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

August, 1978

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

Re: ENGINEERING STUDY OF

COLUMBIA ROAD DRAINAGE BASIN

COLORADO SPRINGS, COLORADO

Gentlemen:

Enclosed herewith is the report concerning the engineering study of the Columbia Road 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 report includes an overview of the basin geology, the rainfall runoff characteristics, and the channel improvements which exist within the basin. Some additions to the existing improvements are noted in the report, together with some upgrading of existing facilities.

The study may be used as a master plan for drainage improvements in the basin and for a plan of improving existing structures which are inadequate. The recommendations should be used as a guide, not as a specific design for a given structure.

Respectfully submitted,
LINCOLN-DeVORE

George D. Morris, P. E.

LDTL Job No. 21430

2700 Highway 50 West
Pueblo, Colo 81003
(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

TABLE OF CONTENTS

SCOPE AND REQUIREMENTS OF THE STUDY:

The Columbia Street Basin has not been studied as a complete unit, insofar as can be determined. Smaller, individual areas and subdivisions filed drainage plans or constructed various structures and ditches. These were apparently designed using quite variable criteria for rainfall and runoff.

The developed area has grown randomly over the years around the major thoroughfare - Columbia Road. At one time, this road connected US Highway 24 (Colorado Avenue) with the road system of the Garden of the Gods Park. With the advent of the elitist movement, however, this connection is now severed and the area has become a "dead end" cul-de-sac-environment. Growth has taken place in the form of individual residences, most of which were constructed above major stream beds. Some confinement of flow in the major stream area has been completed, mostly on an individual basis.

The purpose of this study was to determine the location and capacity of these individual drainage structures, compute the probable flow at various points and to recommend changes in control structures should they be required. To accomplish this, no new road systems were assumed, since there is very little room in the basin for new, major subdivisions or roadways. There is room for additional residences, so it was assumed that most of the area will be developed with - at the least - single family residences averaging 1/4 acre in size.

The major drainageway through the developed area is obvious as to its location. As such, it was taken to be a greenbelt in the sense that the City of Colorado Springs has used the term for drainage design. One major purpose of this report is to point out that the drainageway is much too confined and should be developed to true greenbelt status - which involves wider rights of way.

The intent of this study is to determine the adequacy of the existing drainage system using the present City of Colorado Springs criteria for rainfall and runoff. After this has been noted, improvements and changes are to be recommended for safely disposing of the runoff within the basin. The concepts of rapid removal of water via paved ditches and abandonment of the retention method allows for higher peak flows and rapid water removal. Required structures will be somewhat larger, in brief, simply because the natural channel which now exists will be paved.

The intent of this study is not to establish precise locations or design for storm sewers, ditches or other appurtenances except where the stream already exists. It is intended to establish the general location and size of such drainage appurtenances. The structure and channel sizes shown in this report have been calculated from flows resulting from the City of Colorado Springs method of Rainfall-Runoff computations.

At the time of this study, most of the streets which can be placed in the area are constructed as gravel base roads. Columbia Road is paved. A few future roads can be placed in the basin, but these will be quite restricted in number and location. Since the advent of the elitist movement, new roads in the Park area are out of the question. Therefore, no attempt at replanning areas has been made. It has been assumed that water will flow in existing gullies and valleys without major change or correction by man-made obstacles.

BASIN DESCRIPTION:

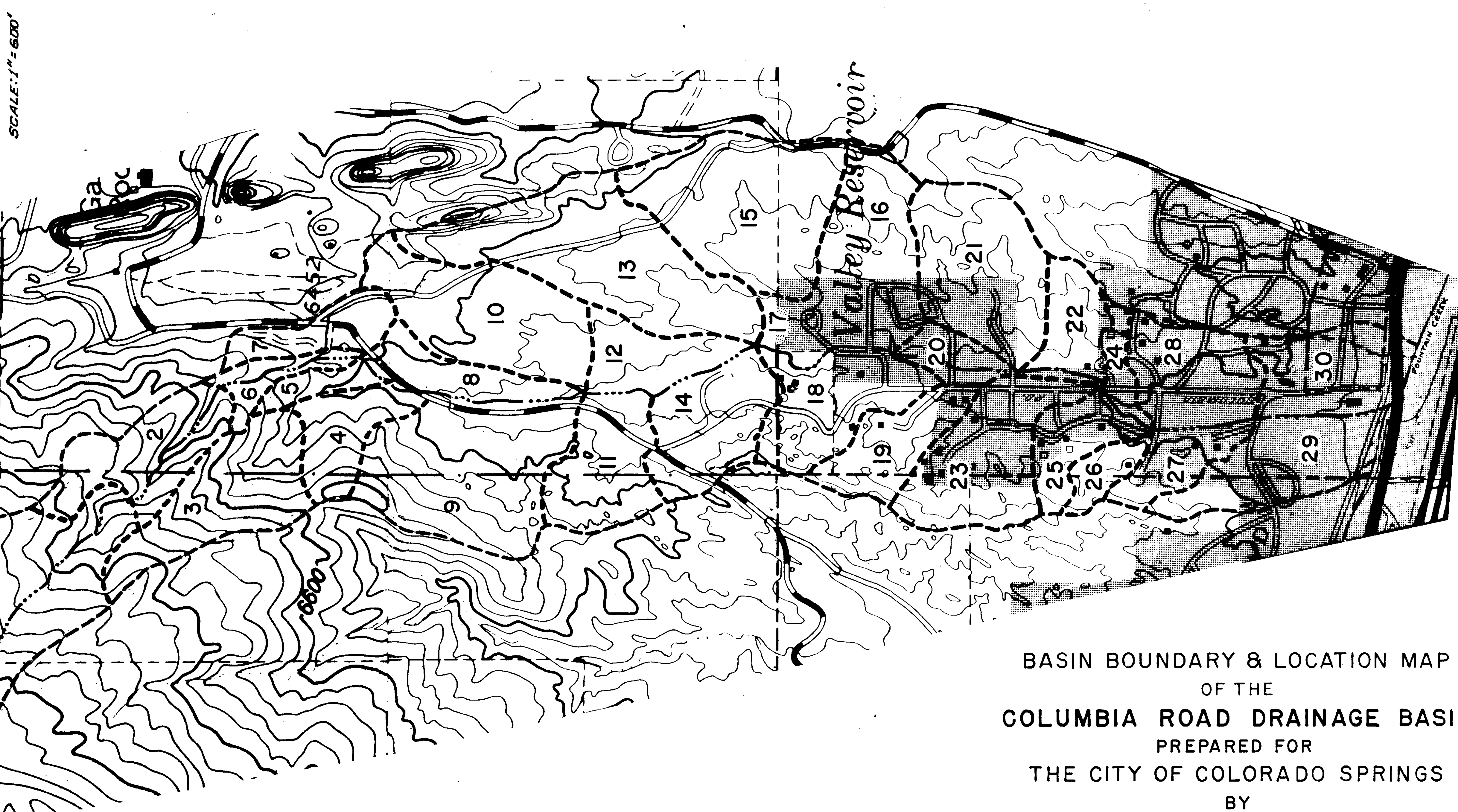
The Columbia Road basin contains approximately 0.62 square miles and lies in the extreme westerly portion of the City of Colorado Springs. A small area of the basin lies within the boundaries of the City of Manitou. The city limits lines are not well defined in the area and small portions of the basin may still be in the jurisdiction of El Paso County.

The eastern basin line is defined by a ridge separating it from the basin of Camp Creek. Ridge Road is rather generally constructed on this ridge line and is the boundary at some points. The southern most high ridge rock in the gateway group defines the boundary at its northeasterly corner. The ridge between this basin and the Camp Creek basin then extends north westerly up the foothills of the Front Range of the Rocky Mountains. The western basin line is defined by a rather steep ridge separating it from an unnamed basin to the west draining the western portion of the Park. The south basin boundary is Fountain Creek, which serves as the outfall.

The basin is a "foothills" type basin and is along the front edge of the mountains. The soil is such that it does not have the high infiltration rate associated with most foothill basins. The topography of the developed portion of the basin is that of a narrow valley between two steep ridges. The topography of the park area is more variable. Except for the east hogback, no very steep ridges exist, but the topography is more typical of the mountain front. Small hills separate rather small valleys in the lower portions of the Park. The northern portion of the Park area is simply the face of the mountains.

Nearly all of the valley areas are covered with thin alluvium and colluvium, the source of which is the hillsides and ridges around each small valley. This alluvium tends to be transported during storms and is now eroding the valleys in the Park area and depositing it in the developed area to the south. Although not generally believed these days, this is a natural process and has been taking place for many years. The basin is very distinctly outlined physically with the single exception of the southeastern subbasin. Development has changed the direction of flow here, and a portion of the basin does not contribute surface flow directly to the outfall. It has been included in this basin report, however, since it will affect the basin use to a degree.

The drainage pattern through the basin is basically dendritic and is very simple in outline. The flow is collected in the main "stream" quite rapidly and flows thence to the outlet. A number of side tributaries enter this main channel, but only a very few contain large amounts of runoff water. It should be noted that the channel and the tributaries are intermittent in nature and do not carry water most of the year.



BASIN BOUNDARY & LOCATION MAP

OF THE

COLUMBIA ROAD DRAINAGE BASIN

PREPARED FOR

THE CITY OF COLORADO SPRINGS

BY

THE LINCOLN — DeVORE TESTING LABORATORY COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison. WYOMING: Rock Springs		
Drawn by: NMB	Scale: 1" = 600'	Date: 8-15-78
Checked by: RNM	Contour Interval: 40 FT.	Revised

BASIN GEOLOGY, SOILS AND WATER TABLE:

Although the Front Range fault and numerous hogbacks exist in the area nearby, the geology of the basin is relatively simple. Most of the basin is underlain by the Fountain Formation, which is a series of deep red to maroon or white sandstones and shales. The two rock units are interbedded so that the normal sequence changes from sandstone to shale to sandstone. In general, the shale member is thicker than the sandstone members.

The alluvium and colluvium generally found at the surface of the ground is usually a mixture of both of these members. The shales are formed of silty clays, for the most part. The sandstones contain sand, of course, but also contain a great deal of clay as a binding material. As a result, the basic soil throughout the basin is a sandy clay. Some variations can be found, of course. The clays are quite silty and their shear strength is such that the material can stand nearly vertical for heights up to ten feet. Eroded ditches in the Park area show this phenomenon quite graphically. Fairly broad valleys are found in which the erosion has been confined to one relatively narrow channel with near vertical sides.

In general, the shales erode easier and faster than the sandstones. It should be noted, however, that the sandstones are quite erratic. Most of the sandstone layers are relatively weak and easily eroded. Some very hard lenses can be found which remain resistant to weathering even when all surrounding material has been removed. The locations of some of the more resistant layers have had a distinct effect on the main drainage and flow channelization.

A few other formations can be found in the extreme eastern portion of the basin. The Lyons and Lykus formations which form the Gateway group are more sandy (in general) than the Fountain formation. These occupy such a small portion of the basin that their effect on soil types and infiltration is minimal. In the same manner, the fault system found in the far eastern portion of the basin has a minimal effect on the general drainage. Its effect is limited to forming two rather small valleys - one of which directs water <u>away</u> from the basin, rather than toward it.

Two other soil types are found in the basin. Both of these are sands and gravels, primarily. The first is the Nussbaum alluvium found in a small section of the basin at the extreme north. This material has a high infiltration rate and tends to collect water and store it rather than releasing it immediately. Here again, this covers a small portion of the basin and its effect on total flow is small.

The second sandy deposit is that of the Piney Creek Alluvium. This is found in a relatively narrow band along the banks of the Fountain Creek. This has been deposited by the creek and can be considered a creek terrace. At this location, the creek deposits are not as broad as further to the east. The band of alluvium is relatively narrow at this point, being confined to that area below Pikes Peak Avenue. This material allows good infiltration unless covered. It does help the flow by absorbing some of it north of Fountain Creek. In general, however, this material also covers such a small area that its effect on the basin is small.

The basic soil within the basin then is a slightly sandy, silty clay. Proportions of the various materials vary considerably from point to point. Some areas may contain sizeable deposits of sand while others are primarily clay lenses. Water can infiltrate rapidly and disappear from the channel at points which are primarily sands. The water will eventually saturate the sands, however, since they are all underlain by clayey material. The net affect is that the soil will act as a hydrologic group C soil. The two sandy alluviums at the north and south extremities of the basin will act as hydrologic type A soils.

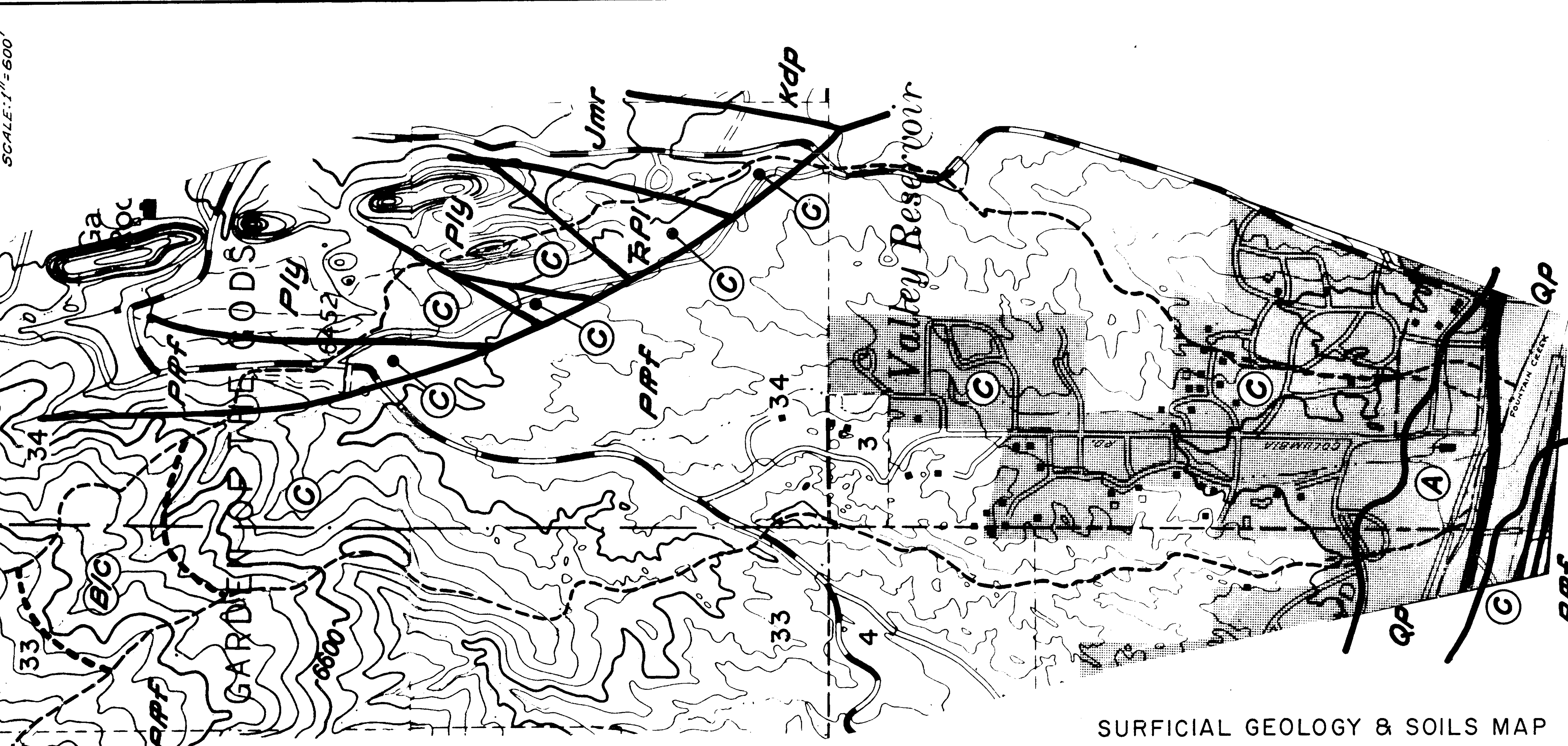
The surface soils (upper 5') were mapped in general throughout the basin. A few samples were taken, but most mapping was visual. Some previous test borings in the basin were referenced. The soil types were mapped and compared with the SCS soil survey. As usual, correlation was fair at best, but considered reasonable. A survey of compacted areas was made, but it was found that compaction had no measurable effect on basin drainage. The only truly compacted areas were streets and roadways.

The geology and soil types within the basin will produce runoff which is quite high for the area involved. Most of the soils do not allow rapid infiltration and formational rock is fairly close to ground surface.

The true free water table under the basin is quite deep. Such a free water table will have no affect on the surface drainage of the basin. No data could be obtained concerning the depth to free water in the basin, but it is well in excess of 200' except in the Fountain Creek Terrace.

It must be noted, however, that formations of this type are such that perched water tables can be readily formed at various points in the upper 100' of the soil profile where rock conditions are correct. If water collects in a basically sandy area which is protected by shale or dense sandstone, the water can collect on a semipermanent basis. The source of this water is rainfall and drainage, of course, so that the perched water feature cannot be considered permanent. Under normal circumstances, it would be a seasonal phenomenon.

Due to its location close to various residential and commercial uses, the stream bed in the developed portion of the basin may be affected by the occasional presence of such perched water tables. This would be found primarily at the southern end of the basin, particularly south of Holly Street.



DESCRIPTION:

Qp.... PINEY CREEK ALLUVIUM (QUATERNARY) - CLAYEY SILT AND SAND.
Qn.... NUSSBAUM ALLUVIUM (QUATERNARY) - LOOSE SAND AND PEBBLE GRAVEL.
Kdp.. DAKOTA SANDSTONE AND PURGATOIRE FORMATION (CRETACEOUS) RESISTANT YELLOW-BROWN SANDSTONE WITH INTERMEDIATE SHALE.
Jmr... MORRISON AND RALSTON CREEK FORMATIONS (JURASSIC) - GRAY, MAROON, AND GREEN SILTSTONE, CLAYSTONE, SANDSTONE, LIMESTONE, CONGLOMERATE, AND GYPSUM.
ƦPl... LYKINS FORMATION (TRIASSIC-PERMIAN) VARICOLORED SHALE, SANDSTONE, LIMESTONE, GYPSUM.
Ply... LYONS SANDSTONE (PERMIAN) - RED AND GRAY RESISTANT SANDSTONE (GATEWAY ROCKS)
PPf... FOUNTAIN FORMATION (PERMIAN-PENNSYLVANIAN) MOSTLY RED-BROWN ARKOSIC CONGLOMERATE, SANDSTONE, AND SHALE.

BOLS
Y RUNOFF
ON-MEDIUM RUNOFF
IGH RUNOFF

SURFICIAL GEOLOGY & SOILS MAP OF THE COLUMBIA ROAD DRAINAGE BASIN

PREPARED FOR
THE CITY OF COLORADO SPRINGS
BY

THE LINCOLN — DeVORE TESTING LABORATORY COLORADO Colorado Springs, Pueblo, Avon-Vail, Gunnison. WYOMING Rock Springs		
Drawn by: NMB	Scale: 1" = 600'	Date: 8-15-78
Checked by: RNM	Contour Interval: 40 FT.	Revised:

RAINFALL AND RUNOFF PATTERNS:

Unofficial records in the vicinity indicate that the basin receives precipitation at a higher annual rate than the NOAA Colorado Springs averages would indicate. Much of this is in the form of snowfall, however, which has a much slower runoff rate than the average summer thunderstorm. The total precipitation in this basin is slightly over 15-1/4 " per year (38.7 cm). About 1/3 of this, on the average, is in the form of snowfall.

As is true of most of the area, precipitation in the basin is normally greatest from May through August and comes in two forms: 1) the slow, four day "upslope" storm condition, which can produce high precipitation, but over longer periods of time and 2) the intense thunderstorm, of short duration but of sometimes very high intensity. Of these storm types, the high intensity, short duration thunderstorm will produce the greatest runoff in a small basin and is the storm for which City of Colorado Springs drainage structures have been designed for over 15 years. (The so called Type IIA storm now used as a local criterion is called a "six hour storm" but its actual duration is practically identical to the old one hour duration thunderstorm which was the criteria up to 1972.)

This basin is sufficiently small that all storms other than the intense thunderstorm can be discarded for design purposes. The location of the basin is at the face of the Front Range, but none of the basin is truly a part of that range. The mountainous area does not often receive the very intense thunderstorm considered in the design criteria. In addition, the infiltration of water in the broken granites is high so that more water is stored and less allowed to runoff. At least locally, damage in basins which head in the mountains is not so much a function of vast amounts of flood water as it is a function of building structures too close to and even in the streambed.

The subject basin is a considerable distance from the "major storm line" which the record indicates exists about 10 miles east of the mountain front. Heavy, although, smaller storms have centered about 2-3 miles east of the mountain front, one in 1965, one in 1967 and most recently, in July 1978. Although not as large as the storms which tend to center further east, the subject basin could easily receive a storm almost as large as that anticipated by city criteria. The basin is also not typical of the mountain areas and would produce a greater runoff (and peak flow) than the average mountain headed basin.

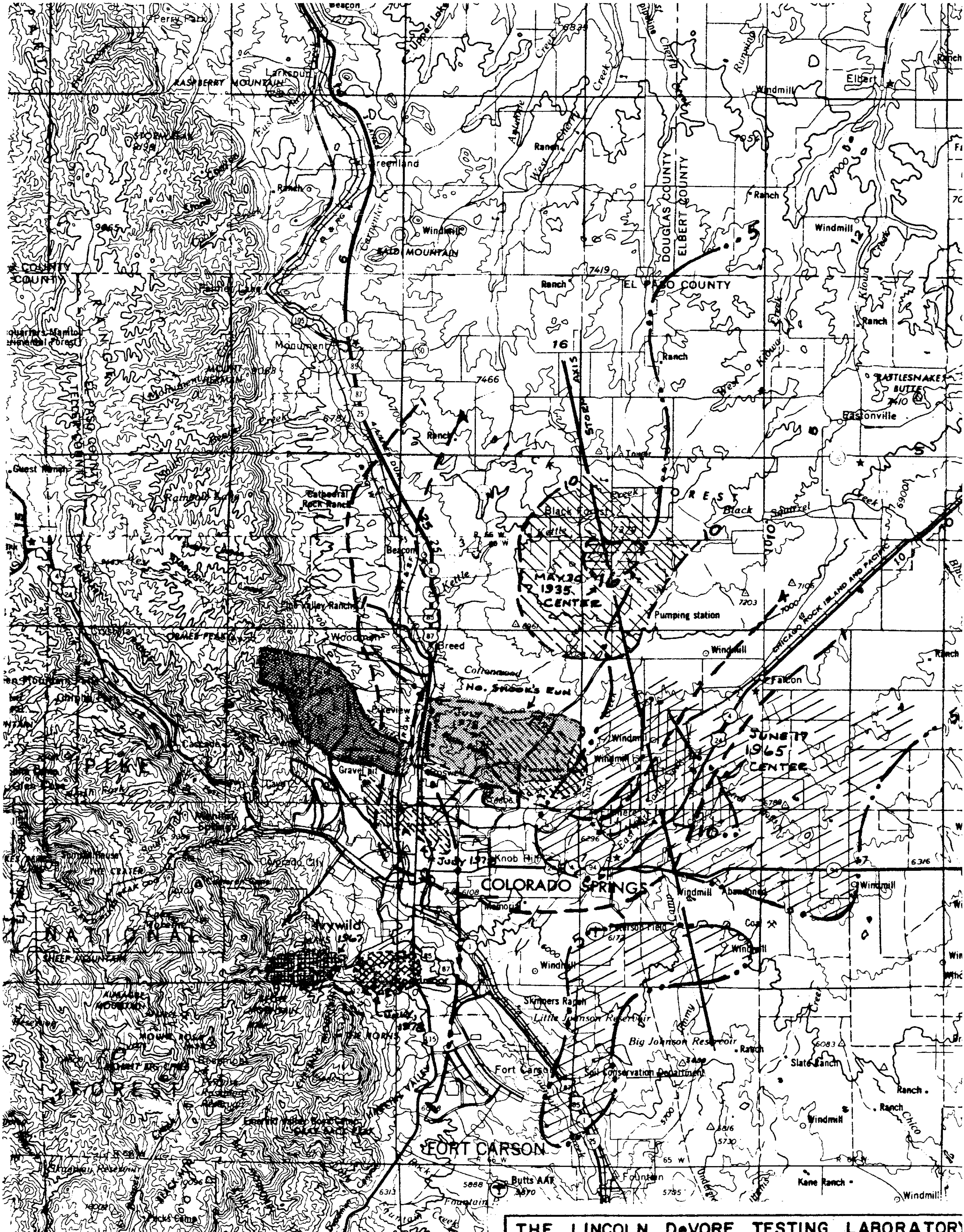
Several storm patterns were examined over this basin. It was determined that the worst storm type for the developed area would be one which was centered over the park at about point 5A on the attached map. Flood peak was checked for this location and for one at the basin head and one centered on the developed area. Although the duration and intensity of the storm is regulated by specifying the so called Type IIA storm, two other intensities and durations were checked to determine if this had any major effect on the location of the strom center. It was found that it did not have any appreciable effect.

It is not known for what storm intensity and duration the major culverts and drainage channels were designed. In fact, it is not even known whether these drainage appurtenances were designed. Analysis of the area, using a "Type IIA" storm centered at about point 5A, shows that, in fact, most of the channels and drainage structures within the basin are sufficiently large to take even the 100 year runoff flow. A few notable exceptions were also found.

A typical runoff hydrograph was computed for the outfall point of the basin, assuming unobstructed flow through the basin. This shows graphically, the amounts of runoff which could be expected at any given time during a 100 year frequency storm at this point. It should be noted that the hydrograph must be modified considerably from its theoretical shape to fit the criterion of a "Type IIA" storm.

No measured runoff data exists for this basin. A small weir structure was found in the ditch north of Pikes Peak Avenue. However, neither the ownership nor the builder of the weir could be determined. If records exist of measured flow at this point, they could not be located.

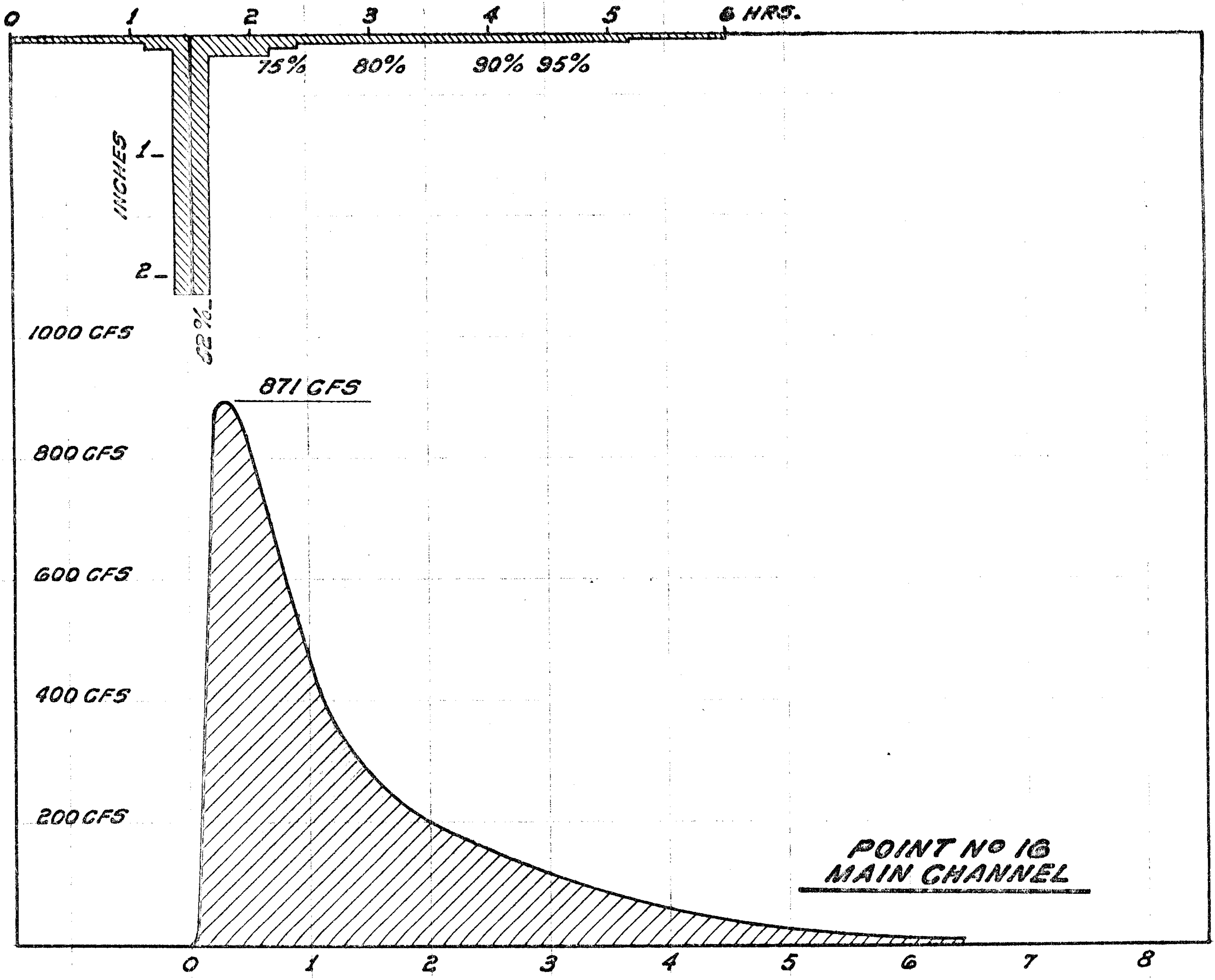
The major basin is sufficiently small and with such a straight-forward drainage pattern, that it was not divided into major basins. It was divided into 30 minor basins for purposes of computation. An outfall point was assigned to each and the peak flow computed at that point. Some additional points were placed along natural channels and greenbelts. The flows peak from each subbasin were added taking stream flow time into consideration until the maximum peak flow in the major green belt was determined. This was accomplished using both the routing method and the city method. It was found that with a few exceptions, major flooding is not a problem within the basin at this time.



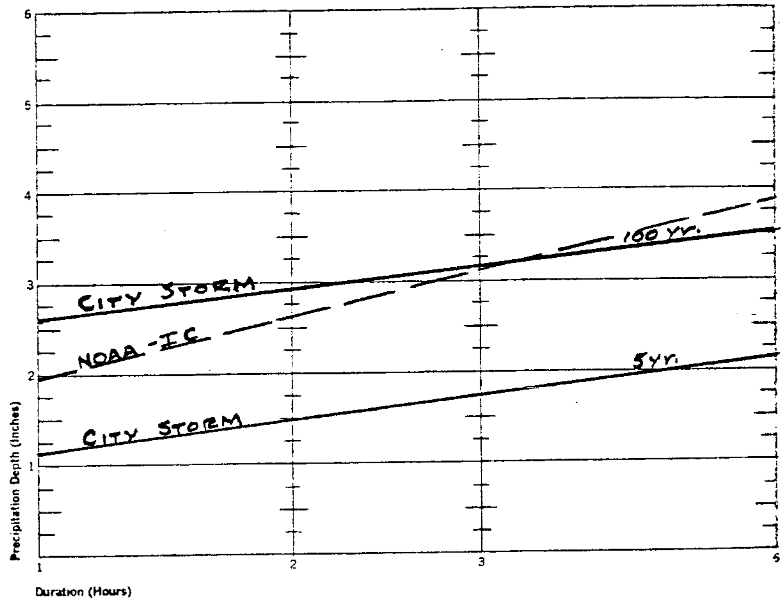
THE LINCOLN DeVORE TESTING LABORATORY

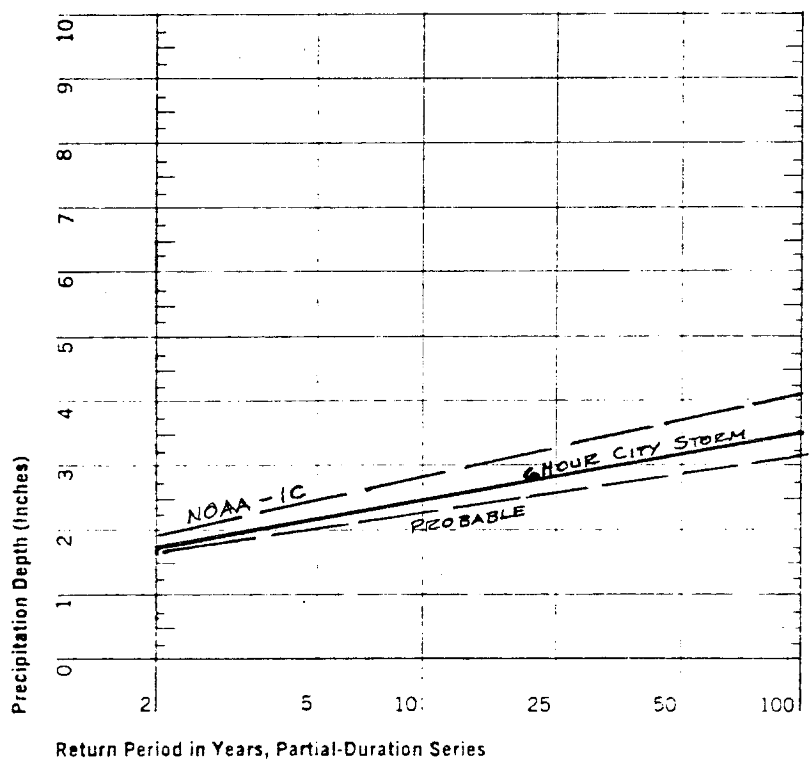
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison.

WYOMING: Rock Sprin



0
1
2
3
4
5
6 HRS.
75%
80%
90% 95%
INCHES
1
2
82%
1000 CFS
871 CFS
800 CFS
600 CFS
400 CFS
200 CFS
POINT No 16
MAIN CHANNEL
0
1
2
3
4
5
6
7
8





RAINFALL DURATION & FREQUENCY WESTERN COLORADO SPRINGS, COLORADO	THE LINCOLN-DeVORE TESTING LABORATORY COLORADO: Colorado Springs, Pueblo, Glenwood Springs, Montrose, Gunnison. WYOMING: Rock Springs

EXISTING DRAINAGE STRUCTURES:

The subdivisions within the developed portion of the basin are all small. Some of the subdivisions are quite old and have been built up for some time. Not all of the older subdivisions were constructed, probably due to difficulty in road construction on hillsides. Some of the buildings are constructed on tracts rather than on subdivision lots. Buildings have been constructed regularly - if somewhat slowly - for a number of years. Very little of the non-park acreage is open to development or unsubdivided.

As a result, some drainage problems have occurred in the area and drainage structures constructed to relieve the problems. It is not known whether these structures were built by a public agency or by individuals to correct immediate problems. The main RCB crossing Columbia Road on the greenbelt route is a county box to protect the Road. It is adequate in size. An RCB constructed near the entrance to Garden Drive appears to also be county constructed box, but it is not adequate in size. The bridge across the greenbelt at El Paso Street (Pikes Peak Avenue) is also adequate and probably of state or county origin.

The drainage structures in the basin appear to be of various ages and appear to have been constructed in response to some past drainage problem. The greenbelt is crossed by RCB's, surface level fording dips, bridges, culverts and in one case, a wooden bridge (at Columbia Court). No real coherent pattern emerges from the analysis of these structures other than at one time flood damage took place and the structure was built.

The "greenbelt" channel shows the same type of construction. At some point, it has been confined by concrete or block walls, while at other points, it is a natural earth ditch. It is probably an earth ditch at those points at which the runoff has been no problem to anyone. At points where the channel is walled in, residences are found quite close to the channel. The inference is obvious.

At any rate, the walled portions of the channel are not of any uniform material or of any rational size. In all cases, the size is adequate for the computed flow, but very wide channels have a tendency to empty into narrow channels. Some channels have square turns and at one point, a relatively large stilling basin exists. The result, of course, is very erratic flow. At some points turbulence and ponding causes back-water rise, while at others, velocity drops and sand and silt clogs the adjoining structure.

All of this existing channel construction should be improved for steadier flow. If costs are too high, however, in most cases the now "improved" channels could be allowed to remain and the unimproved sections paved.

One portion of the channel _must_ be improved. That section passing through the trailer campground south of El Paso (Pikes Peak) is far too small for safety. This section has a ditch right of way easement passing through it, although it did not appear that the existing ditch was entirely within the easement. From a flood hazard point of view, this undersized ditch and culvert could allow the campground and some land above it to be flooded if not enlarged. (See problem areas)

The walled sections of the "green belt" channel are in reasonably good condition, even when constructed of concrete block. Block is not a good construction material for channel sides unless heavily reinforced, however. This did not appear to be reinforced and portions of the block walls were leaning or bulging into the channel.

All major structures along the "green belt" channel were in good condition except for the wooden bridge at Columbia Court. For drainage purposes, this bridge has a large enough opening. The bridge is too narrow, however, and in poor structural condition.

In the park portion of the basin, drainage appurtenances consist of culverts across the three roads (one abandoned) in the basin. One of these was a small RCB. All but one small metal culvert were found to be of the proper size for the drainage area above. Several of these culverts were badly silted, however, and should be cleaned.

All ditches in the park area are natural erosion ditches. Work is presently being done to protect walkways, but no work appears to be in progress on protecting the ditches and preventing further scour and erosion. Silting appears to be a problem throughout the basin due to low flow and erratic velocity.

RECOMMENDATIONS:

MAIN CHANNEL - GREENBELT

Most of the improvements required in this basin are along the main channel. Although quite narrow throughout the developed area, a continuous channel does exist. It should be improved at all possible points and designated as a "greenbelt".

The City drainage criteria for drainage construction can be paraphrased as follows: 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 (1% chance) frequency projection is for less than 500 cfs, all structures will be designed for the 5 year (20% chance) frequency flow. Computations indicate that the 500 cfs flow in the main channel is reached at approximately point 8 on the map, or slightly to the north of the developed area. According to this criterion, the main channel and all structures across it in the developed area should be designed to pass the 100 year frequency flow. For the most part, this is the case.

- At Garden Drive, a short RCB with an overflow to the street is not adequate for the 100 year flow. The overflow would allow for too much water onto the street. This box should be enlarged or added to. Right of way exists.

- At both Arnold Street and Arnold Lane, the main ditch is crossed by "at grade dips" of concrete and asphalt. These should eventually be replaced with RCB structures, although they are adequate for the projected flow as they are. That is, the roads will erode and require repair, but surrounding areas will not be flooded. Right of way exists.

- The timber bridge at Columbia Court has already been discussed. The drainage way is adequate, but the bridge should be replaced for size and safety reasons. Right of way exists.

- The RCB across Columbia Road is adequate.

- The "at grade dip" at Holly Street should be replaced with an RCB structure. (See discussion for Arnold) Right of way exists.

- The weir south of Holly Street should be removed as a channel obstruction. No right of way.

- The bridge at El Paso (Pikes Peak) is adequate.

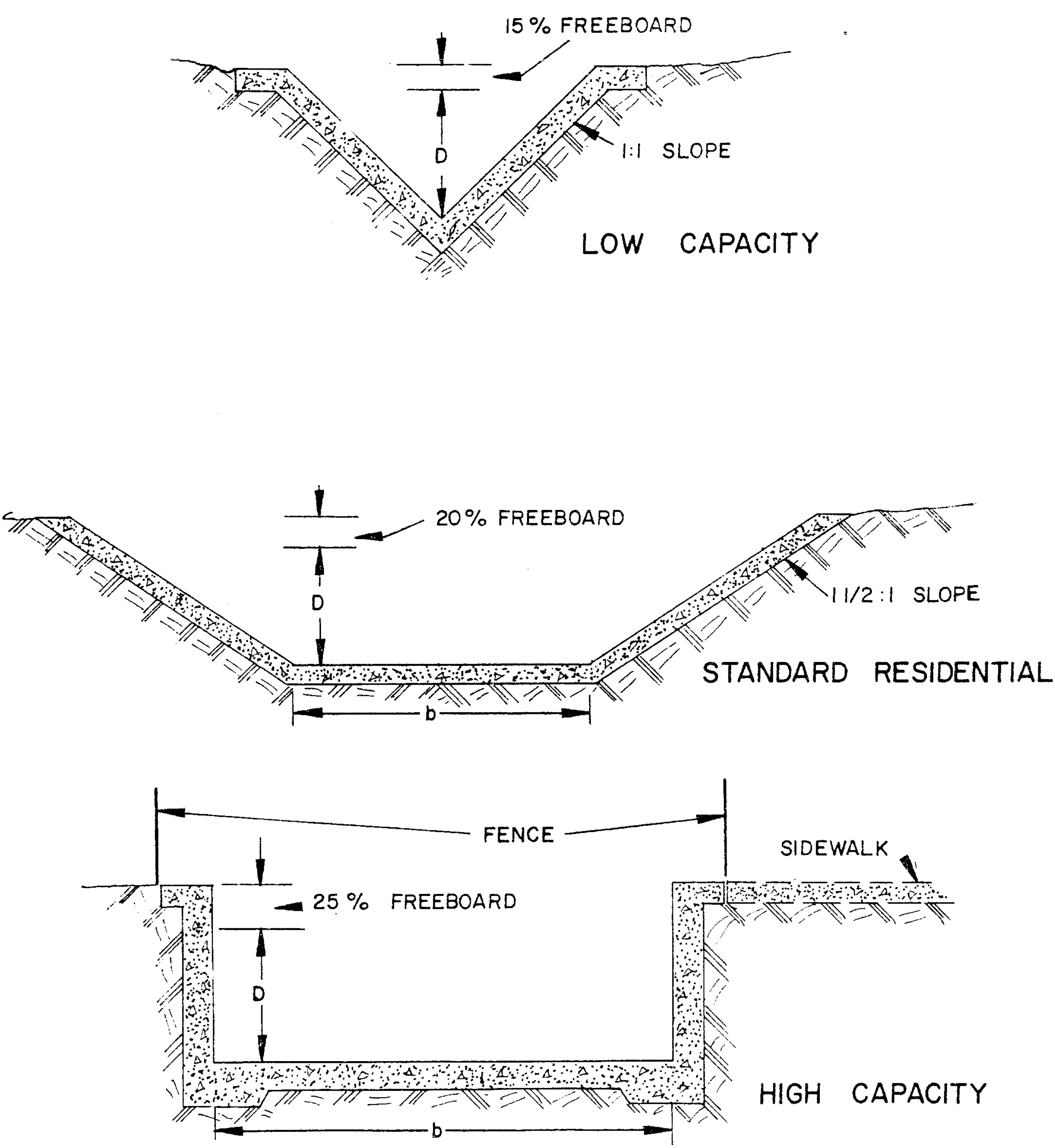
- Culvert at trailer campground internal entry is far too small and should be replaced with an RCB. Right of way exists but is quite restricted. Drainage is by easement only. (See problem sections)

- The steel and timber bridge at the city railway right of way (near Colorado Avenue) is adequate for width but should be deepened and paved. Right of way unknown.

The main ditch between these structures should be paved as a reasonably uniform section to smooth the flow and eliminate, if possible, some sharp turns. Velocity along most of this ditch is and will continue to be relatively high, so that velocity steps are recommended. As previously stated, the existing construction could be left in place to lower costs and only those unimproved sections constructed. The improved sections are relatively short, however, so the saving would not be high.

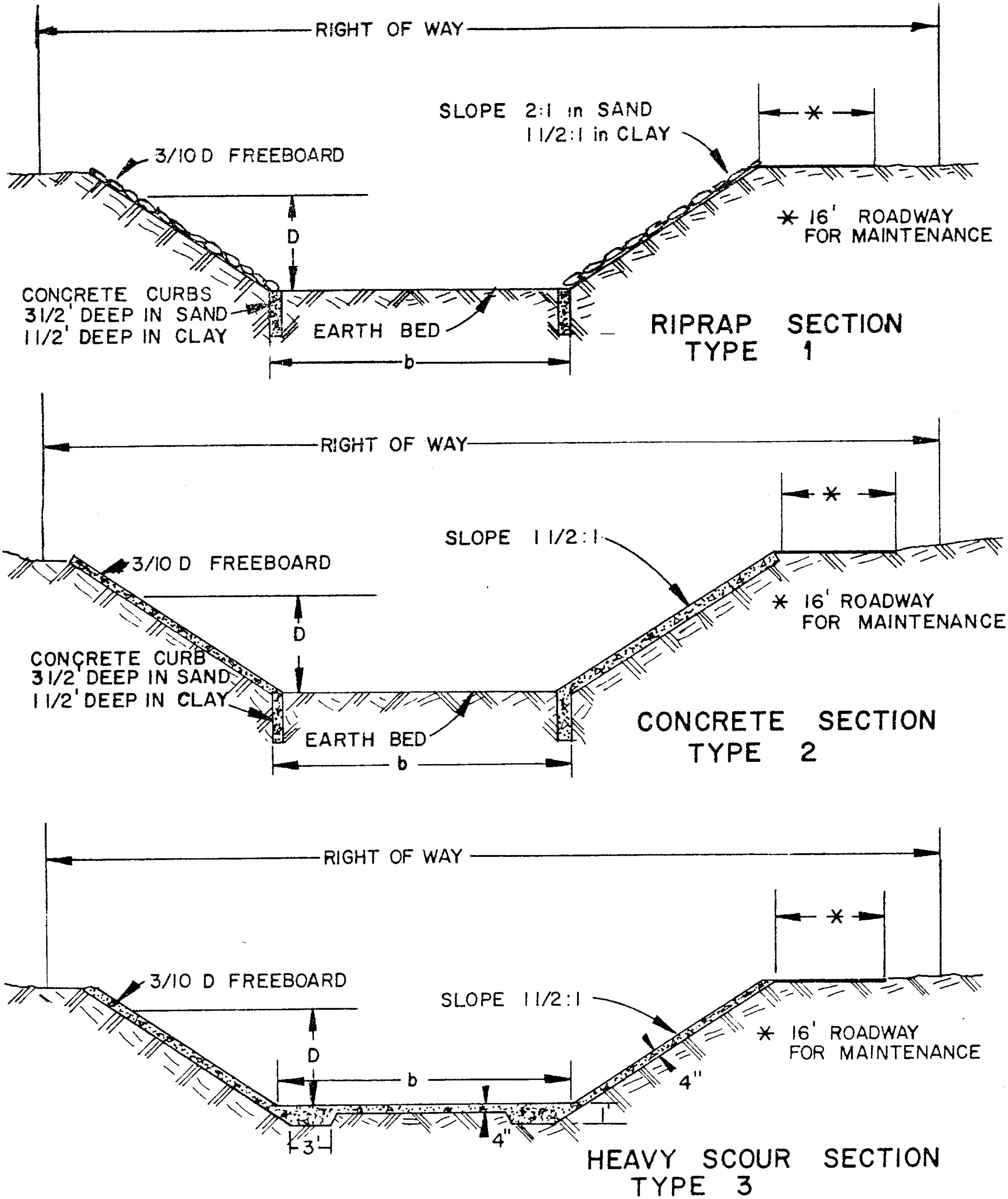
Since the developed portion of the basin consists of residential units close to the main channel, fencing across the channel will be a distinct danger. It is a dangerous practice to extend any fence across a major channel and the practice should not continue.

The entire main channel south of point 8 is plagued with problems caused by silting during low flow. It is recommended that a double embankment silt trap, which can be cleaned, be constructed on Park property immediately before the water enters the main channel. This is by far the best location for such a trap and the trap is badly needed to keep structures open and maintenance costs low. It should be noted here that concrete floors can be constructed with an integral maroon color.



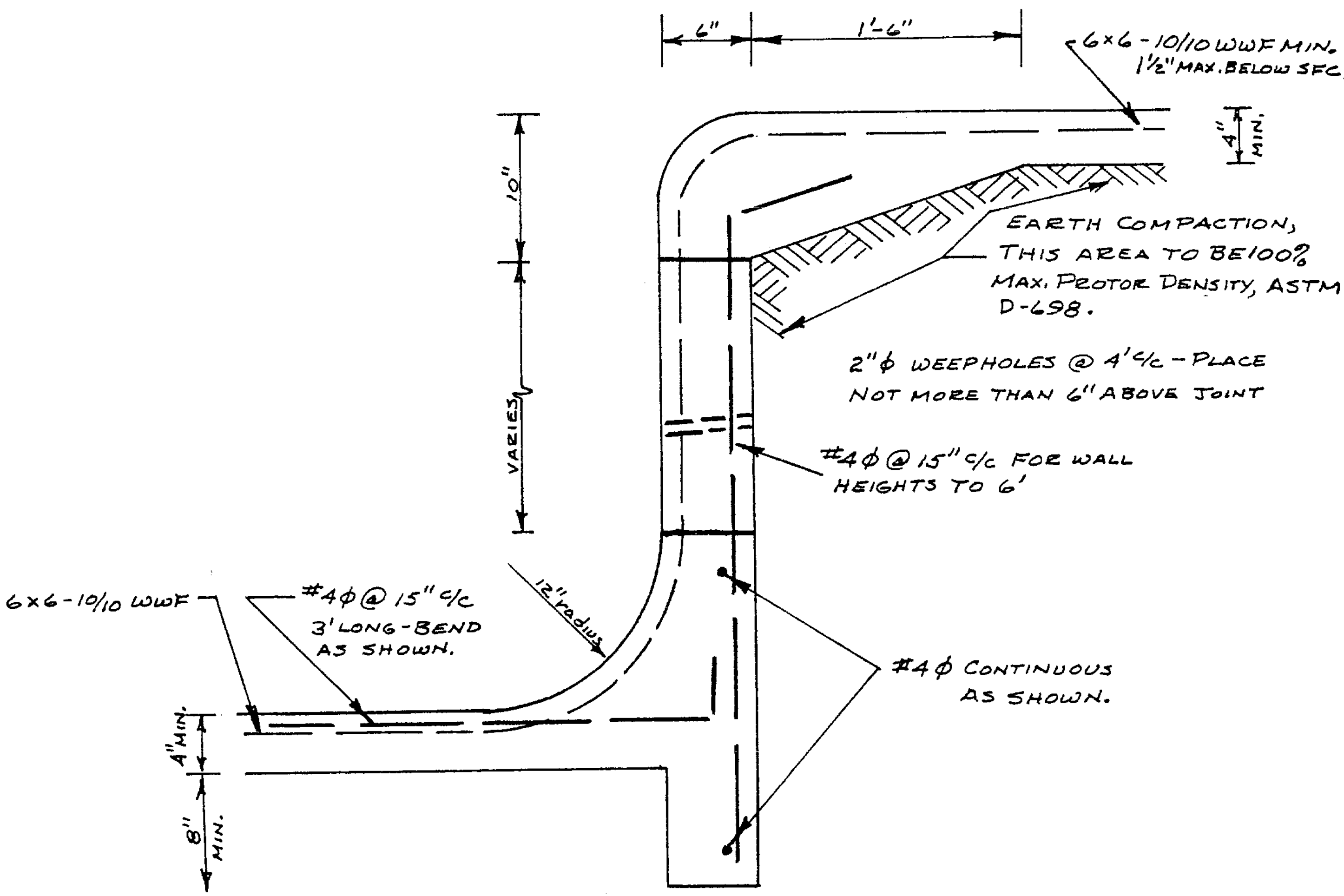
TYPICAL RESIDENTIAL DITCH SECTIONS

THE LINCOLN De VORE
TESTING LABORATORY



TYPICAL GREENBELT 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

INDIVIDUAL IMPROVEMENTS:

Attention is directed to the appendix at the back of this report which lists individual improvements recommended for the basin. The improvements shown will not all be repeated in this section, but some comments are required concerning a few of these. The lists in the appendix cover improvements along the greenbelt, major structures, culverts and storm sewers. A list of street capacities is also included since some improvement of the streets must be recommended. These street costs are not included in the cost estimate, however. Also included is a map of the basin which shows existing and recommended improvements in the basin.

After reviewing the flow and structures along the greenbelt (see previous section), each individual basin was reviewed to determine areas which might require special attention. Water flow at various points was compared to street capacity and distribution. Since most of the streets do not match normal City required widths, the flow in ditches and gutter sections was calculated at actual capacity. The curb flow was computed using the City criterion for water depth.

It was determined that only four small sections of storm sewer were required. Two of these take overflow water off Columbia Road and transfer it to the greenbelt. The third is a very small section removing excess water from Laurel Street and transferring it to the greenbelt. The fourth is a short section of storm sewer required to relieve Columbia Court of excessive water flow. All four are designed for the 5-year storm.

The nature of the basin topographically places almost all improvements along the primary greenbelt. The basin consists primarily of a series of relatively small side valleys and ridges, keeping water flow in the side basins relatively small. In most cases, a paved street section with a dropout to the channel would be adequate. East of Point 10, one section of small ditch - or storm sewer - would be required over and above paving the street. Whenever possible, ditches are recommended to reduce the cost.

The drainage system in the park area is adequately sized for the most part and needs little change. One culvert along Ridge Road should be enlarged. The primary problem within the park is erosion in the natural ditch system. Although some work is being done to preserve foot paths, combined earth and bark surfacing has very little effect on water with the velocity common to the park area.

The ditches should be improved by lowering the gradients and consequently the velocity of flow. A series of timber checks or masonry is recommended along each major eroded ditch. Such a system would be effective both in reducing erosion and consequently in reducing siltation downstream. Filling the existing ditches will have no overall effect in the long run, other than possibly changing the location of the eroded area. Timber checks are recommended to preserve a "rustic" appearance. Red concrete could be used as easily.

It should be noted that each major RCB is recommended to be built with some sort of dropout system from street to greenbelt. These must be rather carefully designed since in most cases, the cross streets are relatively steep. The inlets must, therefore, be designed specifically for each site since a standard D10-R might or might not adequately remove the water. All dropouts and inlets have been taken as equivalent to the capacity of a D10-R for computation purposes.

SPECIFIC PROBLEM AREAS:

A number of the problem areas have been touched on in this report. They are listed in this section to emphasize the problems within the basin.

- First and of great importance, the existing drainage right of way along the greenbelt is either non-existent or much too narrow. The ditches recommended herein have been sized to fit the available easements as well as possible, but at no place in the developed area will it be possible to construct a maintenance road along the greenbelt. It is recommended that the drainage structures be built even though the roadway must be eliminated.

- This report recommends building the greenbelt throughout the developed section of the basin. It has been noted that small portions of this channel already have walls in reasonably good condition. These sections could be used, but they are short and the amount saved will not be large. The flow characteristics of these constructed channels are not consistent and would benefit from reconstruction.

- The weir in the channel should be removed. If it is desired to leave it in place for measurement purposes, the ditch should be constructed to accomodate the increase in upstream head.

- One of the most dangerous existing sections is that between points 15 and 16 in the trailer campground area. The right of way is too small. The ditch and culvert at the entry road are too small. The channel is obstructed by a wire fence at El Paso

(Pikes Peak), and by the boundary fence at the old railroad right of way near point 16. All of these should be cleared and enlarged to allow free flow.

- In a few locations, minor problem areas could be corrected simply by paving the streets and installing high or low curbs as noted on the street inventory. These costs, however, would not be charged to the drainage basin.

- The silt control structure recommended for the park area immediately above the developed area would reduce a great deal of the siltation problems now found in the main channel and structures. In general, this would be a small concrete basin to slow water flow and trap silt and sand before it can enter the primary channel. This basin must be constructed so that it will: A-Trap sands and silts, and B-Allow regular cleanout of collected material. It is strongly urged that this be constructed. The cost of regular cleanout will be far less than the cost of cleanout along a narrow ditch which will have no side road access. "Damage" to the park will be minimal and the appearance of the structure could be controlled with colored concrete and plantings.

SUMMARY AND CONCLUSIONS:

Since about half of this basin is park area and a large portion of the other half is already developed, the City criteria regarding drainage structures should be modified to a degree.

The main channel "greenbelt" can be the relatively narrow paved ditch now in favor for such construction, but without the side maintenance road access. The streets in the basin are presently mostly gravel surfaced, so that street drainage is primarily by side ditches. The at grade dips should all be replaced by concrete boxes to remove the probability of high flow cutting off access.

The basin is well endowed by nature to carry all major flow in a single greenbelt without a large number of side ditches or storm sewer systems. A few problem areas exist, but in general, drainage within the basin is relatively simple.

Specific recommendations are shown in the attached appendices and on the attached map. Although the precise location of the various drainage appurtenances may vary slightly from those shown, all recommended construction meets the various City criteria for drainage basins insofar as this is possible.

It is recommended that the greenbelt channel be paved on bottom and sides. It is recommended that concrete velocity control structures be used in the final design.

It is recommended that timber velocity control structures be placed in the eroded ditches within the park. It is also recommended that a concrete silt trap be placed in the park above the main channel.

The soils in the basin are borderline with regard to sulfate damage. Some of the clayey soils contain sulfates but not in very high concentrations. It is recommended that Type I Cement be allowed for use in concrete throughout the basin.

It is recommended that all new structures included in this plan be built as funds become available. It is recommended that all structures shown as being too small be added to or enlarged. In general, the improvements listed in this report are believed to be necessary and are recommended for design and construction.

COLUMBIA ROAD DRAINAGE BASIN
COST ANALYSIS

Area Breakdown:

City of Manitou	- 10.89 acres
El Paso County	- 0.95 acres
Garden of the Gods Park	- 228.61 acres
Davis Tract (recent Park addition)	- 6.30 acres
National Forest	- 0.35 acres
Total Private Land (including streets)	- 149.80 acres
Total Land in Basin	396.90 acres

Total Private Land	- 149.80 acres
Less existing subdivision & streets	- 92.707 acres
Total Developable Land	57.093 acres

Summation of Costs:

Timber (stone) velocity checks	- $ 10,275
Ditch lining & excavation	- 161,666
Bridge Construction	- 86,780
Culverts	- 955
Storm Sewers	- 34,270
Subtotal	$293,946

Engineering (10%)	- $ 29,395
Contingency (15%)	- 44,092
Total Cost	$367,433

The above can be divided by removing work proposed on the park land as follows:

1. Developer cost (total) - $340,770.50
2. City cost (total) - $ 26,662.50

Developer cost would = $340,770.50/57.093 acres = $5,968.69/acre

Considering that 48% of the "developable" land is in the position that it may probably never be developed (north end of basin) and that the "developable" land is very small in any event, it is recommended that this Columbia Road Basin be continued in the "Miscellaneous Basin" fund.

BIBLIOGRAPHY

Chow, V.T., 1959, Open Channel Hydraulics:McGraw-Hill.

Colorado Springs, City of, Dept. of Public Works Engr. Div., 1977, Determination of Storm Runoff Criteria (revised).

The Computation of Optimum and Realizable Unit Hydrographs from Rainfall and Runoff Data:M.I.T., 1965.

The Design of Storm-Water Inlets:Johns Hopkins Univ., 1956.

Grose, L. Trowbridge, 1960, Geologic Formations and Structure of Colorado Springs Area, Colorado:G.S.A.

Lindsay, R.K., Kohler, M.A. & Paulhus, J.L.H., 1975, Hydrology for Engineers:McGraw-Hill.

Miller, Frederick & Tracey, 1973, Precipitation Frequency Atlas of the Western U.S., NOAA Atlas 2, Vol. 3 - Colorado.

Moore & Morgan, 1969, Effects of Watershed Changes on Streamflow: Univ. of Texas.

Snipes, et al, 1974, Floods of June, 1965, in Arkansas River Basin, Colorado, Kansas and New Mexico:U.S.G.S.

U.S.D.A., 1973, Procedures for Determining Peak Flows in Colorado:SCS

U.S.D.A., 1975, Urban Hydrology for Small Watersheds, T.R. 55: SCS Engr. Div.

U.S.D.A., 1972, Hydrology:SCS National Engr. Handbook, Sec. 4.

U.S. Dept. of Interior, 1973, Design of Small Dams:U.S. BuRec., 2nd Ed.

U.S. Geol. Survey, 1922-1960, Surface Waters of Lower Mississippi Basin, and, 1961-1975, Water Resources Data for Colorado, Water-Supply Papers.

U.S. Geol. Survey, 1967, Roughness Characteristics of Natural Channels: Water-Supply Paper 1849.

U.S. Weather Bureau, Role of Persistance & Instability on Moisture in the Intense Rainstorms in Eastern Colorado, June 14-17, 1965: Tech. Memo-HYDRO-3.

Wright-McLaughlin Engrs., 1975, Urban Storm Drainage Criteria Manual, U.D.F.C.D.

Yevjevich, V., 1972, Probability & Statistics in Hydrology:Water Resources Pub.

MAJOR BASIN A

SUB BASIN	AREA		T C	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 Yr.	100 Yr.	
1	45.8	.072	.0860	61	1.57	9	52	4.2
2	11.3	.018	.0793	75	1.57	10	29	4.2
3	18.1	.028	.0731	75	1.56	15	45	4.2
4	9.1	.014	.0757	75	1.57	8	23	4.2
5	3.8	.006	.0726	74	1.56	3	9	4.2
6	4.3	.007	.0700	75	1.56	4	11	4.2
7	7.1	.011	.0539	72	1.55	5	15	4.1
8	7.9	.012	.1190	69	1.59	4	14	4.3
9	24.2	.038	.0852	74	1.57	19	58	4.2
10	20.6	.032	.0974	76	1.58	19	54	4.2
11	13.5	.021	.0680	74	1.56	10	32	4.2
12	8.5	.013	.0592	71	1.56	5	17	4.2
13	30.6	.048	.1430	75	1.61	25	72	4.3
14	13.4	.021	.0827	74	1.57	10	32	4.2
15	26.8	.042	.0850	75	1.57	23	68	4.2
16	13.6	.021	.1027	79	1.58	15	41	4.2
17	9.8	.015	.0819	81	1.57	13	32	4.2
18	10.3	.016	.0747	78	1.56	11	30	4.2
19	10.5	.016	.0860	79	1.57	12	31	4.2
20	6.1	.009	.0728	83	1.57	9	21	4.2
21	18.7	.029	.0841	78	1.57	19	54	4.2
22	7.6	.012	.0598	77	1.55	8	21	4.1
23	17.0	.027	.1128	79	1.59	19	51	4.3
24	3.5	.005	.0650	82	1.56	4	11	4.2

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 2 A Individual Basin Runoff

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

SUB BASIN	AREA Acr.	AREA Sq. Mi.	T C	SOIL CURVE NO.	T_{po}	FLOW (cfs) 5 Yr.	FLOW (cfs) 100 Yr.	T_b
25	6.2	.010	.0667	81	1.56	8	21	4.2
26	3.6	.006	.0427	80	1.55	5	12	4.2
27	6.5	.010	.0738	84	1.56	10	24	4.2
28	11.2	.017	.0966	82	1.58	15	38	4.2
29	14.2	.022	.1087	86	1.63	25	57	4.4
30	13.1	.020	.0944	85	1.58	22	50	4.2
TOTAL	396.9	.618				364	1025	

HYDROLOGIC COMPUTATIONS - BASIC DATA

Sheet 2 of 2 A Individual Basin Runoff

LINCOLN-DeVORE TESTING LABORATORY

LINE	ACC. AREA		T C	SOIL CURVE NO.	T_{po}	FLOW (cfs)		T_b
	Acr.	Sq. Mi.				5 Yr.	100 Yr.	
1 - 2	57.1	.090	.1100	65	1.69	18	84	4.50
2 - 3	68.5	.1080	.1436	67	1.71	26	106	4.56
4 - 5	27.2	.042	.1052	75	1.68	23	67	4.49
5 - 5A	55.2	.086	.1288	75	1.70	45	133	4.53
3 - 6	152.2	.238	.1434	71+	1.71	84	289	4.56
6 - 7	174.2	.272	.1606	71+	1.72	97	328	4.58
7 - 8	218.2	.341	.1880	72	1.73	124	409	4.63
8 - 10	268.4	.419	.2130	74	1.75	170	527	4.68
10 - 12	314.0	.491	.2330	75	1.76	215	635	4.70
12 - 13	338.6	.529	.2467	75+	1.77	231	672	4.72
13 - 14	351.9	.550	.2557	76	1.77+	248	718	4.74
14 - 15	369.6	.578	.2719	77-	1.78	269	763	4.76
15 - 16	396.9	.620	.2913	77	1.79	307	871	4.79

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 1 of 1 B Total Basin - Accumulative

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

LOCATION			EXISTING					REQUIRED					MISC.
								Comp. Flow					
From	To	Length of Run	Bottom Width	Top Width	Depth	R/W	Design Cpy	5 Yr.	100Yr.	Bottom Width	Depth	R/W	
1	2	940	5'	10'	2'	-	243	18		Velocity	Checks	-	timber only-in park-erosion ditc
2	3	1150	10'	16'	2'	-	399	26		Velocity	Checks	-	"
4	5	935	5'	11'	3'	-	267	23		Velocity	Checks	-	"
5	5A	680	$4\frac{1}{2}$'	9'	$2\frac{1}{2}$'	-		45		Velocity	Checks	-	"
3	6	1670	16'	21'	$3\frac{1}{2}$'	-	977	84		Velocity	Checks	-	"
6	7	495	20'	28'	$3\frac{1}{2}$'	-	1171	97		Velocity	Checks	-	"
7	8	760	30'	55'	5'	-	3206	124		Velocity	Checks	-	"
8A	8	1370	3'	7'	3'	-	150	25		Velocity	Checks	-	"
9A	9	430	7'	14'	3'	-	368	23		Velocity	Checks	-	part in park erosion ditch only
9	10A	440	14'	20'	$2\frac{1}{2}$'		500	26		Velocity conc. entry	Check	-	thru Subdivision
						*				(Sand trap or diversion above)			(change to 100 Yr).
8	10	1180	16'	16'	2'	20	405		527	Velocity 16'	Checks $1\frac{1}{2}$'	16'	wall sec. present
Alt. 8	Alt 10	945	5'	5'	1'	-	15			No change			
10	12	865	18'	24'	$4\frac{1}{2}$'	40' LTC 15' Sub.	1240		635	Velocity 16'	Checks $1\frac{1}{2}$'	21'	earth sec. present
12	13	630	Av. 12'	12'	$3\frac{1}{2}$'	None	746		672	8'	$2\frac{1}{2}$'	19'	present walled sec.

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 1 of 2 C Ditch & Greenbelt Inventory

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

LOCATION			EXISTING					REQUIRED					MISC.
From	To	Length of Run	Bottom Width	Top Width	Depth	R/W	Design Cpy	Comp. Flow 5Yr.	Comp. Flow 100Yr.	Bottom Width	Depth	R/W	
13	14	410	22'	22'	4'	20'	1162		718	12'	$2\frac{1}{2}$'	23'	Present walled sec.
14	15	760	13.5'	20'	$4\frac{1}{2}$'	None	799		763	12'	$2\frac{1}{2}$'	23'	Present earth sect.
15	16	880	2'	9'	2'	20'	53		871	14'	$2\frac{1}{2}$'	21'	Present earth sec. needs lined channels

* Note- R/W's are not continuous, but represent only the platted R/W's existing

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 2 of 2   C   Ditch & Greenbelt Inventory

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

LOCATION			EXISTING			PROPOSED		
Sub Basin	Near Point	Street	Existing Structure	5 Yr. flow	100 Yr flow	Approx. Req'd Structure (RCB on Bridge)	Comment	Estimated Cost
9	5A	Bal.Rk.Rd.	2'x5.67' RCB	45	133	No Change	Improve Intake	1400
17	above 10	Garden	No Structure	215	635	Sand basin & settling bar- 60'x60'	Small curb walls	10100
17	10A	Garden Dr.	2.5'x4' RCB	130	415	alt.3'0"x6'5" add. RCB.	Side T.O.- 2	6820
16	10A	Arnold St.	28'x35' A/C Dip	170	527	3'6"x9'0" RCB	Side T.O.- 2	9620
20	12	Arnold Ln	17'x26' Conc.Dip	174	533	(two barrel) 2-3.5'x6' RCB	Side T.O.- 4	12440
20/21	12	Columbia Ct.	open .5'x18' - timber bridge	215	635	Replace with 2-4'x6' RCB	Side T.O.- 4	14410
22/23	13	Columbia Rd.	open- .4'x10.5'-RCB	231	672	No Change	Improve Intake	--
27/28	14	Holly St.	-A/C Dip	248	718	(two barrel) 2-4'x6.5' RCB	Side T.O- 2	13200
27/28	15	El Paso	(two barrel) 2-5'x11.33-RCB	269	763	No Change	Imp. opening, remove fence	--
27/28	15	Holly St.	Concrete Weir	253	735	Remove		1600
29/30	16	Entry-Trailer Ct.	42" CMP traffic (mashed)	288	816	(two barrel) 2-4x7 RCB with improv. intake	Privately owned	11990
29/30	16	Entry-No.ofColo.	open Timber & 2.5'x17' Steel Bridge	307	871	deepen channel & pave; 4'x17' steel bridge remains	Privately owned?	4200
Total Structures:								$86780

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 1 D Major Bridge Inventory

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

Sub Basin	Near Point	Street	Existing Structure	5 Yr. Flow	100 Yr Flow	Approx. Req'd Structure	Comment	Estimated Cost
6/7	3	Bal.Rk.Rd.	24"Ø VCP	26	106	NO CHANGE	Main Line	
9	5A	Bal.Rk.Rd.	18"Ø CMP	10	29	NO CHANGE	Overflow only	
11	6	Bal.Rk.Rd.	12"Ø VCP	2	5	NO CHANGE		
11	6+	Bal.Rk.Rd.	24"Ø VCP	9	29	NO CHANGE		
14	6+	Bal.Rk.Rd.	15"Ø CMP	4	12	NO CHANGE		
14	7	Blocked in park; Columbia Rd.	24"Ø CMP	8	25	NO CHANGE		
14	8	Blocked in park; Columbia Rd.	15"Ø CMP	2	5	NO CHANGE		
7	3	Ridge Rd.	12"Ø VCP	1	3	NO CHANGE		
10	6	Ridge Rd.	15"Ø VCP	3	6	CLEAN OUT	Plugged	
13	8A	Ridge Rd.	18"Ø RCP	10	21	NO CHANGE	Campground entry	
13	8A	Ridge Rd.	15"Ø CMP	13	36	Remove old cul. inc. to 18"Ø CMP	Could add 15" CMP	955
13	8A	Ridge Rd.	15"Ø CMP	4	12	NO CHANGE		
13	8A	Ridge Rd.	15"Ø CMP	2	5	NO CHANGE		
13	8A	Ridge Rd.	15"Ø CMP	3	7	NO CHANGE		
13	8A	Ridge Rd.	15"Ø CMP	1	2	NO CHANGE		
15	9A	Ridge Rd.	15"Ø CMP	1	2	NO CHANGE		
15	9A	Ridge Rd.	18"Ø RCP	2	4	NO CHANGE		
18	10	Columbia Rd now closed	24"Ø CMP	3	8	NO CHANGE		
18	10	Columbia Rd now closed	18"Ø CMP	3	8	NO CHANGE		
18	10	Columbia Rd headwall across cul.	2-tandem 24" CMP	7	20	NO CHANGE	Headwall needs repair	
18	10	Garden	22"x36" arch CMP	11	30	NO CHANGE	Clean out	
21	12	Ct. Columbia	2-tandem 18"Ø CMP	15	42	30"CMP or another 18"CMP	Private Drive	(745)
25	13	Laurel	18"Ø steel	3	8	NO CHANGE	Private Drive	
					Total-Misc. Culverts			$955

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

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

LOCATION			EXISTING PIPE	REQUIRED					
Sub Basin	Near Point	Street	NONE	Pipe Size	Type	Length	CB	Outlet Structure	Estimated Cost
23	12	Columbia Rd.		15"∅	CMP	310'	4-std	Outlet RCB	9875
23	13	Columbia Rd.		21"∅	CMP	300'	5-std	Outlet RCB	12835
25	13/14	Laurel St.		18"∅	CMP	40'	2-std	Outlet Ditch	2910
21	12	Columbia Ct.		18"∅	CMP	250'	3-std	Outlet Ditch	8650
				Total - Storm Sewers					$34270

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 1 F Storm Sewer Inventory

LINCOLN-DeVORE TESTING LABORATORY

MAJOR BASIN A

Street & Location	S %	R/W	Street Width	Curb Ht.	Street Capacity low	Street Capacity high	Ditch cpy.	Est. Flow 5 yr.	Est. Flow 100 yr.	Required
Columbia Rd. pt. 11	.0240	50'	29'	6"AC	6	9	---	7	17	8" C & G
Columbia Rd. pt. 11B	.0229	50'	29'	6"AC	6	8	---	11	24	Take out part to Arnold Drive
Columbia Rd. pt. 13	.0280	50'	29'	6"AC	6	10	---	29	70	Diversion @ Columbia Ct.
Columbia Rd. pt. 15	.0160	50'	29'	6"AC	5	7	---	8	20	Diversion @ El Paso West
Saints Ct. pt. 11	.0750	50'	30'±	--	10	13	16	11	29	NO CHANGE
Laurel St. studio	.0625	40'	20'±	--	8	11	4	6	17	Pave street - low curb
Laurel St. culvert	.0200	40'	20'±	--	3	5	2	7	18	Pave street - high curb
Laurel St. outfall	.0720	40'	20'±	--	9	13	4	10	26	Pave street-high curb Outlet btwn pts 13 & 14
Holly St. above 14	.1143	30'	16'±	--	5	8	4	8	20	Pave st.-high curb Note-private road?
Holly St. East	.1000	30'	20'±	--	5	8	4	3	9	NO CHANGE
El Paso St. pt. 15	.0200	60'	24'±	--	10	14	2	4	10	Add high curb-S. side Turn out @ bridge
Truman Ln. East	.0816	30'	16'±	--	4	7	6	2	5	NO CHANGE
Columbia Ct. above cul.	.0586	50'	18'±	--	9	13	7	9	27	Pave street-low curb
Columbia Ct. below cul.	.0367	50'	24'±	--	7	10	6	17	48	Add storm sewer
Arnold St. E. of ditch pt. 10	.1000	25'	18'±	--	5	8	7	9	24	Enlarge ditch
Garden Drive above RCB	.0640	40'	18'±	--	8	12	4	4	10	NO CHANGE

HYDROLOGIC COMPUTATIONS - Basic Data
Sheet 1 of 1 G Street Inventory

LINCOLN-DeVORE TESTING LABORATORY