# MASTER PLAN

for

Mesa Drainage Basin

Owner

City of Colorado Springs
Department of Public Works

GILBERT, MEYER & SAMS, INC.
CONSULTING ENGINEERS

CITY OF COLORADO SPRINGS
COLORADO

I N T E R O F F I C E  M E M O R A N D U M

DATE: August 10, 1989

TO: Chris Smith, Subdivision Administrator

FROM: Gary R. Haynes, City Engineer

SUBJECT: MESA DRAINAGE BASIN - SONDERMAN PARK EXCLUSION FROM THE BASIN

The Mesa Drainage Basin Master Plan was revised in 1986 and approved by City Council on March 31, 1986. Recently, a question has risen about the status of Sonderman Park and the payment of drainage fees. In reviewing the fee computation section of the master report, I find it somewhat vague as to the exclusion of the land for Sonderman Park, approximately 95 acres. The intent of the master plan was to exclude Sonderman Park from the drainage basin fee computation due to the fact that it is a natural area and development in the park would be minimal plus the Park and Recreation Department has agreed to maintain the drainage system through the park as it presently exists and improvements will not be necessary to the drainage system through the park.

In summary, the 785 acres used in the fee calculation do not include the acreage for Sonderman Park. Therefore, Sonderman Park land is not subject to drainage fees. Please alert your staff and file this memorandum conspicuously in all files and reports for the Mesa Drainage Basin Master Plan.

Gary R. Haynes
City Engineer

GRH/njh

cc: DeWitt Miller, Director of Public Works
Nancy Lewis, Director of Park and Recreation
Bruce A. Thorson, Assistant City Engineer
Bev Dustin, Land Development Specialist
Bill Ruskin, Park and Recreation Superintendent of Planning

b:gary14.94

# ENGINEERING STUDY AND REVISION OF THE MASTER DRAINAGE PLAN FOR THE MESA DRAINAGE BASIN

PREPARED FOR:

CITY OF COLORADO SPRINGS

DEPARTMENT OF PUBLIC WORKS

PREPARED BY:

GILBERT, MEYER & SAMS, INC.
CONSULTING ENGINEERS
611 NORTH WEBER, SUITE 300
COLORADO SPRINGS, CO 80903

NOVEMBER 1984

FINAL REPORT - JUNE 1985

REVISED - JANUARY 1986

REVISED - MARCH 1986

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## CERTIFICATION

I, Roger J. Sams, a Registered Professional Engineer in the State of Colorado, hereby state that the attached Drainage Study for the Mesa Drainage Basin was prepared under my direction and supervision, and is correct to the best of my knowledge and belief.

Roger J. Sams
Roger J. Sams, P.E.
Colorado No. 11884

Date: MARCH 31, 1986

## APPROVAL

The City of Colorado Springs City Council and Department of Public Works does hereby approve the contents of the attached Mesa Drainage Study. This study shall be used as a guide for development of all drainage facilities within the study area.

Gary R. Hayes City Engineer
Department of Public Works

Date: March 31, 1986
(See attached minutes of COLORADO SPRINGS/EL PASO COUNTY DRAINAGE BOARD for February 20, 1986)

SEE ATTACHED RESOLUTION
City Council

Date: March 25, 1986

CITY OF COLORADO SPRINGS
*The "America the Beautiful" City*
DEPARTMENT OF PUBLIC WORKS ADMINISTRATION (303) 578-6660
30 S. NEVADA SUITE 402 P.O. BOX 1575
COLORADO SPRINGS, COLORADO 80901

# M I N U T E S

## COLORADO SPRINGS/EL PASO COUNTY DRAINAGE BOARD

## for February 20, 1986

The Colorado Springs/El Paso County Drainage Board held its regularly scheduled meeting at 2:00 PM on February 20, 1986 in the City Council Chambers, City Administration Building, 30 South Nevada Avenue.

| Members Present | Members Absent | Others Present |
|---|---|---|
| William Weber, Chairman | Richard Dailey | Gary Haynes |
| George Jury | | Hugh King |
| Fred Gibson | | Jack Smith |
| Mike Mallon | | Tom Woodbury |
| Roland Obering | | Chris Smith |
| Rick Brown | | Allan Morrice |
| | | Don Smith |
| | | Steve Behrens |
| | | Bruce Wright |

The meeting was called to order at 2:05 PM.

Item 1

Approval of the January 16, 1986 minutes.

The Board heard a motion by Mr. Jury to approve the minutes as presented. Mr. Gibson seconded the motion. The motion passed with a unanimous vote.

Mr. Jury asked that Items 2 and 5 be brought up to the Board as separate items.

Mr. Mallon and Mr. Obering abstained from voting on Items 2 through 5.

Mr. Weber asked that Items 3 and 4 be acted upon by the Board first as consent items.

Items 3 and 4

Motion by Mr. Gibson to approve the Staff's recommendation for Items 3 and 4. Mr. Brown seconded the motion. The motion passed with a unanimous vote.

Item 2

Request for cash reimbursement for construction of drainage facilities within the Cottonwood Creek Drainage Basin, Fairfax Subdivisions No. 1 & 2, Research Parkway No. 4, Briargate Development Group, Developer.

Mr. Jury questioned the amount of reimbursement asked for by the developer for a 30" storm sewer tee and RCP per the low bid as shown on the agenda item sheet. Staff explained to Mr. Jury that the $12,240.00 request included the tee and 315 LF of 30" storm sewer.

The Board then heard a motion by Mr. Brown to accept the Staff's recommendation. Mr. Jury seconded the motion. The motion passed with a unanimous vote.

Item 5

Request for cash reimbursement for construction of drainage facilities within the North Rockrimmon Basin, Saddleridge Filing No. 1 & 2 and Rockrimmon Blvd. South Subdivision, Silverado Banking has assumed the position of Park West Corp. as Developer.

Mr. Jury asked that the typographical error of "60% Engineering" reimbursement request be changed to "6% Engineering".

Mr. Jury made a motion to approve the Staff's recommendation for Item 5. Mr. Gibson seconded the motion. The motion passed with a unanimous vote.

Item 6

Request for cash reimbursement for construction of drainage facilities within the Cottonwood Creek Drainage Basin, Cottonwood Creek Subdivision Filing No. 1, The Writer Corp., Developer.

Staff explained to the Board that due to the complexities of the site designs, magnitude of the project, and verification of change orders that a partial reimbursement could be considered on this project.

Mr. Mallon made a motion to approve the Staff's recommendation. Mr. Gibson seconded the motion. The motion passed with a unanimous vote.

Item 7

Presentation of the Mesa Basin Master Drainage Report.

Mr. Haynes and Mr. Roger Sams presented the report to the Board and recommended approval of the study. Mr. Steve Behrens of URS, Inc. addressed the Board and stated that he represented the Hill Development Corporation.

Mr. Behrens stated that the final designs for the proposed detention ponds and channel erosion protection on the Hill property may differ slightly than those general locations shown in the Master Basin Study. Mr. Behrens assured the Staff and Board Members the final design would be in line with the intent of the Master Basin Report.

Mr. Obering made a motion to approve the Staff's recommendation and adopt the Mesa Basin Master Drainage Report with fees set at $3,912.00 per acre. Mr. Brown seconded the motion. The motion passed with a unanimous vote.

Item 8

Discussion of the proposed Ordinance change repealing and reordaining Section 15-3-904 of the Code of the City of Colorado Springs, as amended, relating to Subdivision Drainage Facilities.

The item was presented to the Board by Mr. Haynes, Mr. Jack Smith and Mr. Bruce Wright. The intent of the new ordinance is to insure that if easements must be obtained for public drainage facilities, the costs incurred in acquiring such easements shall be paid by the subdivider and not be reimbursed from the Basin Funds. Costs incurred by the subdividers will be reimbursed back to the subdivider from property owners abutting the easements whose property is subdivided or developed within a period of 15 years after the easement is obtained.

After further discussion, the Board heard a motion from Mr. Mallon to approve the proposed ordinance change and refer it to City Council for their action. Mr. Jury seconded the motion. The motion passed with a unanimous vote.

Item 9

Open for discussion.

Mr. Allan Morrice asked the Board if a work session could be set up with Board Members, County Staff, City Staff, and RMC Corporation to discuss if drainage reimbursements can be made to the Constitution Blvd. Improvement District.

The Board set the date for the work session at the El Paso County Engineering Offices on March 7, 1986 at 2:00 PM.

The Board took no action on this item.

Mr. Gibson made a motion to adjourn the meeting. Mr. Mallon seconded the motion. The motion passed with a unanimous vote.

The meeting adjourned at 3:00 PM.

DeWitt Miller
Director of Public Works

DM/CS/dg

cc: Drainage Board Members
Larry Blick, City Manager
Gary R. Haynes, City Engineer
Jim Colvin, City Attorney
Jack Smith, Assistant City Attorney
Max Rothschild, County Dir. of Transportation
Allan Morrice, County Drainage Engineer
Chris Smith, Subdivision Administrator
Bev Dustin, Land Development Specialist
Public Affairs
Bob Brockman, Planning
Don Steger, HBA, 3730 Sinton Road, #110, COS, 80907
Briargate Development Group, Attn: Joe Kostka, 7710 N. Union, COS, 80918
Mallon Development Company, Attn: Bill Wier, 7730 N. Union, COS, 80918
Nu-West, Inc., c/o Schuck Land Company, Attn: Pat Hartmann, P. O. Box 416, COS, 80901
Mr. Don Jeffries, 3730 Sinton Rd., #250, COS, 80907
Gilbert, Meyer & Sams, Inc., Attn: Roger Sams, 611 N. Weber, Suite 300, COS, 80903

CITY OF COLORADO SPRINGS
COLORADO

**INTER - OFFICE MEMORANDUM**

*Date:* March 11, 1986

*To:* Larry N. Blick, City Manager

*From:* DeWitt Miller, Director of Public Works

*SUBJECT:* MESA DRAINAGE BASIN

At the February 20, 1986 meeting, the City/County Drainage Board approved the restudy of the Mesa Drainage Basin and recommended adoption of the basin drainage fee of $3,912 per acre. The basin was restudied for the City Administration by Gilbert, Meyer, and Sams, Inc. The previous master plan for this basin was adopted in 1976. A copy of the new study is available for review in the City Engineer's Office.

It is this Department's recommendation that City Council establish Mesa Drainage Basin fee as noted above. A copy of the proposed resolution is attached.

GRH. DeWitt Miller

DeWitt Miller
Director of Public Works

DM/GRH/dg

Attachment

cc: Gary R. Haynes, City Engineer

ITEM NO. 12

3-25

RESOLUTION NO. 59-86

A RESOLUTION ESTABLISHING MESA DRAINAGE BASIN FEES FOR 1986

Be it resolved by the City Council of the City of Colorado Springs:

Section 1. That Mesa Drainage Basin Fees for 1986, as recommended by the City/County Drainage Board at their February 20, 1986 meeting, are established for 1986 as follows:

Mesa Drainage Basin Fee $3,912 per acre

Dated at Colorado Springs, Colorado, this 25th day of March, 1986.

Mayor

ATTEST:

City Clerk

# I. SUMMARY AND GENERAL RECOMMENDATIONS

## Purpose

The purpose of this study is to review and update the Master Drainage Plan for the Mesa Drainage Basin prepared in 1976. This update was required in order to reflect changes which have occurred in the basin, proposed development which was not foreseen at the time of the original study, to bring the Master Drainage Plan into conformance with current drainage criteria and standards and to coordinate storm drainage planning within the Mesa Basin. To that end, this report is intended to serve as a guide for addressing existing drainage problems and the coordination and implementation of drainage improvements in the Mesa Basin as continued development occurs. It is hoped that this document will assist City officials, potential developers and the general public in making sound decisions relating to land use and related drainage improvements in the Mesa Basin.

## General

The Mesa Basin contains approximately 2,200 acres of land lying in the west central portion of the City. This basin is unique in many respects. It is one of the smaller drainage basins within the city. Topography within the basin is characteristic of foothill areas with steep slopes and well defined drainage channels. Soil conditions within the basin vary with many of the soil groups having a relatively high runoff potential. Portions of the basin are presently at or near full development while other areas have not been significantly improved to date. Over 75 percent of the available developable land within the

basin is presently controlled by two groups. The Hill Development Corporation now controls approximately two thirds of the developable land and the City of Colorado Springs Park and Recreation Department controls another ten percent.

The central portion of the basin contains the bulk of the undeveloped land. This area is characterized by steep slopes with numerous natural drainageways and a limited number of developable building sites. Existing physical conditions in this portion of the basin will require that careful planning of proposed development be undertaken in order to achieve a desirable balance between land use and the aesthetic quality of the area.

## Criteria

This study has attempted to rationally analyze the various factors affecting storm water runoff as they relate to the Mesa Basin under fully developed conditions. Available land use information, both existing and proposed, has been considered in developing peak runoff rates used for preliminary storm drainage facility design purposes. Hydrologic calculations have been based on the 24 hour duration storm event. Hydraulic analyses were based on peak runoff resulting from the 100 year return frequency storm when the 100 year storm produced peak flow rates greater than 500 cubic feet per second (cfs). When peak flow rates from the 100 year storm resulted in flows less than 300 cfs, peak flow rates resulting from the five year storm were utilized. In cases where the 100 year peak flow rate was between 300 cfs and 500 cfs, the design flow rate used in the hydraulic analyses was selected based on an evaluation of potential damage resulting from runoff in excess of that generated by the five year storm. Methodology utilized in the hydrologic and hydraulic analyses

conducted as part of this study conform with accepted engineering practices and are generally in accordance with current City of Colorado Springs drainage policy. It is therefore felt that this report presents a technically adequate and economically sound master plan for drainage improvements in the Mesa Basin.

As part of the master planning process, specific drainage improvements have been proposed. In arriving at these specific recommendations, numerous assumptions had to be made. Variations from assumed development patterns, changes in proposed street alignments and the timing of implementation of development plans could significantly affect storm water runoff rates and therefore the size, type and/or location of drainage facilities required to safely convey these flows. The desire of developers to incorporate drainage improvements which may be more compatible with their development plans could also lead to modifications or revisions of the specific proposals contained in this report. Signiticant measures have been taken to better assure compatability of the storm water management proposals with proposed development. Extensive input by the major landowner/developer has been utilized in the development of this plan.

The precise size, type and location of the recommended improvements presented herein should not be considered absolute. Sound engineering judgment should be used in applying the design concepts developed in this master plan report. The need for and acceptability of proposed alternative drainage improvements can best be evaluated at the time individual subdivision drainage plans or the detailed design of a specific project is undertaken. At that time, a significantly enhanced level of detail is expected to address site specific conditions. Proposed alternative drainage improvements shall conform with the

intent and design concept developed in this master plan. Any such variations will be subject to acceptance by the City of Colorado Springs. However, City officials should remain flexible in their interpretation of the intent of the master plan in order to maximize the benefits to be obtained from comprehensive storm water management while minimizing adverse impacts on the utilization and aesthetic quality of the Mesa Basin.

Minor Systems

The recommendations contained in this report propose the construction of new structures and improvements together with the modification and restoration of existing structures. Specific recommendations include the construction of storm sewer systems in the easterly portion of the basin in the vicinity of Cooper, Del Norte, Chestnut, Taylor Streets and Mesa Valley Road. As development within this area has occurred, the volume of storm water runoff has increased to the point that many of the existing streets have reached their hydraulic capacity. Also, the increase in storm water runoff has hydraulically overloaded several of the existing drainage structures which were constructed to convey runoff under Interstate Highway No. 25 (I-25). In addition to these remedial storm sewer projects, the proposed extension of Centennial Boulevard from the Holland Park area to Fontanero Street should include a storm sewer system to efficiently drain the street section.

In order to provide a safe and adequate discharge for storm water runoff originating on the west side of I-25, it is recommended that two new outfall sewers be constructed under I-25 and the Denver & Rio Grande Western railroad tracks. A new 84 inch diameter reinforced concrete pipeline is

proposed to convey storm water runoff generated in the area between Fillmore and Van Buren Streets to an outfall in Monument Creek. Hydrologic computations indicate that the tributary runoff originating in this area will exceed the combined hydraulic capacity of the existing highway crossings under 100 year design storm conditions. It is proposed that this new pipeline be located adjacent to the existing 60 inch concrete pipeline which crosses I-25 north of Harrison Street.

It is also recommended that a storm sewer system be constructed to convey storm water runoff to Monument Creek from the area north of Fillmore Street and west of Chestnut Street. The westerly portion of this area is undeveloped at present, however, extensive commercial and office park type development is planned for this area. Hydraulic evaluations indicate that the existing drainage facilities are inadequate to convey the increase in storm water runoff. Under direct runoff conditions, existing facilities are inadequate to convey existing flow, however, existing industrial development (gravel extraction) in this area has caused retention to occur. In evaluating storm water management alternatives for this area, the utilization of storm water detention and conveying runoff from this area to an outfall on Monument Creek south of Fillmore Street were also considered. The major landowner in this sub-basin has proposed the use of temporary on-site private detention facilities to attenuate the peak flow to Chestnut Street. The area will maintain flow rates across property lines at rates which occur under undeveloped conditions. In addition to the proposed storm sewer system, other recommended improvements include a double five foot by six foot reinforced concrete box culvert under Chestnut Street and improvements to the drainageways upstream of Chestnut Street, including enlargement and protective linings to promote the collection of runoff and conveyance of runoff to Chestnut Street.

During the development of this study and master plan report, the landowner in the upper reaches of the basin tributary to Chestnut Street north of Fillmore Street provided considerable input. Based on an agreement reached with the Department of Public Works, Engineering Division, a portion of this area will be graded to drain to the East Fork of the main Mesa drainageway, crossing Fillmore Street after passing through detention basins located on the north side of Fillmore Street.

The existing drainage facilities under Glen Avenue, located north of the Park and Recreation Department offices, are not only inadequate to convey tributary storm water runoff, but also create conditions which adversely affect vehicular traffic and upstream drainage facilities. The existing facilities consist of a 72 inch diameter corrugated metal pipe culvert installed through a depressed roadway embankment. Hydraulic calculations indicate that the existing culvert has inadequate capacity to convey storm water runoff resulting from the five year design storm resulting in the roadway embankment being overtopped. It is recommended that a double eight foot by ten foot reinforced concrete box culvert be constructed to replace the 72 inch culvert and the road embankment raised to remedy the unacceptable conditions which presently exist.

Several of the existing drainage structures in the Kissing Camels area, located east of Mesa Road and north of Fillmore Street, were found to have inadequate hydraulic capacity. This area is presently under private control with limited public access. To date, the City of Colorado Springs has not accepted responsibility for maintenance of roadways and drainage facilities in this area. The inadequacy of these structures presently poses the threat of property damage and inconvenience primarily to the residents of this area and not to the

general public. Also, access for maintenance purposes via local streets is limited by direction of area residents. It is therefore recommended that all drainage structures and improvements in this area remain under private control at least until provisions are made to upgrade those facilities which have inadequate hydraulic capacity and access is provided to city forces for purposes of maintenance and inspection. It is also recommended that all costs associated with upgrading the drainage facilities in this area be borne by the local residents since they will be primary beneficiaries of such improvements.

Major Channels

The natural drainageways located in the central portion of the Mesa Basin are generally in the form of steep banked gullies which have erodible bottoms and side slopes. Field observations reveal that significant erosion problems presently exist and that the natural channels are in a state of degradation. Since soils in the Mesa Basin are extremely susceptible to erosion, it was concluded that channel protection improvements should be implemented to control any further erosion to the greatest extent possible.

A major consideration in developing recommendations for channel protection improvements within the Mesa Basin was providing an optimum level of erosion protection and runoff control while maintaining the existing drainageways in as natural a state as possible. Where it was determined that erosion protection and runoff control are necessary, primary consideration was given to channel protection and channelization methods which would alter natural conditions the least.

Various channel protection alternatives were investigated as part of this study. The extensive use of concrete lined drainageways was found to be aesthetically undesirable and would not prove to be cost effective. Because of the steep slopes which characterize the central portion of the Mesa Basin and the erodability of the soils found therein, the use of unlined or grass lined natural channels does not appear feasible. In natural channels, erosion will occur in some reaches and deposition will occur in others. In nearly all cases, some modification of the existing drainageways would be required to improve the stability and carrying capacity of the existing channels.

Based on the investigations conducted as part of this study, it was concluded that the most cost effective and feasible method to convey storm water runoff through the central portion of the Mesa Basin is the utilization of a riprap lined channel section. In addition to reducing erosion, improvement of the drainageways will reduce the threat of flooding and improve the maintainability of the drainageways. The use of rock riprap for drainage channel stabilization has been reviewed by neighborhood groups and the major land developer in the basin. The extensive use of a lined trapezoidal section was felt to be undersirable by these parties. Aesthetic and cost concerns were raised.

It is the opinion of the City's consultant for this study that extremely careful land use planning, design and construction practices will be necessary to result in truly effective storm water management measures in these channels. The selective use of riprap to treat channel bends or other so-called "hot spot" areas must be well conceived or they themselves become a cause for accelerated erosion and channel alteration. Because of these and other concerns of a technical and operations nature, the Department of Public Works will require the

owner/developer of the major land area south of Fillmore Street to enter into a private maintenance agreement for the East Fork channel, design point 10 to point 14. The West Fork channel from design point 27 upstream to a detention pond proposed at the confluence of basins 23 and 24 will be publicly maintained with selective use of designed riprap channel treatment. A fully lined riprap channel is not considered to be acceptable by the land owner in this area. This channel through Sonderman Park will be maintained by the City of Colorado Springs.

It is also recommended that similar types of channel improvements and erosion protection be provided along the minor tributaries which serve as outfalls for subdrainages located in the northern portion of the Mesa Basin.

Storm Water Detention

The utilization of detention facilities as a storm water management technique offers two primary benefits. Temporary storage can significantly reduce peak flow rates with a resultant reduction in the size and cost of downstream drainage improvements. Also, a reduction in sediment and debris loading downstream of such facilities will reduce the cost of maintaining downstream facilities and will benefit the general public's health and safety by improving water quality and reducing the potential for flooding caused by plugged culverts or blocked channels. In order to arrive at optimum drainage system design, an economic evaluation was conducted to determine if the costs associated with incorporation of major detention facilities could be justified by the reduced cost of downstream improvements. The use of storm water detention was initially investigated at four locations within the Mesa Basin. The

incorporation of detention facilities has been recommended where economically possible to reduce peak runoff rates to the extent that downstream facilities would require little or no improvement. The major land developer in the basin has provided a significant amount of input for private detention ponds and on-site "parking lot" storage.

One of the recommended detention sites is the existing irrigation reservoir for the Kissing Camels Golf Course. Hydrologic and hydraulic calculations indicate that the existing reservoir can be utilized to attenuate peak runoff flow rates with only minimal modification and improvement. Recommended improvements include an ungated outlet structure capable of maintaining a minimum pool for golf course irrigation with inlets sized to limit the outflow rate under 100 year design storm inflow conditions. The outlet structure must also provide overflow capacity to preclude the possibility of overtopping the adjacent roadway embankment. Also, an additional outfall pipeline will be required, extending from the new outlet structure to the existing 27 inch diameter storm sewer located in the Office Park. It is recommended that this facility remain under private control because of its multiple use and its location within private property. The City should, however, obtain rights to reasonable access for purposes of inspection. Costs of improvements to this structure would be reimbursable.

The major land developer in the basin has proposed three detention sites along the East Fork channel of the main drainageways north of Fillmore Street. The consultant for this study originally proposed a single detention facility located in an existing depression adjacent to the Fillmore Street embankment. In order to accommodate the land developer's desires, it appears as if the three

detention facilities are a reasonable alternative. One of the proposed facilities is located on the Kissing Camels Country Club golf course, with another located just downstream from design point 6. Based on an agreement between the developer/land owner and the City of Colorado Springs, Department of Public Works, these structures will remain private, and again, the execution of a private maintenance agreement will be required of the developer. Because the detention facilities have some benefit to downstream areas, these improvements should be included in the overall basin facilities and their cost reimbursable.

This study has evaluated various detention alternatives for limiting the storm water flow through the lower reaches of the main channel, particularly through Sonderman Park. The desire to limit the flow rate would result in minimal improvements to the existing natural channel. An evaluation was prepared to determine the minimum flow rate at which no improvements were required. Based on the cost effective analyses, it appeared as if the cost of construction and operation of detention facilities to reduce the instream flow rates to that level outweighed the cost of channel improvements; thus some compromise is recommended in the level of detention to be incorporated into the project.

Several small detention sites of the "parking lot" nature are proposed along the East Fork channel. These facilities will remain under private maintenance as is proposed for the East Fork channel. It has been agreed with the major land developer of this area that the maximum channel flow rate from the East Fork channel (design point 14) will remain at the undeveloped level. Whatever detention facilities are required within the East Fork basin will be incorporated into the development plans so that the maximum flow rate under the 100 year

and five year 24 hour storm condition at design point 14 will not exceed undeveloped conditions.

In order to minimize the structural channel improvements on the West Fork of the main drainageway, it is recommended that a detention site on the West Fork north of Holmes Junior High be considered. This would be at the confluence of basins 23 and 24. Because this facility will receive flow from several upstream properties of different ownership, access appears to be reasonable and downstream channel improvements can be minimized, it is proposed that this facility be designed, constructed and operated as a public facility. This is in keeping with the previously outlined agreement that the West Fork channel would be publicly maintained. This facility would be constructed in compliance with all requirements of the City of Colorado Springs and the Colorado Division of Water Resources (State Engineer's criteria). The present landowner/developer has developed a schematic grading plan for a facility in this area. Based on this input, it appears feasible to construct a facility exempt from regulation and review by the Colorado Division of Water Resources.

Storm water detention was also considered for the area north of Fillmore Street, west of Chestnut Street and east of Centennial Blvd. A portion of this area, presently used for gravel extraction, has been graded to be reasonably amenable to development. Other portions of this area will be relatively difficult to develop because of topography. Lower portions of the sub-basin are not compatible with any detention facilities due to existing development and topography; however, the upper portion of the basin which may be subject to office/business park development may be amenable to the "parking lot" type of

detention. It has been proposed by the present landowner/developer that detention facilities be constructed in the upper portion of this basin such that runoff from an area of approximately 52 acres be maintained at the undeveloped level. The concept to restrict runoff flows from this area at the undeveloped level was voluntarily initiated by the present landowner/developer as an effort to reduce the size and cost of downstream facilities. It is anticipated that the Department of Public Works will accept this proposal and enter into an agreement with the present landowner/developer which will place a restriction on this property that runoff flow be maintained at the undeveloped level. Such detention facilities must be designed and constructed to properly control runoff from both the 100 year and 5 year, 24 hour storm event.

Minor Improvements

Together with the major drainage facility improvements previously discussed, additional minor improvements are recommended at various locations within the Mesa Basin. For the most part, these improvements are proposed to remedy deficiencies in existing facilities. Generally, these deficient facilities impact small areas and the costs associated with the proposed improvements will be relatively small.

Where existing structures were found to be inadequately sized, they may be removed and replaced with properly sized structures or a new structure could be added such that the sum of the two provides adequate capacity. All structures, both new and existing, should be capable of conveying storm water runoff quantities which reflect fully developed land use conditions.

This report has identified several areas of concern with regard to needed improvements in the Mesa Basin storm drainage system. Some of these concerns are a result of revised criteria used in analyzing storm water runoff, as well as lack of proper maintenance. These areas of concern should be prioritized and scheduled for improvement within a reasonable course of time to prevent further degradation, damage to property and to protect the health and safety of the general public.

## Cost and Fees

Preliminary cost estimates for construction of the improvements recommended within the Mesa Basin have been prepared utilizing criteria in accordance with City of Colorado Springs drainage policy and standards. It is estimated that the total project cost including contingency and engineering fees, to construct the proposed storm drainage improvements in the Mesa Basin will be $5,065,450. Of this amount, the Unit Drainage Fee (Developer Share) is estimated at $2,990.781. In addition, the Basin Fee account had a deficit of $80,013 as of January 1, 1986.

At present, approximately 785 acres of the Mesa Basin remain undeveloped and subject to drainage fees. It should be noted that the 1976 Master Drainage Plan, prepared by Parker and Associates, indicated that 1,756 acres were undeveloped at that time. It appears that the previous study greatly overestimated the amount of undeveloped land in the basin, thus resulting in an unrealistically low drainage fee.

In determining the Unit Drainage Fee for the Mesa Basin, the City of Colorado Springs standard procedure of evenly proportioning the developer project cost

share over the existing undeveloped area was utilized. In order to finance construction of the drainage improvements proposed in this report, it is recommended that a Unit Drainage Fee of $3,912.00 per acre be assessed on the remaining undeveloped land in the basin. This fee should be adjusted periodically for inflation. Based on the preliminary alignment of proposed streets in the basin, it appears that no bridge structures will be required. Therefore, no bridge fee is proposed for the Mesa Basin.

## II. PURPOSE AND SCOPE OF STUDY

The purpose of this Study is to review and update the Master Drainage Plan for the Mesa Drainage Basin, taking into account recent development and plans for proposed development within the Basin. The Mesa Drainage Basin was originally studied in 1976 by Parker & Associates under the general direction of William F. Parker and David A. Henney. At the time of the original study the Mesa Basin was sparsely developed.

The major objectives of this Study are to:

1. Determine the estimated fully developed storm water flows at various points within the basin.

2. Determine the adequacy of existing facilities and recommend improvements necessary to correct deficiencies.

3. Analyze drainage alternatives to determine the most cost effective and efficient drainage plan for ultimate development of the basin.

4. Provide preliminary cost estimates and a proposed drainage fee structure pertinent to future required drainage facilities.

To achieve these objectives, the following generalized steps were employed:

1. Coordination meetings with City of Colorado Springs officials and major land owners in the basin.

2. Collection of field data.

3. Analysis of existing facilities.

4. Review of existing reports and drainage plans.

5. Review and compilation of soil characteristics.

6. Utilization of storm drainage criteria of the City of Colorado Springs.

7. Definition of the drainage basin, subbasins and hydrologic calculations to determine runoff for the 24 hour and 6 hour, 100 year and 5 year frequency storms for fully developed conditions.

8. Development of the most viable drainage plan for consideration by the City.

9. Development of preliminary cost estimates and a proposed drainage fee structure for the proposed drainage plan.

10. Modification of the proposed plan after review of comments by neighborhood groups, the major land developer in the basin and various City departments.

This report has been prepared to serve as a master plan for coordination of drainage facility construction and modification within the study area. The intent of this report is to provide preliminary facility recommendations which are generally in accordance with City of Colorado Springs drainage criteria and to set forth basic criteria against which final designs may be evaluated rather than precise design of storm sewers, drainage channels and other appurtenances. Based on the preliminary design work conducted as part of this study, construction costs were derived to determine a basic fee structure which could be implemented to fund major and minor drainage improvements as development is completed throughout the basin. Projects have also been identified to replace or modify existing structures within the basin which are hydraulically inadequate.

The facilities proposed in this study have been preliminarily sized for the flows determined from the hydrologic calculations contained in this report. It should be noted that proposed development within the basin can only be hypothesized at this time. Variations from assumed development patterns in the area could considerably affect storm drainage flows, and therefore the size and type of drainage appurtenances required. Careful study of proposed development in the undeveloped portions of the basin should be undertaken to insure that drainage facilities will be adequate to handle actual storm water flows.

Variations in proposed development may occur which will require revision or modification of the specific proposals contained in this master plan study. Any such alternative configurations can best be addressed at the time individual subdivision drainage plans are prepared or the detailed design of a specific project is undertaken. At that time, a significantly enhanced level of detail is

expected with regard to site specific conditions. Variations in the type and/or size of required drainage facilities may be expected. However, City of Colorado Springs drainage policy requires that major and minor drainage facility planning and design comply with current master drainage basin studies in terms of concept and outfall point determination. Therefore, proposed alternative drainage improvements shall conform to the intent and design concept developed in this master plan study and such variations will be subject to acceptance by the City of Colorado Springs.

# III. BASIN DESCRIPTION

Ground slopes, soil and vegetative cover, geological conditions, land use and numerous other factors affect the ultimate solution to drainage problems. This study has attempted to analyze all of these factors and to develop a hydraulically adequate and economically sound master plan for drainage improvements.

## Physical Data

The Mesa Basin is one of the smaller drainage basins within the City containing approximately 2,200 acres of land lying in the west central portion of Colorado Springs. The basin lies within an area generally bounded on the North by a ridge line which separates the Douglas Creek and Mesa Basins, on the west by Mesa Road, on the south by Uintah Street, and on the east by Monument Creek. The Mesa Basin includes portions of Sections 25, 26, 27, 35 and 36, Township 13 South, Range 67 West; Sections 1, 2 and 12, Township 14 South, Range 67 West; Section 31, Township 13 South, Range 66 West; and Sections 6 and 7, Township 14 South, Range 66 West. Figure 1 "Vicinity Map" in Appendix A shows the relationship of the Mesa Basin and surrounding drainage basins. Figure 2 "Vicinity Map" in Appendix A indicates the basin boundaries and general topography of the area.

All drainage from the area ultimately enters Monument Creek. Interstate Highway 25 and the Denver and Rio Grande Western Railroad lie

immediately to the west of Monument Creek with major drainage flows from the Mesa area conveyed under the highway and railroad. Interstate Highway 25, Mesa Road and Fillmore Street provide the primary access to the Basin. Other major streets in the area include Chestnut, Cooper and Fontanero.

The Mesa Basin generally slopes from west to east toward Monument Creek, rising from approximately 6,000 feet MSL (mean sea level) to an elevation of 6,600 feet MSL. The northwesterly portion of the Basin, west of Fillmore Street, is characterized by gently rolling, shallow valleys. It is drained by three poorly defined tributary channels which cross Fillmore Street near Coronado High School, the Office Park at Kissing Camels and west of the crest of Fillmore Hill.

The central portion of the basin is characteristic of foothill areas with steep slopes and numerous natural drainage channels. These channels have cut steep, well defined ravines in many cases.

The eastern portion of the basin is almost fully developed. Drainage channels in much of this area are well defined. Existing drainage control in the developed areas consists primarily of curb and gutter, storm sewers, open ditches and drainage culverts which outfall to well defined drainage channels.

Figure 2 "Vicinity Map" and Exhibit No. 1, "Drainage Map" show the basic configuration of the natural drainage channels in the study area. The main channel of the basin forms a "Y" configuration. This main channel

has cut deep gullys in many areas. The most severe conditions exist along the East Fork of the "Y" upstream of the confluence in the upper reaches and in the main channel downstream of this confluence.

The main channel generally has a small quantity of water appearing as surface flow year round. This flow originates from a series of springs which surface in the upper reaches of the main channel on the south side of Fillmore Street.

## Soils and Vegetative Cover

Soil and vegetative cover found in a watershed are important factors to be considered in estimating the amount of precipitation which will become direct runoff. Also, the erodability of the soil must be considered when designing drainage facilities as well as other improvements. Soils information used in this study was obtained from the "Soils Survey of El Paso County Area, Colorado" prepared by the United States Department of Agriculture, Soil Conservation Service (SCS) in cooperation with the Colorado Agricultural Experiment Station.

Soil types within a drainage area have a marked effect on the quantity of direct runoff. The more impervious the soil the greater the quantity of runoff. Exhibit No. 2 "Location and Description of Soils", indicates soil types and approximate location of soil boundaries. SCS soil classifications are related to hydrologic groups. Table 1 in Appendix A "Hydrologic Soil Classification" lists the soil types found in the basin and their corresponding hydrologic group. Soils within the Mesa Basin include three

soil complexes, those being the Chaseville-Midway, Nelson-Tassel and Razor-Midway. The Soil Conservation Service defines a soil complex as a mapping unit of two or more kinds of soil occurring in such an intricate pattern that they cannot be shown separately on a soil map at the selected scale of mapping and publication.

The Chaseville-Midway complex is composed of about 70 percent soils in hydrologic group A, ten percent soils in hydrologic group B and C and 20 percent soils in hydrologic group D. The Chaseville portion of this complex contains significant quantities of commercial grade gravel and is found on the steeper slopes and on ridgetops. Areas of this soil complex located northwest of Fillmore Street in areas presently developed, were assigned runoff curve numbers corresponding to hydrologic soil group A. It was assumed that little disturbance of the soils in these areas would occur. Areas of this soil complex located to the north and southeast of Fillmore Street which are presently undeveloped but are considered developable were assigned runoff curve numbers for hydrologic soil group C. It was assumed that substantial disturbance of the soils in these areas would occur and that much of the commercial grade gravel may be removed from the area or used in roadway construction. The remaining areas of this soil complex were assigned runoff curve numbers for hydrologic soil group D. It was reasoned that the severe erosion which has occurred in these areas has resulted in the loss of the sandy-gravelly portion of the complex and in some areas has removed the overburden soils to the underlying Pierre shale and weathered clays.

The Nelson-Tassel complex is composed of about 50 percent soils in hydrologic soil group B, ten percent soils in hydrologic soil group C and 40 percent soils in hydrologic soil group D. Occurrence of Nelson-Tassel complex soils within the Mesa Basin is very minimal, covering about five acres of the 2190 acres in the basin. The area in which this complex appears is highly developed at present with the major land use being high density single family residential. Runoff curve numbers assigned to this soil complex correspond to hydrologic soil group C. It is realized that assigning group C runoff curve numbers to this soil complex is slightly conservative since at least 50 percent of the soils are classified as hydrologic group B soils. However, since the area involved is relatively small and the density of development is quite high, the use of hydrologic group C runoff curve numbers should not result in significant variations in peak runoff quantities.

The Razor-Midway complex is composed of about 60 percent soils in hydrologic soil group C, 30 percent soils in hydrologic soil group D and ten percent soils in hydrologic soil group B. The predominant soils in this complex have slow permeability ratings, moderate to low available water capacity and medium to rapid surface runoff potential. Runoff curve numbers assigned to areas with Razor-Midway complex soils were taken as the average of runoff curve numbers for hydrologic soil groups C and D.

For a detailed description of basin soils, the reader is referred to the previously referenced "Soil Survey." This publication contains technical data related to soils in the basin including soil characteristics, engineering properties and water management limitations.

Vegetation in the study area ranges from Yucca and natural grasses in the undeveloped areas to well developed lawn grasses in the highly developed areas. Trees are evident in the eastern developed areas and along the main drainage channels.

The Mesa Basin contains a significant amount of land with slopes in excess of 30 percent. The steep slopes and impermeable soils found in the central portion of the basin give this area a high potential for runoff and make the area extremely susceptible to erosion if the ground cover is disturbed. Special care should be taken in development of the steeply sloped areas which are common in the basin. If these slopes are denuded of vegetation or used as unsupervised fill areas, severe erosion could result. The gently sloping land located in the western portion of the basin and the relatively pervious soils makes runoff potential low and erosion potential moderate.

Much of the basin has been abused by the general public. Areas have been used as dumping grounds and in some areas serious erosion has occurred due to the numerous bike and jeep trails that traverse the area. The native vegetation in the area is sparse. When use of these trails wears off the existing vegetation, drainageways are formed which further accelerate erosion.

## Land Use

The actual land use of an area has a major effect on the drainage problems to be encountered. Land use data for this study was developed from

research of platted subdivisions, field investigations, and discussions with and information provided by major land owners and the City of Colorado Springs. Land use data provides basic ground cover information and relationships as to the percentage of pervious and impervious area. This data, when coordinated with soil types, provides design information for storm water runoff calculations.

At present, approximately 60 percent of the Mesa Basin has been developed. To date, the major development has taken place in the eastern and western portions of the basin. In the eastern portion of the basin, along Interstate Highway 25, well established development has occurred. This development has been provided primarily in rectangular block patterns with little regard to natural drainage features. Existing development in this portion of the basin includes residential, commercial and industrial uses. Development in the western portion of the Basin ranges from townhouses and condominiums to single family residential units on large lots. Substantial residential development has occurred in the areas adjacent to the Kissing Camels Golf Course. Additional development is currently planned and is certain to materialize in the future.

The central portion of the basin located between Fillmore Street and Chestnut Street has undergone limited development to date. However, the Hill Development Corporation has developed a master plan for much of this area. The proposed development will occupy approximately 600 acres within the Mesa Basin and will consist of approximately 3,500 single and multi-family residential units; industrial, commercial and office park areas; private open space and public parks. In addition, the City of Colorado

Springs Park and Recreation Department has acquired approximately 95 acres on which further park development is planned. This park will be located along the main drainage channel immediately west of the existing residential development.

The central portion of the basin has been designated as a Hillside Area Overlay Zone; and therefore, proposed development in this area must be approved by the Director of Planning and the Director of Public Works. It is important that development, grading, erosion control and reclamation plans be reviewed carefully with regard to their impact on and conformance with this Master Drainage Plan.

Exhibit No. 3 "Land Use and Development" reflects existing land use and anticipated land use as it is presently proposed.

# IV. HYDROLOGY

Although typical storm drainage flows in the Mesa Basin are of relatively low magnitude, the potential for damaging flows exists. These flows will likely result from runoff caused by the very intense thunderstorms which typically occur during the summer and fall. As development in the basin increases the existing runoff patterns are likely to change and peak flows may increase. Therefore, it is necessary to estimate storm drainage flows for the basin in a projected fully developed condition. These estimated fully developed peak flows are then used in the hydraulic analysis of existing and proposed structures.

Since none of the drainage channels within the Mesa Basin have been gauged, it was necessary to mathematically model the basin to predict peak flows. An attempt was made to utilize computer modeling techniques, specifically the HYMO program developed by the United States Department of Agriculture (USDA) using the Soil Service (SCS) rainfall-runoff relationship. Because of the unique conditions which exist within the Mesa Basin area, particularily small subbasin size, steep topography, and the rainfall intensity distribution selected for this study, the HYMO program was found to be inapplicable. The "Soil Conservation Service Method," as described in the publication "Areawide Urban Runoff Control Manual" prepared for the Pikes Peak Area Council of Governments and the Soil Conservation Service publication "Procedures for Determining Peak Flows in Colorado," was used to model the study area. This methodology conforms with the City of Colorado Springs manual on "Determination of Storm Runoff Criteria." This technique is applicable for

computing peak runoff for drainage basins encompassing 20 acres to 25 square miles.

The use of the "Soil Conservation Method" is felt to be justified in that nearly all of the subdrainage areas being studied were of relatively small size and the subbasins contained within each subdrainage appear to be hydrologically similar. The exception is subdrainage D which contains the main drainageway through the basin. This subdrainage area is quite large in comparison with the average subdrainage area studied; however, the incorporation of detention facilities in the middle reaches of subdrainage D results in this subdrainage area basically being divided into two distinct study areas. Subbasins located upstream of the proposed facilities were judged to be hydrologically similar as were subbasins located downstream of the proposed facilities. Therefore, it was felt that the hydrologic analysis method utilized was appropriate for subdrainage D as well.

It is realized that the "Soil Convervation Service Method" of predicting peak storm water runoff rates may not be as precise as other analytical methods; however, it is felt that this method does result in reasonable, precise, conservative estimates of peak runoff rates. Considering the assumptions which must be made with regard to soil types, land use and proposed development patterns, the use of sophisticated analytical techniques may not materially improve the precision of the peak storm water runoff quantities which are developed.

Drainage of the Mesa Basin occurs through numerous natural drainage channels. In utilizing the Soil Conservation Service mathematical modeling technique, the Mesa Basin was divided into 17 subdrainages and 94 subbasins with 67 design

points. Each subdrainage has a defined outfall to Monument Creek. Design points were established at specific points of interest to determine accumulated peak flow for the hydraulic analysis of existing structures and preliminary design of proposed structures. Exhibit No. 1, "Drainage Map", outlines the subbasins and indicates design point locations. Peak flow data at each design point for each storm event is presented in Appendix A as Tables 4 through 7.

A schematic flow diagram of the Mesa Basin depicting subbasins, design points, and existing structures is shown as Figure 3 in Appendix A "Sub-Basin Schematic." Basic information relating to each subbasin is provided in Table 3 in Appendix A "Sub-Basin Data Summary." The information contained in this table includes the area of each subbasin, the length of the drainage channel, elevation difference within the subbasin and weighted curve number for the subbasin.

In selecting design storms for hydrologic analysis, the occurrence of precipitation is defined by frequency, duration, volume and intensity. For this study, runoff flows were determined for the following storm events: 24 hour, 100 year; 6 hour, 100 year; 24 hour, 5 year; 6 hour, 5 year. The five and 100 year frequency storms have a 20 and one percent chance of being exceeded in any given year, respectively. Flow rates used to analyze existing structures and to size proposed facilities were based on peak runoff resulting from the 100 year frequency storm when the 100 year storm produced peak flow rates greater than 500 cubic feet per second (cfs). When peak runoff rates from the 100 year frequency storm resulted in flows less than 300 cfs, the peak flow rate resulting from the five year frequency storm was utilized. In cases where the 100 year frequency peak flow rate was between 300 cfs and 500 cfs,

the design flow rate was selected based on an analysis of potential damage from runoff in excess of that resulting from the five year frequency storm.

In addition to the total volume of precipitation for a given storm event, the rainfall intensity distribution must be considered. Soil Conservation Service criteria states that a Type IIA rainfall intensity distribution should be used for basins below an elevation of 8,000 feet. Since the entire Mesa Basin is below the 8,000 foot level, a Type IIA distribution was used in this study. This distribution is the most intense rainfall distribution used by SCS and results in the highest peak runoffs.

A normal antecedent moisture condition (AMC-II), which represents an average soil moisture condition prior to a storm, was assumed.

Peak flows were computed utilizing the following equation:

(1) $$q_p = QA\ (CSM)$$

where: $q_p$ = peak runoff, cfs

Q = direct runoff, inches

A = area, square miles

CSM = runoff factor obtained from published curves in cfs per inch of runoff per square mile, based on calculated time of concentration

Time of concentration was determined based on Equation (2) and physical data for the basin obtained from 400 scale topographic mapping. The time of

concentration is defined as the time it takes for runoff to travel from the hydraulically most distant part of the basin to the design point.

(2) $$T_c = \left(\frac{11.9\ L^3}{H}\right)^{0.385}$$

where: $T_c$ = time of concentration, hours

L = length of water course, miles

H = elevation difference, feet

The amount of direct runoff in inches (Q) is a function of rainfall, soil type, land use, cover condition and antecedent moisture condition. The SCS method of calculating the ratio of runoff to rainfall is based on the computation of a weighted curve number (CN) for the area being evaluated. The runoff curve number reflects the runoff potential for an area and represents the combined hydrologic effects of soil classification, vegetative cover and land use. Curve numbers vary throughout the basin and were determined for each subbasin based on projected land use and hydrologic soil classification. Table 2 in Appendix A, "Runoff Curve Numbers", presents a listing of curve numbers used in this study corresponding to land use and soil types.

In determining design point curve numbers, the percentage of each soil type and land use in the area tributary to the design point was determined. This percentage was multiplied by the applicable curve number to obtain a weighted curve number for the entire tributary area.

Once the weighted curve number has been estimated, direct runoff can be related to total precipitation using Equations (3) and (4) developed by the Soil Conservation Service for typical Colorado watersheds.

(3) $$S = \frac{1000}{CN} - 10$$

where: CN = weighted curve number

S = maximum potential difference between precipitation and runoff, inches

(4) $$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

where: Q = direct runoff, inches

P = total storm precipitation, inches

S = from equation (3)

The volume of precipitation (P) in Equation (4) which falls during a given storm event was interpolated from rainfall intensity-duration curves for the Colorado Springs area contained in the previously referenced "Areawide Urban Runoff Control Manual". The following precipitation values were used in the hydrologic analyses conducted as part of this study and generally conform with

the City of Colorado Springs manual on "Determination of Storm Runoff Criteria."

| Storm Event | Total Precipitation (Inches) |
|---|---|
| 24 hour, 100 year | 4.6 |
| 6 hour, 100 year | 3.7 |
| 24 hour, 5 year | 2.55 |
| 6 hour, 5 year | 1.95 |

# V. HYDRAULICS

Since the Mesa Basin was originally studied and the present storm water drainage facilities were designed, changes have occurred in design criteria, the extent of development within the basin has increased and the methods of analyzing watersheds has improved. The new analyses due to these changes has indicated the need, in some cases, to provide capacity for greater runoff which will have an impact on some of the existing structures.

There are currently many drainage facilities within the study area. They are, for the most part, culverts and short sections of drainage conduit used to transport drainage flows under major facilities such as streets, highways and railroads. As such, they were designed to solve specific and isolated drainage problems.

Existing drainage facilities were evaluated on-site to determine dimensions and their physical condition for incorporation in the master drainage plan. Appendix C and Exhibit No. 4, "Drainage Structures", indicate the location and size of the existing facilities. Table No. 8 in Appendix A, "Existing Drainage Structure Evaluation", indicates the estimated capacity of each structure and the design inflow rate. Several of the minor drainage structures which drain median and ramp areas along I-25 were not included in the inventory of existing structures, nor were their hydraulic capacities analyzed.

To determine the adequacy of the existing facilities, and to develop a new system which will conform with this master plan, the design capacity of each

existing structure was calculated. Hydraulic Engineering Circular Number 5, "Hydraulic Charts for the Selection of Highway Culverts", published by the U.S. Department of Commerce, Bureau of Public Roads was utilized to estimate design capacity of the existing structures. Drainage patterns were also studied to determine the suitability of existing drainage facilities and the need for new facilities.

During the course of this study, several components of the existing Mesa Basin storm drainage system were found to be inadequate. Some of these inadequacies are due to recalculated peak flows determined through the use of new design criteria and projected development in the basin. Other problems could be attributed to inadequate maintenance and previous policy. These problems, compounded by the increased flow projections, add to the inadequacy of the existing system. The following sections discuss these inadequacies and offer recommended solutions.

# VI. DRAINAGE STRUCTURE IMPROVEMENTS

This section presents a discussion of specific drainage structure inadequacies and offers recommended solutions to correct these inadequacies. Preliminary cost estimates were prepared based on the recommended solutions contained herein and are presented as Table 10, "Preliminary Cost Estimates", in Appendix B. Location and alignment of proposed improvements are shown on Exhibit No. 4, "Drainage Structures." Variations in proposed development may occur which will require revisions or modifications to the proposals contained herein. The recommended improvements for storm water drainage facilities contained in this report should be reviewed and their required hydraulic capacities, grades, sizes and alignments should be verified during the preliminary design phase for each individual improvement project.

## Kissing Camels Area

Several of the drainage structures in the Kissing Camels area, located north of Mesa Road and west of Fillmore Street, were found to have inadequate hydraulic capacity. Structures in this area found to be inadequate under runoff conditions resulting from the five year design storm event include Structure Nos. 1, 2, and 4, which convey runoff under Kissing Camels Drive and Structure Nos. 14, 15 and 16 which convey runoff under Hill Circle. In general, recommended improvements for these structures would include replacement of the existing inadequate structure with one having sufficient hydraulic capacity, installation of additional structures to convey peak runoff from the design storm event and/or development of roadside or recreation area

detention facilities to temporarily store storm water runoff. However, this area is presently under private control with limited public access. To date, the City of Colorado Springs has not accepted responsibility for maintenance of roadways or drainage facilities in this area. The inadequacy of these structures presently poses the threat of property damage and inconvenience primarily to the residents of this area and not to the general public. Also, under current policy, public access for maintenance purposes via local streets is limited by direction of area residents. It is therefore recommended that all drainage structures and improvements in this area remain under private control at least until provisions are made to upgrade those facilities which have inadequate hydraulic capacity and access is provided to city forces for purposes of maintenance and inspection. It is also recommended that all costs associated with upgrading the drainage facilities in this area be borne by the Kissing Camels Home Owners Association, which is currently responsible for storm water management, since local residents are the primary beneficiaries of such improvements. In light of these recommendations, costs associated with drainage system improvements in the Kissing Camels area have not been included in the determination of the basin drainage fee and said improvements would not be eligible for drainage fee credit or reimbursement since they would remain under private control.

Storm Sewer Improvements

The storm drainage system in the developed eastern portion of the Mesa Basin along I-25, as it presently exists, is not adequate to convey storm water runoff through the area and to Monument Creek. To date, street flow has been the primary method for conveyance of storm water runoff through the area. The

drainage structures which exist are located in the lower portions of the area and were constructed to convey runoff under I-25. As development within the area has occurred, the volume of storm water runoff has increased to the point that many of the streets have reached their hydraulic capacity. In addition, the increase in storm water runoff has hydraulically overloaded several of the existing drainage structures including Structure No. 38 located under Chestnut Street north of Green Ridge Drive, Structure Nos. 45 and 46 located adjacent to Fontanero east of I-25, and Structure Nos. 47 and 51 which convey runoff under I-25 at the east ends of Del Norte and Columbia Streets, respectively. As part of this master drainage plan, five specific storm sewer projects are proposed to help remedy the storm water conveyance problems which have developed over the years. Detailed preliminary cost estimates for each of these proposed projects are contained in Table 10 as items one through five.

Cooper Street Storm Sewer

The proposed Cooper Street storm sewer will intercept storm water runoff in Sub-basins 37 and 38 at Cooper Street and convey it to the main drainageway north of Buena Ventura Street. Interception of storm water generated in the upper reaches of these sub-basins will reduce the peak runoff reaching Structure No. 51. It is estimated that this project will reduce peak runoff rates at Structure No. 51 from 243 cfs to 65 cfs for the 100 year storm event and from 95 cfs to 24 cfs for the five (5) year storm event. With the installation of the proposed Cooper Street storm sewer, Structure No. 51 should have adequate hydraulic capacity to convey design storm runoff without additional improvements.

Del Norte Street Storm Sewer

The proposed Del Norte Street storm sewer will intercept storm water runoff from the upper portion of Sub-basin 49 at Chestnut Street and will also drain an existing sump condition which occurs on Chestnut Street between Del Norte and Caramillo Streets. Storm water will be conveyed by this proposed storm sewer to the main drainageway north of Buena Ventura Street. It is anticipated that this project will reduce peak runoff rates at Structure No. 47 to the extent that additional improvements at this location will not be required.

Chestnut Street Storm Sewer

The proposed Chestnut Street storm sewer will intercept storm water runoff originating in the western portion of Subbasins 44 and 48 at Chestnut Street and convey this storm water to Monument Creek via proposed and existing storm sewers along Fontanero Street. Proposed storm sewer improvements have been sized to convey storm water runoff generated by the five year design storm with a ponding depth of approximately six (6) inches over the storm inlets located beneath the railroad grade separation on Fontanero Street. Under 100 year design storm conditions, ponding depth at these inlets would exceed three feet. It is felt that a six (6) inch ponding depth on Fontanero is acceptable since traffic flow on the entrance and exit ramps for I-25 will not be affected and an alternate access to the City Municipal Service Center yard is available along Glen Avenue. However, at greater ponding depths, traffic access east of I-25 on Fontanero will be severely limited. The increased ponding depth resulting from low frequency storm events may not be acceptable. During the detailed design phase of this storm sewer project, it

may be desirable to include additional improvements to reduce the ponding depth on Fontanero. Required improvements would include additional storm water inlets and an additional 42 inch diameter outfall storm sewer. Under five year design storm conditions, storm water intercepted by this proposed storm sewer system will reduce the hydraulic load on Structures No. 45 and 46 to the extent that additional improvements to these structures would not be required.

Mesa Valley Road Storm Sewer

The proposed Mesa Valley Road storm sewer will convey storm water runoff from portions of Sub-basins 42, 43 and 45 to the west side of I-25. Drainage improvements required to convey storm water runoff from the west side of I-25 to Monument Creek will be discussed later in this section.

Current City of Colorado Springs drainage criteria requires the design of minor drainage structures based on the five year frequency storm event and major drainage structures based on the 100 year frequency storm event. However, many of the storms which occur in the Colorado Springs area have a recurrence frequency in excess of five years and therefore create flooding conditions, if the storm sewer system is designed for only the five year design storm. When the capacity of the storm sewer system and streets are exceeded, property damage is likely to occur particularly at the downhill end of streets and other locations where there is no suitable outlet for the runoff. In many cases, the construction of storm drainage facilities designed for a storm event in excess of the five year design storm will mitigate potential property damage at a relatively small increase in total project cost.

Where the infilling of developed areas is occurring, these types of drainage problems often develop. In an effort to remedy these problems, the City has required that upstream developments provide adequate outfall facilities so that the increased runoff will not adversely affect existing downstream development.

The capacity of the existing and proposed street system to convey storm water runoff resulting from the 100 year design storm event was considered in the preliminary design of the proposed Mesa Valley Road storm sewer system. The proposed storm sewerage system has been preliminarily designed to convey storm water runoff resulting from a 100 year design storm without overtopping the street sections on Mesa Valley Road, Melany Lane and Chestnut Street.

Storm inlets have been recommended along Mesa Valley Road as required to intercept storm water runoff when maximum street capacity is reached. Analysis of the Melany Lane street section indicates that it has adequate capacity to convey 100 year design storm runoff to its intersection with Chestnut Street. However, Chestnut Street has inadequate capacity to convey tributary runoff resulting from the 100 year design storm without over topping the curbs due to its relatively flat longitudinal slope. If storm water overtops the curbs, property on the east side of Chestnut Street could be damaged. In order to mitigate potential property damage, it is recommended that the portion of the storm sewer system constructed in Chestnut Street be sized to collect and convey storm water runoff in excess of street capacity under 100 year design storm conditions.

A hydraulic evaluation of the existing grouted riprap channel located north of the Trails End Subdivision indicates that the existing channel is of inadequate

size to convey tributary runoff from the 100 year design storm. Should this channel be overtopped, adjacent property would be damaged. It is therefore recommended that a 36 inch diameter pipeline be installed parallel to the channel to convey storm water runoff in excess of channel capacity.

It is further recommended that a 60 inch diameter outfall storm sewer be constructed from Chestnut Street to the west side of I-25 to safely convey runoff collected by the proposed upstream improvements. Construction of this proposed outfall pipeline would replace the existing twin 36 inch by 18 inch corrugated metal culverts (Structure No. 38) which cross Chestnut Street.

Taylor Street Storm Sewer

The Taylor Street storm sewer is proposed to improve the interception of storm water runoff in Subbasin 51 and reduce the quantity of runoff which becomes street flow on Chestnut Street. Recommended improvements include the construction of curb inlets at the intersections of Parker and Taylor Streets and Chestnut and Taylor and a 24 inch diameter storm sewer along Taylor Street from Parker to the east side of Chestnut. At the time of development of the land between Chestnut Street and I-25, a 30-inch diameter storm sewer will be extended to the concrete lined channel and culvert at the west side of I-25.

Interstate Highway Crossing and Improvements South of Fillmore Street

Storm water runoff from Subdrainage H (Sub-basins 42, 43, 45, 46 and 52), Subdrainage K (Subbasins 73 and 75) and Subdrainage M (Sub-basins 41, 51, 53, 54, 59, 61, 66 and 74) is conveyed to Monument Creek through an intricate

arrangement of drainage structures. Many of the existing structures in this drainage pattern have inadequate hydraulic capacity to convey tributary runoff (Structure Nos. 20, 21, 32, 34, 35, 39, 41 and 42 all of which are located south of Fillmore along I-25). Furthermore, the combined hydraulic capacity of the existing structures west of I-25 in this area is inadequate to convey design storm runoff under the highway. Item six in Table 10 contains a detailed preliminary cost estimate for the recommended improvements required to effectively drain this area. The following paragraphs discuss the pattern in which storm water runoff is routed to Monument Creek and the proposed improvements required to convey peak runoff rates.

Storm water runoff from Sub-basin 41 exceeds the capacity of the existing storm sewer system in Fillmore Street (Structure No. 20 and 21). No improvements in this storm sewer system are recommended at this time since flow in excess of storm sewer system capacity should travel to Structure No. 32 without major problems. Under five year design storm conditions, Structure No. 32 has adequate capacity to convey 100 percent of the tributary runoff under I-25. However, under 100 year design storm conditions, tributary flow at Structure No. 32 exceeds its hydraulic capacity. This could result in partial inundation of the entrance ramp to I-25 and possibly a portion of the south bound lanes. In order to mitigate this condition, it is proposed that a concrete lined channel capable of conveying 145 cfs be constructed between Structure No. 32 and Structure No. 34. Tributary flow in excess of the hydraulic capacity of Structure No. 32 could then be bypassed to Structure No. 34. It is also proposed that a concrete lined channel capable of conveying 79 cfs be constructed from Structure No. 34 to Structure No. 39. On the rare occasions

that Structure No. 34 cannot convey the total tributary runoff volume under I-25, excess flow could then bypass to downstream drainage structures.

Since the total tributary runoff generated on the west side of I-25 exceeds the combined hydraulic capacity of the existing drainage structures, it is apparent that a new crossing of I-25 and the Denver and Rio Grande Western railroad tracks will be required. As part of this master plan, it is proposed that a new 84 inch diameter reinforced concrete pipeline be installed adjacent to existing Structure No. 41 to convey storm water runoff from the 100 year design storm event on Monument Creek. It is further recommended that a new inlet structure be constructed at Structure No. 39 to maximize flow through this structure.

Storm water runoff conveyed to the east side of I-25 through Structure Nos. 32 and 34 under 100 year design storm conditions may exceed the hydraulic capacity of Structure No. 35. It is therefore recommended that a concrete lined channel capable of conveying 50 cfs be constructed between Structure 35 and 37 to permit excess flow to bypass Structure 35. Hydraulic evaluation at Structure No. 37 indicates that it will have adequate capacity to convey tributary runoff resulting from the 100 year design storm under the railroad tracks.

Interstate Highway Crossing and Improvements North of Fillmore Street

Of particular concern with regard to needed drainage improvements is the area located west of I-25 and north of Fillmore Street which includes sub-basins 13, 55, 56, and 57. Based on hydrologic and hydraulic analyses conducted as part

of this study, it is evident that the existing drainage improvements downstream of this area are inadequate to convey storm water runoff generated under existing development conditions to Monument Creek. Since this area is far from being fully developed, it is apparent that as future development occurs, drainage problems will surely become worse.

The following options were investigated for drainage improvements in this area:

A. Construction of improvements, including detention facilities, to limit the rate of runoff to not more than the maximum capacity of the existing drainage facilities.

B. Construction of improvements to convey runoff from the area to an outfall to Monument Creek south of Fillmore Street.

C. Construction of improvements to convey runoff from the area to an outfall to Monument Creek north of Fillmore Street.

Option A, which includes the utilization of storm water detention, was not found to be a cost effective and practical solution for the entire subdrainage on a permanent basis. Topography in the area does not lend itself to a single, large volume facility. Therefore the incorporation of multiple, small volume facilities would be required. In addition, because of the limited hydraulic capacity of the existing drainage structures, major structural improvements would still be required unless the rate of runoff were limited to less than the capacity of existing facilities. The cost of such drainage system improvements and the expense of maintaining several small detention facilities leads to the conclusion

that this option will not be a cost effective solution for long term storm water management.

Option B involves diverting storm water runoff from its historic drainage pattern. The City of Colorado Springs, as a matter of policy, discourages such diversions of storm water runoff. The primary reason for this relates to Colorado drainage law. When drainage improvements are made which do not follow the natural drainage pattern and storm water causes injury to adjacent land owners, Colorado drainage law holds the entity responsible for the drainage improvements liable. In addition, this option would require construction of a major drainage facility under Fillmore Street. The additional cost and potential utility conflicts associated with this structure result in estimated project costs for this option being relatively high when compared with other options available.

Option C, construction of improvements to convey runoff to Monument Creek north of Fillmore, appears to be the most practical and cost effective solution for drainage problems in this area. Recommended improvements to upgrade the existing drainage system include:

1. Construction of concrete lined, drainage channel improvements upstream of Chestnut Street to promote collection of runoff and conveyance of these flows to Chestnut Street.

2. Construction of a double five foot by six foot reinforced concrete box culvert under new Chestnut Street and a single cell five feet by nine feet box culvert beneath existing Chestnut Street.

3. Construction of a 72-inch diameter reinforced concrete pipeline from the west side of I-25 to an outfall at Monument Creek. This construction includes crossings of I-25, Sinton Road and the Denver and Rio Grande Western railroad tracks. The proposed alignment for this storm sewer is through the parking area north of the Holiday Inn and south of Holiday Mobile Home Park.

4. Construction of improvements and an extension to the existing 48-inch diameter storm sewer at Fillmore and I-25 northerly to the existing Chestnut Street drainage crossing.

In addition to the above described improvements, certain elements of Options A and B may be incorporated in the storm water management plan for this subdrainage. Through discussions with the major landowner in this area and the City of Colorado Springs, Department of Public Works, two approaches have been agreed upon for implementation. First, the area naturally tributary to the subdrainage lying west of Centennial Boulevard will be regraded to drain southerly and south-westerly to detention facilities north of Fillmore Street. The detention pond is to mitigate the effect of additional runoff in the East Fork subdrainage. Secondly, it has been agreed that all of this developer's property lying east of Centennial Boulevard will be developed in a fashion to limit runoff to a rate not to exceed the capacity of downstream structures. The detention facilities required are to be contained within that ownership and be privately maintained. Because of their effect on downstream facilities (flow reduced), it has been agreed the cost of construction will be reimbursable to the developer upon completion to the requirements of the City Engineer's office.

It is proposed that the existing drainage structures in this area (Structures Nos. 22, 24, 25, 26, 27 and 28) be retained to collect and convey storm water runoff generated east of Chestnut Street to Monument Creek. The existing crossing of Chestnut Street (Structure No. 23) would be replaced under this recommended improvement plan. A detailed preliminary cost estimate for these proposed improvements is contained in Table 10 as item seven.

Centennial Boulevard Storm Sewer

Items eight and nine in Table 10 include costs associated with recommended storm sewer projects along the proposed extension of Centennial Boulevard. At present, the alignment of this extension to Centennial Boulevard is in the preliminary planning stage. Final alignment may vary from the route indicated on Exhibit No. 4, "Drainage Structures." Alternate alignments of the roadway could significantly affect the preliminary cost estimates contained herein. It is therefore recommended that project costs for these improvements and the unit drainage fee for the Mesa Basin be reevaluated upon selection of a final alignment for this extension of Centennial Boulevard. The basic purpose of this storm sewer system will be to drain the Centennial Boulevard street section.

Subdrainage Outfalls

Preliminary cost estimate item ten contains costs associated with improvements for subdrainage outfalls located east of the Denver and Rio Grande Western railroad tracks to provide for safe and adequate conveyance of storm water runoff to Monument Creek. Recommended improvements include increasing

channel capacity, lining of drainage channels and installation of pipe outfalls. Recommended improvements included under this item are located in Sub-basins 92, 93 and 94.

Detention Facilities

The incorporation of detention facilities in the Mesa Basin is discussed in detail elsewhere in this report. It is proposed that detention facilities be developed utilizing the existing Kissing Camels golf course irrigation reservoir and the Fillmore Street roadway embankment. Existing Structure No. 12, located downstream of the Kissing Camels irrigation reservoir, appears to have adequate hydraulic capacity provided the criteria developed in Section VIII - Detention Facilities, are utilized in the design of the detention facility outlet structure. Other detention facilities are proposed in the basins. These are discussed in detail in Section VIII - Detention Facilities.

Main Stem Channel Protection

Preliminary cost estimate item 12 includes costs associated with main stem (Subdrainage D) channel protection. A detailed discussion of channel protection and preliminary design criteria are included in the "Channel Protection" section of this report. The costs contained in Table 10 include the furnishing and installation of loose, riprap channel protection material, filter fabric and bedding course material. It is proposed that realignment of the existing channel and alteration of channel sections be kept to a minimum. Where it appeared necessary to make such channel modifications, the costs associated with required earthwork were included in the preliminary cost

estimate. The use of concrete control sections is proposed to help control erosion and to confine possible lining failures to a limited area.

Miscellaneous Improvements

Additional improvements are recommended at various locations within the Mesa Basin. For the most part, these improvements are proposed to remedy deficiencies at specific locations and therefore were not included as a part of a specific project. Preliminary cost estimates for these miscellaneous improvements are included in Table 10 under item 13 and are discussed in the following paragraphs.

Mesa Water Filtration Plant

Structure No. 5 passes through an existing roadway embankment which appears to provide access to a nearby sewage lift station in Subbasin 12. Three alternatives were investigated for remedying the hydraulic inadequacy of this structure, as follows:

A. The existing roadway embankment could be removed, the natural channel recreated and a new access provided to the lift station.

B. The area upstream of the existing structure could be developed as a detention facility.

C. The existing structure could be replaced with a new facility having adequate hydraulic capacity.

Based on evaluation of the alternatives investigated, it is recommended that a new culvert be installed at this location to replace the existing structure.

Fillmore Street Median Inlet

Structure No. 9 located near Coronado High School serves to drain a portion of the Fillmore Street median (Subbasin 25). Hydraulic calculations indicate that the existing structure has marginal capacity under five year design storm conditions. The existing structure utilizes a two foot square grated inlet which is subject to being plugged by debris. It is recommended that this structure be modified to conform with a Colorado Division of Highways Type C median inlet. The modified structure would have adequate capacity to convey runoff generated by the 100 year design storm with a ponding depth over the inlet of approximately 12 inches. The required ponding depth is well within the maximum ponding depth presently available and will not cause traffic lanes to become inundated.

Holiday Mobile Home Park

Storm water runoff in the Holiday Mobile Home Park is collected and conveyed by street flow to an existing storm sewer system (Structures No. 29 and 30). The existing storm sewer system consists of two grated inlets in a sump condition, connected by 18 inch diameter pipe at each location. Storm water collected by these inlets is conveyed through 36 inch diameter reinforced concrete pipes to an open drainage channel west of the Denver and Rio Grande Western railroad tracks. The existing grated inlets have inadequate capacity to collect runoff generated by the five year design storm without overtopping the

curb. It is recommended that curb inlets be added to these structures to increase their capacity. The existing storm sewer pipelines and downstream facilities, including the existing railroad crossing, appear to have adequate capacity to convey storm water runoff to Monument Creek. The adjacent Interstate Commerce Center development has responsibility to convey this runoff through that project to Monument Creek

Glen Avenue Crossing

The existing drainage facilities under Glen Avenue (Structure No. 50) are not only inadequate to convey tributary storm water runoff, but also create conditions which adversely affect vehicular traffic and upstream drainage facilities. The existing drainage facility consists of a 72 inch diameter corrugated metal pipe installed through a depressed roadway embankment. This type of drainage structure is designed to allow storm water runoff in excess of culvert capacity to flow over the roadway and into the downstream channel. Hydraulic calculations indicated that the existing culvert has inadequate capacity to convey runoff resulting from the five year design storm. Therefore, overtopping of the roadway embankment can be expected to occur often. Overtopping of the roadway embankment poses a danger to traffic, accelerates deterioration of the asphalt pavement and could result in severe erosion of the embankment itself. Design of the existing structure also causes a backwater condition which results in sediment being deposited in the box culvert under I-25. Accumulation of sediment in this structure has already occurred and could ultimately reduce its capacity to the point that upstream flooding would occur. To remedy the unacceptable conditions which presently exist at this location, it is recommended that the existing structure be replaced

with a double eight foot by ten foot reinforced concrete box culvert and that the embankment be raised to eliminate the present depression in Glen Avenue.

# VII. CHANNEL PROTECTION

A major consideration in developing recommendations for channel protection improvements within the Mesa Basin was providing an optimum level of erosion protection and runoff control while maintaining the existing drainageways in as natural a state as possible. Where it was determined that erosion protection and runoff control are necessary, primary consideration was given to channel protection and channelization methods which would alter natural conditions the least.

The natural channels in the central portion of the Mesa Basin presently exist in the form of steep banked gullies which have erodible bottoms and side slopes. As has been previously discussed, soils in the Mesa Basin are extremely susceptible to erosion. Field observations revealed that significant erosion problems presently exist and that many of the major drainageways are in a state of degradation. This condition is quite evident in Subdrainage D at the box culvert under I-25. Field observations indicate that as much as four feet of sediment has been deposited in this structure. Adequate measures should be taken as part of the development within the basin to eliminate, to the greatest extent possible, any further erosion in the area. Investigation and analysis of the physical characteristics of the major drainage channels within the Mesa Basin was undertaken in order to determine maximum permissible flow velocities during design storm events. As a result of this analysis a maximum velocity range of 3.5 to 5 feet per second (fps) for flow in unlined natural channels was selected. Limiting velocities within this range should provide adequate erosion protection. In order to provide the degree of protection required by current

City standards, this velocity range must not be exceeded during storm events with a 100 year recurrence interval.

The Federal Emergency Management Agency (FEMA) has developed a significant amount of floodway data for the main drainage channel located in the Mesa Basin. A review of the data presented in the FEMA "Flood Insurance Study for the City of Colorado Springs" indicates that 100 year storm flow depths in the lower reaches of the main channel, in the proposed Sonderman Park area, would be on the order of 4 to 5 feet with a floodway width of 60 to 80 feet. Corresponding mean velocities are on the order of 7 to 10 feet per second. In the upper reaches of the main channel, just south of Fillmore Street, floodway width decreases with a corresponding increase in flow depth and velocity.

Various channel protection alternatives were investigated as part of this study. As a result of investigations to determine the most cost effective and efficient manner to convey storm water flows through the intermediate areas of the basin, the use of concrete drainageways was found to be undesirable due to the preference for maintaining the area in as natural a state as possible. Furthermore, the extensive use of concrete lined channels for large flows would not prove to be economically feasible. For small flows and confined locations, concrete channel paving has been considered.

Utilization of natural channels requires that attention be given to erosive tendencies and adequacy of channel carrying capacity. The changes in runoff patterns which result from urbanization of an area generally result, at least initially, in new and highly active erosional tendencies. In natural channels, erosion will occur in some reaches of the drainageway and deposition will occur in others. Careful hydraulic analyses must be made to counteract these

tendencies. In nearly all cases, some modification of the existing drainageways will be required to improve the stability and carrying capacity of the existing channels.

Because of the steep slopes which characterize the central portion of the Mesa Basin and the erodability of the soils found therein, the use of unlined natural channels, even with drop structures, does not appear to be feasible. The velocity of flow in these drainageways will be such that grass lining will be extremely difficult or impossible to establish and maintain and channel bottoms and side slopes will eventually erode. As previously indicated, velocities need to be limited to less than 5 feet per second in order to provide adequate erosion control. In the upper reaches of the central portion of the basin, naturally occurring slopes exceed four percent and result in 100 year runoff flow velocities in excess of 10 feet per second.

In order to reduce flow velocities to less than 5 feet per second, extensive earthwork would need to be accomplished along with the construction of numerous drop structures. If low height drop structures (1 to 3 feet) were utilized, the number and spacing of these structures would result in extensive alteration of the natural appearance of the drainageways. If high drop structures (greater than 3 feet) were used, the number of structures required would be reduced at the expense of greatly increasing the amount of earth moving required. Also, the use of high height drop structures introduces a risk to the safety of the general public.

Natural channels, particularly those containing numerous drop structures, tend to be difficult to maintain and as a result do not receive adequate maintenance.

These channels tend to become overgrown with trees and other vegetation and often become dumping sites. During periods of high storm water runoff, trees and other debris often become dislodged in upper reaches of a channel and may obstruct the channel or block downstream drainage structures. These conditions can cause localized flooding resulting in damage to adjacent property. Regardless of the environmental acceptability of unlined or grass lined channels which appear to be relatively natural, such channels are difficult or impossible to adequately maintain and will rapidly become degraded. Lack of adequate maintenance in natural channel sections can lead to a reduction in runoff control capability which will adversely effect the usability of land adjacent to the channel and the protection of public and private property downstream.

The most cost effective and practical method to route storm water through the Mesa Basin is by utilizing riprap lined channels, where necessary. Since maximum permissible velocities in a riprap lined channel can be increased to 14 feet per second or more, a minimal amount of rechannelization and earthwork would be required. The use of loose riprap lining material, if sensitively designed and constructed, can result in a channel which has a pleasing appearance and provides for ease of maintenance. However, the manner in which facilities are designed and constructed must conform with Public Works Department guidelines. As is discussed in the following section of this report, some channel reaches will be privately maintained. The City will not dictate the type of channel protection or improvements to be constructed, however the City Public Works Department will review <u>all</u> drainage plans for both public and private facilities.

In order to minimize the visual impact and enhance the areas adjacent to the lined channels, linear open space could be established extending to the northwest and northeast from Sonderman Park. This space could be developed as access routes to the park and other portions of the basin while also providing access for channel maintenance. Foot, bicycle and/or horse paths could easily be incorporated in these greenbelts at minimal cost.

In sections of the lower portion of the basin, where slopes are more gradual, the use of other than fully lined channel sections is an alternative. As an alternative to designing channel improvements to convey storm water runoff resulting from the 100 year storm event, lined channel sections could be sized to convey runoff generated by intermediate storm events, such as the 10, 20 or 50 year design storm, with an undeveloped flood plain established to convey runoff from the 100 year design storm. The size of the required flood plain must be defined prior to initial development so that adequate zoning or easements are in place to protect the drainageway from encroachment. This is necessary to insure that adequate carrying capacity and storage potential are maintained. No improvements which would restrict the flow of water in the 100 year flood plain should be allowed.

This report has been reviewed by the major landowner and neighborhood groups in the basin. As a result of their input, the following approach has been adopted by the City of Colorado Springs Department of Public Works.

(a) The East Fork channel (above design point 14) will be privately maintained with channel protection to be provided at the option of the

developer. The cost of protection or improvements that will be constructed will not be reimbursable to the developer.

(b) The West Fork channel (above design point 15) upstream to Fillmore Street will be publicly maintained. Limited riprap lining will be utilized to control erosion and subsequent channel degradation by storm water flow. Primary emphasis will be placed on control of channel bank undercutting and velocity control. Exhibit No. 4 reflects the general concept to be employed. A case-by-case, "bend-by-bend" examination of the natural channel will be necessary to develop final design and construction scope and details.

(c) The main channel downstream from design point 15 and upstream from Sonderman Park will be treated in a fashion similar to the concept in (b) above.

(d) Channel improvements in Sonderman Park will be the responsiblity of the park development. As such, no costs of that work are included in the basin fee nor is the park area included in the basin fee calculation.

(e) The main channel downstream from Sonderman Park will be considered for full treatment with rock riprap. Because of the proximity to private properties and the potential for extensive damage should channel "failure" occur, it is felt this area demands more of a structural approach than other areas.

While the use of a lined channel section is recommended downstream of Sonderman Park, it is not necessary to employ a uniform trapezoidal section throughout all reaches. Channel side slopes should be laid back to more closely match existing topography unless detailed hydraulic analysis indicates that adverse impact will occur. The use of such modified sections would reduce the quantity of earthwork required while helping to preserve the natural appearance of the channel.

In addition to the channel protection recommended for the main drainageways in the central portion of the basin, similar types of protection are needed in the minor tributaries located along Monument Creek. These minor tributaries serve as discharge points for subdrainages in the northern part of the Mesa Basin. It is further recommended that all drainage channels, including adjacent flood plain areas, be cleared of trees and vegetation which would obstruct the flow of storm water or be damaged by high flows. This is of particular concern in the existing drainageway between Chestnut Street and I-25. Furthermore, construction of surface improvements should not be permitted in areas which would be inundated by runoff from a 100 year design storm. This includes fences, out buildings and other permanent or temporary structures which would tend to obstruct flow. The provisions of the City's flood plain overlay zone can be used to control these factors. Finally, alternative channel protection or channelization proposals should be reviewed on a case by case basis to determine if they are adequate with regard to hydraulic capacity, protection of downstream property, erosion control and ease of maintenance.

# VIII. DETENTION FACILITIES

Detention of storm water runoff offers two primary benefits with regard to storm water management. Temporary storage can significantly reduce peak flow rates with a resultant reduction in the size and cost of downstream drainage improvements. Also, a reduction in sediment and debris loading downstream of such facilities will be realized. Reduction of sediment and debris in drainageways reduces maintenance costs for downstream facilities and benefits the general public's health and safety by improving water quality and reducing the potential for flooding caused by plugged culverts or blocked channels.

Of the several alternatives available for storage of storm water runoff, detention storage is the most common type of control facility. Such facilities are generally designed to pass low flows resulting from the more frequent storm events without significant storage. A portion of the storm water flow associated with high intensity, low frequency storm events is stored within these facilities and is released at a rate less than the peak inflow rate. Attenuation of peak runoff rates in the drainage system results in smaller capacity facilities being required downstream of the detention facility.

The use of existing roadway embankments and existing multiple use facilities for storm water detention is a common practice in many areas. However, the use of roadway embankments to help reduce downstream peak flows must be done with thorough consideration of potential damage to the embankment, the roadway and adjacent properties.

In order to arrive at optimum drainage system design, it is necessary to conduct an economic analysis to determine if the costs associated with incorporation of detention facilities can be justified by the reduced cost of downstream improvements. In addition, a strict cost analysis must be considered along with the impact on aesthetic and operations and maintenance related factors. In this analysis of the Mesa Drainage Basin, temporary storage of storm water runoff was initially investigated at four locations. After review of the draft study by the major land developer within the basin, they indicated a strong desire to incorporate additional detention facilities to better accommodate their proposed concept of development. These additional detention facilities have been agreed to in principle by the City of Colorado Springs, Department of Public Works. The economic analysis indicated that incorporation of detention facilities at selected locations would have a cost advantage by reducing peak runoff rates to the extent that downstream facilities would require little or no improvement. The following is a brief description of those facilities.

## Kissing Camels Golf Course Irrigation Reservoir

One of the potential temporary storage sites investigated is the existing irrigation reservoir for the Kissing Camels golf course. The use of this facility for storm water detention was previously proposed in the subdivision drainage study for the Office Park at Kissing Camels prepared by G. L. Williams and Partners, Ltd., in 1981. Hydrologic and hydraulic calculations indicate that the existing reservoir can be utilized to attenuate peak runoff rates with only minimal modification and improvement. At present, overflow from the irrigation reservoir is controlled by a manually operated gate. Overflow from the

reservoir is routed through the existing storm sewer system located in the Office Park at Kissing Camels and under Fillmore Street. It is estimated that this existing storm sewer system has a maximum capacity of approximately 75 cfs. Fully developed on-site peak runoff from the office park site is estimated at approximately 36 cfs for the 24 hour, 5 year design storm. Thus, maximum discharge from the irrigation reservoir must be limited to about 39 cfs.

Proposed improvements to the golf course irrigation reservoir and outlet works include an ungated outlet structure capable of maintaining a minimum pool for golf course irrigation with inlets sized to limit the outflow rate to less than 39 cfs during a 100 year design storm. This outlet structure must also provide overflow capability to preclude the possibility of overtopping the adjacent roadway embankment in the event that inlets become plugged or actual storm runoff exceeds design runoff rates. Also, an additional outfall pipeline is required extending from the new outlet structure to the existing 27 inch diameter storm sewer located in the Office Park.

With the addition of these proposed improvements, the existing irrigation reservoir would be acceptable as a detention facility. It is recommended that this facility remain under private control because of its multiple use and its location within private property. The City should, however, obtain rights to reasonable access for purposes of inspection. It is suggested that construction of the improvements proposed herein be made a condition of approval for development of upstream subdivisions.

Fillmore Street Road Embankment

The second site being recommended for utilization as a detention facility is located at the lower end of sub-basin 14. At present, the Fillmore Street road embankment acts as a detention facility in that the existing structure under Fillmore has an estimated capacity of approximately 48 cfs while the peak runoff rate for the 24 hour, 100 year storm is in excess of 470 cfs. Addition of a detention facility at this location will notably decrease downstream peak runoff rates. At the existing Chestnut Street box culvert (design point 31), peak runoff from the 24 hour, 100 year design storm is reduced from approximately 1680 cfs (without detention) to about 1485 cfs (with detention) or about 12 percent. Additional detention proposed downstream of Fillmore Street will further reduce the peak runoff rate at Chestnut Street.

After review of the proposed detention facility north of Fillmore Street, the owner/developer of the upstream properties has proposed that the detention facilities be further expanded in this area to increase capability. The additional detention will permit the regrading of the land area lying west of proposed Centennial Boulevard north of Fillmore Street to drain into the lower portions of basin 14. This will decrease the runoff directed easterly to the facilities beneath Chestnut Street, I-25 and the railroad. The expanded detention will mitigate the impact of the additional tributary area which presently does not drain to this location. The expanded detention will include two additional facilities; one located just downstream from design point 5 on the golf course driving range, and another just downstream from design point 6 at the lower end of sub-basin 7. Based on review of these facilities and input from the developer/owner's representatives, these facilities, identified as

detention structure A, B and C as shown on Exhibit 4, are proposed to have active storage volumes of 22 acre feet, 11 acre feet and 31 acre feet respectively. The inflow to detention structure A will be approximately 325 cfs under the 24 hour, 100-year storm event. It is proposed that the outlet from this structure will provide for overland flow downstream to design point 6. The outlet structure from detention area A should be designed in a fashion to limit the discharge rate to approximately 140 cfs under the design storm condition. The resultant inflow to detention structure B will then be approximately 170 cfs at design point 6.

Detention structure B located just downstream from design point 6, having a volume of 11 acre feet, will have a maximum inflow rate of approximately 212 cfs. The outlet structure should be sized to limit the peak discharge rate to approximately 100 cfs. The developer in this area has proposed that this outlet be piped to detention area C adjacent to the Fillmore Street road embankment.

Detention structure C proposed to be constructed adjacent to the Fillmore Street embankment will be located by the developer of this area to best utilize and reflect land developability and cost. The existing culvert crossing at design point 9 is likely to not be utilized with the detention facility being relocated approximately 500 feet west of design point 9. A new culvert crossing of Fillmore Street will be required at this location. In order to provide the appropriate reduction in peak runoff rates, this discharge structure should be designed and constructed in a fashion to limit the discharge to a maximum of approximately 48 cfs. This is the rate at which the existing culvert at design point 9 could discharge under a maximum headwater condition.

The detention structure volumes and discharge structures at detention areas B and A can be somewhat variable provided the maximum discharge of structure C is limited as outlined above. Drainage structure implementation can be phased to coincide with developed runoff provided control of runoff rates crossing Fillmore Street is maintained. This limitation will be in effect in order to provide for proper attenuation of flows generated by areas not presently tributary to proposed detention structure C.

The developer has proposed to the City of Colorado Springs that detention structures A, B and C be privately maintained. The City of Colorado Springs, Department of Public Works, has agreed with that concept. Because of their impact on downstream facilities, i.e., reduction in required size or required capacity, the cost of construction of these facilities will be reimbursable to the developer against the basin fee.

Main Channel Detention

Several alternatives were reviewed for consideration of detention facilities that would affect the flow rates in the major channels south of Fillmore Street. As outlined above, the major purpose in this consideration was to decrease the improvements necessary to adequately convey design flows through the drainage basin.

A site located along the main drainageway was considered for incorporation of a detention facility. This was located just downstream of the confluence of the main tributary branches near Design Point 15. Location of a detention facility at this site was proposed in order to reduce downstream flow rates through the Sonderman Park area to the extent that the existing natural channel would be

capable of conveying these flows without the addition of channel protection and erosion control improvements.

An analysis of the physical characteristics of the existing drainage channel downstream of the proposed detention site was undertaken to determine a maximum permissible flow velocity which would not result in excessive erosion. As a result of this analysis, a maximum permissible flow velocity of five (5) feet per second (fps) was selected. Based on a velocity of five (5) fps, average natural channel slope of two percent and the existing channel cross-section, an allowable flow rate of 40 cubic feet per second (cfs) was computed.

A preliminary design for the proposed detention facility was prepared assuming a maximum outflow rate of 40 cfs and an inflow rate based on the tributary storm water runoff generated under fully developed conditions for the 24 hour, 100 year storm event. In the hydraulic analysis of this detention facility, it was also assumed that the detention facilities north of Fillmore Street previously discussed would be in operation.

The preliminary design calculations indicate that the proposed facility would need to be sized to impound approximately 134 acre feet (43.7 million gallons) of water. In order to impound this volume of water and minimize the quantity of earthwork and surface area involved, an embankment or dam on the order of 35 to 40 feet high would need to be constructed. Acquisition of at least 15 acres of land would be necessary for construction of this facility.

Under current dam safety statutes, such a facility would come under the jurisdiction of the Colorado Division of Water Resources and therefore would be

subject to the design criteria established by the State Engineer's Office. Since the area downstream of the proposed structure is highly urbanized, failure of the dam could well result in loss of human life. Therefore, this structure would receive a high hazard rating and must be designed in accordance with the applicable criteria. The most significant design requirement would involve the construction of an emergency spillway capable of passing runoff generated by a probable maximum precipitation (PMP) storm event. Peak runoff rates for a PMP storm event are generally on the order of three to four times greater than for a 24 hour, 100 year storm event.

A preliminary cost estimate for this proposed detention facility was prepared based on the analyses and preliminary design work conducted as part of this evaluation. It is estimated that the total project cost for this proposed facility will be approximately $1,500,000. This estimate does not include the cost of land acquisition, which is in keeping with current City policy. Assuming that 15 acres of land would be required at a market value of $1.00 per square foot, the cost of land acquisition would add approximately $650,000 to the total estimated project cost.

Construction of this facility would reduce the need for downstream drainage improvements. Riprap channel protection, concrete control sections and a new concrete box culvert would be required if the detention facility were not constructed. The preliminary project costs for these improvements is estimated at about $860,000. It can be seen that construction of the detention facility at $1.5 to $2.2 million is not cost effective when measured against potential savings of $860,000.

Based on inflow from a 100 year storm event and a design outflow rate not to exceed 40 cfs, it is estimated that it will take in excess of 48 hours for the proposed detention facility to drain and be ready to safely store water from the next storm event. In designing detention facilities along the Front Range, it is accepted engineering practice to require that the facility drain within a period not to exceed about 24 hours. Storm patterns during the summer and early fall often result in high intensity, short duration thunderstorms occurring almost every afternoon or evening. It is therefore highly desirable to limit the storage time of storm water detention facilities to less than 24 hours.

As alternatives to a single on-stream detention facility, the use of multiple on-stream or off-stream detention facilities and the use of onsite detention within each subdivision or development area to detain developed flow were also considered. Consideration of multiple detention areas was also given by the owner/developer in the general area of sub-basins tributary to the east and west branches of the main drainage channel (sub-basins 21-29). It was the owner/developer's desire to minimize the cost of channel improvements which might impact overall development costs and development concepts visualized at this time. Accordingly, the developer proposed a series of off-channel detention areas in the basins tributary to the East Fork channel. These would be better defined as areas tributary to design point 14. The developer proposed six (6) separate detention areas which could be utilized within the site development in this area as parking lot or landscape type facilities. Accordingly, agreement was reached with the City of Colorado Springs, Department of Public Works, that the flow under the 24 hour, 100-year design condition at design point 14 would be limited to 437 cfs as proposed by the developer. This flow rate is less than which may occur under undeveloped

conditions. This may be justified to control channel degradation occurring under existing conditions. The East Fork channel upstream from design point 14 to Fillmore Street will be privately maintained. Any channel improvements proposed will be submitted to the Department of Public Works for record. Any development occurring in these subbasins shall be required to practice storm water detention in a fashion to limit the sub-basin outfall rate to the maximum amount previously mentioned. Any single development occurring within this basin (East Fork channel) must evaluate its drainage impact on a total sub-basin basis.

Sub-basin 28 is also tributary to this design point and lies outside of the influence of the major landowner/developer. Any development occurring in this sub-basin will be treated in a similar fashion. That is, any development will be required to practice storm water control in a fashion such that its discharge rate to the East Fork channel shall not exceed that which occurs under undeveloped conditions. The numbers and capacities of individual detention facilities will be at the developer's option. However, any single development must consider those facilities on a total sub-basin basis, ie., all areas tributary to design point 14.

In keeping with the proposal by the developer/owner, the City of Colorado Springs, Department of Public Works, has agreed that the costs of construction of these detention facilities would be reimbursable due to the impact on downstream flows. Because the exact number and capacities of detention facilities is highly variable and may certainly change as development planning progresses, the assumption has been made that a total of seven (7) facilities having a volume ranging from 2 to 7 acre-feet each would be required within

this sub-basin. Based on this facility size, an embankment or retaining structure which would not be subject to state engineer's criteria and outflow structures having capacities typically less than 50 cfs, a budget amount, developed in conjunction with the owner/developer, of $23,000 has been allocated for each of the seven facilities for a total of $161,000 for detention facilities in the area tributary to design point 14. This is the amount which would be considered to be reimbursable or credited against drainage fees upon development in this area.

Extreme caution must be utilized in the administration of such a detention concept in the sub-basins tributary to design point 14. Based on the experience of other drainage regulatory authorities, the use of multiple detention facilities may have limited effect on the attenuation of peak flows if an overall sub-basin approach is not utilized throughout all planning, design and construction. Although individual facilities will typically attenuate peak flows, the time sequence of their discharge becomes simultaneous where natural runoff may stagger peak flows with time. It is expected that such administration should be relatively straight forward in this particular sub-basin because virtually all tributary area is under one ownership. It should be reiterated that this design concept was proposed by the land developer in this area and will be a condition tied to the land as various projects are developed in this area. The use of multiple detention facilities is not deemed to be in the best interest of long term public operation and maintenance because of the significantly higher cost for maintenance of several smaller facilities. The use of off-channel detention facilities of the type proposed minimizes the need for major spillway requirements as would be the case of a single on-stream detention facility.

One major concern expressed by City departments in review of the draft plan for the Mesa Drainage Basin was to maintain the area through Sonderman Park in a natural condition. As indicated above, it appears as if a maximum flow rate in the channel of 40 cfs would be necessary to maintain the existing channel conditions. After review of the City's Subdivision Drainage Ordinance, consideration of major open space, i.e. Sonderman Park, has been deleted from the basin fee calculations.

Detention has also been proposed on the West Fork channel where subbasins tributary to design point 27 are located. Complete channel improvements were initially proposed by the consultant to the City of Colorado Springs for this drainage study. After review by the land developer in this area and various City departments, it was agreed that a combination of detention and natural channel treatment would be incorporated into the proposed improvements in this portion of the basin. A storm water detention facility is proposed to be located just downstream from design points 21 and 26, at the upstream end of Sub-basin 25.

A detention facility was also considered on the north side of Fillmore Street just upstream from Structure No. 8. The Fillmore Street embankment would be the retaining structure with Structure No. 8 being adjusted to function as a controlled outlet. After review of this proposal, this area was eliminated from further consideration due to its potential impact on foundation stability of the nearby school building, the nuisance potential being near the school and the potential impact on a sewage pump station located in or adjacent to the proposed detention area.

At this point in the study it is interesting to note that the consultant's evaluation of the upper areas of the Mesa Basin which exhibit natural ground cover of sparse native grasses, Yucca plants and limited natural shrub growing on relatively coarse grained soils, appear to have a relatively high runoff potential. The development in the Kissing Camels Estates area which consists of golf course development with turf grasses, relatively flat grades and large single family lots with extensive turf grass development has resulted in a slight reduction in runoff producing potential after development. For all practical purposes the runoff produced by developed conditions is virtually the same as that produced under undeveloped conditions in the Kissing Camels Estates area.

Under the above described conditions, there is little advantage to developing detention facilities for purposes of reducing developed flows to undeveloped rates. Obviously the natural channels have experienced a significant degree of erosion under the existing conditions which appear to be slightly less than that which would exist under undeveloped conditions. Accordingly, if the downstream channels are to receive minimal treatment, a reduction below undeveloped flow rates must be considered. Such is the case with the proposed detention facility on the West Fork of the main channel.

The owner/developer in this area has proposed that the detention facilities in this area have a discharge rate of approximately 300 cfs. This would require that the detention facility reduce the peak flow rate at the above described location by approximately 200 cfs. It is very difficult to determine the extent of channel improvements necessary to mitigate additional erosion and channel degradation in the existing channel under a peak flow rate of 300 cfs. As

described above, it appears as if a flow rate of less than 40 cfs would be necessary to maintain the existing natural channel. Based on this assumption, the City of Colorado Springs, Department of Public Works, has agreed upon the proposal of the owner/developer in this area that only channel "hot spots" will be considered for any specific structural treatment. That structural treatment will consist of riprap erosion protection (bedding coarse, filter fabric and rock wearing surface), grade control structures and maintenance access facilities. Particular attention must be given to bends in the natural channel or flow against the outside of a curve or bend will have a tendency to accelerate erosion and undercut existing channel sidewalls. In addition, at locations where significant down cutting of the natural channel could occur, grade control structures should be installed. These grade control structures may consist of an impervious barrier such as concrete or grouted riprap.

Because of the impact on downstream facilities, it has been suggested that the detention facility located at the upstream limit of Sub-basin 25 be considered a public facility and maintained by the City of Colorado Springs. In addition, the channel downstream from this facility to design point 27 will be considered a public channel and maintained by the City of Colorado Springs. The design and construction of the channel treatments will be subject to review by the City of Colorado Springs, Department of Public Works.

As outlined above, it has been somewhat arbitrarily determined to set the maximum outflow rate from this detention structure located at the upstream edge of Sub-basin 25 at 300 cfs. An appropriate outlet structure shall be designed to limit the outflow rate under the 24 hour, 100-year runoff event. Based on the projected inflows, it appears as if this detention facility should have a

minimum active volume of 7.1 acre feet. The major land owner in this area has made available a preliminary topographic representation of the proposed detention facility. Based on a proposed grading plan, it appears that a facility constructed with an embankment exempt from State of Colorado review is possible at this location. In order to construct such a facility, earthwork on the order of 35,000 cubic yards (CY) will be necessary. This master plan is based on a facility not subject to review and approval by the Colorado Division of Water Resources and thus the flood spillway is not subject to State criteria. The spillway should be established for the 24 hour, 100 year runoff as a minimum should the outlet works be inoperable.

Detention North of Fillmore Street

A significant portion of the area lying north of Fillmore Street, east of Centennial Boulevard and west of Chestnut Street is also under control of a single owner/developer. This area, presently used as an industrial site, is quite suitable for development and presently master planned for an office park concept. Its views of the front range as well as the Colorado Springs metropolitan area are a significant amenity to this site.

The owner/developer has proposed to the City of Colorado Springs that detention would be practiced within the development of this land also. The City of Colorado Springs has agreed to entertain a detention concept; however, any detention facility that would be considered must be designed and constructed to properly handle runoff from both the 24 hour, 100-year and 5-year precipitation event. Based on the topography in this area, it is likely that this detention will be limited in its application. However, based on

agreement with this owner/developer it will be considered as part of the basin facilities in this Master Plan. A combination of parking lot and water feature storage may be incorporated.

The basic concept to be implemented will be one of storm water management with limited improvements to existing downstream structures while initially permitting limited development to proceed without major capital expenditures. Storm water detention utilizing parking lot and other on-site features will control the five year precipitation event. Runoff will be maintained equal to or less than the capacity of downstream facilities. Detention area L will be constructed to receive the runoff which exceeds that resulting from the five year storm. The release rate from this detention area will be limited to the rate of runoff which would not exceed the capacity of the upgraded storm sewer under Interstate Highway No. 25 as described below.

Downstream facilities to convey runoff from detention area L to Chestnut Street will be required at the time of development. In addition, improvements to the forty-eight (48) inch diameter storm sewer system which presently exists beneath Interstate Highway No. 25 will be required. That storm sewer system will be extended as shown on Exhibit 4 to accept runoff of approximately 105 cubic feet per second.

When the proposed seventy-two (72) inch diameter outfall storm sewer, shown on Exhibit 4, is constructed, detention area L will be removed and the land area reclaimed for development. Because detention area L is temporary, it is not part of the drainage basin fee calculation. A combination of the forty-eight (48) inch storm sewer system and the new 72 inch pipe will convey the full

developed runoff rate of 604 cfs. Required facilities will include a concrete lined channel and culverts between the existing and proposed Chestnut Street locations.

Just as this study was being published, a consultant retained by the City of Colorado Spring presented a preliminary realignment of Chestnut Street westerly of the Palmer House/Armory facilities. This new roadway construction will provide an excellent opportunity for incorporation of adequately sized drainage facilities. These drainage facilities should not only accommodate the major drainage crossing of this area, but also should incorporate drainage of the roadway section itself and overland flow to the roadway. A storm sewer in the new Chestnut Street section will be provided. We recommend that roadway drainage facilities be designed that will maintain specified driving lanes free of runoff under the 100 year storm event.

## Detention Facility Criteria

Special care must be taken in regard to the planning and design of detention facilities because of the potential for great damage which could occur should an embankment fail during the runoff period. Discussions with the Colorado Division of Water Resources indicate that, under their interpretation of House Bill 1052, the temporary storm water runoff storage facilities recommended in this report are not considered under the jurisdiction of the State Engineer and therefore are not subject to the design criteria of the Division of Water Resources. While not under State jurisdiction, it is strongly recommended that detention facilities planned within the Mesa Basin be analyzed and designed in