FOUNTAIN CREEK DRAINAGE BASIN
PLANNING STUDY

VOLUME I

Prepared For:

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TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME I

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME I
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME I
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME I
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME I
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

LIST OF TABLES

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

LIST OF TABLES
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

LIST OF TABLES
(Continued)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

LIST OF FIGURES

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

TECHNICAL APPENDICES

(Information in the appendices may be found separately in the volumes as referenced in the text)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME II
OVERSIZE FIGURES
(Separate Document)

DRAWING INDEX

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME III
SUPPORTING INFORMATION/TECHNICAL ADDENDUM
(Separate Document)

TABLE OF CONTENTS
FOUNTAIN CREEK DRAINAGE BASIN PLANNING STUDY

VOLUME III
SUPPORTING INFORMATION/TECHNICAL ADDENDUM
(Continued)

1.0 EXECUTIVE SUMMARY

1.1 GENERAL

The purpose of the Fountain Creek Drainage Basin Planning Study was to develop a stormwater management plan for and inventory of the environmental, biological, botanical, wildlife, aquatic and cultural resources along the study reach of the Fountain Creek corridor, to prepare an inventory of drainage facilities, and to assess problems related to flood capacity, stream stability, and habitat quality. The study formulated alternative plans to address problems and enhance resources and developed a recommended plan to guide future activities and improvements along the Creek.

This Drainage Basin Planning Study covers 7½ miles of Fountain Creek lying within the City limits between the County Detention Center and Manitou Springs. The study began in the summer of 1991 with data gathering and resource inventories. The existing and future conditions flood hydrology/hydraulics was completed in early 1992 as preparation for defining conceptual improvement alternatives. Simultaneously, ecological, environmental, cultural, drainage facility, geomorphologic, historic and related corridor characteristics were inventoried in order to establish opportunities and constraints related to prospective corridor improvement options.

1.2 OPPORTUNITIES AND CONSTRAINTS

Major opportunities which were identified included several riparian and wetland areas deserving of preservation/enhancement, recreation and aesthetic enhancement possibilities, alternative mode transportation routes, and urban redevelopment/stream development combinations. Major constraints which were identified included severe stream gradient degradation at several locations; extensive riparian area waste dumping/abuse; extensive channel relocation and floodplain encroachment, particularly upstream of the confluence with Monument Creek; precariously positioned infrastructure; the location of a number of industrial, commercial and residential properties in the floodplain; several structures/features with restrictive hydraulic characteristics; and the mobile/dynamic nature of the Creek. Fountain Creek was divided into eight planning reaches based largely upon their location, their physical characteristics and for consistency with the initially anticipated rehabilitation alternatives.

1.3 ALTERNATIVE DRAINAGE PLANS

Conceptually feasible alternatives were identified for each reach based upon the 1990 Stormwater Management Workshop and this project's "Goals and Objectives" which were developed in conjunction with the Study Group. The City/Consultants Team and the Study Group refined the full range of alternative concepts into a workable number which reasonably represented the range of options available. This resulted in from two to five

alternatives being considered for each reach including "no-action" as alternative 1 in each. While obtaining consistency between reaches was an important criteria, each reach is unique and no single alternative other than "no-action" is common to all reaches. An interesting aspect of the alternatives configuration was that no clear consensus was reached on the level of flood protection necessary and consequently it varies from reach to reach and within alternatives, with a general guideline of the 100-year event being utilized. Examples of improvement alternatives included natural channel restoration, rehabilitative maintenance of existing features, hardline channelization, levees, floodproofing/flood warning and natural channel restoration with ecological enhancement. Each alternative was conceptually designed and its costs estimated. All were reviewed against a common set of qualitative, quantitative, and financial evaluation criteria, based largely upon the considerations which were earlier used to configure the alternatives, and a preferred alternative for each reach was decided upon. The entire process of developing a selected plan included extensive coordination with representatives of the public through six Study Group meetings, a public meeting, a series of meetings with a hydrology review committee, two newsletters, extensive coordination with the City and continuous cooperation with the consultant teams performing the companion Monument Creek DBPS and Pikes Peak Greenway Master Plan.

1.4 PRELIMINARY PLAN

The selected preferred alternatives were developed into a preliminary plan which follows generally a "natural creek" theme and are described as follows, moving from downstream to upstream per individual study reach: F1 -stabilized "natural" channel with ecological enhancement, F2 - stabilized "natural" channel and floodproofing, F3 - stabilized "natural" channel and floodproofing, F4 - stabilized "natural" channel with ecological enhancement, F5 - stabilized "natural" channel, F6 - stabilized "natural" channel, F7 - stabilized "natural" channel and F8 - structural sides with softlined channel bottom. The use of "riffle drops" and enhanced riparian vegetation is recommended for the stabilized "natural" reaches.

The cost for the plan based on October, 1992 (ENR Construction Cost Index 5052) dollars is approximately $21.7 million. Implementation will occur in accordance with a financing plan and a schedule of prioritized actions which remains to be developed jointly with that for Monument Creek and the tributary basins.

There are several important components of the plan which should be implemented as soon as enabling actions are taken. These include:

1. Proactive acquisition and use conversion of high risk land parcels as they become available on the market.

2. Discourage development/redevelopment of land parcels which by their size, physical characteristics or position in the proximity to the Creek would require extraordinary means and/or major unplanned waterway impact to render them economically developable.

3. Emphasis on aggressive enforcement of existing regulations and implementation of new or stronger regulations to prevent further deterioration of the channel and floodplain environment.

4. Enhance the public education/action program to create an awareness of the importance of the Creek and the watershed as natural community assets and a source of pride. Public involvement programs such as "adopt-a-stream" and community celebrations like races or markets help change the image of the Creek from a refuse depository to an asset.

Plan and profile drawings of the preliminary plan were prepared at a scale of 1-inch equals 200-feet. The preliminary plan generally consists of the following elements:

- A series of sloping boulder riffle drops for grade control, protection of infrastructure, and other benefits
- Rehabilitation of steep eroding channel banks through earthwork, vegetation and rock stabilization techniques
- Confluence reconstruction of tributary stream and storm sewer outlets
- Repair of undermined riprap or gabion slope protection structures
- Planting of screening vegetation to soften the appearance of existing concrete or rock bank protection

Probable construction costs for the plan total $20.1 million, exclusive of right-of-way acquisition, engineering, permitting, and administrative costs. The actual costs of the plan will be less if all of the improvements are not built. For example, if actual degradation of the creek is less than the amount planned for in this study, fewer riffle drops would be required. The actual costs of the plan will depend on a variety of other factors, including the schedule of plan implementation, the final project design and scope, and the actual labor and materials costs at the time of construction.

2.0 INTRODUCTION

2.1 STUDY OVERVIEW

Muller Engineering Company, Inc. was authorized by the City of Colorado Springs in Contract No. 91C-2462, dated October 29, 1991 to prepare this Drainage Basin Planning Study (DBPS) of Fountain Creek.

This report is organized in three volumes:

- **Volume I** summarizes the methods, results, and conclusions of the Fountain Creek DBPS. Volume I summarizes essential study elements and findings.

- **Volume II** consists of the oversize drawings (53 sheets). The drawings depict stream corridor resources, floodplain boundaries, stream improvement alternatives, and the preliminary plan of selected stream improvements.

- **Volume III** contains appendices, consisting of the technical information that provided the basis for Volume I. Volume III identifies parties who participated in the public involvement process and the corridor goals and objectives, presents the present value analysis for the alternatives evaluated, and shows the hydrologic and hydraulic model results. In addition, Volume III contains the Drainage Facility Inventory (December 1992) and the Fountain Creek Hydrology Report (May 1992).

This project and two other associated projects were directed by the City of Colorado Springs and guided by "The City of Colorado Springs/El Paso County Drainage Criteria Manual" (Colorado Springs 1987).

2.2 RELATED STUDIES

The Fountain Creek DBPS was intentionally performed concurrently with the following two other studies which together comprehensively provide planning of the two dominant drainageways in the City.

1. Monument Creek Drainage Basin Planning Study. This companion study is being prepared by another consultant for the City Engineering Division of the Planning, Development, and Finance Department and has the same purpose and scope as the Fountain Creek DPBS. The study reach along Monument Creek extends from the Fountain/Monument Creeks confluence at Cimmaron Street upstream to the north edge of the Colorado Springs City limit at the south boundary of the U.S. Air Force Academy. The drainage area at the confluence is 240 square miles and the study reach covers approximately 10 miles of the Creek upstream of the confluence. Continuous coordination was maintained between the Fountain and Monument Creek DBPS's in order to maintain consistency between the studies. This included utilization of the same design storm and input of the resulting Monument Creek hydrographs into the Fountain Creek model.

2. Pikes Peak Greenway Corridor Plan. This study is being prepared by another consultant for the Comprehensive Planning Division of the Planning, Development, and Finance Department and is closely linked to the Fountain Creek and Monument Creek DBPS's. The purpose of the project is to develop a Master Plan for the Fountain Creek/Monument Creek/I-25 Corridor through central Colorado Springs which offers:

   - An urban corridor vision
   - Planning goals and objectives for the future character of the corridor
   - A multi-objective greenway design theme
   - Specific recommendations including a master site plan

   The study is to interrelate drainageway management, expansion of I-25, central city development, flood control, and water quality engineering objectives with preservation and enhancement of the corridor's assets as a major aesthetic, recreational and wildlife habitat amenity. Finally, the study is to initiate an ongoing marketing and implementation process that ultimately results in realization of the plan's vision, goals, objectives, and recommendations.

   The design teams for the Fountain Creek DBPS, the Monument Creek DBPS, and the Pikes Peak Greenway Corridor Plan have worked closely together and have actively participated in joint working meetings and public meetings in order to maintain a high level of teamwork and coordination in preparing the alternative stream improvement plans.

2.3 PUBLIC INVOLVEMENT

A public involvement program was included as an important element of this study. All three previously highlighted projects were part of the same simultaneously conducted public involvement program. The purpose of the public involvement program was to generate interest in the study, provide a forum for acquiring and sharing information and to stimulate active agency and public participation during the entire duration of the study.

Participants in one or more aspects of public involvement are listed below:

(1) State and Federal Agencies: Colorado Department of Transportation (CDOT), U.S. Army Corps of Engineers (USACOE), U.S. Geological Survey (USGS), Federal Emergency Management Agency (FEMA), Soil Conservation Services (SCS), U.S. Fish and Wildlife (USFW), Colorado Division of Wildlife (CDOW) and Environmental Protection Agency (EPA).

(2) Political Jurisdictions: City of Colorado Springs and El Paso County.

(3) Other organizations with specific interest in the study: Springs Area Beautiful Association, Pike's Peak Trails Coalition, League of Women Voters, Homeowners Associations, Private Consultants, Home Builders Association, Partnership for Community Design (Project 2000), the Palmer Foundation, the I-25 Greenway Advisory Committee, private individuals, resource groups, and other public interest groups who have pertinent knowledge or interest in the study.

The Letter of Permission (LOP) process, a program by the USACOE to provide early consideration of Section 404 permit issues, was initially an integral part of the study. This process is conducted in cooperation with local governments and includes significant public involvement. After proceeding with the LOP process for the first 20 months of the study, the USACOE indicated that limitations in their staffing resources precluded continuation of the LOP process and it was suspended. This suspension applied to this study, the Monument Creek study and several other basin studies which were in process.

The public involvement program included developing a project mailing list (Refer to Volume III), distributing periodic mailings which included two project newsletters (Refer to Volume III) and meeting announcements, holding regular meetings of the Monument/Fountain Creek Study Group, holding regular meetings of the Technical Hydrology Review Committee (Refer to Volume III), an initial public meeting, a second public meeting to receive input to the alternatives and the recommended plan, and news media audio-visual and written coverage.

2.4 PROJECT TEAM

The Fountain Creek DBPS is a comprehensive study and required the involvement of experts in a variety of fields. Their individual contributions are composited together in this three volume narrative and supporting documentation. The two associated projects required similar multi-disciplined teams. The composition of the three consultant teams is described as follows:

- Fountain Creek DBPS
  - Muller Engineering Company (Manager and Lead Engineer)
  - Aquatic and Wetland Consultants (Ecological)
  - Thomas and Thomas (Cultural/Land Use)
  - Obering, Wurth and Associates (Surveying and Data Gathering)
  - CTL Thompson (Geomorphology)

- Monument Creek DBPS
  - CH2M Hill (Manager and Lead Engineer)
  - Kiowa Engineering (Hydrology and Hydraulics Engineering)
  - Thomas and Thomas (Resource Inventories)
  - Urban Edges (Multi-Objective Planning)

- Pikes Peak Greenway Corridor Plan
  - Urban Edges (Lead Planner)
  - Thomas and Thomas (Support Planner)
  - Erik Olgierson (Environmental)

The direction and participation of the Two City Project Managers was integral to the success of all three projects. The City's Project Manager for both the Fountain Creek DBPS and the Monument Creek DBPS was Mr. Ken Sampley, P.E., Civil Engineer Supervisor with the City Engineering Division. The City's Project Manager for the Pikes Peak Greenway Corridor Plan was Mr. Craig Blewitt, Senior Planner with the Comprehensive Planning Division.

2.5 PURPOSE

The purpose of this investigation is to develop a stormwater management plan along Fountain Creek, to inventory wildlife and botanical resources as well as cultural resources, and to assess problems related to flood conveyance, stream stability and habitat quality. The information contained in this report is intended for use in developing guidelines for future development and future drainageway improvement projects along with providing the required information for the analysis of current drainage management procedures.

This study will provide an evaluation of the Fountain Creek basin physical geography, environment, culture, geomorphology, hydrology and floodplain hydraulics, which will be used as the basis for the determination of the alternative flood control drainage plans discussed in Section 6. A selected plan of stream improvements was refined into a preliminary plan which is presented in Section 7. The investigation considered multiple objectives in the development of the selected plan of improvements, including flood hazard reduction, stream stabilization, enhancement of environmental resources, and the development of a greenbelt featuring parks, open space, and trail systems.

2.6 SCOPE OF WORK

The Scope of Work for the study evaluation included the following tasks:

1. Meetings with the City of Colorado Springs (Client) to:

    a. Insure compliance with the Scope of Services required under this contract;

    b. Obtain data and other information from the City or other parties;

    c. Obtain and discuss input from the City and other agencies and determine the course of action for the DBPS;

    d. Procure information on drainage problems and right-of-way limitations;

    e. Utilize information available from the City and other agencies/parties;

    f. Present findings of study work items and obtain input from the City and other interested agencies and parties.

2. Coordination with various City departments which have an interest or information pertinent to the study area and study process.

3. Incorporate a public input and information process with input/review from local governments, individuals, and other agencies who have an interest in the study area.

4. Coordination of activities with other consultants completing public study evaluations in the study area.

5. Attending Letter of Permission (LOP), public and Board/Council coordination meetings.

6. Collection of data and information existing in the files of the City, County, and other public agencies which would have an impact on this study. These materials would be obtained when available, reviewed for applicability to this study, incorporated where appropriate and filed for later reference.

7. Utilization of the City's Facilities Information Management System (FIMS) mapping, U.S.G.S. quadrangle maps and commercially available aerial photographs of the study area to prepare base maps for the study.

8. Conducting a drainage facility inventory through the study corridor to update previous inventories.

9. Compilation of available information existing on environmental and open space/park resources within the study corridor.

10. Performing a hydrologic analysis that included the determination of the 10-year and 100-year recurrence interval flood hydrographs for current conditions of development and flood control as well as for future conditions of development and flood control.

11. Preparation of a hydraulic analysis to identify existing flooding problems and flood hazards within the study area and to delineate the 100-year floodplain in the study reach.

12. Identification of conceptual alternative improvement scenarios and evaluation of the pros and cons of an initial list of conceptual alternative drainage plans.

13. Conduct a detailed, evaluation of the four to five alternatives selected for further consideration utilizing both qualitative and quantitative criteria. Recommend a preferred alternative plan with input from the City, County, public and resource agencies.

14. Prepare preliminary design drawings of the selected plan.

15. Develop opinions of probable cost for the selected plan and address financing and implementation issues.

16. Preparation of a preliminary draft report of the DBPS for the City's review.

17. Preparation of final DBPS report for the City and obtaining approval and adoption of the study.

2.7 BACKGROUND INFORMATION

Two Floodplain information reports of Fountain Creek have been prepared by the Department of the Army, Albuquerque District, Corps of Engineers, Albuquerque, New Mexico. The reports provided information on the flood hazard areas that adjoin Fountain Creek and delineated the flood plains. The first report, Flood Plain Information for Fountain and Jimmy Camp Creeks, (USACOE 1973) encompassed 29.8 miles of Fountain Creek, extending south from the mouth of Monument Creek, through the town of Fountain, to the southern El Paso County line. The second report, Flood Plain Information for Fountain Creek, (USACOE 1974) covered the study area that extends along Fountain Creek from the confluence with Monument Creek to the westerly city limits of Manitou Springs. Both reports revealed there have been several past floods, of various magnitudes, that have inundated and inflicted damage in the Fountain Creek corridor. The reports, in their delineations of the standard and intermediate regional flood plains, illustrated that portions of the residential, commercial, and public property and activity along the Fountain Creek corridor were subject to significant property damage and possible loss of life due to flooding.

In 1990, the Federal Emergency Management Agency prepared a revised Flood Insurance Study (FEMA 1990) for the City of Colorado Springs. The study investigated the existence and severity of flood hazards of Fountain and Monument Creeks, along with other drainageways, in the City of Colorado Springs. This study was prepared to aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. The hydrologic and hydraulic analyses for this study were also performed by the USACOE, Albuquerque District, along with the two consulting engineers, Camp Dresser McKee, Inc., and KKBNA Inc.

Individual smaller drainage basins within the Fountain Creek watershed have been the subject of previous hydrologic analysis. Fishers Canyon basin was studied by Muller Engineering Company, Inc. (Muller Engineering 1991), for El Paso County. Lincoln DeVore completed a study of the Southwest Area Drainage Basin (Lincoln DeVore 1984) for the City of Colorado Springs and a study for the Columbia Road Drainage Basin (Lincoln DeVore 1978). In 1977, R. Keith Hook and Associates completed a study of the South 21st Street Basin (R. Keith Hook 1977). Weiss Consulting Engineers, Inc. completed a basin study on Black Canyon (Weiss 1980). United Western Engineers completed a study of the West Side Drainage Basins for the City (United Engineers 1975). Most recently, Bear Creek Drainage Basin was studied by Kiowa Engineering Corporation (Kiowa Engineering 1991) 1991). Basin information from the previous studies was checked for reasonableness and, where appropriate, was used in the current hydrologic and hydraulic analyses. Using existing information avoided unnecessary differences in basin modelling and facilitated the comparison of the model results.

3.0 FOUNTAIN CREEK AND BASIN RESOURCE CHARACTERISTICS

3.1 STUDY AREA LOCATION

For hydrologic purposes, the study area includes the total drainage basin above the downstream study limit, including the Monument Creek drainage basin area. The Fountain Creek drainage basin upstream of the confluence encompasses an area of approximately 120 square miles and at the downstream study limits the drainage basin encompasses approximately 420 square miles incorporating both Fountain and Monument Creek drainage basins. The entire drainage basin is shown on the Vicinity Map (Figure 3.1-1).

The alternative concepts for drainageways along Fountain Creek were investigated for that section of Fountain Creek lying within the incorporated southwest area of Colorado Springs, El Paso County, Colorado. The stream corridor which is the subject of this evaluation extends approximately 7.3 miles from a point 3,500 feet downstream of Circle Drive, upstream to and beyond the confluence with Monument Creek to approximately 33rd Street (westerly City limits).

3.2 GEOGRAPHY

Physiography

The physiography of the Fountain Creek watershed to the west of the Monument and Fountain Creek confluence is characterized by mountain ranges and river valleys. To the east of the confluence, the physiography of the watershed is characterized by gentle sloping plains. This sudden contrast from mountains to plains is regionally a unique geographic position along the Colorado Front Range. Elevations in the Fountain Creek watershed range from 14,110 feet at Pikes Peak to 5,948 feet at the confluence with Monument Creek to 5,800 feet at the downstream study boundary. The drastic changes in elevations from the high points in the watershed to the outskirts of Colorado Springs are covered over relatively short distances. Hydrologically, this physiographical setting creates very variable flooding situations.

Fountain Creek is a perennial stream that originates in Teller County, near the town of Woodland Park. Fountain Creek's source is from the mountains of the Rampart Range, approximately seven miles northwest of Pikes Peak. The headwaters are fed from snowmelt, rainfall and springs. Fountain Creek flows in a southeasterly direction through a narrow, steep-walled canyon for about 22 miles before joining Monument Creek in west Colorado Springs at the junction of U.S. 24 (Midland Expressway) and I-25. The canyon is straight and well drained with ground cover including aspen, spruce, and pine trees. The transition through the foothills area varies from rough sharp-crested ridge formations to gently sloping, narrow-topped mesas covered with cedar, oak, pine and pinon trees. The stream emerges on the high plains near the upstream boundary of the study reach in Colorado Springs.

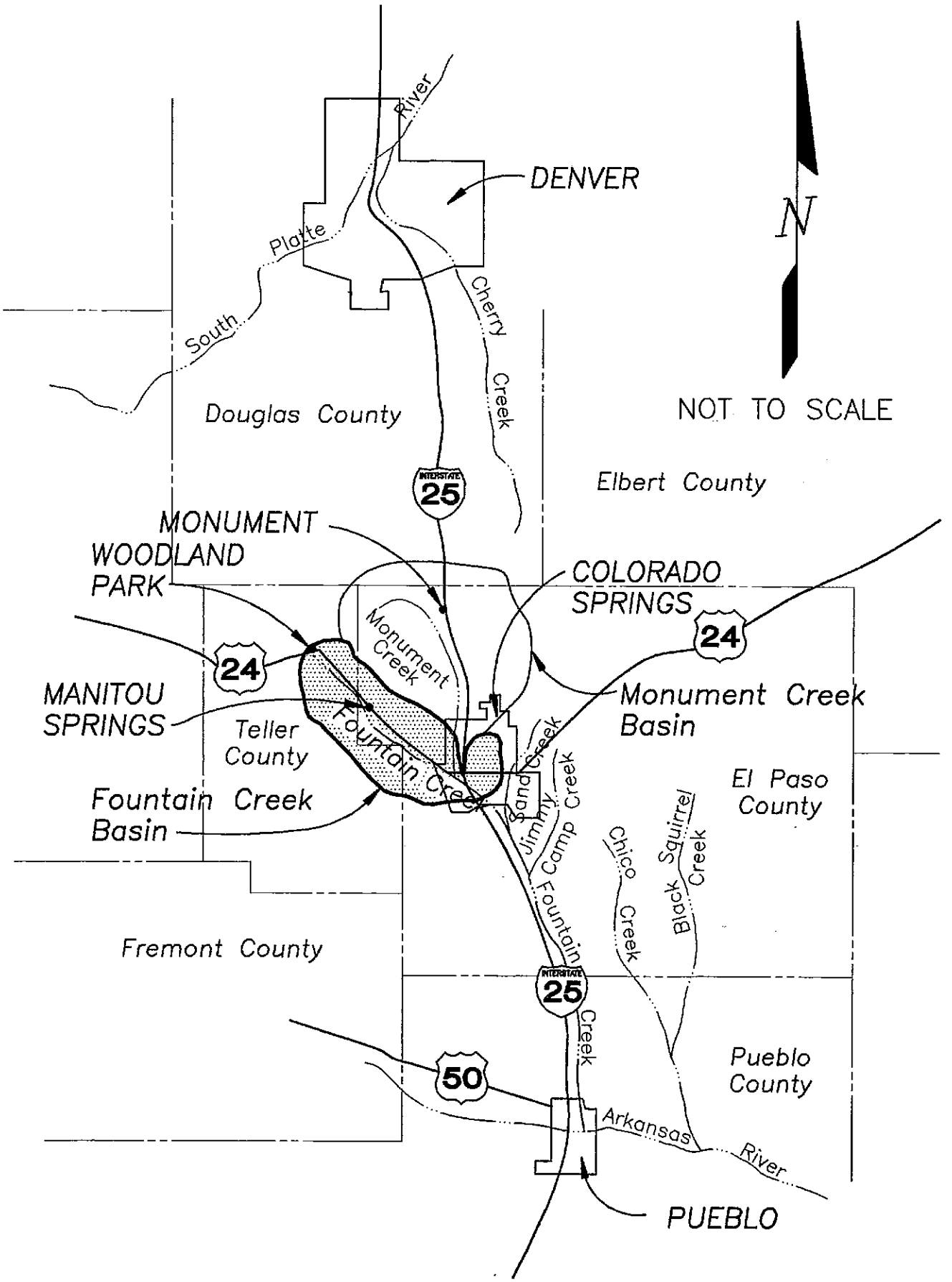

FIGURE 3.1–1
Vicinity Map

CS–VMAP 10/25/93

In the study reach above the Monument and Fountain Creek confluence, the valley width averages about 400 feet with a stream bed slope average of approximately 90 feet per mile. Along the reach in the Manitou Springs area the channel is severely constricted by bridges and building foundations with the channel varying in width from 12 to 50 feet and an estimated average channel capacity of 2,000 cfs. In the study reach downstream of the confluence, the average stream bed slope is approximately 63 feet per mile. The channel in this reach varies in width from 80 to 130 feet and has an estimated average capacity of 8,000 cfs.

The Fountain Creek streambed is composed mostly of some bedrock, some weathered bedrock, mostly sand, and smaller amounts of rock and boulders. Vegetation densities within the channel and on the overbanks vary throughout the study reach from sparse to heavily vegetated regions. Fountain Creek is an alluvial, mobile bed stream which is, hydraulically, subject to fluctuations between aggradation and degradation from reach to reach in the stream corridor. Its upper reaches have a limited tendency to armor.

Agricultural water rights on Fountain Creek are continually being converted to municipal and industrial uses. Irrigation is essentially non-existent along the stream corridor due to the dense development in the area. Only two active diversion structures exist within or near the stream corridor; one is for municipal water supply purposes and the second is for irrigation. The municipal water supply diversion structure is owned by the City of Colorado Springs and is located just upstream of the upstream boundary of the stream corridor. The irrigation diversion structure is owned by the Fountain Mutual Irrigation Company and is located adjacent to the Colorado Springs wastewater treatment facility at the downstream end of the stream corridor.

Several utilities cross Fountain Creek along the stream corridor. Water, wastewater, gas, and electric facilities were researched from the Colorado Springs Department of Utilities records, and this information is available as reference documents for this study. Also researched in this study were the jurisdictional dams within the Fountain Creek watershed. Approximately thirty dams were identified from State records; five of these dams are controlled by the Colorado Springs Water Department. This supporting information is part of Volume III.

Urban development continues to grow throughout Colorado Springs and along the stream corridor. The development of Manitou Springs, Colorado City and Colorado Springs had a dramatic impact on Fountain Creek. Channel realignment for railroad and highway development, mining, utilities construction and land development resulted in such significant changes to Fountain Creek that it bears little resemblance to its "natural" condition. Solid waste and other urban refuse, floodplain filling and intense development of its riparian area have degraded the streams ecologic, aesthetic and recreational value, and the Creek primarily functions as an urban drainageway.

Climate

Within the watershed, precipitation and temperature vary considerably due to altitude differences and wind patterns. Annual precipitation normals within the watershed vary from 24.27 inches at Lake Moraine to 13.19 inches at Colorado

Springs, with most of the rainfall occurring between the period of May through August when the temperature contrast between surface air and upper air is the greatest. At Lake Moraine, the mean annual maximum and minimum temperatures are 47.1 and 24.3 degrees, respectively. At Colorado Springs, the mean annual maximum and minimum temperatures are 62.7 and 35 degrees, respectively. The main source of precipitation along the Front Range is late winter snow influenced by southeasterly winds on up-slopes, spring rain and from summer thunderstorms. At high elevations above 9,000 feet, runoff is dominated by snowmelt characterized by flat low peaked hydrographs. In the eastern plains, below 6,000 feet, runoff is dominated by summer thunderstorms characterized by sharp high peaked hydrographs. This results in a complex meteorologic region in the Front Range foothills between 6,000 and 9,000 feet. The abrupt transition of the gently rolling nature of the high plains area to the multiple, irregular valleys with large variations in elevation at the foothills presents a dramatic orographic impact on meteorologic events. Pikes Peak produces a "rain shadow" effect that causes a semi-arid zone to the east. Further discussion of rainfall as it pertains to storm runoff is described in the hydrology section.

3.3 ENVIRONMENTAL

Introduction and Background

As an integral part of this DBPS, a wetland and riparian resource inventory and assessment has been undertaken to identify existing natural resource characteristics of the Fountain Creek corridor. The inventory and associated mapping have been compiled to locate and describe the following generalized elements: (1) the type and extent of aquatic and riparian habitat, (2) vegetation, wildlife and aquatic life types, (3) channel and bank conditions, and (4) jurisdictional wetlands.

This natural resource assessment is to be used in conjunction with the other analyses to generate appropriate improvement alternatives based upon a comprehensive evaluation of all project factors. The resource evaluation attempts to identify specific significant features that are critical to maintaining a stable ecology within the corridor and providing a particular benefit or function.

The inventory area covers approximately 7.3 miles along the Fountain Creek corridor within the Colorado Springs city limits. The site inventory is limited to the area within 500 feet on either side of the creek centerline upstream of the confluence of Monument and Fountain creeks and 1000 feet from the centerline downstream of the confluence.

The general character and condition of the corridor reflects the long-term urban use of the surrounding area; this is especially true in the reach upstream of the confluence of Fountain and Monument creeks where profound degradation has occurred. This upstream segment reveals an urbanized and channelized character that remains relatively constant throughout the reach. Similarly, the downstream reach also exhibits a particular character throughout, but with qualities that are quite different from the upper reach. Therefore, for descriptive purposes, the two segments of the creek are often referred to, throughout this resource narrative, as unified upstream and downstream reaches.

The goal of the study is to identify and pursue improvement alternatives that will address critical drainage and flood control concerns while preserving and enhancing natural riparian habitat features. The inventory identifies existing resources within the corridor, anticipates potential impacts that could result from several possible improvement alternatives, and recommends wetland protection and habitat enhancement strategies. Initially, a parallel objective in having environmental resource evaluations as a part of the project was to satisfy the needs of the USACOE LOP process. As was described earlier in this text, this process was suspended by the USACOE because of their internal staffing resource limitations.

Many of the improvement recommendations resulting from the overall drainage basin study will be subject to regulatory requirements and federal agency review procedures established to protect wetland and riparian resources. These regulatory criteria will be important in directing and influencing the ultimate decisions regarding corridor improvements. It is, therefore, in the interest of a successful planning initiative that an inventory and assessment of potentially critical resource areas, including an advance identification of jurisdictional wetland areas, has been included as an integral part of the study. This will enable identification of and planning for potential adverse impacts prior to finalizing design decisions and prior to submitting plans for agency review.

Protection of wetlands has become a critical national concern since the enactment of the Federal Clean Water Act, Section 404 permit program in 1977. The Section 404 permitting process regulated all discharges of dredged or fill material into the waters of the United States, including streams, lakes and wetlands. The permit program is jointly administered and enforced by the U.S. Department of the Army Corps of Engineers (USACOE) and the U.S. Environmental Protection Agency. It has been determined that placement of fill in aquatic ecosystems constitutes a direct adverse environmental impact. Indirect and cumulative environmental impacts can also occur, particularly in relation to larger-scale projects. Indirect impacts may include, but are not limited to, dewatering, defoliation, degradation of water quality from non-point source pollution, or other actions that would alter or reduce the functionality of aquatic systems.

Generally the USACOE does not have jurisdictional authority over indirect impacts except where a direct impact is subject to regulatory review under the Section 404 permit process. If a Section 404 permit application is required, application information must disclose the extent of impact by both direct and indirect activities. Further, the applicant must demonstrate that no other practicable alternatives to the anticipated environmental impact exist. If no other less damaging alternatives exist, then compensatory mitigation must be offered to provide for no net loss of aquatic ecosystem function and value.

It may be reasonably anticipated that several of the alternative improvement proposals will require Section 404 review and water quality certification prior to implementation. This report, together with accompanying inventory mapping, will help to identify jurisdictional areas and activities as well as to specify accepted practices that should be followed in order to minimize environmental impacts.

This inventory is to serve as a guideline for future planning and engineering decisions. The generalized identification of jurisdictional wetlands will alert those people responsible for plan implementation to the location of critical resource areas that will require formal permit application prior to facility development. Resource data within the corridor has been collected and presented in a manner that is suitable for planning and preliminary design purposes but should not be construed to be sufficient for Section 404 permitting purposes. A more precise field delineation and assessment of project-specific impacts will be necessary for individual improvements requiring review under Section 404.

Inventory Methodology

Aerial photography for the Fountain Creek area was supplied for purposes of identification and graphic presentation of resource areas and conditions present within the corridor. A map scale of 1"= 400′ was used for the inventory. In some instances, the limitations of this map scale will be reflected in the accuracy of locations and dimensions of depicted resource features. In addition, areas that were not large enough to reasonably delineate at this scale were omitted. It will, therefore, be important to observe and evaluate precise field conditions as specific improvement projects are contemplated.

The resource inventory was conducted during February of 1992 and reflects physical conditions that were observed at the time. The inventory was not hindered by any snow cover, but was, to some extent, complicated by the inherent difficulty in making a positive identification of vegetative features in the winter.

National Wetlands Inventory (NWI) Program composite mapping for the Fountain Creek corridor was obtained from the U.S. Department of the Interior and was referenced in conjunction with the inventory. Due to its scale and level of detail, the NWI mapping does not provide a reliable information source without supplemental field identification. The material presented herein and identified in the resource inventory vary, in some instances, from the NWI mapping; however, the variation is essentially in the level of detail and does not reveal substantive conflicts.

To ensure that a common descriptive standard could be used by all participants in both the Monument Creek and Fountain Creek studies, the City requested that the terminology routinely used by the USACOE be employed for field identification and presentation purposes. The USACOE "Standard Nomenclature for Resource Mapping" (Volume III) was used to describe vegetation, streambed/channel bottom composition, and streambank characteristics.

Within the framework of the standard nomenclature, descriptive terminology is used to characterize vegetative features associated with the wetland areas; the terminology includes riparian shrubland, herbaceous wetland and emergent wetland. Areas within the Fountain Creek corridor that have been identified by these vegetative characteristics are very often, but not exclusively, also jurisdictional wetlands as defined by the Clean Water Act and by the USACOE for Section 404 permitting purposes. Vegetation communities meeting the jurisdictional wetland criteria were delineated and graphically represented (Figure 3.3-1, Volume II). Jurisdictional wetlands within the corridor were

identified in accordance with the Clean Water Act of 1977 (33 CFR Section 323.2) which defines wetland ecosystems as:

> "... those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas."

The Fountain Creek study depicts vegetation communities and jurisdictional wetland areas separately, but both should be considered evaluating habitat quality. Many of the lines representing boundaries between wetland and non-wetland type vegetation/habitats are coincident with the boundaries of jurisdictional wetlands, posing difficulty in presenting both elements on the same maps while maintaining a reasonable degree of clarity, particularly at the 1"=400′ scale used. Vegetation communities, therefore, are shown separately on Figure 3.3-2, Volume II.

Three parameters are implicit in this definition, as outlined in the *Wetland Delineation Manual* (USACOE 1987). Jurisdictional wetland areas are identified by hydrophytic vegetation, hydric soils and wetland hydrology and they must exhibit the following characteristics: (1) vegetation consisting of species typically adapted for life in saturated soil conditions; (2) soils showing evidence of development under anaerobic conditions occurring during periods of prolonged soil saturation; and (3) periodically or permanently inundated or saturated soils.

For wetland delineation purposes, a determination was made in the field as to whether the above criteria had been met for a given area; a conclusion was drawn based on the USACOE multi-parameter approach and methods outlined in the 1987 Manual.

In most cases, visual observation of the dominant vegetation communities was sufficient to conclude whether an area was considered a wetland. The hydrophytic vegetation indicator may be used without deference to the other indicators in communities that are dominated by obligate vegetation, that is, species occurring in wetlands greater than 99% of the time. Many areas along the Fountain Creek streambanks were predominately vegetated with willows, an obligate species; in these areas, this sole indicator rule was applied. Where willows were sparse and isolated or present in an area too small to delineate at the operative scale, the area was generally not considered wetland.

Where questionable circumstances existed or more information was needed to determine the existence of all three of the required parameters, a test pit was dug to allow for observation of sub-surface soil characteristics. Areas were considered jurisdictional wetland if all three of the established indicators were observed. When any one of the three indicators was absent, the area was determined to be non-wetland.

Approximate wetland boundaries were recorded in the field on the 1"= 400′ aerial photographs. Wetland delineations depicted to date in conjunction with this study should be considered preliminary; they are intended to be used only as a

guideline. When specific corridor improvements are proposed, it will be necessary to complete a more accurate wetland boundary delineation which must be verified in the field by the USACOE.

Existing Conditions

Jurisdictional Wetlands

The most frequently occurring wetland type within the project area is characterized as being dominated by sandbar willow (*Salix exigua*) and located along the streambanks adjacent to Fountain Creek. Wetland areas identified throughout the creek corridor were almost exclusively of this willow-dominated type, however, smaller areas of emergent and herbaceous wetland were also encountered. These areas are dominated by sedges (*Carex spp.*) rushes (*Juncus spp.*) cattails (*Typha spp.*) reed grass (*Phragmites australis*) and horsetail (*Equisetum spp.*).

The location of jurisdictional wetland areas may be generalized as occurring, with few exceptions, downstream of the confluence of Monument and Fountain Creeks. The upstream reach has been urbanized and significantly altered as a result of extensive channelization and development. Only a few small, rather isolated riparian willow communities have been identified in this reach.

Within the downstream reach, wetlands are primarily confined to the banks of Fountain Creek. They occur customarily as a strip varying in width from approximately five to twenty-five feet and are generally identifiable by willow-dominated vegetation. A few larger wetland areas also exist below the confluence point. The largest contiguous area of wetland, approximately 6.5 acres, is the "Tejon marsh" and the adjoining wetlands that continue along the edge of the Creek. "Tejon marsh" exhibits characteristics of each of the wetland types identified, riparian, herbaceous and emergent. At present, portions of the marsh have been degraded by debris that has been dumped over the years; it appears, however, that its condition can easily be restored by removal of the dumped material. There were, in fact, during the completion of this study several volunteer work sessions which made significant improvements to the degraded condition of this wetland area.

Vegetation Types

There are several areas designated as shrubland throughout the downstream reach of the Creek; these areas are predominantly vegetated with willows and are often coincident with those areas determined to be jurisdictional wetland. These shrub-type wetland areas tend to appear in generally continuous fashion along the Creek, especially in the downstream reaches. Although they are narrow, there are unbroken stretches over 4,000 feet in length. These more densely vegetated shrub areas, together with the adjacent cottonwood groves, should be regarded as significant habitat features and disturbances should be avoided.

Except in the willow-dominated shrub/wetland areas, the riparian area is primarily vegetated with mature cottonwood trees and grasses. In the downstream reach, there are two large cottonwood groves, connected by a narrower band of trees, which should be regarded as one of the significant habitat areas within

the creek corridor. This area totals approximately 24 acres; it is located immediately southeast of the treatment plant and continues downstream for more than 3000 feet. Small trees and shrubs were evident in many areas as well, particularly in the reach downstream of the confluence.

Beyond the immediate vicinity of Fountain Creek, most areas have been developed and exhibit urban vegetation characteristics. The areas that are not developed are vegetated primarily with grasses and upland tree species, otherwise, lawns and landscaping associated with roadway, commercial and residential development are the predominant vegetative feature.

Streambank Conditions

Observation of the streambanks along Fountain Creek reveals several areas that have been subject to varying degrees of erosion and sedimentation. The severity at specific locations has been influenced by the extent of nearby development activity and alterations that have been made to the natural course of the creek. In areas where the natural character of the channel and a healthy vegetative cover has been maintained, there is little evidence of erosion. In these areas, the vegetative material has helped to preserve the integrity of the streambanks and significantly reduce downstream sedimentation.

The reach upstream of the confluence demonstrates, to a greater degree, the influence of development upon bank erosion. While there are also eroded areas in the downstream reach, they seem to be influenced more by streamflow patterns (albeit, streamflow that has been altered by upstream activities) and normal river hydraulic characteristics rather than by development, additional impervious surfaces and storm drainage design.

Upstream bank erosion is generally sporadic and, in some areas, apparent haphazard remedies have been applied. For example, it was not uncommon to see thirty to one hundred foot long strips where rubble, broken concrete and other debris have been dumped. It is difficult to ascertain in many instances whether the placement of these materials was intentionally for erosion control purposes or simply for disposal.

As a general standard, in areas where the creek gradient is low and the natural character of the channel has been maintained, there is little evidence of erosion. In these areas, the riparian vegetation has helped to preserve the streambanks and significantly reduce downstream sedimentation. In several locations, banks have been structurally reinforced either with concrete walls, riprap or gabions. The placement of reinforcement materials is primarily associated with road and bridge construction, however, some walls and riprap have been installed in conjunction with general urban development activities.

Channel Characteristics and Streambed Composition

The Fountain Creek streambed has become embedded due to the settling and compaction of sand and silt. High gradient sections have a streambed composed mainly of boulders and cobble while the channel bottom of low gradient reaches is generally composed of cobble, gravel, sand and silt. Rubble was a significant

component of the Fountain Creek streambed above the confluence point, but was less abundant in the downstream reaches.

Water Quality

No water sampling was undertaken as a part of this project. Water quality sampling, however, has been performed by the City of Colorado Springs in conjunction with their wastewater treatment facility operations. Water quality throughout the study area is affected by a high sediment load. Numerous stormwater drainage pipes which outlet into Fountain Creek are an apparently significant source for the introduction of nonpoint source pollutants to the Creek.

The Colorado Water Quality Control Commission's Classification and Numeric Standards for the Arkansas River Basin categorized the stream classification and standards for the following two stream segments of Fountain Creek:

1. Mainstream of Fountain Creek, including all tribtaries, lakes, and reservoirs, from the source to a point immediately upstream from the confluence with Monument Creek.

   Designation: None (Insufficient data to properly designate)

   Classifications: Aquatic Life Class 1 (Cold)
   Recreation Class 2 (Secondary Contact)
   Water Supply
   Agriculture

   Numeric Standards: Physical and Biological (D.O., pH, Fecal Coliforms)
   Inorganic (NH_3, Cl_2, CN, S, B, NO_2, NO_3, Cl, and SO_4)
   Metals (As, Cd, Cr III, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, and Zn)

2. Mainstream of Fountain Creek from the confluence with Monument Creek to the confluence with the Arkansas River.

   Designation: Use-Protected (Special protection not warranted)

   Classifications: Aquatic Life Class 2 (Warm)
   Recreation Class 2 (Secondary Contact)
   Water Supply
   Agriculture

   Numeric Standards: Physical and Biological (D.O., pH, Fecal Coliforms)
   Inorganic (NH_3, Cl_2, CN, S, B, NO_2, NO_3, Cl, and SO_4)
   Metals (As, Cd, Cr III, Cr IV, Cu, Fe, Pb, Mn, Hg, Ni, Se, Ag, and Zn)

The water quality of Fountain Creek is currently designated by the State in the 305(b) report as impaired due to sediment and fecal coliform. The State is required by the federal "Clean Water Act" to update the 305(b) report every two years. Fecal coliform levels, as sampled at the City's wastewater treatment

facility, occasionally exceed water quality standards throughout the City, but the relative contributions of point and nonpoint sources is not clear. Discharges from the City's wastewater treatment facility are incompliance with State standards. Generally, the most affect the wastewater treatment facility's operation has on the stream is the increased levels of Nitrogen compounds.

The physical, chemical, and biological water quality of Fountain Creek has been assessed in recent reports. The physical and biological water quality of Fountain Creek was assessed in a study conducted by the USGS during the years 1985 to 1988 (USGS, 1989). The purpose of the study was to determine the effects of sediment transport on benthic-invertebrate. Benthic-invertebrate, or larval stage insects, are a main source of food for fish in natural streams. The benthic insects feed by attaching the end of their body to the substrata and extending their filter apparatus into the flow to collect detritus, algae, and zooplankton. Sediment and benthic-invertebrate data were collected at three locations along Fountain Creek: 1) near the westerly city limits of Colorado Springs upstream of Monument Creek, 2) Colorado Springs near the confluence with Cheyenne Creek downstream of Monument Creek, and 3) Security, Colorado. The USGS determined that the population of benthic-invertebrate was greatest at sites where there was little or no change in stream bed elevation, large-diameter stream bed material, low sediment transport, and few periods of flooding. It was concluded from the USGS study that the population of benthic-invertebrates was more abundant at the sample site on Fountain Creek upstream of the confluence with Monument Creek and the least abundant at the Security sample site because of the increase streamflow and sediment discharges affecting the more habitat-sensitive taxa.

Fish and Wildlife Habitat

The wildlife habitat along Fountain Creek is a discontinuous riparian corridor with limited connections to adjacent upland habitat. It serves as a travel corridor for some species and seasonal or year round habitat for others. While the quality of aquatic and terrestrial habitat along the reach is somewhat limited, there is still a healthy wildlife population and several valuable wildlife habitat areas associated with Fountain Creek. The fish population is generally composed of minnows and other non-game species, and is only in fair condition due to water quality impacts. In relation to waterfowl and mammal species, Fountain Creek is highly beneficial as a wildlife migration corridor.

Wildlife species in the area are those which have adapted to human dominance, can survive in a patch work of native habitat, and/or transient.

Above the confluence with Monument Creek, wildlife species are generally limited to waterfowl, songbirds, raccoon, and small mammals. Below the confluence, resident wildlife species also include whitetail deer, mule deer, coyote, fox, porcupine, beaver, muskrat, owl, blue heron, and raptors. Species which are less adaptable to urban environments and requiring longer areas of contiguous habitat, such as mountain lion and bear, are generally absent from the Fountain Creek corridor. This general wildlife character is likely to remain without significant change in the future.

Valuable wildlife habitat along Fountain Creek is concentrated below the confluence and includes stands of cottonwood trees, willow shrub communities, and emergent wetlands (Fig. 3.3-2). The identified valuable wildlife habitats are all adjacent to the creek and relatively large in size, encompassing 5 acres or more.

Channelization, and general development activity have contributed to the destruction of Fountain Creek wetlands and natural areas, thereby reducing opportunities for many plant and animal communities to thrive throughout the reach. Modifications to wetlands and plant communities within the riparian corridor will have an impact upon both terrestrial and aquatic species. Several factors, including wetland filling, alteration of the stream channel, sedimentation, and degraded water quality have been most detrimental to aquatic species' populations within the reach.

General observation and electrofishing population data collected by CDOW during June through August of 1989, has shown that several fish species are present in Fountain Creek. The aquatic ecosystem supports a small population of warm water fishes including suckers, chubs and minnows. In conjunction with electrofishing data collection, CDOW established four sites within the reach, as follows:

Site #1 ⇒ Woodland Road
Site #2 ⇒ upstream of the wastewater treatment plant
Site #3 ⇒ downstream of the wastewater treatment plant
Site #4 ⇒ the downstream edge of the City limits.

The collected data indicates that while some fish species occur in relative abundance, observances of others are infrequent enough to be considered somewhat of an aberration. Two species were observed at all four of the sites; these are the flathead chub, the dominant species at all sites, and the longnose dace. Additional species that were observed in the relatively coller reaches, i.e., Sites #1 and #2, include longnose sucker, creek chub, and white sucker. The brook stickleback was observed at Site #1 and the fathead minnow at Site #2. Overall the size and diversity of the fish population is poor. The collected data cites only one specimen each of the green sunfish and brown trout; this observance was recorded at Site #3. The sand shiner, stoneroller and brook stickleback (which was also recorded at Site #1) were observed at Site #4. Trout have been observed in some of the deeper pools located above the confluence, but few macroinvertabrates inhabit the reach, thus limiting available food supplies for the fish. While, on occasion, trout have been observed in the lower reaches below the confluence, this has occurred following a rainfall which would probably indicate that they have been washed downstream rather than that populations can sustain in these downstream waters.

There has been some speculation that specimens of the Arkansas darter may be present in Fountain Creek as its natural range also includes the tributaries of the Arkansas River. The species is currently listed as threatened in the state of Colorado and is a candidate species (status "1") for federal listing as a threatened species. The preferred habitat for the darter is one with cool, clear spring-fed pools and creeks where vegetation is abundant and most are found south of Colorado Springs. They are sensitive to impacts from pollution and are not well-suited to thriving in streams with silt and sediment accumulations. Given

the set of criteria that defines the darter's ideal habitat, populations would probably find survival difficult in this area of Fountain Creek, particularly under present conditions.

Wetland Protection/Streambank Stabilization

There are several areas within the corridor which have been determined to be jurisdictional wetlands; their presence indicates a need to evaluate critical habitats and resource issues prior to undertaking any improvements that might alter the integrity and function of the wetland system. Wetlands serve a vital role in controlling floods, maintaining groundwater supplies, trapping sediments and pollutants, purifying water and providing essential habitat areas. The Clean Water Act, 33 CFR 320.4(b)(1), states that "...wetlands constitute a productive and valuable public resource, the unnecessary alteration or destruction of which should be discouraged as contrary to the public interest." Protection and enhancement of the remaining wetlands should be regarded as a priority in any improvement alternatives.

When evaluating and granting a permit request to impact wetlands, the Corps of Engineers must conclude, according to the Section 404 guidelines and consultation with other regulatory agencies, that no practicable and less damaging alternative to the proposed activity exists and that "...the benefits of the proposed alteration outweigh the damage to the wetlands resource". It is, therefore, incumbent to promote an improvement program that examines practicable alternatives improvement program that examines practicable alternatives (including "no action") and avoids all activity in wetland areas wherever possible. Where avoidance is impossible within the public interest and least damaging alternative parameters, the regulatory guidelines provide for an opportunity to establish a mitigation program to offset or compensate for an anticipated loss of wetlands.

Typically, a mitigation program might include one of or a combination of the following: (1) replacing lost wetland area and function by creating new wetlands elsewhere on the site or, as a less desirable alternative, at an off-site location; (2) upgrading the condition of deteriorated wetlands that are in danger of further degradation or loss; (3) acquiring off-site wetland properties to be held, in perpetuity, as protected open space; or (4) making a financial contribution to a land trust or other entity to be used for land acquisition and protection purposes. Options involving creating or upgrading wetlands would be accompanied by a plan to effectively ensure the long term success and function of such areas.

Wetland mitigation opportunities along Fountain Creek corridor are numerous. Upland areas adjacent to existing wetlands could be excavated to create new wetlands, and Fountain Creek aquatic habitat could be restored and enhanced. Wetland mitigation is most easily accomplished by transplanting the soils and vegetation from wetlands to be disturbed into wetland creation areas. This method allows for the creation of similar plant communities and provides for no-net-loss of wetland function and value.

Where there is evidence of degraded streambank conditions, efforts can be made to improve their condition and reduce opportunities for further degradation.

Erosion control and streambank stabilization are integral to several of the drainage improvement alternatives and new development projects along Fountain Creek. The preferred bank stabilization strategy should include biotechnical and revegetation measures. Streambank stabilization activities will function not only as an erosion control measure, but also as new and enhanced habitat to help sustain existing fish and wildlife species. As such, habitat restoration can occur simultaneously with drainage improvement activity.

3.4 CULTURAL

Cultural and Historic Resources

The Fountain Creek Drainage Basin Planning Study also documents the cultural and historic resources within the study area. From the confluence of Monument Creek and Fountain Creek west is recognized as a major link between Colorado Springs and the mountains. Fountain Creek, or better know by the early settlers as Fountain qui Boville, provided a passageway into the mountains for the settlers and Indians. The Araphoe, Cheyenne and Ute Indians utilized the basin area as hunting grounds, camping sites and sacred grounds, ie. Garden of the Gods, Manitou Springs.

The first rush of permanent settlers came with the discovery of gold. In 1858, Colorado City was developed as a supply town. By 1872, the settlers had developed a primitive road along Fountain Creek to provide better access into the mountains and to the gold. The Ute Pass became an essential area providing resting areas and lodging.

As a result of this early development, the Old Colorado City area, as it is known today, has been listed on the National Register of Historic Places. Public and institutional buildings were critical elements in the early growth of the area. Other districts listed on the Register that are within the stream corridor are the Manitou Springs Historic District and South Downtown Historic District. These districts each have historic structures that are individually listed on the register; however, these historic structures have not been individually identified as part of this study.

A second category of resources with historic significance are the buildings and sites that may be eligible for listing on the National Register. Some of these significant cultural and historic resources within the stream corridor are the following:

1. Ivywild School
2. Boys Club
3. South Church Rose of Sharon Temple
4. United Brethren
5. Colorado Springs Day Nursery*
6. Rio Grande Engine*

*See Monument Creek Drainage Basin Planning Study for confluence historical information

The third category which inventories historic districts, buildings, sites and objects consists of locally significant cultural resources. These properties are not eligible for listing on the National Register of Historic Places, although they contribute to the historic setting and local character of the Old Colorado City area and adjacent corridor. Following are some of the more predominant locally significant cultural and historic resources in the study area:

1. Colorado Springs Hotel
2. Guadelupe Building
3. Lowell Elementary School
4. South Jr. High School
5. Dorchester Park
6. Central Uniform
7. Colorado Springs Interurban
8. Midland Terminal Van Briggle Art Pottery
9. Anway House/Hotel
10. City Hall 2nd
11. Myron Stratton Home
12. General Store - 2802 W. Colorado Ave.
    - 2411 W. Colorado Ave.
13. El Paso Canal
14. Evergreen Cemetery
15. CO Midland R.R. Grade
16. Janitell Farm
17. Colorado Springs Interurban & Power - powerstation
18. Denver & Rio Grande R.R.
19. Minuteman Press Building
20. Nikola Tesla Museum of Science and Industry
21. Marco Polo Shop

These locally significant resources, along with the resources listed on or eligible for the National Historic Register are mapped on Figure 3.4-1 in Volume II. Individual residential lots have not been identified or listed, but are critical elements to the corridor. The area around the confluence has been mapped and discussed in the Monument Creek Drainage Basin Planning Study.

Archaeological Resources

In addition to the historic resources inventoried for this study, there are archaeological sites which exist in or near the study area. According to the Colorado Historical Society Office of Archaeology and Historic Preservation, an archaeological survey along I-25 from North Academy Boulevard to South Academy Boulevard includes two archaeological sites. One site has been vandalized and heavily disturbed. Only four flakes, of an originally reported 200, were observed at the time of the survey. The artifacts present at this site are catalogued as flakes, quartzite and petrified wood. The second archeological site listed by the survey consists of a partial pot buried below water laid gravel and silt. Although these sites are not specifically located along Fountain Creek, they provide historical information about the corridor perimeter.

Existing and Future Land Use

The existing and future land use data were based upon information prepared by the City of Colorado Springs, El Paso County and Pikes Peak Area Council of Governments for a recent planning study entitled "Socioeconomic Forecasts for Transportation Planning Beyond the Year 2010". The one million population planning horizon scenario was used for the future land use data.

The existing land use has very distinct qualities; first the dense urbanization that exists from Nevada Ave. north to the confluence and then west to 31st St., and secondly the large tracts of land south of Nevada Ave. that are as yet undeveloped. The dense urbanized areas are usually comprised of properties held in single ownership, small parcels stretching across or to the center of the Creek, depending on recent erosion and stream migration. The land use north of Nevada Ave. and west of the confluence is primarily commercial, warehouse, auto salvage and industrial storage facilities. In the Old Colorado City area, there is a small percentage of residential usage. The land use south of Nevada Ave. is primarily commercial or industrial in nature, with several large tracts being held by the City of Colorado Springs, such as the Martin Drake Power Plant, wastewater treatment facility, and a recent purchase by the Park and Recreation Department and the State Department of Highways. Figure 3.4-2 in Volume II identifies the existing land use within the watershed.

Property value is primarily determinant on the land use and location. As part of the alternatives analysis in Section 6 of this report, property values were determined for the land along the corridor. The City of Colorado Springs prepared an evaluation of property value assumptions for the Fountain and Monument corridors. The City projects that an increase of 10 to 15 percent in property values will occur for 1993 and for the next two to five years as a result of inflationary/sudden market upswings. The City's evaluation assumed a 15 percent annual increase from 1992 to 1996. To estimate the property values for the simplified capital cost estimates of land needed to be acquired for the drainage improvements, the 1996 estimates were discounted at a 3 percent rate. This estimate of the property value would represent a conservative value for 1993; however, it was believed over the project life would be a reasonable estimate. It was estimated that the 1993 land values along the stream corridor would be $0.32 per square foot for industrial land use, $0.48 per square foot for commercial, $1.65 per square foot for multi-family residential, and $2.80 per square foot for single-family residential.

The future land uses are to be compatible with the "2010" plan, the approved Midland/Fountain Creek Parkway Corridor Plan, Downtown Action Plan, Comprehensive Plan and Westside Plan. The future land uses should be sensitive to the needs of the recreational amenities the creek corridors have to offer. Figure 3.4-3 in Volume II identifies the future land use within the watershed.

Recreation, Park, Open Space and Trail Resources

The Fountain Creek corridor has a tremendous amount of variety in its recreational amenities and opportunities, including providing access to Ute Pass, Garden of the Gods, urban parks, historic districts and rural open spaces.

The City of Colorado Springs Transportation Plan has identified existing and proposed on-street and off-street bicycle routes. The entire length of the corridor has been identified in the Multi-Use Trails Plan as providing a major spine trail linking to the spine trail along Monument Creek, Foothills trail and Sand Creek spine trail. The City of Colorado Springs Comprehensive Plan emphasizes the goal of providing a system of conveniently located parks, access points, encouraging bicycle routes and enhancing the natural setting within the built environment. The existing on-street bike routes provide an initial frame work for such a system.

The location of the existing City regional park, Garden of the Gods, at the western extremity of the corridor, provides a natural destination point. Bear Creek Nature Center provides a mid-corridor destination point and Fountain Creek Nature Center provides a southerly destination point. There are three smaller neighborhood parks along the corridor, Vermijo, Blunt and the historic Dorchester Park. Bancroft Park is in the Old Colorado City Historic District providing another small park unique feature. A unique feature recently developed, adjacent to Dorchester Park, is the Tejon Street Marshes, which provides a special habitat for birds and wildlife amidst an urban setting.

The aspect of open space along the corridor is dramatically different from the more congested mountainous western end to the open rural prairie quality at the southern end of the corridor.

There are only two large tracts of undeveloped land along the western section of the corridor, the Bach property and Gold Hill Mesa. The Bach property has Garden of the Gods type formations and was previously used as a landfill site. Gold Hill Mesa is primarily comprised of gold tailings that need to be remediated because they have a high arsenic content. The smoke stack from the old refinery is considered a locally significant feature.

The confluence of Monument and Fountain Creeks is rather well hidden by the I-25 and Highway 24 interchange. The opportunity exists for development of this area into a destination area providing unique urban features.

South of Nevada Ave., the corridor is not as congested providing opportunities for a larger corridor width and open space development. There exists large, unique vegetation stands at the intersection of I-25 and the Highway 24 bypass, as well as at the confluence of Shooks Run. There are a limited number of access points into the entire southern end of the corridor.

3.5 GEOMORPHOLOGY

General

The drainage basin lies within the Rampart Range and its foothills contained within the Southern Rocky Mountain physiographic province. In the western part of the basin are mountains consisting primarily of hard, Precambrian granitic rocks. The dominant feature of the Ute Pass area is the Ute Pass Fault which is located within the Fountain Creek Valley and extends to Woodland Park. To the west of Manitou Springs, the oldest sedimentary rocks in the region overlie the granitic rocks. These sedimentary rocks have been uptilted by faulting and

mountain building. These upturned beds of sedimentary rock are well exposed upstream from 30th Street westerly along Highway 24 and in the Fountain Creek valley. The dip of the strata rapidly decreases as one travels to the east. At the confluence with Monument Creek, the bedrock dips at very slight angles towards the northeast.

Bedrock underlying the Study Reach (33rd Street downstream to the County Jail) consists mainly of the Pierre Shale. The contact between the Pierre Shale and older sedimentary rocks occurs roughly at Fountain Creek and 31st Street. Westerly of this point, upturned and faulted sedimentary rocks of various formations are exposed. Overlying the bedrock units within the Study Reach are various surficial deposits which were deposited in more recent geologic times. These various geologic units are plotted on the Geomorphology and Geologic Resource maps labelled Figure 3.5-1 in Volume II, and are described in more detail by the following narratives.

Bedrock Units

Undifferentiated Bedrock Units (UBR)

In the extreme westerly part of the study reach, upturned sedimentary rocks of various formations are exposed. The formations in this area of the study reach include (from oldest to youngest) the Lyons Sandstone, Lykins Formation, Morrison Formation, Ralston Creek Formation, Dakota Sandstone and Purgatorie Formation, the Carlisle Shale, Greenhorn Limestone, Graneros Shale, and Niobrara Formation. As mentioned, these sedimentary rocks have been upturned by faulting by the Ute Pass Fault and by the Rampart Range Fault which terminates just south of this area. Bedrock types exposed within the outcrops south of Fountain Creek include sandstone, siltstone, limestone, and shale. Recent construction in the extreme western end of the study reach and realignment of Fountain Creek required heavy ripping and jackhammering to excavate the hard sandstone bedrock.

Pierre Shale (Kp)

The Pierre Shale is the bedrock unit which underlies the majority of the study reach. The Pierre Shale was deposited during the Cretaceous Age in a shallow inland sea. This bedrock formation consists mainly of clay shale which is typically blue-grey in its unweathered state, very dense, and contains some interbedded limestone and sandstone layers. The Pierre Shale is known for being expansive in weathered forms. Within the study reach, the clay shale dominates. Publications indicate the thickness of this formation varies from about 3,000 to 5,000 feet. The Pierre Shale is exposed at several locations downstream of the confluence with Monument Creek. Upstream of the confluence within the stream channel, few exposures of bedrock were found.

Surficial Deposits

During relatively recent geologic times, the region has been subject to various erosional and depositional episodes, including some secondary glacial effects. This has resulted in an eroded bedrock surface on which the younger surficial deposits have been deposited. Even some of the surficial deposits have been

subject to younger erosional processes which have tended to dissect and erode the older deposits.

Louviers Alluvium (Qlo)

The Louviers Alluvium is the oldest surficial deposit found within the study reach and consists of alluvial deposits associated with Fountain Creek when it flowed at higher levels. It can be found in a wide band paralleling Fountain Creek upstream of the confluence with Monument Creek. The Louviers Alluvium forms an elevated, broad, relatively flat terrace on which the major portion of Old Colorado City has been built. In the downtown area, the Louviers forms the elevated, broad terrace on which the downtown region has been developed. The Louviers Alluvium typically consists of stratified sand, silt, and gravel material containing cobble and boulder material. Upstream of the confluence with Monument Creek, it typically contains larger sized materials (cobbles and boulders) than does the Louviers material in the downtown area, upstream of the confluence.

Broadway Alluvium (Qb)

The Broadway Alluvium is a younger alluvial deposit also associated with Fountain Creek when it flowed at higher levels. These deposits also exist as an elevated terrace lying above the present stream levels. Deposits of Broadway Alluvium can be found associated with Cheyenne Creek and Fountain Creek downstream of the confluence with Cheyenne Creek. These materials typically consist of a stratified sequence of sand, silts, clays and gravels containing cobble and boulder-sized materials.

Piney Creek Alluvium (Qp)

The Piney Creek Alluvium consists of low terraces parallel to Fountain Creek, lying just above the floodplain areas. It is possible that some areas of Piney Creek Alluvium could be prone to flooding under extreme conditions. These are similar to the older alluvial deposits in that they consist of sand, silt, clay, and gravel and contain some cobble and boulder-sized materials.

Recent Alluvium (Qal)

Recent Alluvium is associated with the physiographic floodplain of Fountain Creek and is found in a narrow to wide band paralleling the creek. The alluvium consists of sand and gravel with scattered cobble to boulder-sized materials and silt and clay layers. Upstream of Circle Drive the natural stream channel has been at least partially altered by filling, dumping, channelization, and development encroachment. The Recent Alluvium as indicated on the geologic maps therefore largely represents a predevelopment condition; the location of Recent Alluvial deposits prior to filling, encroachment and development. The mapped location of the Recent Alluvium can only be approximated, however, because development along the floodplain has been occurring for over 100 years.

Man-Placed Fill (Fill)

Man-placed fill exists along at least portions of the creek channel upstream of Circle Drive. Upstream of the City's wastewater treatment facility, virtually the entire floodplain and/or channel has been altered by filling, dumping, and development encroachment. Fill materials consist of all types of soil materials mixed with varying amounts of man-made materials such as concrete, asphalt, metal, wood, and debris. The presence of the manmade fills along the channel and in the floodplain could provide a source for pollution and solid waste problems. During flooding, the presence of organics and wood could also provide additional sources for floating debris. Known or suspected solid waste landfill areas where pollution sources may be more probable have been indicated on the geomorphology and geologic resource maps. Given past management practices, the presence of industrial and commercial development along the channel and within the floodplain also increases the likelihood of pollution sources.

<u>Geologic Factors Affecting Drainage</u>

Several geologic factors affect the overall drainage conditions in the study reach. These include the location and type of bedrock, location and type of surficial soil deposits, and manmade development and disturbances within the basin and floodplain.

The extreme upper portion of the study reach is underlain by relatively resistant sandstone bedrock; however, the majority of the reach is underlain by the Pierre Shale. Although in its unweathered state the shale is considered to be "hard", it is still erodible and subject to slaking due to wet and dry cycles. The shale is eroded by scour during flooding, by slaking during cycles of wetting and drying, and by slaking during freeze-thaw cycles. Data published in the Drainage Criteria Manual (Colorado Springs 1987) indicates that during flooding, the unweathered shale materials should be capable of withstanding water velocities on the order of 6 feet per second. Observations of shale exposures along both Monument and Fountain Creek indicate erosion of the shale along the active channel areas may be occurring at the rate of 1 foot every 10 to 15 years. Areas of shallow exposed shale, such as the area around the confluence with Spring Creek, result in a relatively stable channel bottom.

The surficial soil deposits and man-placed fill materials are the most erodible materials along the study reach. These are also the materials which dominate the channel bottom and side slopes. The soil and fill deposits along the study reach are highly variable in classification ranging from clay and silt layers, to fine sand, to coarse mixtures of sand, gravel, cobbles and boulders. In fill areas, these soil materials are mixed with varying amounts and types of debris.

Published literature indicates these fill and soil materials should be capable of withstanding water velocities ranging from about 2 to 5 feet per second. The presence of organics and wood in the man-placed fill materials provide an additional source for floating debris during erosion and flooding.

Due to filling, dumping, and development along the channel and within the floodplain, the stream has been altered and constricted. Development along the study reach has occurred for over 100 years and has resulted in a narrower

channel and/or floodplain generally upstream of Circle Drive. Observations along the study reach indicate erosion rather than deposition is the dominant process along the bed and banks. Erosion is also concentrated at several "hot spots" such as where the creek bends, where utility crossings resulting in drops, and at some road crossing abutments. Unless protected from erosion, it appears the future tendency will be for further bed and bank degradation.

The filling and dumping along the channel along with localized bank erosion has resulted in some steep streambank slopes. Although these steep slopes may stand vertically for an indefinite period of time when dry, when flooding occurs, the slopes become saturated, erosion occurs, and the slopes are subject to instability and slumping. In the development of mitigation designs, it is therefore important to provide slope stabilization in addition to erosion protection.

Hydrologic Soil Classifications

Soil classification and locations were taken from the U.S. Department of Agriculture Soil Conservation Service El Paso County Soil Survey issued 1981 (SCS 1981), and from the draft report "Soil Survey of the Pike National Forest - Eastern Part, Colorado" compiled by the U.S. Department of Agriculture Forest Services from 1979 to 1982.

Soils are classified into four hydrologic groups (A,B,C and D). Group A soils have a low runoff potential with a high infiltration rate. They consist primarily of deep, well to excessively drained sands or gravels. Group B soils have moderate infiltration rates and consist of primarily moderately fine to moderately course material. Group C soils have a slow infiltration rate and consist chiefly of soils with moderately fine to fine texture. Group D soils have a high runoff potential with a very slow infiltration rate. They consist chiefly of clay soils or shallow soils over a nearly impervious material.

Fountain Creek downstream of Manitou Springs lies within a narrow bank of loamy Ustic Torriflucents (U.T.) and Ellicott loamy course sand. The U.T. soil is a grayish brown to very dark grayish brown gravely sandy loam to clay loam, 6 to 8 inches thick. The stratified underlying material, to a depth of 60 inches, ranges from heavy clay loam to sand. Permeability of the U.T. soil is moderate with a corresponding hydrologic soils group classification of B. The Ellicott loamy course sand is typically a grayish brown loamy course sand about 4 inches thick with an underlying light brownish gray course sand at a depth of 60 inches. Permeability of the Ellicott loamy course sand is rapid with a corresponding hydrologic soil group classification of A. The remaining drainage basin encompasses a wide variation in soil group classifications from A to D.

Hydrologic soil classification for the U.S. Forest Service land, within the watershed, was developed utilizing three independent methods. The first method consisted of referencing data published by the U.S. Forest Service. The U.S. Forest Service describes the predomininate soil type in the Pike National Forest, which is within the Fountain Creek watershed, as "somewhat excessively drained shallow soil formed in deeply weathered granite of the Pikes Peak formation." When comparing the soils description with the hydrologic soil classification given above, the soil could be classified within either the A or B categories.

The Forest Service, however, classifies this soil in the D hydrologic soil group due to the parameter of depth, in this case a shallow 8 to 20 inches.

The second approach looked at the weathering of the Pikes Peak granite from an analytical approach. Weathering of granite is accomplished through two separate processes: breaking down the rock by either mechanical and/or chemical processes into smaller pieces. The abundant minerals comprising granite are quartz, sodium feldspar and potassium feldspar. Gravels and sands are typically comprised mostly of quartz and feldspar. With the weathering of the Pikes Peak granite into smaller pieces of quartz and feldspar, the end product is a soil comprised of a gravel and sand mixture. Upon field reconnaissance it was estimated that this weathered granite layer averaged 8 to 20 inches in depth with medium to high infiltration rate and a corresponding hydrologic soil group of a B or C.

The third approach looked at existing and approved hydrologic reports completed for sub-basins within the Fountain Creek watershed. Two reports referenced for the area west of U.S. 24 were the Bear Creek Drainage Planning Study (Kiowa Engineering 1991) and the Engineering Study of the Southwest Area Drainage Basin (Lincoln DeVore 1984). Both reports used a hydrologic soil grouping from A to D. In the Bear Creek report, it was reported that 5 percent of the basin belongs to Type A soil, 70 percent of the basin is Type B soil, 10 percent of the basin is Type C soil, and 15 percent of the basin belongs to Type D soil. For the area east of U.S. 24, the Black Canyon drainage study (Weiss 1980) places the watershed in the hydrologic soils group C. In the Southwest Area Drainage Basin Study (Lincoln DeVore 1978) the watershed was placed in the hydrologic soil groupings of A and B.

In weighing all the options from each of the analysis, a hydrologic soil group was classified for the U.S. Forest Service land within the Fountain Creek study. It was determined that a hydrologic soil classification of C best represents the majority of the soils contained within the watershed. Different hydrologic soil classifications do exist within the watershed and the limit of the various soil formation exposures as they are related to hydrologic classifications are presented on Figure 3.5-2 in Volume II and tabulated in Tables 4.7-2 and 4.7-3 of Appendix A, Volume III.

4.0 HYDROLOGY

4.1 INTRODUCTION

A hydrologic analysis was undertaken to establish peak flood rates and hydrographs for rare event hydrology as experienced in this region of Fountain Creek. Ten-year and 100-year return period floods reflecting existing and future watershed conditions were developed as baseline hydrology for use in the study. Hydrologic information generated as described herein was utilized primarily as input information for the hydraulic analysis of water as it flows in the Creek during these frequency events; that is, the elevations and lateral extent of flooding as a continuum along Fountain Creek. Hydrology and the related hydraulics also provided information for the geomorphologic fluival evaluation. The emphasis was to compute the streamflow at frequent enough intervals to enable the evaluation of current streamflow characteristics in each and how these might impact or be affected by the various alternative creek improvement configurations.

As indicated previously, there is approximately 420 square miles of drainage area that contributes runoff to the Monument and Fountain Creek DBPS study reaches. Due to the size of this area and the interrelatedness of the two basins, it was determined that the hydrologic methodology utilized should be consistently developed and applied between the two studies.

To guide the development of the hydrologic model, a Technical Hydrology Review committee was established consisting of representatives from the COE, Soil Conservation Service (SCS), Colorado Water Conservation Board (CWCB), FEMA, National Weather Service, and various City and County departments.

A series of technical meetings were held during the development of the hydrologic model to discuss pertinent hydrologic principles, and consider how they might be applied to the Monument Creek and Fountain Creek watersheds. Discussions pertained to rainfall type, rainfall amounts, areal adjustment of rainfall and its applicability, contribution to flooding from land above 8,000 feet in elevation, storm tracking, average storm cell size, reservoir routing, stream gage analysis and its applicability to this basin, and historical flooding the basin and in the region.

4.2 EXISTING INFORMATION

The two U.S. Army Corps of Engineers reports for Monument and Fountain Creeks, (USACOE 1973) and (USACOE 1974) were used as the basis for the existing hydrology. The flows presented within these reports estimate the 100-year flood event at 16,000 cfs, 20,500 cfs, and 45,000 cfs for the Manitou Gage, upstream of the confluence, and at the Tejon Gage, respectively. The Federal Emergency Management Agency Flood Insurance Study (FEMA 1990) used the same 100-year flood events as the USACOE reports and included 10-year flood event estimates of 3,700 cfs, 4,400 cfs and 9,200 cfs occurring at the Manitou Gage, upstream of the confluence, and at the Tejon Gage, respectively. Table 4.2-1 shows a complete listing of the USACOE/FEMA 100-year flood event flow estimates along the study reach.

TABLE 4.2 - 1
COE / FEMA FLOOD FLOW ESTIMATES FOR FOUNTAIN CREEK

FOUNTAIN CREEK DESIGN POINTS	DESIGN POINT NUMBER	APPROXIMATE DRAINAGE AREA (SQ MI)	APPROXIMATE COE/FEMA Q100 (CFS)	APPROXIMATE GAGE Log-Pearson III Q100 (CFS)	COMMENTS
D/S MANITOU SPRGS	24	103	16,000	-----	None
MANITOU GAGE (sta 07103700)	24	103	16,000	3,180*	32 years of continuous record including 1965 flood of 359 cfs ranked 15th - no information on 1935 flood.
U/S OF FOUNTAIN/ MONUMENT CONFLUENCE	27A	120	20,500	-----	Maximum known Q of 5,000 cfs estimated for 1935 flood No known floods > 8,000 cfs since at least 1864.
D/S OF FOUNTAIN/ MONUMENT CONFLUENCE	27B	358	42,200	-----	Maximum known Q of 5,000 cfs estimated for 1935 flood.
TEJON GAGE (sta 07105500)	29	392	45,000	21,000*	14 years of continuos record not including the 1935 or the 1965 floods - Maximum known Q of 55,000 cfs estimated for the 1935 flood - No information on the 1965 flood.
JANITELL GAGE	None	413	46,500	-----	New gage - no available record
D/S PROJECT LIMIT	31	418	48,000	-----	None
SECURITY GAGE (sta 07105800)	N/A	495	65,000	26,800*	26 years of continuous record including the 1965 flood of 25,000 cfs as flood of record - No information on the 1935 flood.

1. Gage statistics on period of record flows only with outlier skew and outlier handling per WRC 17-8.

2. From verbal and known records the three largest floods since 1864 (earliest recorded flood) were in 1864, 1935 and 1964 upstream of the confluence and 1864, 1935 and 1965 downstream of the confluence (although most floods have seemed to occur East and South of Colorado Springs).

4.3 STREAMFLOW

Stream gage and discharge records are available from the U.S. Geological Survey (USGS) for three stations within the Fountain Creek drainage basin study and for one station located downstream of the study boundary. Gage 07103700 (the Manitou Gage) is located near the west city limits of Colorado Springs, approximately one mile downstream of Sutherland Creek, and has a period of record from April 1958 to the current year. The peak flow rate for this period of record is a discharge of 2,630 cfs, on August 4, 1964. Natural flows upstream of this station are affected by storage reservoirs, power generation developments, diversion for irrigation and municipal use, and at certain times, transbasin diversion from the Beaver Creek drainage and transmountain diversions from the Colorado River Basin.

Gage 07105500 (the Tejon Gage) is located 31 feet upstream from the bridge on Nevada Avenue, approximately 1.3 miles downstream from the confluence of Monument and Fountain Creeks. The gage has a period of record from October 1921 to September 1924, and January 1976 to the current year. The peak flow rate for this period of record is a discharge of 5,300 cfs, on July 29, 1978. Natural flows upstream of the gage are affected by storage reservoirs, power developments, groundwater withdrawals, diversions for irrigation and municipal use, return flows from irrigated areas and discharges from sewage treatment facilities.

Gage 07105530 (the Janitell Gage) is located on the upstream side of the newly constructed Janitell Road bridge. The gage has a period of record from October 1989 to September 1990. This gage was not considered in the gage analysis due to the limited period of recorded data.

Gage 07105800 (the Security Gage) is located downstream of the study boundary at Security. The gage is on the upstream side of Carson Road bridge and has a period of record from October 1964 to the current year. The peak flow rate for this period of record is a discharge of 25,000 cfs, on July 24, 1965. Natural flows upstream of the gage are affected by reservoirs, power generation developments, diversion for irrigation and municipal use, return flows from irrigated areas and flows from sewage treatment facilities. Refer to Figure 4.3-1 (Volume II) for gage locations.

The positioning of the Manitou, Tejon and Security gages and their period of record permits them to be used as hydrologic index locations for the purposes of the computation of design hydrology.

4.4 FLOOD HISTORY

Historical documents, newspaper files, publications by the U.S. Geological Survey and the Colorado Water Record were utilized as sources of past flood damage and flood discharge estimates within the drainage basin. Documentation on past flood events from historical sources indicate that several floods have inundated and inflicted damage in some portions of the study area since 1864. Historical records on flooding are generally informative; however, specific information on intensity, duration, and magnitude of the storms and corresponding floods are lacking.

The flood of June 10, 1864, approximately five years after the founding of Colorado City, marked the beginning of Colorado Springs flood history and may have been the flood of record since the time of initial pioneer presence in the area. The following are descriptions of known large floods that have occurred on Fountain Creek in the vicinity of Colorado Springs, from locally published news accounts:

- June 10, 1864:

  A 20- to 30-foot rise in Fountain Creek "swept away almost all of Colorado City, killing several people".

- July 3, 1882:

  Bridges and railroad tracks were destroyed and one person was killed in a flood down Ute Pass in Manitou Springs.

- July 25, 1885:

  Flooding along Shooks Run produced by a waterspout-type storm just north of Colorado College which washed away bridges, damaged several homes, and killed one person.

- August 1, 1915:

  This flood, often referred to as the "Great Sand Creek Flood", damaged many roads east of Colorado Springs.

- June 3, 1921:

  At Colorado Springs, neither Fountain Creek nor Monument Creek flows went overbank, but with additional flows from Shooks Run and other tributaries severe damage was caused below the mouth of Spring Creek.

- August 31, 1929:

  After an intense downpour, the Ute Pass Fish Club dam bursts near Crystola and a flood "wipes out the resort area" called College Gulch.

- May 30, 1935:

  This flood resulted from excessive rainfall of short duration over an area less than 100 square miles in the Monument Creek basin. At Colorado Springs, the west side area along Monument Creek suffered most severely, followed closely by the city's south end, flooded by Fountain Creek.

- June 17, 1965:

  Several days of rain caused flooding in the Squirrel Creek, Sand Creek and Fountain Creeks. Seven inches of measured rainfall caused heavy

damage along the east side of the city and in the Security and Fountain areas.

- July 24, 1965:

  Flash flooding in the Seven Falls area causes extensive damage in the Cheyenne Mountain region.

- July 24, 1970:

  Flash floods in northeastern Colorado Springs causes heavy damage to roads and homes.

- August 20, 1970:

  9 to 11 inches of rain caused flooding in Rock Creek Canyon prompting rock slides and extensive property damage.

- July 2, 1980:

  Heavy rain causes extensive flooding throughout Colorado Springs.

- July 19, 1985:

  Thunderstorms "dumped" up to 5-1/2 inches of rain in the Broadmoor area in three hours causing flash floods throughout the southwest sections of the city.

4.5 HYDROLOGIC APPROACH

Extensive hydrologic information exists or was generated as a part of this evaluation and its companion hydrologic analysis for Monument Creek (CH2M Hill, unpublished). Since the companion analysis occurred partly in advance of this evaluation and established much of the background assumptions, these will simply be referenced herein rather than described in detail. The magnitude of the 10-year and 100-year floods for Fountain Creek were estimated using several different procedures. The comparison and composite of results from the existing information, and statistical, design storm and regional hydrologic analyses were utilized to produce recommended design flows in a following section of this report.

4.6 STREAMFLOW STATISTICAL ANALYSIS

The first of these hydrologic procedures is one which utilizes the statistics of annual peak flow records from the stream gaging stations. A Log-Pearson Type III frequency analysis, in accordance with the United States Water Resource Council Bulletin #17B (HECWRC 1982), was performed on the three previously described gage stations (Tejon, Janitell, and Security gages). Table 4.6-1 contains the Log-Pearson Type III 100-year discharges developed for the Manitou Gage. The use of past historical floods, their magnitude, and how they are incorporated into the hydrology model analysis can greatly affect the estimated peak flow. In the initial Log-Pearson Type III analysis on the flows from the Manitou Gage,

TABLE 4.6 - 1
LOG-PEARSON TYPE III GAGE ANALYSIS
(MANITOU GAGE)

	OBSERVED GAGE RECORD		5,000 CFS HISTORICAL FLOW FOR THE 1935 FLOOD	
RETURN PERIOD (YR)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)
0.002 (500 YR)	2740	3370	4820	6480
0.005 (200 YR)	2180	2550	3490	4340
0.010 (100 YR)	1810	2040	2700	3180
0.020 (50 YR)	1480	1610	2050	2320
0.040 (25 YR)	1180	1260	1530	1660
0.100 (10 YR)	839	868	992	1040
0.200 (5 YR)	612	622	674	689
0.500 (2 YR)	338	338	341	341
0.800	190	187	186	183
0.900	142	138	139	135
0.950	112	106	111	106
0.990	72	65	75	69

FILE: GAGE.WK1

incorporating 33 years of continuous data, historical data (i.e. estimated information from outside of the gage period of record) was not used. An estimated Q_{100} discharge of 1,810 cfs was calculated at the Manitou Gage. This value was then compared to the flow given when the estimated 1935 flood of 5,000 cfs was entered into the analysis as an historical flow. The inclusion of the 1935 flood as an historical flow increases the 10- and 100-year flow by almost 72 percent (to 3,180 cfs for the 100-year event). Therefore, care must be taken when using historical data with the Log-Pearson Type III procedure with an understanding that with large estimated historical values, the magnitude of flood flows can be greatly increased. Time and date of occurrences, locations, gage flow data, source of estimate, and how the estimate was arrived at are some items that must be analyzed in an effort to determine the validity of the historical flow estimate. In this instance, inclusion of the 1935 flood estimate value was accomplished because it was felt that accuracy was added to the statistical analysis.

Studies by Ott and Nasseri indicate that 80 percent of the estimates of the 100-year flood based on 20-years of record will be too high and that 45 percent of the overestimates will exceed 30 percent. Table 4.6-2 lists a recommended length of record in years required to estimate floods of various probabilities with a 95 percent confidence (Kinsley, Kohler, Paulus 1985).

TABLE 4-6.2
ACCEPTABLE DESIGN PROBABILITY ERROR FOR STREAM GAGE RECORDS

Design Probability	Acceptable Error 10%	25%
0.1 (10-year)	90	18
0.02 (50-year)	110	39
0.01 (100-year)	115	48

The Tejon and Security Gages were evaluated statistically in the same manner as the Manitou Gage and the results of these analyses are presented in Table 4.6-3 and 4.6-4, respectively. It is significant to note that no estimated flow for the 1935 flood is available for the Security Gage, however, the 1965 flood was handled alternatively as a high outlier.

4.7 DESIGN STORM HYDROLOGIC ANALYSIS

Hydrologic Parameters and Modeling

The second of these hydrologic procedures is a design storm method which uses rainfall to produce runoff utilizing knowledge of the basins physical characteristics.

TABLE 4.6 - 3
LOG-PEARSON TYPE III GAGE ANALYSIS
(TEJON GAGE)

	OBSERVED GAGE RECORD		GAGE RECORD PLUS 55,000 CFS HISTORICAL FLOW FOR THE 1935 FLOOD	
RETURN PERIOD (YR)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)
0.002 (500 YR)	8600	10700	24600	48700
0.005 (200 YR)	7770	9180	18500	29800
0.010 (100 YR)	7130	8130	14800	21000
0.020 (50 YR)	6480	7160	11800	15000
0.040 (25 YR)	5810	6240	9200	10800
0.100 (10 YR)	4890	5080	6460	7000
0.200 (5 YR)	4130	4220	4770	4960
0.500 (2 YR)	2960	2960	2880	2880
0.800	2070	2020	1900	1860
0.900	1710	1630	1590	1530
0.950	1450	1340	1390	1310
0.990	1060	878	1120	1020

FILE: GAGET.WQ1

TABLE 4.6 - 4
LOG-PEARSON TYPE III GAGE ANALYSIS
(SECURITY GAGE)

	OBSERVED GAGE RECORD		25,000 CFS HISTORICAL FLOW FOR THE 1969 FLOOD	
RETURN PERIOD (YR)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)	COMPUTED FLOW (CFS)	EXPECTED PROBABILITY FLOW (CFS)
0.002 (500 YR)	35600	48600	35100	48500
0.005 (200 YR)	27700	34900	27300	34700
0.010 (100 YR)	22500	26900	22200	26800
0.020 (50 YR)	18000	20600	17800	20400
0.040 (25 YR)	14100	15400	13900	15300
0.100 (10 YR)	9660	10200	9580	10100
0.200 (5 YR)	6820	7000	6780	6960
0.500 (2 YR)	3550	3550	3540	3540
0.800	1880	1840	1890	1840
0.900	1360	1300	1370	1300
0.950	1050	973	1050	974
0.990	643	553	647	553

FILE: GAGES.WK1

The hydrologic model of the Fountain Creek drainage basin consists of 106 numbered sub-basins which are contained within 32 regional basins as shown on Figure 4.3-1 (Volume II). Table 4.7-1 lists each regional basin, its abbreviation and the corresponding numeric range for the sub-basins. Each sub-basin has been assigned an alphanumeric designation corresponding to the regional basin which it is located within. Each alphanumeric designator is unique to each individual sub-basin that comprises the regional basins. Eleven of these regional basins have previously been delineated as drainage basins by either the City of Colorado Springs or El Paso County. Whenever possible, existing sub-basin delineation was followed or consulted in the compiling of sub-basins in this study. For the purposes of this study, sub-basins from the individual studies were combined into larger basins in order to simplify the computational procedures that arise when dealing with a large number of drainage basins.

In order to achieve maximum consistency between the Fountain Creek and the Monument Creek studies, hydrologic parameters set forth in the companion analysis of Monument Creek were followed in the Fountain Creek analysis. Within the hydrologic computer model HEC-1 (USACOE, September, 1990), the Soil Conservation Service (SCS) Dimensionless Hydrograph model was used to develop runoff estimates. Variables required for this procedure for each individual sub-basin are the area, curve number (CN), and the lag time (T_{lag}). Sub-basin areas were estimated, using a planimeter, from U.S.G.S quadrangle maps (1" = 4166.7'). Curve numbers were determined for each sub-basin utilizing the hydrologic soil characteristics, ground cover and corresponding imperviousness, in addition to Tables 5.4 and 5.5 of the City of Colorado Springs/El Paso County Criteria Manual (Colorado Springs 1987). Soil hydrologic soil groups are illustrated on Figure

3.5-2, Volume II and corresponding CN values are presented in Tables 4.7-2 and 4.7-3 (Appendix A, Volume III). Lag time (T_{lag}) was calculated based on its relationship with the time of concentration (T_c) using the following equation:

$$T_{lag} = 0.6T_c$$

Time of concentration for each sub-basin was determined by adding travel times for overland flow, channel flow, and pipe flow from the hydrologically most distant point in the basin to the outfall point. To estimate initial times of concentration several expressions have been developed, including the following form of Kirpich's equation:

$$T_c = ((3.35 \times 10^{-6} L^3)/(h))^{0.385}$$

Where:
T_c = Time of concentration (minutes)
L = Stream length in feet
h = Difference in elevation in feet between the upper and lower limits of the drainage basin.

TABLE 4.7-1
REGIONAL SUB-BASINS ABBREVIATIONS AND
NUMERIC RANGES

Drainage Basin	Basin Abbreviation	Basin Number Series
Bear Creek	BRC	1210 - 1214
Beckers Lane	BL	3410
Black Canyon	BKC	3310
Camp Creek	CPC	3610 - 3616
Cascade Basin	CB	3010 - 3012
Catamount Creek	CTC	2410 - 2417
Chipita Park	CP	2210
Crystal Creek	CLC	2310 - 2312
Crystola Creek	CRC	2510 - 2513
Columbia Road	CR	3510
Englemann Canyon	EC	1710 - 1718
Fischers Canyon	FHC	4110
French Creek	FRC	2010 - 2015
Indian Trail	IT	1910 - 1911
Lofland Gulch	LG	2710
Manitou Springs	MS	1810
Misc. Basin	MSC	4210
Palmer Trail	PT	1510
Sand Gulch	SG	2810
Severy Creek	SVC	2110 - 2115
Shooks Run	SR	3910 - 3916
Southwest Area	SW	1100 - 1118
Spring Crek	SPC	4010 - 4016
Sutherland Creek	SC	1610 - 1614
Talcott Gulch	TG	2610 - 2611
Villa De Mesa	VM	1310 - 1311
Waldo Canon	WLC	3110 - 3111
Wellington Gulch	WG	2910
Westside	WS	3810 - 3813
Williams Canyon	WC	3210 - 3211
19th Street	19S	3710
21st Street	21S	1410

A second expression is the following equation modified from the original equation initially proposed by Hathway:

$$T_c = ((2Ln)/(3*S^{0.5}))^{0.47}$$

Where: Tc = Time of concentration (minutes)
L = Channel length (feet)
S = Mean slope of the basin
n = Manning's roughness coefficient

Final T_c values were determined by adding travel times for the various conveyance elements to the initial overland flow time.

Six major detention structures have been included in the hydrologic model. These structures are North and South Catamount Reservoirs, Crystal Creek Reservoir, Manitou Reservoir, Lake Moraine, and Big Tooth Reservoir. Smaller detention structures were not considered in the hydrologic analysis because the effects of such structures would not be seen on the mainstream of Fountain Creek. These facilities do not have a dedicated flood control function and as such provide only incidental alteration of flood flow release.

Routing of flow in the hydrologic model was accomplished using the Muskingum-Cunge method. This routing technique is a new method of hydrograph routing available within HEC-1 version 4.0. Parameters used in this method for each individual reach or sub-basin include the length, slope, Manning's roughness coefficient, type of channel, bottom width of the channel, and channel side slope.

Within the HEC-1 computer program, rainfall is input and runoff is calculated for each individual sub-basin. Definition of rainfall and runoff information is described in more detail in following sections of this report. This runoff is either combined with runoff from another basin, routed through a reach, or routed through a detention structure, to establish discharges at various points throughout the Fountain Creek basin. Combination points are denoted by "DP" and a numerical value (i.e., DP27) within the HEC-1 input data. Where DP is a abbreviation for design point and the numerical value is a location identifier.

Channel and reservoir routing is denoted by "RT" and a numerical value (i.e., RT 131). Similar to the combination points, the RT is an abbreviation for routing of flow and the numerical value is a location identifier. At all design points a minimum of two and a maximum of five hydrographs were combined to determine the outflow hydrograph at that specific point. Design point peak flows for the Fountain Creek mainstream are presented in Tables 4.7-4 and 4.7-5. Design point hydrographs for select locations along Fountain Creek are presented in Figures 4.7-1, 4.7-2 and 4.7-3 for existing and future conditions.

TABLE 4.7 - 4
EXISTING LAND USE DESIGN STORM PEAK FLOWS

	UPPER FOUNTAIN CREEK DRAINAGE BASIN HYDROMET 51/52 HEC-1		FOUNTAIN & MONUMENT CREEK COMBINED DRAINAGE BASIN HYDROMET 51/52 HEC-1	
DESIGN POINT STATION (DP)	10-YEAR 24-HOUR PEAK FLOW (CFS)	100-YEAR 24-HOUR PEAK FLOW (CFS)	10-YEAR 24-HOUR PEAK FLOW (CFS)	100-YEAR 24-HOUR PEAK FLOW (CFS)
10	210	850	—	—
11	225	918	—	—
13	304	1,161	—	—
14	402	1,528	—	—
15	540	2,062	—	—
16	739	2,797	—	—
17	1,101	3,822	—	—
18	1,268	4,135	—	—
21	1,725	5,655	—	—
22	2,285	7,400	—	—
23	2,415	7,678	—	—
24	3,580	10,851	—	—
25	3,661	11,121	—	—
26	3,776	11,449	—	—
27A	3,820	11,524	—	—
27B	—	—	10,857	30,456
28	—	—	10,949	30,969
29	—	—	11,785	32,844
30	—	—	12,241	33,408
31	—	—	12,226	33,480

NOTE: Point 27A is located immediately upstream of the confluence
Point 27B is located immediately downstream of the confluence.
Includes flow from the Monument Creek Watershed.

TABLE 4.7 - 5
FUTURE LAND USE DESIGN STORM PEAK FLOWS

	UPPER FOUNTAIN CREEK DRAINAGE BASIN HYDROMET 51/52 HEC-1		FOUNTAIN & MONUMENT CREEK COMBINED DRAINAGE BASIN HYDROMET 51/52 HEC-1	
DESIGN POINT STATION (DP)	10-YEAR 24-HOUR PEAK FLOW (CFS)	100-YEAR 24-HOUR PEAK FLOW (CFS)	10-YEAR 24-HOUR PEAK FLOW (CFS)	100-YEAR 24-HOUR PEAK FLOW (CFS)
10	210	850	----	----
11	226	918	----	----
13	535	2,061	----	----
14	642	2,419	----	----
15	809	2,954	----	----
16	1,019	3,693	----	----
17	1,357	4,814	----	----
18	1,513	5,196	----	----
21	2,161	6,999	----	----
22	2,741	8,910	----	----
23	2,817	9,155	----	----
24	3,994	12,274	----	----
25	4,079	12,546	----	----
26	4,216	12,865	----	----
27A	4,264	12,934	----	----
27B	----	----	16,473	35,860
28	----	----	16,697	36,371
29	----	----	18,134	38,426
30	----	----	18,959	39,075
31	----	----	19,067	39,167

NOTE: Point 27A is located immediately upstream of the confluence
Point 27B is located immediately downstream of the confluence.
Includes flow from the Monument Creek Watershed.

FIGURE 4.7-1

FOUNTAIN CREEK DBPS

DP 24, 100-Yr 24-Hr Hydrographs

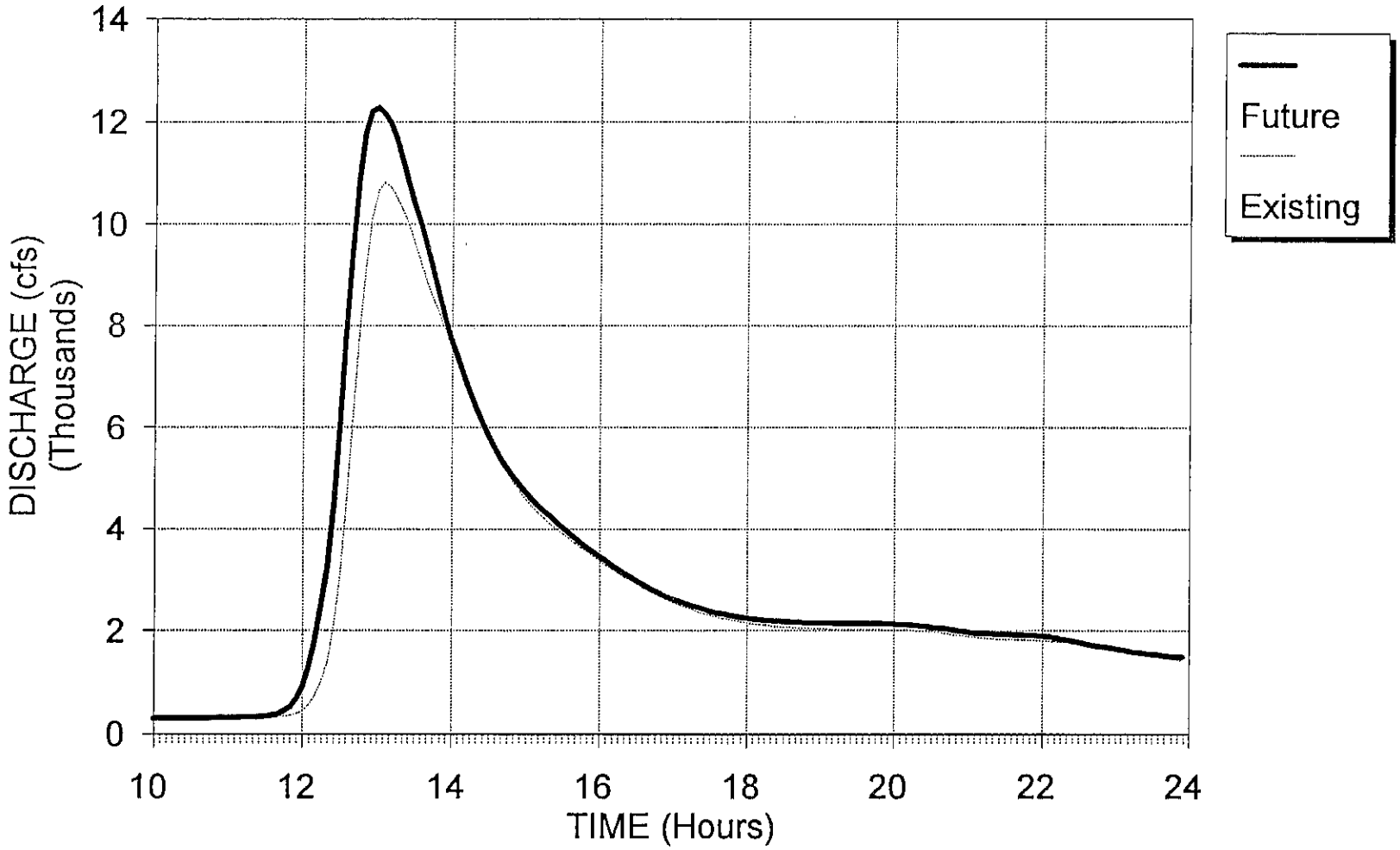

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FIGURE 4.7-2

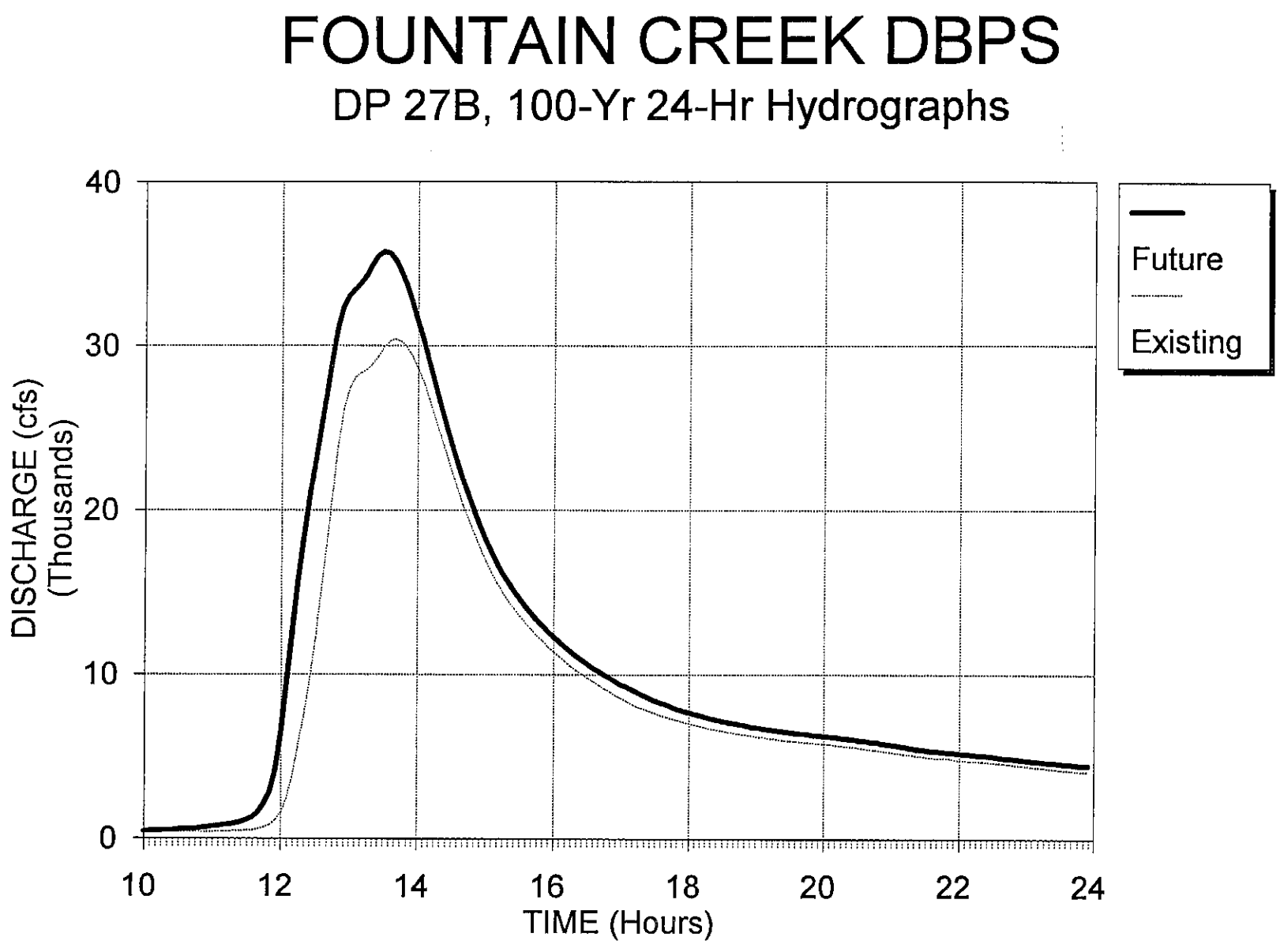

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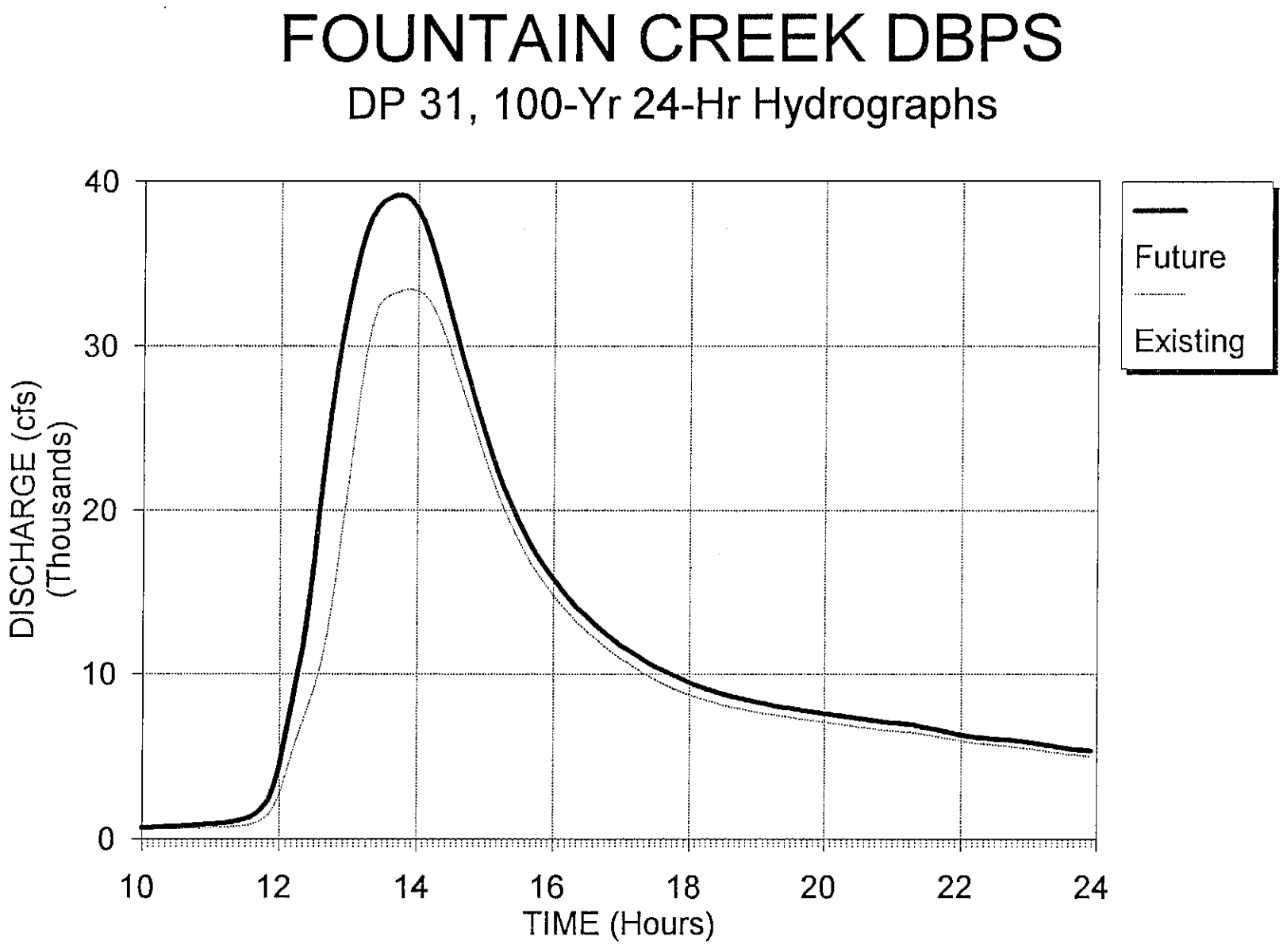
FIGURE 4.7-3



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Rainfall

A number of separate procedures for the determination of storm rainfall amounts for use in hydrologic models are outlined in the City/County Drainage Criteria Manual. The storm type used for this drainage basin study utilizes the 24-hour SCS Type II storm distribution determined to be the critical storm in the companion Monument Creek Study.

Point rainfall depths of 3.10 and 4.35 inches for the 10- and 100-year storms, respectively, were extracted from the National Oceanographic and Atmospheric Administration (NOAA) Atlas 2 precipitation-frequency maps (NOAA 1973) for the Fountain Creek area. The point rainfall amounts along with the basin size were used in the development of depth-area-duration relationships, then elliptical rainfall patterns, following the procedures presented in Hydrometeorological Reports No. 51 (NOAA 1978) and No. 52 (NOAA 1982). There has been no modification to the rainfall values to reflect the known orographic impacts of the foothills which include the reduction of precipitable moisture with increase in elevation and the breakup of storm centers into multiple smaller cells over more local areas.

Hydrometeorological Reports No. 51 (HMR 51) and 52 (HMR 52) were used in accordance with requirements set forth by the City of Colorado Springs, City Engineering Division, and are consistent with expressed opinions of the hydrology review committee and the application of this procedure in the companion study. While HMR 51 and HMR 52 were originally developed to apply to the PMS/PMF computation, for this study the procedure was applied to the 10- and 100-year frequency events by imputing the proper rainfall amounts.

The HMR 52, "Probable Maximum Storm Computation" computer program developed by the U.S. Army Corps of Engineers, was used to perform the computationally intense operations to produce basin-average precipitation isohyetal values for the elliptical pattern previously mentioned. It utilized as input the 10- and 100-year rainfall depth-area-durations computed by hand in accordance with HMR 51 and a digitized description of the drainage basin boundaries.

HMR 51 and HMR 52 were applied by delineating two drainage basins within the Fountain Creek study. An elliptical storm pattern was first developed for the Fountain Creek drainage basin upstream of the confluence with Monument Creek as shown on Figure 4.7-4 (Volume II). Initial point rainfall depths were subsequently adjusted to reflect the actual basin centroid location. The revised numbers were 3.00 inches and 4.20 inches for the 10- and 100-year storms respectively.

The second elliptical storm pattern generated was for the combined Fountain and Monument Creek drainage basins. Figure 4.7-5 shows the elliptical storm pattern placement over the Fountain and Monument Creek watersheds. Figure 4.7-6 (Volume II) shows the combined elliptical storm pattern placement over the Fountain Creek watershed in more detail. Isohyetal values and centroidal storm placement over the basins was used to determine sub-basin average rainfall values for each individual basin for input into the hydrologic model.

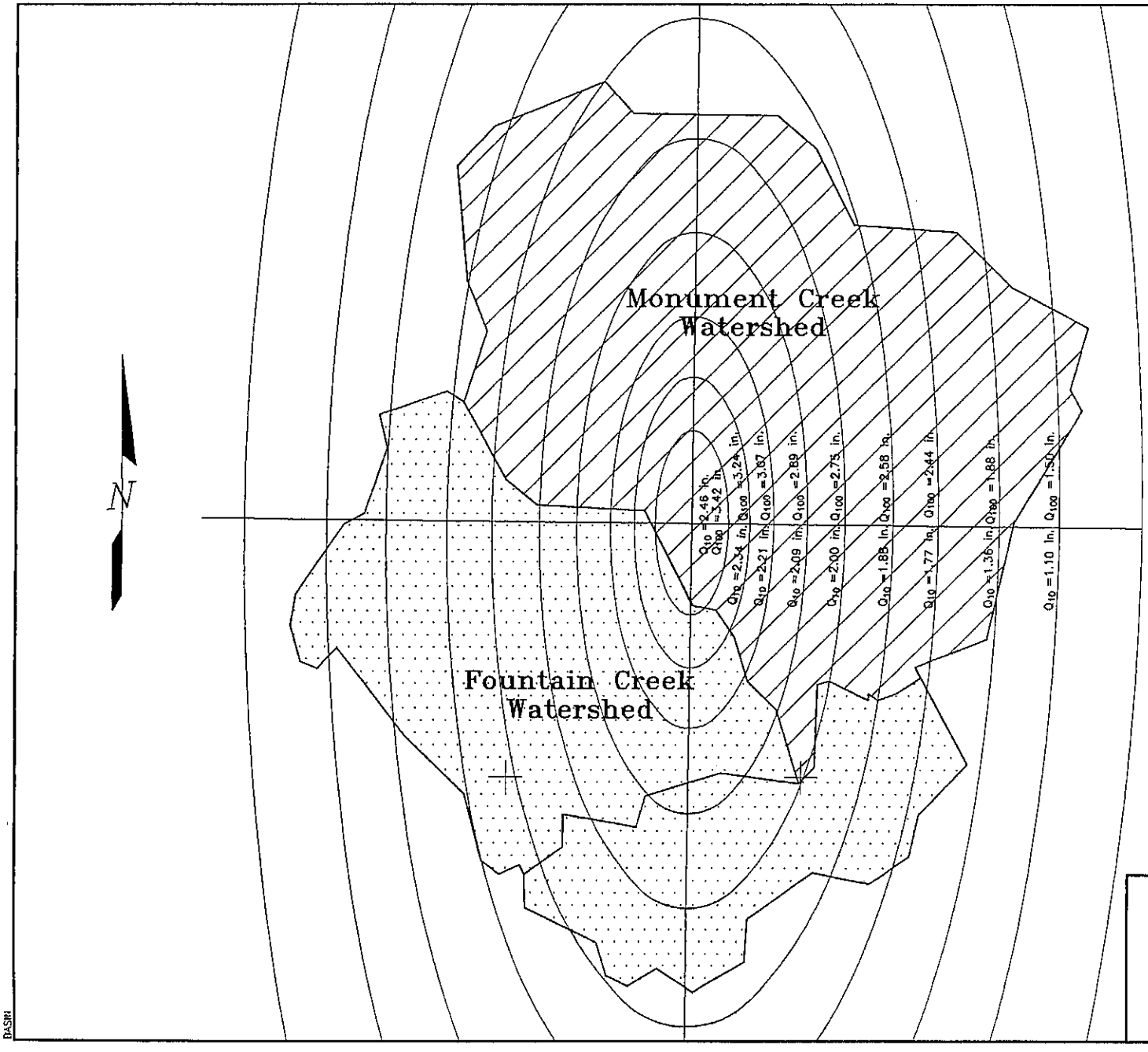


FIGURE 4.7–5

Fountain Creek DBPS

Elliptical Design Storm for the Combined Fountain and Monument Creek Drainage Basins

BASIN

Runoff

In accordance with the City of Colorado Springs/El Paso County Drainage Control Manual, the Corps of Engineers HEC-1 Flood Hydrograph computer model (September 1990) was used to develop storm runoff hydrographs for the Fountain Creek watershed. The HEC-1 model simulates the surface runoff response of a river basin to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components.

The hydrologic runoff model simulates flows on the Fountain Creek mainstream. In an effort to develop the largest runoff potential, the elliptical storm pattern was placed directly over the centroid of the watershed and aligned by procedures developed in the HMR 51 and HMR 52 calculations. With the decreasing intensities of the isohyetal with the increased distance from the center of the storm cell, flows developed from individual basins will not necessarily be the 10- and 100-year flow discharges. However, this storm placement will develop the estimates for the 10- and 100-year storms along the mainstream of Fountain Creek, which this study is to determine.

Hydrographs were developed for existing and future development conditions, with an initial storm recurrence interval of 10-years and a major storm recurrence interval of 100-years, following the SCS unit hydrograph procedure within HEC-1. This synthetic unit hydrograph method is based on a dimensionless unit hydrograph developed from an analysis of a large number of unit hydrographs for small rural watersheds. An equation for the peak discharge of a unit hydrograph is derived on the basis of the assumption that the dimensionless unit hydrograph can be represented by an equivalent triangular unit hydrograph. The rising limb of the hydrograph accounts for 35.7 percent of the runoff. The ordinates of the unit hydrograph are determined through interpolation of the dimensionless unit hydrograph curve at points defined according to the specified computational interval, which is also the duration of the rainfall excess.

Routing for six significant reservoirs was accomplished with the Modified Puls Routing Method found within HEC-1. This method applied to a reservoir consists of a repetitive solution of the continuity equation. The individual and net impact of smaller detention facilities is not reflected within the model as previously described.

The Muskingum-Cunge routing technique was chosen to route stream flow within the computer model. This routing technique can be used to route either lateral inflow from either kinematic wave overland flow plane or lateral inflow from collector channels and/or an upstream hydrograph through a main channel.

The result of the modeling process is the computation of stream flow hydrographs at desired locations and design points in the river basin. The 10- and 100-year hydrographs developed in the companion study for Monument Creek were input into the Fountain Creek analysis at the Monument and Fountain Creek confluence. The composite hydrographs are presented on Figures 4.7-1, 4.7-2 and 4.7-3, previously presented in this text.

Hydrograph Analysis

A typical hydrograph resulting from an isolated period of rainfall consists of a rising limb, crest segment, and falling limb, or recession. The shape of the rising limb is influenced mainly by the character of the storm which caused the rise. The SCS Type II storm distribution used during this study is evident in the steep slopes along the rising limb of the hydrographs developed. With the use of the SCS Type II storm distribution approximately 50% of the rainfall occurs within a one-hour period.

Computed 10- and 100-year flood flows from the Fountain Creek watershed produced relatively smooth hydrographs. The 100-year event hydrograph produced by the companion study from the Monument Creek watershed is relatively smooth, however, the 10-year hydrograph is multi-peaked with flows of 6698 cfs and 6697 cfs. Combining the hydrographs within the HEC-1 model at the confluence, the resulting hydrograph resembles the shape and smoothness of the Fountain Creek watershed hydrographs with the timing and peak flows controlled by the Monument Creek Basin.

With time 0000 representing the commencement of rainfall, the time to peak (T_p) for the Fountain Creek watershed upstream of the confluence occurs at 1345 and 1315 for the 10- and 100-year flood events, respectively. As was expected, the T_p for the Fountain Creek watershed for the 100-year event is shorter than the 10-year event. T_p values of 1310 and 1345 for the 10- and 100-year events, respectively, were shown to occur for the Monument Creek basin according to the analysis completed in the companion study. When the basins were combined the T_p for the watershed downstream of the confluence developed were 1333 and 1358 for the 10- and 100-year events, respectively.

It is interesting to note that the basin does have a characteristic of naturally attenuating peak flows as they move downstream. This is dramatically obvious from the 1965 flood on Jimmy Camp Creek which produced a peak of 124,000 cfs at its confluence with Fountain Creek, but the Fountain Creek peak at Pueblo was 47,000 cfs where the basin is 17 times as large, including Jimmy Camp Creek. This is due to both the temporal and spatial spreading of the runoff volume and the limited areal extent of even this major flood event.

4.8 REGIONAL HYDROLOGIC ANALYSES

Often individual drainage basins may have an insufficiently documented history of flooding either in information available or the period of record for which information is available. Transposition of information from other meteorologically and physiographically similar areas is a commonly accepted hydrologic technique of supplementing site-specific information with data which may be more statistically complete. This can be accomplished in a mathematically precise method such as a multiple regression analysis or a single (or composite) variable comparison such as peak flow per square mile of drainage area. This is the third hydrologic procedure utilized for this study.

Pitlick (1988) developed a "Colorado Foothills" regional flood frequency curve which can be used for developing estimated peak flows for selected frequencies based upon the statistical value of the mean annual flood. This is based upon

the assumption that streamflow gage analyses are sufficient in length to produce a reliable mean annual flood and the assumption that more infrequent flows which are not accurately represented at all gages are represented at some. His regional analysis produces the following values for peak flows at the Manitou Gage:

Q_{10} = 2.4 x 359 cfs = 862 cfs
Q_{100} = 12.5 x 359 cfs = 4,488 cfs

This method was not felt to be particularly applicable to Fountain Creek downstream of the confluence with Monument Creek due to the large percent of the drainage basin located in the high plains versus the foothills. However, the resulting peak flow values for the Tejon Gage have some relevance as another piece of information:

Q_{10} = 2.4 x 3,072 cfs = 7,373
Q_{100} = 12.5 x 3,072 cfs = 38,400

Muller (unpublished) developed an approximate regional analysis of peak historical flows on similar foothills drainage basins and, separately, on adopted design flow discharges for a similar group of streams which drain these areas. Using the peak historical flow rates experienced at these gages, which have records of from 72 to 104 years, the peak discharge in cubic feet per second per square mile varied from 25 to 102 and provided an average of 57 cfs/mi^2 (including the highest and lowest values) and an average of 54 cfs/mi^2 (without the highest and lowest values). Using 60 cfs/mi^2 as reasonably representative of a similar foothills stream at its mouth for a 100-year event produces an estimated 100-year flood peak of 6,180 cfs at the Manitou Gage. Adopted 100-year peak flow unit discharge rates per square mile ranged from 42 to 84 and provided an average of 56 (including the highest and lowest values). This provides indirect confirmation of the 60 cfs/mi^2 number described for the historical peak comparison. This evaluation is not applicable to Fountain Creek below the confluence with Monument Creek.

Among the regional hydrologic methods which were not utilized is Technical Manual No. 1 (Colorado Water Conservation Board 1976) which was judged not to be applicable to foothills streams because of the lack of such streams in the data sample used for development of this method, and the lack of recognition that such streams represent a distinct category which is neither "mountain" or "plains". The U.S. Army Corps of Engineers' unpublished hydrologic re-evaluation, for Fountain Creek upstream of the confluence with Monument Creek was not accepted by the City of Colorado Springs and therefore was also not included in this analysis.

Paleohydrologic analyses have also been utilized to estimate the peak rate of flow and related frequency from flooding evidence examined in the field. Precise numerical information is not produced by this type of hydrologic method but it can produce valuable information which in combination with other methods helps describe extreme event hydrology.

Jarrett (1987) developed unit discharge values, in cubic feet per second per square mile, based upon field paleohydrologic evaluations of maximum experienced floods or those floods which have occurred since the last ice age (10,000 year

frequency). This relationship produces the following values for peak flows at the following gages:

Manitou:
$1{,}075\ cfs/mi^2 \times 103\ mi^2 = 110{,}725\ cfs$

Tejon:
$1{,}075\ cfs/mi^2 \times 392\ mi^2 = 421{,}400\ cfs$

Using a straight-line relationship, with the mean annual flood as the second point, a linear relationship is produced as shown on Figures 4.8-1 and 4.8-2 using paleohydrologic evidence.

Jarrett (1987) also studied in detail paleohydrologic evidence along Fountain Creek and its tributaries and while little flood flow frequency numerical information was developed, the following conclusions can be reached:

1. Streams above 7,500'± show little evidence of large floods in terms of peak unit discharge per square mile.

2. Many individual basins in the elevation range of 6,000 - 7,500' show very high unit discharges per square mile but not for the same meteorologic events. This illustrates that the largest floods were caused by intense rainfall which was very localized, possibly due to orographic characteristics and other factors.

3. There is a preference for floods on basins facing southeast toward the prevailing flow of moisture.

4.9 HYDROLOGIC SUMMARY AND DESIGN FLOW RECOMMENDATION

Rationale

In consideration of the size of the Fountain Creek drainage basin, its regionally unique geographic position along the Front Range of Colorado, the site specific basin characteristics, and the lack of consistent, reliable rainfall/runoff information, no one hydrologic method can be depended upon to be uniquely correct. As such, the results of the methodologies described in the previous sections have been compiled on discharge/frequency Figures 4.8-1, 4.8-2 and 4.9-1 for the purpose of comparing the estimated 10-year and 100-year flows for each of the hydrologic index locations previously described. This provides a summary of information in a visual format which assists the responsible entity in choosing values and/or a method which is acceptable for the purposes for which those values are to be used. The following paragraphs discuss Figures 4.8-1, 4.8-2 and 4.9-1 and interpret the results of the various methods. The final section makes recommendations on design flows to be adopted.

Early in the hydrologic evaluation it was discovered that the U.S. Army Corps of Engineers, authors of the currently adopted flood peak information (used also in the FEMA flood insurance studies), consider that information obsolete and the numbers too high for the reach of Fountain Creek upstream of the confluence. The

FIGURE 4.8-1

MANITOU GAGE
FREQUENCY DISCHARGE

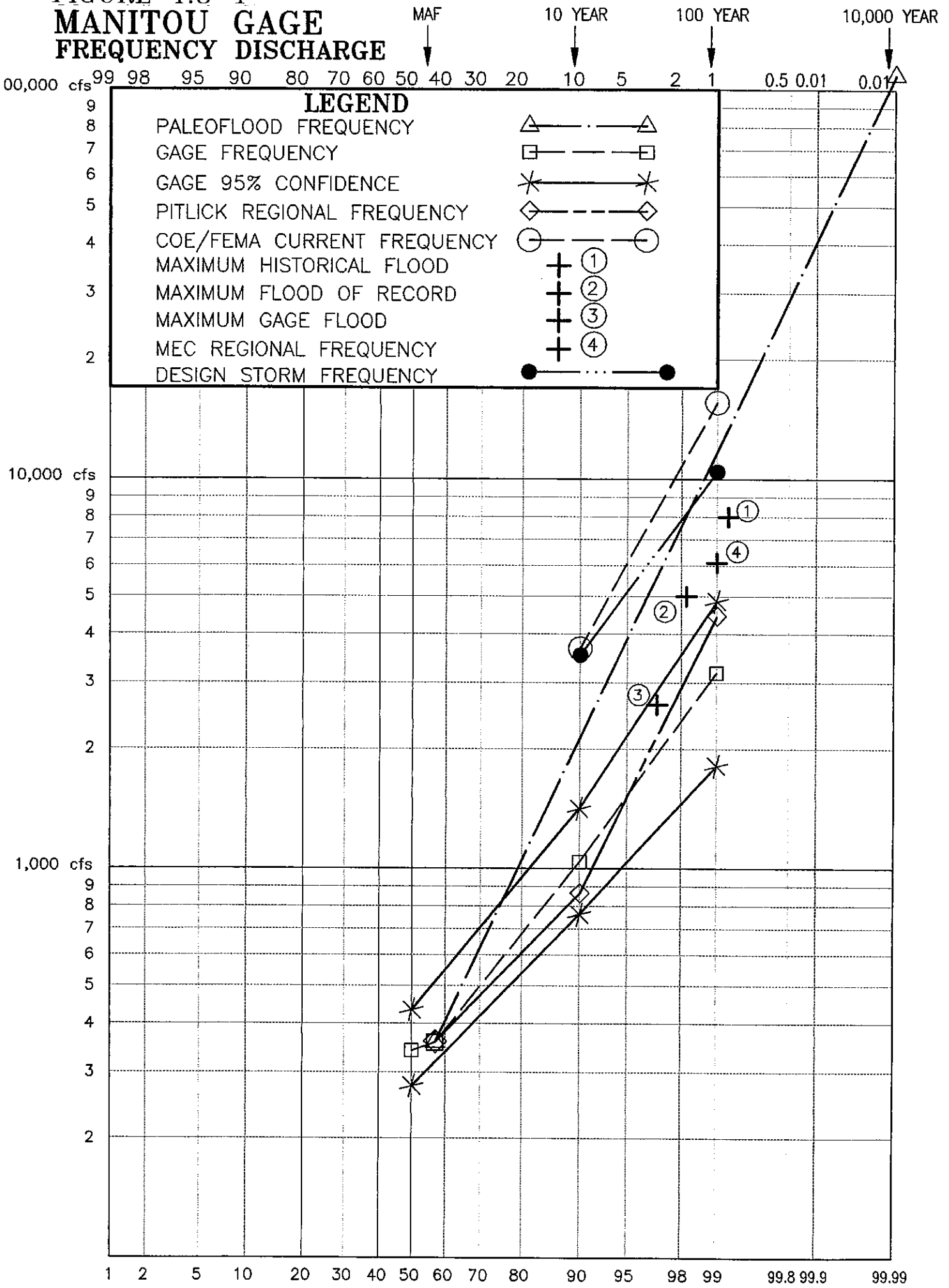


FIGURE 4.8-2

TEJON GAGE

FREQUENCY DISCHARGE

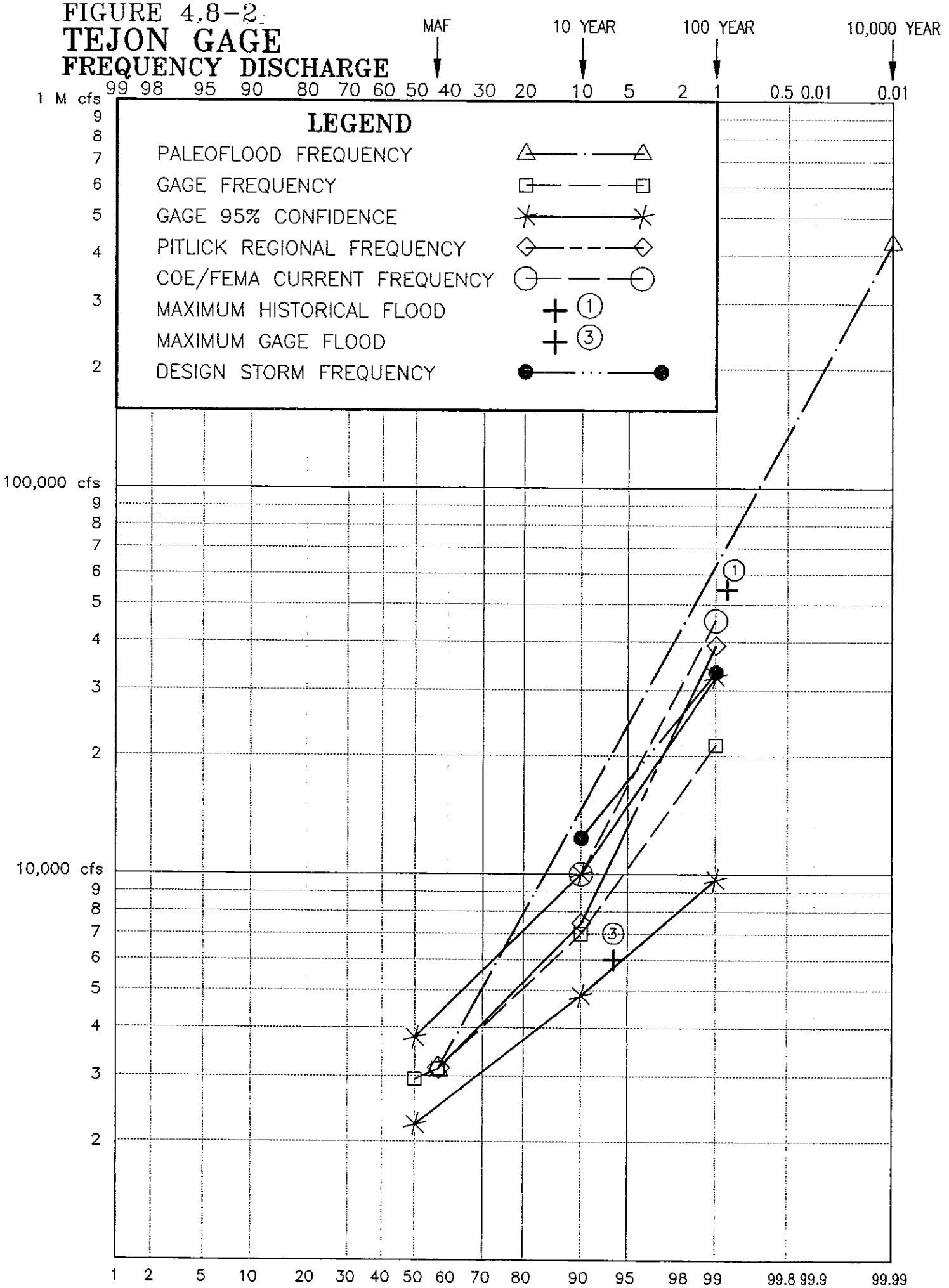
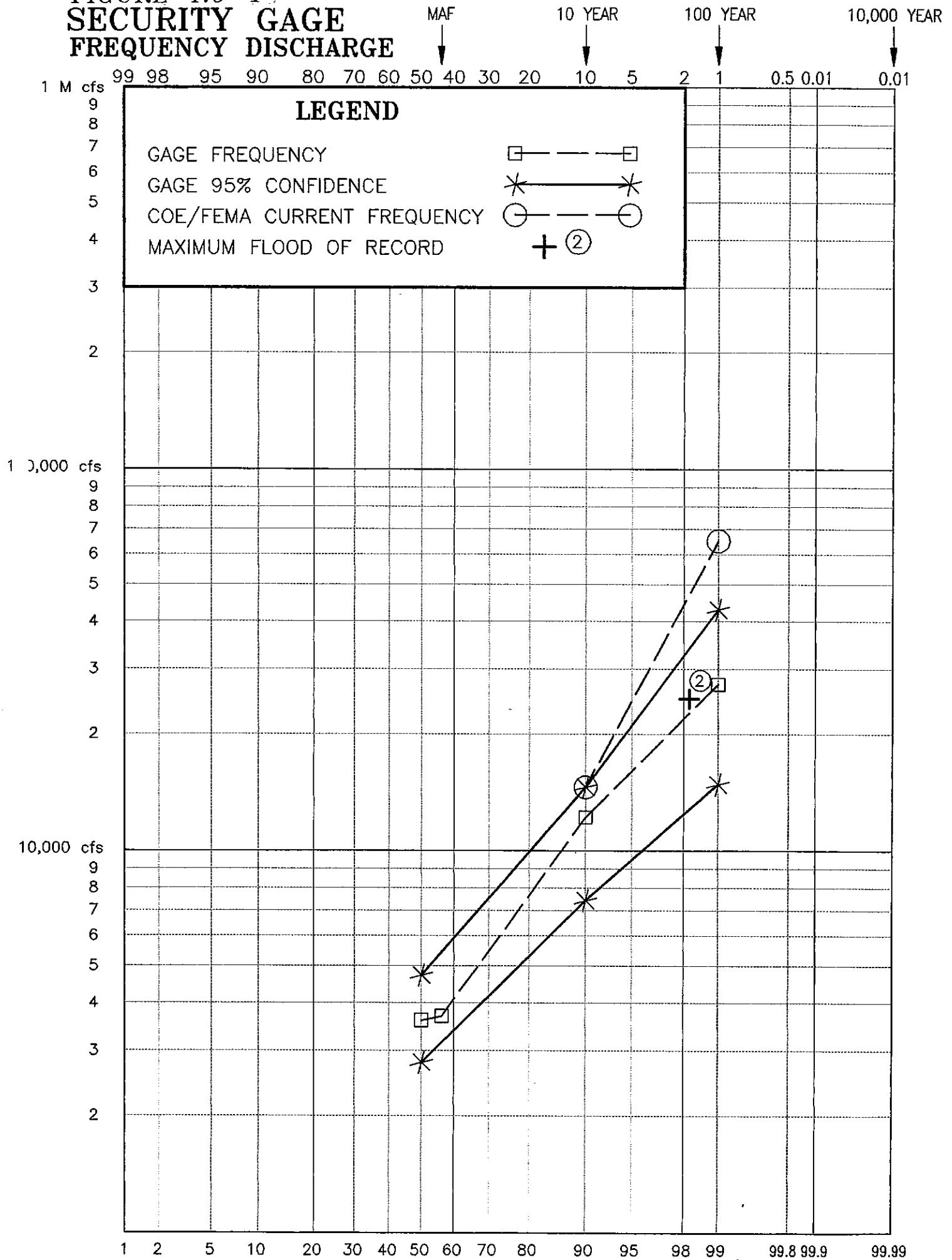


FIGURE 4.9-1

SECURITY GAGE FREQUENCY DISCHARGE



inference from this opinion is that the flows downstream of the confluence are also in question and possibly too high. The primary value of these numbers is, therefore, the consistency they provide on regulatory issues. These values and that of the paleohydrologic evaluation are judged to have the additional value of defining the upper end of the envelope encompassing the field of reasonable flow values.

The streamflow statistical analysis, for all three gaging stations, both with and without approximate values for the 1935 flood, is distinguished by the absence of high flow events. This is believed to be an inaccurate representation of the true distribution of flood events. This is partly indicated by the wide variance in numbers bracketing the 95% confidence interval (i.e. low confidence) of projected 10-year and 100-year flows. The only reliable value developed from the statistical analysis is the mean. The projected flows for the 10-year and more infrequent events are judged to be unreliable and probably represent the bottom end of the envelope encompassing the field of reasonable flow values. In addition, paleohydrologic evidence confirms that high intensity, high peak flood events have occurred historically in most individual basins, but not on a basis which is widespread enough to cause major flooding on Fountain Creek. The issue as to whether or not extreme meteorologic events can occur over a large enough area of highly variable topography remains, unfortunately, unresolved.

Regional analyses by Muller (unpublished) and Pitlick (1988) and individual experienced extreme hydrologic events occur within the envelope of values between the current adopted flow values and the statistically generated values plotted on Figures 4.8-1, 4.8-2 and 4.9-1.

Design storm methods in general are used either where gaging information is inadequate and/or where theoretical future flood peaks caused by urbanization are of interest. Typically they are not used, without calibration to "real" events, to determine design flow values for major drainageways such as Fountain Creek. Unfortunately, the absence of known frequency flood values places a significant limitation on performing such calibration accurately. Without calibration, design storm methods characteristically produce flows which are on the high side of the true values (in those rare instances where comparisons can confidently be made). This is due to the tendency of hydrologists to estimate (even by a small amount) the values of individual parameters "on the conservative side" to compensate for inadequate information or other uncertainties. Some of these design storm methods even have this conservatism embedded in the methods in order to produce numbers "on the safe side." There are many opportunities in the choice of variable values and algorithms (storm pattern, rainfall amounts, ground cover interpretation, CN estimation, routing parameters, antecedent moisture assumption, soils interpretation, etc.) for this uncertainty to become compounded with the result that numbers on the high side are produced. Even with these limitations, a design storm method (the SCS unit graph procedure in this case), can produce reasonable results if parameter values are chosen with objective care (including varying values for varying frequencies), reflecting as accurately as possible the physical realities involved. This was the approach taken herein. Figure 4.9-2 graphically shows the design future peak flows for the study reach by stream distance according to discharge.

Recommendation - Existing Conditions

From the information presented in the immediately preceding sections of this report conclusions can be reached on existing condition flow values and/or methods which come the closest to producing those values. Other considerations also enter into the process of actually deciding upon flow values to be adopted. Those include:

1. The purpose for which the flows are to be used.
2. The scientific supportability and level of uncertainty associated with the flows proposed for adoption.
3. The local government philosophy of flood control, current flood regulations and consistency/fairness in handling flood-related issues.
4. The threat of flood damage and loss of life and the effectiveness of timely flood warning programs.
5. Economic impact.

Factoring these characteristics into the decision making process is difficult and subjective, however, it is necessary to do so.

Based on the information of the previous section of this report we believe the values in Table 4.9-1 at the hydrologic index locations and the study limits are the most reasonably accurate existing conditions hydrologic peak flows which can be developed with the information available.

TABLE 4.9-1
MOST REASONABLY ACCURATE PEAK FLOW VALUES

	Design Point	10-Year	100-Year
At Manitou Gage (Upstream Study Limit)	24	2,000 (3,300±)*	9,000 (16,000)*
Upstream of Confluence	27A	2,500 (4,400)*	10,000 (20,500)*
Downstream of Confluence	27B	8,500 (9,200)*	30,000 (42,200)*
At Tejon Gage	29	9,000 (10,000±)*	33,000 (45,000)*
At Downstream Study Limit	31	9,500 (10,500±)*	34,000 (48,000)*

* Currently Adopted Regulatory Values

The design storm method produces peak flow values which approximate the most reasonably accurate values as illustrated by Table 4.7-4, which is summarized by values at hydrologic index locations and the study limits in Table 4.9-2. As can be seen from Figures 4.8-1 and 4.8-2, the design storm method produces peak flow values which are lower than the current regulatory flows but still in the upper portion of the flow frequency envelope. Based upon the results of this existing conditions flow evaluation we recommend using the design storm method, as described herein to produce design flows for use in this study.

TABLE 4.9-2
EXISTING LAND USE FLOW SUMMARY

	Design Point	10-Year	100-Year
At Manitou Gage (Upstream Study Limit)	24	3,580	10,851
Upstream of Confluence	27A	3,820	11,524
Downstream of Confluence	27B	10,857	30,456
At Tejon Gage	29	11,785	32,844
At Downstream Study Limit	31	12,226	33,480

Recommendation - Future Conditions

The design storm hydrologic analysis which was recommended in the previous section as producing the existing conditions design flows can be used to produce future conditions design flows as well. Future land use conditions reflected by modified CN values (Table 4.7-3, Appendix A, Volume III), were input to the previously described model and the peak flow values that were produced are presented in Table 4.7-5. A summary of the peak flow rates from Table 4.7-5 for the hydrologic index locations and study limits is provided in Table 4.9-3.

TABLE 4.9-3
FUTURE LAND USE FLOW SUMMARY

	Design Point	10-Year		100-Year	
At Manitou Gage (Upstream Study Limit)	24	3,994	(3,300±)*	12,274	(16,000)*
Upstream of Confluence	27A	4,264	(4,400)*	12,934	(20,500)*
Downstream of Confluence	27B	16,473	(9,200)*	35,860	(42,200)*
At Tejon Gage	29	18,134	(10,000)*	38,426	(45,000)*
At Downstream Study Limit	31	19,067	(10,500)*	39,167	(48,000)*

* Currently Adopted Regulatory Values

We recommend the values listed in Table 4.9-3 be utilized as future conditions peak flow rates in this study. Furthermore we recommend that the future conditions peak flow rates serve as the hydrology design flow values to be used for the sizing of drainageway conveyance features for Fountain Creek for this study. A diagram of peak flows from this tabulation is presented on Figure 4.9-2.

GRAPH

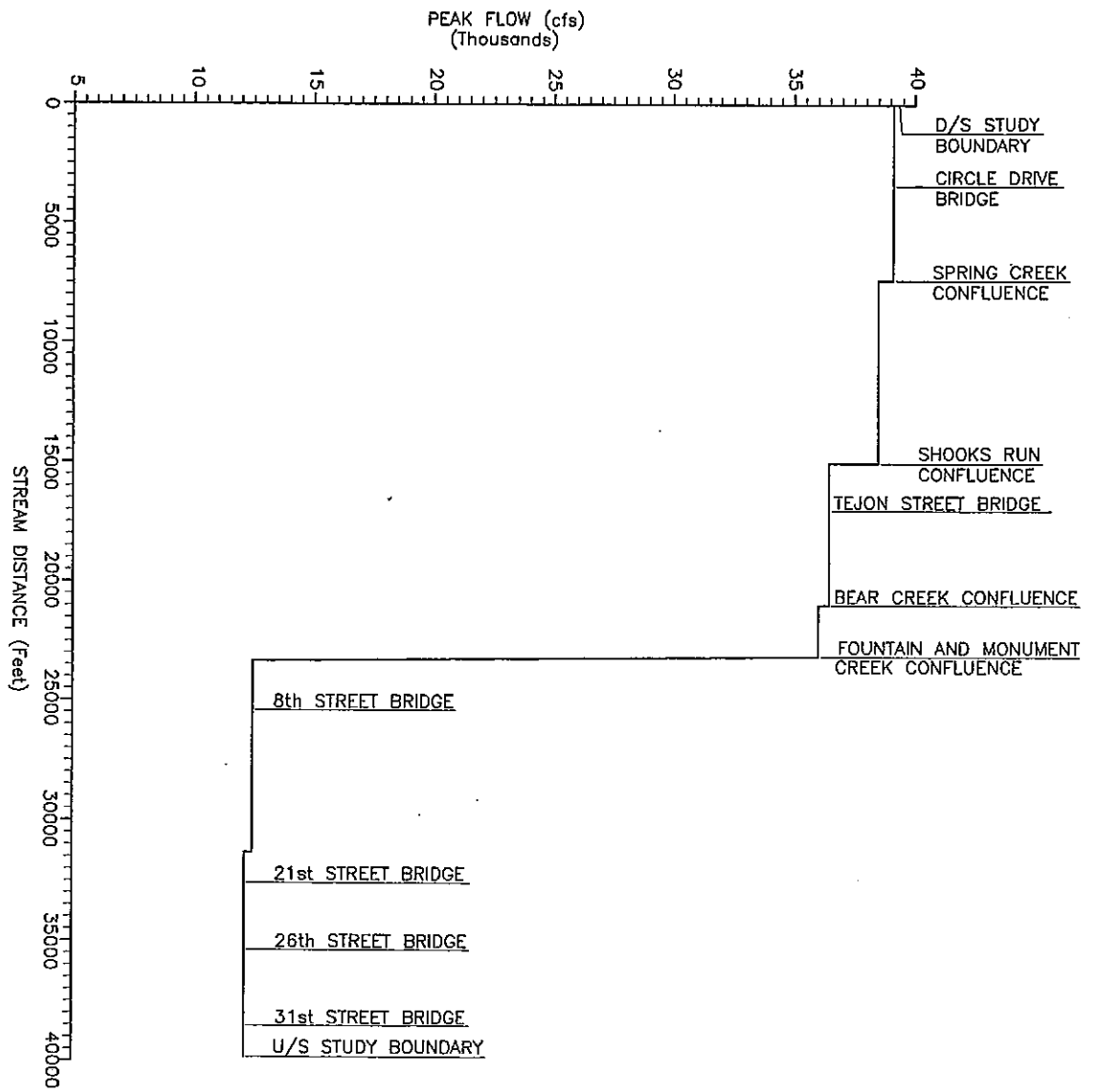


FIGURE 4.9-2

Fountain Creek DBPS

Design Peak Flow Diagram

Colorado Springs, Colorado

5.0 HYDRAULICS

5.1 GENERAL

There is a need in this planning study to evaluate the depth, velocity, distribution of flow, plan areas covered by water during flooding events and related characteristics of the water flow in the channel and overbank areas along Fountain Creek. While the hydrologic computations define the rate of flow for floods of selected frequencies at various points along Fountain Creek through the study reach, the hydraulic computations reflect dynamic conditions of the water flowing downstream as affected by the channel size, subsurface roughness, structures along the channel, channel vegetation, and similar physical characteristics. In this instance of a channel with generally sandy bed, the flowing water also has an impact on the physical form of the channel itself. This will also be addressed as a consideration in the planning process. The flood discharge values described in the "hydrology" section of this report and the physical characteristics of the creek provide the primary input characteristics to the hydraulic evaluations.

The two Corps of Engineers reports (USACOE 1973) (USACOE 1974) and the FEMA flood insurance study (FEMA 1990) were the prime sources of background information for this study. Both reports contain 100-year hydrology and hydraulics studies including descriptions of flooded areas and water surface profiles. It is important to note that the flooding information in these documents is based upon higher existing conditions peak 100-year discharges as described in the "Hydrology" section of this report.

There have been at least two major changes to this reach of Fountain Creek in the years since these flood evaluations were computed. In 1990, Janitell Road bridge was realigned and widened, and the U.S. 24 bypass is currently under construction approximately 4,800 feet upstream of Circle Drive. The hydraulics described herein reflects the effects of this new construction together with the hydraulic features which existed at the time of the referenced reports.

The impact of hydraulics on the works of man is the primary reason for the preparation of any drainage master plan. For this planning study the following are the primary items of interest:

1. Revisions (updating) of the flood profiles and floodplain limits to accurately depict the current Fountain Creek hydraulic characteristics as defined by the revised hydrologic values and the existing hydraulic features.

2. The production of information regarding likely future physical changes to Fountain Creek which are relevant to configuring alternatives to effectively handle streamflow.

3. The construction of a model which can be modified to evaluate the hydraulic effect of physical changes associated with selected alternative flow conveyance concepts including the alternative selected for implementation.

4. Determination of the flood profiles and floodplain limits which correspond to the study hydrology and the selected alternative plan provided in this study.

5.2 HYDRAULIC CHARACTERISTICS

Fountain Creek within our study limits was divided into 8 separate reaches corresponding to the designations within the "Alternatives" section of this report. This reach designation was made in accordance with concensus from the Study Group. A description of the general hydraulic characteristics in each reach is made in the following eight paragraphs.

Reach F1 extends from the County jail to Circle Drive incorporating stream stationing 00+00 to 35+00±. This reach is the only one within the study limits which remains largely an unchannelized natural riparian area. The east side of the Creek is characterized by a narrow floodplain bordered by a high bluff and is 100% undeveloped to Las Vegas Street with the exception of a power line which runs generally north-south along the top of the bluff and a major developed storm drainage outfall. The Creek has a degrading sand and gravel bed with relatively stable stream banks, a significant exposed rock outcrop on the east bank and several isolated eroded slopes. The west side of the creek is characterized by a wide floodplain, the fringe of which has been partially developed as a commercial area. There is no flooding of developed properties in this area, according to current FEMA mapping. The Circle Drive bridge span is positioned well above the 100-year flood and its piers/abutments have only a minor impact on flood levels. A sanitary sewer gravity main and a force main cross the creek at its bed level in this reach, constituting minor flow obstructions and a need for protective grade stabilization.

Reach F2 extends from Circle Drive to Shooks Run incorporating stream stationing 35+00 to 151+00±. This reach is dominated by the City of Colorado Springs wastewater treatment facility on the north bank and industrial/commercial property development as the Creek flows from the City into the County. The land use in this area has encouraged the creek to become deteriorated/neglected by pollution and solid waste problems. Extensive ledge outcrops at the streambed level with some superficial gravel covering provides a relatively stable channel bed. Several high vertical and actively eroding sand/gravel banks exist on the south and west stream bank upstream of the Spring Creek confluence. The Fountain Mutual Irrigation Company ditch diversion dam and the dam created by a degraded utility crossing immediately downstream; and the wastewater treatment facility outfall limit active use of the creek itself and adjacent riparian area. The new Janitell Road bridge, the U.S. 24 bypass and the eastbound U.S. 24 bypass on-ramp, all cross Fountain Creek in this reach. None of these new structures offer a significant floodwater obstruction. The Fountain Mutual Irrigation Company ditch diversion at the wastewater treatment facility offers an obstruction to floodwater, partially causing 100-year overtopping of I-25, and baseflow. The approximate minimum channel capacity in this reach is 3,000 cfs. The drop structure/utility crossing (abandoned) just downstream of the Shooks Run confluence bed level, the water line crossing under the U.S. 24 bypass, and the degraded, exposed utility crossing downstream of the Fountain Mutual ditch diversion are minor obstructions to floodwater and are in need of grade

stabilization rehabilitation. A pedestal supported gas main crosses over Fountain Creek under the new U.S. 24 bypass, offering a potential location for debris accumulation. A modest flooding problem exists in this reach particularly at the wastewater treatment facility and the trailer park near its downstream end.

Reach F3 extends from Shooks Run to Conejos Street (extension), incorporating stream stationing 151+00 to 197+00. This reach is entirely commercially developed. Arvada and Las Vegas Streets are low areas parallel to the Creek which are occasionally flooded. The primarily sand bed through this reach appears to be aggrading and there are no problems with exposed utilities in this reach, but there is the potential for increased flooding as a result. This reach of the stream is channelized and the floodplains have been encroached upon by adjacent development. The primary hydraulic structures in this reach are the Nevada Avenue and Tejon Street bridges. A concrete/gabion retaining wall borders the south and west bank along this reach. The Tejon Marsh, the areas largest defined wetland, lies just upstream of the Tejon Street bridge on the small north floodplain fringe. Just off the southeast end of the Drake Power Plant where its levee/railroad siding ends, the left bank is low enough to allow spatially varied flow to occur down Las Vegas Street; the flow eventually returns to Fountain Creek in the vicinity of Shooks Run. Floodwater can also spatially divert south through the Tejon Street and Nevada Avenue underpasses where flow then generally follows Arvada Street on the south side of I-25 to a point where it rejoins the main flow near the Shooks Run confluence. This flooding could occur frequently, not just every 100-years, can cause significant damage in the both overbanks.

Reach F4 extends from the Conejos Street (extension) to the confluence, incorporating stream stationing 197+00 to 234+00. This reach is dominated by the Drake Power Plant on the east and I-25 on the west. The upstream end of this reach is characterized by a severely degraded (6-feet) streambed which has exposed the Cimarron Street bridge foundations and major utility crossing above the confluence on Monument Creek. The failure of the grade control structure immediately downstream of the bridge is the cause of this degradation. At the downstream end of the north levee, spatially varied flow occurs in the next downstream reach. The sand/gravel streambed is degrading and there is a possibility that with continued degradation the existing concrete check structure may fail, and further expose the several utility crossings in the area. A high bank exists on the west side where a partially failing retaining wall protects electric transmission towers. Generally, the streambeds are relatively well protected with vegetation. There are no significantly restricting structures in this reach and no apparent flooding problems. The channel conveyance is adequate to carry 100 year flow.

Reach F5 extends upstream from the confluence to the 10th Street (extension), incorporating stream stationing 234+00 to 271+00. This reach is strongly influenced by the conditions at the downstream confluence with Monument Creek. A failed grade control structure has allowed severe degradation of bridges at Cimarron Street, I-25 access ramp, and I-25. Proceeding upstream, the north side of the Creek in this area is in heavy commercial use and the south side is occupied by roadways and commercial land use. The streambed and banks are primarily sand and the Creek is degrading having been extensively relocated, channelized and its floodplain fringes filled. The floodplain is broad,

particularly in the confluence area, and flooding of private property is significant on both sides of the Midland Expressway (U.S. 24). Several utility crossings have been exposed by channel degradation. Both the Midland Expressway and 8th Street bridges present hydraulic restrictions and cause minor spatially varied flow to occur south along the west side of I-25.

Reach F6 extends from 10th Street (extension) to the Midland Expressway crossing, incorporating stream stationing 271+00 to 321+00. This reach is dominated by the Gold Hill Mesa, which is an abandoned gold tailings pile of modest historical significance, located along the south floodplain fringe. This feature is a known source of sediment and water quality degradation. At the upstream end of this reach, there is a severely eroded 30 foot high bank and stream confluence just downstream of the U.S. Highway 24 bridge. U.S. Highway 24 borders the Creek continuously on the north. Flooding in this reach is primarily at its downstream end in the trailer park area. The slightly degraded sand and gravel bed characterizes this section of Creek that has been almost completely channelized. A single exposed utility crossing exists immediately downstream of the rock outcrop at the U.S. Highway 24 bridge. The Midland Expressway crossing at the upstream end of the reach is both positioned at an awkward skew and is a hydraulic restriction which causes minor spatially varied flow.

Reach F7 extends from the Midland Expressway crossing to 31st Street, incorporating stream stationing 321+00 to 388+00. This reach is essentially 100% developed in mixed use. The Creek has been channelized and the floodplain encroached upon on both sides. The Creek is bordered by U.S. Highway 24 on the south and by Old Colorado City on the north. The Creek has a degrading sand and gravel bed and generally steep/eroding channel banks with dumping activity apparent. Several at-grade and aerial utility crossings exist and several private bridges provide flood conveyance restrictions in the reach. Flooding of floodplain fringe properties on both sides of the Creek, including a campground, is characteristic of this reach.

Reach F8 extends from 31st Street to 33rd Street, incorporating stream stationing 388+00 to 406+00. This reach of the Creek is commercially developed on the north and is undeveloped on the south due to the presence of U.S. Highway 24 and a steep rock outcrop. The area is undergoing redevelopment yet maintains the current situation of flooding developed properties on the north. The Creek has a degrading sand and gravel bed with a very narrow riparian fringe along rubble/debris covered banks. The redevelopment contains channel enhancements for floodwater conveyance and channel bottom enhancement. This reach is undergoing a transition to vertically walled structural banks with an internal rock lined low-flow channel and rock drop structures. Downstream of 31st Street, an exposed concrete encased sanitary sewer line acts as a grade control structure over the lower portion of the reach.

A complete inventory of drainage facilities from bank to bank and in three distinct sheet flow areas was accomplished as part of this work and that information is found in Volume III.

5.3 METHODOLOGY

The hydraulic calculations, are accomplished by developing mathematical descriptions of the river's physical characteristics, then combining these with algorithms which describe the dynamics of water movement. This was done in computer model HEC-2 (USACOE 1990). HEC-2 calculates water surface profiles for steady, gradually varied flow. This computational procedure is based on the solution of the one dimensional energy equation with energy loss due to friction evaluated with Manning's equation, generally known as the standard step method. HEC-2 can be configured to model existing physical conditions theoretically or through calibration, and can be used to evaluate the impact of conceptual improvements such as channel alterations, use of levees, etc.

Several key discriptors of physical characteristics are input in mathematical form. Stream cross sections perpendicular to the stream flow are input in horizontal and vertical digital coordinate form. Cross section locations are chosen to define special or average hydraulic conditions, and to separate reaches with distinctive flow regimes. They are dimensionally connected by use of a common vertical datum and input of channel and overbank distances. The digital cross section information for Fountain Creek was obtained from the City of Colorado Springs "Facilities Information Management System" (FIMS) mapping and field surveyed cross sections at selected locations. The maximum cross section spacing is approximately 800 feet, and an average of 13 cross sections per mile of stream was used. Regular geometric cross sections can be represented by a mathematical algorithm. Besides the geometry reflected by each cross section, mathematical representations of the physical characteristics which help describe the dynamics of flow are also needed. Numerical values are used to reflect the surface roughness or resistance to flow at each location represented by a cross section. The Manning's "n" value is used in this method to reflect the representative roughness at each cross section. That roughness was estimated by using two stepwise methods (CHOW 1959) (SCS 1956) to account for the incremental roughness due to each physical characteristic. The composite roughness was then checked for physical reality against actual field values (Barnes 1967) and the information from current research (Trieste 1987). The final roughness parameters vary from 0.045 to 0.065 in the channel, 0.045 to 0.155 in the left overbank, and 0.045 to 0.20 in the right overbank. The magnitude of the physical changes from one cross section to the next are reflected by input coefficients for weirs, contraction/expansion, orifices, etc.

These hydraulic characteristics are listed on the HEC-2 input data tabulation of card images, an example of which is presented in Appendix B, Volume III. The calculations of the Manning's "n" roughness coefficients are also presented in Volume III.

5.4 HYDRAULIC ANALYSIS

The physical characteristics of the drainageway and the peak rates of flow produced from the watershed constitute the two primary groups of data input for the HEC-2 computer model (USACOE 1990). HEC-2 gradually varied water surface profiles were computed for the current physical conditions and the conditions with the future improvements as proposed per the preliminary plan (Section 7) based on future 10- and 100-year peak discharges (Table 4.9-3). The floodplain

limits and water surface elevations determined by this study for the existing and future conditions were not significantly different from one another. The primary differences between the two conditions were associated with the enlargement of the Midland Expressway bridge near 21st Street and the removal of the 25th Street bridge and campground bridge near 31st Street for the future conditions. The HEC-2 summary output tables of the future and existing conditions are presented in Appendix B, Volume III.

These water surface profile computations were not significantly different than the current (USACOE 1973) (USACOE 1974) regulatory floodplain information. The difference for the 100-year event was a small reduction, which was primarily due to the lower (77% to 82% of the USACOE) flow rates. For the 10-year flows, there was an increase in the flood limits and elevations which was primarily due to the higher (121% to 182% of the USACOE) flow rates.

Moreover, there were no significant differences between the existing regulatory flooding areas/elevations and those which result from this study's evaluation in-so-far-as the prospective configuration of the alternatives was concerned. Restrictive bridges remain, spatially varied flow still occurs off Las Vegas Street, overbank flow still occurs on Upper Fountain Creek due to restricted channel capacity, and most other flooding characteristics were only modestly different. The 100-year floodplain limits of the future physical conditions, and the existing conditions where noncoincident with future physical conditions are presented in Figure 7.2-2, Volume II. Profile depictions are presented in Figure 7.2-3, Volume II.

5.5 SEDIMENT TRANSPORT/EQUILIBRIUM SLOPE ANALYSIS

For the past century, Fountain Creek has been affected by greater than normal erosion rates, which is believed to have begun in the late 1870's as a result of agricultural development. In the last 40 years, the study reach of Fountain Creek has been largely replaced by urban development that has caused impediments or redirection of flow by the encroachment of residential, industrial development and its associated various channelization structures. These changes in land use have affected the equilibrium of the stream as is evident in the active aggradation and degradation of the streambed.

The U.S. Geological Survey prepared two reports for the Colorado Springs, Department of Utilities in 1989 that studied the sedimentation effects in the Fountain Creek drainage basin upstream from Widefield, Colorado, which is approximately 3 miles south of Colorado Springs. The first report, Suspended Sediment and Sediment-Source Areas in the Fountain Creek Drainage Basin, Water Resource Investigations Report 88-4136 (USGS Report 88-4136 1989), identified the suspended sediment concentrations and yields, and sediment-source areas by a network of 24 synoptic sampling sites in the basin. The second report, Sediment -Transport Characteristics and effects of Sediment Transport on Benthic Invertebrates in the Fountain Creek Drainage Basin, Water Resource Investigations Report 89-4161 (USGS Report 89-4161 1989), defined the sediment-transport characteristics and the effects of sediment-transport on benthic invertebrates in Fountain and Monument Creeks through data collection at seven sites from 1985 through 1988.

Samples collected from the two studies indicate that the median grain size of the bed-material was very coarse sand to small cobbles, and the median grain size of the bedload was coarse sand to very fine gravel. The measurements of the grain sizes taken at the sites within the study reach were used in this study in determining the average sediment size distribution for the sediment-transport analysis.

The bed material transport capacities of the existing stream corridor conditions were analyzed using a procedure that incorporates the Meyer-Peter, Mueller equation for determining the bed loads with a revised Einstein procedure for determining the suspended loads. Computations were made at 100 cross sections along the stream corridor at approximate 400 foot intervals. These computations of the bed material transport capacities were then summarized for each reach of the eight study reaches. Table 5.5-1 presents the summary of the bed material transport capacities for reaches 1 through 8 under 100-year, 10-year, and average annual floods for the existing-stream conditions. The table also distinguishes whether the reaches are subject to degradation or aggradation.

TABLE 5.5-1
SUMMARY OF SEDIMENT TRANSPORT ANALYSIS
EXISTING CONDITIONS

LOCATION	100-YEAR (CUYD)	10-YEAR (CUYD)	AVERAGE ANNUAL (CUYD)	DEGRADATION AGGRADATION
REACH 1	94,690	27,549	7,757	DEGRADATION
REACH 2	85,146	26,602	7,396	DEGRADATION
REACH 3	23,662	4,355	1,357	AGGRADATION
REACH 4	50,777	15,018	4,216	DEGRADATION
REACH 5	24,596	3,951	1,278	AGGRADATION
REACH 6	23,650	5,140	1,537	DEGRADATION
REACH 7	21,814	3,735	1,186	AGGRADATION
REACH 8	46,306	8,134	2,565	DEGRADATION

Degradation and aggradation are the long-term vertical downcutting or raising, respectively, of the river which can occur from natural or man induced changes, such as urban development and flood control measures. Quantitative analysis methods using equilibrium concepts have been formulated to provide insights into the behavior of a river system. One such method is the "Equilibrium Slope Analysis."

The equilibrium channel slope is defined as the slope at which the channel's sediment transporting capacity is equal to the incoming sediment supply. Under this condition, the channel neither aggrades or degrades. When the existing slope of the channel is greater than the equilibrium slope, the channel will degrade in order to reach its equilibrium slope. The equilibrium slope analysis was used as one form of information in this study to help determine what measures were needed to stabilize the effects of degradation and aggradation of the stream bottom. Table 5.5-2 presents the summary of the equilibrium slopes for reaches 1 through 8 along with the associated bed material transport capacities for the 100-year, 10-year, and average annual flooding events.

TABLE 5.5-2
SUMMARY OF SEDIMENT TRANSPORT ANALYSIS
EQUILIBRIUM SLOPE METHOD

LOCATION	100-YEAR (CUYD)	10-YEAR (CUYD)	AVERAGE ANNUAL (CUYD)	EQUILIBRIUM SLOPE
REACH 1	48,311	15,467	4,282	0.0072
REACH 2	58,027	14,385	4,179	0.0072
REACH 3	40,768	7,878	2,424	0.0072
REACH 4	26,172	10,227	2,745	0.0072
REACH 5	35,849	5,238	1,742	0.0153
REACH 6	20,495	5,912	1,667	0.0123
REACH 7	26,823	4,976	1,547	0.0153
REACH 8	19,865	5,118	1,475	0.0125

Sediment transport is greatly affected by the water velocities. Observations in the field reveal that aggradation has occurred in isolated areas of the channel when large floods overtopped the channel banks and the sediment laden water slowed. In some circumstances this sediment will deposit at a hydraulic structure and reduce its conveyance capabilities. During these instances, the stream velocities decreased causing the stream to aggrade. These isolated areas of aggradation will eventually be transported downstream during the next large flood. Resolving this phenomenon is a very complex topic that has not been studied in detail. Alluvial channel systems are dynamic and experience significant changes in depth, width, alignment and stability with time, particularly during floods of long duration.

This sediment transport evaluation is based upon the assumption that Fountain Creek has a mobile streambed with bed movement dependent upon flow rate and particle size. However, the streambed of Fountain Creek through the study reach is in a transition from the classic rigid mountain drop/pool type stream to the truly fully mobile bed type stream reflected by the preceding calculations. The presence of occasional rock outcrops, both natural and human placed larger streambed material, and periodic instream structures are significant interruptions to the development of a true equilibrium slope. As such Table 5.5-2 offers primarily a guide for the evaluation of the stability of bed material in each reach, for use in the alternatives evaluation and for presentation of the selected alternative preliminary plan. These characteristics may include local permanent gradient control features, a tendency of local reaches to progressively develop a streambed armor versus an equilibrium slope, streamflow characteristics, etc.

Sediment movement is also an element of streambed stability. Since this study addresses the main channel of Fountain Creek and the primary sources of sediment are upstream, tributary basins, there is little opportunity to address sediment sources. Stream gradient control, bank erosion protection and the remediation of "Gold Hills Mesa" feature located immediately adjacent to Fountain Creek are several of the sediment control activities which will be addressed as a part of the following alternatives evaluation and presentation of the selected alternative preliminary plan.

6.0 ALTERNATIVE DRAINAGE PLANS

6.1 EVALUATION CRITERIA

General

An integrally key element of the planning study was the configuration of alternative development plans from which to choose a single most acceptable plan for preliminary design. This involved a lengthy interactive series of discussions and evaluations within the City/Consultants Teams and the Study Group. It addressed such issues as the idea of a central river corridor theme, the evolution of "opportunities and constraints" from the resource inventories, the development of criteria to use in the configuration and review of alternatives, the consideration of alternatives in sections by "reaches" or "rooms", the configuration of individual alternatives by selecting components from a menu of list of possible treatment techniques, and consistency of alternative scenarios between reaches and related topics.

Criteria Development/Use

The basis for formulating the alternatives and reviewing them was developed before the commencement of this drainage basin planning study. The first is the statement of the City's planning "goals and policies" which is reprinted in Appendix C, Volume I. The second was a set of broad goals defined at the local 1990 Stormwater Management Workshop as:

- Provide recreational and social benefits
- Assure public safety and welfare
- Maintain and enhance aesthetics
- Aid in control of pollution/enhance water quality
- Maintain a high level of benefit to cost
- Promote community development
- Protect and enhance aquatic environment and adjacent riparian and upland ecosystems

In January and February of 1992 these were revisited with the intent of formulating, first a set of goals for this study and the companion Monument Creek study and second a more detailed use of objectives for each goal. This list of "goals and objectives" was used to configure alternatives then to review them. The "goals and objectives" were the subject of discussions and progressive refinements to the point where they were accepted for use at the July 7, 1992 Study Group meeting. They are reprinted for reference purposes in Appendix C, Volume I.

In August of 1992 the list of "goals and objectives" was modified to serve as a list of rating criteria for use in evaluating the alternatives on a common basis. An example of this list with circles which can be filled in to reflect; fully satisfies criteria (solid circle), partly satisfies criteria (half solid circle), does not satisfy criteria (empty circle) or not applicable (circle with a line through it) is provided in Appendix C, Volume I.

6.2 ALTERNATIVES CONFIGURATION

General

The configuration of alternative drainage improvement plans proceeded in parallel with the development of evaluation criteria. This process also began early in 1992 at a point in the study where the resource inventories and hydrologic study were in progress. As information became available, it assisted the City/Consultants Team and Study Group to progressively refine alternative concepts into a workable number which reasonably represented the range of options available.

Alternatives Development Process

The process began with discussions of individual identified drainage deficiencies and the Creek's existing physical characteristics through use of typical cross sections. The earlier described resource inventories provided complimentary information for a holistic perspective of the Creek. This helped categorize the Creek into consistent "rooms" or "reaches" and helped develop the definition of typical design treatments to deal with the needed improvements.

As the resource inventories were completed and combined, a composite picture of "opportunities and constraints" evolved as the basis for developing the alternatives. The preparation of the composite "opportunities and constraints" work maps were completed in June of 1992 by which time the Study Group had already been involved in the alternatives development process. In the process of defining creek reaches it became clear that their unique characteristics defied having a common set of alternatives for all the reaches. The tentative "reach specific" alternatives were defined by the City/Consultants team and presented to the Study Group on July 7, 1992. These alternatives consisted of a "no action" option for all reaches, a full development option for most reaches, a rehabilitative maintenance option for most reaches and a natural creek option for most reaches. A sprinkling of reach specific options including levees, floodproofing, etc. completed the alternative options. These were then described in tabular form, presented to the Study Group and revised reflecting relevant suggestions. The final list of alternatives which were developed using this process are described in Tables 6.2-1 thru 8 of Appendix C, Volume I. The alternatives described in narrative form were then illustrated in cross sectional form as shown on Figures 6.2-1 thru 8 of Volume II. The elements of the alternatives were illustrated in plan view (Figure 6.2-9 of Volume II) using an "ICON" system of identification of standard design treatments. These details and their associated icons are illustrated on Figure 6.2-10 of Volume II.

6.3 ALTERNATIVES ANALYSIS

General

The configured alternatives have one primary common characteristic. That is the handling of peak flow rates through the respective reaches. It shall be noted here that conveyance capacities can be reduced by the redistribution of the rainfall runoff in time to reduce the peak flow rate. This "detention" or

"retention" of stormwater was addressed before proceeding with the analysis of the conveyance alternatives.

Alternatives were evaluated considering primarily cost and non-cost criteria. The cost criteria included the construction elements of the conceptual alternatives, and the non-cost criteria included the management elements of the environmental and administrative issues of the stream corridor. These elements when incorporated together with the goal being to help preserve and enhance the stream corridor as an amenity to the City.

Hydraulic Attenuation

General

Attenuation of peak flow rates experienced in drainageways can be accomplished by the use of detention or retention facilities, which are usually surface ponds. Detention facilities are designed to temporarily store a volume of water from the peak of a hydrograph and discharge it at a later time, thereby reducing the peak flow rate. Retention facilities store all water they receive up to a certain point, then discharge the remaining flow as it is received. The stored water evaporates, infiltrates or remains in the pond, but does not discharge directly back to the drainageway. As detention ponds (with or without a permanent pool of water) are most common, we will primarily be referring to this type of facility in the remaining narrative. This attenuation can be accomplished on a local, on-site basis where only conveyance facilities and properties in the immediately downstream vicinity of the detention pond are impacted; or on a regional basis where an off-site pond is positioned to reduce the flows experienced by many properties located an extended distance downstream.

Local Detention

It is a well established fact that the process of urbanization leads to an increase in both the volume and rate of rainfall runoff. According to the Colorado Springs Drainage Criteria Manual (Colorado Springs 1987), detention storage of runoff is one of several acceptable methods of stormwater management. The manual describes detention storage as characterized by collection and storage of excessive runoff to mitigate local flooding hazards.

Detention is not required, but is one of several techniques which can be used. Local detention of stormwater is provided primarily to reduce peak flow rates sufficiently so that floodwater can be conveyed to a receiving waterway with a minimum of investment in new conveyance facilities.

With this concept, locally detained water reaches a receiving waterway at a different timing and peak flow value than it would without detention. This has an impact on the flow pattern of the receiving waterway. The impact is inadvertent in that the local detention was provided to change local conveyance facility flow characteristics, not those of the main stream. The flow pattern of the mainstream is that which evolves as the composite of many detained and undetained flows from all the individual contributing areas. These combine in a manner which is uncontrolled and complex. The use of local detention to reduce discharges for the main drainageway is therefore ineffective and depending on the

situation could actually increase peak discharges in the drainageway. In general, the fewer detention facilities covering the greatest land area produces the most reliable and effective results. However, since these facilities are not designed to function in unison, any attenuation is accidental and highly dependent on local rainfall distribution. A Denver Regional Study on Detention Policies (Urbonas 1983) concluded that local detention ponds are largely ineffective in adequately controlling flows on downstream drainageways. Furthermore the practice of the Urban Drainage and Flood Control District is to not consider the detention effect of facilities which have no responsible, organized operating entity, in the estimation, planning and design of peak flow rates. Even local detention facilities which are owned and operated by responsible entities have a poor record of adequate maintenance, have eutrophication characteristics, insect and weed growth problems, lack proper control, etc. In some instances they are poorly built, never built, intentionally filled in, filled with sediment, or otherwise rendered ineffective by adjacent new construction. This coincidental impact of local detention on receiving water flows can not be relied upon to provide any significant modification to flows which will occur in the future.

With flows on Fountain Creek as the primary item of interest, it is obvious that local detention can not be considered a reliable alternative for flow attenuation. Secondary benefits of local detention do exist, including water quality and ecologic enhancement, but these are largely unproven and subject to some of the same limitations as is water quantity handling. At present there is no water quality enhancement component to the City regulatory process. Regional detention affecting entire basins which involves numerous properties under private and public ownership offers the best possibility for achieving effective stormwater peak attenuation.

Regional Detention

Regional detention is a subject which has received consideration in this drainage basin previously. The most in-depth evaluation was a study completed approximately ten years ago by the U.S. Army Corps of Engineers. A basin-wide search for feasible detention facility sites produced two possibilities which were considered in more detail. These were sites located one mile upstream of Crystola with a drainage area of 4.2 square miles and a storage capacity of 250 acre feet; and 3,000 feet downstream of Crystola with a drainage area of 9.3 square miles. They concluded that the 100-year peak flow reduction on Fountain Creek in the Manitou Springs area varied only from 5-17% as a result of constructing either or both of these flood control reservoirs. This was not significant enough an impact to warrant further consideration of a regional detention alternative.

The potential effectiveness of regional detention can also be ascertained by evaluating the attenuation impact of existing reservoirs. As an example, the mathematical image of the Crystal Creek Reservoir, which has a drainage area of 4.5 square miles and provides incidental detention during a 100-year flood event, was removed from the hydrologic model. The impact of this modification was an increase of the 100-year peak flow rate at the Monument Creek confluence with Fountain Creek of only 19 cfs; indicating a negligible attenuation impact of this large 3,500 acre foot reservoir.

An independent conceptual evaluation of prospective detention pond or flood control reservoir sites was conducted as a part of this study, emphasizing the area upstream of the Monument Creek confluence with Fountain Creek. The Fountain Creek valley is steep, narrow and extensively developed with roads and building structures making it difficult to locate undeveloped areas which would be a good dam site and would have sufficient storage volume. If placed along Fountain Creek, any dam higher than 30-feet± would require relocation of U.S. Highway 24. In order to have a significant attenuation impact on stream flows in the developed area from Manitou Springs through Colorado Springs, a regional detention facility would have to be located on Fountain Creek itself and as close to the west edge of Manitou Springs as possible. No feasible sites with these characteristics were identified. As a response to recent inquiries, the Corps of Engineers and the City both indicated they are also not aware of any good potential sites. A similar review of sites downstream of the confluence was conducted. A dam on Fountain Creek is infeasible due to a lack of suitable sites, its prospective position in the middle of the protection area, and the extent of existing development. Few sites exist on the side tributaries and those provide control over such small drainage areas that their prospective impact on main stream flows is negligible.

To illustrate the maximum possible attenuation of flows through Colorado Springs, an infeasible location (due to the displacements of people and structures required) and an infeasibly high dam at the east edge of Manitou Springs could detain the 100-year flood thereby reducing the flows downstream of the confluence by only 32%. Such a project is not likely to remove more people from flooding than it displaces by its construction and would cost in excess of $30 million.

In conclusion, no suitable dam/reservoir sites were located that would provide a reasonable level of downstream flood protection at a reasonable cost. In addition, any such facility would be unlikely to meet such criteria as having an acceptable level of ecologic disturbance, an acceptable extent of property acquisition and relocations or a justifiable loss of land which is more valuable for other purposes.

Review of Attenuation Options

Neither local or regional detention are physically or economically viable as independent alternatives to provide flood protection along Fountain Creek through peak flow reduction. It seems most logical to maintain the current local detention practice, applying it uniformly, in order to provide local attenuation of peak flood flow rates, understanding that this policy is unlikely to significantly reduce flow rates on Fountain Creek itself. It is also suggested that, detention facilities, when they are justified, be built as large as feasible, few in number and also serve as a water quality function.

Evaluation

Cost

Following the final development and description of the alternatives, an extended period of analysis, review and presentation of results occurred. Sizing, quantity takeoffs and unit pricing provided the input information to estimating conceptual level accuracy cost estimates.

An analysis was made of the construction costs associated with each of the different conceptual alternatives evaluated for the eight reaches along Fountain Creek. Cost estimates were prepared for conceptual planning purposes to identify the relative differences in construction costs between alternatives. These estimates will be evaluated as part of the alternative selection process discussed in the following section of this report.

The cost estimates were prepared to address the drainage improvements outlined in the Alternative Description Matrices (Tables 6.2-1 through 6.2-8 in Appendix C, Volume I), and reflect the drainage related construction items depicted on the Alternative Plan Drawings (Figure 6.2-9 in Volume II). Associable costs for park, open space, and clearly non-drainage related improvements were not included in the cost estimates; it was assumed that these costs would be separately estimated at a later date when the scope of work for these improvements were more defined.

The alternative construction cost estimates are presented on Tables 6.3-1 through 6.3-23 in Appendix C, Volume I. Cost estimates for the No Action Alternatives were not prepared, as the initial capital construction cost is zero. Each alternative cost estimate includes allowances for mobilization, unlisted items, and contingencies. Mobilization was estimated as 5% of the total costs, unlisted items as 10%, and contingencies as 25%.

Costs for the construction items were estimated using the unit prices in Table 6.3-24, and quantities were calculated using the cost equations on Table 6.3-25. The intent of the estimated costs was to provide a sufficient degree of accuracy to allow a comparison to be made between alternatives. However, after the preferred alternative is selected, the preliminary plan will refine further the costs for the plan to be implemented.

TABLE 6.3-24
UNIT PRICES USED IN CONSTRUCTION COST ESTIMATES
(OCTOBER, 1992 ENR CCI 5052)

IMPROVEMENT	UNIT	UNIT COST
Site Preparation	SF	$ 0.50
Structural Excavation/Fine Grading	CY	5.00
General Embankment	CY	5.00
Structural Backfill	CY	10.00
Riprap/Boulders (including filter fabric)	CY	45.00
Gravel Bedding/Backfill	CY	25.00
Concrete-Flatwork	CY	200.00
Concrete-Structural	CY	250.00
Grout for Boulders	CY	120.00
Revegetation-Riprarian	SF	0.50
Revegetation-Dryland	SF	0.25
Trail Bridge	SF	50.00
Road Bridge	SF	70.00
Utility Relocation-Major (including mobilization)	LF	250.00
Utility Relocation-Minor (including mobilization)	LF	100.00
Land Acquisition	SF	0.32 - 2.80

Notes:

1) Unit costs do not include allowances for engineering, administrative, or contingency costs.

2) Base information was provided by CH2M Hill in coordination with the Fountain/Monument Creeks Drainage Basin Planning Studies.

3) Based on land use and floodplain location. Prices reflect 1993 value of 1996 property values as stated in February 17, 1993 letter from City of Colorado Springs to CH2M Hill.

TABLE 6.3-25
CONSTRUCTION COST EQUATIONS (1)

Improvement	Variable(s)	Equation
Vertical Structural Drop	Height, crest length	Cost ($) = (6 × H + 60) × (L + 60) × (2.5/27) × ($110) + (3 × H) × (6 × H + 60) × ($250/27) + ($10,000 × H)
Sloping Boulder Drop	Height, crest length	Cost ($) = (7 × H + 60) × (L + 60) × 2.5/27 × ($110) + ($10,000 × H)
Baffled Drop	Height, crest length	Cost ($) = 7,834 × (H^0.195) × (L^0.492)
Riffle Drop	Height, crest length	Cost ($) = (18 + 12 × H) × 2.5 × (L + 20)/27 × ($45) + (34 + 12 × H) × (L + 20) × ($0.75)
Riprap Bank Protection	Height, length	Cost ($) = [(H + 2) × 2 × 2 + (7 × 2/2)]/27 × ($45) × L
Concrete Bank Protection	Height, length	Cost ($) = [(H + 3) × 2 × 0.5/27 × ($250) + 10.5 × 3/2/27 × ($45)] × L
Eroding Bank Stabilization (Concrete Wall)	Height, length	Cost ($) = H × L × ($45)
Vertical Bank Loading (X5)	Height, length	Cost ($) = [(H^2) × 3/2/27 × ($5) + (3 × H + 10) × ($0.50)] × L
Levee	Height, length	Cost ($) = [((H^2) × 3 + 15 × H)/27 × ($5) + (2 × 3 × H + 15 + 20) × ($0.50)] × L
Enhancement of Riparian Vegetation	Length, width	Cost ($) = L × W × ($0.50)
Screening Vegetation	Length, width	Cost ($) = L × W × ($1)
Pedestrian Bridge	Length, width	Cost ($) = L × W × ($50)
Road Bridge	Length, width	Cost ($) = L × W × ($70)
Utility Relocation (major)	Length	Cost ($) = L × ($250)
Utility Relocation (minor)	Length	Cost ($) = L × ($100)
Thalweg Grading (X2)	Length, width	Cost ($) = L × W × 1/27 × ($5)
Channel Excavation	Height, length, width	Cost ($) = H × L × W/27 × ($5) + L × W × ($0.75)
Remove/Cover Bank Dumping	Length, width	Cost ($) = L × W × [5/27 × ($10) + ($0.50)]

(1) Base information was provided by CH2M Hill in coordination with the Fountain/Monument Creeks Drainage Basin Planning Studies.

Non-Cost, Environmental Issues

The downstream reaches of Fountain Creek generally exhibit a more natural corridor that has not been subject to the degree of development encroachment that has occurred in the upstream reaches. Although reaches F1 through F4 have experienced a certain degree of degradation resulting from adjacent development, upstream activities and natural phenomena, there are distinct opportunities to enhance and preserve instream and riparian resources within these reaches.

Slow-moving, deep water habitat is a necessary component of a healthy stream ecosystem. These areas are important in providing a cool, shaded and more or less "protected" resting and feeding area for fish and other organisms. The tail areas of pools (and/or the head of riffle areas) are critical for spawning and reproduction for fish. These areas must maintain very specific conditions including a suitably sized substrate which is not embedded or inundated with fines, and must also maintain minimum levels of dissolved oxygen.

There are significant areas of jurisdictional wetland and healthy riparian vegetation remaining within these downstream reaches; a corridor improvement program that recognizes the vital functions of these areas should be enacted. Table 6.3-26 presents the acreages of the wetlands impacted and the temporarily impacted wetlands that have the potential to be restored for each of the alternatives. Riparian areas are important in terms of flood water storage and flow desynchronization; soil stabilization, erosion control and resultant water quality protection; and in promoting biodiversity. A well-developed riparian corridor creates microclimate areas which physically benefit the stream by providing cover and shading; the increased humidity and cooler air and water temperatures resulting from a developed overstory promote diverse flora and fauna species compositions, indicating a complex food web with a range of available niches. A substantial tree canopy also protects the system from winds and solar exposure, thus reducing evaporative loss.

The range of alternatives discussed for reaches F1 through F4 varies significantly in the degree to which each encourages ecological enhancement. In each reach, alternative 1 calls for no action. While on the surface it may appear that a no action alternative equates to preservation of existing conditions, stream dynamics are such that erosive forces and other conditions will continue to degrade creek segments that are subject to degradation. Protective measures, therefore, are required to simply maintain existing conditions in the downstream reaches. To realize any improvement in habitat and productivity, more extensive actions would have to be specifically implemented. In Reach F3, the no action alternative includes continuation of clean up activities associated with Tejon Marsh that have already been initiated.

The biological component within the upper reaches, F5 through F8, of Fountain Creek has suffered from urbanization, development encroachment and the resulting constriction of the creek, leading to a lack of suitable habitat for an abundance of both aquatic and terrestrial life. There are few jurisdictional wetland areas throughout the upper reaches and none within reaches F7 and F8. Because significant biological resources are scarce in these reaches, there is little that can be further impacted. Impacts associated with proposed improvements in

TABLE 6.3-26 JURISDICTIONAL WETLAND IMPACTS		
REACH F1: 0+00 - 35+00		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	0.05 acres	0.05 acres
#3	none	N/A
#4	none	N/A
REACH F2: 35+00 - 150+00		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	0.29 acres	0.29 acres
#3	1.41 acres	0.83 acres
#4	2.05 acres	2.05 acres
#5	0.29 acres	0.29 acres
REACH F3: 150+00 - 195+00		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	none	N/A
#3	0.32 acres	0.32 acres
#4	2.47 acres	2.47 acres
#5	negligible	N/A
REACH F4: 195+00 - 232+50		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	0.14 acres	N/A
#3	3.50 acres	3.50 acres
#4	3.50 acres	3.50 acres
REACH F5: 232+50 - 267+50		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	0.37 acres	0.37 acres
#3	0.37 acres	N/A
#4	none	N/A
REACH F6:267+50 - 319+00		
ALTERNATIVE	WETLAND ACREAGE IMPACTED	POTENTIAL RECOVERABLE ACREAGE*
#1	undetermined	N/A
#2	0.10 acres	N/A
#3	0.10 acres	0.10 acres

THERE ARE NO JURISDICTIONAL WETLANDS WITHIN REACH F7 OR REACH F8

*Temporarily impacted wetlands should be able to be restored through an effective replanting program.

these areas can, therefore, be generally regarded as inconsequential from a resource perspective.

Any meaningful attempt to upgrade habitat and resource features in these reaches would have to focus on a unified instream and riparian area improvement program. An effective program would probably require extensive acquisition of private land or properties adjacent to Fountain Creek, an option that was not considered to be feasible at this time.

Alternative 1 remains the no action alternative in reaches F-5 through F7; in each of these reaches there are potential problems associated with existing structural features in disrepair. There are undermined utility lines, failing retaining walls and steep banks that are prone to erosion. In addition, in many areas the aesthetic quality of the corridor is lost due to widespread debris and rubble on the banks and within the stream channel. Under the no action alternative, the environmental quality in these reaches of the Creek is likely to undergo further degradation and the unsightly conditions and hazards would persist.

In reach F8, alternative 1 is, again, the no action alternative; however, in this case "no action" means continuing with construction activities that are currently underway but proposing no additional improvements. The stream bed and banks, as well as an undermined utility line, would remain in their present condition.

Specific Reach Non-Cost, Environmental Evaluations

Reach F1

Alternative 2 proposes installation of several concrete vertical drop structures throughout the reach for grade control purposes. It is necessary to control the stream gradient to prevent excess erosion and the resulting accumulation of eroded materials in the channel substrate; however, grade control should, ideally, be accomplished in a manner that will not create a barrier and restrict instream movement and migration of fish and macroinvertebrates. Fish will, without obstructions, move upstream and downstream, but insects generally go with the stream flow, moving downstream in what is referred to as "macroinvertebrate drift"; where and when this drift occurs influences the types of fish found in any given reach. Straight vertical drops of approximately 1½ to 2 feet high are generally considered insurmountable obstacles to fish and, therefore, are features that will clearly impact the overall ecology of the riparian system. In addition, the larger drops also preclude uses such as boating, tubing and kayaking.

Installation of the drop structures would cause impacts to wetlands in the vicinity of the construction activity. A total of approximately one-half acre of existing wetlands would be affected as a result of construction. These impacts, however, could be reversible over time by replanting the disturbed areas. There could, in fact, be resulting beneficial effects upstream; the drop structures could act to raise the localized water table and ultimately create new wetlands.

Alternative 2 also proposes to reinforce a 300 foot eroding bank section by installing a concrete retaining wall; while there are no direct wetland impacts associated with this measure, riparian vegetation in this area would be adversely affected. A replanting program or measures to ensure a sustained water source for the vegetation remaining after construction has not been specified as part of this alternative.

Alternative 3, like alternative 2, provides for grade control within the reach; the method, however, is more ecologically sound, aesthetically preferable and is more likely to promote better instream habitat. Instead of the vertical drop structures, a series of 10 riffle drops constructed of boulders are proposed throughout the reach.

Riffles are vital features within the stream ecosystems, providing habitat for algae, bacteria and macroinvertebrates; in addition, they provide an essential aeration function, maintaining proper levels of dissolved oxygen and act to moderate sediment transport. The physical structure of the channel substrate is a critical factor influencing the abundance, species composition and ultimate productivity of the riparian ecosystem. A good, heterogenous mixture of river substrates promotes an adequate range of niches throughout the ecosystem. The surfaces of rocks and cobbles become covered with algae, fungi and bacteria, forming the basis for primary productivity within the entire stream ecosystem. It is important that river substrates remain free of fine silts and sediments which fill spaces between river cobbles, removing and/or destroying macroinvertebrate habitat, consequently, affecting the higher-order animals which feed on them.

Vegetative enhancement, in several areas throughout the reach, is also proposed as part of alternative 3. No adverse impacts to existing wetlands are anticipated and opportunities may exist to upgrade or perhaps even create additional wetland as a result of replanting efforts.

Alternative 4, the preferred option of the study group, proposes the same treatments as alternative 3 but also provides for additional planting in the riparian areas as well as vegetative screening, where required. This alternative will, presumably, provide the greatest beneficial impacts relative to enhancement of the natural character of the riparian area and aquatic and terrestrial habitat areas. Maintenance of healthy stream-side and overstory vegetation contributes to the ecosystem in various ways, including production of annual leaf litter which supplies vast amounts of soluble nutrients for plants and algae and supports specific functional groups of macroinvertebrates. Overstories also prevent excessive levels of sunlight from reaching the water surface, cooling water temperatures and reducing aesthetically unacceptable algae accumulations.

Reach F2

Alternative 2 specifies repair and/or replacement of existing degraded structural elements. Repair of the dam near the sewage treatment plant is proposed as part of this alternative as well as each of the other alternatives, 3 through 5. No new structures or improvements are proposed and there are no discernable resource impacts associated with this alternative.

Structural bank reinforcement is proposed in two locations as part of alternative 3. Highly erodible banks in many areas throughout reach F2 have contributed to problems associated with sedimentation and sediment transport. In a 400 l.f. area, riprap is proposed to stabilize the banks; in another area, a 1600 l.f. retaining wall is specified. Installation of the retaining wall would impact a 0.58± acre wetland area and inhibit growth of riparian vegetation. Alternative 3 also proposes concrete vertical drop structures at 8 locations, potentially impacting 0.54± acres of wetland, at least temporarily, as described above under Reach F1, alternative 2.

Alternative 4 proposes incremental riffle drops to improve channel grades and habitat. Where structural reinforcement is proposed as part of alternative 3, alternative 4 proposes, instead, to regrade the banks and use vegetational stabilization methods to prevent further erosion. Construction of a levee (approximately 2500 l.f.) is proposed to reduce potential flood damage. Provided the levee is constructed above the elevation of the existing wetland areas, permanent wetland impacts can be avoided; up to 1.76 acres, however, could be impacted during construction.

Alternative 5 was the Study group's preferred alternative for this reach. It proposes all of the same elements as noted for alternative 4, but does not include construction of the levee, therefore, potential wetland impacts are eliminated and a more natural character is maintained.

Reach F3

There are no improvements associated with alternative 2 that will impact riparian resources within the reach.

Vertical grade control structures are proposed in conjunction with alternative 3; wetland impacts of 0.09± acres are anticipated with this scenario but, following a re-vegetation effort, the disturbed wetlands should be able to be fully re-established. Existing eroded banks are proposed to be cut back and reinforced with buried riprap for 4400 l.f. Approximately 0.23 acres of wetland will be impacted; much of this area should be recoverable with a post-construction re-vegetation program.

Maintenance of a natural stream corridor is the general objective of alternative 4; some bank regrading and re-vegetation efforts are proposed as is cleanup and enhancement of vegetation in the Tejon marsh area. Instream improvements are limited to installation of one riffle drop structure. Under alternative 4, two levees for flood control purposes are proposed within this reach. Construction of a 2000 l.f. levee is likely to impact 0.27 wetland acres; however, this area should recover over time provided construction takes place above the wetland elevation. Another 2400 l.f. levee in the Tejon Marsh area could potentially disturb 2.2 acres of wetland on a temporary basis due to construction activities. Construction is proposed at the upland edge of the marsh. Because the marsh receives stormwater which is partially responsible sustaining it, outlets will be constructed in the levee to ensure proper drainage and a continued water source to support the marsh.

Alternative 5, was selected as the preferred alternative; this alternative includes similar improvements to those proposed in alternative 4 except that cnstruction of the levees is eliminated. Minimal impacts to existing resources are anticipated.

Reach F4

Alternative 2 proposes a 400 l.f retaining wall for bank stabilization, impacting 0.14 acres of jurisdictional wetland and also riparian vegetation in the vicinity. A total of 5 vertical concrete grade control structures are proposed; these structures could adversely impact habitat functions.

Rather than the vertical structures proposed in alternative 2, alternative 3 specifies, instead, construction of riffle drops at 9 locations throughout reach for grade control and as habitat improvement features.

Bank grading and replanting of grass and riparian vegetation is proposed over a 3600 l.f. area for bank stabilization purposes. Wetland impacts resulting from regrading could be up to 3.5 acres, however, it is presumed that the cuts and fills will be specifically designed to reshape banks to promote growth of riparian vegetation, stabilizing but not radically changing bank slopes or hydrology in the existing wetland areas. It is further presumed that improvements will occur as spot treatments rather than throughout the entire reach; many areas included in the 3.5 acres of potential impact area will not be impacted in reality. In addition, the hydrology will be maintained so impacted areas will be likely to restore themselves over time.

Like alternative 3, bank regrading and stabilization by vegetative means is proposed in conjunction with alternative 4, the preferred alternative. Bank grading will be generally at a slope of 3:1, and in some areas riprap will be used, as required, where further stabilization is necessary. In addition, vegetative screening is planned in various locations throughout the reach. Nine riffle-type drop structures are proposed throughout the reach as in alternative 3.

Reach F5

Alternative 2 proposes to execute necessary repairs to existing failing structures and install riprap to stabilize banks in two locations to prevent further erosion. In one of the proposed bank stabilization locations, a 0.37 acre area of wetland is nearby and will probably be impacted at least on a temporary basis. A well designed and executed plan for placement and installation of the riprap could avoid impacts to this wetland area, the only one within the reach. If impacts result on a temporary basis due to construction, the area should be restored through appropriate replanting efforts.

Both alternatives 2 and 3 propose installation of concrete vertical drop structures for grade control, rather than the more environmentally and aesthetically preferable boulder structures.

Within the entire reach, approximately 3700 l.f., alternative 3 proposes to cut existing banks on both sides to enlarge the channel for increased flood capacity

and install a vertical concrete wall to stabilize eroding banks. The wall is to be installed above the natural low flow channel and will vary in height from approximately 5-8 feet of exposed wall. Under alternative 3, necessary repairs would also be undertaken.

The 0.37 acre wetland would be physically separated from its water source as a result of installing the channel walls; wetland hydrology would, therefore be impacted. There are no other jurisdictional wetlands within this reach but riparian vegetation throughout the reach may be impacted due changes in the available water source.

Alternative 4, the preferred alternative, preserves, as much as possible, a more natural riparian corridor by improving bank conditions through regrading and recontouring slopes to better support and maintain areas of natural vegetation throughout the reach. Grade control will be achieved by installing riffle drop structures using boulders rather than the concrete structures proposed in conjunction with alternatives 2 and 3. Because of extensive development encroachment that has occurred, restoring the creek to a truly natural condition would require measures and expenditures that are beyond the scope of improvements considered at this time.

Reach F6

The existing conditions as well as the treatments proposed in reach F6 are similar to those indicated for the other reaches in the upstream portion of the Creek. Alternative 2 treatments include installation of 3 vertical and 1 baffled drop structure for grade control; impacts associated with these features have been previously discussed. Banks within a 750 l.f. area in this reach are eroding and in need of stabilization; retaining wall segments and riprap stabilization will be used for this purpose under alternative 2.

Instead of vertical drops, alternative 3 proposes riffle drops and 1 baffled drop, and to stabilize eroding banks and increase channel area, banks will be cut, regraded and replanted. Five sedimentation ponds are also proposed within this reach. Alternative 3 is the preferred alternative.

Wetland resources are almost nonexistent within this reach, however, approximately 0.10 acres of wetland may be impacted as a result of the proposed bank improvements. If a retaining wall or riprap is installed in the vicinity, the wetlands will probably be reduced or destroyed; impacts from regrading activities will more likely be temporary in nature. Construction of the retaining wall will probably also impact riparian vegetation, at least temporarily.

Reach F7

Alternatives 2, 3 and 4 each propose utility line repairs, removal of bridges at 25th, 26th, 28th and 31st Streets and installation of a retaining wall near 28th Street. A bridge to the east of 21st Street would be replaced under alternatives 2 and 3. Alternatives 3 and 4 specify installation of pedestrian bridges in the vicinity of 22nd and 26th Streets.

Under alternative 3 an 800 l.f. flood control levee is proposed. In addition, bank stabilization is to occur in a 6550 l.f. area; banks are proposed to be cut back to enlarge the channel area then reinforced, where necessary, with riprap. Efforts to stabilize eroded banks in this area are also proposed under alternative 4, however, after regrading, vegetative stabilization methods rather than use of riprap is specified.

Instream improvements include vertical drop structures at two locations proposed in conjunction with alternatives 2 and 3. The preferred alternative 4, proposes riffle drops at these locations.

There are no jurisdictional wetlands within this reach. Because of the channelization that has already occurred within the upper reaches, resource values are limited and no discernable impacts have been noted.

Reach F8

Only one other alternative besides the no action alternative has been proposed for reach F8. The City's preferred alternative, alternative 2, includes completion of the present improvement actions and repair of the undermined utility line. Riffle drops are proposed for installation at various instream locations throughout the reach. As with the other reaches in the upstream portion of the study area, direct resource impacts are not readily quantifiable; there are no specific resource features that will be adversely impacted. No other modifications are proposed in this reach.

Non-Cost, Administrative Issues

Presently, the City of Colorado Springs and El Paso County have flood protection and flood management regulations. The overall intent of these ordinances is to protect the public health, safety and welfare and to minimize loss to public and private facilities. These ordinances provide guidelines so that development can occur in flood prone areas providing certain criteria are met. The flood plain overlay zone (Chapter 14, Article 3, Part 28) of the City of Colorado Springs Zoning Code provides specific guidelines for development within a flood plain area.

The Comprehensive Plan for the City of Colorado Springs specifically addresses as a goal to preserve and enhance drainageways as amenities to the City by incorporating a comprehensive system of detention ponds in conjunction with "soft linings" or natural drainageways as the preferred method of treatment whenever possible.

In conjunction with the Comprehensive Plan, a community-wide storm water workshop was held in 1990, which identified the following goals for drainage policy and criteria:

1. Public safety and welfare
2. Aesthetics (natural linings, parks/wetlands, open space, buffers)
3. Social/Recreational benefits
4. Control of stormwater pollutants
5. Costs