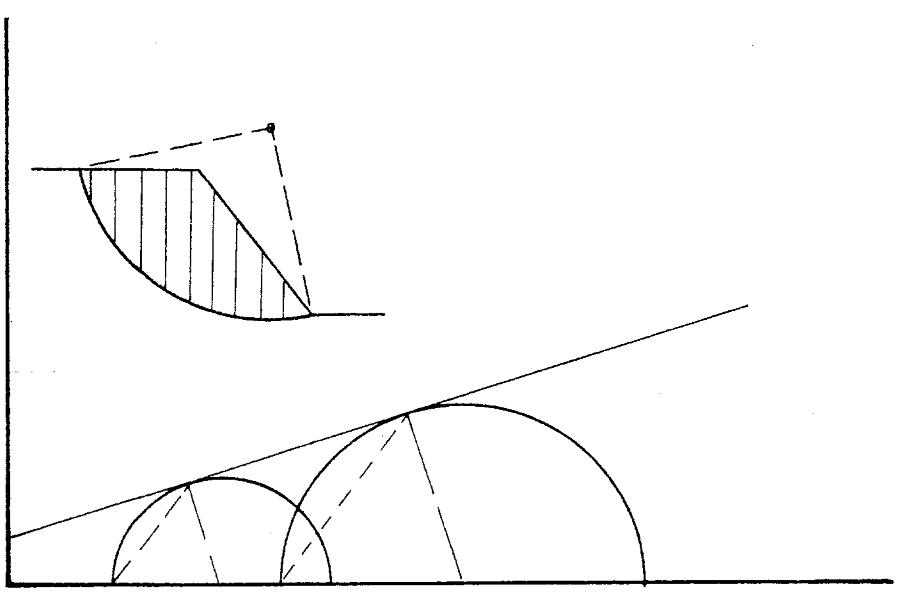
DOUGLAS CREEK DRAINAGE STUDY

JUNE 1974

THE LINCOLN DeVORE TESTING LABORATORY
COLORADO SPRINGS, COLORADO



THE LINCOLN-DeVORE TESTING LABORATORY

MEMBER A.S.T.M.
A.S.C.E.
CEC
ACI

George D. Morris, P.E.

1000 W. Fillmore
Colorado Springs, Colorado
303-632-3593

Soil Testing

Foundation Evaluation

Materials Tests

Concrete Batch Design

Asphalt Mix Design

Geologic Interpretation

Groundwater Hydrology

by

Registered Professional Engineers

&

Geologists

Colorado Springs, Colorado

Pueblo, Colorado
Howard M. Dump

Rock Springs, Wyoming
Jerold K. Elliott
Robert L. Beck

June 10, 1974

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

Dear Sir;

Enclosed herewith is the engineering study and revision of the Douglas Creek Flood Drainage Basin authorized by the City Council of the City of Colorado Springs.

This report includes a study of the basin geology, the rainfall runoff characteristics and the channel improvements required for the entire basin. It also includes a re-study of the various storm sewer requirements, hydrographs and existing drainage appurtenances in the basin.

This study may be used as a master plan for drainage improvements in the unsubdivided portion of the basin and as recommended improvements for upgrading those structures which have been built, but are inadequate.

Respectfully submitted,

LINCOLN-DeVORE TESTING LAB.

George D. Morris, P. E.

GDM/sam

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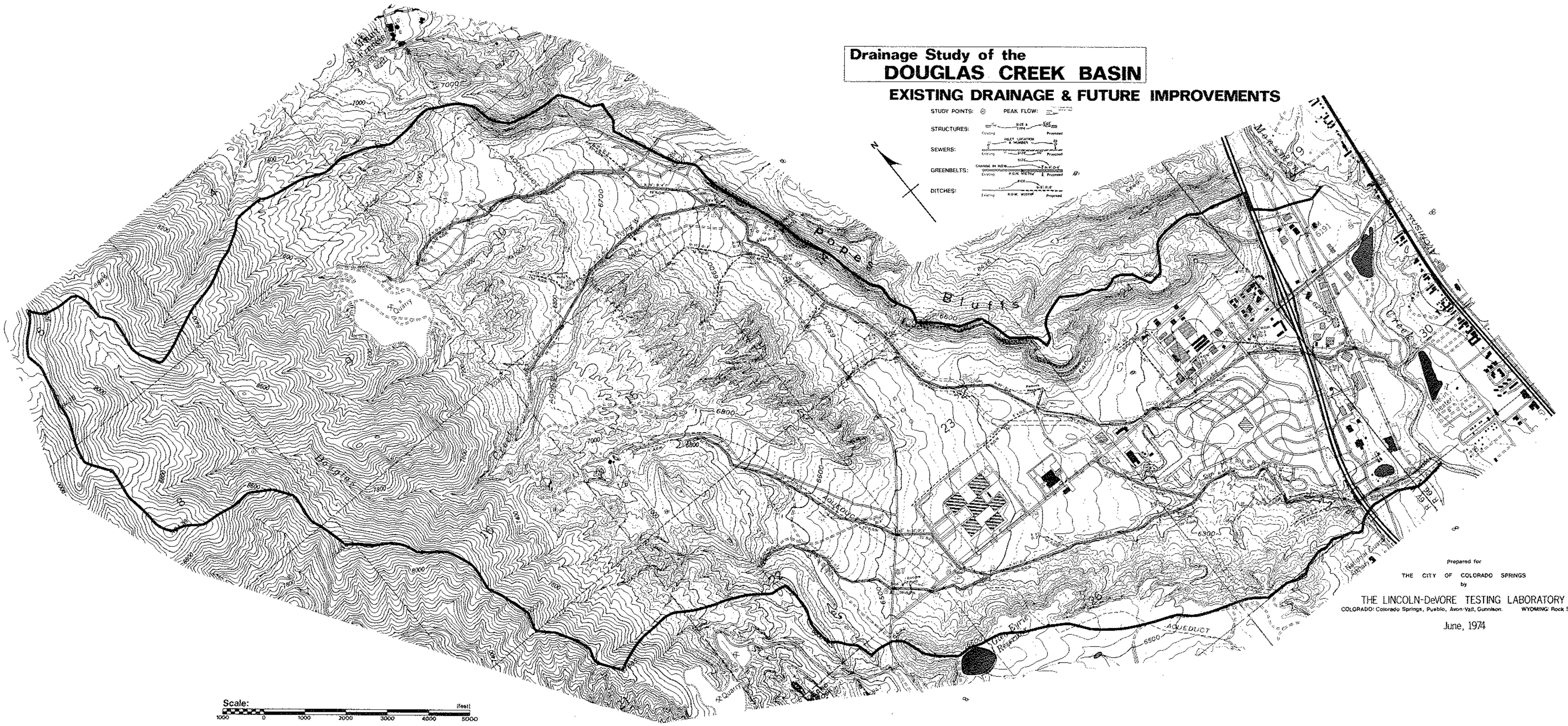
Drainage Study of the
DOUGLAS CREEK BASIN
EXISTING DRAINAGE & FUTURE IMPROVEMENTS
STUDY POINTS:
PEAK FLOW:
STRUCTURES:
SEWERS:
GREENBELTS:
DITCHES:
Existing
Proposed
N
Pope Bluffs
Douglas
AQUEDUCT
Prepared for
THE CITY OF COLORADO SPRINGS
by
THE LINCOLN-DeVORE TESTING LABORATORY
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison. WYOMING: Rock Springs.
June, 1974
Scale:
(feet)
1000 0 1000 2000 3000 4000 5000

SCOPE AND GENERAL REQUIREMENTS OF THE STUDY:

The Douglas Creek basin was originally studied in June of 1964 by United Western Engineers under the general direction of George D. Morris, P. E. At that time, most of the basin was undeveloped although plans were being formulated for the use of at least part of the basin as an industrial park. At the time of the original study, some roads were hypothecated at points of high runoff in a pattern which would be typical of such an industrial park. Where storm sewers were required, they were shown on the original plan. As the basin was developed, however, many of the proposed locations for these roads were covered with buildings and the south end of the basin, in particular, was developed as a residential area which changed the design of the proposed streets and roads. In some senses, the basin has developed as anticipated, but in others, it has not and the change has eliminated the necessity for many drainage structures on the site. This report is intended to furnish the basis for an overall plan for placing drainage structures in the basin during the time of completing the improvements on the site.

In this re-study of the basin, the placing of streets at points of high drainage has not been attempted. The only streets which are shown on this study are those which are now in existence or are definitely planned. Either method of anticipating future plans has certain disadvantages. In this re-study of the basin, roads have been taken where they exist and culverts placed across the roads at those points where the drainage is high. In general, ditches have been used to carry the runoff water between these culverts. It is quite conceivable that storm sewers will be desirable in place of these ditches making the cost of the basin somewhat higher. It has been determined that in this re-study of the basin, a system of streets will not be shown unless they are present or planned.

In addition to changes within the basin, the City's criteria for the study of drainage basins has been changed since the original study. Several criteria changes alter the drainage picture through the basin entirely from the original study in 1964. First, the use of small storage retention reservoirs have been eliminated by direction of the Colorado Springs Drainage Board and a revision of greenbelt sizes is therefore necessary. The purpose of these small reservoirs was to slow down the movement of water and to store some of it temporarily so that large ditches would not be necessary. With the elimination of such temporary storage, water moves much more rapidly and greenbelt design must be changed to reflect this change in water speed. Erosion control structures must be used, particularly in intersections and greenbelts and ditches must be paved to avoid erosion along the ditch. The paving itself speeds the water movement and allows the use of somewhat narrower ditches. Other major criteria change is that concerning the amount of water allowable in streets. At the time of the 1964 report, streets were allowed to carry water to a depth of two-thirds the height of the curb. Since that time, it has been determined that this is far too much water on a traveled street so that greater amounts of water must be carried by storm systems and by ditches.

The intent of any study of this type is not to establish the precise design or location of storm sewers, ditches or other appurtenances. It should rather establish the general location of required storm drainage structures and their generally required sizes. Fortunately, nearly all of the major greenbelts or channel areas have been left open by the development in the basin and are available for use. In some cases, the sizes of these channels require increasing and bridges which were built across the channels in anticipation of the construction of storage reservoirs must also be increased. In other cases, the more rapid movement of water has allowed the decrease in size of some of the major greenbelts, although the locations of these greenbelts are in essentially the same position as they were in the original report.

At the time of this study, most of the industrial area has been at least planned and approximately half of it has been constructed. That area of residential development in the southeastern portion of the basin has been mostly completed or planned. In these areas, the locations of storm sewers and drainage appurtenances can be rather closely established. In the northern and western portions of the basin, however, plans are not completed at the time of this study and the drainage structures in these areas must be relatively general.

The Douglas Creek basin is somewhat different than the other basins which have been studied under the City drainage program. The use of long underground storm sewers is not extensive in this basin and can be avoided in great part. Since a large portion of the basin is an industrial park, the use of ditches is not detrimental to the area and they are, therefore, used more extensively. All of the studies of undeveloped basins which the City has commissioned in the past have provided at least the basis of a logical overall storm drainage plan prior to the time of general subdivision development. In re-doing the Douglas Creek basin, it was noted that some changes had been made, but that the original plan was helpful in avoiding several areas of blind drainage.

BASIN DESCRIPTION:

The Douglas Creek basin contains approximately 10.3 square miles and lies generally in northwestern Colorado Springs. Almost the entire basin lies either within the bounds of the Pike National Forest or the city limits of the City of Colorado Springs. It is generally bounded on the north by the line of Pope's Bluff and on the south by the Mesa. The upper reaches of Douglas Creek have their origins on the east face of the Front Range and approximately one-third of the basin lies within the rather steep mountains and foothills of the Front Range.

That portion of the Douglas Creek basin which lies within the bounds of the Pike National Forest was considered to be undevelopable as far as subdivision or other construction is concerned. Even though this area is relatively steep, the drainage from the forest will remain small. The Pike National Forest contains approximately 3 square miles of the basin.

The Douglas Creek basin is somewhat unusual in that it contains two rather distinctly defined drainage areas. The stream which is named Douglas Creek flows from approximately the northwest corner of the site within the National Forest along the bounds of Pope's Bluff to its intersection with Garden of the Gods Road. At this point, this stream turns almost due east and flows into Monument Creek near its intersection with Cascade Avenue. The southern channel is actually not named, but for the purposes of this report shall be called South Douglas Creek.

This drainage rises near the southwestern corner of the basin in the Front Range, crosses Garden of the Gods Road near Wilson Road and flows along the base of the Mesa to its intersection with the Monument Creek at a point near the southeast corner of the basin. At least a low flow of water can be found in either of these channels during part of the year. It should be noted that the upper reaches of North Douglas Creek are generally dry, however.

Approximately the western third of the Douglas Creek basin is mountainous with a slow transition through foothills to lower ground. Due to the geology of the area, several water gaps exist along the standing formations on the east edge of the mountains. This has the effect of concentrating water at these points and forming the main stream at these points. The lower portion of the basin consists of an alluvial plain deposit lying between two steep-sided bluffs. This area is of lower grade and the grade is much more uniform. In general, the basin sides are relatively steep.

BASIN GEOLOGY, SOILS AND WATER TABLE:

Since the geology of this basin affects the flow in the two Douglas Creeks to a considerable extent, this has been studied at somewhat greater length than the geology of other basins. A map of the various formations and their hydrologic characteristics is included in the report and attention is directed to this map to more easily follow the discussion.

This is an interesting valley from the standpoint of drainage, since North Douglas Creek exists in its present form due to stream piracy from the original flow which reached Monument Creek through Dry Creek basin. South Douglas Creek is somewhat smaller than it originally was due to the piracy of portions of this stream by Camp Creek. With the exception of the mountainous mass near the western boundary of the area and Pope's Bluff on the north, almost the entire valley has reached its present shape by erosion and deposition of fairly recent period. The upper or western portion of the basin is along the east slope of the Front Range and consists of Pikes Peak Granites, either in a solid state or in decomposed gravel condition. Although the slopes are very steep in this area, infiltration is high and bank storage is very high. Runoff through this portion of the site is therefore quite low.

At a point near the eastern limit of the Front Range hills, one major fault line and several minor faults are found. These are all a part of the Front Range fault which extends along nearly the entire Front Range. The major fault follows the line of the mountain base approximately north/south across the basin. Two minor faults extend southeasterly toward the outlet of the basin, for approximately 1-1/2 miles. The presence of these faults influences the amount of water which reaches the lower alluvium. It indirectly affects the flow of the water by raising the sedimentary layers found east of the faults.

Immediately east of the faults and extending for approximately 2 miles to the east, many sedimentary formations are found. This is the same geologic series which is found in the Garden of the Gods area and it is found in a quite similar condition. The formations themselves are nearly vertical from the position in which they were originally bedded, so that a series of bands of different materials can be found extending along the mountains and, at least roughly, parallel to the mountain front. The more resistant of these beds exist as hogbacks or hills, while the less resistant are found in the form of valleys. The presence of these resistant sedimentary layers has a distinct effect on the water flow in the creeks. At several points, the water flow is quite constricted and the actual channels below are formed at these points. This is found along both creeks, but is much more obvious on South Douglas Creek. The attached geologic map shows these formations extending almost in echelon along the fault line and indicates their hydrologic characteristics.

Along the east line of these echelon formations is the Pierre Shale. This material has a shallower dip than the other formations near the fault zone. This formation, in fact, is more or less flattened out and extends beneath the entire city of Colorado Springs and far to the east. It is found on the surface of the ground over a fairly large area of the basin. This material weathers easily upon exposure to air and water, but even when highly weathered, is resistant to infiltration and increases the runoff from any given rainfall to a considerable degree. The Pierre Shale is found along the base of the Mesa beneath most of the Holland Park area and under a wide area near Wilson Ranch.

The north edge of the basin is defined quite distinctly by a bluff known as Pope's Bluff. Most of this bluff is high, except at two points where Douglas Creek has pirated the streams originally feeding Dry Creek in the northern portion of the basin. Pope's Bluff is basically formed by the Laramie Formation which is predominately a very dense clay and sandstone. This is a coal bearing formation in the Pikes Peak region. All of these materials may be seen exposed on the surface and sides of the bluff. Pope's Bluff is surrounded by a talus slope which consists primarily of sands and clays from the cliffs above. This talus slope allows high infiltration although the formation itself does not.

The central portion of the basin is covered with alluvium which is primarily a silty sand or clayey sand. This material is derived from the Pikes Peak Granite and from various older alluvial deposits in the higher portion of the basin. Most of this alluvium allows some infiltration in the upper portion of the valley. That alluvium in the lower or eastern portion of the valley does not readily allow infiltration, however, so that the runoff will be higher from this alluvium than from alluvium along the mountain front. The geology of this basin almost guarantees very high runoff in any major rainstorm.

The surface soils over the site consist almost entirely of sandy clays and clays. Some thicker deposits of sands are noted, particularly on the top of mesas where the remnants of the old Verdos Alluvium still exist. Nearly all of the material at lower levels is a fine grained, silty sand or clayey sand. Hard, dense, formational Pierre Shale underlies almost all of the eastern portion of the valley and tends to cause a higher than normal runoff from this area.

Since the streambeds are very closely controlled by the geologic features in the area, the underground water table is also so controlled. The only points which contain major free water below the surface of the ground are in areas of alluvium immediately along the lines of the two Douglas Creeks. Some areas which have relatively flat topography near the creeks tend to be slightly swampy, but the majority of the basin consists of relatively hard, dry soil with very little underground free water.

RAINFALL AND RUNOFF PATTERNS:

The average annual precipitation in the Douglas Creek basin is slightly high of the Colorado Springs average since it is along the foothills. Total precipitation is approximately 15 inches per year, but much of this is in the form of snow. Snowmelt involves an entirely different approach to the computation of stream flow and is usually relatively slow. Since snowmelt does not produce high peak flows within the stream, this portion of the annual precipitation will not be considered in this report.

Slightly over half of the annual precipitation occurs in May, June, July and August in the form of relatively intense rainfall. Depending on the persistence and instability of gulf air flow over the area, these rains can take the form of either lengthy storms lasting two or three days with occasional intense periods or they can take the form of the more usual intense, short duration thunderstorm. Since this basin is at the boundary between the mountains and the eastern plains, either type of storm can occur over the basin. The long term storms produce large amounts of runoff, but relatively low peak flows due to the period of time involved and higher infiltration rates. The short, intense thunderstorm does not produce as much total runoff, but produces a very high peak flow due to the intensity of the rain and the fact that such a storm generally covers a smaller area. As subdivision development in the basin becomes more extensive, the peak becomes higher and the runoff time becomes shorter.

The original basin report investigated four storm types. They were:

1) 30-minute duration, .8-inch intensity, 2-year frequency storm;
2) 1-hour duration, 2-inch intensity, 50-year frequency storm;
3) 6-hour duration, .75-inch intensity, 25-year frequency storm;
4) 6-hour duration, 3-inch intensity, 50-year frequency storm.

This initial investigation indicated that the 1-hour duration, 2-inch intensity, 50-year frequency storm would produce the highest flood peak. This criteria was checked in this second investigation and found to be correct. The City criterion for runoff studies is now the use of a 50-year frequency storm for local drainage and the 100-year frequency storm for major channels and greenbelt design. For this reason, two further storm types were examined. These were:

5) 1-hour duration, 3-inch intensity, 100-year frequency storm;
6) 6-hour duration, 4.6-inch intensity, 100-year frequency storm.

Experience in the past has indicated that the drainage basins around the City of Colorado Springs which originate in the Front Range mountains do not have as high a peak flow as those streams which originate on the plains to the east of the City. To determine the probable cause of this, rainfall patterns during previous storms were examined and the soil types in the mountainous areas were carefully examined. A study of four very intense storms for which some data exists indicates that the centers of these storms lie to the east of the mountains. Oddly enough, the centers of these major storms lie along an axis roughly parallel to the mountains, extending through the center of Black Forest and Peterson Field. Two of these storms have been plotted on the location sheet included in this report. These are the storm of May 30, 1935 which produced the Memorial Day flood and the storm of June 17, 1965 which produced a flood in the Widefield-Security area. It can be noted that the centers of these storms lie in the southern portion of the Black Forest area and near Peterson Field. Rainfall near the mountains, in both cases, was high, but not as extreme as near the center of the storm.

In addition to this, a careful examination of the stream valleys within the Front Range system indicates that large amounts of talus slope material can be found near the streams. This allows a considerable amount of bank storage along the stream and much less runoff. The amount of this talus material found indicates that, in almost any storm up to a 3 or 4-day duration, the runoff from the mountainous area would be relatively small. In addition, in this particular basin, some of the more resistant hogbacks tend to pond the water and form natural reservoirs. Summing all these factors, it can be see that this area will produce somewhat smaller runoff than the streams which originate east of the City. Although all computations for this basin report have been made using a 3-inch, 100-year frequency storm, as required by City criteria, it is believed that runoff in this basin will be somewhat less for a true 100-year frequency storm.

Considering the localized storm with a 50-year frequency rate, it must be noted that a storm of this intensity can be expected on a local basis about every 7 years.

For design purposes, therefore, it is not safe to consider any storm of lesser rainfall than the 2-inch, 50-year frequency rain used for local design.

No measured runoff data exists for the basin other than occasional observations which have been taken mostly during flood periods. These observations indicate that the design peak flows will be approximately correct for the local 50-year storm and that the design peak flows will be somewhat high for a true 100-year storm.

In general, the land use within the basin has not changed greatly since the original report on the basin. For the most part, those drainage appurtenances which have been placed within the basin since the original report are correctly sized. Some increase in size is required by the use of the 3-inch rainfall for major flow. This increases the total flow and requires an increase in sizes of major culverts and bridges. In general, however, the greenbelt sizing in the original report is satisfactory for today's criteria.

The hydrographs included in this report are based on the assumption that the entire area will develop along the lines shown on the attached plans. The overall basin was divided into five major sub basins and the 100-year flow anticipated in the greenbelts was computed using these five sub basins. These major sub basins were divided into 67 minor sub basins. An outfall point was assigned to each sub basin and a synthetic hydrograph constructed for each of these points. Due to the absence of measured stream flow, the available data from the various existing sources must be used together with the computations made herein.

Both the 50-year and the 100-year storms were routed along the lines of the greenbelts through the basin. These greenbelts, in general, follow the existing streambeds in both the North Douglas Creek and South Douglas Creek. It must be noted that in the upper portions of both creeks, the physical location of a streambed is not precise. In both locations, flow at the present time is more that of sheetflow down alluvial deposits of low permeability. True gullying does not commence until the water is east of Wilson Road.

For the purposes of this computation, it was assumed that the storm occurred over the entire basin at the same time and the water from the sub basin was routed along the main stream using this assumption. It should be noted that by the time the streams cross Wilson Road, drainage appurtenances are relatively large. This is mostly due to concentrations of water rather than high runoff factors. Water does not reach a stage of being a flood hazard until it reaches the Garden of the Gods Road along North Douglas Creek and the proposed Centennial Boulevard along South Douglas Creek. From these points on, to Monument Creek, the flood crest can be destructive at any time it is allowed to leave the greenbelt. Under certain conditions, the flood crest can, of course, be destructive above these points, but will be on a more localized basis.

EXISTING DRAINAGE WORK IN THE BASIN:

Due to the construction of several residential subdivisions in the southeastern portion of the basin and the more recent construction of commercial and industrial buildings to the east of Interstate Highway 25, some drainage work has been done in these areas. Although the industrial development along Garden of the Gods Road is in an advanced stage of construction, a smaller amount of drainage work has been done in this area. Fortunately, the streambeds for the proposed greenbelts have been left open and development has not interfered with these greenbelts. Over most of the area, rights-of-way for the greenbelts have not been officially given to the City and the greenbelts themselves have not been constructed.

Along North Douglas Creek, a greenbelt exists between Interstate Highway 25 and the Denver & Rio Grande Railroad, for a short distance on each side of its intersection with Chestnut Street, and from its crossing of Garden of the Gods Road for a distance of approximately 2000 feet to a reservoir which exists at that point. These stretches have been at least partially constructed, but not lined. No true greenbelt construction could be found along the line of South Douglas Creek.

Several small reservoirs and stock ponds exist in the basin, mostly along the northern reaches of the north branch of Douglas Creek. Most of these are relatively small and will be removed if and when development reaches them. Any aid which they might give toward reducing the size of the flood peak or lengthening the time of flow will be ended as soon as the area is developed.

One reservoir, in the southeastern corner of Section 23, north of the Kaman Nuclear site, is relatively large but should be removed from the site to allow free flow. No major reservoirs were found on the south branch with the exception of one pond immediately west of the hogback area in the foothills.

In the eastern portion of the site, a number of bridges, culverts and some storm sewers have been constructed over the past 10 years. One older arch culvert "bridge" carries North Douglas Creek under Garden of the Gods Road. A box culvert bridge has recently been completed at Chestnut Street and North Douglas Creek and a large culvert has been placed under Chestnut Street at South Douglas Creek. The arch culvert and Chestnut Street culvert are too small and should be replaced. The reinforced concrete box bridges, however, are mostly of satisfactory size and can be used as they exist. The structures beneath the Interstate Highway are both too small for the calculated flow. Along North Douglas Creek, a railroad passage exists immediately beside the ditch beneath Interstate Highway 25 and this will serve as sort of an emergency spillway making the existing structure beneath the Interstate adequate. Along South Douglas Creek, the major structure beneath Interstate Highway 25 is very nearly adequate and can be used if some area is allowed for water backup behind Chestnut Street.

Some ditch and storm sewer systems have been constructed in the area. One such system drains the northernmost basin east of Interstate 25, carrying drainage water to the railroad right-of-way and then south to Garden of the Gods Road. In conjunction with this, another storm sewer system has been constructed from the new Hilton Inn site east along Garden of the Gods Road to Monument Creek. A storm sewer system exists along Holland Park Drive and Chestnut Street in the original Holland Park Subdivision. Both of these systems are on North Douglas Creek. On South Douglas Creek, a rather comprehensive storm sewer system has been developed by Hewlett-Packard internally and along Garden of the Gods Road. The only requirement left in this area would be to regrade the ditch leading to the greenbelt from Garden of the Gods Road at this point. Another storm sewer system has been developed in Holland Park leading from Chestnut Street across Interstate 25 and then down Sinton Road to the South Douglas Creek channel. Part of this was developed in the Holland Park Subdivision and parts of it were developed by commercial subdivisions east of the Interstate Highway. All of these systems are presently in existence. The last mentioned storm sewer is not completely adequate, but cannot be easily increased in size.

Very little right-of-way has been given in the basin for drainage structures. The various structures and sewers mentioned have generally been constructed as required by the road use. Many of the drainage systems which have been started, particularly in the industrial area, have been only partially completed. If these systems should be filled with runoff, many of them would have blocked exits and no outlet channels. Numerous culverts were found in the area which were either partially or wholly blocked. Most of these are too small and should be replaced.

MAIN CHANNELS GREENBELTS:

The previous study commissioned by the City of Colorado Springs recommended a rather extensive greenbelt drainage system through the basin. This is a desirable system since most of the streambeds already exist and channel flow is the most economical method of removing flood runoff from the developed area. The cost of open ditches or a drainage channel is usually lower than that of a series of large pipes. All major channels which would be required to carry the 100-year flow are shown in this report as greenbelts. In some areas where the ditches run through the Pierre Shale Formation, paving is not needed on the bottom and is only required on the sides. In other areas, the full section of the ditch is paved.

Since almost all of the construction in this basin has taken place since the 1964 report, the channel lines for the greenbelts, as proposed, have not been encroached upon. By and large, rights-of-way or actual channels have not been constructed, but the streambeds have not been obliterated. Developed greenbelts are usually preferable but the streambeds are usable as drainage runs with or without paving. As a consequence, nearly the entire length of greenbelts in the basin is available for use.

With the exception of the extreme western portion of the basin, most of the greenbelts are fairly well defined. All of the greenbelts were designed in the original report to follow the natural streambeds and not to interfere with land suitable for development. This study found that the same streambeds should be used for drainage as were proposed in 1964. In the lower basin, the subdivisions have grown around the streambeds and these are the only locations through which water could move easily.

Some relatively small changes have been made in these greenbelts, however. In this report, the greenbelts have been extended somewhat further west and practically to the Forest Service boundary. This is partially due to the information received concerning the development in the area along the Forest Service boundary and west of Wilson Road. The laboratory was informed that the gravel of the Verdos Alluvium was planned to be removed for use as aggregate prior to developing the area. After this is removed, the area will be developed as a low density residential district. If the gravel or Verdos Alluvium is removed from this area, the Pierre Shale will be at the surface of the ground and infiltration will be reduced considerably. This will allow much greater runoff, even considering the larger lots proposed. Since this is the case, it was felt that the major greenbelt should be extended to the Forest boundary on the west to allow a system of relatively short ditches or streets to drain this proposed development. Most of the remaining flow in this area is carried in small ditches rather than in storm sewers. Development should be designed around these ditches.

The greenbelts in the upper reaches of the basin will require full paving. In the lower reaches of the stream, on soils which can be eroded, full paving is also required. In the lower reaches of South Douglas Creek, the Pierre Shale is found on the surface of the ground. This material will not easily erode and the bottom of the ditches need not be paved over all of this line. The points which require paving are shown on the attached inventories. It should be noted that over most of the length of the greenbelt, simple riprap will not be adequate to protect the banks from scour and concrete lining is required. Along South Douglas Creek, immediately south of the Holland Park Subdivisions, an area exists which could be protected by gabions along points of erosion and the majority of the channel need not be paved. This area immediately west of Chestnut Street has been marked with a high water line and should be left generally in the native state. At all points along either of the Douglas Creeks, riprap should either be in the form of gabion or in the form of large rocks with a minimum weight of 400 pounds. No smaller riprap can be considered, except where the channel is to be used as a natural, strip park. All bridges along the greenbelts must be fully paved to avoid scour at entries.

It must be noted that several structures along these two greenbelts will tend to impede the flow and cause the greenbelt to act as a storage reservoir for a short time. The abandonment of the storage reservoir concept indicates that these structures should either be increased in size to accommodate the flow or the criterion should be changed so that upstream from these points, buildings will not be placed in areas of potential flooding. The two major points which are too small at the present time are the corrugated metal arch beneath Garden of the Gods Road along North Douglas Creek and the corrugated metal culvert beneath Chestnut Street along South Douglas Creek. The recommendation of this report is to increase the size of these two structures.

Under no circumstances should fences, particularly chain link fences, be allowed to cross a greenbelt. In most cases, the greenbelts will be deeded to the City and fences will not be probable. In some cases, however, greenbelts may be placed in easements and property line fences could extend across the greenbelt. This is not recommended and should not be allowed.

INDIVIDUAL IMPROVEMENTS:

Attention is directed to that portion of the appendix at the back of the report which lists individual improvements recommended in the basin. These lists are made up as inventories showing both the existing and proposed appurtenances in the basin. These lists of ditches, greenbelts, storm sewers, bridges and culverts together with the map of the basin show recommended improvements in the area.

After designing the main channel and greenbelts, each individual basin was studied using the minor basin hydrographs previously described. Water flow at various points in each basin was compared to street capacity and distribution. The street capacity used was in accordance with the latest City chart of usable capacity. In such cases, it was found that the specification of certain size streets would be sufficient to distribute runoff properly.

In most cases, drainage was carried in small individual ditches. In a few cases, small storm sewer systems were recommended to relieve street drainage where ditches cannot be easily designed. A storm sewer system is proposed along Garden of the Gods Road from approximately the Kaman Nuclear site to the proposed Centennial Boulevard. Another storm sewer system is proposed for an area to the west of the Western Forge site along Garden of the Gods Road. A third such system is proposed in an area south of South Douglas Creek and east of Centennial Boulevard, as proposed.

It was noted along the northern reaches of North Douglas Creek that drainage streets would trend toward the greenbelt as a series of relatively parallel streets. This design will not allow the streets to carry drainage into the greenbelt without overloading the streets. For this reason, a series of ditches was placed in this area leading from the hillsides to the greenbelt. These ditches are all placed in relatively low areas and the streets can be placed around the ditches.

Most of the small ditches shown on this plan must be paved at their junction with the greenbelt. Some ditches above this point can be riprapped, while some ditches are so steep that they will require full paving. In any event, the junction at the greenbelt must be paved so that secondary erosion does not take place at these points. It should also be noted that in locations of major street drainage or storm sewer systems entering the greenbelts, dropout structures should be placed along the curb at the junction of the greenbelt and the street or storm sewer. Every bridge or concrete box which is placed in this basin should be constructed with drains from the streets carrying water into the greenbelt. Insofar as is possible, these dropouts should be surface design dropouts for efficiency. If this is not possible, then the second best system would be that of curb boxes. The number of dropout boxes required has been included in the inventory lists and in the estimate, using a City standard dropout as a typical structure. Dropout structures are rather difficult to design and must be individually designed for different conditions.

Inlet problems are very difficult, particularly in the case of streets with steep grade. Here again, such problems must be worked out for each area, since the individual street design will alter any inlet design. City standard criterion have been used to determine the number of inlets which are required at any point. The number of inlets listed in the proposed inventory of appurtenances assumes that 6-foot inlets will be used throughout. Larger inlets may be used, if desired, and the total number of inlets would then be somewhat less.

SPECIFIC PROBLEM AREAS:

Several problem areas were noted in the basin, most of which are related to storm sewer appurtenances which have been planned and apparently authorized, but not completely constructed. As an example of this, along South Douglas Creek, from the proposed Centennial Boulevard east to Monument Creek, a streambed exists. Most of this streambed has not been deeded to the City, however, and practically no greenbelt construction has taken place in this area. Several of the Holland Park drainage plans and a few of the industrial drainage plans east of Interstate Highway 25 show this greenbelt as being planned.

At the same point and in addition to the greenbelt, the 96-inch culvert beneath Chestnut Street is far too small and should be replaced. If this cannot be accomplished, then an area upstream from the culvert which is sufficiently large to contain 55 acre feet of water above the top of the culvert should be reserved with no structures allowed to encroach on this area. If this pipe beneath Chestnut Street is allowed to remain in place, then no structures downstream need be enlarged. To fit the strip park plans in this area, it is recommended that this overflow area be designed.

In the same general area, a small drainage system exiting Holland Park at three points, crossing Interstate 25 at three points and entering a storm sewer system along Sinton Road is an unusual system. Almost none of the pipe is properly sized under the highway after it leaves the Holland Park Subdivision.

Fortunately, large areas in the Highway right-of-way can support ponded water. If, for some reason, the Highway Department should desire to eliminate these ponds of water, the system should be redesigned and enlarged with special emphasis on points at which 48-inch pipes enter 24-inch pipes. At this time, however, no changes should be made.

Two problem areas are found on South Douglas Creek at approximately the location of the Hewlett-Packard complex. At the eastern corner of the Hewlett-Packard complex, a storm sewer system around the buildings and down the Garden of the Gods Road enters a ditch which runs south toward the greenbelt. Unfortunately, this ditch is graded so that it drains to the north. This should be changed so that it drains toward the south and the water will be carried away to the greenbelt.

Along the western boundary of the Hewlett-Packard site, the main greenbelt is shown as being bent so that it runs from Wilson Road to the Hewlett-Packard boundary and then to the south along the boundary. The topography, at this point, is such that the greenbelt can be placed almost anywhere in this triangle of land. It is, however, recommended that it be placed on this boundary simply for convenience so that the tract to the west of Hewlett-Packard can be more conveniently used or developed.

Along North Douglas Creek, several problem points were noted. In the northern portion of the valley, near the junction of sub basins A and B, it can be noted that the streambeds tend to be redundant; that is to say, two streambeds tend to move parallel and very close to each other. This should be eliminated since it is wasteful of both culverts and ditches. Several points north of Garden of the Gods Road along North Douglas Creek have been changed to bring the streambeds together at points which would allow the use of less culverts and to gather the streams all into one channel as soon as possible.

The drainage plan for the Hewlett-Packard complex shows a drainage ditch along the north boundary of this complex. This will cut off a certain amount of flow from the north and will keep water off of the Garden of the Gods Road making the existing storm sewer adequate. In order that the storm sewer along Garden of the Gods Road can be used as it exists and that it not require increasing, this ditch must be constructed. It is shown extending from approximately the northwest corner of the Hewlett-Packard property to the greenbelt at approximately the old reservoir.

The existing large reservoir along North Douglas Creek must be removed. At this time, it is recommended that it simply be breached and that the water be allowed to flow through the dike along the greenbelt. Eventually, however, when the area is fully developed, the reservoir should be completely eliminated as part of the overall grading plan.

The final problem area on the North Douglas Creek line is the ditch along the western side of the D & RGW Railroad and north of North Douglas Creek. This is a borrow ditch for the railroad and is not designed as a major drainage ditch. This ditch should be paved in cooperation with the railroad so that the existing track is not damaged. It should also be noted that at the intersection of the ditch with the Garden of the Gods Road, a four-way interchange is located. One pipe and the ditch enter this interchange; two pipes exit. The two exiting pipes are not quite large enough and under full design flow, the action of the water as it reaches this point is completely unpredictable. It is generally recommended that this intersection be paved as part of the ditch and a box especially designed so that flow is removed from the site as rapidly as possible.

SUMMARY & RECOMMENDATIONS:

Experience in the City of Colorado Springs with the past drainage basins indicates several things. First, it is futile to try to control runoff with street drainage only. Second, it is generally uneconomic to design ditches of sufficient width that the velocities are reduced and paving is not required. This can be seen in almost every drainage basin where channels have been narrowed to the least possible width and paved, rather than leaving wide channels through developed areas. Third, although drainage control structures are easily constructed and maintained, insufficient funds exist for proper maintenance of these structures. This is particularly true of structures which actually control water rather than merely guide it.

As a result of this combination of experiences, most drainage control structures being built today consist of fairly narrow paved ditches with a high first cost and, assuming that the construction is proper, a relatively low maintenance cost. Since these past experiences have indicated that, locally, this is the most economical type of system, this is used in this report. If, at some future time, funds become available for maintenance, greenbelts could be widened and made into very pleasant strip parks.

The use of streets as drainage flow structures can, of course, be tolerated up to a point. Specifications of the City of Colorado Springs indicate that only small amounts of water are desired in the streets, particularly arterial streets. It is therefore recommended that all the streets in this area be designed to be used as drainage ways insofar as the limits of the City regulations allow. There is a point at which any street is simply unable to carry both water and traffic at the same time. At this point, a storm drainage facility must be designed. For this purpose, the greenbelts, ditches and storm sewers have been recommended in this report.

The specific recommendations in the report are shown in the appendix, on the attached inventory sheets and on the attached maps. The greenbelt widths are specified along with the ditch sizes and storm sewer sizes. Some caution must be used in applying these sizes in undeveloped parts of the basin, since new streets in the basin can affect both the size and location of the proposed appurtenance.

It is recommended that all of the greenbelts in the area be paved on the sides of the ditches, with the exception of a short stretch on South Douglas Creek between Centennial Boulevard and Interstate Highway 25. With the exception of greenbelts which are founded in the hard Pierre Shale, it is recommended that these channels be paved on the bottom also, over most of the area. The greenbelt of North Douglas Creek should, therefore, be completely paved. The greenbelt on South Douglas Creek would be paved on the sides, except between Centennial Boulevard and Interstate 25. It would be paved on the bottom, north of Garden of the Gods Road and east of Interstate Highway 25.

It is recommended that all structures which are too small for the proposed flow be enlarged by adding additional culverts or boxes, as the case may be, so that the structures can carry the full flow. The only exceptions to this would be the north creek crossing at Interstate Highway 25, the 96-inch culvert at the south creek crossing Chestnut Street and the two railroad structures. It is recommended that all ditches and culverts be properly sized where they do not now exist. This construction should not take place until the area through which the water flows is developed.

The general recommendation of this study is that the design features shown in the appendices, on the inventory sheets and on the attached maps be followed in at least general terms for planning purposes.

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SUMMARY ESTIMATE OF COSTS (TOTAL BASIN)

ITEM	QUANTITY	UNIT	TOTAL
1. GREENBELT - sides fully paved, natural park south of Holland Park and bottom paved except in Pierre Shale	59290	lin.ft.	$3,780,040.00
2. MAJOR DITCHES - partly paved, partly riprap	19785	lin.ft.	688,450.00
3. BRIDGE STRUCTURES- new (see inventory for separate cost breakdown)	8	ea.	293,650.00
4. BRIDGE STRUCTURE - replace inadequate (railroad bridges not included)	1	ea.	89,100.00
5. MAJOR CULVERTS	25	ea.	207,800.00
6. STORM SEWER SYSTEMS includes inlets, outlets, etc.	3 major lines & renovation		285,510.00
	TOTAL ESTIMATED BASIN COST -		$5,344,550.00

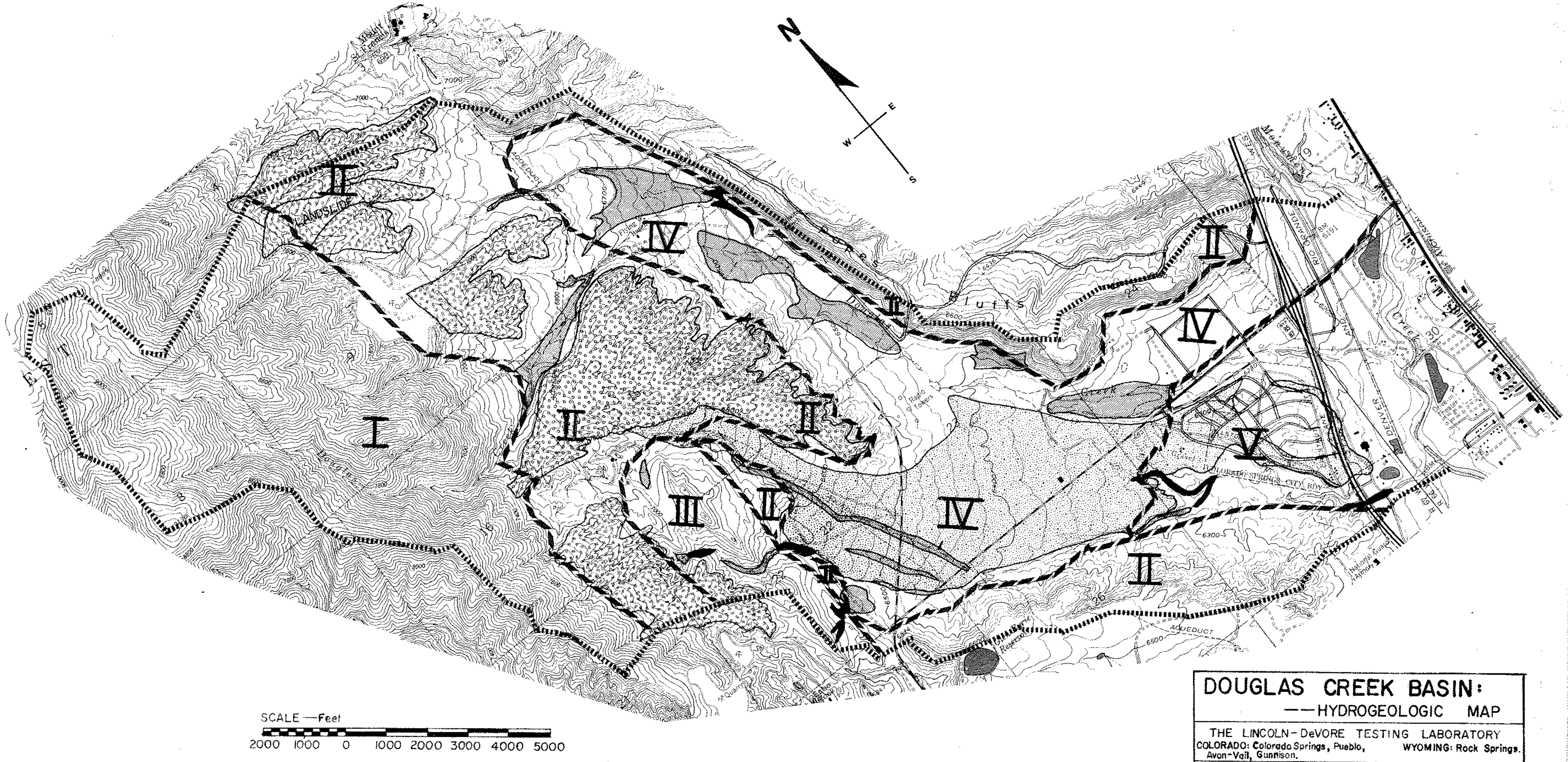
BASIN AREAS:	City Bridge Area	General Fee Area
Total	6525.3	6525.3
Existing platted subdivisions		639.5
Existing public rights-of-way		142.5
Pike National Forest	1879.7	1879.7
	4645.6	3863.60

Bridge Cost Only - $382,750.00

Private Basin Fee = $\frac{\$4,961,800}{3863.6}$ = $1,284.25 or, say, $1,285.00/acre

City Bridge Cost = $\frac{\$382,750}{4645.6}$ = $82.39 or, say, $83.00/acre

NOTE: of total fee area,
City of Colorado Springs property = 40.1 acres
D & RGW Railroad right-of-way = 23.5 acres



STREAM DRAINAGE PATTERNS

I — Medium to Fine, Youthful, Dendritic.

II — Fine, Developing Dendritic.

III — Coarse, Youthful, Trellis.

IV — Coarse, Meandering, Braided.

V — Coarse, Incising, Youthful, Dendritic.

HYDRO-GEOLOGIC CONDITIONS

General Mountainfront Alluvial Fans, Discontinuous 'Bajada' terrain features, Rapid erosion occurs at the fronts of these fans.

Remnant of the original Douglas Creek Alluvial Fan, The head and middle portions of the fan. Rapid erosion occurs at the front and sides of this fan.

Stream Alluvium, Includes remnants of the foot portion of the original Douglas Creek Alluvial Fan. Erosion rates are moderate.

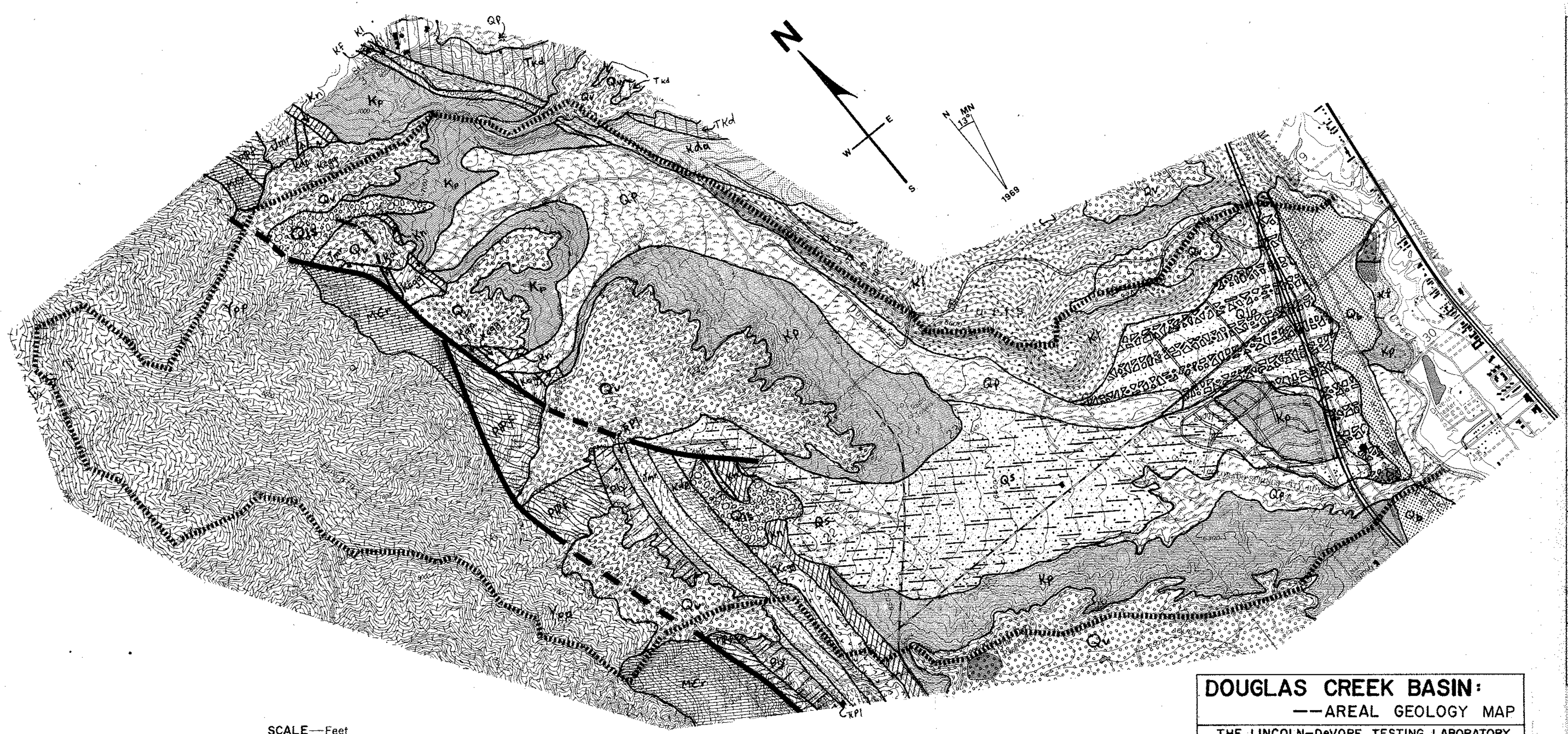
Areas of Current Deposition, Due to a rapid decrease in the stream velocities. Large cobbles are present in the western portions of the lower basin.

Areas of Constricted, Incised, Channels, Very high stream velocities.

DOUGLAS CREEK BASIN: —HYDROGEOLOGIC MAP

THE LINCOLN-DeVORE TESTING LABORATORY
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison. WYOMING: Rock Springs.

Drawn by:	Checked by:	Scale: 1" = 2000'	4-8-1974



SCALE—Feet

2000 1000 0 1000 2000 3000 4000 5000

Geology adapted from Scott and Wobus, "Reconnaissance Geologic Map of Colorado Springs and Vicinity, Colorado, U.S. Geological Survey Pub. No. MF-482, 1973.

EXPLANATION

AGE		FORMATION	HYDROLOGIC GROUPS A	B	C	D
Quaternary	Qp	Piney Creek Alluvium			X	
Quaternary	Qls	Landslide Deposits	X			
Quaternary	Qb	Broadway Alluvium	X			
Quaternary	Qlo	Louviers Alluvium			X	
Quaternary	Qs	Slocum Alluvium		X		
Quaternary	Qv	Verdos Alluvium	X			
Tertiary	TKd	Dawson Formation (Arkosic)				X
Cretaceous	Kda	Dawson Formation (Andesitic)			X	
Cretaceous	Kl	Laramie Formation			X	
Cretaceous	Kf	Fox Hills Formation			X	
Cretaceous	Kp	Pierre Formation				X
Cretaceous	Kn	Niobrara Formation				X
Cretaceous	Kcgg	Carlile, Greenhorn, and Graneros Formations			X	
Cretaceous	Kdp	Dakota and Purgatoire Formations				X
Jurassic	Jmr	Morrison and Ralston Creek Formations			X	
Triassic–Permian	RPl	Lykins Formation				X
Permian	Ply	Lyons Formation		X		
Pennsylvanian	PPf	Fountain Formation			X	
Cambrian–Mississippian	MCr	Manitou Formation		X		
Precambrian	Ypp	Pikes Peak Granite		X		

Faults — Major, Concealed, Minor

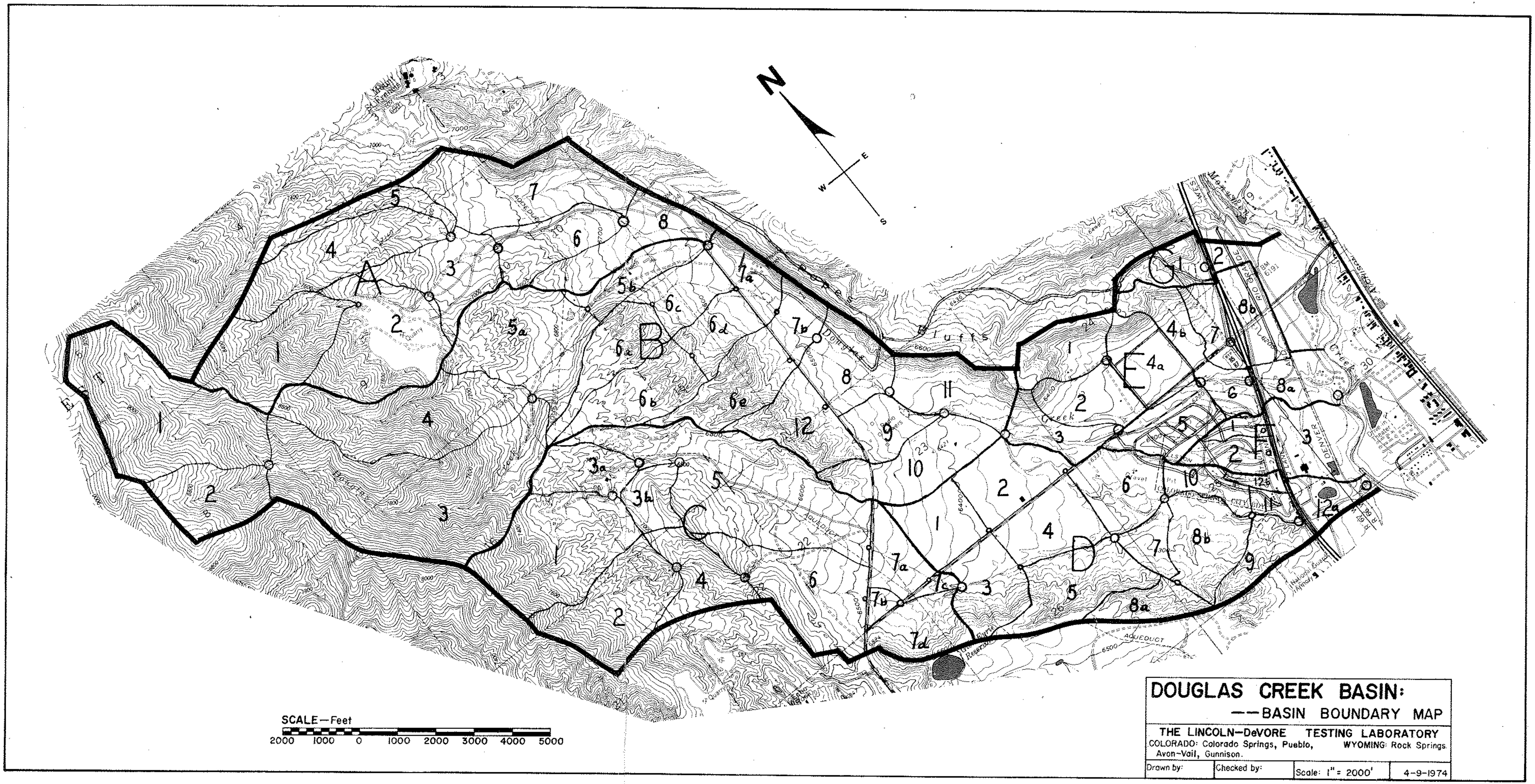
BASIN BOUNDARY

DOUGLAS CREEK BASIN:
—AREAL GEOLOGY MAP

THE LINCOLN-DeVORE TESTING LABORATORY

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

Drawn by:	Checked by:	Scale: 1" = 2000'	4-5-1974



DOUGLAS CREEK BASIN:
——BASIN BOUNDARY MAP

THE LINCOLN—DeVORE TESTING LABORATORY
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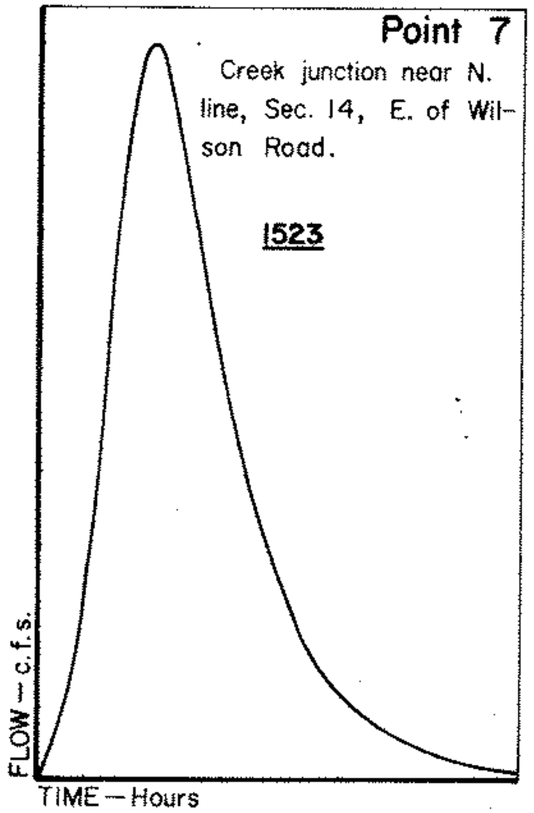
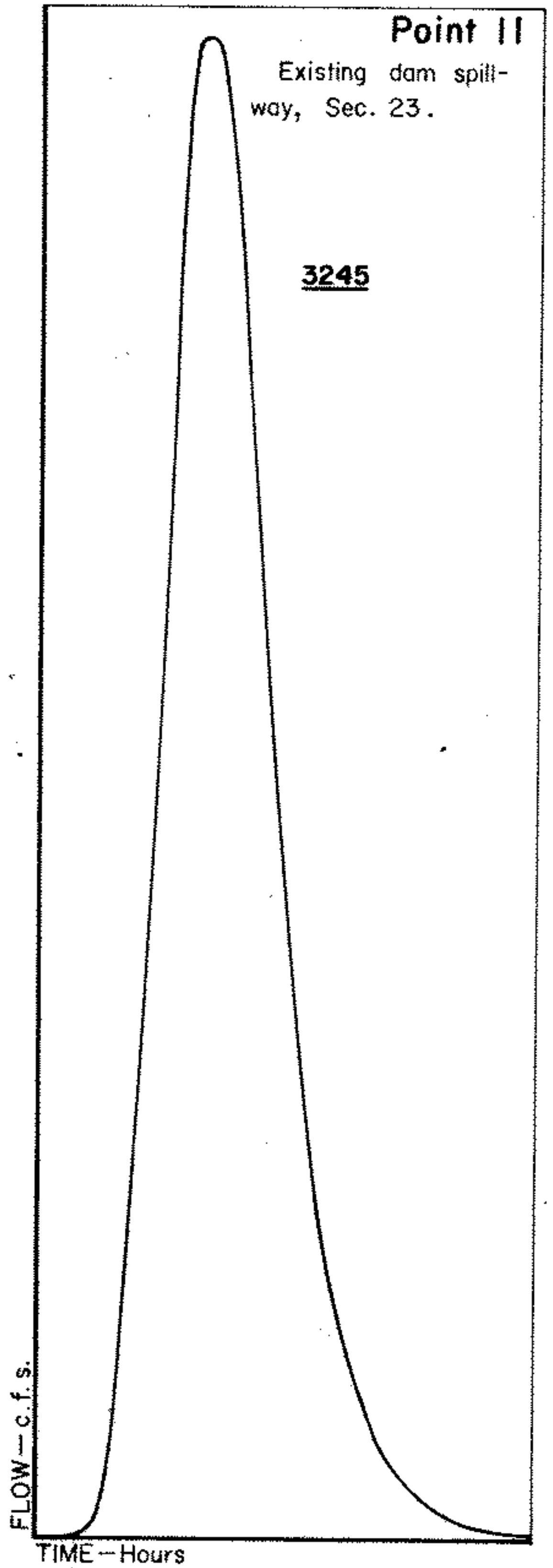
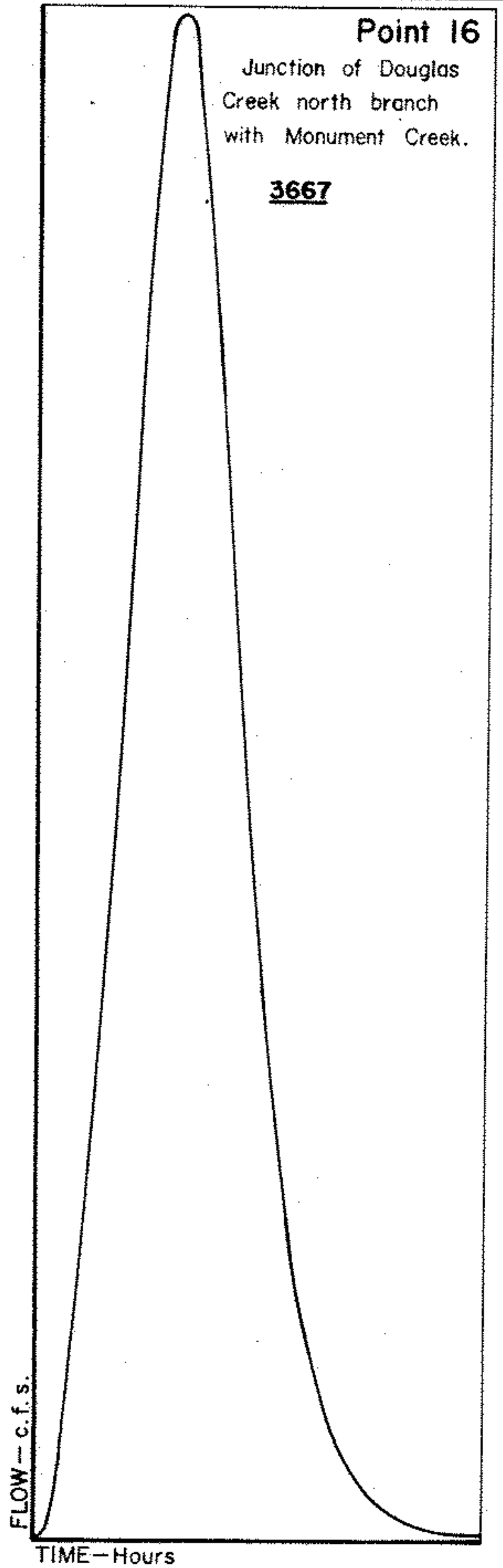
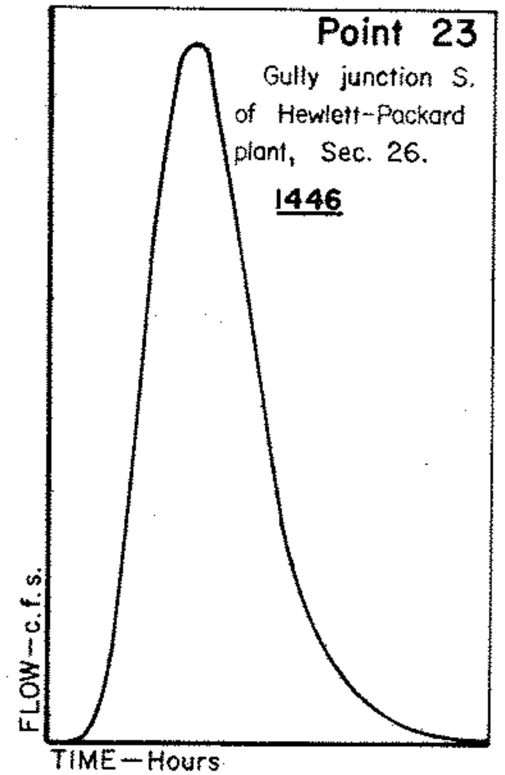
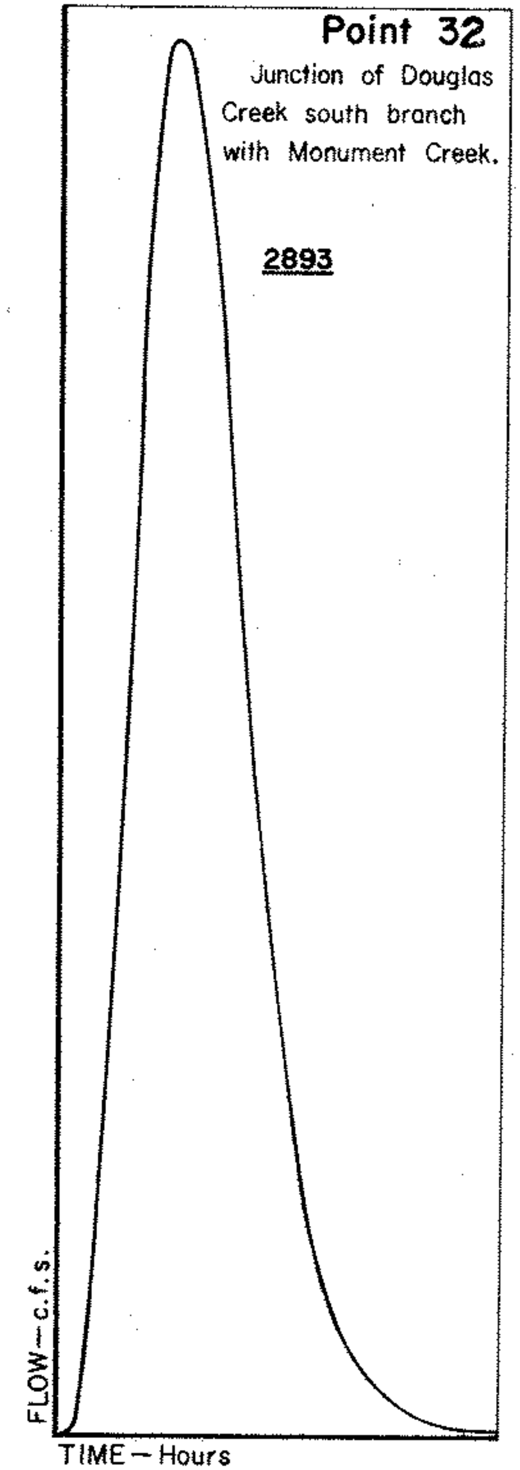
Drawn by:	Checked by:	Scale: 1" = 2000'	4-9-1974











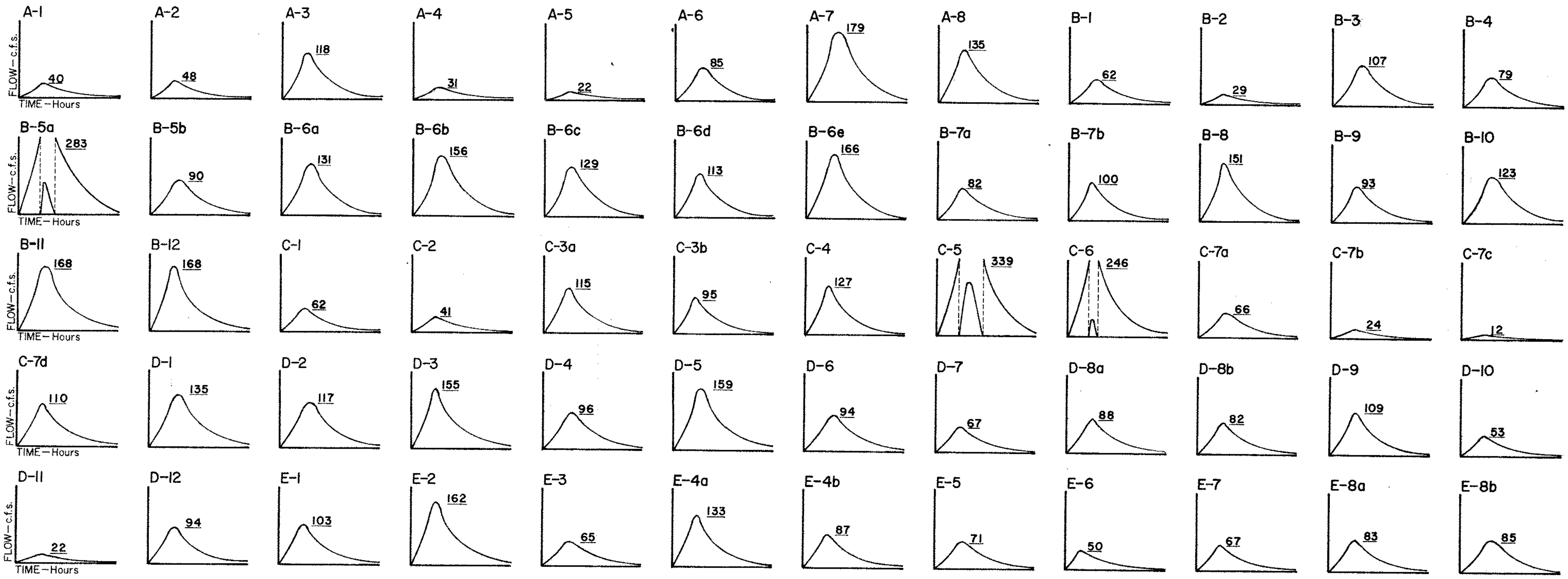
Vertical Scale: 1 inch = 400 cubic feet per second.
Horizontal Scale: 1 inch = 2 hours.
Underlined numbers are peak flows in cubic feet per second.

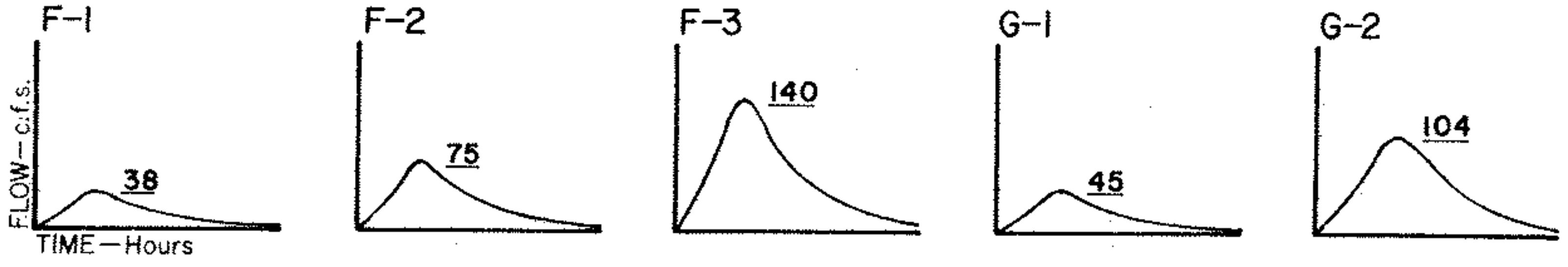
Principal Point Hydrographs:

DOUGLAS CREEK DRAINAGE STUDY (REVISION)

for the City of Colorado Springs, Colorado.

THE LINCOLN — DeVORE TESTING LABORATORY
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison.
WYOMING: Rock Springs





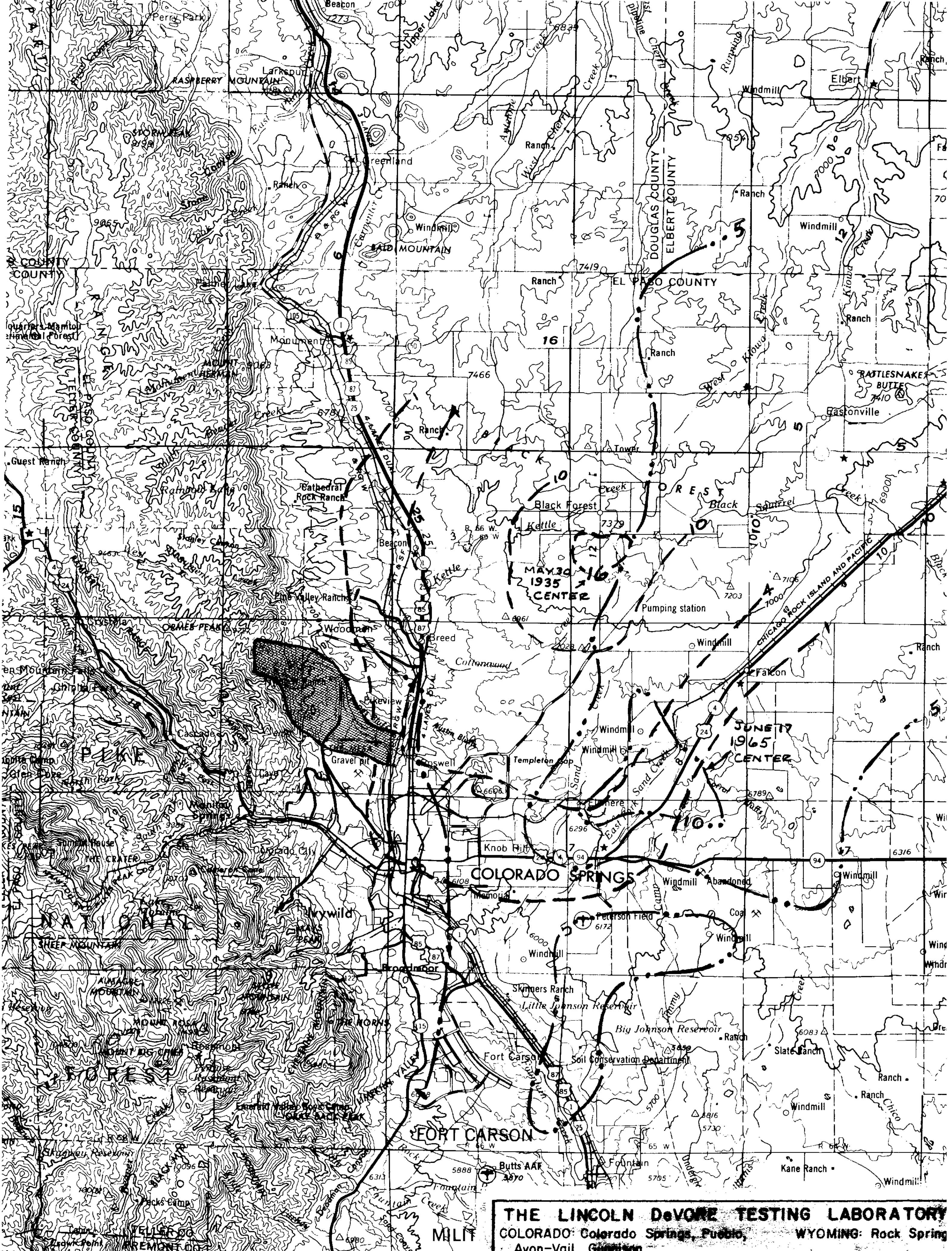
Vertical Scale: 1 inch = 200 cubic feet per second.
Horizontal Scale: 1 inch = 2 hours.
Underlined numbers are peak flows in cubic feet per second.

Individual Sub-Basin Hydrographs:

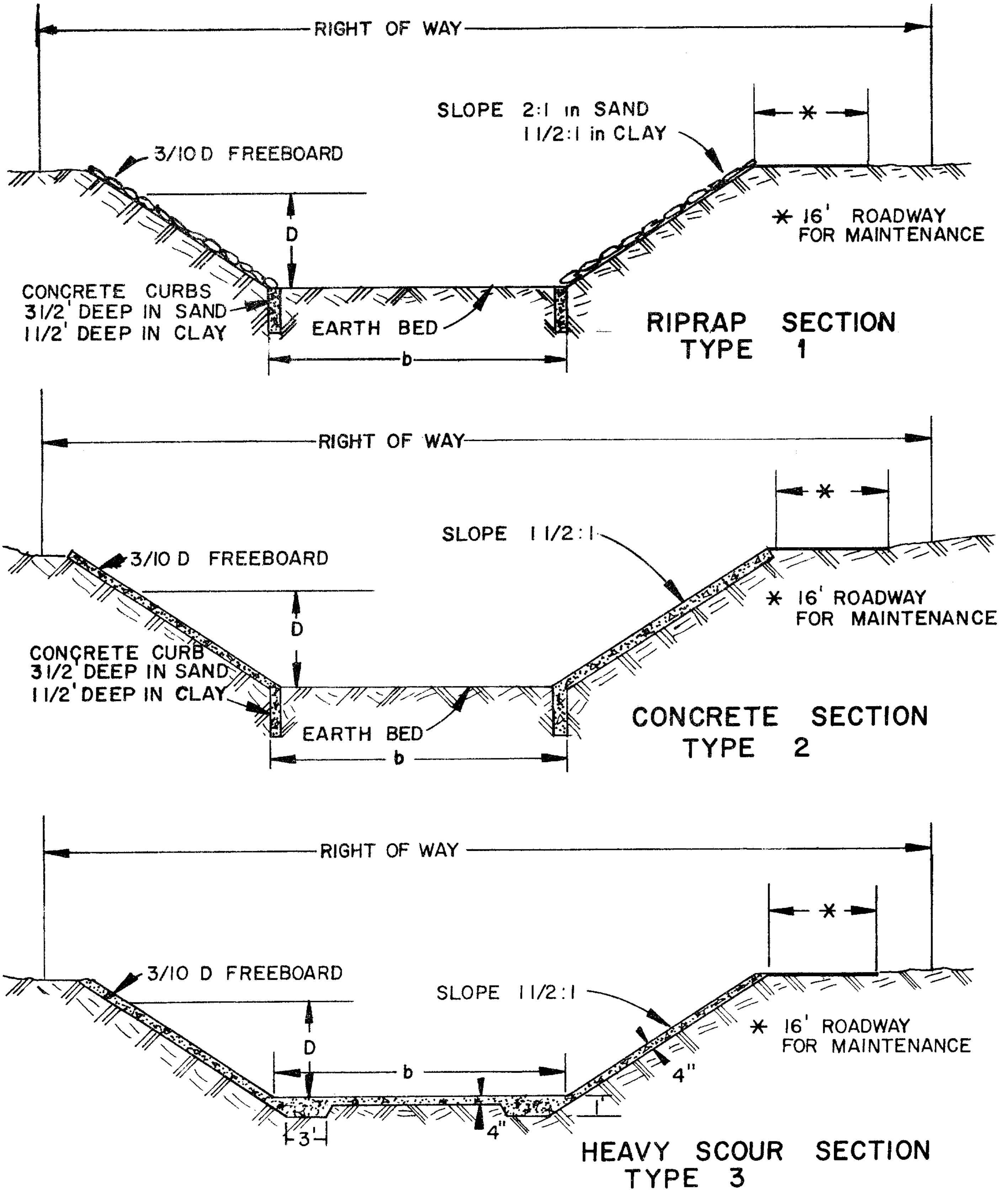
DOUGLAS CREEK DRAINAGE STUDY (REVISION)

for the City of Colorado Springs, Colorado.

THE LINCOLN—DeVORE TESTING LABORATORY
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison.
WYOMING: Rock Springs

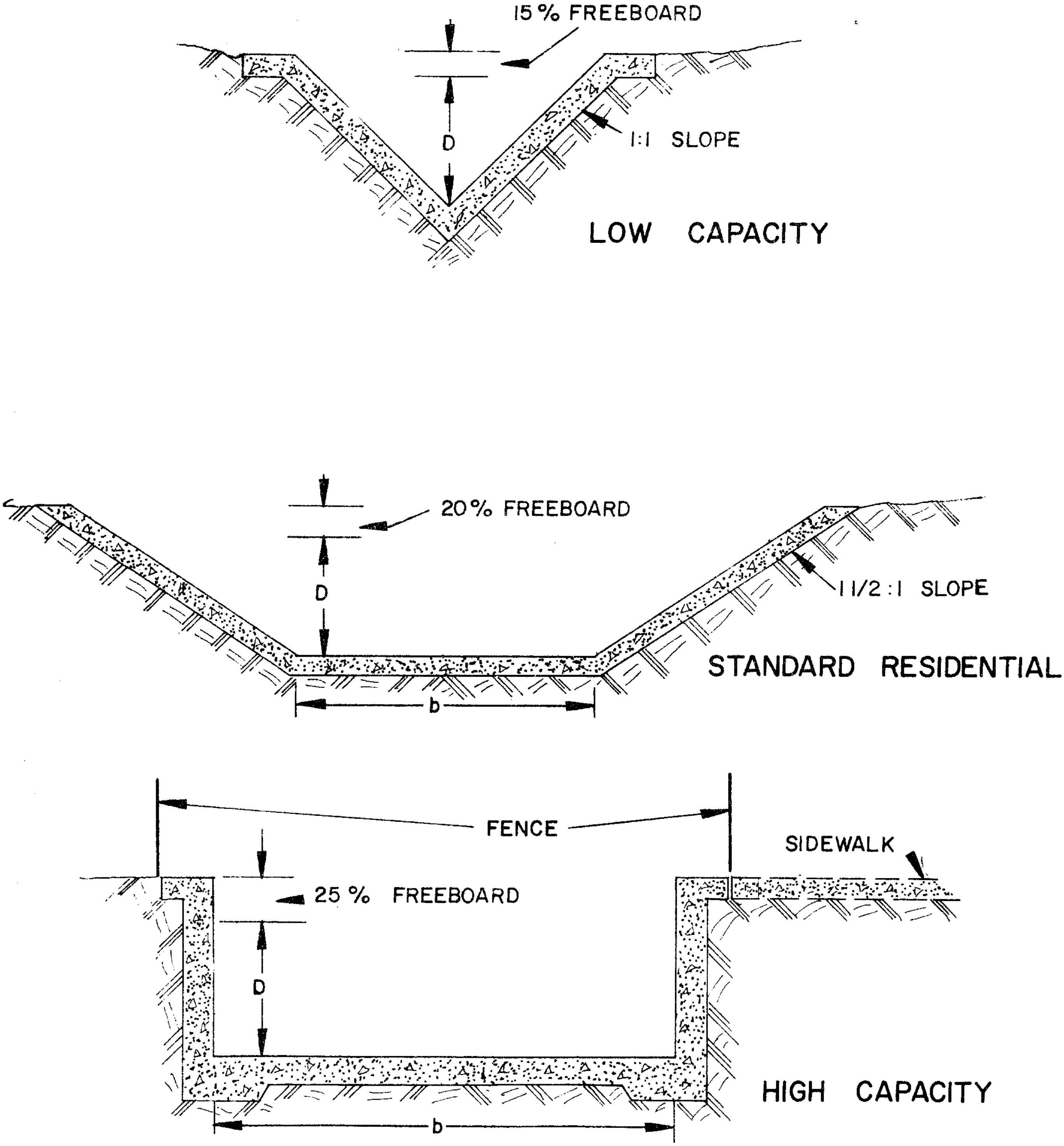


THE LINCOLN DeVORE TESTING LABORATORY
COLORADO: Colorado Springs, Pueblo, Avon-Vail, Gunnison. WYOMING: Rock Springs



TYPICAL GREENBELT DITCH SECTIONS

THE LINCOLN DeVORE TESTING LABORATORY



TYPICAL RESIDENTIAL DITCH SECTIONS

THE LINCOLN DeVORE
TESTING LABORATORY

MAJOR BASIN	SUB BASIN	AREA Acr.	AREA Sq. Mi.	BASIN L-ft	BASIN L-Mi	BASIN H	T C	DITCH L	DITCH S	SOIL CURVE NO.	T_{po}	FLOW Q(in)	FLOW q_p cfs	T_b
A	1	162.6	.254	4440	.841	1280	.14			69	.64	0.21	40	1.71
	2	193.2	.302	3930	.744	1450	.11	2650	.1358	68	.61	0.20	48	1.63
	3	115.8	.181	3650	.691	600	.14	2350 1250	.0851 .0880	87	.64	0.86	118	1.71
	4	157.0	.245	6020	1.140	1400	.19			66	.69	0.18	31	1.84
	5	53.0	.083	5100	.966	1000	.17			74	.67	0.36	22	1.79
	6	90.1	.141	3820	.724	355	.19	3950	.0329	87	.69	0.86	85	1.84
	7	196.4	.307	6000	1.136	525	.27			88	.77	0.93	179	2.06
	8	95.2	.149	3200	.606	390	.15	2600	.0365	92	.65	1.22	135	1.74
TOTAL A	*	1063.4	1.662	14800	2.80	2345	.47	(13000	.1158)	78	.728	1.24	1370	1.94
B	1	295.1	.461	5600	1.061	1240	.18			67	.68	0.19	62	1.82
	2	107.4	.168	2760	.523	1040	.08			69	.58	0.21	29	1.55
	3	430.2	.672	7400	1.402	1570	.23	9350	.1390	70	.73	0.24	107	1.95
	4	224.5	.351	6820	1.292	1850	.19			73	.69	0.32	79	1.84
	5a	190.0	.297	4000	.758	650	.16	2630	.0570	93	.66	1.30	283	1.76
	5b	65.9	.103	4550	.862	365	.22	4100	.0427	93	.72	1.30	90	1.92
	6a	90.4	.141	4680	.886	430	.22			94	.72	1.38	131	1.92

HYDROLOGIC COMPUTATIONS - Basic Data Sheet 1 of 12	LINCOLN-DeVORE TESTING LABORATORY, INC. Colorado Springs, Colorado

*Denotes 100-year computations
all other are 50-year computations

MAJOR BASIN	SUB BASIN	AREA Acr.	AREA Sq. Mi.	BASIN L-ft	BASIN L-Mi	BASIN H	T C	DITCH L	DITCH S	SOIL CURVE NO.	T_{pc}	FLOW Q(in)	FLOW q_p cfs	T b
B	6b	106.1	.166	4550	.862	420	.21			94	.71	1.38	156	1.90
	6c	83.6	.131	3250	.616	240	.18	2600	.0538	94	.68	1.38	129	1.82
	6d	63.4	.099	2500	.474	260	.13	2350	.0638	95	.63	1.48	113	1.68
	6e	108.0	.169	3920	.742	390	.18			94	.68	1.38	166	1.82
	7a	52.2	.082	2300	.436	210	.13	2950	.0186	93	.63	1.30	82	1.68
	7b	56.1	.088	1780	.337	220	.09	1400	.0271	94	.59	1.38	100	1.58
	8	89.4	.140	2300	.436	240	.12	2100	.0190	94	.62	1.38	151	1.66
	9	49.7	.078	2150	.407	110	.15	1800	.0235	96	.65	1.60	93	1.74
	10	105.2	.164	4940	.936	370	.25	1700	.0230	91	.75	1.16	123	2.00
	11	129.4	.202	3400	.644	280	.18			94	.68	1.38	198	1.82
	12	98.7	.154	2100	.398	240	.11			90	.61	1.10	134	1.63
TOTAL B	*	2349.6	3.673	30500	5.78	2880	.92	9500 29500	.0226 .0827	83	1.05	1.48	2506	2.80
C	1	214.4	.335	4300	.814	1340	.13			70	.63	0.24	62	1.68
	2	166.5	.260	4100	.777	1255	.12			68	.62	0.20	41	1.66
	3a	69.3	.108	2800	.530	360	.13	1230	.0488	94	.63	1.38	115	1.68
	3b	46.8	.073	1250	.237	310	.05	1080	.0417	95	.55	1.48	95	1.47

MAJOR BASIN	SUB BASIN	AREA Acr.	Sq. Mi.	BASIN L-ft.	L-Mi.	H	T C	DITCH L	S	SOIL CURVE NO.	T_{po}	FLOW Q(in)	q_p cfs	T_b
C	4	83.6	.131	2050	.388	520	.08	2050	.0780	91	.58	1.16	127	1.55
	5	333.8	.522	6400	1.212	410	.32	5100	.0588	90	.82	1.10	339	2.19
	6	174.4	.272	2800	.530	430	.12	4500	.0556	91	.62	1.16	246	1.66
	7a	44.4	.069	2500	.474	80	.20	1700	.0412	94	.70	1.38	66	1.87
	7b	15.09	.024	1220	.231	40	.12	950	.0358	93	.62	1.30	24	1.66
	7c	7.4	.011	1200	.227	40	.11	800	.0313	94	.61	1.38	12	1.63
	7d	78.7	.123	2530	.479	260	.13	1750	.0286	91	.63	1.16	110	1.68
TOTAL C	*	1234.4	1.928	14780	2.80	1560	.62	<13210	.1204>	85	.870	1.60	1716	2.32
D	1	98.8	.154	3000	.568	110	.22			93	.72	1.30	135	1.92
	2	94.5	.148	3050	.578	80	.25			92	.75	1.22	117	2.00
	3	90.9	.142	2200	.417	260	.11	1950 1800	.0205 .0222	94	.61	1.38	155	1.63
	4	84.0	.131	3050	.578	110	.23	2700	.0259	90	.73	1.10	96	1.95
	5	111.2	.174	3600	.682	270	.19			93	.69	1.30	159	1.84
	6	96.0	.150	2700	.511	80	.22	2150	.0286	88	.72	0.93	94	1.92
	7	37.7	.059	2100	.398	160	.13	1850	.0216	95	.63	1.48	67	1.68
	8a	50.4	.079	2250	.426	150	.14			95	.64	1.48	88	1.71

HYDROLOGIC COMPUTATIONS - Basic Data

LINCOLN-DeVORE TESTING LABORATORY, INC.
Colorado Springs, Colorado

MAJOR BASIN	SUB BASIN	AREA Acr.	AREA Sq. Mi.	BASIN L-ft.	BASIN L-Mi.	BASIN H	T C	DITCH L	DITCH S	SOIL CURVE NO.	T_{po}	FLOW Q(in)	FLOW q_p cfs	T_b
D	8b	46.8	.073	2650	.502	250	.14	2500 1600	.0640 .0250	95	.64	1.48	82	1.71
	9	57.9	.090	2800	.530	270	.14	2000	.0200	96	.64	1.60	109	1.71
	10	22.0	.034	2600	.492	100	.19			88	.69	0.93	22	1.84
	11	48.4	.076	1250	.237	60	.10			87	.60	0.86	53	1.60
	12	66.8	.104	2050	.388	100	.15	2000	.0350	92	.65	1.22	94	1.74
TOTAL D	*	905.4	1.414	12500	2.37	400	.66	12100	.0240	92	.90	2.20	1673	2.40
E	1	76.5	.120	2580	.489	320	.12			90	.62	1.10	103	1.66
	2	99.2	.155	3150	.597	400	.14			94	.64	1.38	162	1.71
	3	47.3	.074	3300	.625	140	.22	2950	.0271	93	.72	1.30	65	1.92
	4a	82.6	.129	2400	.455	330	.11	1800	.0222	93	.61	1.30	133	1.63
	4b	55.6	.087	2600	.492	260	.13	2000	.0175	93	.63	1.30	87	1.68
	5	72.9	.114	2700	.511	80	.22	1750	.0210	88	.72	0.93	71	1.92
	6	32.2	.050	1100	.208	50	.09	1450	.0207	92	.59	1.22	50	1.58
	7	38.5	.060	1700	.322	150	.10			94	.60	1.38	67	1.60
	8a	62.3	.097	2000	.379	80	.16	2500	.0240	91	.66	1.16	83	1.76
	8b	71.7	.112	2800	.530	50	.28	2200	0182	92	.78	1.22	85	2.08

LINCOLN-DeVORE TESTING LABORATORY, INC.
Colorado Springs, Colorado

MAJOR BASIN	SUB BASIN	AREA Acr.	AREA Sq. Mi.	BASIN L-ft.	BASIN L-Mi.	BASIN H	T C	DITCH L	DITCH S	SOIL CURVE NO.	T_{po}	FLOW Q(in)	FLOW q_p cfs	T_b
TOTAL E	*	638.8	.998	8800	1.67	480	.46	8900	.0180	92	.780	2.20	1362	2.08
F	1	20.8	.032	1800	.341	60	.15			96	.65	1.60	38	1.74
	2	40.4	.063	1800	.341	60	.15			96	.65	1.60	75	1.74
	3	108.1	.169	2600	.492	85	.21	2750	(av.) .0327	92	.71	1.22	140	1.90
TOTAL F	*	169.5	.264	6100	1.155	200	.52			93	.810	2.20	347	2.16
G	1	47.7	.075	2300	.436	120	.16			86	.66	0.82	45	1.76
	2	116.6	.182	4200	.796	90	.35	2750	.0327	89	.85	1.00	104	2.27
TOTAL G	*	164.3	.257	6500	1.231	310	.42			88	.752	1.82	301	2.01
TOTAL BASIN		6582.7	10.286											

HYDROLOGIC COMPUTATIONS - Basic Data

Sheet 5 of 12

LINCOLN-DeVORE TESTING LABORATORY, INC.

Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
I	A	11	1370	.728	9500	.0226	.189	.917				
	B	11	2506	1.050				1.02	1.05 .917	.97 1.11	3783	Combine
	11	16	3783	1.05	8900	.0180	.206	1.13	1.26 .780	.90 1.45	4623	Add E Outlet (1) North
II	C&D	32	1716	.870	12100	.0240	.310	1.09	1.18 .90	.92 1.21	3221	Outlet (2) South

HYDROLOGIC COMPUTATIONS - Stream routing

100 YEAR

LINCOLN-DeVORE TESTING LABORATORY, INC.

Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
A	Basin 1 & 2	(1)	40 48	.64 .61	2650	.1358	.066	.62	.65	.94	86	
	Basin 4 & 5	(2)	31 22	.69 .67				.67	.69	.97	52	
	(1)	(3)	86	.62	2350	.0851	.065	.68				
	(2)	(3)	52	.67	1250	.0880	.035	.71				
									.70	.68 .71	136	Combine-assume paved ditch after Pt. 3
	(3)	(4)	136	.70	3950	.0329	.091	.78	.69 .77	1.13 1.03	394	Add 6 & 7
	4	7	394	.78	2600	.0365	.060	.84 .78	.65	.93 1.20	510	Add 8
B	Basin 1,2,3	6	62 29 107	.68 .58 .73	9350	.1390	.236	.80	.91 .81 .73	.88 .99 1.10	190	
	Basin 4	6	190	.80				.80	.69	1.16	265	Combine all at (6)
	6	6A	265	.80	2630	.0570	.061	.86 .76	.66	.88 1.15	508	Assume paved ditch E of (6). Widen bottom to reduce V
	6A	7	508	.76	4100	.0427	.095	.86 .84	.72	.98 1.17	592	
								.82	.78 .84	1.05 .98	1091	Combine Basins A & B at this point. Pt. 7

HYDROLOGIC COMPUTATIONS - Stream routing

Sheet 7 of 12

50 YEAR

LINCOLN-DeVORE TESTING LABORATORY, INC.

Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
B	Basin 6A	7C	131	.72	2600	.0538	.056	.73	.68	.94 1.07	254	Local basin 6. Add 6C, assume paved invert
	Basin 6B	7C	156	.71	2350	.0638	.050	.71	.63	.93 1.13	261	
								.72	.73 .71	.99 1.01	511	Combine at 7C
	7	7D	1091	.82	2950	.0186	.068	.83	.72 .63	.93 1.15 1.32	1621	Main channel flow-Combine all.
	Basin 6E	8	166	.68	960	.0380	.024	.70			166	
	7D	8	1621	.83	1400	.0271	.030	.84	.70 .59	.98 1.20 1.42	1829	Combine 6E Main chan.
	Basin 12	9	168	.61	1850	.0368	.043	.65			168	
	8	9	1829	.84	2100	.0190	.058	.89	.61 .62	.99 1.46 1.44	2040	Combine 12 & 8 Main channel
	9	10	2040	.89	1800	.0235	.045	.94	.65	1.45	2105	Add 9
	10	11	2105	.94	1700	.0230	.043	.98	.68 .75	1.44 1.31	2325	Add 10 & 11 Bottom of Basin 3

HYDROLOGIC COMPUTATIONS - Stream routing

Sheet 8 of 12 50 YEAR

LINCOLN-DeVORE TESTING LABORATORY, INC.

Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
E	Basin 1	13	103	.62	1800	.0222	.050	.65	.67 .64	.97 1.02	262	Combine 1 & 2
	Basin 4	13	133	.61				.64	.65 .61	.98 1.05	391	Add 4a
	11	13	2325	.98	2950	.0271	.074	1.05	1.05 .61 .72	1 1.72 1.46	2558	Main line - add 3 & combine above
	13	14	2558	1.05	1750	.0210	.044	1.09	.72 .63	1.51 1.73	2647	Add 5 & 4b
	14	15	2647	1.09	1450	.0207	.040	1.13	.59	1.92	2666	Add 6
	Basin 7	17A	67	.60	2200	.0182	.078	.68	.78	.87	148	Side line-Basin 7- Add 8B
	15	16	2666	1.13	2500	.0240	.069	1.20	.68 .66	1.76	2765	Main line-add 8B & 8A End - North line

HYDROLOGIC COMPUTATIONS - Stream routing LINCOLN-DeVORE TESTING LABORATORY, INC.

 50 YEAR Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
C	Basin 1	19	62	.63	1230	.0488	.031	.62	.60 .63	1.03 .98	175	Add 1 & 3B. All points assumed paved after 18
	19	20	175	.62	1080	.0417	.027	.63	.65 .55	.97 1.15	264	Add 3a
	20	21	264	.63	5100	.0588	.118	.79	.75 .82	1.05 .96	594	Add 5
	21	22	594	.79	1700	.0412	.039	.81	.83 .70	.98 1.16	650	Add 7a
	22	23	650	.81	800	.0313	.020	.83	.61	1.36	659	Add 7c Hold for second branch
	Basin 2	25	41	.62	2050	.0780	.057	.62	.68 .58	.91 1.07	164	Add 2 & 4, all points after 24 paved.
	25	26	164	.62	4500	.0556	.113	.66	.73 .62	.90 1.06	400	Add 6
	26	27	400	.66	950	.0358	.024	.68	.62	1.10	424	Add 7b
	27	23	424	.68	1750	.0286	.041	.70	.72 .63	.97 1.11	528	Add 7d
								.77	.83 .70	.93 1.10	1163	Combine at 23 (& C)

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
D	Basin 1	23B	135	.72	1200	.0283	.033	.75			135	
	23	23B	1163	.77	1950	.0205	.049	.81	.82 .75 .61	.99 1.08 1.33	1422	Main line - add 1 above and 3
	2	29	117	.75	3150	.0286	.080	.78	.83 .72	.94 1.08	207	Add 2 & 6
	23B	28	1422	.81	2700	.0259	.068	.87	.88 .73 .69	.99 1.19 1.26	1650	Main line - Add 4 & 5
	34	29	1650	.87	1850	.0216	.043	.89	.91 .63 .78	.98 1.41 1.14	1887	Add 7 & 2 & 6 above
	Basin 8A	30	88	.64	2650	.0640	.057	.67	.70 .64	.96 1.05	168	Add 8a, 8b
	35	30	1887	.89	1600	.0250	.037	.93	.60 .67	1.55 1.39	2014	Main line - add 10 & 8a, 8b above
	36	31	2014	.93	2000	.0210	.046	.98	.64 .60	1.53 1.63	2113	Add 9 & 11
	37	32	2113	.98	2000	.0330	.056	1.04	.65	1.60	2166	End basin C/D

HYDROLOGIC COMPUTATIONS - Stream routing

Sheet 11 of 12 50 YEAR

LINCOLN-DeVORE TESTING LABORATORY, INC.

Colorado Springs, Colorado

LINE	FROM	TO	BASE q_p	BASE T_p	DITCH L	DITCH S	DITCH Time	T_p at POINT	T_p of NEXT	RATIO	q_p (cfs)	REMARKS
G	Basin 1	34	45	.66	2750	.0327	.085	.80	.74 .85	1.08 .94	147	Add Basin 2
F	Basin 1 & 2	32	75	.65	2750	.0327	.076	.72	.73 .75 .71	.99 .99 1.01	252	Add 3

50 YEAR

GREENBELT INVENTORY - NORTH DOUGLAS CREEK

POINTS FROM	TO	DESIGN FLOW	BOTTOM WIDTH	REQUIRED DEPTH	ACCESS	RECOMMENDED R/W	LENGTH	COMMENTS
1	3	172	6'	3'	16'	35'	1750'	
3	4	580	24'	3'	16'	50'	3850'	
4	7	1022	25'	4'	16'	60'	2400'	
6	6a	770	24'	3'	16'	50'	1400'	
6a	7	898	33'	3'	16'	70'	3700'	
7	Wilson entry	1880	63'	4'	16'	100'	1340'	
Wilson entry	7d	2387	55'	5'	16'	100'	1250'	Enters Centennial
7d	8	2530	50'	5'	--	100'	1000'	Centennial 70'
8	9	2820	66'	5'	--	100'	2200'	Centennial 80'
9	10	2962	59'	5'	--	100'	1780'	Centennial 75'
10	11	3245	50'	6'	16'	100'	1750'	
11	13	3398	66'	5'	16'	150'	3450'	R/W exists ditch-earth (not dedicated)
13	14	3523	57'	6'	16'	150'	2250'	
14	15	3541	58'	6'	16'	150'	1350'	
15	16	3605	60'	6'	16'	150'	1140'	75' width exists of R/W

GREENBELT INVENTORY - SOUTH DOUGLAS CREEK

POINTS FROM	TO	DESIGN FLOW	BOTTOM WIDTH	REQUIRED DEPTH	ACCESS	RECOMMENDED R/W	LENGTH	COMMENTS
20	W21	489	13'	3'	16'	40'	4330'	
W21	21	716	24'	3'	16'	50'	1700'	
21	23	798	30'	3'	16'	55'	2660'	
25*	26	482	15'	3'	16'	40'	3780'	
26*	23	646	27'	3'	16'	55'	2390'	
23*	23b	1887	61'	4'	16'	100'	2040'	
23b*	28	2196	44'	5'	16'	100'	2150'	
28*	29	2340	50'	5'	16'	130'	1620'	
23c	29	460	21'	3'	16'	50'	2550'	
29✓	30	2688	54'	5'	16'	150'	1800'	
30✓	31	2797	59'	5'	16'	150'	1820'	
31	32	2893	60'	5'	16'	150'	1840'	Probably 100' is all possible.

NOTE: All basins should be fully paved except those marked with (*) which need to be paved only on the sides, and those marked with (✓) which do not need to be paved.

MAJOR DITCH INVENTORY - NORTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	DESIGN FLOW	EXISTING BOTTOM WIDTH	DEPTH	R/W	REQUIRED BOTTOM WIDTH	REQUIRED DEPTH	RECOM. R/W	LENGTH	COMMENTS
A-7	4	246	None			14'	3'	50'	1500'	Change stream course
B-5a	6a	283	None			24'	3'	50'	1400'	Remove dam
B-6c	7c	235	None			10'	3'	35'	2100'	
B-6d	7c	276	None			11'	3'	40'	2000'	
B-7a	7d	511	None			38'	3'	65'	640'	
B-7b	N8	187	None			8'	3'	30'	750'	
B-8	9	185	None			8'	3'	30'	1450'	
B-10	11	123	None			0	5'	30'	3850'	Ditch only-14' V 13.5 top
E-1	12	82	None			4'	3'	15'	600'	Roadside
E-2	13	82	None			3'	3'	15'	100'	
E-4a	13	30	None			2'	3'	15'	200'	
E-4a	14		10'	2'	None					Not required
E-4b	14	74	None			3.5'	3'	15'	575'	
E-4b	14	87	None			2'	3'	15'	400'	Called for, but not built
E-6	15	159	6' exist.	2' ditch	None	6'	2'	(RR)	800'	Line exist.
E-8b	E17	85	10' exist.	2' ditch	None	6'	3'	(RR)	1670'	Line exist.
E-8a	E17	220	8'	3'	None	8'	3'	(RR)	1920'	Line exist.
G-1	33	22	5'	5'	None	--	-	--	2840'	Line exist

SOUTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	DESIGN FLOW	EXISTING BOTTOM WIDTH	DEPTH	R/W	REQUIRED BOTTOM WIDTH	REQUIRED DEPTH	RECOM. R/W	LENGTH	COMMENTS
C-3a	20	175	None			6'	3'	35'	780'	Change stream course
D-4	23b	146	Ditch-no shape no grade			5'	3'	30'	1310'	
D-6	29	20	None			0	1'	25'	720'	Called for but not built V 6' top
D-8b	30	150	None			2'	5'	20'	470'	
D-9	31	109	None			3'	4'	20'	940'	
D-12	E31	130	9'	1.5'	None				310'	

BRIDGE INVENTORY - NORTH DOUGLAS CREEK
(including concrete boxes)

APPROX. LOCATION SUB BASIN	NEAR POINT	STREET	EXISTING STRUCTURE	50-yr. FLOW	100-yr. FLOW	REQUIRED STRUCTURE (RCB) OPEN	WIDTH	COMMENT	ESTIMATED COST
A-B	7	Wilson Rd.	1 2-1/2 x 7' box	1091	1523	1 6'x36'	44'	Replace	$21,384.00
B-7a	Y	Wilson Rch. entry road	None		1880	1 6'x44'	40'		23,760.00
B-7b	7d	Centennial Boulevard	None		2387	1 7'x43'	50'		33,860.00
B-8	N9	Technology Drive	None		2820	1 8'x40'	50'		36,000.00
B-9	9	Centennial Boulevard	None		2962	1 8'x46'	56'		46,368.00
E-3	13	Garden of Gods Road	CMP arch 10.6'x17.5'		3398	1 10'x36'	150'	Replace-storage inadequate	89,100.00
E-5	14	Chestnut Street	1 8'x50' RCB		3523	1 8'x54'	70'	OK	
E-6	15	I-25	1 7'x16'; alt. overflow railroad box		3541	1 8'x56'	240'	OK because of alt.	
E-8a	RR	RR main	7'x9' RR arch		3605	1 12'x32'	40'	RR	

BRIDGE INVENTORY - SOUTH DOUGLAS CREEK
(including concrete boxes)

APPROX. LOCATION: SUB BASIN	NEAR POINT	STREET	EXISTING STRUCTURE	100-yr. FLOW	REQUIRED STRUCTURE (RCB) OPEN	WIDTH	COMMENT	ESTIMATED COST
D-7	E28	Centennial Boulevard	None	2340	1 8'x32'	85'		$48,960.00
D-7	29	Holland Park Boulevard	None	2503	1 8'x38'	70'		47,880.00
D-9	W37	Chestnut Street	96"ØCMP	2797	1 12'x18'	90'	probably adequate-storage	
D-9	37	I-25	1 12'x14' RCB	2797	1 14'x14'	200'	probably adequate-storage	OK
D-12	E37	Sinton Road	1 14'x24' wood bridge	2810	1 14'x16'	45'	probably adequate-storage	35,438.00
D-12	W38	RR main	1 12'x24' plate girder	2893	1 12'x30'	30		RR

MAJOR CULVERT INVENTORY - NORTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	STREET	EXISTING STRUCTURE	cfs 50-yr. FLOW	cfs 100-yr. FLOW	REQUIRED	LENGTH	COMMENT
A-2	W1	Pikeview Quarry Rd.	None	72	160	54"Ø	55'	
A-2	1	Pikeview Quarry Rd.	None	86	172	66"Ø	60'	
A-3	NW3	Pikeview Quarry Rd.	None	104	---	54"Ø	55'	Not on Greenbelt
A-7	4	Pikeview Quarry Rd.	None	--	246	78"Ø	64'	
B-3	6	Flying W Ranch Rd.	None	80	---	45"Ø	50'	Not on Greenbelt
B-5a	6a	Flying W Ranch Rd.	None	--	770	120"Ø	66'	
A-8	7	Wilson Ranch Rd.	30"ØCMP	--	---	None		Remove
B-6c	7a	Road not named	None	131	---	54"Ø	44'	Not on Greenbelt
B-6d	7b	Road not named	None	156	---	66"Ø	46'	Not on Greenbelt
B-7a	7c	Wilson Ranch Rd.	None	742	---	120"Ø	60'	Not on Greenbelt
B-6e	7e	Wilson Road	24"Ø CMP	166	---	60"Ø	46'	Ht. not on Greenbelt
B-7b	W8	Centennial Boulevard	None	187	---	60"Ø	48'	To Greenbelt
B-12	8a	Wilson Road	24"ØCMP	168	---	60"Ø '	48'	Ht. not on Greenbelt
B-12	S8a	Wilson Road	27"x42" CMP	33	---			OK
B-10	S8a	Wilson Road	30"ØCMP	30	---			OK
B-8	W9	Centennial Boulevard	None	185	---	66"Ø	54'	Not on Greenbelt
B-10	W11	Centennial Boulevard	None	123	---	54"Ø	140'	

SUB BASIN	NEAR POINT	STREET	EXISTING STRUCTURE	cfs 50-yr. FLOW	cfs 100-yr. FLOW	REQUIRED	LENGTH	COMMENT
E-6	E14	RR Spur	None	75	---	54"Ø		
G-1	33	I-25	24"ØRCP	22	---			OK
G-1	S33	I-25	36"ØRCP	26	---			OK
G-1	S33	Point of Pines	18"ØCMP	Plugged now			Not required	
E-8b	E17	Garden of Gods Rd.	arch 36"x58"CMP	103	---	54"Ø	85'	OK
E-8a	E15	Spur Line Railroad	48"ØCMP	220	---	72"Ø	55'	

MAJOR CULVERT INVENTORY - SOUTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	STREET	EXISTING STRUCTURE	cfs 50-yr. FLOW	cfs 100-yr. FLOW	REQUIRED	LENGTH	COMMENT
C-5	S20	Tour Rd.	None	--	489	96"Ø	45'	
C-5	W21	Tour Rd.	None	--	640	108"Ø	45'	
C-5	21	Wilson Rd.	30"ØCMP	--	716	120"Ø	55'	Replace
C-7a	22		arch 18"x29"CMP	--	792	120"Ø	80'	Replace
C-6	E25	Tour Rd.	None	--	266	84"Ø	48'	
C-6	26	Wilson Rd.	30"ØCMP	--	482	108"Ø	60'	Replace
C-7b	27	Garden of Gods Rd.	arch 27"x42"	--	522	108"Ø	80'	Replace
D-6	S23c	Centennial Boulevard	None	--	288	72"Ø	95'	
F-3	W37	Main line Railroad	72"ØCMP					OK
F-3	W37	Main line Railroad	72"ØCMP					OK

STORM SEWER SYSTEMS INVENTORY - NORTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	LOCAL FLOW	EXISTING PIPE SIZE	TYPE	LENGTH	CB	OUTLET STRUC.	REQUIRED PIPE SIZE	TYPE	LENGTH	CB	OUTLET
E-4a	13	30	None-------------------------					36"Ø	CMP	125'	3 curb	pipe to ditch pave
E-2	W13	82	None-------------------------					36"Ø	CMP	1000'	1 ditch 2 curb	
			None-------------------------					42"Ø	CMP	740'	3 curb	1 pipe to ditch + 3 curb pave
E-4b	N14	51	None-------------------------					30"Ø	CMP	50'	3 curb	1 pipe to ditch + 2 curb pave
			None-------------------------					48"Ø	CMP	120'	2 curb	
E-4b	E14	74	21"Ø	RCP	90'	2-(6')		OK-------------------------------				
			24"Ø	RCP	60'	1-(8')		OK-------------------------------				
			30"Ø	RCP	75'	1 ditch entry		OK-------------------------------				
			36"Ø	RCP	500'	(1 MH)		OK-------------------------------				
			42"Ø	RCP	160'	---	o-to ditch	OK--------------------------				add 2 curb pave
			None-------------------------					48"	RCP	160	3 curb	
E-5	SW14		18"Ø	CMP	250'	15-30"		OK-------------------------------				
(NOTE: exact size & length could not be determined. Shown as it should be)		48	24"Ø	CMP	540'			if sized as believed-------------				
		57	30"Ø	CMP	540'			"	"	"	"	-------------
		71	36"Ø	CMP	1060'		o-to ditch	"	"	"	"	---------pave outlet
E-7	17	62	21"Ø	RCP	70'	1-(6')		OK-------------------------------				
E-8b	to	"	24"Ø	CMP	120'	2 grates		OK-------------------------------				
G-2	33	74	42"Ø	CMP	1360'	1 spill & gate 2 grates		OK-------------------------------				
		159	42"Ø	CMP	1750'	1 grate 2 culvert	o-to creek	OK-------------------------------				

STORM SEWER SYSTEMS INVENTORY - NORTH DOUGLAS CREEK (cont.)

SUB BASIN	NEAR POINT	LOCAL FLOW	EXISTING PIPE SIZE	TYPE	LENGTH	CB	OUTLET STRUC.	REQUIRED PIPE SIZE	TYPE	LENGTH	CB	OUTLET
E-8b	E32	22	27"x43"	CMP	900'±	1 ditch entry 1-(3')	o-to RR ditch	OK-------				pave outlet
E-8b	E32	26	27"x43"	CMP	900'±	1 ditch entry 1-(3')	o-to RR ditch	OK-------				pave outlet

STORM SEWER SYSTEMS INVENTORY - SOUTH DOUGLAS CREEK

SUB BASIN	NEAR POINT	LOCAL FLOW	EXISTING PIPE SIZE	TYPE	LENGTH	CB	OUTLET STRUC.	REQUIRED PIPE SIZE	TYPE	LENGTH	CB	OUTLET
D-1	W32a		18"Ø	RCP	200'	5-(3')		OK-------				Add 1(6') south
			24"Ø	RCP	80'	2-(3')		OK-------				
			36"Ø	RCP	50'	1-(3')		OK-------				
			27"Ø	RCP	1060'	--		OK-------				
		54	36"Ø	RCP	870'	--		OK-------				
			42"Ø	RCP	1130'	3-3'	open intake	OK-------				Add 3-(6')
		125	2-34"x52"	RCP	200'		out to ditch	OK-------				pave ditch
D-6	W23c		None-------					18"Ø	CMP	300'	5-(6')	
		52	None-------					36"Ø	CMP	750'		
		74	None-------					48"Ø	CMP	780'	2-(6')	1 ditch pave
D-8b	W30		None-------					18"Ø	RCB	480'	12-6'	
		67	None-------					36"Ø	RCB	440'		
		97	None-------					42"Ø	RCB	370'		

STORM SEWER SYSTEMS INVENTORY - SOUTH DOUGLAS CREEK (cont.)

SUB BASIN	NEAR POINT	LOCAL FLOW	EXISTING PIPE SIZE	TYPE	LENGTH	CB	OUTLET STRUC.	REQUIRED PIPE SIZE	TYPE	LENGTH	CB	OUTLET
D-8b	W30	112	None----------------------------					48"Ø	RCB	420'		
		133	None----------------------------					54"Ø	RCB	290'		1 ditch pave 3(6')
F-1	35	38	24"Ø	CMP	100'±	4-30" 1-4'		OK-------------------------------				
		38	30"Ø	CMP	120'±		Conc. apron	OK-------------------------------				
		38	24"Ø	RCP	200'±		ditch out	OK-----------------------				pave ditch
		15	24"Ø	CMP	700'±	1 ditch inlet		OK-----------------			pave inlet	
F-2	36	75	24"Ø	CMP	100'±	5-30" 1-4'		OK-------------------------------				
			48"Ø	CMP	120'±	2 grates	Conc. apron	OK------------------------------				
			24"Ø	RCP	200'±		ditch out	48"Ø (OK if rec. can be used)				pave ditch
			24"Ø	RCP	30'±	1 ditch inlet		"			pave inlet	
		30	30"Ø	RCP	580'±			36"Ø*	RCP	580'±		
D-12a	S36	17	24"Ø	CMP	120'±	2 grates	Conc. apron	OK-------------------------------				
			24"Ø	RCP	200'±		ditch out	OK----------------------				pave ditch
			30"Ø	RCP	30'±	1 ditch inlet		OK-----------------			pave inlet	
		55	30"Ø	RCP	970'±			42"Ø*	RCP	970'±		
		55	36"Ø	RCP	50'±	1-(3')	ditch out	42"Ø	RCP	50'±		pave ditch

*ignoring highway

INDEX TO PHOTOGRAPHS

1. View of the northwest quarter of Section 22, looking southeast. Note water gap in Dakota sandstone (left center) and developing north-south trellis drainage in the Morrison and Lykins formations. The alluvial gravel pediment (uplands at right) is being stripped away by headward erosion, exposing the less permeable older rocks. Erosion here is via short, steep gullies extending into the gravel. Vegetation includes scrub oak, mountain mahogany, cedar and ponderosa pine.

2. Same area; closeup of water gap, looking due east. Niobrara limestone forms ridge in middle distance. Note the extreme constriction of the channel, as well as the abrupt 90° turn in the water course. The channel is further blocked by the workings of an abandoned quarry in the Dakota ridge (out of sight behind trees at center).

3. Same area; looking northwest. Relatively level area is a gravel pediment - Verdos Alluvium - while steeper slopes in distance are Pikes Peak Granite. The gravel is highly permeable and infiltration is high even during intense rainstorms. The pediment is, however, being destroyed by headward erosion of streams - note lengthy major channels and short, steep gullies in a random, but generally west-to-east pattern.

4. Same area; looking north. Shows break between gravel pediment and exposed older rocks. Note ridge and water gap in Lyons sandstone (right center). Picture shows how the random, west-east drainage on the pediment is being replaced by the north-south trellis drainage as the gravel is removed. The north-south pattern is caused by the relatively greater erodability of the softer formations as compared to the harder, ridge-forming rocks.

5. View of central portion of valley, looking north from the Mesa. Shows transition from granite mountains to alluvial flats. Pediment - water gap area of photos 1 - 4 is immediately out of picture to left. Garden of the Gods Road and Wilson Road run across the middle of the picture. Dakota hogback forms a sharp ridge with two peaks, against mountains in upper left corner. Smaller Niobrara ridge (below Dakota hogback) is partially buried by an ancient landslide derived from the Dakota (near horizon, above bush in foreground). The horizon in the center is occupied by a low gravel ridge of Verdos Alluvium; it is separated from the old landslide by a wide, flat valley, trending north-northwest, which is fault controlled and which may have once carried the main channel of Douglas Creek in the early Ice Ages. The ridge in the upper right corner is Pope's Bluff, of the Laramie Formation.

6. View of southern portion of valley, looking east from the Dakota ridge. Shows pattern of development in the valley. Note peculiar double drainage - the north part of the valley drains along Pope's Bluff (upper left corner), north of the industrial buildings, and the south part drains along the base of the Mesa (upper right corner). The valley floor is formed of alluvial material of various types. Pope's Bluff is of the Laramie Formation, and the bluffs in the distance are of the Dawson Formation.

7. Closeup view of photo No. 5, showing ancient landslide, wide valley and alluvial ridge.

8. View of northern part of valley, looking west. The mountains are Pikes Peak Granite; the quarry is in an isolated remnant of Manitou limestone. The large canyon in the mountains (upper left corner) is the main channel of Douglas Creek. Water movement across the flats is mainly sheet flow; channels are only vaguely defined. Concentration into channels begins to be apparent towards the right center of the picture - note the conspicuous nick point at the head of the gully. This nick point is located in the northeast quarter of Section 10.

9. Closeup of nick point shown in photo No. 8. Note the poorly developed channels across the alluvium above the nick point.

10. View of gully containing Douglas Creek crossing Wilson Road in the southwest quarter of Section 11, looking west. The flow is channelized only a short distance west of the road - note sheet flow area in background. The small culvert under Wilson Road here is an example of one which will be grossly undersized in the event of development of this part of the basin.

11. View of same gully, looking downstream from general location of culvert in photo No. 10. The gully is incised in the very young, poorly permeable Piney Creek Alluvium, and becomes gradually deeper to the south.

12. View of same gully at point of maximum depth in the northwest quarter of Section 14, looking south. South of this point, Douglas Creek gradually loses its gully attributes and takes on the characteristics of a "normal" stream channel.

13. General view of area covered in photos No. 10 and 11. Douglas Creek emerges from the mountains and foothills (upper left corner), degenerates into sheet flow, and is reconcentrated into a channel near Wilson Road. Flying W Ranch is at extreme left.

14. View of north part of basin, looking northwest. Area is north of Flying W Ranch; level ridge at right is north boundary of basin. This is a close view of the flat area of sheet flow between the mountain channels and the lower basin channels. Note sparsity of vegetation (other than weeds) and presence of water-worked coarse gravel and cobbles.

15. View of dam across North Douglas Creek, northwest of Kaman Sciences property, looking southeast. This dam is proposed for removal. Original spillway was cut through to South Douglas Creek (to the right). Newer construction has breached the dam and diverted flow into an unlined ditch, seen along the edge of the channel (upper left corner).

16. View of south end of existing drainage structure on Garden of the Gods Road in the extreme northeast corner of Section 27. Large half-culvert is a surface drain from the road; small opening beneath hammer is a 27" x 42" pipe-arch culvert. This blocked culvert theoretically carries almost the entire flow of subbasin C - more than 1000 cubic feet per second!

17. View of Denver and Rio Grande Western Railroad structure across North Douglas Creek, looking east. This structure is much undersized; in floods, water dams up behind the embankment, placing water in the structure under a considerable head.

18. View of culvert containing the trackside drainage ditch under the Rusina Valley Railway spur immediately north of North Douglas Creek and west of the junction with the railroad mainline. This culvert is blocked by weeds and debris, and is typical of many structures needing maintenance.

1.

2.

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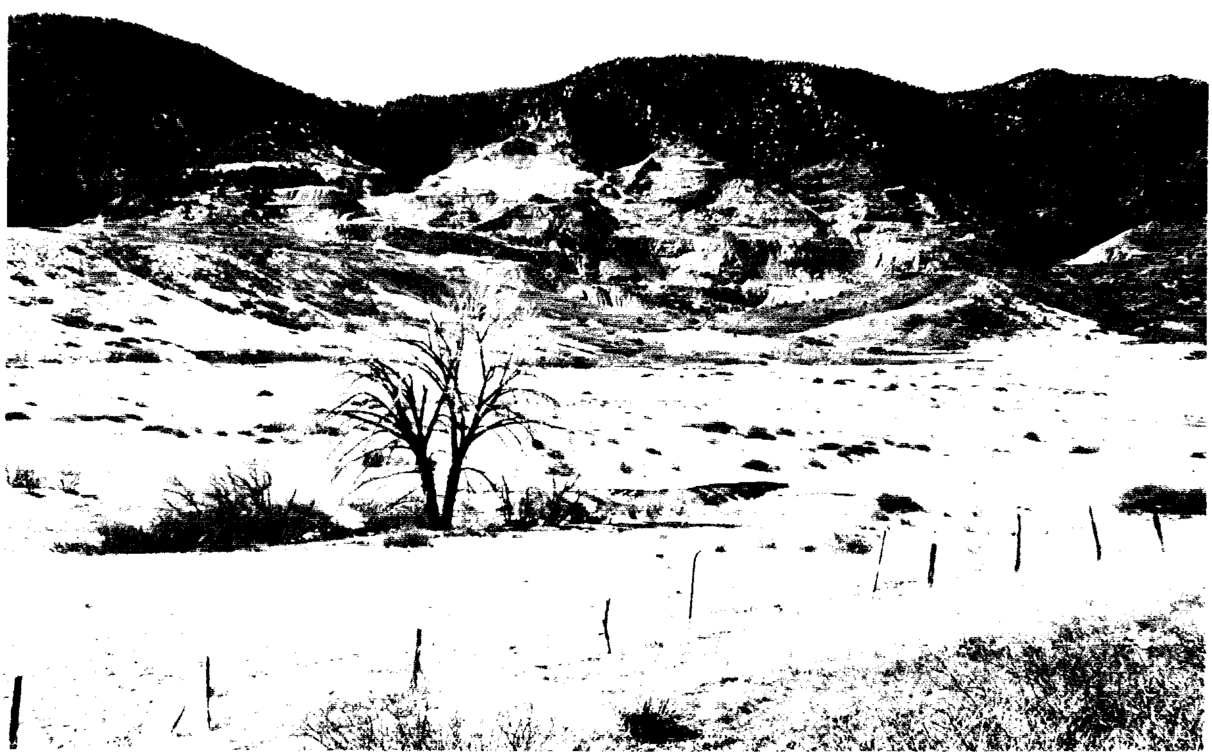

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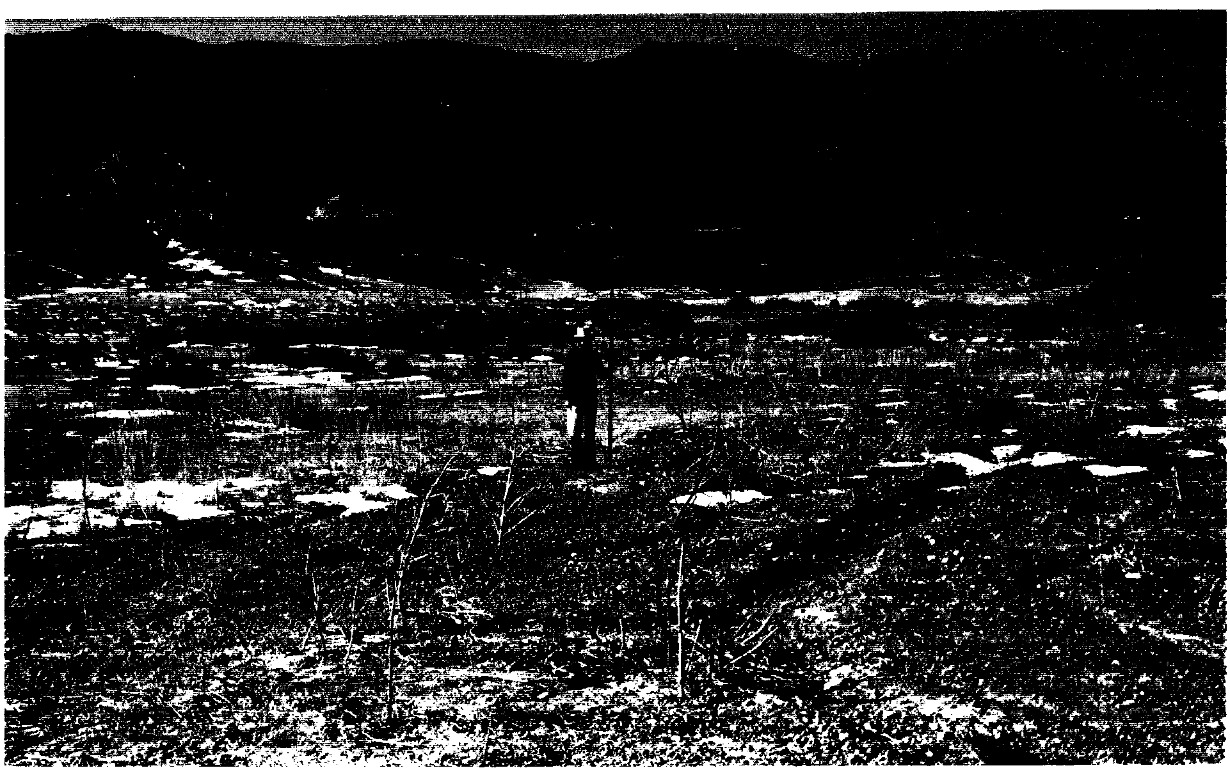

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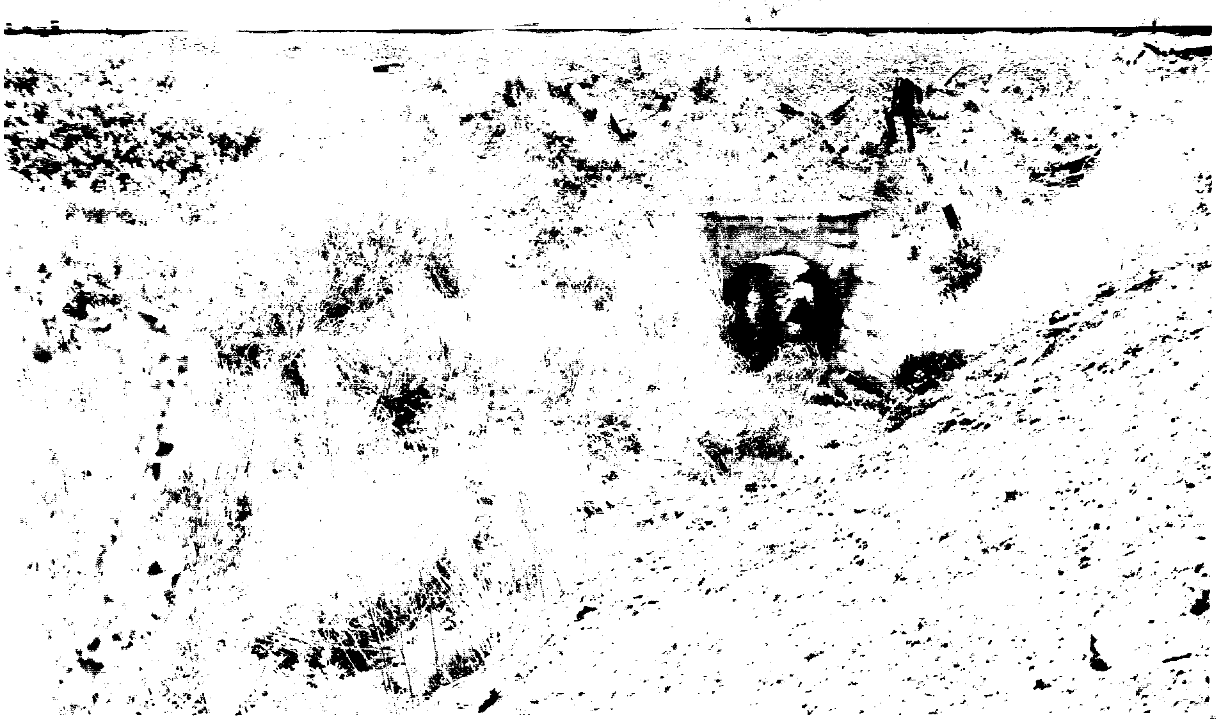

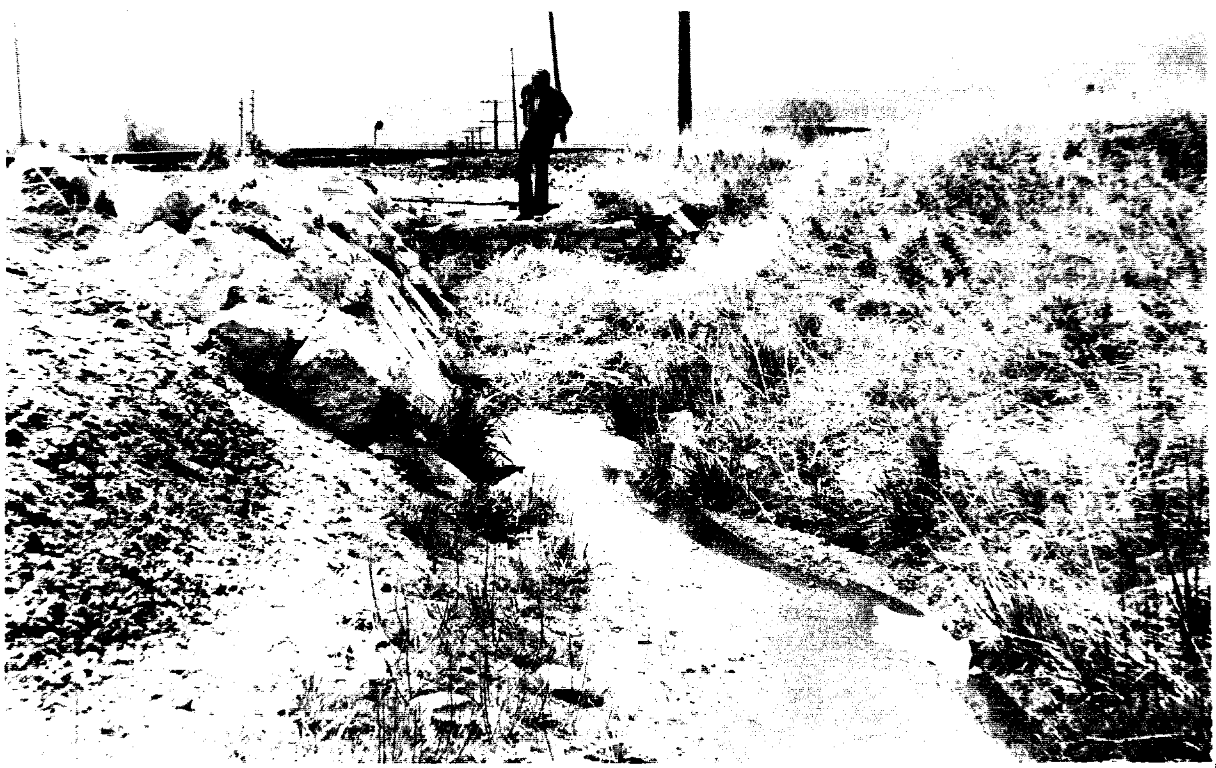

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