controlled by the relative percentage of these constituents at any given point. The formation is also noted for containing large lenses of claystones. These lenses are usually hard and in some cases, are quite sensitive to water entry and are expansive. The majority of clay and clayey soils appear to be found in the south and west portions of the basin. The area between Union Blvd. and Interstate 25 contains numerous large clay and clayey lenses and can be considered quite erratic as to soil type.

The western portion of the basin contains large areas of alluvium deposited along the major stream beds. In the streams which carry water most of the year, this alluvium consists primarily of sands, some gravel, and silts. Smaller intermiltant stream beds contain relatively large amounts of clay. The soils in the area are, of course, mostly mixtures of these various soil types. Most of this alluvium is dated as the Pinery Creek Alluvium. For the most part, the sandy alluvium and some of the silts have the hydrologic 'A' classification. Siltier and clayey alluvium and the weathered clayey sands have a hydrologic 'B' classification. The deposits of clays, sandy clays and hard sandstones have a hydrologic 'C' or 'D' classification depending on precise constituents and hardness. Some wind blown (aeolian) sands have been found on the slope south of Cottonwood Creek and in Basin B and the mid portion of Basin A. The hydrologic classification of this soil depends primarily on the depth of deposit.

The depth of weathered soil and alluvium are quite variable. This has a considerable effect on basin flow. Deeper weathered sands and sandy alluvium in the upper basin have a tendency to store water deeply by infiltration during rainfall periods.

Much of the upper basin thus tends to reduce flow in the main streams. Conversely, the basin contains a number of swampy areas. This is particularly true of the western portion of the basin. In these areas, the sands and silts are closely underlain by less pervious soils - clays, dense silts or sandstone. The topography of these areas is usually such that water can enter more rapidly than it can leave. The less permeable material lies relatively flat, at the general formation dip, while the upper terrain is eroded at a steeper slope.

The surface soils in the western, closely studied, portion of the basin were mapped by three methods. Records of test borings drilled throughout this part of the basin were studied and plotted. The surface soils were studied in a field reconnaissance, and study of air photographs flown in 1942 and in 1978. The results were plotted over the entire basin since soil type and condition have considerable effect on the final runoff. This plot was compared with soil types mapped by the SCS in its survey of El Paso County surface soils. The correlation was fair. The SCS survey is rather generalized and with far too much dependence on air photo interpretation for good, spot correlation. In this basin, the correlation was found to be better than usual.

The overall geology of the basin and the soil types noted near the surface in the area will produce runoff which is relatively low for the basin area. Infiltration is relatively high throughout the basin, but particularly in the north and east. The western portion of the basin, being considered more fully developed, will produce higher local runoff.

The true free water table beneath the basin is quite deep, and will have little effect on runoff within the basin. Except in the stream beds, the water table will be found at a depth in excess of 200 feet. A few deep wells have been drilled in the basin, but records of the upper major water table are sparse.

The swampy areas referred to previously, on the other hand, tend to collect water near the surface. These areas would be greatly affected by antecedent storms. If the design storm should take place after a wet period, these areas would act as nearly impermeable areas. Runoff would be quite rapid, if not quite instantaneous. This study has taken this into account by assigning a more rapid runoff rate to these areas. The antecedent moisture in other areas has been taken as normal - or condition II, as defined by the SCS.

Cottonwood Creek has a base flow which varies from zero to about two cfs. This, in itself, is not sufficient to affect the point hydrographs, but it does affect flow by saturating the alluvium along the creek bed. The same saturated sands can be found along the south branch in basin 23.

Rainfall & Runoff Patterns

The NOAA weather station is located at Peterson AFB, approximately 12 miles southeast of the basin, so that no official precipitation records exist for the basin. A number of unofficial reports have been made over the years, however. Precipitation in the lower (western portion) of the basin is approximately the same as the annual average precipitation for Colorado Springs - approximately 15 inches per year (38.1 cm.). Precipitation in the upper basin is a bit higher, averaging approximately 16 inches per year (40.6 cm.). About 40% of the total precipitation is in the form of snowfall, with greater amounts of snow measured in the Black Forest area. It must be emphasized that these figures are based on fragmentary reports and should not be used for precise calculations.

The Black Forest area in the northerly portion of the basin receives more snowfall than average for the general Colorado Springs area. This snow affects the base flow in Cottonwood Creek, but has a relatively minor affect on the maximum, or flood flow. As is the case over most of the metropolitan area, precipitation in the basin is normally the greatest from May through August. Major rainfall seems to come in two forms: 1) The slow, four day 'upslope' storm condition, which can produce high precipitation, but over a longer period of time; and, 2) the intense thunderstorm of high intensity but short duration.

Of these two types of storm normal to the area, the high intensity, short duration thunderstorm produces the greatest runoff flow, if such a storm is assumed to occur over the entire basin. This type of storm is that for which City of Colorado Springs drainage structures have been designed since 1963. The rainfall criterion have been changed in that time, of course, as new data becomes available. The Type IIA storm used as the local criterion for design is a storm of six hour duration, but with an approximate one hour burst during the second hour. It is not greatly different in character from the one hour storm used until 1972.

This basin is relatively large but is not so large that it could not be covered by such a thunderstorm. The computations used in this study are based on such an intense storm, centered at about point four in the basin, and falling at the same rate over the entire basin. This configuration will yield the peak runoff for the design storm. Such storms actually move from west to east, which tends to reduce the flood peak in the developed area. Several storm patterns were investigated in this study to determine the location resulting in the probable high runoff for a Type II-A storm.

One important fact must be considered in assigning a rainfall pattern or intensity to this basin. The upper portion of the basin lies under an area which is described as a major storm axis, generally east of Colorado Springs. The mountains to the west, particularly the Pikes Peak massive, tend to produce a storm shadow along the valley of Monument Creek. With some notable (and recent) exceptions, the centers of major storms tend to be located along this axis. This axis is not a line, incidently, but rather a strip about six miles in width centered on Black Forest and Peterson Field.

Some heavy, but smaller storms have centered on a line two to three miles east of the mountain range. The most notable recent storms include the 1965 Monument - Palmer Lake storm, the 1967 Ivywild - Broadmoor area storm, the 1967 Mesa area storm, the 1978 north Colorado Springs storm and the 1979 Manitou storm. Most of these caused considerable damage of one sort or another, but not major flooding. The exception to this was the major flood caused by the 1965 Monument - Palmer Lake storm in Douglas County. This however was part of an overall major storm which had another center along the storm axis in the Peterson Field area.

It must also be noted that the heaviest 24 hour rainfall reported along this storm axis was over the upper portions of the Cottonwood Creek, Pine Creek and Kettle Creek basins. This was the rainfall center of the May 30, 1935 flood on Monument Creek. Kettle Creek was the prime contributor to this flood flow, but flow in other creeks - particularly Cottonwood - was also quite high. No accurate measurement was made of either precipitation or runoff, but precipitation was reported unofficially as 16 inches in 24 hours near Burgess Road. This unofficial report is probably high, but there is no doubt that a considerable amount of rainfall during several intense periods within the general 24 hour storm.

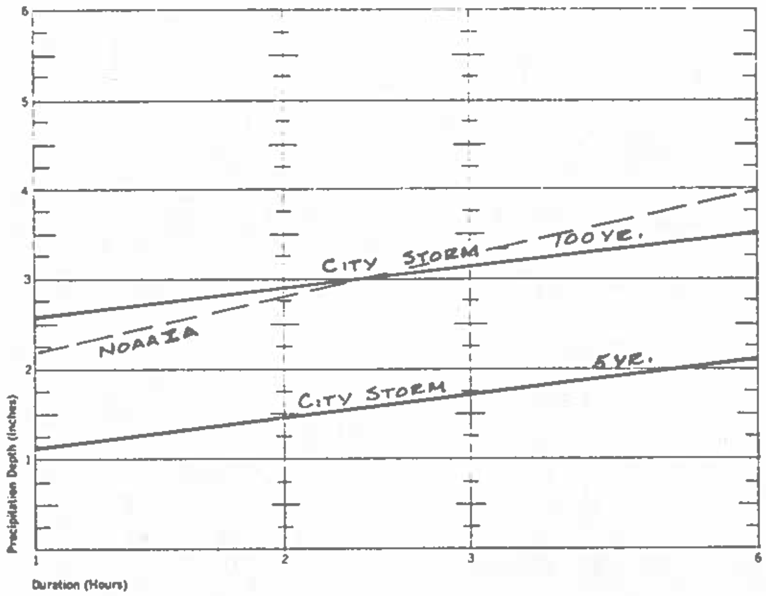
The storm defined as the 100 year frequency (.01 percent chance of occurrance) and known locally as the Type II-A storm, is a six hour duration, low intensity storm with a very high intensity burst at about the 1-1/2 hour point. The 1935 storm appears to have been similar to a series of three or four such storms connected in a single 24 hour period. This type of occurance would provide the high antecedent moisture condition III prior to one of the high intensity periods, and would produce higher main channel flow on the order of 13500 cfs at Academy Blvd. & Cottonwood Creek.

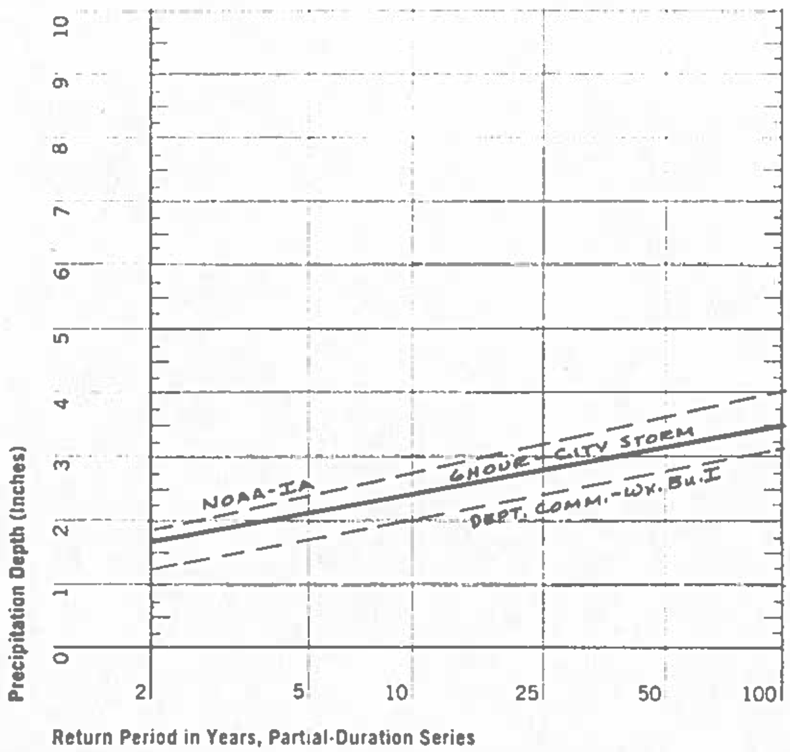
Main Channel Runoff could vary considerably, depending on the type of storm. This condition is considered in the appropriate section of this report. At the present time, this area has been settled only about 120 years and accurate precipitation records kept for less than 70 years. The true 100 year storm for the area cannot be accurately known with such short term records. For purposes of this report, the existing City design 100 year frequency storm (Type II-A) has been used and is recommended.

Typical runoff hydrographs were computed for points 6, 9 & 10 in the basin. These points are along Cottonwood Creek and correspond to the approximate location of Powers (point 6) and the exact locations of Union Blvd. (point 9) and Academy Blvd. (point 10). These hydrographs are based on the Type II-A storm and assume relatively unobstructed flow through the channel. Hydrographs for individual basins were not constructed except at points of recommended retention ponds. These were necessary to determine approximate required height and size of the pond.

The total basin was divided into three major internal basins and the outfall point assigned for each. These major internal basins were, in turn, divided into 40 minor internal basins and an outfall point assigned to each. The peak flows were routed along the three or four major channels by adding individual hydrograph points taking stream flow time into consideration. This method was used to check the results of the City method of computation. A third check was made using the HEC-1 computor program. Some data was varied in the computor programs to determine probable differences in flow assuming changes in antecedent moisture.

These computations indicate that while flooding in the developed portion of the basin will be relatively minor, some changes must be made in the drainage systems of the older developed areas to prevent damage.

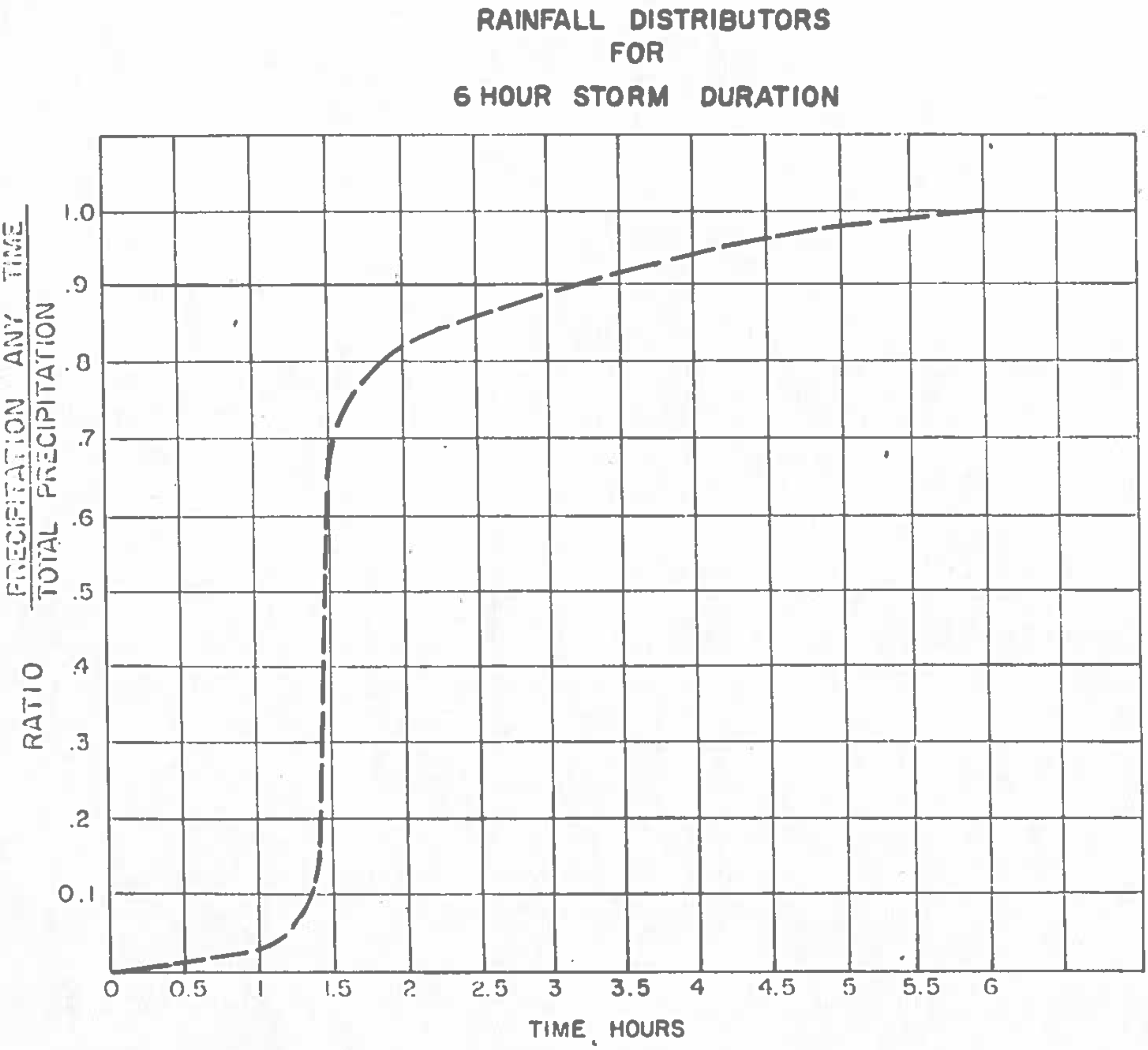




RAINFALL DURATION & FREQUENCY
NORTHEAST COLORADO SPRINGS

LINCOLN DeVORE ENGINEERS-GEOLOGISTS

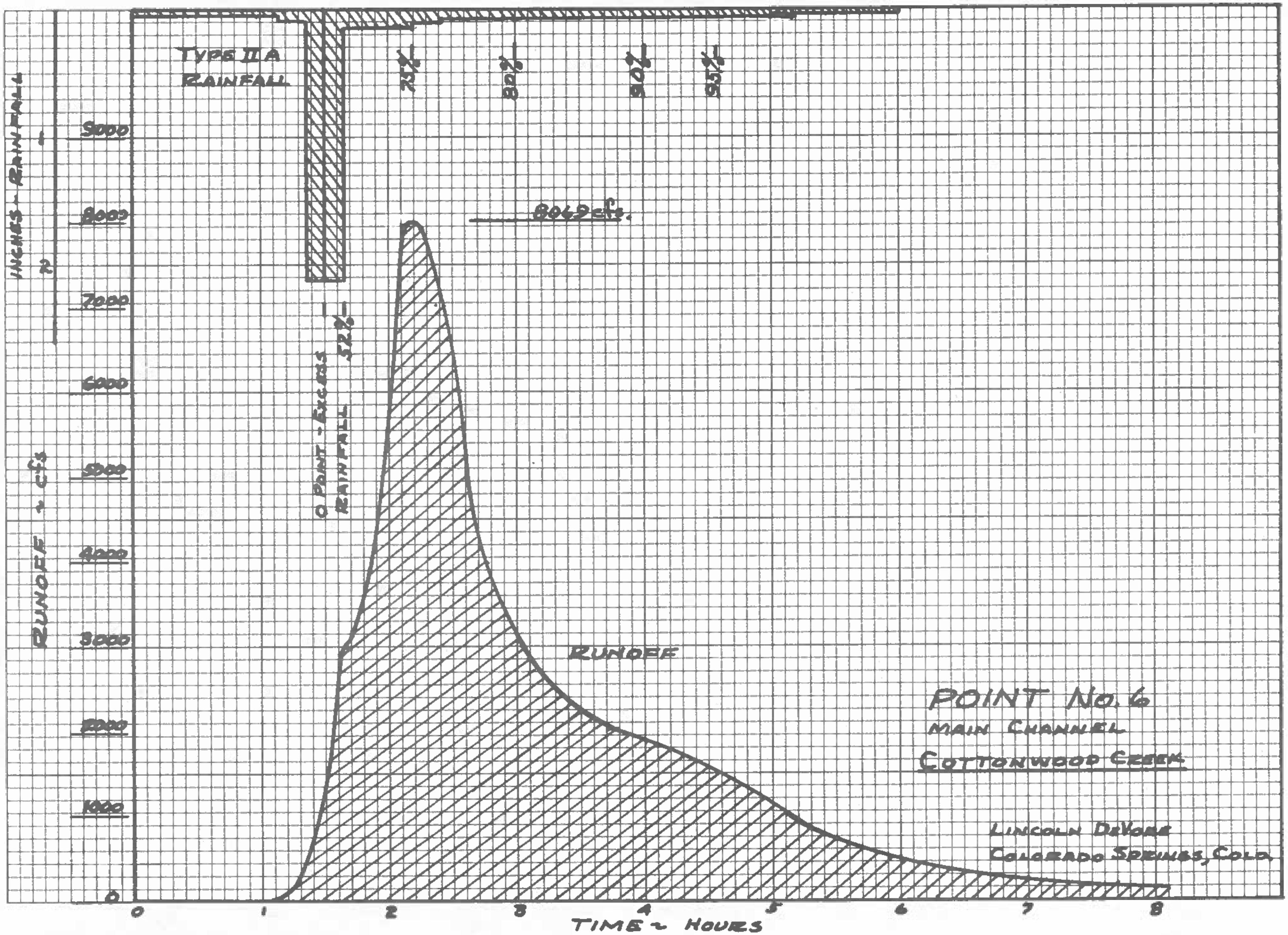
COLORADO: COLORADO SPRINGS, PUEBLO, GLENWOOD SPRINGS, GRAND JUNCTION, MONTROSE, WYOMING: ROCK SPRINGS



TYPE IIA STORM - MASS CURVE
FROM P.P.A.G.G. STORM DRAINAGE MANUAL

LINCOLN DeVORE ENGINEERS. GEOLOGISTS

COLORADO: COLORADO SPRINGS, PUEBLO, GLENWOOD SPRINGS, GRAND JUNCTION, MONTROSE, WYOMING: ROCK SPRINGS



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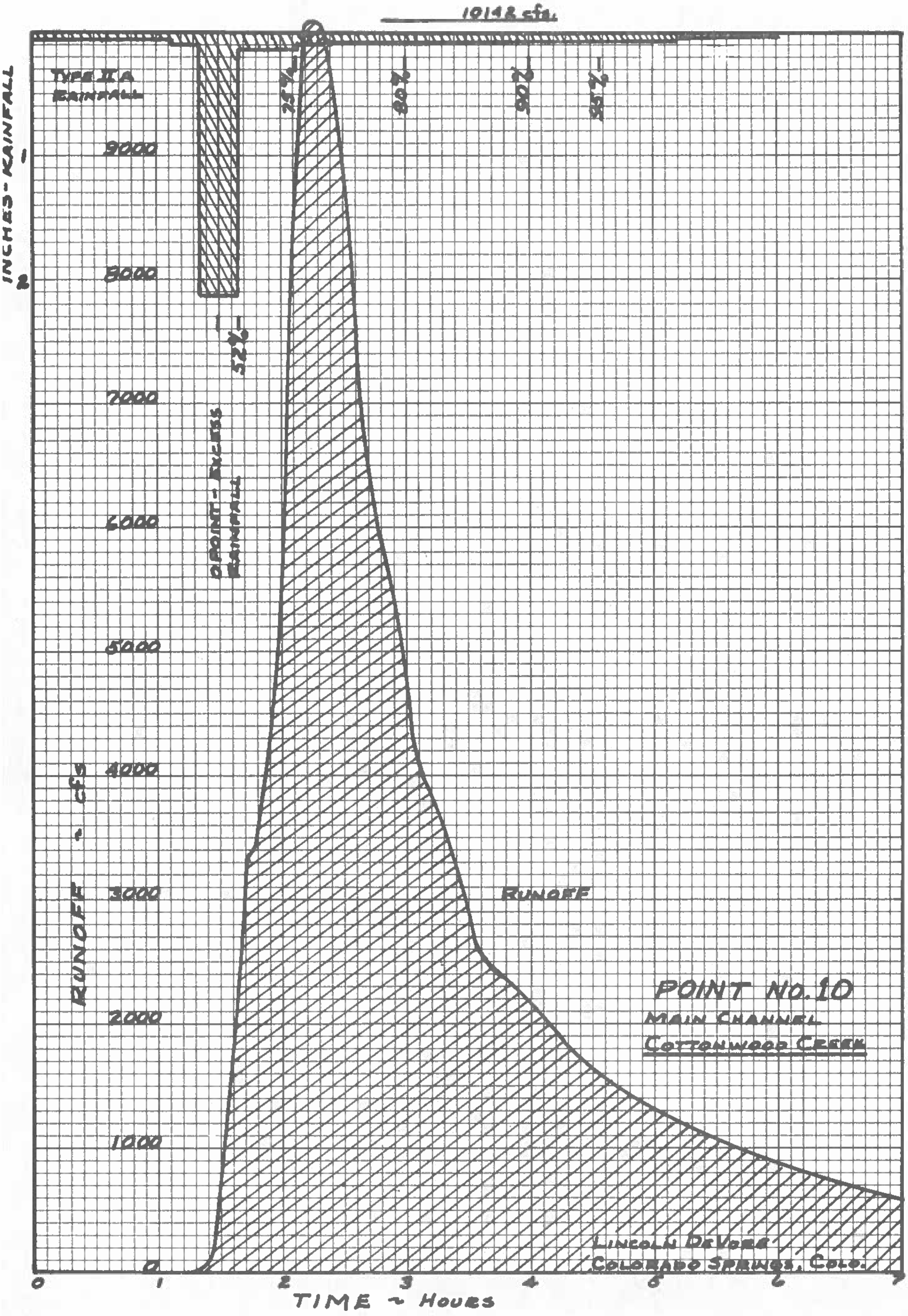
75%
80%
90%
95%
INCHES ~ RAINFALL
1
2
9000
8000
8049 cfs.
7000
6000
5000
4000
3000
2000
1000
0
RUNOFF ~ cfs
0 POINT - EXCESS RAINFALL
52%
RUNOFF
POINT No. 6
MAIN CHANNEL
COTTONWOOD CREEK
LINCOLN DEVORE
COLORADO SPRINGS, COLO.
0
1
2
3
4
5
6
7
8
TIME ~ HOURS



10148 cfs.
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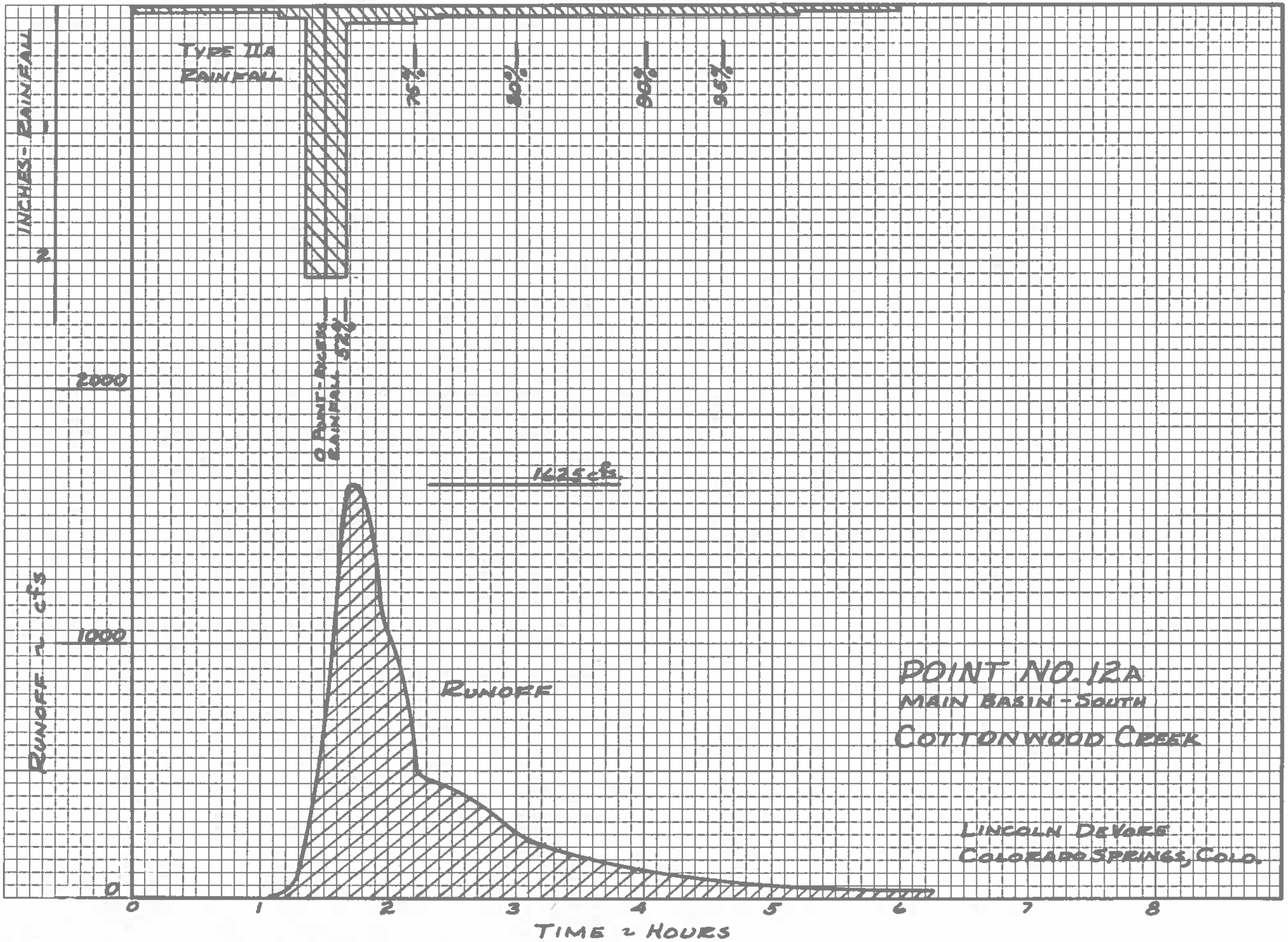
INCHES - RAINFALL
1
2
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
RUNOFF - CFS
75%
80%
90%
95%
52%
0 POINT - EXCESS RAINFALL
RUNOFF
POINT NO. 10
MAIN CHANNEL
COTTONWOOD CREEK
LINCOLN DEVORE
COLORADO SPRINGS, COLO.
0
1
2
3
4
5
6
7
TIME ~ HOURS



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TYPE IIA RAINFALL
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80%
90%
95%
0 POINT RAINFALL 57%
2000
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1000
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RUNOFF ~ cfs
RUNOFF
POINT NO. 12A
MAIN BASIN - SOUTH
COTTONWOOD CREEK
LINCOLN DEVORE
COLORADO SPRINGS, COLO.
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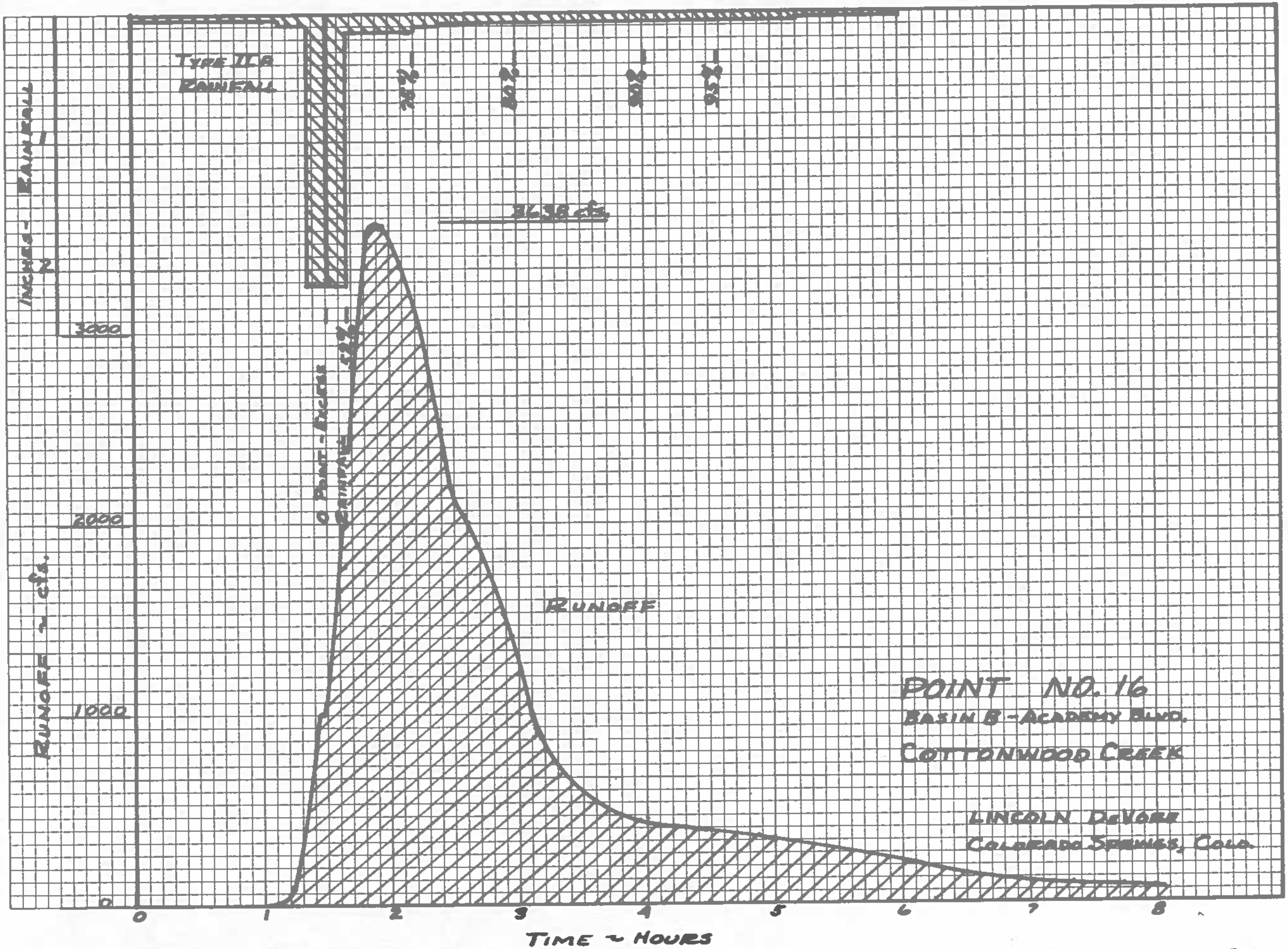
1
2
3
4
5
6
7
8
TIME ~ HOURS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INCHES - RAINFALL
1
2
3000
2000
1000
0
3638 cfs.
0 POINT - EXCESS RAINFALL
RUNOFF
RUNOFF ~ cfs.
0
1
2
3
4
5
6
7
8
TIME ~ HOURS
POINT NO. 16
BASIN B - ACADEMY BLVD.
COTTONWOOD CREEK
LINCOLN DeVORE
COLORADO SPRINGS, COLO.

Existing Drainage Structures

The existing drainage structures in the upper (northeastern) portion of the basin consists almost solely of small to medium sized culverts beneath roads and streets. The major exceptions to this general rule are approximately 16 small "stockpond" type reservoirs and bridges over Cottonwood Creek at Templeton Gap (Black Forest) Road, Cowpoke Road near Point 2, and Woodmen Road near Point 4. In addition, a few defacto reservoirs have been created by construction of high road embankments coupled with inadequately sized culverts.

In this upper basin, water flow is in natural channels throughout. A few minor changes have been made in the natural channels at the sites of bridges and other structures, but these changes are minimal. At the locations of the three major bridges, the main channel of Cottonwood Creek is rather deeply incised. The openings of these three major bridges are all adequate for the flow at those points.

Some consideration should be given to reconstruction of the drainageway below the Templeton Gap Road. Flow at this bridge is not smooth and the south abutment has been undercut by erosion. The condition of the bridge foundation at Woodmen Road is presently excellent, since the bridge is relatively new. The sharp bend in the channel requires further protection, however, to prevent loss of the west abutment during a flood flow.

Specific problem areas were not to be studied in the northeastern portion of the basin. However, many, if not most, of the culverts beneath road sections are undersized. Combined with some areas of high road embankments, these points become dams, in effect. This effect was considered in the flow of the upper basin by increasing the time of peak flow slightly. The stockponds will generally not affect the flow except by slight increase in the length of time to peak. For the purposes of this study, these stockponds were assumed to be at spillway level at the beginning of the storm.

The western (closely studied) portion of the basin contains a number of structures, both major and minor. These are of variable age, with the oldest being the masonry arches along the old A. T. & S. F. Railroad right of way. West of the Woodmen Road bridge noted above, the first major structure along Cottonwood Creek is a large box culvert structure at Academy Boulevard. This structure is too small and should be increased in size. West of this, a series of three structures exists. The first is the old railroad arch; the second is a 1930 style concrete bridge on Old Highway 85-87; the third is a double bridge concrete structure at Interstate 25. The open area for the channel is adequate in all three cases. The concrete apron beneath the bridge on the Interstate 25 is being eroded and should be repaired.

The south Sub-basin 23 contains a number of existing drainage structures--most of which are recent. A 5 by 10 concrete box exists at Tuckerman Street, at the end of a mid-sized concrete lined ditch. This box is slightly too small but is best corrected by improving the inlet and increasing the size of street dropouts. The box is not so undersized that it warrants reconstruction.

A 9 by 9 concrete box culvert is located beneath Academy Boulevard. This structure is properly sized but should be subject to inlet improvement. West of this, a presently unlined ditch follows the middle of Dublin Drive to a point about opposite West Wicklow Circle. The ditch is properly sized, especially if lined, but all culverts along the ditch line (at crossings and outlet) are badly undersized. The exit from this ditch to Cottonwood Creek is being rebuilt and enlarged. After this construction, it is still too small to carry the full 100-year flow. The choice at this point is to increase this exit again, or to allow an overflow of over 600 cfs onto Dublin Drive.

The Northerly basin, B, contains a number of bridges and large boxes. At the outfall to this basin, three bridges exist. The first is another large masonry arch at the old railroad right-of-way. The second is a concrete bridge at Interstate 25. The third is a concrete bridge at an access road which is an extension of Gillen Road. All three of these structures are adequate to allow free passage of the 100-year channel flow.

On Academy Boulevard, between Jamboree Drive and Briargate Road, a large concrete box system exists. This a double 6 by 6 concrete box extending across Academy Boulevard and curving beneath a subdivision and Kelly Johnson Boulevard. This structure is nearly 900 feet long and discharges into a concrete lined ditch leading directly to the overflow gully near the Air Force Academy boundary. From here, the flow follows this overflow gully to Monument Creek. For reasons to be discussed under the section on special problems, this box structure is too small to carry the 100-year flow.

Numerous smaller sewer systems and culverts exist in the western portion of the basin. The storm sewer systems are listed in the Appendices E & F and will not be described in detail here. In general, the sytems constructed in the recent subdivisions (mostly within the City Limits at this time) are adequate in size and drain their areas reasonably well. A few additions and changes are proposed herein, but in general, the newer areas appear to be properly drained according to the City criteria for drainage.

Drainage in the older subdivisions is somewhat erratic. These subdivisions were designed with road-side ditches, for the most part, with culverts placed at road intersections and numerous low, swampy areas used for flood storage. This system tends to channel flow into the low areas and has been almost completely inadequate.

Some more extensive drainage systems exist, primarily in the Brookwood area. We could not determine when these were placed. The distribution of these systems would indicate that they were constructed in response to drainage problems in the past. These systems appear to fit the City drainage criteria insofar as pipe size is concerned. Inlet capacity is inadequate, however.

The numerous small culverts found in these older subdivisions and the original Academy Boulevard system are plotted as well as possible on the attached map. No detailed list of these was prepared, since many are so small as to be almost useless under the 100-year storm conditions. Those which are usable in an overall drainage system have been listed.

As in so many basins in the area, the lack of planning an area for drainage is painfully obvious. Intense point rainfall is capable of overloading any drainage system and occasional local flooding can be expected--possibly with minor damage. In these older subdivisions, however, almost any rainfall will cause damage in the lower areas. If development is to continue, the drainage within these areas must be improved to reduce damage.

All major structures along the major drainageways were found to be in good structural condition. Most of the true bridges appear to have been designed for structural considerations with insufficient channel improvement. A number of these bridges have allowed turbulent flow with its consequent erosion.

The major channels have been left in the location and general condition in which they existed when developed. As a result, the channels are quite winding in places, allowing bend erosion. At some points, the channels are wide and poorly defined. At others, the channel is narrow and deeply incized. The resulting flow is relatively turbulent--at least during higher flows. This is disruptive, since it forces the use of deeper channels than necessary and larger riprap and structures than would be required by smoother flow. Insofar as possible, this study recommends smoothing the flow in all major channels.

Main Channel - Drainageways

For the most part, the primary drainageway channels in the three basins are well defined, have been in existence for many years, and are presently being used as outfall points for smaller drainage systems. It is desirable that this system be maintained in future design. This will be the most economical way of removing water from the subdivided areas and most major bridges already exist. This system has been continued by this study, with all major channels being designed to carry the 100-year frequency flow as defined by the City of Colorado Springs.

The main channel of Cottonwood Creek through the study area has been found to require a 150-foot wide bottom width, approximately 6.5 feet in depth including free board and a 200-foot wide right-of-way. The right-of-way and bottom widths would hold constant from the Woodmen Road bridge near Point 4 to Monument Creek. The depth would be variable, reaching 8 feet at the highway bridges at the west end of the basin.

The only problem area encountered, using this width, exists in an area about 1000 feet each side of the Academy Boulevard bridge. In this area, subdivisions have been platted on both sides of the channel, restricting its potential width. It is believed that a 200-foot right-of-way can be obtained in this area. If it cannot be obtained, then the widest practical width must be used (up to 200 feet) and the channel deepened accordingly.

From Academy Boulevard to the railroad arch near Point 11, the channel of Cottonwood Creek is deeply incised and some sandstone lines the channel. In this reach, it may be impractical to widen the channel as recommended. Adequate depth exists to carry the flow in the existing channel. It is, therefore, more practical to leave this reach in its existing condition, except for smoothing a few of the more radical bends to allow smoother flow.

The channel of the south, Sub-basin 23, is gradually being converted to a man-made channel throughout its entire length. At the outfall, it consists of the adequately sized channel down the center of Dublin Drive. Constrictions exist at the outfall itself and at crossing culverts along the channel. From Dublin Drive to Tuckerman, the channel is still essentially natural. It is also somewhat swampy. If this area is ever to be developed as assumed herein, a lined channel with subdrains will be required through this reach. Basically, this channel would follow the existing drainageway.

From Tuckerman to Union, the channel is entirely man-made at present. The water problems in the Maroon Bells Street area make it imperative that some underdrains be completed in the area immediately above the existing ditch paralleling Maroon Bells. The remaining reach of this channel is now being drained by a storm sewer system along Vickers Drive.

The channels in the north basin (B) do not extend far into the basin. Drainage improvement must therefore be more extensive in this area than in the other areas. The two natural channels which do exist must be maintained and improved. The major outfall channel, extending from Cragin Road west of Academy Boulevard, through the railroad arch and bridge at the Interstate, to Monument Creek, should be fully lined, with a minimum bottom width of 6 feet, a depth of about 3.5 to 4 feet and a minimum right-of-way of 50 feet.

The channel extending from Academy Boulevard at Interstate 25, in a southwesterly circle behind Kelly Johnson Boulevard and extending to the outfall ditch is a special problem. This should be constructed with lined sides and stepped to reduce velocity. In general, the existing channel would be followed. This type of channel would be constructed with a bottom width of 10 feet, an average depth of 4 feet and a total right-of-way of 50 feet.

The existing channel system is relatively short and will require extension into this sub-basin. The south portion of the basin is a series of older subdivisions and an underground system will be required. In the northern portion of "B" basin, it is still possible to use a system of lined ditches. This is recommended for a number of reasons. In general, however, the portion of "B" basin east of Academy is divided into a number of "tributaries" so that each of these ditches will be relatively small. A retention system is recommended along these ditches to decrease the size of required structures. See Problem Area section for discussion of this.

The major drainageways will require either riprap or paving where they pass through the studied part of the basin. The sides of the main Cottonwood Creek channel should be improved by use of either riprap, gabions or concrete paving. The riprap or gabion system is preferable on this stream, provided that the size of riprap is large enough to resist the full flood tractive forces. The average weight of riprap pieces should be not less than 350 pounds. The bottom of this channel should remain as earth.

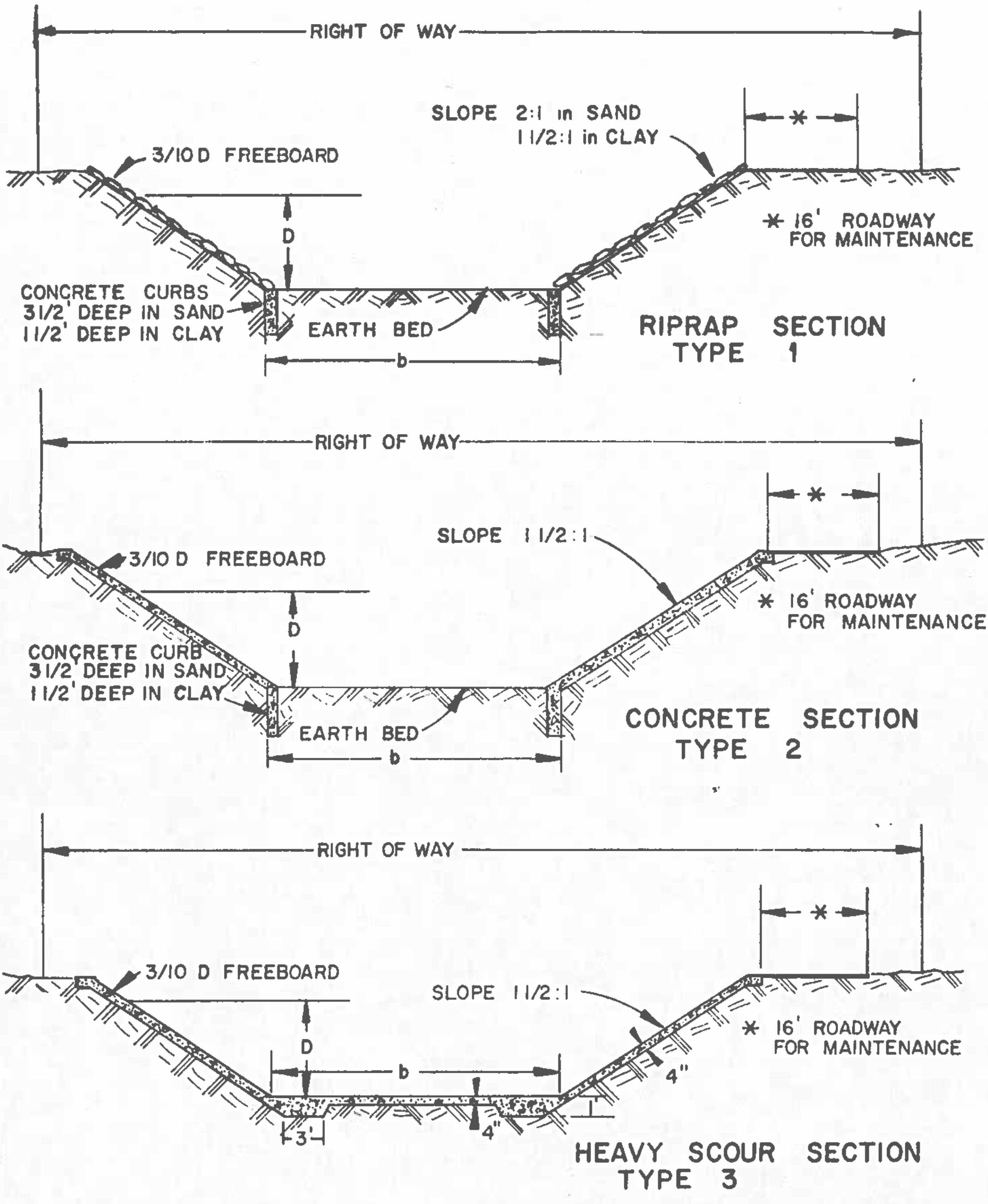
The subsurface moisture conditions along the main channel of south Sub-basin 23 dictate that this drainageway should be fully lined or placed in an underground system. In some areas a subdrainage lateral system should also be used for proper development of the load. In general, concrete paving with appropriate velocity reduction steps is the preferable system.

All bridges and concrete boxes along drainageways must have intake and outlet paved adjacent channels and scour protection lips at points which use earth bottom channels. Since a few ditches may be in easements from necessity, precautions against placing fences across the ditches are required. Placing any fence, particularly of the chainlink variety, across a drainageway is a dangerous practice, cannot be recommended and should not be allowed.

All proposed bridges and concrete boxes over major drainageways should be designed to carry the

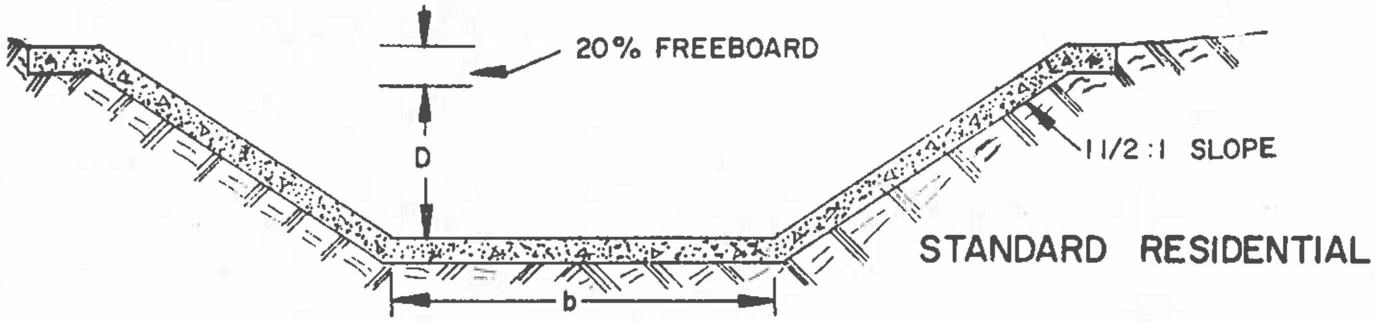
100-year frequency flow, as defined herein, with an overflow section capable of carrying potential excess over this amount. Such overflow sections must be reasonably clean to allow water flow without damage to the structure. The existing multiple box culvert at Academy Boulevard and Cottonwood Creek is presently too small and should be enlarged as noted in Appendix D.

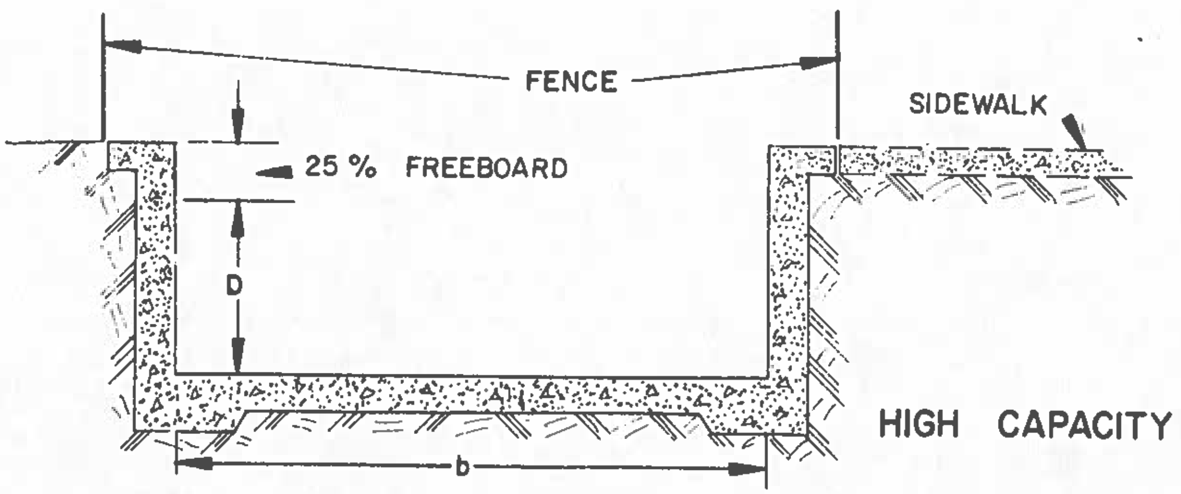
Existing bridges, two in the upper basin and two in the studied lower basin, which have foundation erosion problems, should be repaired. Two proposed bridges should be constructed to carry the design flow noted above. The locations of these two proposed bridges are at Union Bouldvard and Cottonwood Creek and at the new by-pass loop (Powers ?) at approximately Point 6.



TYPICAL GREENBELT DITCH SECTIONS

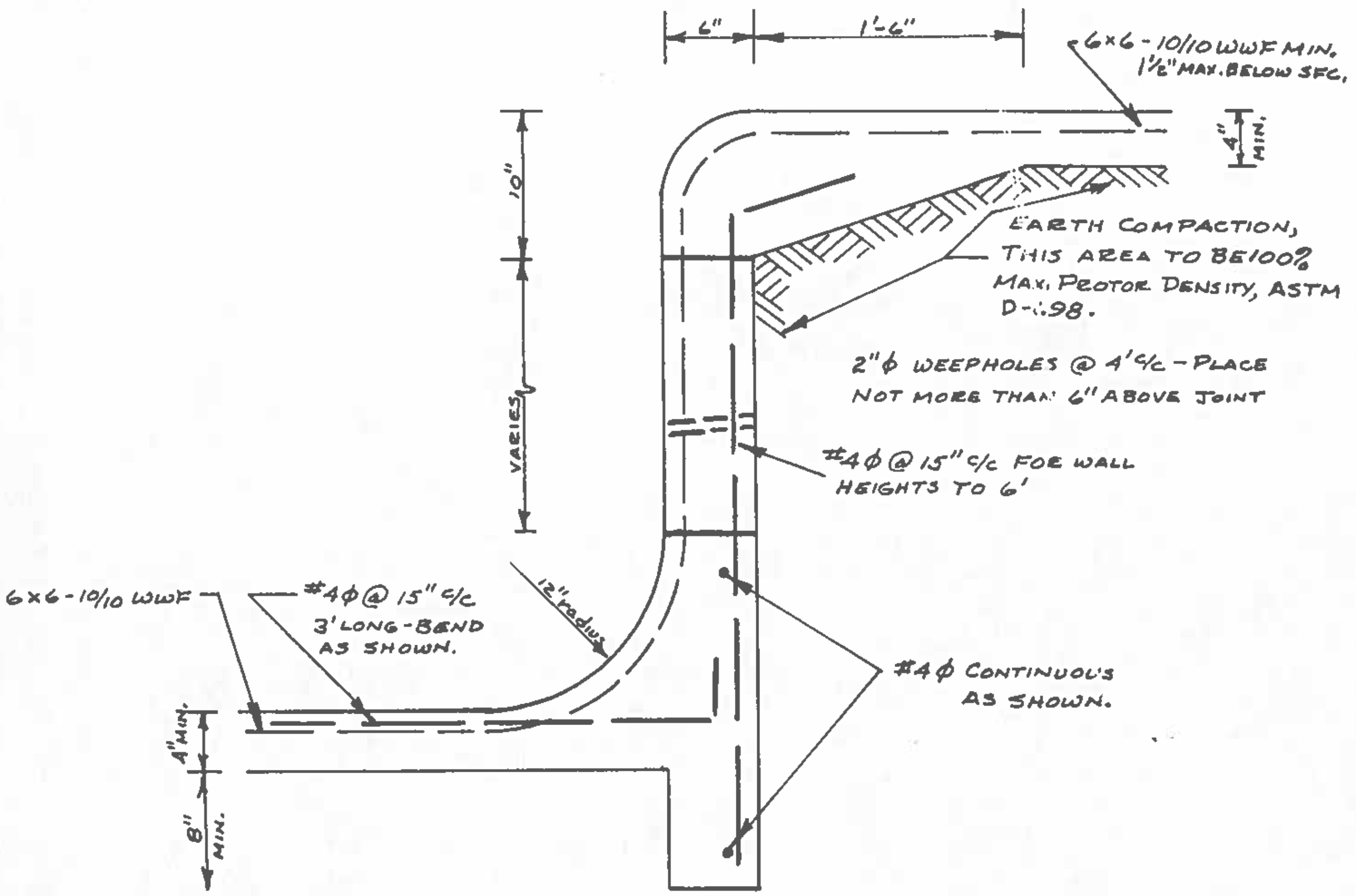
THE LINCOLN DeVORE TESTING LABORATORY





TYPICAL RESIDENTIAL DITCH SECTIONS

THE LINCOLN DeVORE
TESTING LABORATORY



CONCRETE: 3000 psi @ 28 DAYS
MAX. SLUMP - 3"
WOOD FLOAT FINISH ONLY.
REMOVE LAITANCE IMMEDIATELY.

SCALE ~ 1" = 1'-0"

TYPICAL GRADE CONTROL STEP GREENBELT OR MAJOR PAVED CHANNEL	THE LINCOLN-DeVORE TESTING LABORATORY COLORADO: Colorado Springs, Pueblo, Glenwood Springs, Montrose, Gunnison. WYOMING: Rock Springs

Storm Sewer and Ditches - Individual Improvements

Attention is directed to Appendices C, D, E, and F which list individual improvement recommendations for the studied portion of the basin. These also list major existing drainage structures within this portion of the basin. Also included is a set of maps of the basin showing existing and recommended drainage structures within the basin. The discussion in this section will be limited to major construction and will be general in nature.

After study and sizing of the main channels, each individual basin in the study area was studied using the predicted 5-year and 100-year runoff of each. Runoff at various points in each basin was compared to actual or probable street capacity and distribution. Street capacity used for the computation was in accordance with the City chart of allowable street runoff. In some cases, runoff was spread over a sufficient number of streets that no drainage system was required, other than dropouts into the main channel. In other cases, flow is concentrated and a drainage system was found to be required.

The City drainage criterion for drainage construction can be paraphrased as: All drainage structures in areas in which the 100-year frequency flow is projected as greater than 500 cfs will be designed for the 100-year frequency flow. Where the 100-year frequency projection is for less than 500 cfs, all structures will be designed for the 5-year frequency flow. According to this criterion, practically all of the main drainageways must be designed for the 100-year frequency flow. Storm sewer systems will vary in requirement, some being designed for the 5-year and some for the 100-year frequency.

Where possible, this study has followed the practice of proposing small ditch construction through presently undeveloped areas. Ditches are generally more efficient at removing water, can be designed into street systems and, even considering boxes at street crossings, are generally less expensive than comparably sized storm sewer systems. Inlet systems are much simplified, also. In addition, the topography of much of this basin lends itself to ditch construction.

In areas of developed land, particularly the older subdivisions, storm sewer systems are proposed. In most of these areas, the street systems cannot carry the probable flow in the existing ditches and certainly will not carry the flow with pavement and curb and gutter. The additional storm sewer systems are therefore considered necessary in such areas.

Considering individual basins within the study area, a number of different conditions exist, calling for a number of potential solutions. Basin A, Sub-basins 13, 14, 15, 16 and 17 are all presently undeveloped basins. All of these basins will require at least one ditch reach to transfer collected runoff to Cottonwood Creek. These ditches are of variable length, depending primarily on the geometry of the basin. Sub-basins 16 and 17 are such that storm sewer systems should also be used. In effect, these extend the ditch further into the basin (17), or serve as a collector for the ditch (16).

To allow further development of Sub-basin 18, particularly that portion now within the City Limits, a "Y" storm sewer system is required. The principal sewer will extend up Union Boulevard (proposed) to Woodmen Road. The "Y" extends up an existing gully to remove water placed in the area by a large culvert under Woodmen Road.

The storm sewer and street system flow within Sub-basin 20 is reasonably efficient and adequate. Several points exist at which streets attempt to turn rapidly moving water 90°. These points may require the construction of an additional curb inlet and connecting pipe, but the overall system appears adequate. Two dropout channels and a small storm sewer system is proposed in the northeast, undeveloped, corner of Sub-basin 20.

Sub-basin 21 is the better drained portion of the previously developed subdivisions. Adequate storm drain systems have been constructed through the Brookwood Subdivision, but with totally inadequate catch basin facilities. New catch basins are proposed and relatively small extensions of the systems are proposed.

Sub-basin 22 required the connection of several culverts crossing Academy Boulevard and Woodmen Road into a storm sewer system. This system should be constructed to drain a proposed commercial area at the southwest corner of Academy and Woodmen, then continue to Cottonwood Creek for outfall. This system would help drain the portion of the sub-basin east of

Academy and remove some of this drainage from Basin B. The commercial area in the west portion of this sub-basin is well graded and planned. Its runoff enters Cottonwood Creek almost directly.

Nearly all of the required drainage structures in the south Sub-basin 23 are required along the main channel. Very few other systems or extensions will be required. Most of these have already been constructed.

The northern portion of Basin B is undeveloped, for the most part. The topography consists of a number of valleys separated by relatively low, rolling hills. Northeast to southwest gradients are relatively steep. A series of ditch systems is proposed for this area, with storm sewer "collector" systems at the upper ends of the ditches. The major ditch systems are located in Sub-basins 1, 2, 3, 4, 6 and 9. Except for minor development along Jamboree Drive, these basins are undeveloped.

Two stockponds exist in this area; one in Sub-basin 4 and one in Sub-basin 9. These have been retained in the plan, upgraded with proper emergency spillway and additional height where required. A third retention reservoir has been included in Sub-basins 3/5 (see "Problem""Section). These should not be used as storage points after development of the area. They must be designed for temporary retention <u>only</u>. The primary object of this retention is to reduce the size and cost of structures downstream.

In Sub-basin 10, a double sewer system will be required to accomplish two purposes. First, flow from the newly developed areas east of Grashio Road can be removed from the area more easily. Second, ponding and overflow at Academy Boulevard will be prevented. These two branches of storm sewer have been combined to move down Cragin Road (Sub-basin 12) and to a ditch system which is the shortest and least obstructed path to the outfall.

An additional storm sewer pipe is required from collection Point 16 (Sub-basins 6 and 9), to cross Academy and Kelly Johnson Drive to an existing ditch outfall. (See "Problem" section).

The final storm sewer system to be discussed is at the west end of Sub-basin 13. A series of small storm sewers up Collins, Shrider and VenHorst Roads will drain this low area into a concrete lined ditch following the old A.T. and S.F. Railroad right-of-way. This ditch would be constructed south along the old right-of-way to Cottonwood Creek in Basin A. This would require a box culvert at Woodmen Road and a chute at Cottonwood Creek.

The area west of the old railroad right-of-way will require no public storm drainage facilities, except for the major channels. This area is relatively small and slopes into Monument Creek rather steeply. Proposed commercial developments in this area would require drainage, but this would be a private system as proposed.

The small portion of the residential subdivision in the far north portion of Sub-basin 14 will require no major drainage systems. Some small dropout structures could be utilized if curb and gutter is installed throughout the development. These would flow directly to the creek or outlet, however. Some of this subdivision is below the 100-year flow level of Monument Creek, so that the effectiveness, even of dropouts, is conjectural.

In general, any ditch or storm sewer systems entering major drainageways must be paved so that erosion does not take place at the point of entry. Such pipes and ditches should also be angled so that the flows merge as smoothly as possible. Bridges or concrete boxes placed in the basin should be constructed with dropout boxes or drains from the street above to the channel below. These should be surface design dropouts for better efficiency.

The City standard curb inlet, D-10R, has been used for size computations and cost analysis in this report. At some points, high velocity inlets might be more efficient. It is noted in passing that inlet problems can be quite difficult. All inlets or dropout structures should be specifically designed for each site, insofar as this is possible. Although a certain number of inlets, together with the required size, have been shown in this study, this study is not intended as a design. The study should not be substituted for a site specific inlet design.

Specific Problem Areas

A number of problem areas exist within this basin, most of which are connected with the older subdivisions. Although partially discussed in other sections of the report, further discussion of specific problems is required to completely understand the flow system proposed.

1. The primary problem in the upper basin is a number of undersized culverts across various roadways. This portion of the basin was not to be closely studied, therefore, increases in the size of these culverts was not included in the cost estimate or map. Most of the desirable changes are obvious, however.

2. The concrete box under Tuckerman in south Sub-basin 23 need not be enlarged if the drainage down Tuckerman is diverted into the mainstream by construction of larger dropouts at the box. Provision for minor overflow should also be made.

It is noted that this entire channel has a large subflow. At one time, the storm sewer at Vickers Drive had been damaged by removal of side support by this underflow. If this pipe has not been repaired, it should be, as soon as possible. At the time of the damage inspection, the pipe had lost nearly 1/4 of its capacity.

This underflow (seepage) continues to follow the clay surface beneath the channel to Tuckerman. At this point, it is the partial cause of the large swampy area affecting Maroon Bells. This entire area should have a subdrainage system. However, it is already fully developed, and the City drainage ordinance does not address subdrainage. Therefore, the need is stated here, but not included in the cost estimate.

3. The various culvert crossings along the ditch in the center of Dublin Drive must be increased to a size sufficient to carry the flow. The ditch is sufficient, but these culverts are not. Smooth flow should be maintained. The exit from the ditch has just been reconstructed in a larger metal pipe system, but is still too small to allow the full flow to move into Cottonwood Creek.

Two possible solutions exist to removal of this runoff. First, the exit from the Dublin Drive channel can be enlarged again, to proper size. This study recommends that this be done. The second would be to allow an overflow from the ditch onto Dublin Drive. The amount of this overflow is considerably greater than the Drive and its existing storm sewer can handle. The result will be similar to that shown by the Corps of Engineers study, except that the overflow would not cover quite as wide a path. This study believes this to be an unacceptable solution.

4. The Academy Boulevard bridge at Cottonwood Creek must be widened as recommended herein. This study recommends that it be enlarged to adequately accept the runoff at this point caused by the City's 100-year frequency storm. In addition, this study recommends that it be designed to accept overflow without damage should a greater storm occur. The position of this bridge makes it imperative that it be kept open and silt, such as now exists, removed.

The channel at and above the bridge must be made as wide and deep as possible, consistent with the distance between subdivisions opposite and the flowline elevation of the bridge. Right-of-way width need not exceed 200 feet, however. The channel below the bridge should be straightened into smooth bends to remove water more quickly.

The identical procedure is recommended for the proposed bridges at Union Boulevard (Point 9) and the new Boulevard (believed to be Powers) near Point 6. At both of these locations, the banks of the Creek are relatively low and high bridges are not generally practical. The bridges should be constructed as high as practical and capable of allowing the City design 100-year frequency flow. These bridges should also be designed to allow overflow without damage.

5. The area from Cragin Road north to Interstate 25 along Academy Boulevard is an inter-related problem area. Basically, the crossing structures under Academy Boulevard are not adequate to carry the 100-year flow from Basin B. The area is reviewed from North to South.

The 6 by 10 concrete box across Academy Boulevard near the Interstate 25 interchange collects run-off from outside the basin. Since the construction of the highway, this box must carry the flow from Pine Creek, the next basin to the north. The Pine Creek basin is a relatively small basin with only minor development. It is, however, capable of producing a 100-year frequency flow at this point, of about 2600 cfs. The box culvert is hopelessly inadequate to carry this flow across Academy Boulevard.

An additional consideration is the fact that this channel must also carry the overflow from the holding reservoir system of Kettle Creek. The storm contemplated by the City for use as a 100-year frequency would be unlikely to cover all three basins. Therefore, such an overflow has a low probability, but is a distinct possibility. Such a storm could easily cover the Cottonwood and Pine Creek basins, however, so this flow must be considered.

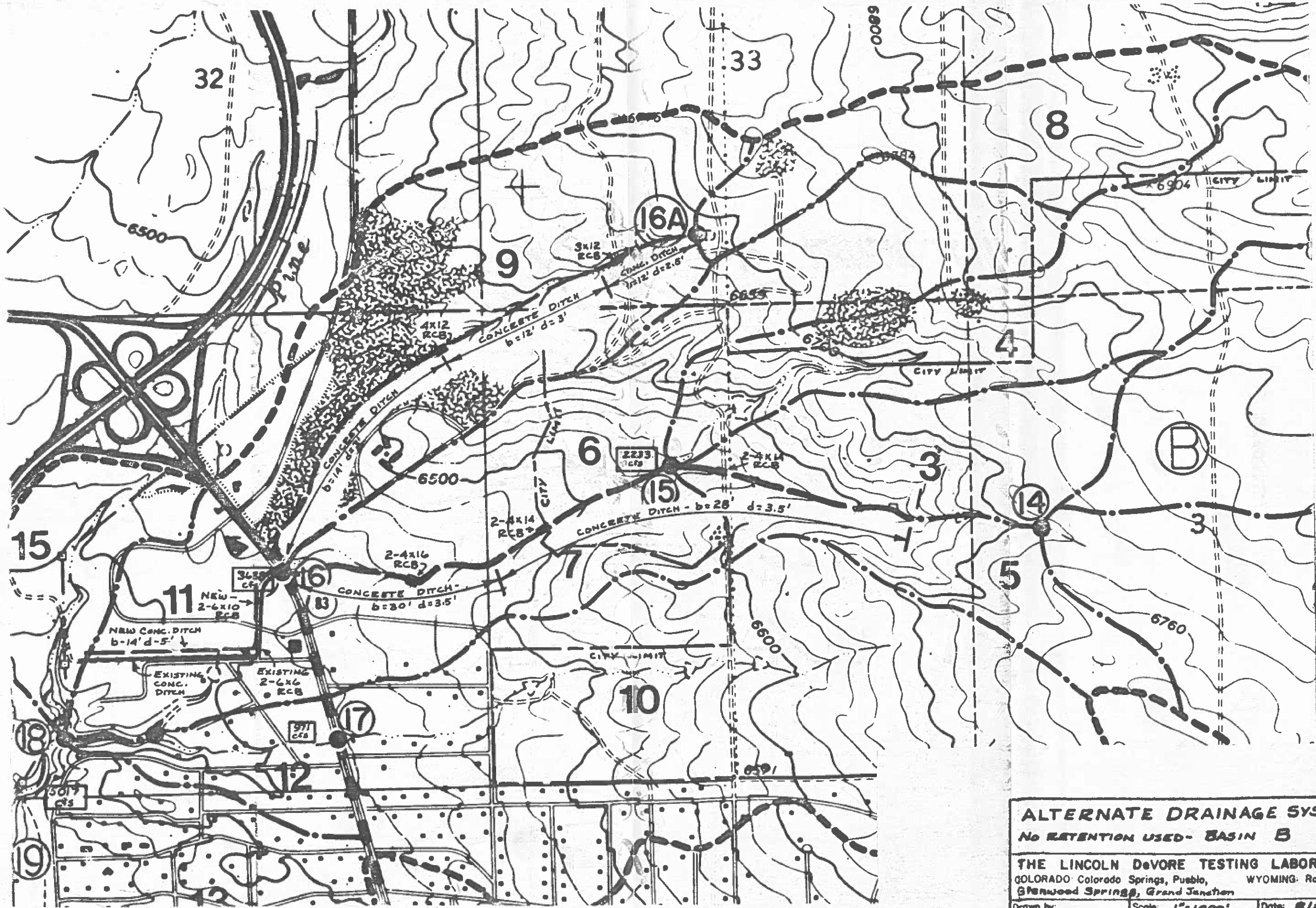
The large box culvert near Briargate Boulevard is less than half of its required size, assuming unobstructed flow and full development of the basins above. In addition to this, should the smaller box, discussed above, overflow, some of this overflow will add to the flow from the upper basins at this long box culvert. The remainder of the water will overflow Academy and the area to the west.

To reduce the cost of enlarging these culverts, three holding or retention reservoirs are proposed at good reservoir locations in the upper basins above this point. Two of these retention reservoirs already exist in the form of stock ponds. With some modification, these can be used for retention at relatively low cost. The third retention structure must be constructed completely. With these three retention structures, the peak flow from the upper basins can be reduced considerably. An additional 78-inch RCP will still be required across Academy Boulevard, however.

To prevent overflow from Pine Creek, the box culvert near the interchange should be roughly doubled. The protective wall behind the culvert must be reconstructed to turn the flow without damage and to leave an adequate channel around the protected development. The remaining channel must be riprapped on the sides and completed around Kelly Johnson Road to the basin outlet.

The system of retention reservoirs has been recommended for several previous basins. It has proven unfeasible to construct and maintain such reservoirs. In this case, the decision must be made to construct and maintain such reservoirs, or to construct a box culvert and ditch system 2-1/2 times as large as that which presently exists. This study recommends that construction and use of these reservoirs in the locations shown, together with the culvert enlargement at the interchange. It is believed to be the less expensive of the two alternatives.

One continuing problem in this basin and many others, is the attempt to turn a rapidly moving street flow 90° in direction. This is often required at Tee intersections at the bottom of steep slopes, and at major drainage street crossings. Such an attempt is futile when limited to surface guides, as many owners of property on the side opposite the slope can testify. The street must carry traffic. Large scale warping of the paved sections is rigidly limited. Such turns must be made by underground systems, reducing the flow above the turn.



ALTERNATE DRAINAGE SYSTEM

No RETENTION USED - BASIN B

THE LINCOLN DeVORE TESTING LABORATORY

COLORADO: Colorado Springs, Pueblo, Glenwood Springs, Grand Junction — WYOMING: Rock Springs

Drawn by:	Scale: 1"=1000'	Date: 8/8/79
Checked by:	Contour Interval: 20'	Revised:

Summary and Conclusions

This basin is typical of many around the City of Colorado Springs, in that the lower portion of the basin has been partially developed at the major outlet locations. Existing drainage structures in such cases are almost always either, a) too small, or b) haphazard reactions to some problem which has arisen. Some construction will be difficult due to the existence of the previously existing subdivisions and undersized structures.

The allowable city development is controlled by water supply at the present time. It would appear that this controlling factor would allow full development of the studied portion of the basin. It would also appear that, considering other areas of development around the metropolitan area, not much more of the basin can be developed. Changes concerning water supply and possible subdivisions supplied by deep well water could revise this estimate, of course. At this time, however, the studied portion of the basin appears to be the practical limit of heavily developed area.

With this estimate in mind, the population of the upper basin was limited to the 1/2 to 5-acre development now existing, expanded to cover the upper basin. The lower basin was assumed to be fully and more compactly developed. Flows were calculated using this estimate, together with the City rainfall/runoff criteria. All structures recommended by this study fit the runoff developed by this criteria, with no major overflow allowed, other than the amounts allowed under the City street flow criterion.

The use of streets as drainageways is allowable up to the point at which waterflow interferes with traffic. The specifications of the City of Colorado Springs allow relatively small amounts of water to flow in the streets. In any given area, either the flow must be spread over a number of streets, or it must be diverted to some type of drainage structure. Particularly in undeveloped, unplanned areas, this is somewhat difficult to assess, since the street pattern is not known. Final development of drainage systems will probably be somewhat different for the undeveloped areas than is shown herein. The basic pattern should be about as the study recommends, however, with changes mostly in detail.

Experience in the metropolitan area has led to a number of changes in the City drainage regulations and criteria. The design of drainageways was originally planned as broad and shallow to reduce velocity and allow between storm use of the strip. This has proven economically unfeasible, and drainageways today are designed as deeper, narrower, fully lined channels. The retention reservoir system of control was abandoned some years ago for lack of proper maintenance funding. It has been determined that, for channels of any size, grass lining could not be maintained and the channel became rough and eroded. Therefore, regardless of environmental concerns, most channels within the City have concrete linings.

With this basin, however, reconsideration of the economics of some of these abandoned systems should be undertaken. This basin contains three recommended retention structures (plus a number which exist in the upper basin). These are recommended because it is believed the economical development of the basin will be enhanced by their construction. Wide ditches are still not economical and have not been recommended. However, with the development of such products as engineering filter fabric, fabric formed mats and concrete/grass gridded mats, it again becomes feasible to avoid the stark appearance of patched concrete ditches. This study recommends that such materials be more fully utilized in future construction. Considering maintenance costs of some existing concrete lined ditches, the newer types of lining may even require less maintenance.

The specific recommendations made by this study are fully listed in the Appendix, on the inventory sheets and on the attached maps. As noted previously, the locations of proposed structures and inlets must not be taken as exact. Various differences in planning streets will fix these locations and such changes in detail must be allowed if reasonable. The general outline should be followed, however.

This study recommends that the major channel, Cottonwood Creek, be riprapped, matted or lined on the sides only, with the bottom left as sand. An exception would be aprons above and below the major structures and at velocity checks. The same construction is recommended for the outfall which removes runoff from the Pine Creek drainage. Most other major channels and all the smaller ditches should be fully lined or matted.

Gradients are generally fairly steep within the basin and velocity checks must be used liberally. Care should be taken in the design and construction of entries and velocity checks. Water will erode poor quality concrete, as much of the drainage construction in the metropolitan area shows, beyond question. It should be noted that the basin consists primarily of sands which will allow the use of Type I Cement. Large areas of clays and sandy clays also exist, however, which require the use of Type II Cement. Air entrainment should be used throughout.

Those structures listed as too small to carry the design flow should be increased in size or parallel structures constructed. All structures on the main channels should have the capacity to carry the full design flow smoothly. It should be noted, on the other hand, that some structures are very slightly too small and will require only inlet or dropout improvement.

All structures, ditches and storm sewers should be properly sized where they do not now exist. These will be constructed as the various open areas are developed, but the runoff flows given herein should be used for their design throughout the basin.

Structures shown as required in areas already developed cannot be constructed until funds become available, of course. These funds should be budgeted, however, to reduce existing and potential problems within the developed areas. This basin also contains a number of areas of high perched water (described as "swampy" in this study), which should be drained. Such water causes damage to buildings, streets, storm sewers and utilities.

The general recommendations of this study is that the storm drainage structures of all types shown on the inventory sheets and on the maps be constructed approximately as shown. This study has included areas both inside and outside the present City Limits, for planning purposes.

COTTONWOOD CREEK DRAINAGE BASIN
COST ANALYSIS

Studied Basin within City Limits only:

Unplatted Existing Public Streets	48.0 acres
Existing Subdivisions (Streets & Parks included)	1177.1
Remaining Private Land	2420.7
Total Area	3645.8 acres

Summary of Costs:

I. Developer	
(C) Ditches & Stream Lining	$ 2,115,019.00
(E) Major Culverts	106,793.00
(F) Storm Sewer Systems	1,078,283.00
Sub-Total	$ 3,300,095.00
Engineering (10%)	330,010.00
Contingency (5%)	165,005.00
Total Developer Basin Cost	$ 3,795,110.00

Developer Drainage Fees: $\frac{3,795,100}{2420.7}$ = 1567.77, use 1570.00

II. (D) Bridges (Constr. & Renov.)	301,374.00
Engineering (10%)	30,137.00
Contingency (5%)	15,069.00
Total Bridge Cost (direct)	$ 346,580.00

Total Developer Bridge Fees: $\frac{346,580}{2420.7}$ = 143.17, use 145.00

III. Other Basin Cost (direct)	
(C)	79,983.00
(E)	169,964.00
(F)	30,787.00
Sub-Total Other Basin Cost	$ 280,734.00
Engineering (10%)	28,073.00
Contingency (5%)	14,037.00
Total Other Basin Cost (direct)	$ 322,844.00
(D) State Bridge repair & addition cost (No City Bridge Costs)	$ 58,400.00

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MAJOR BASIN A

SUB BASIN	AREA		TC	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 yr.	100 yr.	
A 1	1078	1.68	.900	64	2.10	135	686	5.61
2	365	0.57	.526	62	1.82	49	277	4.86
3	1074	1.68	1.083	69	2.15	218	830	5.74
4	1232	1.93	.880	70	2.03	313	1131	5.42
5	1520	2.37	1.070	75	2.14	530	1602	5.71
6	827	1.29	.689	75	1.91	380	1149	5.10
7	334	0.52	.502	79	1.80	242	655	4.81
8	163	0.25	.540	77	1.83	98	279	4.89
9	416	0.65	.671	72	1.90	155	570	5.07
10	363	0.57	.996	74	2.10	123	382	5.61
11	672	1.05	1.010	74	2.11	225	697	5.63
12	441	0.69	.997	74	2.10	149	462	5.61
13	444	0.69	.466	79	1.78	328	888	4.75
14	476	0.74	.451	80	1.77	385	1019	4.73
15	103	0.16	.250	88	1.65	170	367	4.41
16	160	.250	.298	79	1.68	142	385	4.49
17	185	.289	.401	88	1.74	267	577	4.65
18	294	.459	.289	78	1.67	248	689	4.46
19	184	.288	.435	88	1.76	260	562	4.70
20	392	.613	.498	86	1.80	457	1043	4.81
21	386	.603	.506	84	1.80	396	936	4.82
22	417	.652	.537	87	1.82	498	1109	4.86

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 1 of 2 A Individual Basin Runoff

LINCOLN-DeVORE TESTING LAB., INC.

MAJOR BASIN A

SUB BASIN	AREA		TC	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 yr.	100 yr.	
A-south 23A	231	.36	.249	86	1.65	335	764	4.41
23B	163	.26	.193	84	1.62	216	512	4.33
23C	154	.24	.330	84	1.70	190	449	4.54
23D	143	.22	.203	83	1.62	170	414	4.33
B 1	608	.950	.618	75	1.87	296	895	4.99
2	364	.569	.467	74	1.78	187	579	4.75
3	98	.153	.271	77	1.65	77	220	4.41
4	272	.425	.481	75	1.79	149	450	4.78
5	104	.163	.353	78	1.71	81	226	4.57
6	188	.294	.525	77	1.82	115	330	4.86
7	111	.173	.376	80	1.73	97	255	4.62
8	154	.241	.469	77	1.78	99	283	4.75
9	304	.475	.448	83	1.71	336	822	4.57
10	462	.722	.544	81	1.81	377	971	4.83
11	108	.169	.346	82	1.70	113	283	4.54
12	57	.089	.372	81	1.72	53	136	4.59
13	270	.422	.439	83	1.76	271	663	4.70
14	131	.205	.300	78	1.68	108	301	4.49
15	84	.131	.257	80	1.66	82	216	4.44

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 2 of 2   A Individual Basin Runoff

LINCOLN-DeVORE TESTING LAB., INC.

MAJOR BASIN A

SUB BASIN	AREA		TC	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 Yr.	100 Yr.	
A 1	1443	2.25	.780	64	1.97	202	1022	5.26
2	3749	5.86	.983	67	2.09	649	2690	5.58
3	5603	8.75	1.090	70	2.15	1274	4596	5.75
4	6593	10.29	1.065	71	2.14	1675	5753	5.71
6	7069	11.03	1.071	72	2.14	1950	6424	5.71
A 5	779	1.22	.768	73	1.96	289	921	5.23
6	1892	2.96	.968	74	2.08	645	2000	5.56
6	8961	13.99	1.070	72	2.14	2450	8069	5.71
7	9508	14.84	1.090	73	2.15	2745	8756	5.75
8	9853	15.40	1.145	73.3	2.19	2808	8796	5.84
9	10331	16.14	1.150	73.7	2.19	2996	9373	5.84
10	11109	17.36	1.216	74.5	2.23	3314	10142	5.95
11	11526	18.01	1.240	75.0	2.24	3486	10419	5.99
23 12C	231	0.36	.249	86	1.65	335	764	4.41
12B	394	0.62	.271	85	1.65	545	1265	4.41
12A	548	0.86	.329	84.7	1.69	699	1625	4.51
12D	691	1.08	.369	84.4	1.69	826	1936	4.51

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 1 of 2 B - Total Basin - Accumulative

LINCOLN-DeVORE TESTING LAB.

MAJOR BASIN B

SUB BASIN	AREA		TC	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 Yr.	100 Yr.	
B 14	972	1.52	.566	74.6	1.84	482	1469	4.91
15	1446	2.26	.560	75	1.84	747	2233	4.91
16	1745	2.73	.598	75.6	1.86	929	2707	4.96
16A	154	.24	.469	77	1.78	99	283	4.76
16	458	.72	.484	81	1.79	390	1003	4.78
16	2203	3.44	.574	76.7	1.84	1264	3638	4.92
18	2311	3.61	.615	77.0	1.87	1331	3768	4.99
17	462	.72	.544	81	1.83	377	971	4.88
18	519	.81	.552	81	1.83	415	1067	4.88
18	2914	4.55	.594	77.7	1.86	1797	5017	4.97
19	3184	4.98	.602	78.2	1.86	2013	5527	4.97
20	3315	5.18	.610	78.3	1.87	2085	5763	4.98
		ADD PINE CREEK:						
18						2604	7577	
19						2790	8057	
20						2850	8273	

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 2 of 2 B - Total Basin-Accumulative

LINCOLN-DeVORE TESTING LAB., INC.

SUB BASIN	LOCATION			EXISTING					REQUIRED					MISC.
	FROM	TO	LENGTH OF RUN	BOTTOM WIDTH	TOP WIDTH	DEPTH	R/W	cfs cpy. flow	COMP. FLOW 5Yr.	COMP. FLOW 100Yr.	BOTTOM WIDTH	DEPTH	R/W	
A	2	3	6250	±100'	±160'	±16'	--	53000	1274	4596	100'	3.6'	130	
	3	4	4600	±150'	±190'	±18'	--	95900	1675	5753	150'	3.0'	130	
	4	6	5700	±180'	±250'	±10'	--	38400	1950	6424	150'	3.7'	200	riprap Sides $319,200.00
	6	7	1750	±120'	±400'	±10'	--	40900	2745	8756	150'	4.2'	200	riprap Sides $98,000.00
	7	8	1900	±110'	±600'	± 6'	--	20768	2808	8796	150'	4.5'	200	riprap Sides $114,000.00
	8	9	2950	±130'	±300'	± 9'	--	27200	2996	9373	150'	4.6'	200	riprap Sides $177,000.00
	9	10	5750	± 80'	±160'	± 6'	--	7790	3314	10142	150'	4.8'	200	riprap Sides $198,400.00
	10	11	6800	± 60'	±150'	±16'	--	42000	3486	10419	150'	4.6'	200	riprap Sides $217,600.00
	12B	12A	3550	± 6'	± 80'	± 3'	--		699	1625	16'	4.5'	45	part fully lined, part
														sidelining $172,295.00
	12A	12D	2450	18'	48'	7'	48'		826	1936	18'	7.0'	48'	Sidelining $101,919.00
	12D	Cottonwood Creek	440	20'	30'	± 7'	30'		826	1936	20'	7.0'	30'	Sidelining $19,664.00
	Maroon Bells	12B	1400	5'	15'	5'	30'	1320	545	1265	None	--	--	--

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 4 C Ditch & Stream Inventory

LINCOLN-DeVORE TESTING LABORATORY, INC.

SUB BASIN	LOCATION			EXISTING					REQUIRED					MISC.
	FROM	TO	LENGTH OF RUN	BOTTOM WIDTH	TOP WIDTH	DEPTH	R/W	cfs cpy. flow	COMP. FLOW 5Yr.	COMP. FLOW 100Yr.	BOTTOM WIDTH	DEPTH	R/W	
A 13	Creek 6	center	1500'	--	--	--	--	--	294	795	12'	3.5'	35'	fully lined $69,550.00
13	Center	uphill	1500'	--	--	--	--	--	255	690	6'	3.5'	30'	fully lined $55,500.00
13	drop out to Creek	creek	200'	--	--	--	--	--	34	93	6'	2.0'	12'	fully lined $7100.00
14	mid FP 14	creek nr.8	1150'	--	--	--	--	--	361	955	14'	3.0'	36'	fully lined $55,589.00
15	7	creek flood plain	250'	--	--	--	--	--	170	367	8'	3.0'	16'	fully lined 9070.00
16	F.P.-16	Creek	650'	--	--	--	--	--	142	385	4'	3.0'	12'	fully lined $23,725.00
17	Sewer 17	Creek	700'	--	--	--	--	--	267	577	12'	4.0'	36'	fully lined $35,575.00
18	Woodmen Rd.	Shrider Rd.	1730'	--	--	--	--	--	135	374	5'	3.0'	30'	fully lined $63,145.00
18	Shrider Rd.	Fuller Rd.	1070'	--	--	--	--	--	66	177	2'	4.0'	12'	fully lined $39,055.00
18	Fuller Rd.	Tecumseh Rd.	600'	--	--	--	--	--	40	112	0'	2.5'	12'	grass ditch top 10' 2940
19	Dublin	Reuben	420'	3'	7'	3.5'	23'	209	84	180	None	--	--	----------
19	Reuben	Creek	1180'	4'	7'	3'	23'	296	187	290	None	--	--	----------
19	Deliverance	Creek	120'	4'	--	$1\frac{1}{2}$'	10'	64	34	73	None	--	--	curb-drop outs-
19	Deliverance	Creek	120'	4'	--	$1\frac{1}{2}$'	10'	64	29	62	None	--	--	curb-drop outs-
20	Dublin	300' North	300'	2.5'	6'	3.5'	26'	331	136	311	None	--	--	----------
20	300'North	Creek	1560'	4'	7'	3.5'	26'	369	136	311	None	--	--	----------
20	N.E. Corner	Creek	760'	--	--	--	--	--	70	160	4'	3.0'	26'	$27,740.00
20	N.W.Corner	Creek	180'	--	--	--	--	--	25	59	4'	2.0'	12'	curb D.O. $6570.00

SUB BASIN	LOCATION			EXISTING					REQUIRED					MISC.
	FROM	TO	LENGTH OF RUN	BOTTOM WIDTH	TOP WIDTH	DEPTH	R/W	cfs cpy. flow	COMP. FLOW 5Yr.	COMP. FLOW 100Yr.	BOTTOM WIDTH	DEPTH	R/W	
A 21	Woodmen Rd.	Creek	510	---	---	---	---	---	12	27	2'	2'	24'	fully lined $15800.00
22	Woodmen Rd.	Cottonwood Creek	1450	eroded	20'±	3'±	---	---	265	652	12'	3.5'	26'	(RRR/W) $67,731.00
23B	Vickers	Maroon Bells	600	planned 4'	7.2'	1.6'	24'	120	14	31	None			----------
22	Prince	Looart	130'	8'	8'	1'	10'	44			None	- -	--	---------
B 1	Jct. 14	NE	1600'	---	----	---	---	---	268	810	12'	2.5'	34'	fully lined $63,892.00
1	NE	Center	1540'	---	----	---	---	---	193	585	13'	2.5'	34'	fully lined $64301.00
1	Center	Depress	1550'	---	----	---	---	---	132	398	10'	2.5'	32'	fully lined $54,604.00
2	Jct	Center	1500'	---	----	---	---	---	170	528	12'	3.5'	36'	fully lined $70,161.00
3 & 5	14	15	Spot	---	----	---	---	42ac.ft.	607	1815	Area ± 4 AC.	25'±	+6AC	Holding res. 350 cfs release $88,570.00
3 & 5	Reservoir	Connect. W. Res.2	1540'	---	----	---	---	---	---	525	10'	3.5'	34'	fully lined $65,052.00
4	above	15	spot	--- Stockpond	----	existing ---	---	7 ac.ft.	149	450	Area ± 1AC.	12'±	±1½AC	Holding res. 100cfs release $31,026.00
4	Res.2	Ditch 15	620'	---	----	---	---		---	105	2'	3'	24'	fully lined $21,700.00
4	Res.	Quarry	1400'	---	----	---	---	---	143	432	10'	3'	32'	fully lined $54,811.00
4	Quarry	Pipe	2000'	---	----	---	---	---	128	385	9'	3'	32'	fully lined $73,724.00
5	Res.	Jct. 14+	2850'	---	----	---	---	---	560	1692	18'	4'	45'	fully lined $181,300.00
6 & 7	15	16 1500'E	3500'	---	Swamp ----	---	---	---	---	760	12'	4'	36'	fully lined & step $175,923.00
6 & 7	16 1500'E	16	1500'	---	----	---	---	---	---	1210	18'	4'	45'	fully lined & step $95,690.00
9	-----	16A	Spot	---	----	---	---	6acft	99	283	area 1½AC±	7'±	+2AC	Holding res. 100cfs release $37,900.00

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 3 of 4 C Ditch & Stream Inventory

LINCOLN-DeVORE TESTING LABORATORY, INC.

SUB BASIN	LOCATION			EXISTING					REQUIRED					MISC.
	FROM	TO	LENGTH OF RUN	BOTTOM WIDTH	TOP WIDTH	DEPTH	R/W	cfs cpy. flow	COMP. FLOW 5Yr.	COMP. FLOW 100Yr.	BOTTOM WIDTH	DEPTH	R/W	
B 9	Reservoir	930' W.	930'	----	---	---	----	---	---	332	5'	3.5'	28'	fully lined & step $29,388.00
9	930'W.	Antelope Loop	1500'	----	---	---	----	---	---	634	10'	3.5'	34'	fully lined & step $63,162.00
9	Antelope Loop	Jamboree	3180'	----	---	---	----	---	---	870	12	4'	36'	fully lined & step $160,186.00
10	Briargate		Spot	approx. 2 AC	---	±10'	± 3AC	12Acft.	189	486	None added			Holding Res. 81 cfs release
10	Briargate		Spot	±.25AC	---	± 2'	±.4AC	.41AcFt.	14	35	None			small holding Pond 10 cfs release
10	Anderosa		240'	4'	---	8"	10'	6	15	13	None			fully lined
10	Anderosa		280'	6'	----	8"	10'	8	8	20	None			fully lined
11	Kelly Johnson	ditch to 18	2050	12'	17	5'	----	1738	---	1950	None	into Fs	36'	
12	Cragin	ditch Jct.	840'	Not. ditch		---	----	1020	401	1040	6'	3.5'	50'	fully lined $29,400.00
12	ditch Jct.	18	940'	Not. ditch		---	----	1120	415	1067	20'	4'	50'	Sides lined $33,462.00
13	Collins Rd.	Shrider Rd.	450'	R.R.R./W ditch					89	208	8'	2'	28'	fully lined $17,110.00
13	Shrider Rd.	Woodmen Rd.	1450'	R.R.R./w ditch				729	271	663	16'	2.5'	38'	fully lined $69,244.00
15	Academy	18	3200'	ditch bet. I-25 & (natural) Kelly Johnson					807	2573	16'	5'	50'	riprap-sides $192,000.00
A 22	E. Side Looart Site	Creek	1730	---	----	----	---	---	101	228	4'	3.5'	25'	fully lined $70,065.00

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 4 of 4 C Ditch & Stream Inventory

LINCOLN-DeVORE TESTING LABORATORY, INC.

MAJOR BASIN A

LOCATION			EXISTING			PROPOSED		
Sub basin	Near Point	Street	type Structure	5 Yr. flow	100 Yr flow	Approx. Reqd Structure	Comment	Est. Cost
A-3	2	Blk Forest Road	prestressed conc 15x32 open	600	2520	None	footings undermined	$4400
A-5/7	2	Cowpoke Road	prestressed conc steel center col & precast abut. 20x96	650	2700	None	deep gulch	----
A-14	4	Woodmen Rd.	prestressed conc. 2 steel cols-pre-cast abut.22x118	1675	5753	None	deep gulch	----
A-15/16	7	No Name Powers	None	2745	8756	3-8x14 RCB	corps reqs 4-8x20 RCB	$ 201,400
A-18/19	9	Union	None	2996	9373	7-6x12 RCB	corps reqs 11-6x14 RCB	$ 301,374
A-20/21	10	Academy	5 unit 7x20 RCB	3314	10142	add 1 unit 7x20 RCB	corps reqs 4 addl 7x20 RCB	$ 110,000
A-22	11	Old U.S. Hwy 85/87	Conc. in place 39x100 bet.2piers	3445	10350	None	could be removed	
A-22	11	I-25	Conc.prestr. 2 rows piers 17x121 open	3486	10419	None	patch badly eroded, abut west end	$ 12,000
A-22	11	Old AT & Sf R.R. R/W	2-21.5x22 stone arches	3360	10200	None		
B-13	18	Old AT & SF RR R/W	2-25x21 stone arch	1910 / 2680	5360 / 7810	None	could be removed	
B-13/14	19	I-25	conc.arched w. no piers 24x108 open	2013 / 2790	5527 / 8057	None		
B-14	19	Access Rd.	conc.slab- v-top-185', B-70 h-40 2 piers	2013 / 2790	5527 / 8057	None		

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 1 of 1 D Major Bridge Inventory

LINCOLN-DeVORE TESTING LAB., INC.

LOCATION			EXISTING			REQUIRED		
SUB BASIN	NEAR POINT	STREET	TYPE STRUCTURE	cfs 5 yr.	cfs 100 Yr.	TYPE STRUCTURE	COMMENT	EST. COST.
A-23 B/C	12B	Tuckerman	5x10 RCB	545	1265	add larger dropout Improve inlet	will over-flow @100 years	$4,820
A-23 C/D	12A	Academy Blvd.	9x9 RCB	699	1625	None		------
A-23D	12D	Dublin Blvd.	2-72" CMP	826	1936	8x10 RCB	Alt.-allow 350cfs over-flow onto Dublin entering SW exits.	$30,240
A-23D	12A	Dublin Blvd.	2-42" CMP	---	1484	3-66" RCP(equiv)		$54,000
A-23D	12D	Dublin Blvd.	3-42" CMP	---	1710	3-72" RCP(equiv)		$44,904
A-23D	12A	Aplewood Ridge	-------	---	1452	3-66" RCP		$36,000
A-23D	12A	Channel	None	---	1640	1-7x12 RCB		
B-13	11	Woodmen Rd.	None	271	633	5x10 RCB		$19,150
B-15	entry-PineCr.	Academy Blvd.	6x10 RCB	800	2570	add 6x12 RCB with bend street	should be increased to accomodate Pine Creek	$46,400
B-6/11	16	Academy Blvd.	2-6x6 RCB	1264	3638	Alt.1-upstream retention basins + 78" RCP		$206,595x
B-6	15	None at present	48" RCP	---	---	-----------	will be removed	

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 2 E Major Culvert Inventory

LINCOLN-DeVORE TESTING LAB., INC.

LOCATION			EXISITING			REQUIRED		
SUB BASIN	NEAR POINT	STREET	TYPE STRUCTURE	cfs 5 Yr	cfs 100Yr.	TYPE STRUCTURE	COMMENT	EST. COST.
A-14	4	Woodmen Rd.	42" CMP	40	108	----------	-----	----
A-14	7	Woodmen Rd.	72" CMP	55	146	----------	-----	----
A-16	8	Woodmen Rd.	72" CMP	46	126	----------	------	-----
A-18	9	Woodmen Rd.	54" RCP	93	186	----------	-----	----
A-21	10A	Woodmen & Junice	42" CMP	16	38	----------	------	----
A-21	10	Academy & Shrider	30" CMP(100') 24" CMP (50')	12 --	32 --	----------	add 20', 18" CMP 2-6'CB	$ 460.00 $2650.00
A-21	10	Academy & Collins	30"CMP(100') 24"CMP(50')	15 --	36 --	----------	add 20'-18" CMP 2-6CB	$ 460.00 $2650.00
B-1	14	City limit	———	193	585	72" RCP	crossing inlet	$15108.00
B-1	14	Proposed	———	268	810	4x10 RCB	crossing inlet	$15,276.00
B-2	14	Proposed	———	170	528	3.5x12 RCB	crossing inlet	$19,300.00
B-4	15	Proposed	———	128	385	60" RCP	crossing inlet	$8,954.00
B-5	14	Proposed	———	560	1692	4x18 RCB	crossing inlet	$31,732.00
B-6	15	Proposed	———	---	700	4x12 RCB	crossing inlet	$20,644.00
B-6	City Lim.	Proposed	———	---	760	4x12 RCB	crossing inlet	$20,644.00
B-6	16	Proposed	———	---	1200	2-4x9 RCB	crossing inlet	$23,160.00
B-9	16A	Proposed	———	---	332	54" RCP	crossing inlet	$ 8,917.00

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 2 of 2   E Major Culvert Inventory

LINCOLN-DeVORE TESTING LAB., INC.

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCT.	Est. Cost
A 16	8	None @ Pres.					120	327	30"RCP	240'	3-8'	Conc.ditch	$11904
									24"RCP	330'	2-8'		$ 9765
									18"RCP	60'	2MH'		$ 1970
17	8	None @ Pres.					212	459	42"RCP	700'	2-8' 1-12'	Conc.ditch	$46,470
							201	434	36"RCP	540'	1-8' 1-10'		$27,600
							176	380	30"RCP	420'	2-10' 1-8'		$18,057
									24"RCP	60'	3MH		$ 2,880
									18"RCP	45'			$ 660
18	9	Woodmen & Union	60" RCP	see major culverts		open	176	478	60"RCP	310'		open to Creek	$34,875
							136	377	54"RCP	1300'	2-8' 2-10'		$131,335
							41	103	30"RCP	450'	2-8'		$ 16,883
									24"RCP	550'	2-8' 2-10'		$ 17,875
									18"RCP	165'	4MH		$ 4,593
19	9	Del Paz	24"CMP	180'	1-4' 1-10'	energy dissapator							
19	9	Del Paz	24"RCP	180'	1-6' 1-6'out	street							
19	9	Lange Circle	18"CMP	250'	2-4'	open	14	32	18"CMP	590'		sewer Dublin	(add) $ 8,555
19	9	Dublin Dr.	36"RCP	200'	1-10'	ditch							(under const.)
			24"RCP	400'	2-8'								
			18"RCP	55'									

HYDROLOGIC COMPUTATIONS - Basic Data

 F STORM SEWER INVENTORY

LINCOLN-DeVORE TESTING LAB., INC.

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
A 20	9	Union Blvd.	36"RCP	2070'	3-8'	to creek	53	119	30"RCP	220'	1-10'	Sewer-Union	$ 8,587
			30"CMP	220'	1-12'	to sewer Union							
			24"CMP	150'	1-8'								
20	9	None @ Pres.					70	160	36"RCP	125'	2-8'	ditch to creek	$ 8,625
									24"RCP	290'	1-8' 1-12'		$ 9,545
									18"RCP	80'	1MH		$ 1,710
20	6A		36"RCP	1150'	4-8' 1-16'	to ditch			36"RCP	700'	add: 2-6'		$ 34,800
20	10	Dublin Dr.	42"RCP	140'	1-12' 1-8'	Creek							
			36"RCP	390'	2-8'								
			24"RCP	305'	2-8'								
			18"RCP	80'									
20	10	Dublin - Academy	39x66" CMP	110'		Creek							
			36"CMP	220'									
			24"CMP	460'	1-10' 1-12'								
			18"CMP	100'	1-4'								
20	10	Dublin Loop	18"CMP	215'	1-2'x3'	Creek							
21	10A	Stinson Rd.	66"RCP	820'	5-3'Ø grated MH	Creek	60	143	Add: 42"RCP	180'	1-12'	exist. sewer	$12,738
			24"RCP	100'			40	94	30"RCP	450'	2-10'		$17,483
			12"RCP	80'			20	49	24"RCP	680'	2-8'		$16,940

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
A 21	10	Rosewood	48"RCP	590'	3-3'Ø grated MH	Creek							
			42"RCP 27"RCP	400' 80'	1-40"x66" Grate				Add: 24"RCP	100'	1-12'	exist. sewer	$4,150
21	10	Academy	24"CMP	260'	1-2'x3' Grate	Creek							
21	10	Brookwood ease	48"CMP	140'	1-4'	Creek							
			30"x48" CMP	60'	open								
22	10	Academy/ Woodmen											
							97	215	48"RCP	540'	1-10'	Ditch	$47,158
			27x42" CMP	100'		Connect	74	166	42"RCP	800'	4-8' 1-12'		$58,000
			22x36" CMP	310'		Connect			36x58" CMP	610'	1-8'		$52,009
			24"RCP	200'			53	119	22x36" CMP	450'	2-8'		$19,083
			24"CMP	120'	2-4'				24"RCP	420'	6MH		$11,910
22	10	Knight	24"CMP	140'	1-8'	Creek							
22	10	Prince	13x22 CMP	250'	2-4'	Ditch							
23A	12C	Cortina	36"RCP	530'	1-8' 2-16'	1-20' out to st.							
23A	12C	Vickers	72"CMP	400'	2-10' 1-HV 2-12'	open							damaged
			60"CMP	410'	3-8' 2-10'								damaged
			54"CMP	860'	4-8'								
			42"CMP	1370'	2-6' 3-8'								
			36"CMP	980'	10-16' 4-8'								

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
			30"CMP	94'	1-10'								
			27"CMP	105'									
			24"CMP	380'									
A 23B	12B	Vickers	24"CMP	80'	2-12'	open							
23B	12B	Maroon Bells	30"RCP	120'	1-16'	ditch							
			24"RCP	110'	3-8'								
23B	12B	Maroon Bells	30"RCP	130'	1-12'	ditch							
			24"RCP	110'	2-8' 1-10'								
23C	12A	Ptarmigan Ln.					14	32	21"RCP	510'	2-4'	ditch	$ 10,615
			18"RCP	190'	2-4'								
23D	12A	Dublin	30"CMP	55'	2-16"x 28"grates	ditch							
			21"CMP	35'									
23D	12D	Dublin	30"CMP	190'	2 grates 16x28"	ditch							
23D	12A	Lemonwood	18"CMP	300'	1-6' 1-4'out								
A 13	5/6	None					125	332	42"RCP	700'	4-10' 1-8'		$ 54,570
							91	244	36"RCP	1400'	1-10' 1-6'		$ 66,100
									24"RCP	150'	1-4'		$ 4,175
									18"RCP	50'	3MH		$ 2,375

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
A 23	12A	None @ pres.					44	107	36"RCP	400'	4-6'	ditch	$23,200
							35	86	30"RCP	400'	2-10'		$15,940
B 1	14	None @ pres.					54	162	48"RCP	1780'	4-8' 4-10'	ditch	$150,082
							40	108	42"RCP	1100'	2-8' 3-10'		$73,410
									24"RCP	280'	4MH		$ 7,940
2	14	None @ pres.					119	368	54"RCP	600'	2-12'	ditch	$61,770
							81	248	48"RCP	850'	1-8' 2-12'		$71,065
							60	187	36"RCP	580'	1-6' 1-8'		$28,900
									24"RCP	170'	1-10' 3MH		$ 6,935
4	15	None @ pres.					89	266	54"RCP	700'	2-8' 2-10'	ditch	$70,165
							75	218	48"RCP	700'	2-8'		$60,430
							61	183	42"RCP	680'	1-6' 1-10'		$43,288
							50	154	36"RCP	700'	1-12' 2-10'		$37,200
									24"RCP	220'	4MH		$ 6,710
6	16	None @ pres.					85	246	48"RCP	550'	1-12' 2-10'	ditch	$47,995
							62	176	36"RCP	400'	2-10'		$21,600
									24"RCP	490'	2-8'		$13,045

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
									18"RCP	45'	3MH		$ 2,303
B 6	16	Jamboree	27x43CMP	240'	1-10' 1-12'	RCB			(remove)				$ 720
			42"CMP	165'		RCB			(remove)				$ 495
							390	1003	96"RCP	240'	2-10' 2-12'	RCB	$ 84,702
10	17	N.Branch- Academy					90	232	(twin) 48"RCP	(total) 4200'	1-8' 4-10'		$332,820
			twin 29x42CMP	210'	5-6'	sewer-	reduced to above						
			48"CMP	2400'	6-6'								
			42"CMP	510'	open								
			30"RCP	1020'	7-6' 1-4'								
			24"RCP	440'	1-4' 11-6'								
10	17	Briargate	48"CMP	680'	3-10' 2-30'	Det.Pond							
			42"CMP	660'	2-8' 2-10' 2-14'				(UNDER CONSTRUCTION)				
			30"CMP	160'									
10	17	S. Branch Academy					102	270	54"RCP	630'	2-10'	sewer- outfall-12	$ 65,489
					change 2-6		86	212	48"RCP	1400'	2-6' 3-8'		$114,760
			36"RCP	200'	1-12'	into 54"right	61	152	30"RCP	1350'	1-6' 2-8' 1-10'		$ 45,948
							34	85	24"RCP	660'	1-6' 1-8'		$ 18,130
									18"RCP	170'	5MH		$ 5,215

LOCATION			EXISTING				COMP FLOW		REQUIRED				
SUB BASIN	NEAR POINT	STREET	PIPE	LENGTH	CB	OUTLET STRUCTURE	5 Yr.	100 Yr.	PIPE	LENGTH	CB	OUTLET STRUCTURE	ESTIMATED COST
B 11	16	Kelly Johnson						1950	78"RCP	1020'	open 1-MH	special entry to ditch	$235,594
11	18	Kelly Johnson	48"CMP	470'	1-12'	ditch							
			30"CMP	90'	1-12'	ditch							
12	17	Cragin Rd.					188	492	72"RCP	1470'	2-10' 2-MH	ditch	$262,244
13	20	Collins Rd.					76	178	42"RCP	580'	1-6' 1-8'	RR ditch	$ 37,078
									24"RCP	80'	1-10' 1-12'		$ 5,540
13	20	Shrider Rd.					92	234	48"RCP	760'	1-8' 1-10'	RR ditch	$ 61,744
							69	179	36"RCP	620'	1-8' 2-12'		$ 33,000
									24"RCP	100'	2MH		$ 3,150
13	20	Ven Horst Rd.					78	188	42"RCP	760'	1-4' 1-10'	RR ditch	$ 47,816
							60	144	30"RCP	630'	1-8' 2-12'		$ 25,135
									24"RCP	100'	2MH		$ 3,150

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 7 of 7 F STORM SEWER INVENTORY

LINCOLN-DeVORE TESTING LABORATORY, INC.