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Cottonwood Creek Drainage Basin Planning Study

City of Colorado Springs and El Paso County

JUNE 9, 1994

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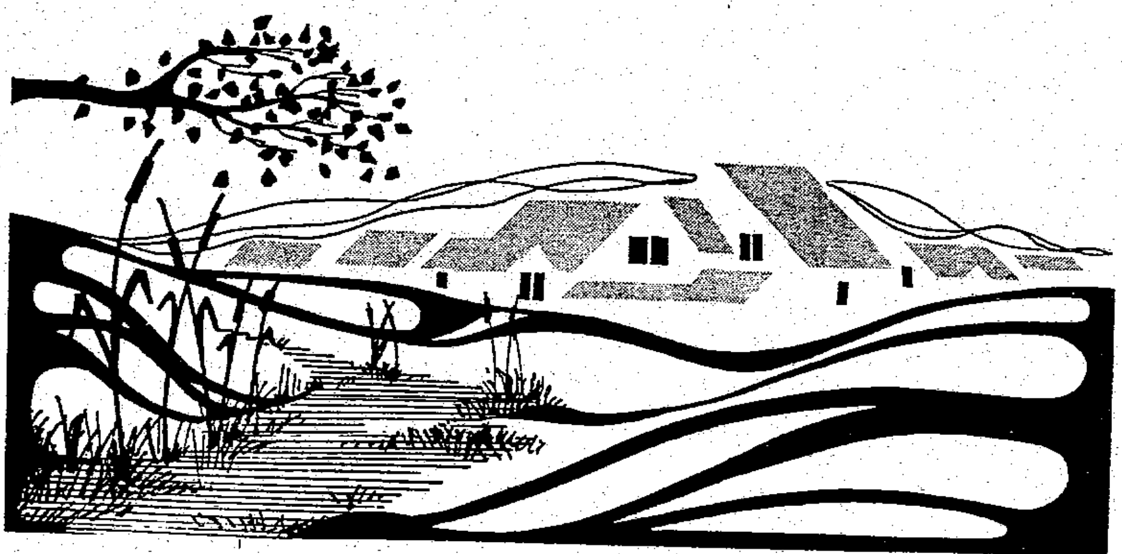

Cottonwood Creek Drainage Basin Planning Study

City of Colorado Springs and El Paso County

APPENDIX A

MAPS AND PLANS

(ALSO SEE ROLLED MAPS)

JUNE 9, 1994

COTTONWOOD CREEK
DRAINAGE BASIN PLANNING STUDY

July 31, 1991

Revised: January 29, 1992

Revised: June 30, 1992

Revised: July 15, 1992

Revised: August 24, 1992

Revised: June 9, 1994

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Executive Summary

EXECUTIVE SUMMARY

The Cottonwood Creek Drainage Basin Planning Study (DBPS) was authorized on December 27, 1988 to restudy the basin per current criteria. The last complete study of this basin was approved in 1979 with a partial restudy done in 1984 but never approved. There have been a significant number of changes in the development of the basin and drainage criteria since the last approved study.

The Cottonwood Creek DBPS includes both the Cottonwood Creek Drainage Basin and the South Pine Creek Drainage Basin within its study limits. The basin lies within northeast Colorado Springs as well as unincorporated El Paso County. The basin is generally bounded by Monument Creek and I-25 on the west, Research Parkway on the north, Vollmer Road on the east, and Vickers Drive on the south. The total study area consists of 24 square miles, 55 percent of which is already developed or platted. The basin generally slopes from east to west at one to two percent grades.

Incorporated in the study has been a series of Public Agency/Citizen involvement meetings. Upon the City's request and concurrently with the basin planning process, the U.S. Army Corps of Engineers (COE) conducted a Letter of Permission (LOP) process to determine if an LOP permit can be issued for the basin. The LOP permit would establish a list of categories of types of construction activities that are planned for the basin and the types of mitigation and best management practices that are required as part of those activities. The LOP would streamline the individual permit requests for the basin under Section 404 of the Clean Water Act. In working with the COE on the LOP permit, they indicated that they would no longer be able to continue with the LOP process for this DBPS due to resource constraints. However, the DBPS concepts could be utilized when applying for an individual permit for a specific project. In addition to the full individual permit, Nationwide and Regional Permits are available depending upon whether the project specifics meet the limitations in these permits. These permits could be utilized in many situations and result in more efficient processing.

In addition to the Public Agency/Citizen meetings and as part of the LOP process, a public meeting was held for the basin study and LOP on August 29, 1990. This DBPS was initially approved by the City/County Drainage Board in their meeting of September 17, 1992. However, several concerns were expressed relating to the equitability of the proposed drainage basin fees at the Drainage Board meeting and the City Council meeting on October 27, 1992. As a result, a Drainage Task Force was formed to study the basin fee computation method for this DBPS. The results of the Task Force meetings were discussed in the September 16, 1993 Drainage Board meeting and the elements of a draft resolution for City Council consideration were discussed and approved by the Drainage Board.

A final resolution was then prepared through additional discussion by the Task Force and City Engineer. This final resolution was discussed and approved by the Drainage Board on March 17, 1994 and the City Council on April 12, 1994. County approval of the DBPS plan occurred at the County Planning Commission meeting on October 20, 1992 and the fees were adopted at the County Commissioners meeting on May 5, 1994. Copies of the approval documents are included in Section VII of this study.

This study incorporates a wide range of considerations in the study and selection of alternatives. All of the following items were considered as part of the alternative selection process:

- Type of Existing Protection
- Existing and Available Channel Capacity
- Erosion Potential
- Type of Wetlands Present
- Wildlife Habitats and Corridors
- Existing and Proposed Utilities
- Type of Current and Proposed Land Uses
- Existing Development Limits
- Multi-use Opportunities (i.e. - recreation, trails, open space)
- Capital Costs
- Maintenance Considerations
- Safety or Flood Protection Considerations

The first phase of the study generated an inventory of the drainage basin features, including those above. A matrix was created to summarize the results of the inventory. There were also four basic channel alternatives and three detention alternatives selected for study. These items were presented to the agencies/citizens as part of the meeting process. The initial presentation was based on general areas of the basin that had similar existing characteristics. Later presentations of the alternatives were based on individual reaches of the basin.

The second phase of the study applied the conclusions from the meetings to the basin on a reach by reach basis. This incorporated comments received during the public agency/ interested citizens meetings. There are approximately 101 different reaches that were studied. When the reaches with existing channel improvements and the reaches with a 100-year flow of less than 500 cubic feet per second were eliminated, there were 39 reaches left in which the full alternative analysis was performed. The channel alternative analysis including recommendations for each channel reach was completed and presented to the agency/citizen group as well as in a public meeting. Copies of these documents are included in Appendix B.

The final phase of the study was to finalize the report and provide specific recommendations. Drainage Fee policy in effect and applied to the facilities in this study include the following:

Initial Systems

Initial systems were analyzed for two example locations only, and are not included in the drainage system recommendations or the determination of the Drainage Fee for this basin (see Appendix B). Initial drainage systems will be required to be built per current drainage criteria but they are not eligible for reimbursement from the drainage basin fund for this basin.

Major Facilities

- The cost estimates for channel systems include construction costs, additional land required (right-of-way) in excess of the 100 year floodplain widths, and Wetland/Riparian mitigation.

- The cost estimates for pipes, box culverts, and bridges (non-arterial) include construction costs and Wetland/Riparian mitigation.

- The cost (as determined above) for new major public drainage facilities where none currently exist were included entirely in the drainage basin fee determination and are reimbursable from the drainage basin fund after construction.

- The upgrade cost (as determined above) for new major public drainage facilities where they currently exist were included in the drainage basin fee determination to the extent that the cost was attributable to the updated hydrology/hydraulics for the basin generated as part of this study. This prorated cost share would then be considered reimbursable from the drainage basin fund after completion. The remainder of the cost is considered to be public capital improvements and is to be reimbursed as funded/authorized by the appropriate public jurisdiction (City or County).

- The basin fund balance was included in the determination of the new drainage basin fees.

- The cost estimates for detention ponds include construction costs, additional land required (right-of-way) in excess of the 100 year floodplain widths, and Wetland/Riparian mitigation.

This study encompasses a total drainage area of 15,275 acres. As of August 24, 1992 and excluding the U.S. Air Force Academy, ROW for roads, and presently platted acreage within the basin, there was approximately 6978 acres of unplatted developable acreage within the basin. Of this area, 740 acres are planned as 5 acre lots, 151 acres are planned as 2-1/2 acre lots and the remaining 6,087 acres are planned at a density greater than or equal to 1 acre lots. Therefore, under current drainage policy, the estimated amount of land that would be charged fees at the time of platting is 6,295 acres.

CITY BASIN FEES

The resolution adopted by City Council on April 12, 1994, sets the following stipulations for City Basin Fees for this basin:

"Section 1. That the Cottonwood Creek Drainage Basin Planning Study, dated August 1992, by URS Consultants as amended by the Task Force on September 16, 1993, is adopted for use on an interim basis until January 1, 1996. The recommendation for sizing and layout of the various drainage structures in the study are based upon existing criteria.

Section 2. That for 1994, a Cottonwood Creek Drainage Basin fee be established as not less than $4,663/acre and not more than $5,247/acre, that a Cottonwood Creek Detention Pond Fee be established as $333/acre, and that a Cottonwood Creek Bridge fee established as not less than $234/acre and not more than $464/acre, as part thereof. Until City Council shall finally determine the Cottonwood Creek Basin Fee, the $4,663/acre drainage fee and the $234/acre bridge fee shall be paid as normal by the developer and the difference between the low and high values shall be covered by "acceptable assurances" as provided in Chapter 15, Article 3, Part 11 of the City Code. Such acceptable assurances could take the form of payment bonds, letters of credit, or off setting credits for existing drainage improvements."

COUNTY BASIN FEES

At the County Commissioners meeting May 5, 1994, the following County Basin Fees were adopted for this basin:

County Drainage Basin Fee	=	$5,512/acre
County Drainage Land Fee	=	$ 68/acre
County Bridge Fee	=	$ 255/acre

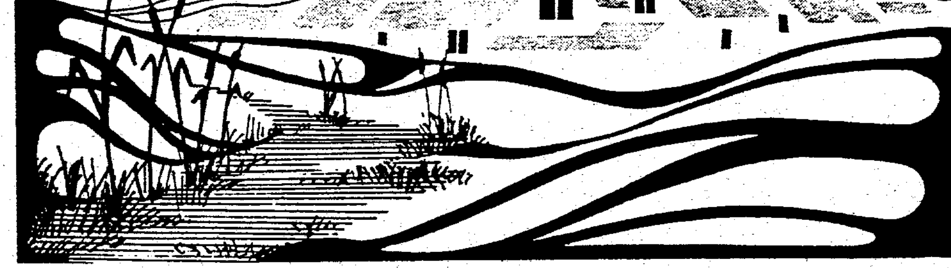
The County did not adopt a separate Detention Pond Fee for the basin. Instead, they included these fees in the Basin or Land Fee, as appropriate.

BRIDGE FEE CLARIFICATIONS

Arterial roadway bridges have a separate development fee system. For the portion of this basin within the City of Colorado Springs, the City participates in the construction of arterial roadway bridges (for the cost over 68 feet in length perpendicular to the roadway within the ROW). The remaining cost is allocated to the remaining City land resulting in a City bridge fee for the basin. See Section VI. B. for a more detailed description of how this fee was determined.

For the portion of this basin outside the City of Colorado Springs, there is only one arterial bridge, namely at Black Forest Road. El Paso County will not participate in the construction of this arterial roadway bridge since the bridge is of adequate size but needs replacement due to its roadway width and structural condition only. The full cost is allocated to the remaining County unplatted developable land resulting in a County bridge fee for the basin.

Introduction



I. INTRODUCTION

A. CONTRACT AUTHORIZATION

This study of the storm water management facilities within the Cottonwood Creek (including South Pine Creek) Basin was authorized under terms of an agreement between the City of Colorado Springs and URS Consultants approved by the Colorado Springs City Council on December 27, 1988. URS staff and subconsultants of URS participating in the study include the following:

1. URS Project Manager	- Clyde Pikkaraine, P.E.
2. URS Project Engineer	- Brad Robenstein, P.E.
3. Land Planning and Graphics	- NES, Inc.
4. Geotechnical Engineering	- GCI, Inc.
5. Environmental Considerations	- Erik Olgeirson, Ph.D.

B. NATURE AND PURPOSE OF STUDY

The drainage basin planning study is a key part of the drainage planning process. A basin wide study provides a guide to future designs and construction of facilities and ensures consistency within the basin. The basin planning process provides the public and interested agencies an opportunity to have input into the form our drainage facilities will take in the future. The study is intended to form broad guidelines as to the type of facilities that are to be planned within the basin. The interim basin fees established for the basin are described in Section VI. Figure 1 shows the location of the Cottonwood Creek basin.

C. SCOPE OF WORK

The specific scope of work for this project was identified to occur in the following three phases:

1. Phase 1 - Basin Concept Study
2. Phase 2 - Basin Alternative Analysis
3. Phase 3 - Final Drainage Basin Planning Study

Phase 1 of the project included all of the basic inventory items and the mapping for the basin. The existing drainage systems were identified on 1"=200' scale topographic maps including an orthophoto background (Figures 8-18, Appendix A) and included in a computer data base. The maps showing the existing facilities and the computer database from Appendix B are available for review in the City Engineer's Office.

Additional inventory items were identified and included the following:

1. Type of Existing Protection
2. Existing and Available Channel Capacity
3. Erosion Potential
4. Type of Wetlands Present
5. Wildlife Habitats and Corridors
6. Existing and Proposed Utilities
7. Type of Current and Proposed Land Uses
8. Existing Development Limits
9. Multi-use Opportunities
10. Capital Costs
11. Maintenance Considerations
12. Safety or Flood Protection Considerations

These overlays were produced on 1"=1000' scale base maps of the basin. The project deliverables for this phase of the study included an overall base map for the basin, inventory forms for the existing facilities, and maps with overlays of the inventory results. Figures 2 through 6 (36" x 60" maps, Appendix A) show the various inventory items on an overall topographic map of the basin.

Phase 2 of the project included hydrology development and analysis, hydraulic analysis, development of alternatives, and evaluation of alternatives. A hydrologic report was produced at the end of the second phase of the project. Figure 7 (24" x 36" map, Appendix A) depicts the hydrologic routing for the basin. Appendix B (a separate volume) gives the full printouts for the existing facility inventory as well as the hydrologic and hydraulic models.

Phase 3 of the project was the final production of the drainage basin planning study. This study presents the recommended plan for the basin. It includes the drainage and bridge fees, final hydrology for the basin, and approximate water surface profile elevations for the channels and bridges. Figures 8 through 18 (36" x 48" maps, Appendix A) are the 1"=200' scale maps which show the recommendations for the basin.

D. PAST STUDIES - RELATED INVESTIGATIONS

Basin studies performed in recent years are as follows:

1. DBPS (approved in 1979) prepared by Lincoln DeVore
2. DBPS started in 1984 by DMJM, but only partially completed and not adopted.
3. Approved flood insurance maps by FEMA

The most significant change from these previous studies is in the drainage criteria and the hydrologic methods and design storm used. The approved (1979) Lincoln DeVore study used the SCS Type IIA storm of six hour duration for recurrence intervals of 5 and 100 years. The design flow for full development at the confluence of the Cottonwood Creek main channel with Monument Creek was 10,419 CFS per this study. The design flow of the south Pine Creek confluence with Monument Creek was listed as 5,527 CFS. The draft (1984) study by DMJM also uses the SCS Type IIA storm of six hour duration for recurrence intervals of 5 and 100 years. The design flow is shown to be 11,329 CFS at the confluence of Cottonwood Creek with Monument Creek. The design flow is 3650 CFS at the confluence of South Pine Creek with Monument Creek. The DMJM study used the HEC-1 computer model to predict the overall flows and routing for the basin and it appears that hand methods were used in the Lincoln DeVore study. The FEMA study uses only present development in the basin at the time of the study (1986)and had peak flows of 10,000 CFS and 7,600 CFS at the confluences of Cottonwood and Pine Creeks, respectively.

We have also obtained copies of the adjacent basin studies from the City and have verified the boundaries with those used in this study. The adjacent basin studies available are:

1. Pulpit Rock Basin
2. Sand Creek Basin
3. Pine Creek Basin
4. Templeton Gap Basin

E. AGENCY JURISDICTIONS (GOVERNMENTAL)

The Cottonwood Creek and South Pine Creek basins are located partly in the City of Colorado Springs and partly within unincorporated El Paso County. The City of Colorado Springs City Engineering Division and the El Paso County Department of Public Works have responsibility for implementation of the approved DBPS. The COE, EPA, and Division of Wildlife were closely involved in the development process. Also involved in an advisory role are the various City and County Departments affected by the plan such as Parks, Planning, Utilities, etc. A list of agencies and individuals involved in the Basin planning process is included in Section IV.C.

F. DRAINAGE CRITERIA

The City/County Drainage Criteria Manual, as of August 24, 1992, was used for analyzing the hydrology and hydraulics for this study. A key point in the City resolution adopting this study calls for a Technical Criteria Study to review then hydrologic method, sediment transport evaluation, detention ponds, technical criteria, stormwater quality, and basin development philosophy. Changes to this DBPS may occur as a result of the Technical Criteria Study. That study is expected to be completed prior to January 1, 1996. On an interim basis, current drainage criteria and this DBPS govern design of facilities in the Cottonwood Creek Basin.

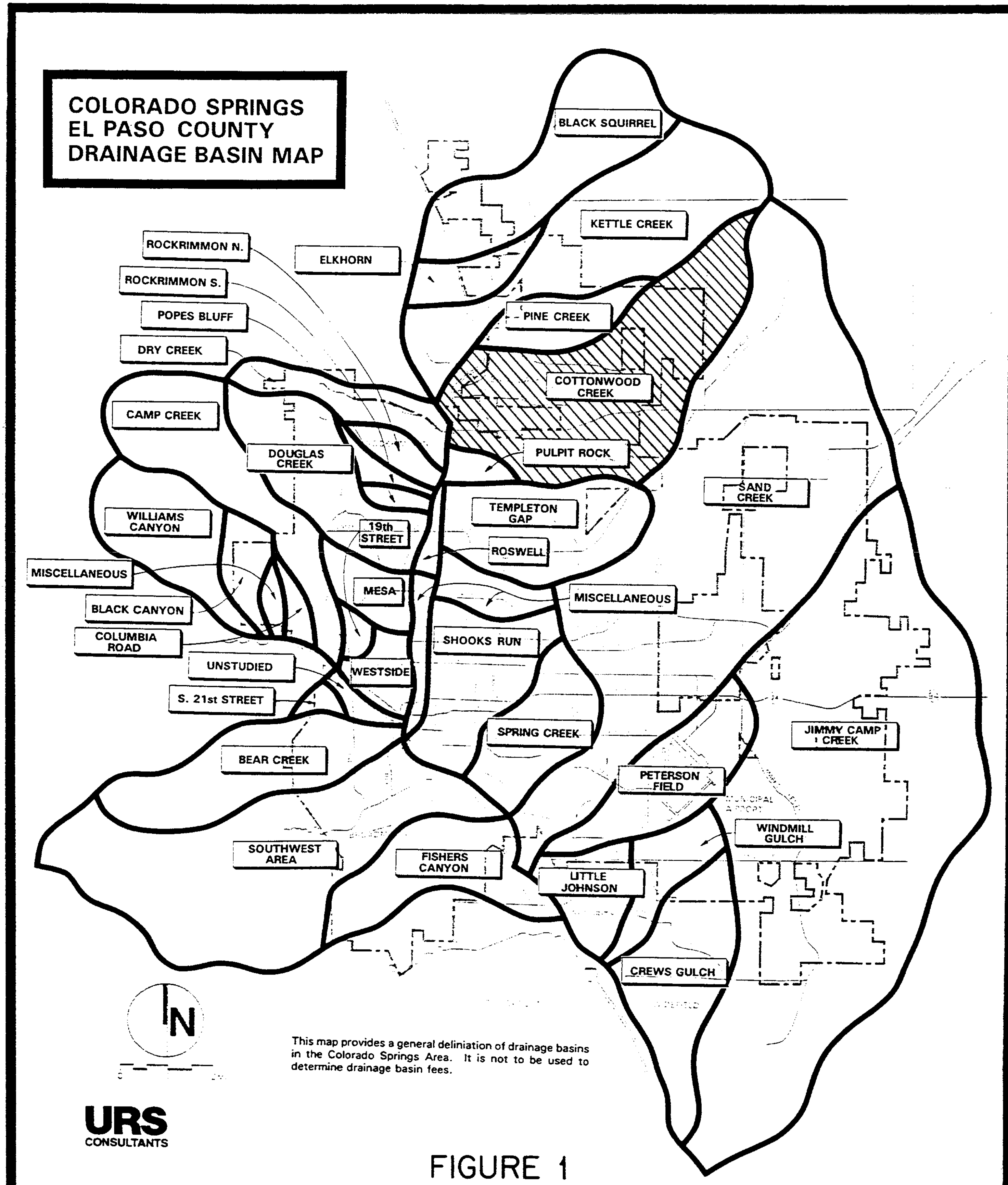

COLORADO SPRINGS
EL PASO COUNTY
DRAINAGE BASIN MAP
BLACK SQUIRREL
KETTLE CREEK
ROCKRIMMON N.
ELKHORN
ROCKRIMMON S.
POPES BLUFF
PINE CREEK
DRY CREEK
COTTONWOOD CREEK
CAMP CREEK
PULPIT ROCK
DOUGLAS CREEK
SAND CREEK
TEMPLETON GAP
WILLIAMS CANYON
19th STREET
ROSWELL
MISCELLANEOUS
MESA
MISCELLANEOUS
BLACK CANYON
COLUMBIA ROAD
SHOOKS RUN
UNSTUDIED
WESTSIDE
S. 21st STREET
SPRING CREEK
JIMMY CAMP CREEK
BEAR CREEK
PETERSON FIELD
WINDMILL GULCH
SOUTHWEST AREA
FISHERS CANYON
LITTLE JOHNSON
CREWS GULCH
N
This map provides a general deliniation of drainage basins in the Colorado Springs Area. It is not to be used to determine drainage basin fees.
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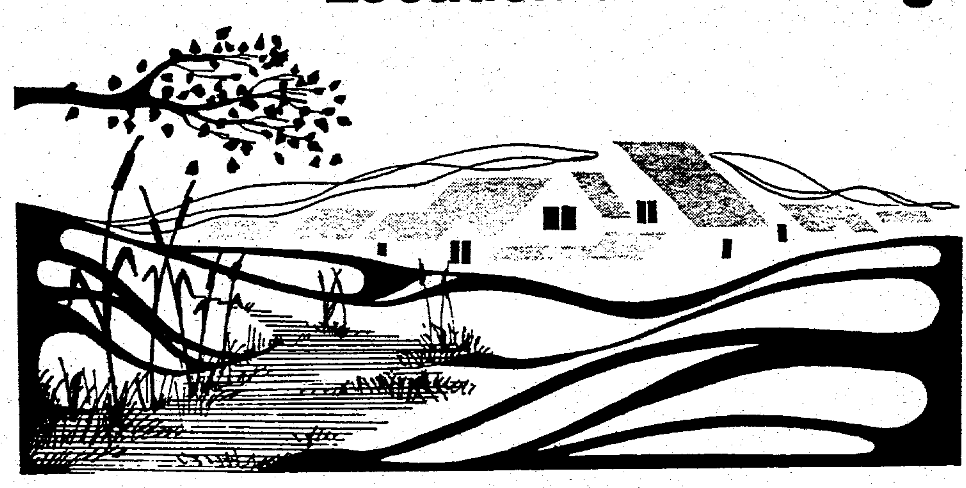
FIGURE 1

Project Description, Location and Drainage



II. PROJECT DESCRIPTION, LOCATION, AND DRAINAGE

A. BASIN DESCRIPTION AND LOCATION

1. General Basin Location

The basin is surrounded by the following adjacent basins:

a. Pine Creek on the north
b. Kettle Creek (unstudied) on the northeast
c. Sand Creek on the east
d. Templeton Gap on the southeast
e. Pulpit Rock on the south
f. The outfall is Monument Creek on the west

The basin can generally be described as bounded by Research Parkway on the north, Vickers Drive on the south, I-25 on the west, and Black Forest or Vollmer Roads on the east. The remaining major roads in the basin include parts of Academy Blvd., Union Blvd., Rangewood Drive, Austin Bluffs Pkwy., Templeton Gap Road, Dublin Blvd., Woodmen Road, Briargate Blvd., and Lexington Drive.

The total study area is approximately 24 square miles, of which approximately 16 square miles are in the City of Colorado Springs and the remaining 8 square miles are in unincorporated El Paso County.

2. Key Features and Characteristics

The basin generally slopes from east to west with the outfall being Monument Creek. The existing channel slopes range from 1% to 5% with the majority of slopes being in the 1% to 2% range. The side slopes away from the channels range in slopes of from 2% to 20%.

The majority of the basin consists of hydrologic soil types A and B soils with some C and D on the ridges and areas of shallow bedrock. The soil type is mostly variations of sandy loam soil that is well drained and is susceptible to both wind and water erosion in disturbed areas. The soil is generally poor for both channel and dam construction materials due to its high seepage rates and erodibility. The primary concern for vegetative lining is to keep the velocities down and to maintain enough water in the soil to allow vegetation to maintain its protection in dry periods (i.e.- some irrigation may be required). There are existing sandstone and claystone outcrops in parts of the basin.

The existing landscape for the basin can be generally described as follows. The western 10% of the drainage basin near Monument Creek is hilly with rangeland type vegetation away from the channels and cottonwoods and conifers along the main channels. As we proceed upstream (east), the land tends to flatten somewhat with more rolling terrain and this area is mostly built out with residential type development and higher density uses on or near the major streets. Most of the channel in this area are either bare, sandy bottom channels, cottonwoods and conifers in the channel, or man-made structures. As we proceed east of Rangewood Drive, the terrain flattens significantly and can be characterized as open rangeland typical in Colorado. The channels are characterized by either willows or low lying grassy areas. This then changes in the upper part of the basin to forest areas with marshes, pondmargins and protected places along the channels as we enter the Black Forest area.

B. AERIAL MAPPING

Aerial mapping was obtained from Landmark Mapping, Inc. for approximately the west 70% of the basin. It was flown in January of 1989 and final maps were obtained in May. The mapping consisted of 1"=200' scale maps with a two foot contour interval on an orthophoto base. The contour base was then reduced to 1"=1000' scale to combine with USGS mapping for the remainder of the basin. The result was a 1"=1000' scale base map on which most of the inventory results are delineated graphically. Copies of color photography of the basin flown in the summer of 1987 were obtained for aid in the environmental inventory.

C. MAJOR DRAINAGEWAYS AND FACILITIES

The existing types of channels and condition can be split into several distinctive areas. The natural channels between the outfall and just downstream of Academy Blvd. are steep canyon type channels that are filled with brush and some trees. Most of the natural channels between Academy Blvd and the Colorado Black Forest are sandy bottomed with some vegetated banks. The channels in the Black Forest are heavily vegetated with some stockponds on them. Man-made channels include concrete lined channels, riprap lined channels, partially lined channels, and underground structures. A list of existing facilities which are suspected to be undersized has also been discussed with City staff and field verified as to their condition.

The existing main channels for both Cottonwood and Pine Creek near I-25 have problems with the steepness of the existing banks and sloughing of the banks into the channels. The bridge crossings are deeply eroding below their original creek level.

The type of existing soil or rock in several areas may dictate the type of improvement desired. The area downstream of Academy Blvd. has some areas of claystone. The Pine Creek outfall is in sandstone. The US Air Force Academy has expressed a reluctance to allow any lining in the area that they control. This specifically applies to the Pine Creek section upstream of Academy Blvd. The Pine Creek DBPS was negotiated to have a flow in excess of the box capacity through negotiations with the AFA, CDOT, City, County, and Briargate.

There is a tight constriction on Pine Creek south of Academy Blvd. due to the development around the channel. This is also an area where there have been citizen complaints on the adequacy of the existing channel. This is also related to overtopping of the existing channels and pipes north of Academy due to sediment buildup. The current FEMA floodplain shows Academy being overtopped during the 100-year storm.

D. EXISTING AND PROPOSED LAND USE

Major developments in the basin include Briargate, Norwood, Falcon Estates, and Chapel Hills. Approximately 55% of the basin is already platted or developed. An inventory of all ownerships in the basin over 100 acres was performed. Figure 3 shows the existing and proposed land uses for the basin.

Ultimate land uses were projected from existing master plans, zoning, and best guess assumptions at this time. In cases where questions exist, the study will tend to predict the denser of the combination of land uses. This is not intended to be a land planning document and the conservative approach was used because it is significantly more expensive to upgrade a facility later for higher densities. The majority of the basin is residential land uses with higher densities concentrated around the major transportation links.

A significant part of the projected land uses (for undeveloped areas) along the main channel of Cottonwood Creek allow for open space or park land next to the channel. This will present more opportunities to have the creek be an amenity to the community.

E. EXISTING IRRIGATION FACILITIES

No existing irrigation facilities were found in our investigations.

F. EXISTING SURFACE WATER IMPOUNDMENTS

There are numerous small stockponds in the Black Forest area and the undeveloped rangeland just west of the forest. Existing regional detention facilities were found in the South Pine Creek basin and these were included in the hydrologic analysis for that basin. Plans for these existing detention facilities were obtained from the City and the ponds are named Chapel Hills Detention Ponds No. 1 & 2 and Anderosa Estates Detention Pond.

G. EXISTING/PROPOSED UTILITIES

As part of this study, the City Gas Department, Electric Department, Water Department, and Wastewater Department were contacted to determine the location of existing and proposed major utility corridors. US West, AT&T, Mountain View Electric, Woodmen Water & Sanitation District, Colorado Interstate Gas, and Colorado Springs Cablevision were contacted regarding their corridor locations.

The majority of the major utility corridors are along the major roads in the basin. There are three significant exceptions to this. The first exception to this is that water and wastewater lines also generally follow the alignment of the main channel of Cottonwood Creek in addition to being in the major roads. The second exception to this is a major gas line approximately two miles north of Woodmen Road in the northeast side of the Cottonwood Creek basin. The third exception to this is a proposed major electric line running north/south in the basin. Since the exact locations of future utility lines is subject to change, each individual development should contact all of the appropriate utilities early in the development process. Each of the City utility departments have overall planning maps and detailed maps showing the location of existing utilities. The existing facilities were mapped as part of the recent FIMS study by the City Utility Department. The majority of the potential drainage facility/utility conflicts should be crossings where the major roads cross the drainage channels and pipes. While the utility corridors did not have a major role in the selection of alternatives (except along the main channel) due to their locations away from the drainage systems, they do need to be accounted for in designing and constructing future drainage facilities.

We have obtained copies of the major thoroughfare plans from City Traffic and El Paso County Public Works. We have plotted the results on the overall basin map (Figure 2). The major roadways running from north to south are Interstate 25, Academy Blvd., Union Blvd., Rangewood Drive, Austin Bluffs

Pkwy., Black Forest Road, and Vollmer Road. The major roadways running from east to west are Vickers Drive, Templeton Gap Road, Dublin Blvd., Woodmen Road, Briargate Blvd., Lexington Drive, and Research Parkway.

H. SOILS/EROSION POTENTIAL

1. Introduction

This section of the report contains the results of a geologic study conducted in the Cottonwood Creek Drainage Basin. The purpose of this study was to provide geologic information to aid in the planning study and in selecting facilities alternatives. The geologic information was obtained by photogeologic analysis, research and review of published references in the area, and the review of private studies which have been conducted within the region. The geologic information has been plotted on a 1" = 1000′ scale topographic base map (Figure 4).

Upon completion of the geologic mapping, the geologic units were compared to City of Colorado Springs and El Paso County Drainage Criteria Manual, Table 10-3, and their erosion potential estimated. These estimations provided for a more detailed delineation of the erosion characteristics of the soils and bedrock within the drainageways. The stream reaches with estimates of soil erosion potential groups were plotted on a blueline copy of the base map and used in the matrix analysis of channel alternatives. A discussion of the erosion potential of the soils within the drainageways is also included in this report.

It must be emphasized that geologic information and mapping was conducted based on aerial photograph interpretation and experience within the Basin. Erosion potential estimates were based on this geologic mapping and our experience within the Basin. No specific field subsurface studies were undertaken as part of this study. Field reconnaissance and mapping of stream reaches are likely to result in revisions to our mapping, and more detailed studies should be completed for design purposes. The geologic conditions on the Geologic Map are based on pre-development conditions. Obviously, infrastructure construction, mass grading, and construction of structures have altered the natural geologic conditions to some extent.

2. Geologic Setting

The Cottonwood Creek Basin lies easterly of the foothills at the base of the Rampart Range of the Southern Rocky Mountain Physiographic Province. The area of the Cottonwood Creek

Basin is underlain by sedimentary rocks, deposited in the Denver Structural Basin.

Bedrock underlying the Cottonwood Creek Basin area consists of four units which comprise the Dawson Group. In ascending order and starting in the lowest part of the basin at Monument Creek, is the Lower Andesitic Member of the Arapahoe Formation, the Upper Arkosic Member of the Arapahoe Formation, the Denver Formation, and the Dawson Arkose. Overlying these bedrock units within the basin are various surficial deposits which were deposited in more recent geologic times. These various geologic units are plotted on the Geologic Map, and are described in more detail in the following sections.

The northeasterly portion of the Cottonwood Creek Basin is dominated by a dendritic drainage pattern in which the main channels flow generally north-south. West of Powers Boulevard, the main channel of Cottonwood Creek flows toward the southwest and west.

The drainageways in the upper part of the Basin appear to be dominated by relatively sandy soils which have been weathered from the Dawson Arkose. Just southerly of the Black Forest area, the main stream channels appear to be eroded into the bedrock materials and the streams apparently have become entrenched. This is generally the case in the undeveloped parts of the Cottonwood Creek Basin, upstream of Rangewood Drive. In the extreme southeasterly portion of the basin, the drainageways are contained within the sandy, surficial deposits.

In the westerly portion of the basin, the drainage patterns are much less well developed because of the geologic conditions in this region. Since much of the area is dominated by wind-blown sand deposits, many interior and blind drainages were once characteristic of this region. Development in the last 15 years within the westerly portion of the Cottonwood Creek Basin has resulted in the channelization of these flows and redirection of drainage in man-made structures.

3. Bedrock Units

Arapahoe Formation: The Arapahoe Formation is the lowest formation in the Dawson Group and consists of two distinct units.

Arapahoe Formation, Lower Andesitic Member (Kal): The Lower Andesitic Member directly overlies the Laramie Formation. This member consists of interbedded claystones, carbonaceous shales, sandstones, and siltstones. These materials were derived from the weathering of volcanic rocks (andesites and basalts) and are characterized by dark browns, greens, and blue-grey colors. These rocks are known in the region for containing highly expansive clay minerals. Because of the relatively low resistance to erosion, the Andesitic Member typically forms low ridges and more gentle topographic features. This unit is exposed in the stream cuts and roadcuts in the extreme westerly part of the basin.

Arapahoe Formation, Upper Arkosic Member (Kau): The Upper Arkosic Member of the Arapahoe Formation underlies the westerly part of the basin. This bedrock unit consists of coarse grained, arkosic sandstones and conglomerates with some interbedded claystones. Although typically not highly cemented, the unit does contain local layers and lenses of iron cemented sandstones. The sandstones are typically very dense and moderately to highly resistant to erosion especially where cemented. The Upper Arkosic Member of the Arapahoe Formation forms the cliffs at Pulpit Rock and steeper ridges in the extreme southwesterly portion of the basin. It is exposed in the Falcon Estates area westerly of Academy Boulevard and along the main channel generally westerly of Academy Boulevard.

The sandstones and conglomerates of the Arkosic Member were formed from the weathering of the Pikes Peak Granite to the west of the area. They, therefore, tend to be arkosic (contain a significant amount of feldspar in addition to the quartz grains).

Denver Formation (TKd): The Denver Formation contains sandstones, siltstones and claystones, and is highly variable and lenticular, as opposed to text book layer-cake type strata. Considerable variability exists within the formation both laterally and vertically. This high variability is reflected in the bedrock materials encountered within the region. Based on our experience with the Denver Formation in this basin, the sandstones (starting at the coarse end of the rock spectrum) vary from medium to coarse pebbly sandstones and grade downward (finer) to fine grained, silty, cemented sandstones. Some of these sandstones are friable and easy to excavate, while the cemented ones are very hard. The sandstones are varicolored, ranging from various shades of brown and red to blue gray, and white. These sandstones were derived from andesite and basalt (volcanic rocks). The andesitic or volcanic derived sandstones dominate within the Denver Formation with the arkosic sandstones being relatively minor in the lower and middle part and more common in the upper part. Overall, the sandstones are less abundant than the claystones and siltstones in the Denver Formation.

The sandstones of the Denver Formation grade into the fine sandy siltstones. These siltstones, in turn, grade into (are transitional to) the silty and fine sandy claystones. No clear divisions exist between these different rock types, but rather a full spectrum of materials are present, starting at a coarse pebbly sandstone on one end, and ending in a fine grained, high plastic claystone on the other end.

The claystones themselves, are also varicolored and range from low plastic, fine sandy and silty to slightly silty, very fine grained and high plastic.

The Denver Formation strata are exposed in the Briargate area in the ridges southwesterly of Rampart High School and along Cottonwood Creek and its tributaries generally easterly of Rangewood Drive.

Dawson Arkose (Tda): The Dawson Arkose overlies the Denver Formation and is the uppermost formation in the Dawson Group. It underlies the northeasterly portion of the basin, generally easterly of Powers Boulevard (and proposed Powers). In the region, the Dawson Arkose consists of a variable sequence of light gray to orangish to white arkosic sandstones, and green to gray claystones. Typically, the Dawson Arkose is also lensatic, resulting in a high degree of variability, both laterally and vertically. Claystones within the Dawson Arkose can vary from low to high plastic and from low to high expansive. The sandstones typically are fine to coarse grained, arkosic, and usually are not highly cemented. Some highly cemented layers do however exist within the sequence, and can be found in outcrops in the mapped area.

Exposures of the Dawson can be found along Cottonwood Creek and in numerous outcrops within the upper part of the basin.

4. Surficial Deposits

During recent geologic times, the bedrock has been eroded and weathered, producing a series of ridges and valleys. This weathered and eroded bedrock surface has subsequently been covered by various younger surficial deposits. During glacial times, melt water laden streams deposited alluvium in the form of pediments (Verdos and Slocum Alluvium) eroded from the highlands in the Black Forest and the Front Range. Lower terraces and more recent alluvium (Piney Creek Alluvium and Alluvium/Colluvium), not associated with the glacial episodes, have also been deposited along Cottonwood Creek and its tributaries.

In more recent geologic times (within the past 10,000 years or so), large portions of the mapped area have been covered by eolian (wind blown) sand. In the Briargate area, this sand was deposited as a series of large chevron shaped dunes, which generally trend in an east-west direction. These dunes are now stabilized and obtain thicknesses approaching 100 feet in some areas. The dune deposition resulted in the formation of interior drainage basins, blind drainages, and other unusual drainage patterns.

In the most recent geologic time (and presently), alluvium and colluvium are being deposited in the stream bottoms. Alluvial fans are also being created at the mouths of some of the small drainageways and gullies. Colluvium (slope wash) is being deposited by actions of sheet wash and gravity.

Alluvium/Colluvium (Qac), Recent Alluvium and Alluvial Fan Deposits (Qaf and Qafo): These water deposited sands, silt and clay materials were deposited by water action and are found in the drainageway bottoms, generally within the active flood plains. The alluvium will tend to be highly stratified and variable, may be organic directly in valley bottoms, and is typically characterized by a high groundwater table.

Alluvial fans are deposited where a stream's gradient is reduced and the stream dumps its suspended load or at the mouths of gullies. Alluvial fan deposits would have characteristics very similar to the recent alluvial deposits.

Colluvium (Qc): Colluvium is unconsolidated surficial deposits which are deposited as the result of water, wind, sheet-wash, and gravity. Over some of the region, colluvium mantels the underlying bedrock or older surficial deposits. The colluvium consists of intermixed sands, silts and clays, which have been eroded from the various other geologic units within the region, and is found on the side slopes and in the swales.

Eolian Sand (Qes): Eolian (wind-blown) sand covers a majority of the western portions of this region. The wind-blown sand deposits vary in depth from a thin veneer to greater than 50 feet. The eolian deposits consist of fine to coarse grained silty to slightly silty sand. The larger dune fields are typified by interior drainage basins, large rolling hills and elongated ridges.

Piney Creek Alluvium (Qp): The Piney Creek Alluvium represents an older and more extensive alluvial deposit than the recent alluvium. These older alluvial deposits can be found in broad, gently sloping wide bands (elevated terraces) along Cottonwood Creek and the larger tributaries. Thicknesses as much as 20 feet can be expected locally. The

Piney Creek Alluvium will tend to be stratified and mixed, much like the recent alluvial soils.

Slocum Alluvium (Qs): The Slocum Alluvium is an alluvial pediment deposit that formed during a glacial time period. Glacial meltwater-laden streams deposited a series of gravelly sand deposits that now exist high above present day drainages in the region. Substantial deposits of the old alluvium exist in the northern portion of the Cottonwood Creek Basin, and underlies a part of the dune field in the northwest part. The alluvium was derived mostly from the Dawson Arkose located in highlands to the north of the area.

Verdos Alluvium (Qv): The Verdos Alluvium is also an alluvial pediment deposit associated with glacial times. One small area of Verdos Alluvium has been mapped in the northwestern part of the basin. This deposit consists of gravelly to cobbly sand, commonly derived from the granitic rocks along the Front Range.

5. Geologic Factors Affecting Drainage

Several geologic factors affect the overall drainage conditions in the Cottonwood Creek Basin. These include the location and type of bedrock, topographic conditions, location and type of surficial deposits, and man-made development and disturbances within the basin.

The upper portion of the basin is characterized by the Dawson Arkose bedrock and sandy, surficial deposits weathered from the Dawson. Gentle to moderate slopes and generally shallow bedrock conditions characterize the upper portion of the basin. In the basin generally upstream from Rangewood Drive, but south of the Black Forest, along the major tributaries, the drainageways have eroded down into bedrock. Most of the bedrock of the Dawson Group is considered to be relatively soft and erodible.

Throughout the Basin, the younger surficial deposits are generally sandy because of the sandy source rock and sandy surficial deposit sources which exist in the region. The relatively large areas underlain by the deeper sandy surficial deposits result in an overall lower runoff coefficient within these parts of the Basin.

Man-made disturbances, such as drainage structures, dams and general development in the basin, have resulted in alteration of natural drainage patterns. This is especially the case in the Briargate area where man-made drainage structures and development have altered the pre-existing drainage patterns once characteristic of the dune field.

Our previous experience in the region indicates that the floodplain of Cottonwood Creek has generally been confined by the incised nature of the creek in bedrock upstream of Rangewood Drive. Downstream of this area, it appears that Cottonwood Creek has been characterized by a braided stream channel with rather extensive lateral stream terraces consisting of unconsolidated sandy soils. Downstream of Academy Boulevard, Cottonwood Creek once again becomes entrenched in the bedrock to its confluence with Monument Creek.

6. Soil Erosiveness

In a broad, general sense, the geology consists of recent alluvial and eolian deposits overlying relatively soft sandstones and shales of Tertiary and Cretaceous Ages. The eolian, or wind-deposited, surficial materials are located primarily to the west and south, while the surficial materials to the north and east are more likely to be alluvial soils. The surficial materials are primarily sands and the erosiveness is largely a function of grain size, with the finer grained materials being highly erosive and the coarser materials being moderately erosive. The erosiveness of the bedrock materials is also dependent upon material type. Siltstone and claystone bedrock is generally of moderate erosiveness, while the soft sandstones are somewhat more resistant to erosion.

In order to facilitate using this report in conjunction with the geologic mapping completed by GCI, the relative erosiveness of each geologic unit will be discussed in turn. In order to provide a somewhat quantitative description of the erosiveness, the erosion resistance of each unit will be described in terms of permissible maximum velocities of flowing water over the soil materials. For consistency of interpretation, these values will be correlated with the values given in Table 10-3, located on Page 10-9 of the City of Colorado Springs and El Paso County Drainage Criteria Manual. Beginning with the youngest geologic unit and progressing to the oldest material, descriptions and permissible design velocities are as follows.

Qac - Alluvium and Colluvium: This material consists primarily of fine to coarse sand with perhaps a slight clay content at some locations. This corresponds with Fine Sand (2.0 feet per second) to Coarse Sand (4.0 fps) in Table 10-3 of the Drainage Criteria Manual.

Qc - Colluvium (slopewash): This material consists of sand or a sand and clay mixture of fine to medium grain size. It corresponds with Fine Sand (2.0 fps) to Ordinary Firm Loam

(3.5 fps). Very little of this material is mapped within the Basin.

Qaf - Alluvial Fan: This consists primarily of fine grained sand, corresponding with Fine Sand (2.0 fps).

Qes - Eolian Sand: These sands deposited by wind are of generally fine grain size. They correspond with Fine Sand (2.0 fps). Significant deposits of this material exist in the basin, notably within the Briargate area.

Qp - Piney Creek Alluvium: This material consists principally of sand ranging from fine to coarse grain size. In terms of erosiveness, this corresponds with Fine Sand (2.0 fps) to Coarse Sand (4.0 fps).

Qafo - Alluvial Fan-Older: This material is expected to consist of silty, slightly clayey sand. It will probably correspond with Ordinary Firm Loam (3.5 fps).

Qs - Slocum Alluvium: This alluvium consists of fine to coarse silty sand. Values will again range from Fine Sand (2.0 fps) to Coarse Sand (4.0 fps).

Qv - Verdos Alluvium: This material is encountered in a limited portion of the basin, principally to the extreme west. It consists of a sandy to silty gravel. It probably corresponds most nearly with Fine Gravel (5.0 fps).

Tda - Dawson Arkose: This formation consists generally of fine to coarse grained, silty to clayey sandstone with occasional siltstone and claystone beds. The sandstone exhibits relatively little cementation. Velocity ranges for this formation correspond with Soft Sandstone (8.0 fps) to Soft Shale (3.5 fps).

Tkd - Denver Formation: This formation is similar to the Dawson Arkose, previously described, but has a higher percentage of siltstone and claystone materials than the sandstone. Velocities for this formation will correspond with Soft Shale (3.5 fps) to Soft Sandstone (8.0 fps).

Kau - Arapahoe Formation (Upper Arkosic Unit): This material consists primarily of arkosic sandstone. The sandstone is, however, interbedded with claystone and siltstone lenses. In terms of velocities, most of the formation will correspond with Soft Sandstone (8.0 fps) with some materials which correspond with Soft Shale (3.5 fps).

Kal - Arapahoe Formation (Lower Andesitic Unit): This formation consists primarily of claystones and siltstones. It does, however, contain occasional layers and zones of soft to cemented sandstone. Most of the formation will correspond with Soft Shale (3.5 fps) with some Occasional Soft Sandstone (8.0 fps).

While the geologic units above have been categorized in terms of the maximum velocity of water flow which they can be expected to sustain, this is only one factor related to erosion of the soils. Other factors include stream geometry (gradient and width and depth of flow), channel roughness, and quantity of discharge. These factors are potentially as important as the sustainable velocities. It is possible to have "erosive" soil conditions, but due to stream gradient or other factors, the stream is actually depositing materials. Alternatively, highly resistant soils can be eroded from sustained significant flows at high velocities, as is evidenced by mountain gorges and canyons. In determining the ultimate erosiveness or need for erosion protection in any given area or stream reach, these other factors should be considered as well.

In order to assist in analyzing erosion protection requirements, we have evaluated the relative erodibility of specific stream reaches in terms of the probable maximum flow velocities that the materials in the beds and banks can sustain. For purposes of this analysis, soils with permissible velocities on the order of 0 to 3 feet per second were considered highly erodible, soils in the 3 to 5 feet per second range were considered moderately erodible, and soils or rock materials with permissible velocities of 5 feet per second or greater were considered to have a low erosion potential. We would note that these classifications of low, moderate, and high are relative to soil and geologic conditions within this basin and might not be appropriate for other areas.

These criteria were applied to specific channel reaches contained in a list provided to GCI by URS. In evaluating the individual reaches, the maximum sustainable velocities given earlier for each geologic unit were used. In some instances the soil conditions vary enough within a reach that the difference was potentially significant. In these cases, we have divided the reaches. For purposes of analysis, the reach can either be divided into two new reaches, or the most conservative assumption for the entire reach can be used.

We would note that our level of effort did not include inspection of channel reaches to determine presence or absence of lining or storm sewers. Therefore, only the reaches in which we are familiar with the existence of channel lining or conduits were we able to so indicate. It will, therefore, be necessary to override our erosiveness values in reaches where there is adequate existing channel protection.

I. ENVIRONMENTAL CONCERNS

1. Introduction

Additional issues such as wetlands, wildlife habitat/corridors, aesthetics, open space, and trails were considered in the alternative selection. National wetland inventory maps were obtained that show overall characteristics for the basin. Using these, the aerial photography for the basin (both color and black/white), and field reconnaissance, an inventory of the existing wetlands was performed. From these results, it appears that the wetlands occur mainly along the main channels and are scattered along the channels. The aesthetic features desired by the community were addressed through the public involvement process. Many of the land development plans in this basin are considering multi-use opportunities for the channels. Planned open space or park land surrounding the channel allows more flexibility in alternative selection. This study incorporates the trail system proposed adjacent to the main channel of Cottonwood Creek.

2. Field Trip

A field meeting was held with agencies involved in the L.O.P./Section 404 permitting procedures. The intent of the meeting was to get agency involvement in the basin planning process in order to go through the Corps of Engineers for the basin. The attendance at this meeting was as follows:

Name	Organization
Clyde Pikkaraine	URS Consultants
Ken Sampley	City Engineering
Anita Culp	Corps of Engineers
Bruce Goforth	CO Division of Wildlife
Sarah Fowler	EPA
Erik Olgeirson	Wetland Consultant

A brief presentation was made at the City Engineering office to present the current status of the basin study for Cottonwood Creek and South Pine Creek. The proposed land uses, geologic, environmental, and hydrologic maps were discussed to provide some background for the field trip. After this presentation, the group proceeded to the field.

The field trip consisted of looking at twelve representative sites that were typical for the nine categories of channel types that were identified in the environmental inventory for the basin. These nine types are listed in more detail below.

3. Drainage Inventory and Mapping

A major consideration of the drainage inventory was the evaluation of the affects of increased base flow on existing wetland and riparian vegetation. The evaluation of potential opportunities for the use of these vegetation types in controlling floods and water quality was of equal importance.

A reconnaissance level riparian and wetland vegetation inventory was conducted along Cottonwood Creek and its tributaries. The purpose of this study was to determine typical channel units, as defined by vegetation; to evaluate potential effects of increased runoff on these units; and to determine alternative flood drainage channel types, considering future development projections.

Typical channel types were mapped at a scale of 1"=1000' and are shown on Figure 5. Jurisdictional habitat areas, which include wetland and non-wetland vegetation types, were also mapped. Typical channels are also illustrated on isometric projections. Nine typical channel units identified in the reconnaissance study are discussed below and located on Figure 5, the Environmental Inventory Map. The nine categories of channel types in the Cottonwood Creek Basin are as follows:

Agricultural Channel
Backwater Wetland
Structural Floodway
Herbaceous Wetland
Modified Channel
Open Water
Riparian Forest
Shrub Wetland
Prairie Swale with included Wetlands

The significance of these units as natural areas also relates to potential regulatory issues. Changes to the areas as a result of development may require obtaining permits from various state and federal regulatory agencies, including the Army Corps of Engineers, the Environmental Protection Agency, the U.S. Fish and Wildlife Service and the Colorado Division of Wildlife. Wetlands and waters of the United States may be regulated under Section 404 of the Clean Water Act. Wildlife habitat may be regulated by Section 7 Consultation related to the 404 process and other legislation. Significant wildlife habitats are generally those areas containing mature stands of plains cottonwood and emergent wetlands. In addition, the natural drainage channels provide corridors for wildlife to move from one location to another in the basin.

The occurrence and extent of these jurisdictional areas are shown on the Environmental Inventory Map. Future reference to these areas should be made to insure compliance with state and federal environmental legislation. Mapping of these units does not necessarily constitute a required permit.

4. Typical Channel Units

a. Agricultural Channel

In the upper and middle parts of the Cottonwood Creek basin drainage channels are frequently deeply incised and surrounded by agricultural lands used chiefly as pasture. These channels intermittent and carry runoff during the spring and periodic precipitation events during the growing season. Wetland vegetation is poorly developed or non-existent, occurring along slumped banks and in the channel. Common species are weeping alkaligrass (Puccinellia distans), Nebraska sedge (Carex nebrascensis), Baltic rush (Juncus arcticus), smooth brome (Bromopsis inermis), western wheatgrass (Agropyron smithii), sand dropseed (Sporobolus cryptandrus), big bluestem (Andropogon gerardii) and foxtail barley (Hordeum jubatum).

b. Backwater Wetland

Backwater wetlands occur above constrictions along the tributaries. Constrictions to flow occur above road crossings. This channel type is the most well-developed emergent wetland type occurring along the tributaries. Backwater wetlands can be relatively large, covering as much as several acres. These wetlands are significant songbird and small mammal habitat. They also function as natural filters for sediment and pollutants, as well as storing flood waters. Wetland vegetation is dense and relatively diverse. Standing water and saturated soils occur throughout the year. Common plant species include narrowleaf cattail (Typha angustifolia), broadleaf cattail (Typha latifolia), alkali sacaton (Sporobolus airoides), three square (Scirpus americanus), hairy sedge (Carex lanuginosa), pondweed (Potomogeton pectinatus), water hyssop (Bacopa rotundifolia), weeping alkaligrass, tule (Scirpus lacustris), rabbitfoot grass (Polypogon monspeliensis), smartweed (Persicaria cf. hydropiper), blister buttercup (Ranunculus scleratis var multifidus) and duckweed (Lemna minor).

c. Structural Floodway

Four types of hard lined channels are found in the basin. Some sections of the stream have concrete armored banks. The channel bottom is relatively undisturbed. The low flow channel in this type would typically be undefined. The wetland bottom in this type will carry greater surface flows and support wetland vegetation. The second type is a traditional trapezoidal section that is completely lined with concrete. This channel type replaces existing natural channels in some places and has been newly constructed in others to manage drainage from adjacent development. The third type is riprap lined banks with natural bottoms. Typically, the riprap has been covered by dirt and vegetation. The fourth type is a traditional trapezoidal section that is completely lined with riprap. Common species include smooth brome, western wheatgrass, reed canarygrass (Phalaris arundinacea), sandbar willow (Salix exigua), peachleaf willow (Salix amygdaloides), chokecherry (Prunus virginiana), snowberry (Symphoricarpos albus), Wood rose (Rosa woodsii) and plains cottonwood (Populus sargentii).

d. Herbaceous Wetland

Well-developed herbaceous wetlands occur sporadically along Cottonwood Creek and the lower reaches of tributary channels. This channel type is diverse and variable in character. Wetland vegetation is significant in is development. Common species include foxtail barley, sand dropseed, American managrass (Glyceria maxima ssp grandis), rabbitfoot grass, slender wheatgrass (Agropyron riparium), smooth brome, western wheatgrass, weeping alkaligrass, inland saltgrass (Distichlis spicata), alkali sacaton, spike sedge (Eleocharis palustris), hairy sedge, three square, tule, smartweed, duckweed, blister buttercup, scouring rush (Equisetum hymenale), sandbar willow, peachleaf willow, chokecherry, snowberry (Symphoricarpos albus), Wood rose (Rosa woodsii) and plains cottonwood.

e. Modified Channel

The modified channel type occurs principally in residential areas where drainage channels have been reduced to ditches along streets. These ditches tend to be relatively deep and contain the majority of high flow regimes. Common plants are both obligate and facultative wetland species, such as hairy sedge, broadleaf cattail, narrowleaf cattail, sandbar willow, peachleaf willow, wild licorice (Glycyrrhiza lepidota) and plains cottonwood.

f. Open Water

This unit is composed of retention ponds, some of which are livestock ponds. The adjacent areas are typically grazed and contain few wetland species. Common species include spike sedge, western wheatgrass, switchgrass (Panicum virgatum), broadleaf cattail and Baltic rush.

g. Riparian Forest

This channel unit is the most well-developed type within the Cottonwood Creek drainage. This channel type is diverse and variable along its length and is the most significant wildlife area. Redwing and yellow headed blackbirds, several raptors, fox and water fowl use this corridor. Wetland and riparian vegetation is also significant in its development. Riparian forest occurs on broader floodplain areas, including old channel scars. These areas have been modified by channelization in some areas, but there is significant remaining habitat. Vegetation diversity is relatively high along these reaches. The tree overstory is mature and dominated by plains cottonwood. The herb layer is dominated by willows. Herbaceous vegetation is primarily native grasses. The low flow channel is broad and relatively sinuous. The high bank generally contains high flows.

Common species include foxtail barley, sand dropseed, American managrass, rabbitfoot grass, slender wheatgrass, smooth brome, western wheatgrass, weeping alkali grass, alkali sacaton, spike sedge, hairy sedge, water sedge, three square, tule, smartweed, duckweed, sandbar willow, peachleaf willow, chokecherry, snowberry and Wood rose.

h. Shrub Wetland

Shrub wetlands occur along the middle and upper reaches of Cottonwood Creek and its larger tributaries. The channels dominated by shrubs are typically incised and eroded. The high banks are unstable and vegetated with shrubs and grasses. Shrubs grow in the channel bottom, as well. These areas are significant wildlife habitat, as well as wildlife corridors. Common plant species include sand bar willow, snowberry, western wheatgrass, switchgrass, hairy sedge, weeping alkaligrass, carpet bentgrass, Wood rose, sand dropseed and alkali sacaton.

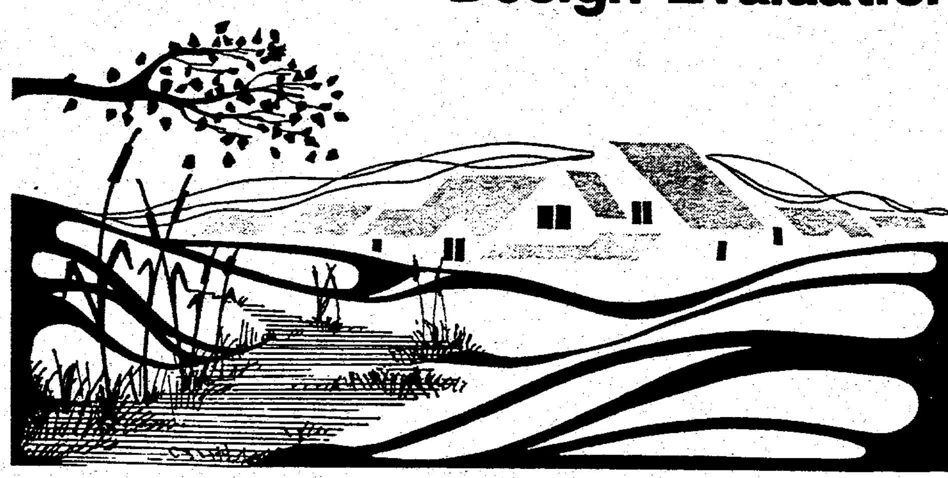
i. Prairie Swale

The channel type occurs toward the upper reaches of Cottonwood Creek and its tributaries. The unit is characterized by a poorly defined, flat bottom with an indistinct low flow channel. Typical width of these swales is 80 to 100 feet. Overbank flows are dispersed to adjacent agricultural fields and pastures. Common plant species include alkali sacaton, sand dropseed, foxtail barley, Nebraska sedge, and slender wheatgrass (Agropyron trachycaulum). The swales are bonded by low shrub growth, dominated by rabbitbrush (Chrysothamnus nauseosus). A variation of this type is a wetland swale with emergent wetlands. This unit is a more well-developed variant of the previous channel type. This swale is somewhat deeper and may have a defined low flow channel bounded by plains cottonwood and sandbar willow. Wetland vegetation is more dense and more well-developed that the previous type. Common plant species are alkali sacaton, sand dropseed, hairy sedge, foxtail barley, Nebraska sedge, arctic rush, weeping alkaligrass, three square, spike rush, saltmarsh sandspurry (Spergularia marina), smooth brome, western wheat grass and slender wheatgrass. Wetland species tend to occur at greater density in low pockets and along meanders of the low flow channel. Upland shrubs occur within the channel, as well as along the outer banks.

J. RESULTS OF BASIN INVENTORY

The results of the inventory and matrix analysis of drainage basin features described in the previous sections are summarized in Table 8 (Appendix B). The reach designations shown are based on the design points and subbasins shown on Figure 2.

Hydrologic and Hydraulic Design Evaluation



III. HYDROLOGIC AND HYDRAULIC DESIGN EVALUATION

A. BASIN HYDROLOGY

1. Assumptions and Model Used

The basins were modelled using the U.S. Army Corps of Engineers HEC-1 computer program with the SCS Unit Hydrograph method of determining runoff for the subbasins. The results are for the 100-year 24-hour storm using AMC-2. The drainage basin boundaries were determined from a combination of 1"=200' scale contour maps at a two foot interval, provided by the City, and USGS quad maps. The basin curve numbers were determined from projected land uses that were developed from current zoning, master planning, and discussions with the City Planning Department and the County Land Use Department. The SCS hydrologic soil types were obtained from the SCS soil survey of El Paso County. A rainfall depth of 4.4 inches for a 24-hour storm was used for the basin based on isopluvials for the basin area. Individual subbasins were also analyzed with the Rational Method as outlined in the City's "Drainage Criteria Manual" and compared to the results from HEC-1. The model for the Pine Creek basin incorporates the modelling done for the north branch of Pine Creek (see the Pine Creek Drainage Basin Planning Study) in order to obtain results downstream of the confluence of the north and south portions of that basin.

In addition, for the Cottonwood Creek drainage basin, we have used an area reduction factor for the basin since it is over 10 square miles in size. Using the depth/area/duration curves for Zone 4 from "The Design of Small Dams" by the U.S. Bureau of Reclamation we obtained a precipitation reduction factor of 94%, when applied to the unadjusted rainfall, this results in a total precipitation of 4.14 inches for this basin. The precipitation distribution for each 15 minute increment of cumulative precipitation is shown on Table 9 (Appendix B). It was based on a Type IIA storm precipitation distribution.

The following is a list of the basic assumptions used in the model:

a. 100-year 24-hour Type IIA storm was used.
b. Antecedent Moisture Condition 2 was used.
c. Areas where SCS hydrologic soil type A was encountered were analyzed as type B soils due to anticipated regrading of the sites with development.
d. Average densities were assumed for the projected land use type.
e. A five minute interval was used for hydrographs.

f. The basin was split into subbasins of approximately 100 acres in size. Table 10 (Appendix B) presents the sub-basin hydrologic data used in the models.
g. Time of concentration calculations were done with combination of overland flow and street and/or storm sewer system travel times. Table 11 (Appendix B) presents the subbasin time of concentration calculations.
h. Existing major detention ponds were input using the elevation, volume, discharge curves shown on construction plans on file at the City.
i. A total rainfall depth of 4.4 inches was used.

2. Overall Results

The results of the full flow through hydrology for Cottonwood and Pine Creek basins at their confluence with Monument Creek are as follows:

Basin Location	Peak Flow
Cottonwood Creek Outfall into Monument Creek	17,400 CFS
Pine Creek Outfall into Monument Creek	5,960 CFS

The results of the models indicate significant increases in flow over the previous studies done for the basin. This is mainly due to the change in criteria and development assumptions since the previous studies were done. The basin alternative analysis included detention alternatives for the basin to reduce the flows to better correlate with existing channel capacities of previously improved channel sections. The remainder of this section provides the detailed information that was used to evaluate those alternatives. A flow chart of the basin model is shown on Figure 7.

Appendix B contains the subbasin hydrologic data for both the SCS and Rational Methods. Table 1 (this volume) presents the fully developed peak flows modelled with the aid of the HEC-1 model at each design point. This is for both the full flow through model and the model with the recommended detention ponds at each design point. The individual subbasin peak flows are also presented for both the SCS and Rational Methods. Figures 19 through 27 (this volume) are the hydrographs at each detention pond location showing both the inflow and release for each pond in the recommended plan.

3. Sensitivity of the Results

The hydrologic model was tested at various points in this study to determine the sensitivity of the results to changes in basic assumptions. The results of the sensitivity analysis for each of the basic assumptions are as follows:

a. The previous studies used different design storms than the current study. The approved 1979 study and the draft 1984 study used the 100-year 6-hour storms for runoff calculations. We previously had run the HEC-1 model presented in the 1984 draft with only changing the 6-hour storm to the 24-hour storm and had an increase in flows of 47%. This area of the model is very sensitive to changes, but the 100-year 24-hour storm is now the required storm to analyze.

b. Based upon past experience, the model is very sensitive to changes in the antecedent moisture condition. The average condition was used per current City drainage criteria.

c. The change in hydrologic soil type from A to B results in a higher curve number. Since the model was run with various values for curve number in the basin, we estimate that this assumption resulted in an increase of 16% in the basin flows.

d. Average curve numbers were used since it was felt that this would most accurately represent the future basin flows. The model showed a change of approximately +/- 10% in the flows when it was assumed that the highest or lowest density occurred. (i.e. - the residential land use of 1/4 acre to 1/3 acre lots can be analyzed using an average curve number for those two densities or by using the higher or lower density.)

e. A standard time interval for hydrograph steps of 5 minutes was used to maintain consistency with the majority of the studies done in recent years. Comparing these results with longer and shorter time intervals tells us that resulting discharges can vary +/- 10% depending on the time interval selected.

f. The model was run with subbasins approximately 600 acres in size compared to the 100 acre subbasins used. The model with 600 acre subbasins was within 5% of the 100 acre subbasin model when these results were compared.

g. The model was run with arbitrary changes in the time of concentrations to determine the sensitivity in this area. The results were within 5% until the time of concentration was approximately 3 times as long.

Since the calculations were done using standard methods and actual drainage systems and patterns, no changes were made in this area.

h. Three existing detention ponds were used in the South Pine Creek analysis. These detention ponds all operate without overtopping the dams and result in a decrease in flow of approximately 20-30% for that basin.

B. MAJOR DRAINAGEWAY HYDRAULICS

The hydraulics of drainage channel alternatives were analyzed for each channel reach. Various assumptions were used to analyze alternatives and include the following:

Overall Assumptions

1. Channel flows were based on recommended detention scheme
2. Existing drainage facilities were taken from an office inventory of the existing plans available from the City and County
3. Existing topographic conditions were taken from aerial photography for the basin
4. Width of ROW proposed included access road/trail
5. Existing channels were sorted based on the type of existing channel improvement and existing capacities, natural channels were considered for full range of alternatives, existing improved channels stayed as same type of improvement

A series of four alternative drainageway treatments were identified. These alternatives range from no lining to partial lining and full lining. Each alternative has a letter designator, with Alternative A having no lining (except at drop structures/grade control) and Alternative D utilizing full lining.

Alternative A Assumptions

1. Mannings n=0.06
2. Maximum channel slope is 1.5%
3. Grade control or drop structures were used to limit this slope
4. Side slopes were taken as what it is now in the field
5. Critical depth was used if the flow was supercritical
6. Normal depth was used if the flow was subcritical
7. Freeboard was based on the equation in the Drainage Criteria Manual
8. Bridge hydraulics for natural channels were based on inlet control nomographs

9. Additional channel buffer areas were estimated for different existing channel types in a meeting with the City based on the channel configuration, slope, geologic conditions, discharges, etc.

Alternative B Assumptions

1. Mannings n=0.06
2. Maximum channel slope is 1.5%
3. Grade control or drop structures were used to limit this slope
4. Side slopes were taken as what it is now in the field (not to exceed 1:2 side slopes)
5. Critical depth was used if the flow was supercritical
6. Normal depth was used if the flow was subcritical
7. Freeboard was based on the equation in the Drainage Criteria Manual
8. Bridge hydraulics for partially lined channels were based on inlet control nomographs

Alternative C/D Assumptions

1. Mannings n=0.015
2. Channel slopes were estimated from topographic maps
3. Drop structures were used to limit this slope
4. Side slopes were assumed to be 1.5 horizontal to 1 vertical
5. Normal depth was used if the flow is supercritical
6. Freeboard was based on the equation in the Drainage Criteria Manual
9. Bridge hydraulics for concrete lined channels with supercritical flow were based on comparing the velocities in the channel and bridge (i.e. - the conveyance of the channel section versus the bridge section was used)

Storm Sewer/Street Combination Assumptions

1. Used this if 100-year flow was less than 500 CFS
2. Mannings n=0.013
3. Pipe slope was taken at the slope of the existing ground along the pipe route
4. Full pipe flow capacities were used without pressurizing the pipe

COTTONWOOD CREEK DBPS - TABLE 1
BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS
100-YEAR STORM

DESIGN POINT	TRIBUTARY AREA (ACRES)	* DETAINED RUNOFF Q(CFS)	* FLOW THRU RUNOFF Q(CFS)
21	11,878	11,173	17,378
20	11,814	11,112	17,305
19	11,731	11,127	17,347
18	10,822	10,000	16,148
17	10,560	9,837	15,918
16	10,163	9,416	15,367
15	9,664	8,790	14,861
14	9,523	8,598	14,806
13	8,998	7,844	13,976
12	6,349	4,026	7,891
11	5,331	3,008	6,136
10	4,403	2,531	4,443
9	4,256	2,332	4,220
8	3,648	1,715	3,306
7	2,048	854	1,296
6	1,946	673	1,222
5	1,600	90	870
4	934	467	467
3	653	335	335
2	224	114	114
19G	179	528	528
19F	672	1,560	1,560
19E	557	1,285	1,285
19D	422	893	893
19C	326	726	726
19B	243	495	495
19A	192	390	390
18A	141	317	317
17A	179	312	312
16C	179	368	368
16B	211	395	636
14C	192	513	513
14B	147	426	426
14A	186	371	371
13S	192	425	425
13R	384	1,058	1,058
13Q	384	1,066	1,066

* INCLUDES PRECIPITATION AREA REDUCTION FACTOR FOR COTTONWOOD CREEK BASIN

COTTONWOOD CREEK DBPS - TABLE 1 BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS 100-YEAR STORM			
DESIGN POINT	TRIBUTARY AREA (ACRES)	* DETAINED RUNOFF Q(CFS)	* FLOW THRU RUNOFF Q(CFS)
13P	230	653	653
13O	1,875	2,414	5,116
13N	1,779	2,341	4,935
13M	352	1,117	1,117
13L	282	892	892
13K	198	657	657
13J	1,357	3,686	3,686
13I	1,242	3,438	3,438
13H	1,133	3,186	3,186
13G	243	642	642
13F	134	375	375
13E	256	752	752
13D	179	579	579
13C	538	1,628	1,628
13B	461	1,454	1,454
12D	160	600	600
12CP	550	252	1,289
12B	384	947	947
12A	230	541	541
11G	160	310	310
11F11P	704	112	1,607
11F	576	1,341	1,341
11E	109	265	265
11D	390	901	901
11C	154	361	361
11B	237	539	539
11A	154	335	335
9B	307	101	577
9A	122	255	255
8H	256	592	592
8G	1,235	555	1,632
8F	256	246	246
8E	698	861	861
8D	256	330	330
8C	186	233	233
8B	448	552	552
8A	205	179	179

* INCLUDES PRECIPITATION AREA REDUCTION FACTOR FOR COTTONWOOD CREEK BASIN

COTTONWOOD CREEK DBPS - TABLE 1 BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS 100-YEAR STORM			
DESIGN POINT	TRIBUTARY AREA (ACRES)	* DETAINED RUNOFF Q(CFS)	* FLOW THRU RUNOFF Q(CFS)
6A	186	417	417
5A	179	101	101
32	6,259	5,674	11,505
31	6,182	5,613	11,267
30	5,805	4,981	10,669
29	5,638	4,589	10,422
OFF-29	3,194	2,583	5,634
28	2,317	2,770	5,600
27	1,472	518	3,213
26	1,344	253	2,970
25	1,024	118	2,201
24	915	1,999	1,999
23	819	1,807	1,807
22	282	578	578
U4B+X4	218	538	538
28H	2,067	2,344	4,980
28G	1,581	794	3,487
28F	493	1,563	1,563
28E	365	1,120	1,120
28D	128	356	356
28C	237	775	775
28B	243	430	651
28A	179	256	426
26B	320	138	797
26A	154	454	454
23A	269	511	511
22A	147	300	300
* INCLUDES PRECIPITATION AREA REDUCTION FACTOR FOR COTTONWOOD CREEK BASIN			

COTTONWOOD CREEK DBPS - TABLE 1
BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS
100-YEAR STORM

BASIN	BASIN AREA (ACRES)	RATIONAL RUNOFF Q(CFS)	BASIN	BASIN AREA (ACRES)	RATIONAL RUNOFF Q(CFS)
A1	120.6	81.0	C20	72.5	176.4
A2	134.2	98.8	D1	105.7	325.5
A3	103.9	75.2	D2	127.1	407.1
A4	162.4	128.0	D3	81.1	311.7
A5	134.2	100.4	D4	75.2	313.7
A6	90.0	68.4	D5	81.7	270.6
A7	87.4	64.3	E1	59.5	124.6
A8	153.3	107.3	E2	57.7	221.6
A9	126.0	97.5	E3	93.7	313.4
A10	108.2	78.3	E4	98.6	236.1
A11	76.1	63.6	E5	81.4	249.1
A12	76.2	127.4	E6	28.8	85.9
A13	102.9	75.7	E7	75.2	240.8
B1	122.6	172.5	E8	79.6	248.0
B2	68.6	177.0	E9	67.2	178.6
B3	93.2	226.4	E10	59.9	161.6
B4	66.6	154.6	E11	63.8	166.8
B5	68.2	256.9	F1	87.7	224.8
B6	117.2	376.4	G1	115.1	380.2
B7	190.1	455.1	G2	68.7	188.1
B8	101.8	317.9	G3	116.9	341.6
B9	108.0	267.2	G4	84.7	301.7
C1	105.3	175.4	G5	75.5	231.9
C2	98.3	95.8	G6	89.0	228.9
C3	103.6	165.7	G7	109.6	309.0
C4	143.1	258.9	G8	52.1	182.9
C5	145.6	189.3	H1	107.9	455.1
C6	68.3	191.4	H2	67.7	286.4
C7	99.6	262.6	H3	90.2	218.5
C8	109.2	286.1	H4	82.1	248.9
C9	132.0	292.0	H5	231.9	907.9
C10	67.7	151.6	H6	136.8	494.9
C11	79.7	190.9	H7	89.9	318.7
C12	71.6	201.3	H8	80.0	242.1
C13	79.9	158.6	H9	110.4	318.7
C14	66.7	187.0	H10	40.8	149.6
C15	54.6	155.4	H11	92.2	382.5
C16	90.5	231.9	H12	104.0	359.6
C17	56.4	139.0	H13	81.7	288.0
C18	128.5	307.0	H14	73.6	311.0
C19	71.9	162.3	H15	53.4	205.2

COTTONWOOD CREEK DBPS - TABLE 1
BASIN HYDROLOGY - SUMMARY OF PEAK FLOWS
100-YEAR STORM

BASIN	BASIN AREA (ACRES)	RATIONAL RUNOFF Q(CFS)	BASIN	BASIN AREA (ACRES)	RATIONAL RUNOFF Q(CFS)
H16	68.0	230.7	Q2	128.6	335.9
H17	65.0	214.4	Q3	50.0	135.3
H18	111.0	358.8	Q4	82.2	264.8
H19	75.2	218.5	Q5	98.2	255.2
H20	45.4	139.1	Q6	134.4	504.2
H21	51.7	214.5	Q7	116.4	348.4
H22	113.7	481.0	Q8	53.8	175.5
H23	67.0	214.6	R1	114.6	412.3
I1	129.7	343.4	R2	79.6	220.4
I2	64.7	163.2	R3	47.4	182.1
I3	85.4	222.0	R4	124.1	461.5
I4	111.2	240.3	R5	124.4	450.1
I5	157.2	374.1	R6	127.8	331.9
I6	175.1	620.9	R7	105.7	311.7
I7	95.7	323.6	S1	84.1	273.1
I8	68.2	216.6	S2	85.8	262.7
I9	29.4	84.5	S3	116.8	333.5
I10	109.7	333.2	T1A	56.9	202.4
J1	136.1	333.2	T1B	81.4	237.5
J2	54.2	196.1	T2	101.7	250.1
J3	84.6	369.3	T3	74.6	203.8
K1	108.0	300.5	T4A	60.7	182.4
K2	119.9	404.4	T4B	48.0	164.5
K3	62.8	216.4	U1	86.9	288.6
K4	93.8	290.9	U2	92.7	242.4
L1	92.7	287.6	U3	66.1	297.3
L2	94.0	211.7	U4A	53.4	150.2
M1	57.6	241.4	U4B	100.0	239.7
M2	130.9	391.9	V1	146.6	418.9
M3	102.1	290.8	V2	90.6	343.1
M4	146.5	344.3	W1	134.0	476.3
M5	65.1	182.0	W2	79.7	330.7
M6	64.6	189.0	W3	67.3	311.9
N1	98.1	358.2	X1A	30.6	83.5
N2	58.4	151.6	X1B	79.7	181.0
N3	162.4	422.9	X2	94.3	361.3
O1	72.0	226.5	X3	118.8	473.1
O2	77.8	243.0	X4	117.3	373.7
P1	77.8	236.0	X5	78.9	270.0
P2	53.7	131.8	Y1	79.6	228.0
P3	127.7	346.9	Y2	97.3	391.0
Q1	65.1	206.0			

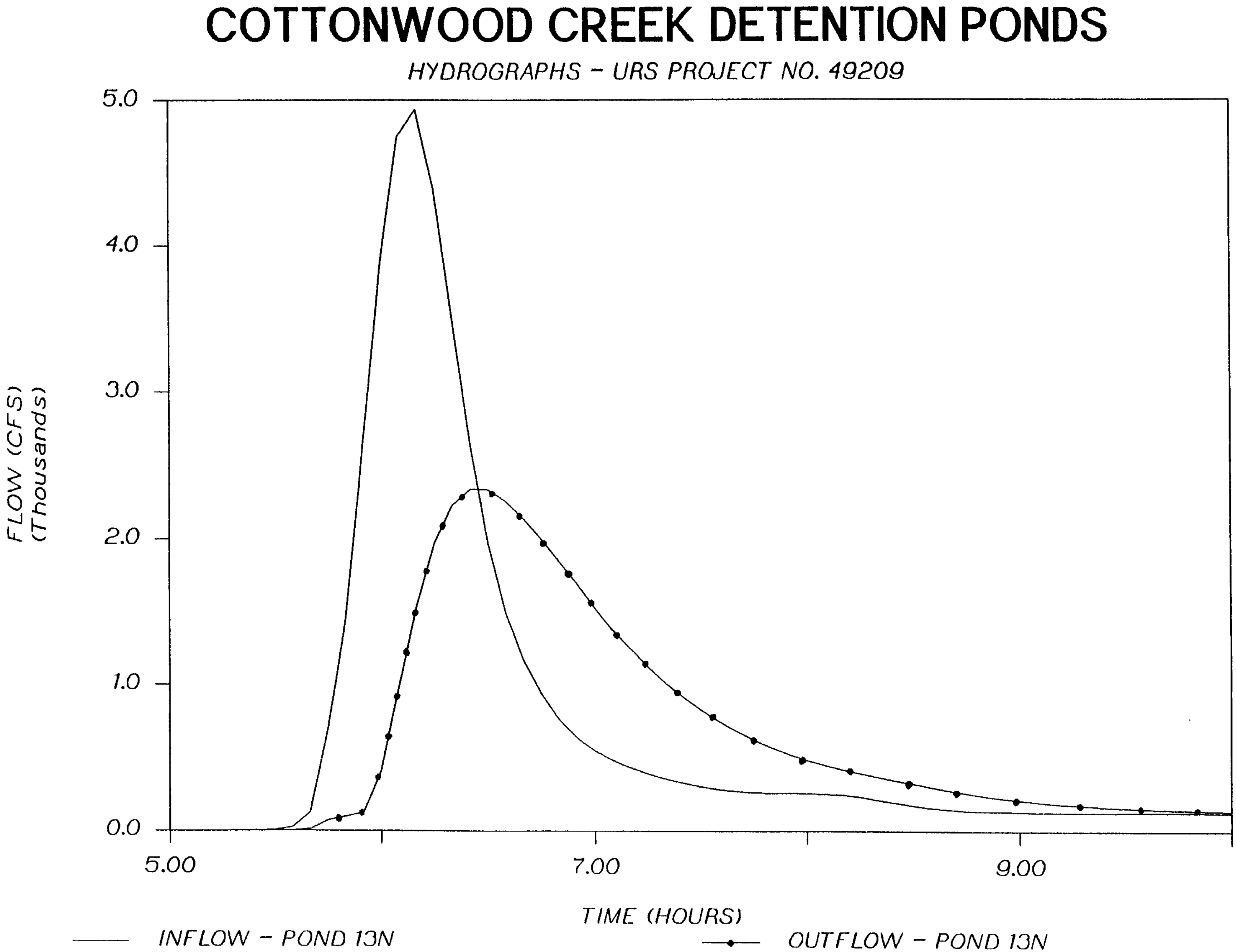

COTTONWOOD CREEK DETENTION PONDS
HYDROGRAPHS - URS PROJECT NO. 49209
5.0
4.0
3.0
2.0
1.0
0.0
FLOW (CFS)
(Thousands)
5.00
7.00
9.00
TIME (HOURS)
INFLOW - POND 13N
OUTFLOW - POND 13N

FIGURE 19

COTTONWOOD CREEK DETENTION PONDS

HYDROGRAPHS - URS PROJECT NO. 49209

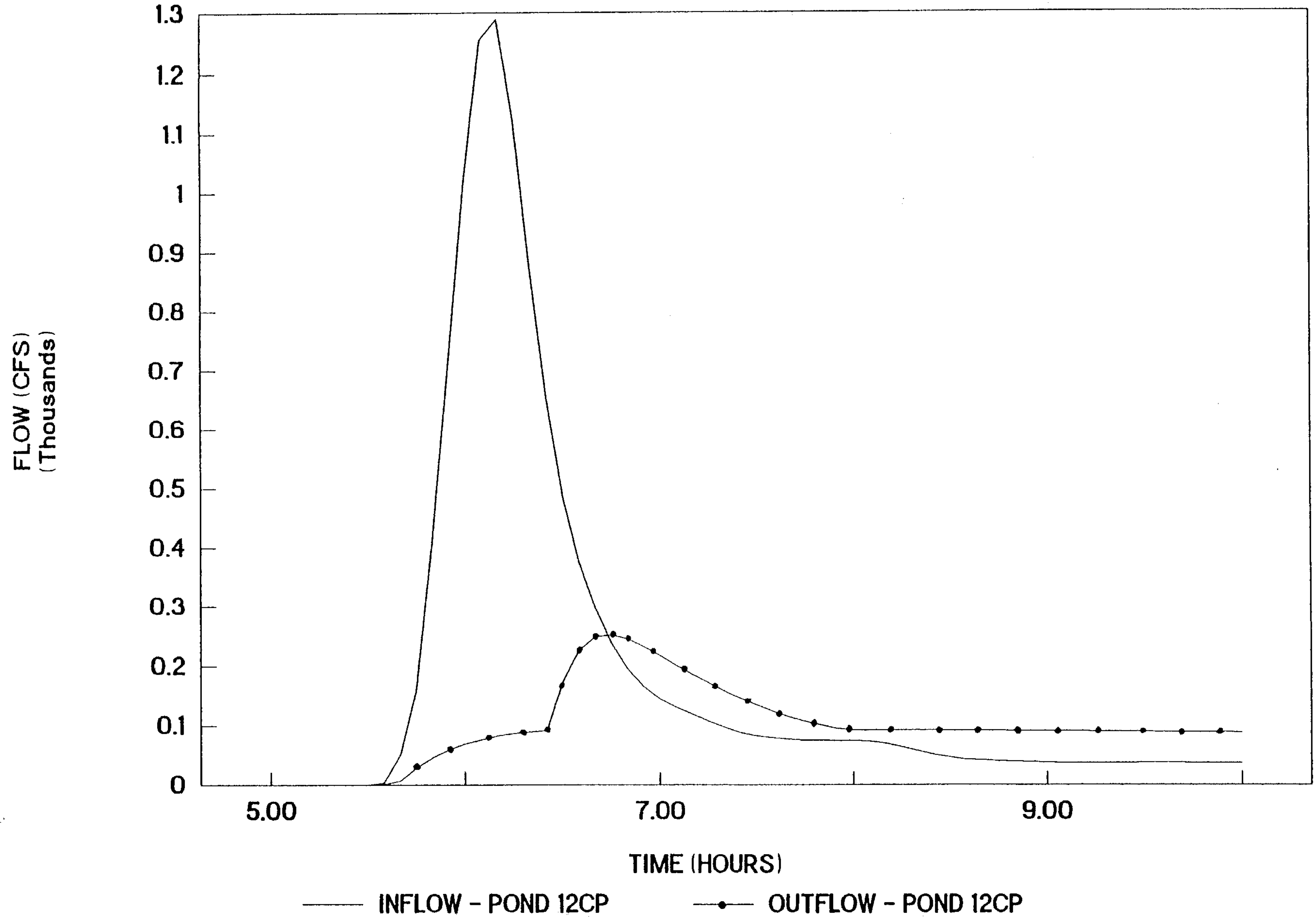


FIGURE 20

COTTONWOOD CREEK DETENTION PONDS

HYDROGRAPHS - URS PROJECT NO. 49209

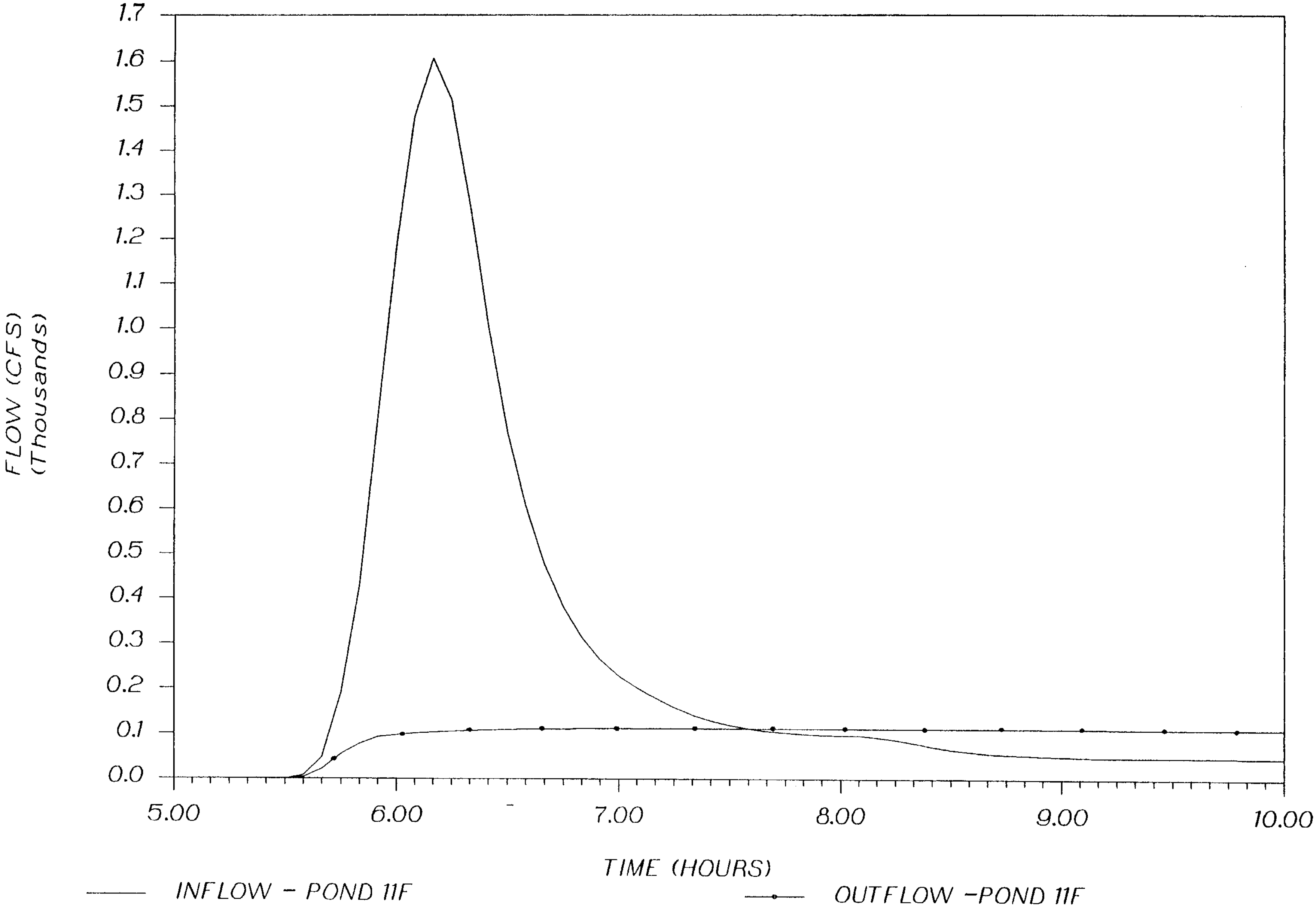


FIGURE 21

COTTONWOOD CREEK DETENTION PONDS

HYDROGRAPHS - URS PROJECT NO. 49209

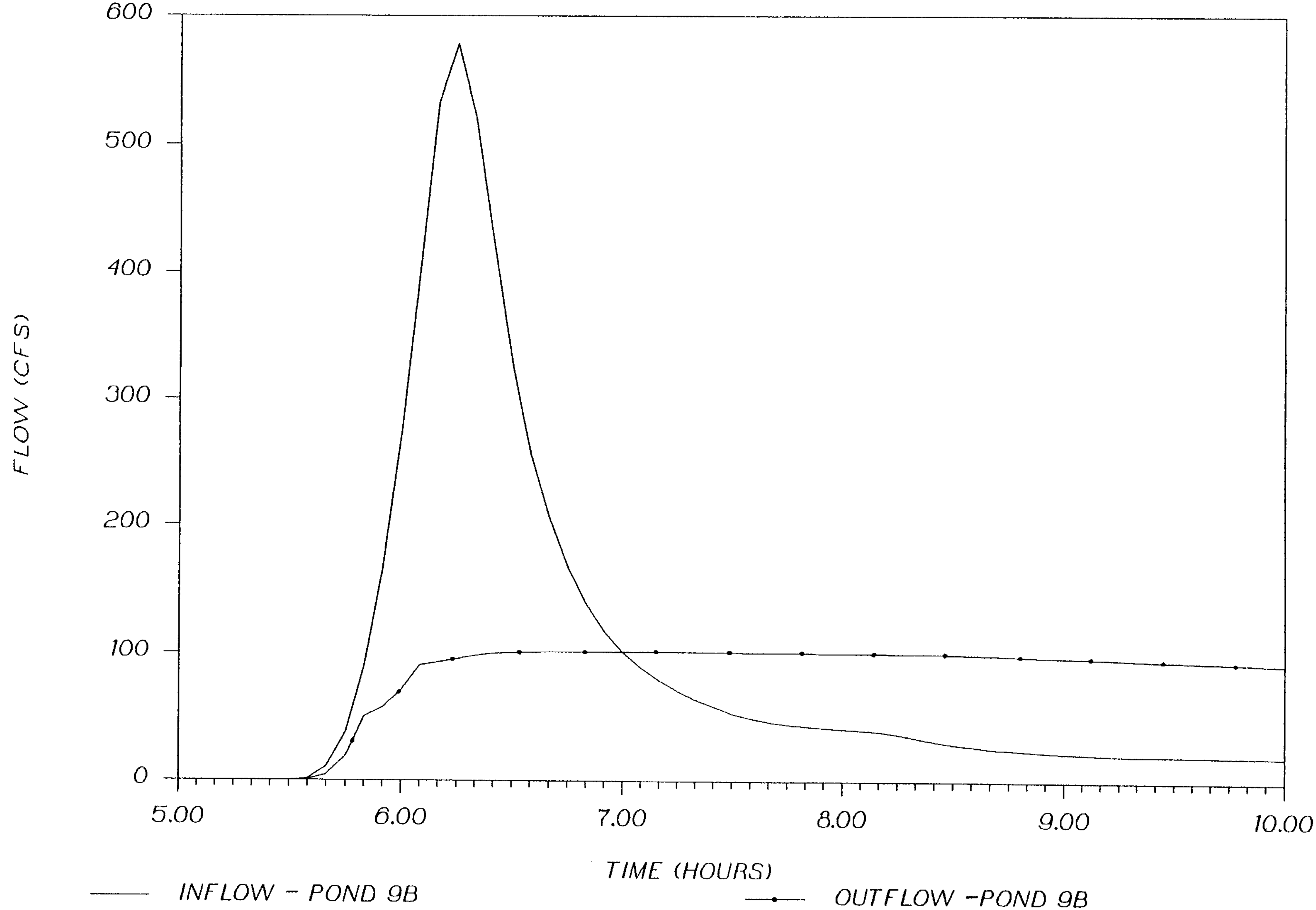


FIGURE 22

COTTONWOOD CREEK DETENTION PONDS

HYDROGRAPHS - URS PROJECT NO. 49209

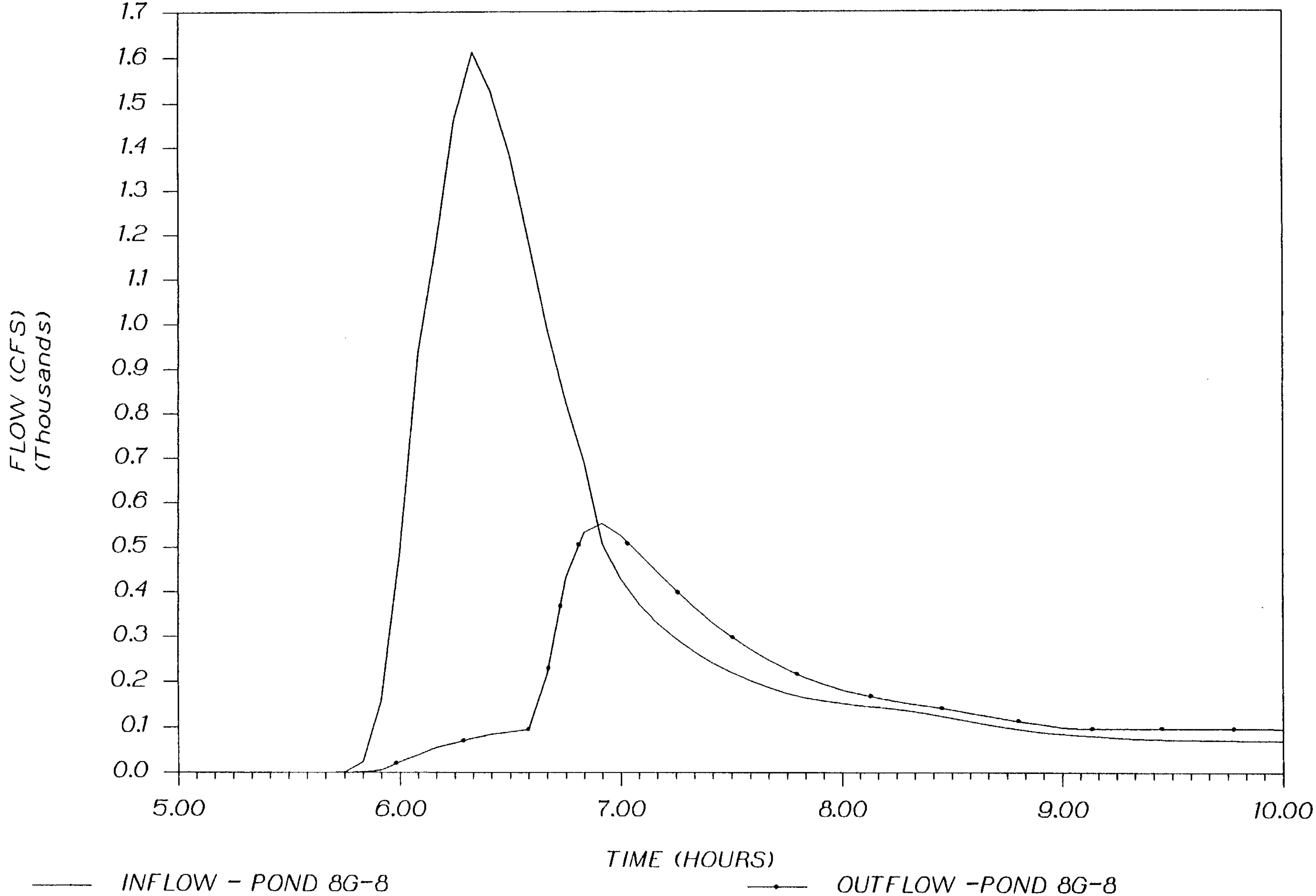


FIGURE 23

COTTONWOOD CREEK DETENTION PONDS

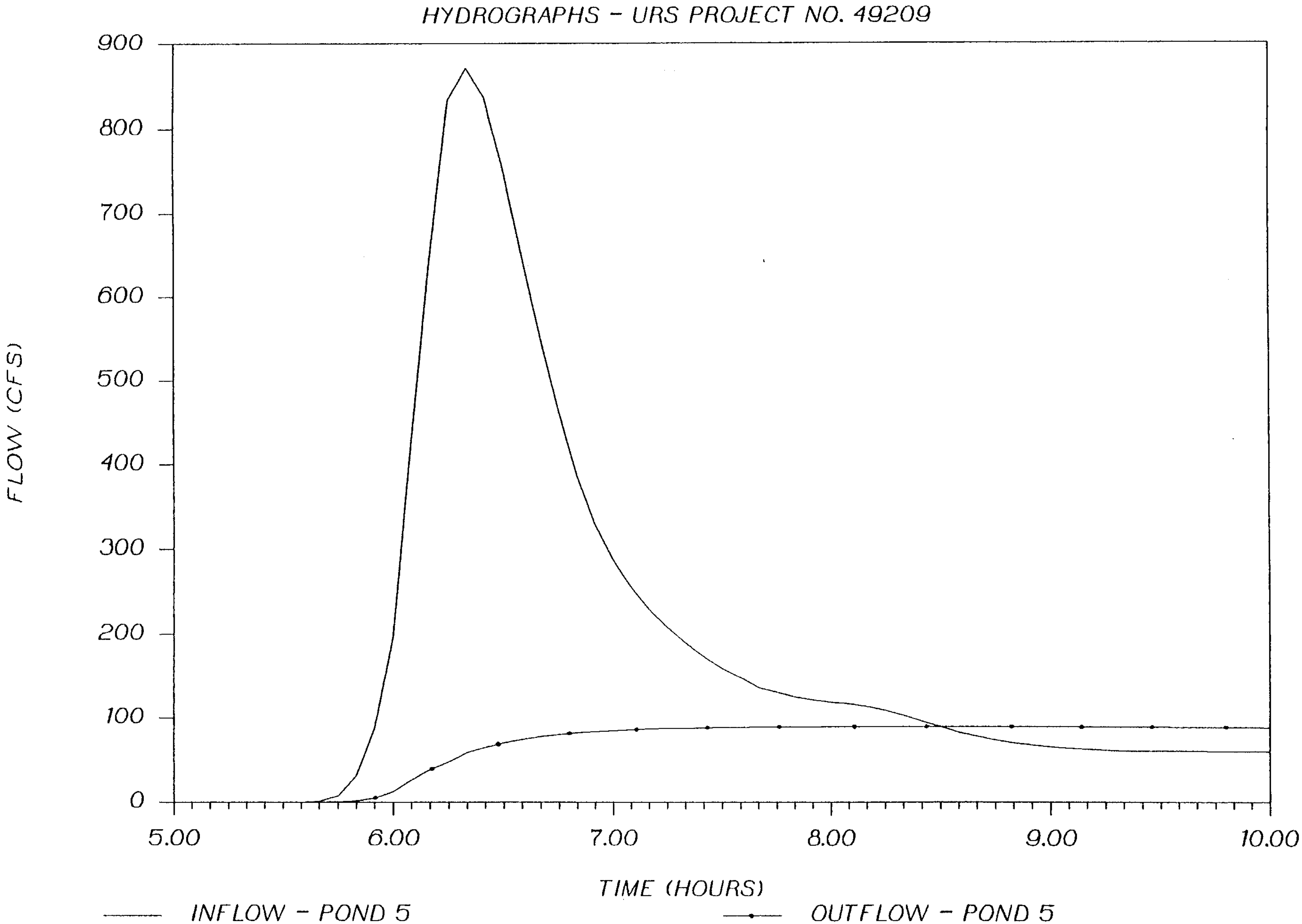


FIGURE 24

PINE CREEK DETENTION PONDS

HYDROGRAPHS - URS PROJECT NO. 49209

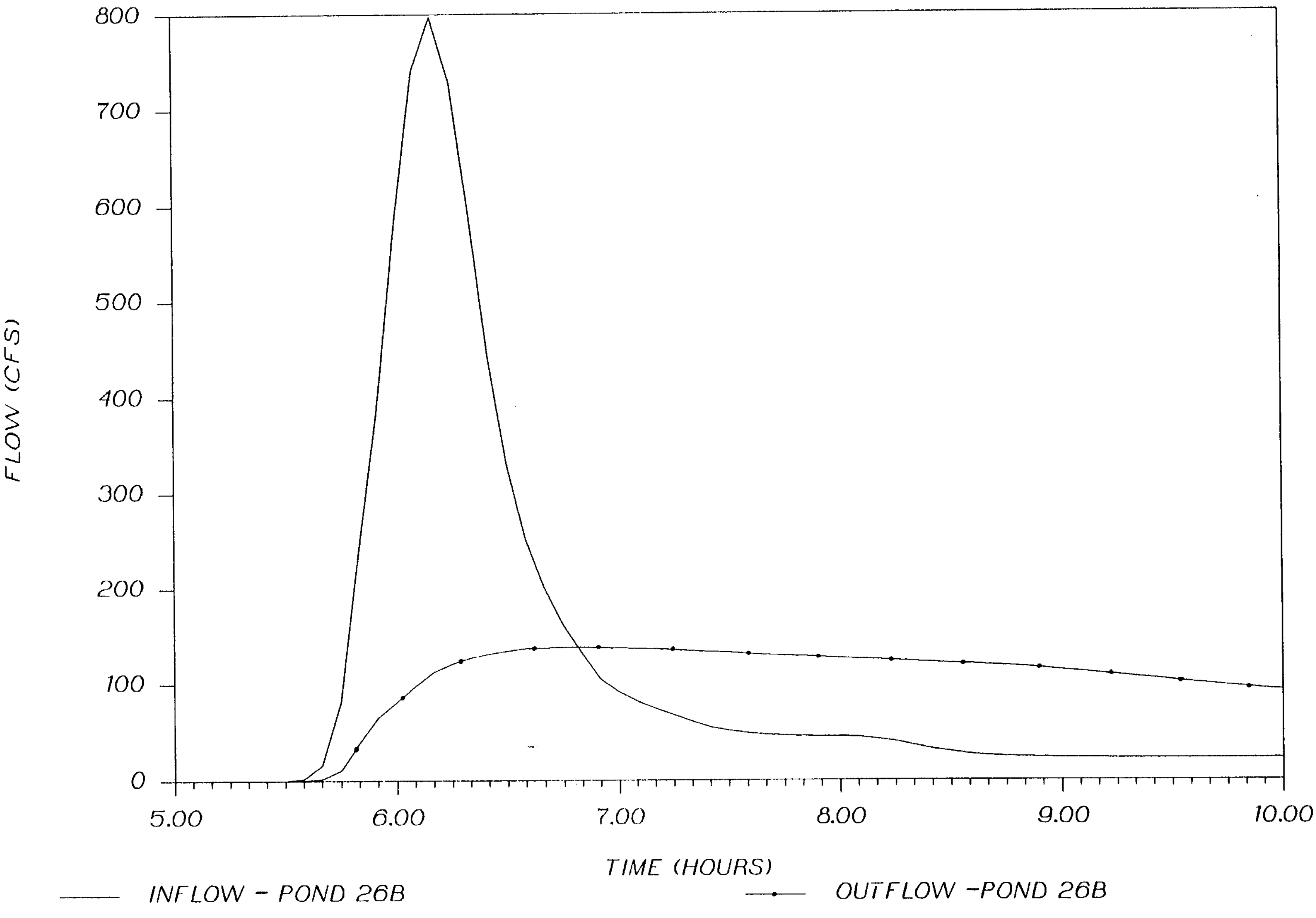


FIGURE 25

PINE CREEK DETENTION PONDS

HYDROGRAPHS – URS PROJECT NO. 49209

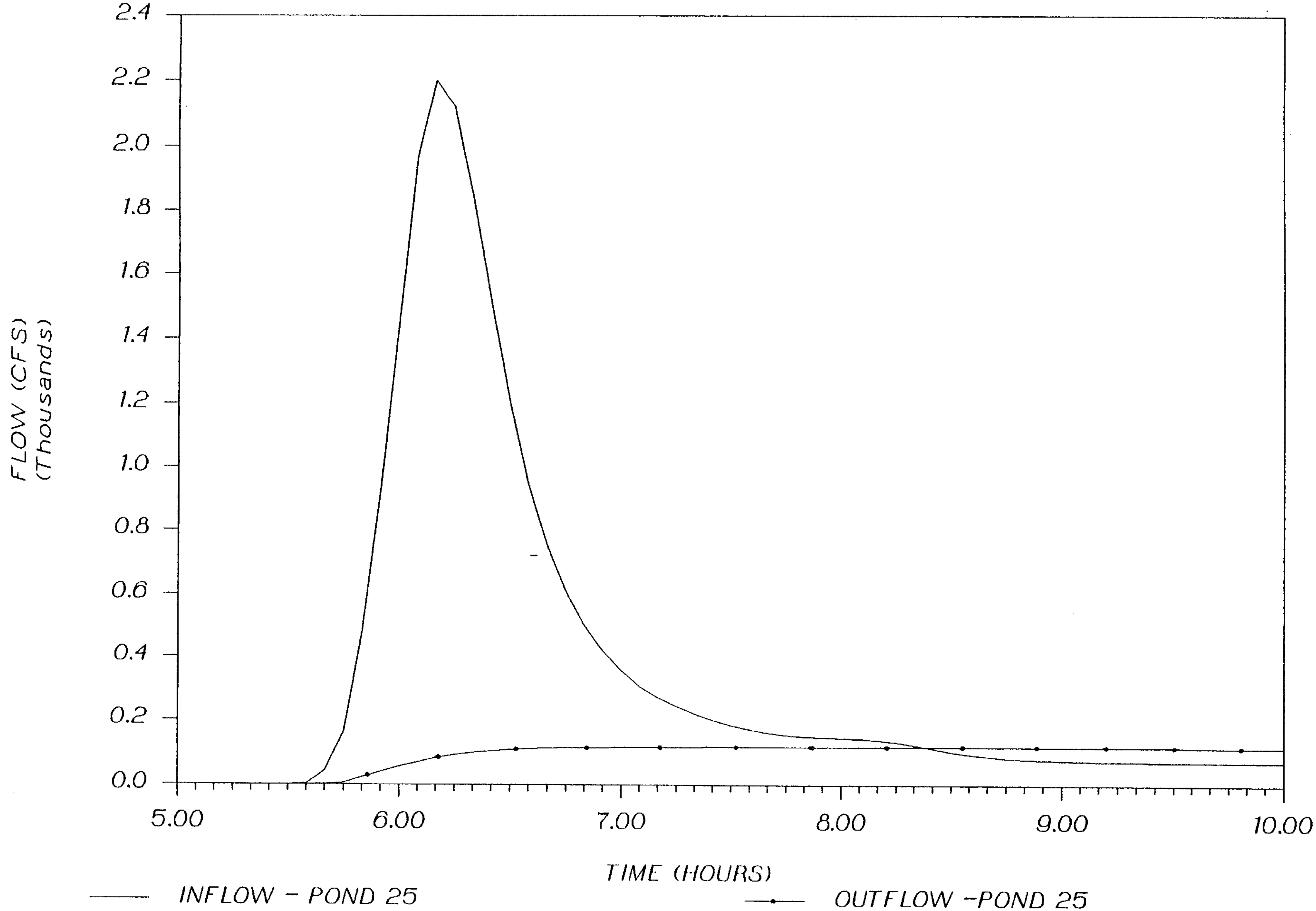


FIGURE 26

PINE CREEK DETENTION PONDS

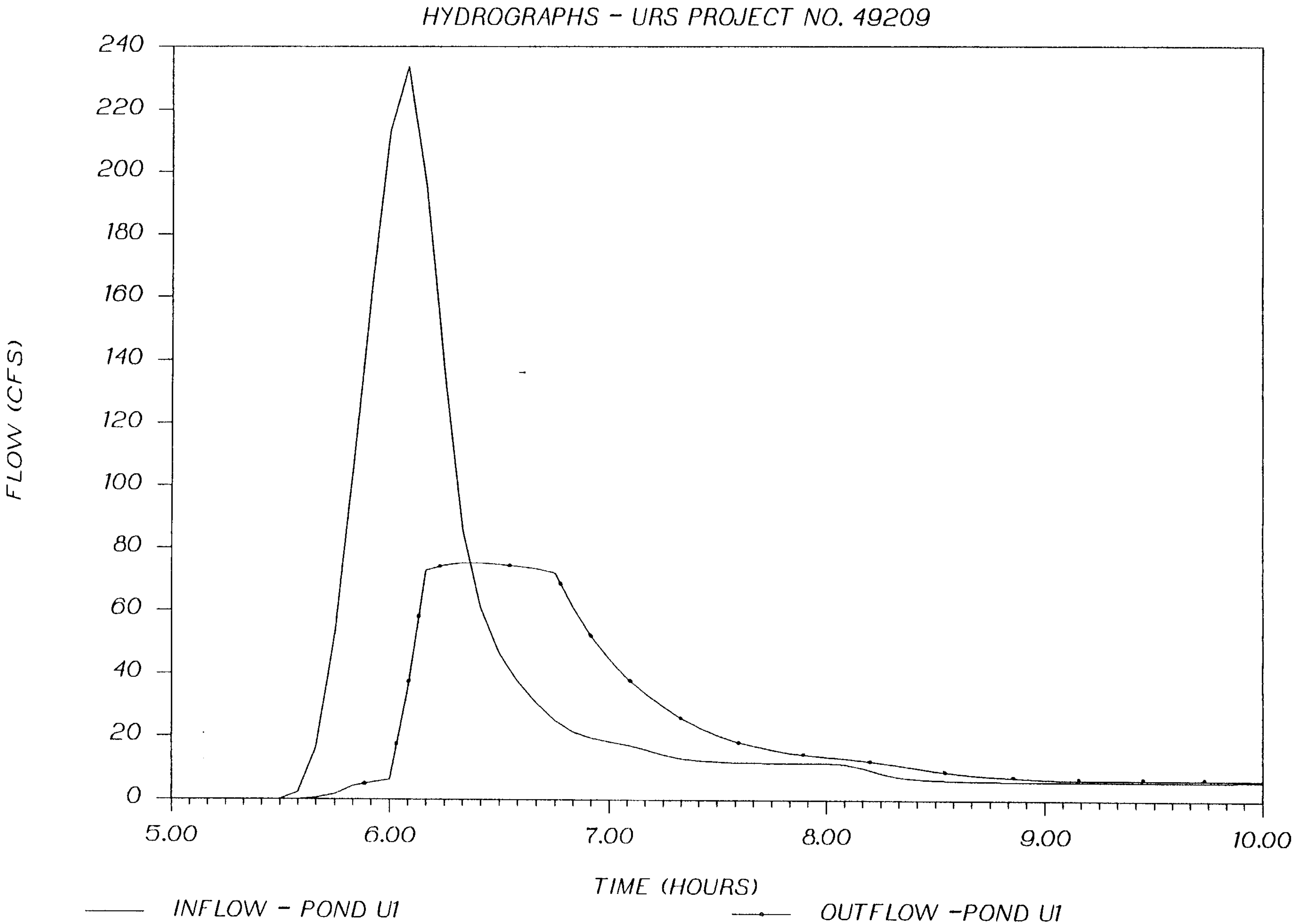
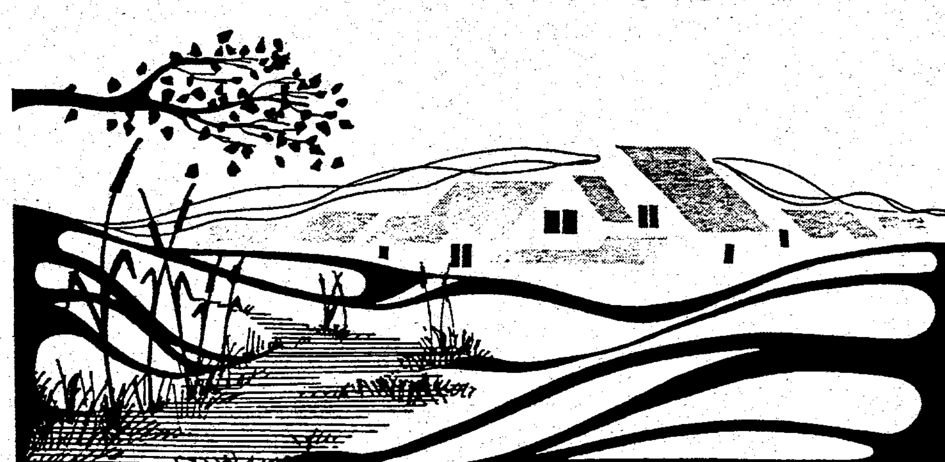


FIGURE 27

Proposed Alternative Solutions



IV. PROPOSED ALTERNATIVE SOLUTIONS

A. ALTERNATIVE DELINEATION

1. Detention Pond Alternatives

Cottonwood Creek Basin

Three detention pond alternatives for the basin were considered. All of the detention ponds are of the regional or subregional size per current criteria. Current criteria does not allow the use of onsite detention ponds for permanent, public facilities. Based on the existing reach capacities, it was concluded that there was a desire to reduce the flows above the following reaches. The most critical reach is the one from design points 16 to 14 (upstream of Union Blvd.). This area has been almost fully developed and the channel is partially lined in this section. The problem is that there is not enough elevation difference between the channel and adjacent properties to the north to increase the capacity by adding depth and the land is not available to expand horizontally for additional capacity. This confirmed earlier discussions that we needed to look at detention upstream of Rangewood Drive.

The first alternative was to place the detention in the upstream portion of the main channel for Cottonwood. The second alternative was to place the detention in the major tributary that joins Cottonwood from the south at Rangewood Drive. The third alternative was a combination of the first two alternatives. For this alternative it was decided to select the best detention pond locations from the first two alternatives in terms of compatibility with the adjacent land uses. That is, ponds were sited in proposed park, open space, or low density land uses. Under the full flow-through situation, there are approximately equal flows coming from these two tributaries. By delaying the peak flows in one of these tributaries, detention can reduce the combined peak flow rate. Another consideration was to place the detention in these alternatives upstream of the major road crossings, where possible, to reduce the facility requirements at these crossings. In the main channel, this would mean placing the ponds upstream of Powers Blvd or Briargate Parkway. In the south tributary this would mean placing the ponds upstream of Austin Bluffs Pkwy. Another consideration that was important was that the topography for the area be suitable for placement of the detention ponds.

Pine Creek Basin

The existing detention ponds in the basin were analyzed. Based on the existing reach capacities, it was concluded that there was a desire to reduce the flows above the following reaches. The most critical reaches are : a) From design point 28 to design point 29; b) design point 28C to design point 28E; c) design point 23A to design point 25. The first listed reach can be widened to get additional capacity, is in poor condition and needs to be rebuilt anyway. For the second reach, detention was considered but not recommended in the final plan due to the high density land uses in this area. The area for the third reach has been fully developed leaving no land available for a detention pond.

In addition, we looked at increasing the capacity of the Chapel Hills Detention Ponds 1 and 2. Due to the extent of development in this basin it was difficult to look at different detention alternatives for this basin. Therefore, no ponds were proposed in addition to the three ponds that already exist in this basin.

2. Channel Alternatives

We classified the reaches for the basin study by type of existing improvement and by available capacity. From this classification, we grouped the reaches into the following categories:

a. No Improvement Required

This classification of channel already has existing protection and adequate capacity to pass the 100-year storm. This includes fully-lined channels (concrete or riprap), storm sewer/street combinations, or partially lined channels (riprap) for existing improvements.

b. Upgrade Existing Facility

This classification of channel already has existing protection but does not have the capacity to pass the recommended plan hydrology. This includes fully lined channels (concrete), storm sewer/street combinations, or partially lined channels (riprap) for existing improvements. These sections can be modified by increasing the depth or width of the channel to provide adequate capacity or to run a parallel storm sewer system. In some cases, the channel cannot be modified sufficiently to have adequate capacity without affecting existing developed properties and therefore detention was provided as outlined earlier.

c. Existing Natural Drainage System

These systems consist of natural drainageways with adequate capacity, not enough capacity but able to increase depth to gain adequate capacity, or not enough capacity and unable to increase depth to gain adequate capacity. Alternatives A, B, and C/D were evaluated for these reaches. The existing channel widths or depths were modified, where appropriate, to see what size of facilities were needed. In addition to the facility sizes, the existing slopes and expected velocities were roughly determined to see what factors are appropriate for alternative selection. Figures 28 through 31 show schematically the different channel alternatives considered.

B. ALTERNATIVE EVALUATION/CRITERIA

The channel reaches were analyzed for thirteen factors that affect the selection of channel alternatives. These thirteen factors are presented in matrix form on Table 8 (Appendix B) which was discussed previously. The matrix has the thirteen factors across the top of the matrix and the 101 reaches that were considered down the side. The factors considered are as follows:

a. Existing Protection
b. Available/Additional Capacity
c. Erosion Considerations
d. Wetland Considerations
e. Wildlife Considerations
f. Compatibility with Utilities
g. Land Use Compatibility
h. Land Availability
i. Multi-Use Opportunities
j. Capital Costs per Alternative
k. Maintenance Considerations per Alternative
l. Safety or Flood Protection Considerations
m. Additional Comments

The basin was then divided up into five similar types of reaches along the main channel based on similar channel characteristics and two tributaries. Each area is shown on Figure 41 (Appendix B) and described in Table 13 (Appendix B). Table 13 also lists the advantages and disadvantages for each alternative type for each overall area. This information along with preliminary recommendations were presented to the Resource Agency/Interested Citizens group and discussed.

C. ALTERNATIVE SELECTION

The selection of alternatives for each reach of the basin was done by weighing all of the alternative evaluation parameters. There are conflicting interests throughout the alternative selection process due to different value sets and differing regulations that govern drainage. These conflicts can not be resolved without balancing the interests and reaching some compromises. As an example, the steep terrain and erodible soils require some type of channel protection for the majority of this basin in order to avoid having significant erosion and changes in the channel or hazards to life and property. On the other hand, it is desirable to leave this basin as close to natural as possible to minimize the impact to vegetation and wildlife. This basin plan considered all of these factors and made decisions on what is the most appropriate plan for the Cottonwood Creek basin. The recommended plan is a result of much effort and discussion with appropriate government agencies and interested citizens and presents what was considered to be the consensus of those parties involved. We would like to thank the following groups for their participation in this study:

Federal Agencies	**Representative**
Corps of Engineers	Ms. Anita Culp
Environmental Protection Agency	Ms. Sarah Fowler
U.S. Fish and Wildlife Service	Mr. Bill Noonan
Federal Emergency Management Agency	Dr. John Liou
USDA Soil Conservation Service	Mr. Ed Spence
State Agencies	
Colorado Division of Wildlife	Mr. Bruce Goforth
Colorado Department of Transportation	Mr. Ray Brown
Colorado Water Conservation Board	Mr. Larry Lang
Local Agencies	
City Dept. of Planning, Dev., & Finance	Mr. Gary Haynes
City Dept. of Planning, Dev., & Finance	Mr. Ken Sampley
City Dept. of Planning, Dev., & Finance	Mr. Dave Nickerson
City Dept. of Planning, Dev., & Finance	Mr. Bruce Thorson
City Dept. of Planning, Dev., & Finance	Mr. Chris Smith
City Planning Division	Mr. Craig Bluett
City Planning Division	Mr. Jim Mayerl
City Parks and Recreation	Mr. Bill Ruskin
City Parks and Recreation	Mr. Jim Rees
El Paso County Dept. of Public Works	Mr. Max Rothschild
El Paso County Dept. of Public Works	Mr. Alan Morrice
El Paso County Planning Department	Mr. Mark Gebhart
El Paso County Parks Department	Mr. Jeff Brauer
Regional Flood Plain Administrator	Mr. Dan Bunting
Regional Building Department	Ms. Bev Dustin

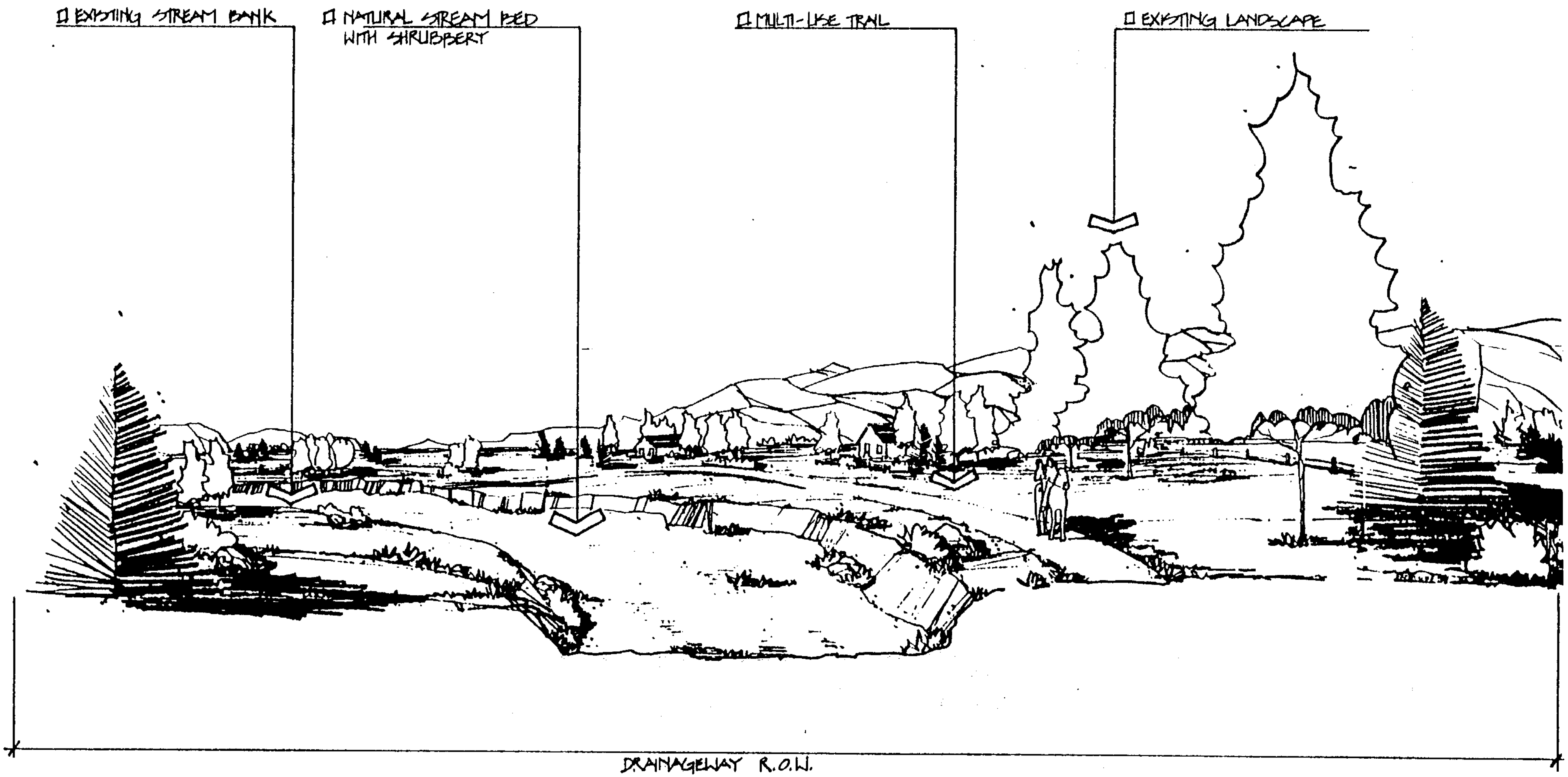
Local Agencies	Representative
City Attorney's Office	Mr. Wes Tyson
Colorado Springs Electric T&D Dept.	Mr. Ron Gallegos
Colorado Springs Gas Dept.	Mr. Rob Franson
Colorado Springs Wastewater Dept.	Mr. Gary Rombeck
Colorado Springs Water Dept.	Mr. Russ Nicklin
Colorado Springs Street Division	Mr. Dave Zelenok
Companies/Citizen Groups	
Olive Company	Mr. Kevin Walker
League of Women Voters	Ms. P.J. Wenham
League of Women Voters	Ms. Pam Bryant
Trails Coalition	Mr. John Maynard
SPABA	Mr. Thomas Huber
Palmer Foundation	Mr. John Covert
Columbine Estates Homeowners	Mr. Larry Tobias
Vintage Companies	Mr. Jerry Novak
Vintage Companies	Mr. Joe Kostka
Norwood Development	Mr. Kent Petre
Norwood Development	Mr. David Jenkins
Brown Diversified Investments	Mr. Ben Brown

City/County Drainage Board

Mr. Rob Alexander
Mr. Chuck Donley
Mr. Jerry Novak
Mr. Kent Rockwell
Mr. Phil Weinert
Mr. Lew Biegelsen
Mr. Bill Vaupel
Mr. Roland Obering
Mr. Guenther Polok
Ms. Jean Hunt

Cottonwood Creek Drainage Basin Task Force

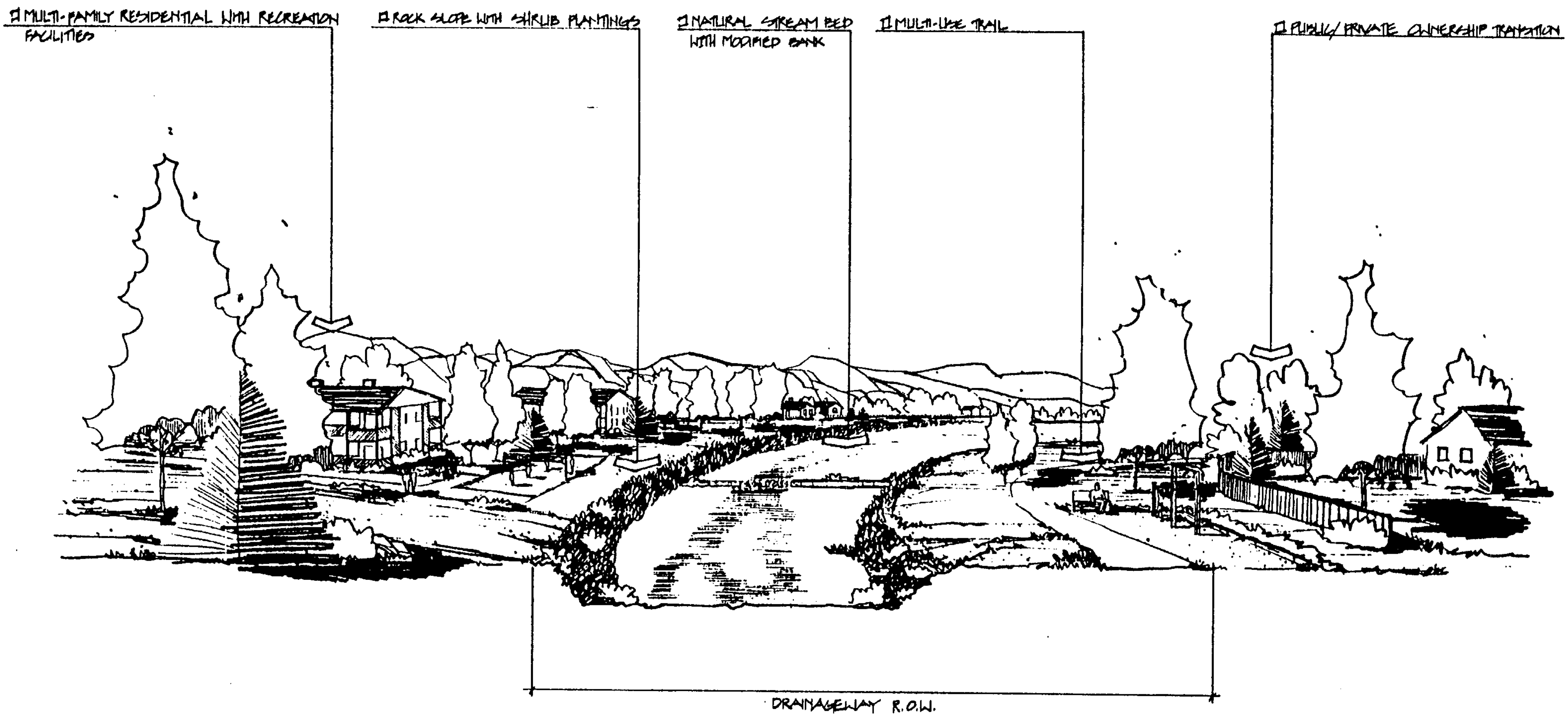
Mr. Chuck Donley
Mr. Mike Hausman
Mr. Terry Schooler
Mr. David Jenkins
Mr. Guenther Polok
Mr. Roger Sams
Mr. Joseph DesJardin
Mr. Alan Morrice
Mr. David Lethbridge
Mr. Don Steger



ALTERNATIVE A

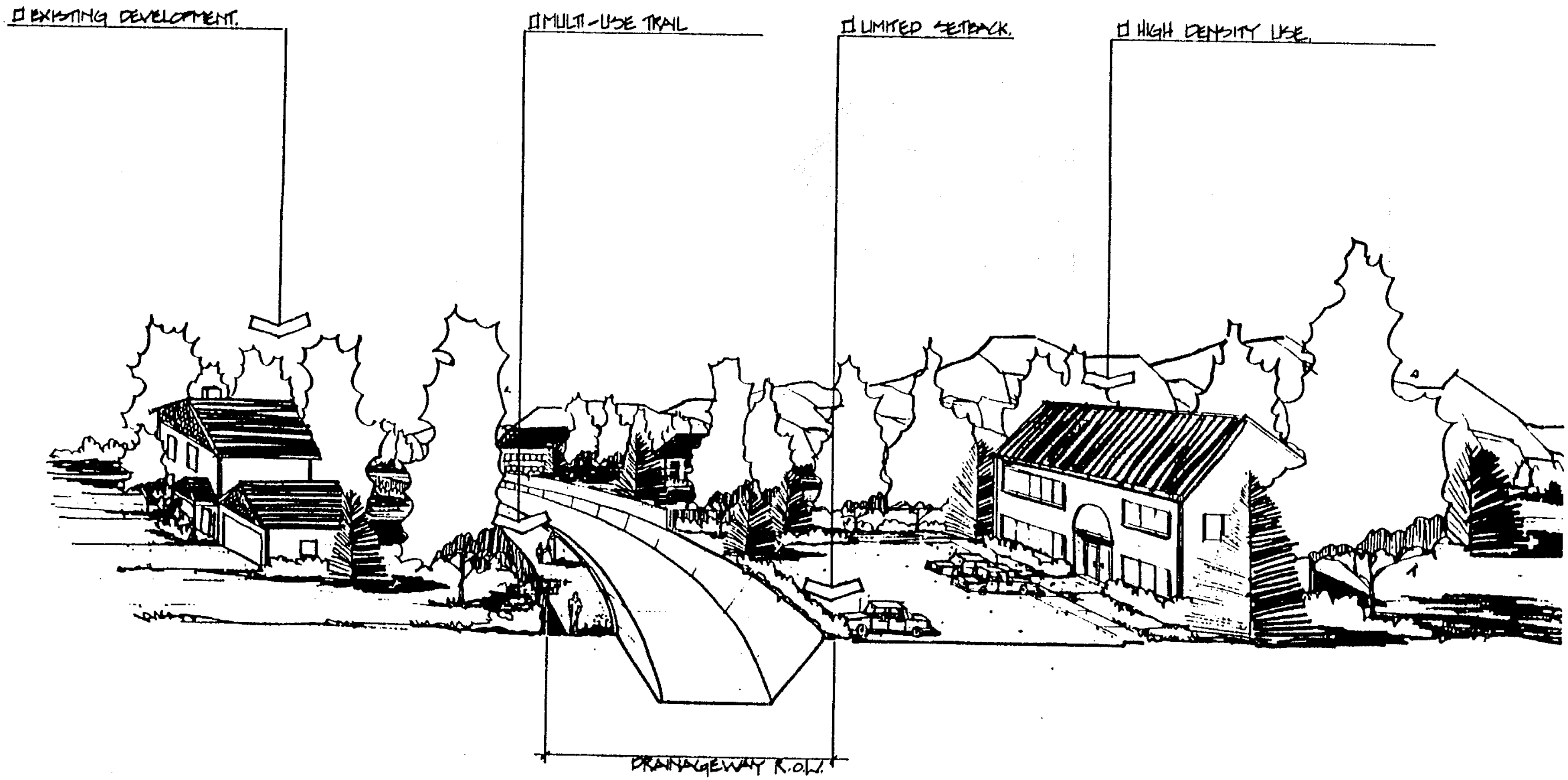
FIGURE 28

URS



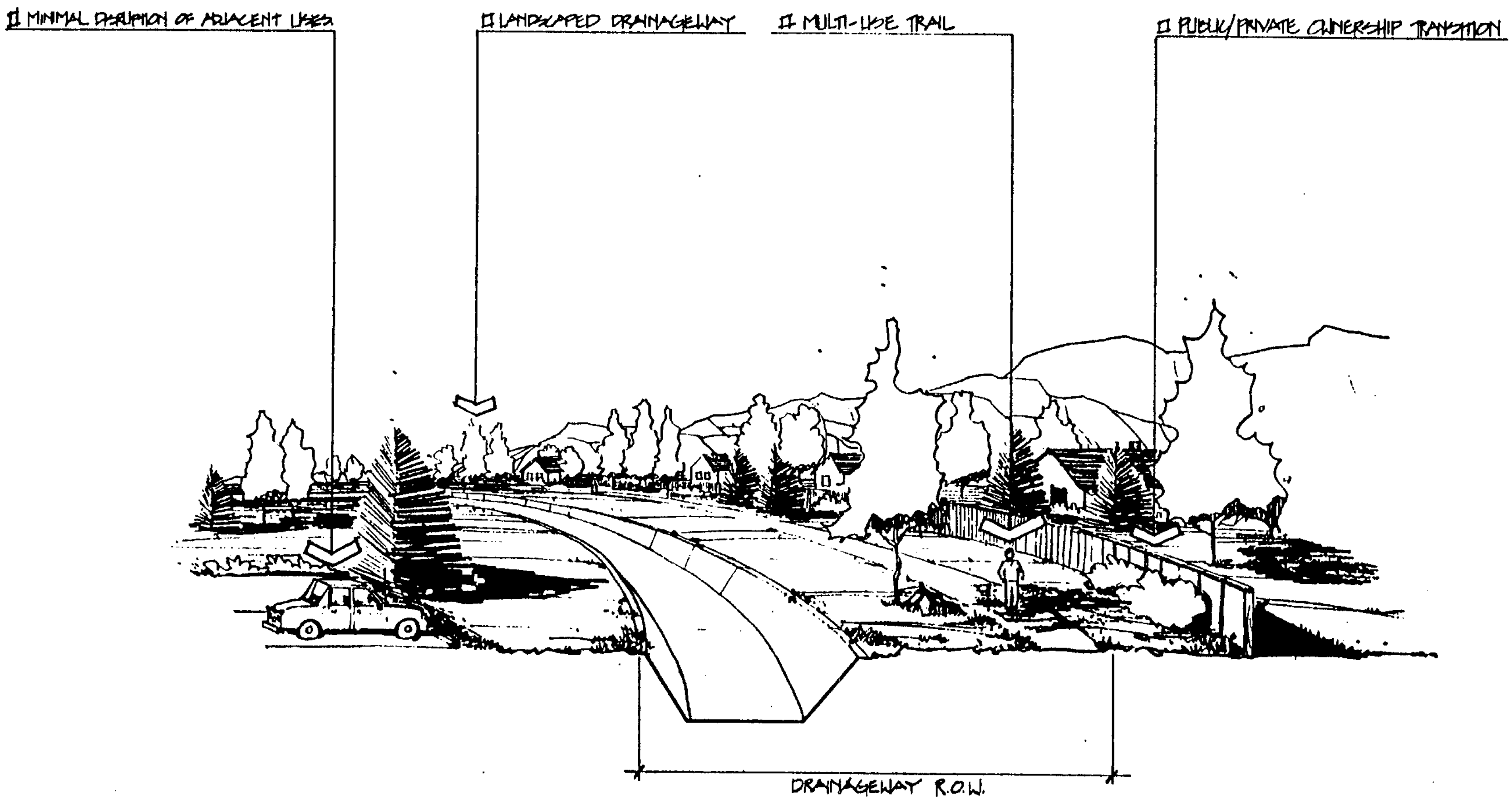
ALTERNATIVE B

FIGURE 29



ALTERNATIVE C

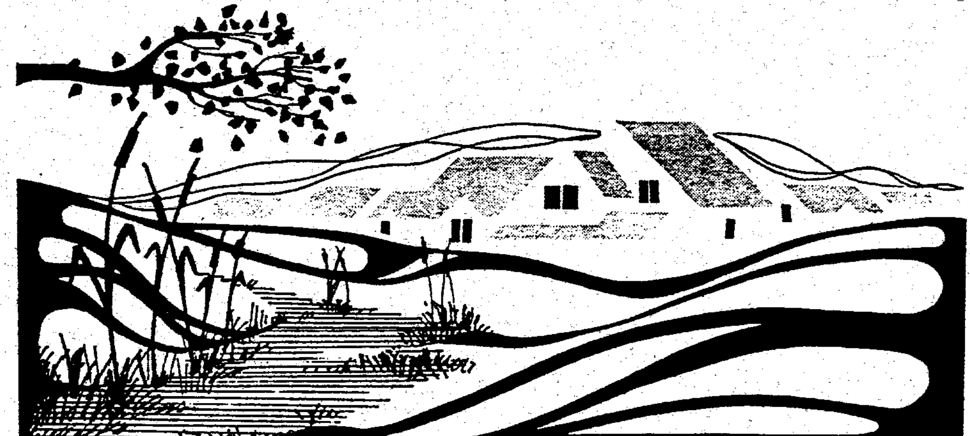
FIGURE 30



ALTERNATIVE D

FIGURE 31

Recommended Plan



V. RECOMMENDED PLAN

A. DETENTION PONDS

1. Cottonwood Creek Basin

The Cottonwood Creek basin does not currently have any detention ponds. This study recommends that six detention ponds be constructed as part of the overall basin improvements. The ponds were sized to reduce the overall peak flow rates in the main channel of Cottonwood Creek to the capacities which the current facilities can handle. As an example, the peak flow for the main channel of Cottonwood Creek at the confluence with Monument Creek was reduced from 17,400 CFS to 11,320 CFS. This reduces the requirement for upgrading much of the current facilities to match the new completed peak flow rates. It also reduces the sizes of facilities where improvements are needed.

The detention ponds were located on tributaries of the basin in order to keep their size to a minimum within the limits of using regional type detention ponds. The ponds range in size from a storage volume of 21 acre-feet to 128 acre feet for the 100-year, 24-hour storm. Table 2 presents the design information for the detention ponds. The locations of all detention ponds are shown schematically on the overall basin map, Figure 2 (Appendix A), with more detail being provided of each pond location on the appropriate 1"=200′ scale map, Figures 8 through 18 (Appendix A).

2. South Pine Creek Basin

The South Pine Creek basin currently has three existing detention ponds. This study recommends that no new detention ponds be constructed. The current ponds are sized adequately to pass the 100-year 24-hour storm without overtopping the dam. It should also be noted that the Pine Creek DBPS includes additional detention ponds that are proposed in the approved basin plan for the north tributary of Pine Creek. These were incorporated into the hydrologic model for this study with the information from the computer model used in that DBPS.

The detention ponds are located on tributaries of the basin in order to keep their size to a minimum within the limits of using regional type detention ponds. The existing ponds range in size from storage volumes of 29 acre-feet to 146 acre feet for the 100-year, 24-hour storm.

3. Overall Considerations

Existing detention pond depth/storage/release curves were obtained from construction plans for the detention ponds. Proposed detention pond depth/storage/release curves were either determined using existing topographic mapping or by extrapolating the volume of the existing detention pond curves. The extrapolation was used for the detention ponds that did not have detailed topographic mapping available. This was done by using the same elevation/volume curves as the existing detention ponds in South Pine Creek and adjusting the elevation/outflow curves (determined by size of spillway) to achieve the desired peak release rate. Construction costs for the detention ponds are presented in a later section and were done using a unit price of $9000 per acre foot of storage based on previously constructed detention facilities in the City of Colorado Springs.

It should be noted that the detention ponds may be considered jurisdictional dams by the Colorado State Engineer's Office due to the heights of the dams exceeding 10 feet. Final design of these ponds will require coordination with the State Engineer's Office to make final determinations as to their jurisdictional status, hazard ratings and the type of spillway required. The approximate pond and 100-year water surface locations are shown on Figures 8 through 18 (Appendix A) depending on which area of the basin the pond is in.

Subdivision drainage reports will need to address the detention facilities as part of each proposed development. The actual sizes of the ponds will need to be refined in the subdivision drainage report. All of the detention ponds proposed in this plan are considered public facilities and need to have adequate right-of-way for both the pond area and downstream. Current detention pond policy allows reimbursement for land in excess of the flow-through channel to be reimbursed at the current park land dedication rate and is included as part of the fee structure.

B. CHANNELS

1. Channel Types

Channels are defined in this section of the study as those channels or pipes required downstream of the 100 acre +/- subbasins shown in this report. These channels are to be designed for the 100-year 24-hour storm peak flows presented in the hydrology section of this study. Refer to the initial system section (Appendix B) for examples of improvements required upstream of the 100 acre subbasins.

Three basic channel types were conceptually developed as alternatives for current drainageways in response to future runoff conditions. These were presented previously in Figures 28 through 31 (Alternatives A, B, and C/D).

The final recommendations of this study outlines several specific types of channel treatment utilizing the basic concepts presented for the three channel types. These specific channel recommendations are consistent with future land use, wetlands, and wildlife habitat. Each channel type also meets the objective of reducing stream velocity and erosion, where practical. The locations and type of channel improvements are shown on Figures 8 through 18 (Appendix A). These channel types can be further described as follows:

a. Leave natural and provide sufficient easement width for natural changes to the channel

This channel type is occupied by native wetland and riparian vegetation. The channel bottom is natural and sinuous. The channel banks are very steep and very deep. It is not considered practical to lay the banks back at flatter slopes or to get construction equipment into the bottom of the channel without totally disrupting the existing vegetation and habitat. The prudent choice is to leave the channel alone and provide sufficient easement or right-of-way to allow for natural changes to the channel to occur within the easement. While proposed widths are shown on Figures 8 through 18 (Appendix A), the actual easement or right-of-way width needs to be determined at the subdivision drainage report level.

b. Leave natural except provide buried riprap and grade control at existing bridges

This channel type is occupied by native wetland and riparian vegetation. The channel bottom is natural and fairly straight. The channel banks are very steep and very deep. The channel has been and is continuing to downcut vertically. It is necessary to protect the existing bridges from failure due to undercutting of their foundations. However, the remainder of the channel will be left natural with sufficient easement or right of way to allow for natural changes to the channel to occur within the easement. While proposed widths are shown on Figures 8 through 18 (Appendix A), the actual easement or right-of-way width needs to be determined at the subdivision drainage report level.

c. Leave natural except provide gabions and grade control at key locations

This channel type is occupied by native wetland and shrub vegetation. The channel bottom is natural and fairly straight. The channel banks are nearly vertical and fairly deep. The channel has been and is continuing to downcut vertically. It is necessary to protect existing buildings and houses from bank failure due to sloughing or lateral migration of the channel. The banks are too steep to practically use buried riprap. The locations of the protection proposed is shown on the detailed maps. However, the remainder of the channel will be left natural with sufficient easement or right of way to allow for natural changes to the channel to occur within the easement. While proposed widths are shown on Figures 8 through 18 (Appendix A), the actual easement or right-of-way width needs to be determined at the subdivision drainage report level.

d. Natural bottom with grass/shrub banks and grade control

This channel type is occupied by either native wetland or upland vegetation. The channel banks have moderate to steep slopes. The channel slopes need to be flattened to reduce velocities. The type of bank protection (grasses and shrubs) will enhance the habitat and maintain wildlife corridors. The wetland bottom will contain increased runoff and support wetland vegetation similar to that existing in the drainageway, but at higher densities and diversity. Drop structures will be used to reduce velocities, help prevent erosion and allow establishment and enhancement of the existing bottom vegetation.

e. Natural bottom with erosion matting/grass banks and grade control

This channel type is occupied by either native wetland or upland vegetation. The channel banks have moderate to steep slopes. The channel slopes are steep and need to be flattened as much as possible to reduce velocities. The channel velocities are still too high to have a stable vegetated lining alone, thus the requirement for erosion matting. The type of bank protection (grasses) will provide an aesthetic appearance and maintain wildlife corridors. The wetland bottom will contain increased runoff and support wetland vegetation similar to that existing in the drainageway, but at higher densities and diversity. Drop structures will be used to reduce velocities, help prevent erosion and allow establishment and enhancement of the existing bottom vegetation.

f. Natural bottom with buried riprap banks and grade control

This channel type is occupied by either native wetland or upland vegetation. The channel banks have moderate to steep slopes. The channel slopes are very steep and need to be flattened as much as possible to reduce velocities. The channel velocities are still too high to have a stable vegetated or erosion mat lining alone, thus the requirement for buried riprap. Burying the bank protection and planting grasses will provide an aesthetic appearance and maintain wildlife corridors. The wetland bottom will contain increased runoff and support wetland vegetation similar to that existing in the drainageway, but at higher densities and diversity. Drop structures will be used to reduce velocities, help prevent erosion and allow establishment and enhancement of the existing bottom vegetation.

g. Fully lined concrete channel or storm sewer

This channel type is mainly occupied by native upland vegetation. The channel banks have moderate to steep slopes. The channel slopes are so steep (4 to 5%) that it is not practical to provide drop structures since they would have to be located one right after another. The channel velocities would still be too high to have a stable vegetated or erosion mat lining, thus the requirement for a fully lined section or an underground pipe. **There are only parts of two reaches that have this concrete lining proposed.** The reaches that have underground pipes proposed could be replanted with native vegetation in the easement for the pipe as long as the pipes could be maintained. This would still maintain existing wildlife corridors above the pipe.

2. Alternative Lining Types

As part of the study analysis and as discussed with the resource agencies/interested citizens, there are a variety of channel lining types used in the various recommended alternatives. Figures 32 through 38 show the types proposed. While this study identifies certain of these for the specific readers, it is recommended that the type of channel lining be verified during final design according to how well it fits into the current setting.

These linings need to be designed to withstand the anticipated channel velocities, minimize the environmental impacts, and provide an aesthetically pleasing drainageway.

3. Multiple Use Opportunities

The drainageways within this study area create an opportunity to provide multiple use of these corridors. The location of the proposed major trail systems are shown on Figure 3 (Appendix A). A maintenance road/trail link is required to be provided for the channels unless conditions dictate otherwise. Approval of eliminating road/trail requires approval from the appropriate City/County agencies. Multiple use opportunities that are encouraged for this study area include, but are not limited, to the following items:

a. Stormwater Conveyance
b. Provide Trail Network
c. Enhance Wetlands
d. Enhance Wildlife Habitats
e. Provide Recreation Facilities
f. Provide Open Space
g. Use as Utility Corridors
h. Protect the Public from flooding
i. Provide Maintenance Access
j. Enhance Water Quality
k. Provide Groundwater Recharge

4. Channel Recommendations

The proposed treatment for each reach area studied is shown in Table 3 along with the approximate size of the facilities. Detailed drainage reports and construction plans need to refine these channel concepts and determine the best fit into the existing drainageway. **It should be pointed out that the approval of this plan does not eliminate regulatory requirements of the appropriate government agencies.** This plan is intended to be a guide for the overall plan for the basin and actual application of these concepts should take this consideration into account. It is important that additional, more detailed study of the environmental types be made at the time of the subdivision drainage report in order to verify that the environmental types and associated mitigation will match that shown in this plan.

The channel recommendations are a result of analyzing factors specific to the Cottonwood Creek Basin erosion/deposition potential. The basin geology essentially consists of weak rocks overlain by sandy soils. Generally the maximum velocity for a stable sandy channel varies from about 3 to 5 feet per second depending upon the amount of stabilizing vegetation present in the channel. The maximum velocity for the weak sedimentary rocks generally varies from about 5 to 7 feet per second. Beyond these velocities, the channel will erode. This results in an existing drainage system that is not stable as evidenced by the significant erosion of natural channels that has occurred throughout the basin. This erosion is very evident at many of the roadway bridges across the main channel.

Therefore, most of the channel recommendations include some type of grade or bank stabilization. Further investigation could be performed at the design level to verify or refute these assumptions.

C. BRIDGES

Arterial roadway bridge sizes and design flows are presented in Table 4. Bridges were sized using either the inlet control nomographs or by comparing the channel and bridge velocities and shapes of inlet area. The freeboard requirements are in the Criteria Manual and sizing was done for the 100-year 24-hour storm peak flows presented previously. The bridge costs were based on CDOT unit costs for bridge or box culvert construction. Bridge types were selected to best fit the type of channel system proposed on both sides of the bridge.

D. INITIAL SYSTEM

The initial system is designed for the initial design storm outlined in the current Drainage Criteria Manual with a provision for proper conveyance of the overflow for the 100-year storm. The initial drainage system for the basin was analyzed for two example locations in the basin. This was done for both an upgrade of the initial system already built and for what the initial system would need to be if the area was undeveloped ground.

Figures 42 and 43 (Appendix B) show the two example areas studied for this basin. Tables 14 and 15 (Appendix B) show the facilities required for each example area. These two locations were selected to be representative of the entire drainage basin initial system. The mix of land uses and the amount of time since the areas were developed was felt to be a reasonable representation of the basin as a whole. Initial systems are required by current drainage criteria but are not considered in detail in this study.

Initial system improvements could consist of the following types and need to consider the same factors as presented in the previous channel sections:

1. Street and Storm Sewer Combination
2. Street and Roadside Ditch Combination
3. Channel System

E. LETTER OF PERMISSION PROCEDURE

DEFINITION OF LETTER OF PERMISSION
(From Corps of Engineers Handout)

(33 CFR 325.2(e)(1))

Letter of Permission. Letters of permission are a type of permit issued through a processing procedure which includes coordination with Federal and state fish and wildlife agencies, as required by the Fish and Wildlife Coordination Act, and a public interest evaluation, but without the publishing of an individual public notice. Letters of permission may be used:

(ii) In those cases subject to section 404 of the Clean Water Act after:

(A) The district engineer, through consultation with Federal and state fish and wildlife agencies, the Regional Administrator, Environmental Protection Agency, and the state water quality certifying agency develops a list of categories of activities proposed for authorization under LOP procedures;

(B) The district engineer issues a public notice advertising the proposed list and the LOP procedures, requesting comments and offering an opportunity for public hearing; and

(C) A 401 certification has been issued or waived or presumed either on a generic or individual basis.

BASIC CONCEPT

There are several things that need to be clearly pointed out about the LOP procedures. An individual section 404 permit application to the Corps of Engineers is still required for all jurisdictional areas. The individual permit application has the same level of detail requirements as if the LOP did not exist. An individual public notice may still be required if the type of activity or impact is significantly different from the LOP or it is requested by one of the resource agencies or the public. In working with the COE on the LOP permit, they indicated that they would no longer be able to continue with the LOP process for this DBPS due to resource constraints. However, the DBPS concepts could be utilized when applying for an individual permit for a specific project. In addition to the full individual permit, Nationwide and Regional Permits are available depending upon whether the project specifics meet the limitations in these permits. These permits could be utilized in many situations and result in more efficient processing.

F. LIST OF CATEGORIES OF ACTIVITIES

Table 5 lists the matrix of categories of activities versus environmental channel types that are included as part of this drainage study. This list of activities corresponds with the master planned drainage improvements called for previously. In addition, it provides for temporary construction and maintenance activities that are required for those improvements. The basic concept behind this list of categories of activities is to ensure that best management practices be used for construction in the basin and that the activities have corresponding mitigation measures for the type of environment that is currently present for this basin. These categories of activities are intended as guidelines and need to be refined further at the individual project level.

The matrix shows all possible cases for the existing channel types (environmental classification) versus proposed type of improvement in this study. The actual individual channel recommendations were selected to minimize the amount of disturbance of wetlands and wildlife habitat while still considering all other factors discussed previously. Each individual project or activity that is applied for under the individual permit application should have a more detailed study of the environmental categories for that particular project. The results of the detailed study should be included in the individual section 404 application to the Corps of Engineers. The results of the new mapping needs to address which is the appropriate mitigation for the project proposed and provide detailed site mitigation plans.

G. ENVIRONMENTAL GUIDELINES

The mitigation concept for this basin study is for any mitigation to be done on site (wherever possible) for the proposed improvements in this basin. That is, revegetation and restoration of disturbed areas will be done at the project location in which the disturbance occurs. In addition, the following sections describe guidelines for what needs to be included in the site specific plan.

1. Environmental Inventory Requirements

A site specific inventory of a defined area where alterations in stream bank conditions are proposed must be undertaken to define existing vegetation. Inventories must be conducted by a qualified wetlands biologist using the methods detailed in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands, Latest Revision. The provision of this type of information is a requirement of Section 404 of the Clean Water Act and collateral supporting legislation where wetlands or waterways of the United States are concerned. The appropriate level of field investigation for a given action is described in the before-mentioned manual. Basic requirements are outlined for reference, as follows:

a. A map of the area at a scale ≤1" = 200′ showing the boundaries of existing vegetation classified by specific type of wetland, riparian or upland vegetation

b. A description of vegetation types including plant species present, indicating wetland indicator status and dominance, to determine if the criteria for hydrophytic vegetation are met:
   - Obligate wetland plants are those that occur almost always in wetlands under natural conditions (≥99% probability)
   - Facultative wetland plants are those that usually occur in wetlands (67-99% probability), but occasionally are found in non-wetlands
   - Facultative plants are those that are equally likely to occur in wetlands or non-wetlands (33-66% probability)
   - Facultative upland plants are those that usually occur in non-wetlands (67-99% probability), but occasionally are found in wetlands (1-33% probability)
   - Upland plants are those that almost always occur in non wetlands under natural conditions (≥99% probability)

c. A description of soil characteristics on the site to determine if the criteria for hydric soils are met including examination for the following:
   - Histic soil characteristics
   - Aquic soil characteristics
   - Soils that are ponded for long duration during the growing season
   - Soils that are frequently flooded for long duration during the growing season

d. A description of hydrologic conditions on the site to determine if the criteria for wetland hydrology are met including evaluation of the following:
- In somewhat poorly drained mineral soils saturation of soils to the surface occurs when the water table is 0.5 feet from the surface for seven days or more during the growing season
- In poorly drained mineral soils saturation of soils to the surface occurs when the water table is less than 1.5 feet from the surface for approximately seven or more days during the growing season
- In variably permeable mineral soils saturation of soils to the surface occurs when the water table is less than 1 foot from the surface for seven days or more during the growing season
- In poorly drained organic soils saturation of soils to the surface occurs when the water table is at a depth where saturation occurs more than rarely (i.e., the water table is managed, such as by irrigation)
- Inundation or saturation occurs by flooding or ponding for seven days or more during the growing season

e. A tabulation of the areal extent of wetland and riparian vegetation existing in the area and to be disturbed by the proposed action

f. A tabulation of the areal extent of wetland and riparian vegetation to be mitigated and a description of the mitigation area and category, i.e., restoration, enhancement or replacement [Note: The purpose of the regulations surrounding the Clean Water Act, and subsequent refinements created by the recent Memorandum of Understanding between the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency is principally directed at no net loss of wetlands.]

2. Analysis of Alternatives

a. Project Purpose

This is a discussion of the reasons requiring construction of the project. Examples include stabilization of eroding stream banks, road crossings, access roads, hike/bike trail systems, building construction and park development. Guidelines to this analysis are in the sections that follow.

b. Project Actions and Practicable Alternatives

The applicant must develop dialogue that clearly illustrates that the proposed construction cannot be accomplished in an upland area. The discussion must follow the 404 (b)(1) guidelines, as summarized below. These guidelines require that any action resulting in the disturbance of wetlands be demonstrated as the most practicable alternative in terms of logistics, technology and economics.

Section 230.10 (a)(1) and (2) provide, in pertinent part:

Except as provided under Section 404 (b)(2)[pertaining to navigation], no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem so long as the alternative does not have other significant adverse environmental consequences.

An alternative is practicable if it is available and capable of being done after taking into consideration cost, existing technology and logistics in light of overall project purposes. If it is otherwise a practicable alternative, an area not presently owned by the applicant which could reasonably be obtained, utilized, expanded or managed in order to fulfill the basic purpose of the proposed activity may be considered*.

In practice, the application of Section 230.10 of the Section 404(b)(1) Guidelines requires[sic] an assessment of alternatives to a proposed activity and the identification of practicable alternatives, if they exist. Then there must be an assessment of otherwise adverse environmental impacts to determine if they are significant.

If an activity is not water dependent, there is a presumption that less damaging alternatives exist unless clearly demonstrated otherwise by the applicant {Section 230.10(a)(3)}.

The application of the alternatives test requires an interpretation or understanding of the terms used. The following criteria provide direction in assisting alternatives to proposed projects pursuant to the Section 404(b)(1) Guidelines.

1) To be considered practicable, an alternative to a proposed discharge must be both available and

capable of being done after taking into consideration cost, existing technology and logistics in light of overall project purposes; i.e., an alternative must be available and feasible.

2) The assessment of practicability requires an interpretation of the basic project purpose of a proposal. Under the Guidelines, an alternative must be capable of satisfying the basic or overall project purpose of the proposed project (taking into consideration cost, technology and logistics). An applicant's proposal is a starting point for identifying the basic project purpose. The Guidelines do not demand an acceptance of every aspect of a developer's characterization of his project purpose. The preamble to the Section 404(b)(1) Guidelines provides the following example;

... fill to create a restaurant site is not water dependent, since restaurants do not need to be in wetlands to fulfill their basic purpose of feeding people.

3) The presumption that other practicable alternatives exist for non-water dependent projects serves to direct developments away from sensitive aquatic resources and it preserves such sites which truly require access to water. The presumption correctly and logically recognizes that non-water dependent projects can usually be located someplace other than special aquatic sites.

4) An applicant's submission of information clearly within its expertise is normally accepted by the reviewing agency. Where the information seems in conflict with other available information, independent judgement must be used to determine the matter at issue. Although providing important insight, issues raised by an applicant to justify rejection of an alternative cannot be automatically considered adequate or sufficient to satisfy the rebuttal of alternatives in the Section 404(b)(1) Guidelines. The Section 404(b)(1) Guidelines require an alternative to be only feasible, not that it is equal or better than the proposed site. Since the applicant usually selects the site which is best from his perspective, alternatives are often, by

definition, less desirable to the applicant. Alternatives which are located in non-water dependent areas may not be eliminated from consideration solely on their being less desirable to the applicant.

5) One element of feasibility is a consideration of cost of an alternative. For an alternative to be dismissed due solely to cost, the applicant must clearly demonstrate that the alternative is not economically feasible.

c. Requirement of Access to Water

The applicant must address that construction of the proposed action is water-related. Examples of action that are water related are bridges, road crossings, grade controls and stream bank stabilization.

3. Mitigation Design Process

The focus of wetland mitigation should be to produce a diverse and self-sustaining combination of aquatic, wetland and riparian habitat. The components of a detailed wetland mitigation design are:

- Resource requirements for plant materials, soils and hydrology, as determined by the characteristics of the existing area to be disturbed
- Proposed location that meets the above requirements
- Mitigation planning and documents including construction drawings, specifications and construction supervision
- Monitoring of mitigation success and maintenance of site

a. Plant Materials

The applicant must provide a list of plant materials suitable for use in mitigation. The basis for this list are those species occurring in the existing site to be disturbed and can be augmented with nursery stock. The applicant should indicate the source of the plant materials to be established in the mitigation site, for example transplant source areas and nursery stock sources.

b. Planting Plan

A detailed planting plan must be provided showing the location, sizes and quantities of plant materials to be established in the mitigation site. Species to be seeded must also be shown. The plan should also indicate grading and earthwork for the mitigation site showing contours at two foot intervals. Specifications must be provided in sufficient detail to show the method(s) of setting and establishing plant materials, and seeding methods. The scale of this drawing should be ≥"=50'.

d. Soil Preparation

Specifications for site preparation, topsoiling, fertilizer application and other soil amendments must be provided in sufficient detail to assure that proper soil characteristics are established on the mitigation site.

e. Hydrologic Maintenance

The mitigation plan drawings must also indicate sources of water that will maintain the hydrologic character of the wetland mitigation site. Average annual flow into the mitigation site should also be determined.

4. Impact Mitigation

Details of protection of existing natural vegetation and flowing water must be given. This can take the form of a site plan that indicates access routes, traffic patterns, no-traffic areas and erosion control measures and locations. The purpose of this plan is to assure protection of existing water quality and protection of existing wetlands.

5. Monitoring Program

A monitoring program must be developed that details the period during which the mitigation plan will be evaluated for successful establishment. The recommended period is two growing seasons following construction. The monitoring plan must also detail methods of evaluation and success standards. Annual findings of the monitoring evaluation must be documented in a submittal to the appropriate agencies.

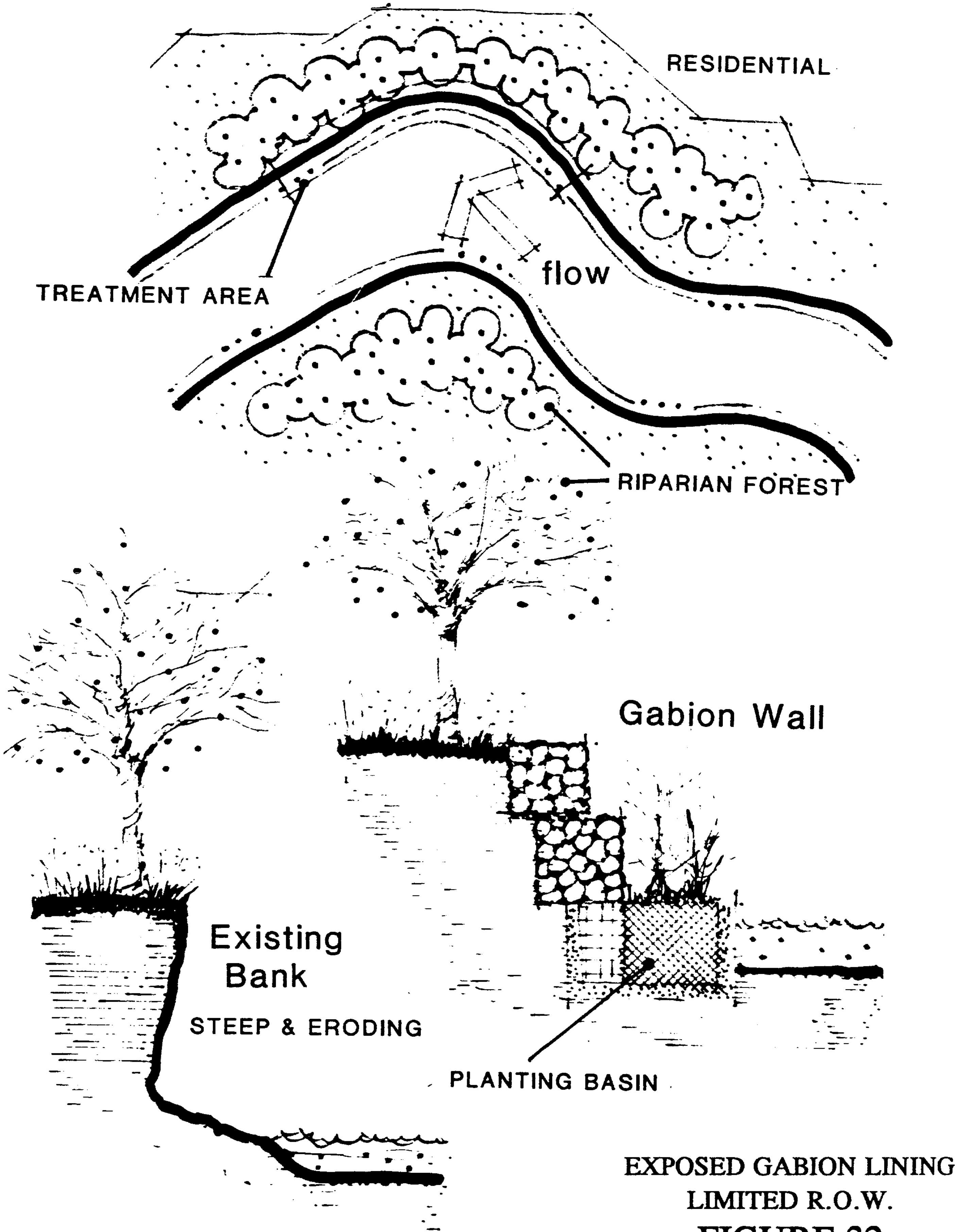
6. Maintenance

A plan for maintenance of the mitigation area must be formulated that integrates the findings of the monitoring program with required repairs or plant material replacements. The maintenance period should be the same as the monitoring period. Financial assurances for maintenance should be provided in amounts that are sufficient to guarantee meeting the success standards established for mitigation.

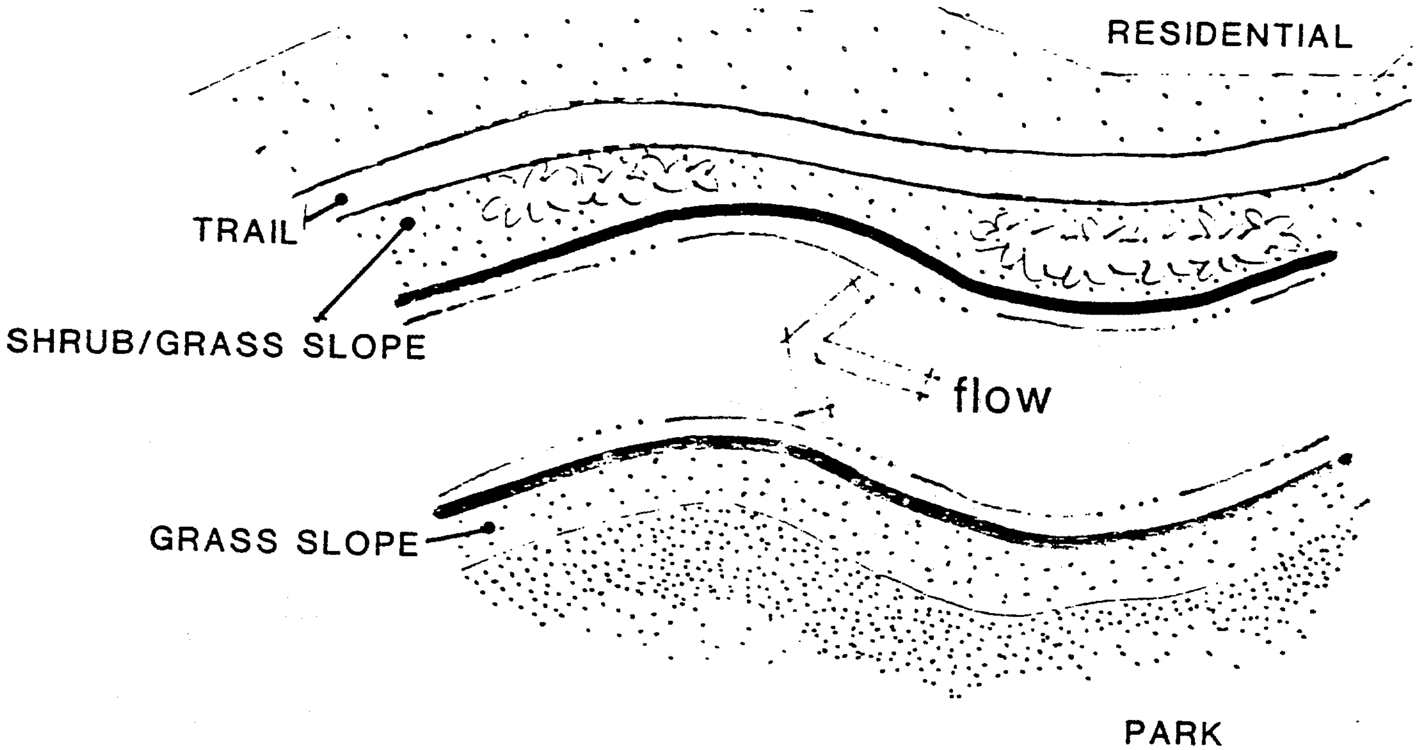
COTTONWOOD CREEK DBPS - TABLE 2
DETENTION POND RECOMMENDATIONS

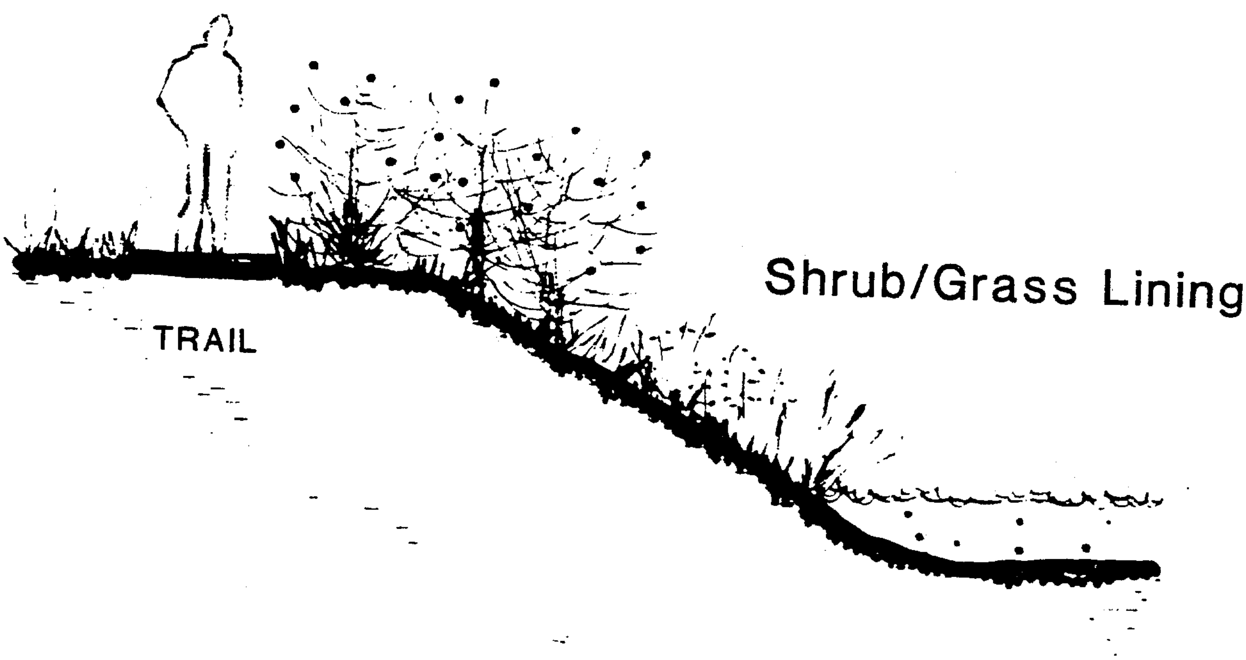
	DESIGN POINT	HEC-1 INFLOW (CFS)	HEC-1 RELEASE (CFS)	RECOMMENDED IMPROVEMENT	TOTAL DEPTH (FT)	ROW AREA (ACRES)
	POND AT 13NP	4806	2270	128 AC-FT DETENTION POND	29.5	17.4
	POND AT 12CP	1289	252	51 AC-FT DETENTION POND	27.0	6.2
*	POND AT 11P	1607	112	77 AC-FT DETENTION POND	37.8	8.1
	POND AT 9BP	577	101	21 AC-FT DETENTION POND	27.2	3.1
	POND AT 8G-8P	1612	555	74 AC-FT DETENTION POND	29.8	9.9
	POND AT 5	870	90	52 AC-FT DETENTION POND	23.5	8.9
	POND AT 26B	797	138	EXISTING 29 AC-FT DETENTION POND	20.0	N/A
	POND AT 25	2201	118	EXISTING 118 AC-FT DETENTION POND	39.1	N/A
	POND AT U1	234	75	EXISTING 6 AC-FT DETENTION POND	9.0	N/A

* SEE FAIRFAX AT BRIARGATE MDDP FOR ALTERNATIVE DESIGN

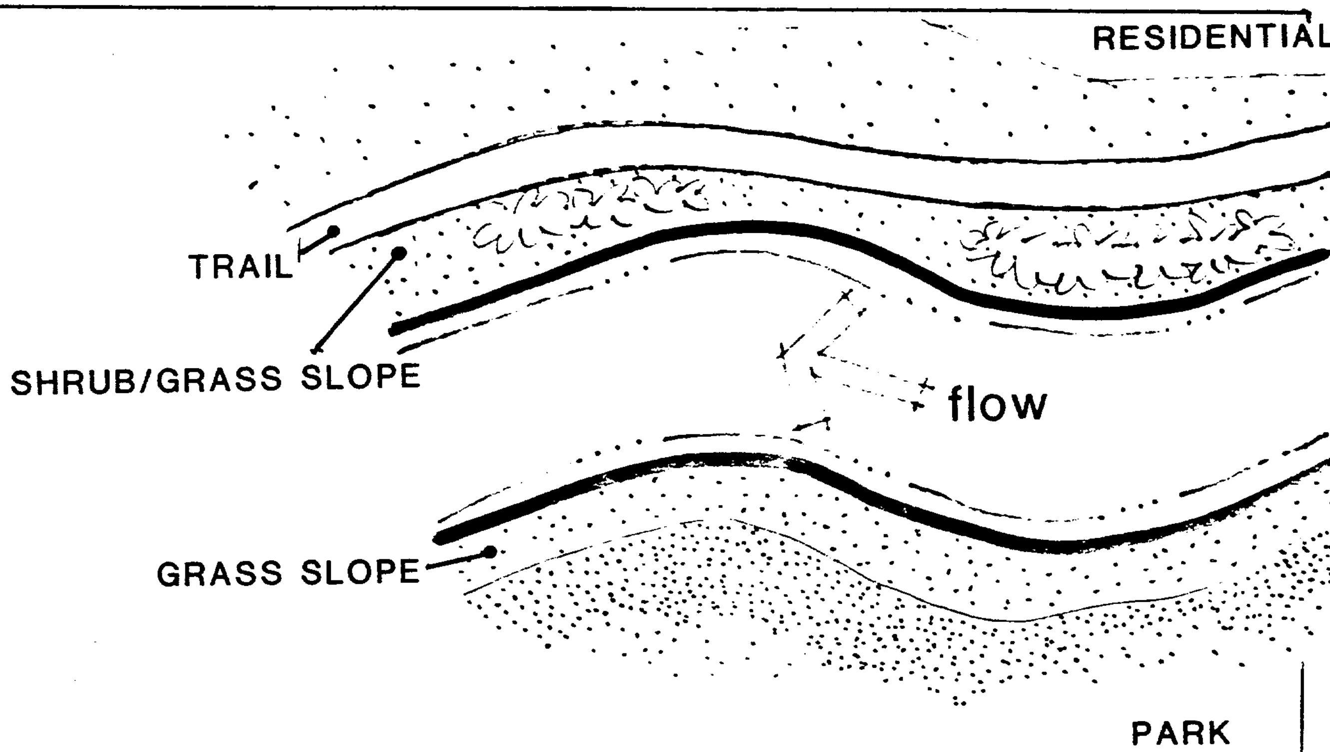


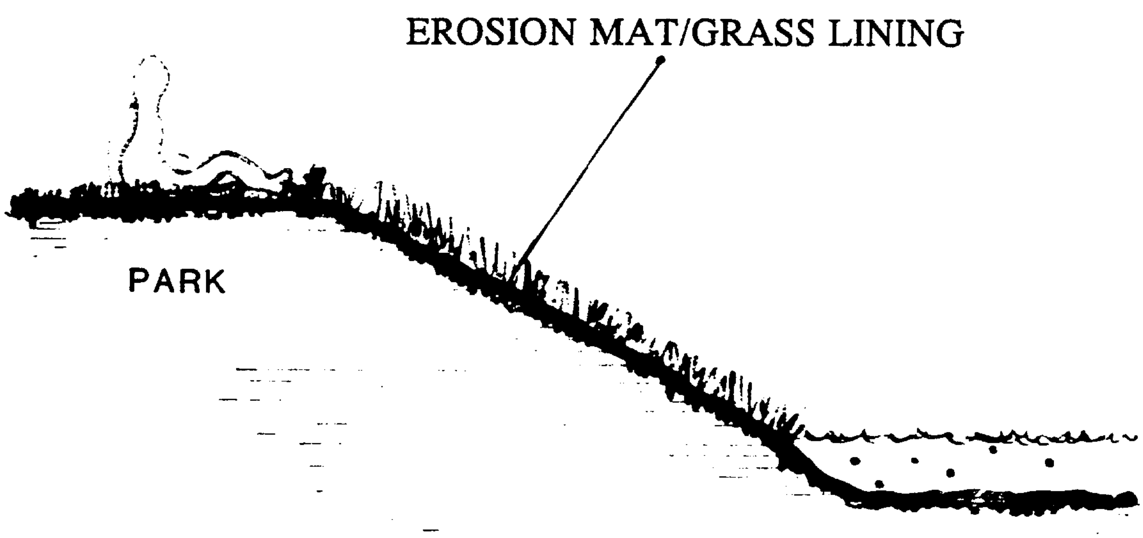
EXPOSED GABION LINING
LIMITED R.O.W.
FIGURE 32



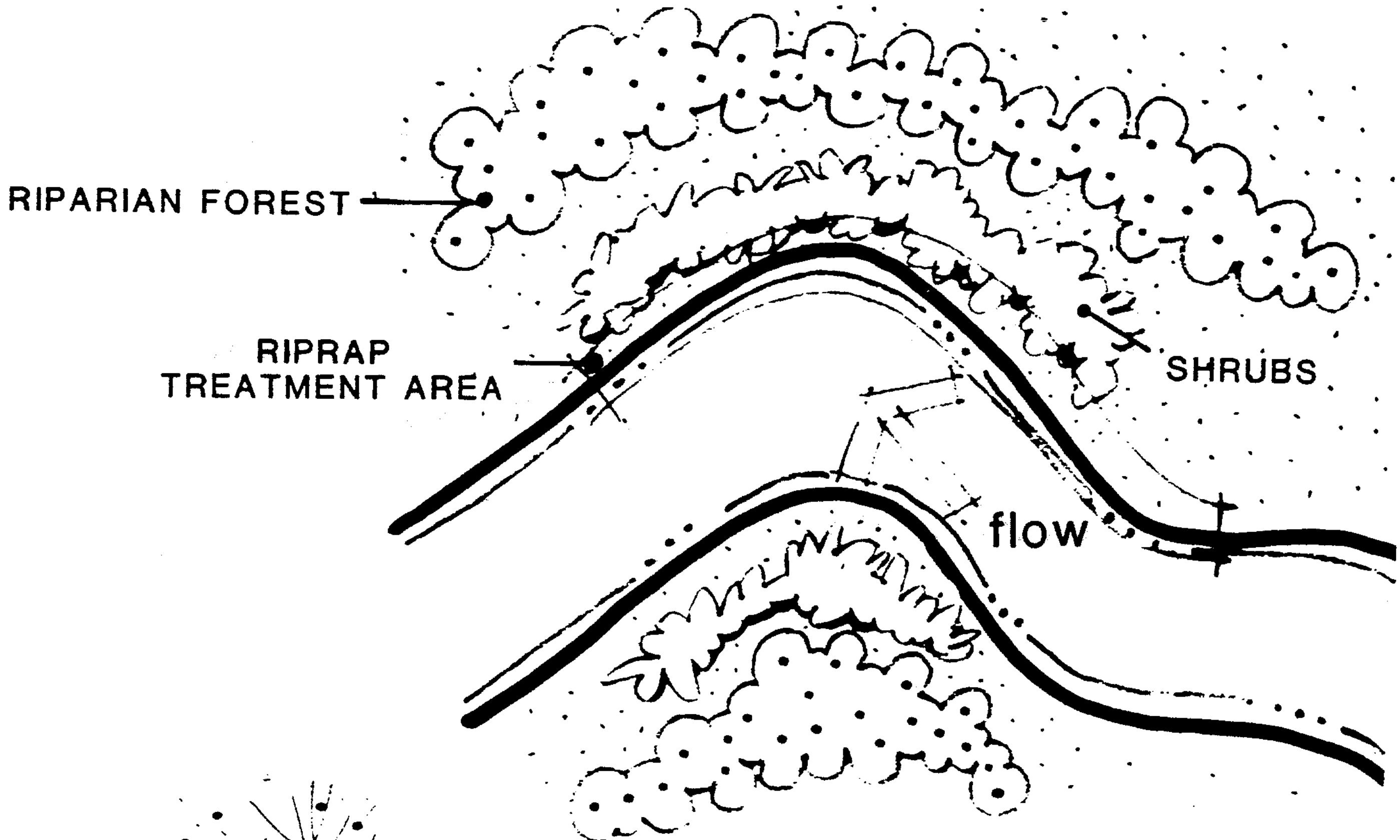


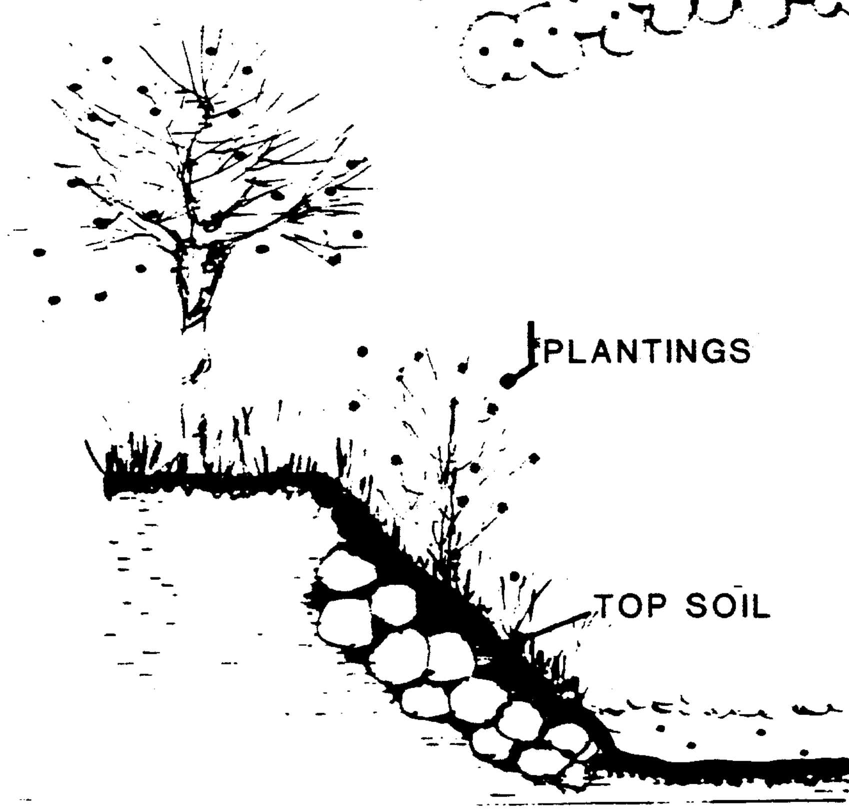
GRASS/SHRUB LINING
SUFFICIENT R.O.W.
FIGURE 33





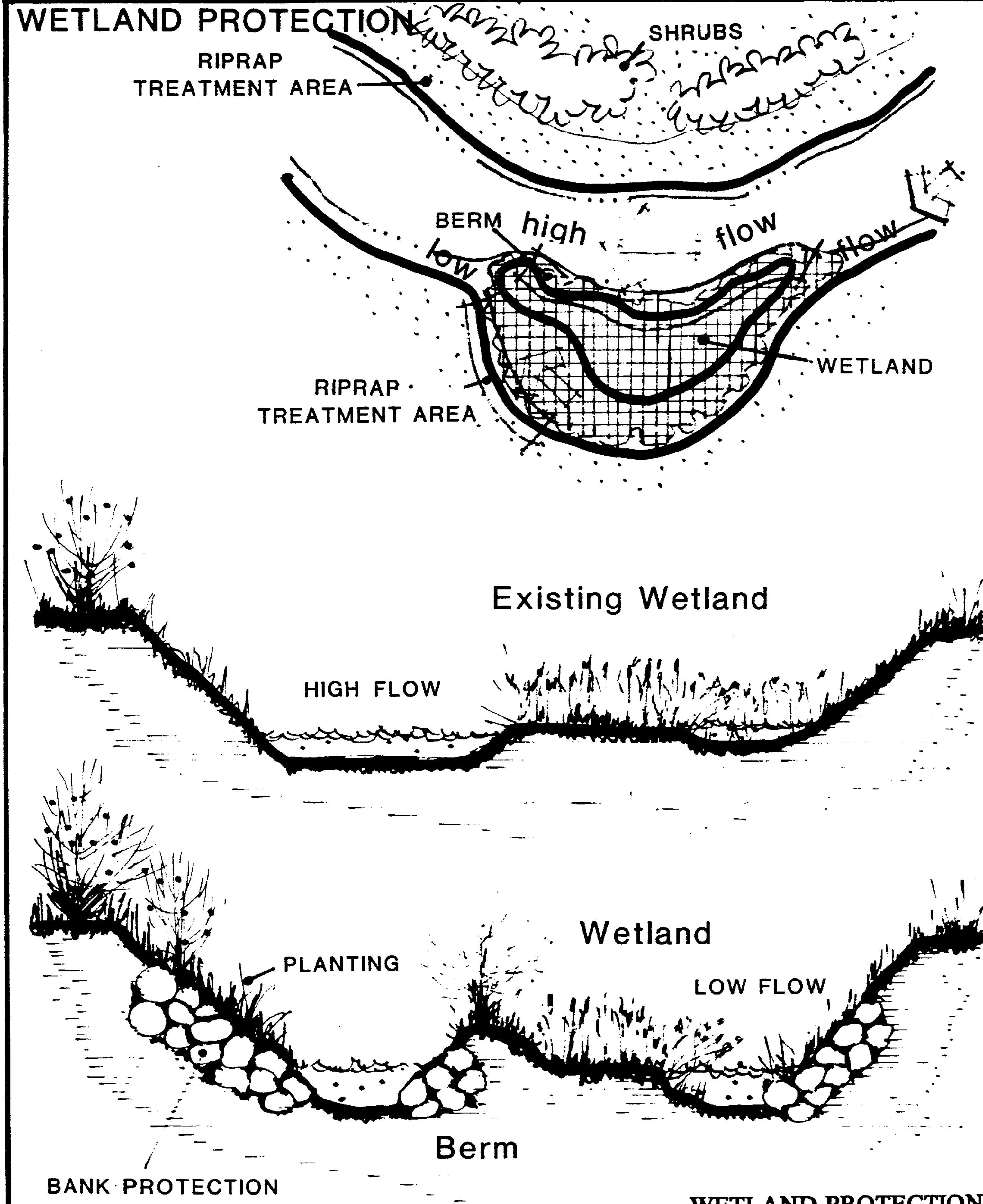
EROSION MAT/GRASS LINING
SUFFICIENT R.O.W.
FIGURE 34





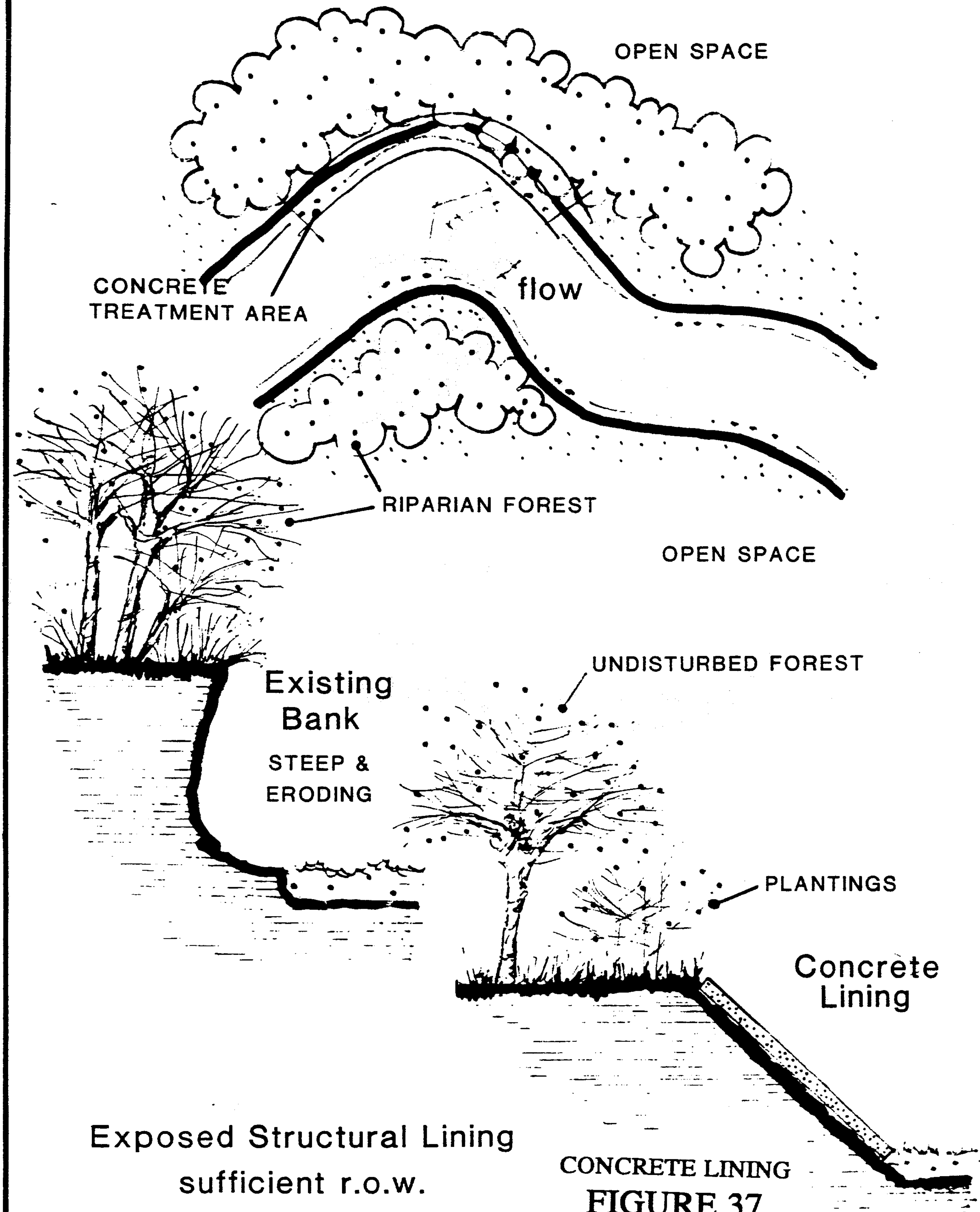
Buried Structural Lining- -Riprap

BURIED RIPRAP LINING
R.O.W. VARIES
FIGURE 35



WETLAND PROTECTION
FIGURE 36

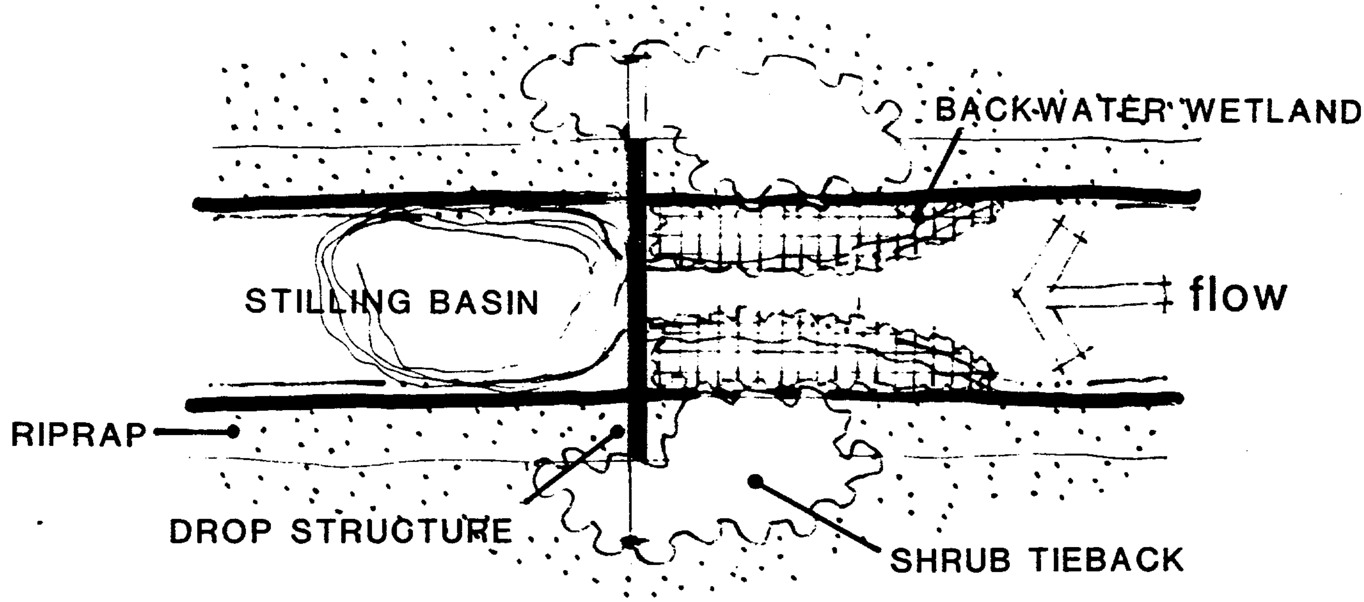
BANK PROTECTION

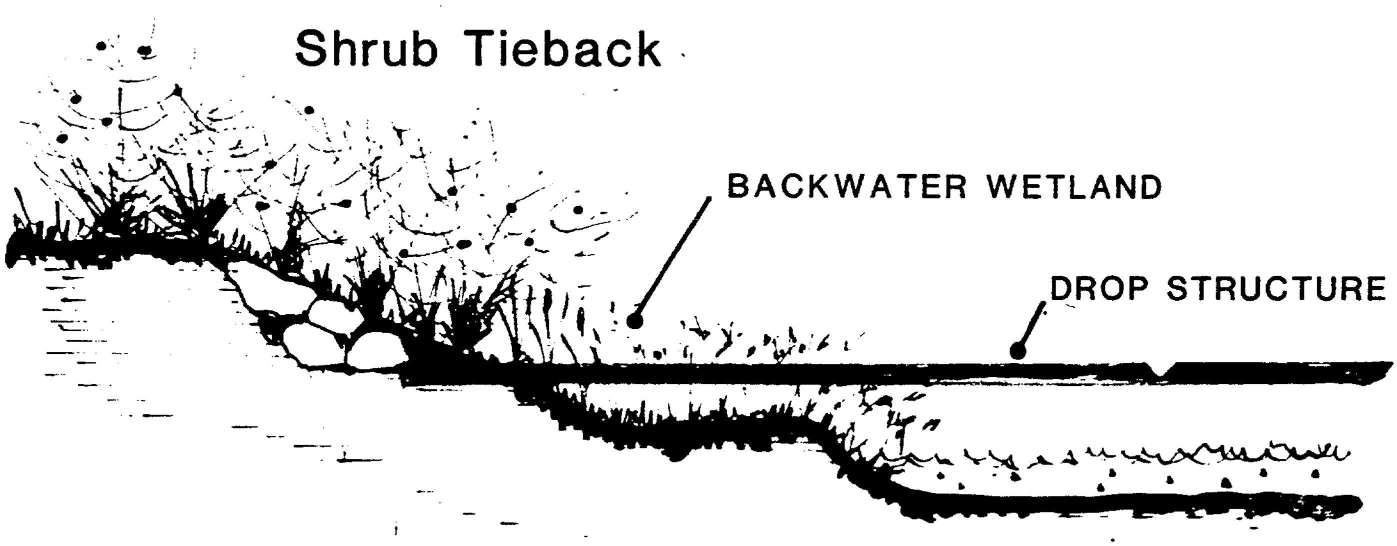


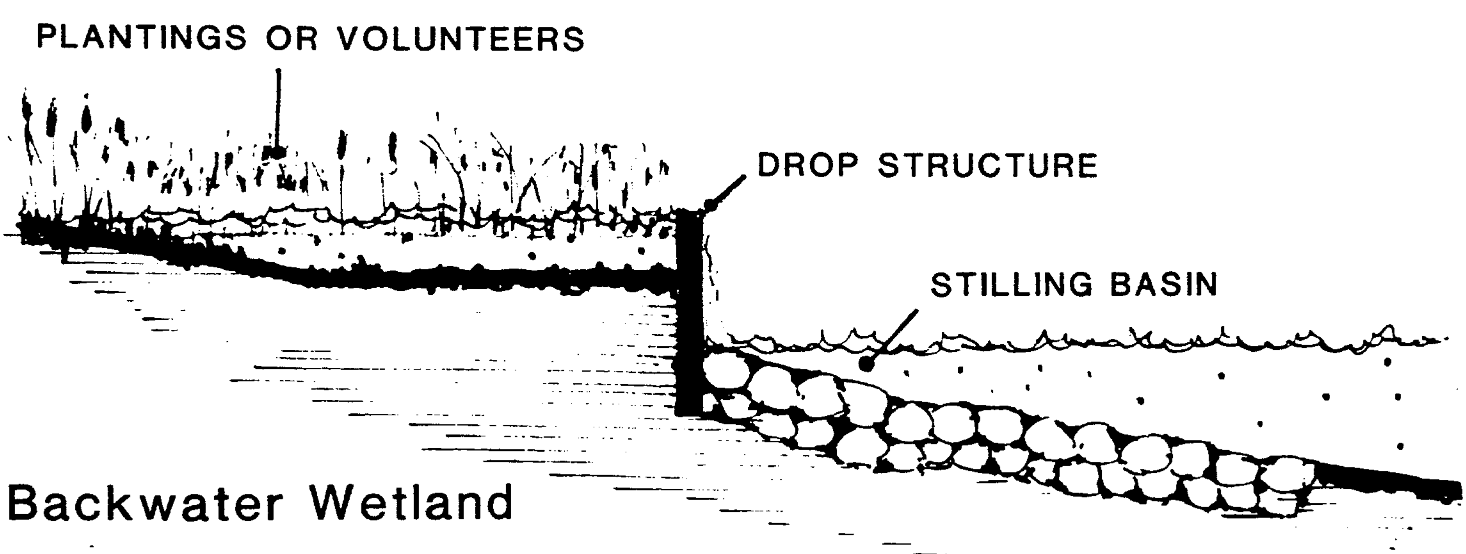
Exposed Structural Lining
sufficient r.o.w.

CONCRETE LINING
FIGURE 37

GRADE CONTROL STRUCTURES







GRADE CONTROL STRUCTURES
FIGURE 38

COTTONWOOD CREEK DBPS - TABLE 3

CHANNEL & CULVERT RECOMMENDATIONS

REACH	HEC-1 FLOW w/det. (CFS)	CHANNEL OR CULVERT LENGTH(FT)	EXISTING IMPROVEMENT	RECOMMENDED IMPROVEMENT	TOTAL BOTTOM WIDTH (FT)	TOTAL DEPTH (FT)
21 TO DESIGN POINT 20	11,173	1,800	NATURAL	NATURAL EXCEPT PROVIDE BURIED RIPRAP & GRADE CONTROL AT I-25 BRIDGES ONLY (500'& 2 DROPS)	50	14.0
20 TO DESIGN POINT 19	11,112	2,400	NATURAL	NATURAL EXCEPT PROVIDE GABION WALLS & GRADE CONTROL AT BRIDGES (600') & PORTIONS OF SOUTH BANK (1,550')	40	15.0
19 TO DESIGN POINT 19.2	11,127	1,500	NATURAL	NATURAL EXCEPT PROVIDE GABION WALLS & GRADE CONTROL FOR PORTIONS OF SOUTH BANK (300') & NORTH BANK (500')	40	15.0
19.2 TO DESIGN POINT 19.1	11,127	700	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 3 DROPS)	40	16.0
19.1 TO DESIGN POINT 18	11,127	1,200	F.LINED	NO IMPROVEMENT REQUIRED	80	12.0
18 TO DESIGN POINT 18.1	10,000	400	P.LINED	NO IMPROVEMENT REQUIRED	115	12.0
18.1 TO DESIGN POINT 17	10,000	2,000	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 12 DROPS)	115	12.0
17 TO DESIGN POINT 17.2	9,837	1,000	P.LINED	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 5 DROPS)	115	12.0
17.2 TO DESIGN POINT 17.1	9,837	1,100	P.LINED	NO IMPROVEMENT REQUIRED	115	9.0
17.1 TO DESIGN POINT 16	9,837	1,000	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 2 DROPS)	100	11.0
16 TO DESIGN POINT 15	9,416	2,500	P.LINED	LOWER CHANNEL BOTTOM BY NATURAL EROSION WITH PHASED BURIED RIPRAP BANKS & GRADE CONTROL (WITH 9 DROPS)	150	8.0
15 TO DESIGN POINT 14	8,790	1,400	P.LINED	INCREASE DEPTH OF BURIED RIPRAP LINING ON NORTH SIDE & GRADE CONTROL (WITH 4 DROPS)	150	7.5
14 TO DESIGN POINT 14.1	8,598	1,300	P.LINED	NO IMPROVEMENT REQUIRED	200	8.0
14.1 TO DESIGN POINT 13	8,598	1,000	P.LINED	INCREASE DEPTH OF BURIED RIPRAP LINING ON NORTH SIDE	200	6.5
13 TO DESIGN POINT 13.2	4,702	2,000	P.LINED	NEED BURIED RIPRAP LINING ON SOUTH SIDE & GRADE CONTROL (WITH 3 DROPS)	200	5.0
13.2 TO DESIGN POINT 13.1	4,702	1,100	P.LINED	NEED BURIED RIPRAP LINING ON SOUTH SIDE & GRADE CONTROL (WITH 3 DROPS)	105	7.0
13.1 TO DESIGN POINT 12	4,702	2,300	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 5 DROPS)	105	7.0
12 TO DESIGN POINT 11	4,026	5,500	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 16 DROPS)	80	8.0
11 TO DESIGN POINT 10	3,008	1,100	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 3 DROPS)	80	6.5
10 TO DESIGN POINT 9	2,531	1,800	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 4 DROPS)	80	6.5
9 TO DESIGN POINT 8	2,332	3,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 10 DROPS)	80	6.5
8 TO DESIGN POINT 7	1,715	3,500	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 12 DROPS)	80	5.0
7 TO DESIGN POINT 6	854	3,500	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 9 DROPS)	50	4.5
6 TO DESIGN POINT 5	673	7,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 12 DROPS)	50	4.0
5 TO DESIGN POINT 4	870	3,000	VEG. LINING	GRADE CONTROL (7 DROPS)	50	4.0
4 TO DESIGN POINT 3	467	3,500	VEG. LINING	GRADE CONTROL (12 DROPS)	20	4.5
3 TO DESIGN POINT 2	335	3,500	VEG. LINING	GRADE CONTROL (11 DROPS)	20	4.0
2 TO DESIGN POINT 1	114	2,300	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 5 DROPS)	20	3.0
T4B TO DESIGN POINT 19G	528	1,700	STORM/NAT.	STORM SEWER FROM EXISTING 48" CMP OUTLET DOWNSTREAM TO MAIN CHANNEL	72" RCP	N/A
19E TO DESIGN POINT 19F	1,560	2,400	CONCRETE	NO IMPROVEMENT REQUIRED	12	6.0
19D TO DESIGN POINT 19E	1,285	3,400	CONCRETE	NO IMPROVEMENT REQUIRED	13	6.0
19B TO DESIGN POINT 19C	810	2,800	CONCRETE	NO IMPROVEMENT REQUIRED	5	5.0
Q1 TO DESIGN POINT 19A	390	2,200	72" PIPE	PARALLEL PIPE (1,650')	36" RCP	N/A
T4A TO DESIGN POINT 18A	260	1,200	48" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
17A TO DESIGN POINT 17	312	1,000	66" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
T2 TO DESIGN POINT 17A	205	1,200	NATURAL	STORM SEWER	48" RCP	N/A
P2 TO DESIGN POINT 16C	368	2,300	48" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
M4 TO DESIGN POINT 16B	492	2,400	P.LINED	NO IMPROVEMENT REQUIRED	N/A	N/A
M3 TO DESIGN POINT 16	291	1,400	36" PIPE	PARALLEL PIPE (1,250')	30" RCP	N/A
M1 TO DESIGN POINT 14C	513	3,000	48" PIPE	PARALLEL PIPE (2,000')	48" RCP	N/A
O1 TO DESIGN POINT 14B	426	3,700	48" PIPE	PARALLEL PIPE (2,600')	48" RCP	N/A
L1 TO DESIGN POINT 14A	371	1,700	42" PIPE	PARALLEL PIPE (1,700')	36"/42" RCP	N/A
J1 TO DESIGN POINT 13S	425	3,100	42" PIPE	PARALLEL PIPE	48" RCP	N/A
13Q TO DESIGN POINT 13R	1,058	750	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 1 DROP)	75	4.0

COTTONWOOD CREEK DBPS - TABLE 3

CHANNEL & CULVERT RECOMMENDATIONS

REACH	HEC-1 FLOW w/det. (CFS)	CHANNEL OR CULVERT LENGTH(FT)	EXISTING IMPROVEMENT	RECOMMENDED IMPROVEMENT	TOTAL BOTTOM WIDTH (FT)	TOTAL DEPTH (FT)
13P TO DESIGN POINT 13Q	1,066	2,300	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 4 DROPS)	55	4.5
13J/M TO DESIGN POINT 13N	4,935	700	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 1 DROP)	50	8.0
13NP TO DESIGN POINT 13O	2,341/overflow	1,300	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 1 DROP)	80	4.5
13L TO DESIGN POINT 13M	1,117	1,900	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 8 DROPS)	20	6.0
13K TO DESIGN POINT 13L	892	1,500	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 5 DROPS)	15	6.0
13I TO DESIGN POINT 13J	3,686	1,800	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 5 DROPS)	75	7.0
13H TO DESIGN POINT 13I	3,464	1,100	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 4 DROPS)	70	8.0
13F TO DESIGN POINT 13G	642	3,000	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 11 DROPS)	10	6.5
13D TO DESIGN POINT 13E	752	2,400	NATURAL	STORM SEWER	84" RCP	N/A
H2 TO DESIGN POINT 13D	400	1,800	NATURAL	STORM SEWER	72" RCP	N/A
13B TO DESIGN POINT 13C	1,628	2,000	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 8 DROPS)	50	6.0
13C TO DESIGN POINT 13H	1,652	800	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 3 DROPS)	50	6.0
H5 TO DESIGN POINT 13B	984	2,100	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 7 DROPS)	30	5.5
H6 TO DESIGN POINT 13B	494	1,800	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 6 DROPS)	10	6.0
D3 TO DESIGN POINT 12D	315	1,500	NATURAL	STORM SEWER	54" RCP	N/A
12C TO DESIGN POINT 12CP	1,289	600	NATURAL	FULLY LINED CONCRETE CHANNEL WITH ENERGY DISSIPATOR AT UPSTREAM SIDE OF DETENTION POND	9	5.5
12CP TO DESIGN POINT 12	252/overflow	500	NATURAL	STORM SEWER WITH OVERFLOW PROVISION	54" RCP	N/A
12B TO DESIGN POINT 12C	1,289	2,500	CONCRETE	NO IMPROVEMENT REQUIRED	8	4.0
G2 TO DESIGN POINT 12B	430	2,800	48" PIPE	PARALLEL PIPE (2,200')	36" RCP	N/A
G1 TO DESIGN POINT 12A	541	2,400	CONCRETE	EXTEND CONCRETE LINED CHANNEL UPSTREAM (1,350')	8	4.0
C16 TO DESIGN POINT 11G	310	4,800	NATURAL	STORM SEWER (4,200')	48"/54" RCP	N/A
11F TO DESIGN POINT 11P	1,607	1,200	NATURAL	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 6 DROPS)	34	7.0
* 11P TO DESIGN POINT 11	218/overflow	1,300	NATURAL	STORM SEWER	48" RCP	N/A
* E6 TO DESIGN POINT 11E	265	4,000	NATURAL	STORM SEWER (1,300')	54" RCP	N/A
* 11D TO DESIGN POINT 11F	1,341	1,700	NATURAL	FULLY LINED CONCRETE CHANNEL WITH ENERGY DISSIPATOR AT UPSTREAM SIDE OF DETENTION POND	8	7.0
* E2 TO DESIGN POINT 11C	361	3,300	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 17 DROPS)	10	4.5
* 11A TO DESIGN POINT 11B	539	3,300	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 17 DROPS)	12	5.0
* E1 TO DESIGN POINT 11A	335	3,000	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 4 DROPS)	12	4.5
9A TO DESIGN POINT 9B	577	6,800	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 27 DROPS)	50	3.5
C14 TO DESIGN POINT 9A	255	2,500	NATURAL	STORM SEWER	48" RCP	N/A
B5 TO DESIGN POINT 8H	592	4,800	NATURAL	STORM SEWER	60"/72" RCP	N/A
8G TO DESIGN POINT 8	555/overflow	4,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 13 DROPS)	50	3.5
C5 TO DESIGN POINT 8F	594	6,300	NATURAL	NATURAL BOTTOM WITH EROSION MATTING/GRASS BANKS & GRADE CONTROL (WITH 21 DROPS)	30	4.0
8E TO DESIGN POINT 8G	973	3,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 8 DROPS)	80	4.0
8C TO DESIGN POINT 8D	330	4,500	NATURAL	STORM SEWER	60" RCP	N/A
8A TO DESIGN POINT 8B	552	4,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 16 DROPS)	50	3.5
C2 TO DESIGN POINT 8A	179	3,000	NATURAL	STORM SEWER	36"/42" RCP	N/A
B2 TO DESIGN POINT 6A	417	3,000	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 12 DROPS)	30	4.0
5A TO DESIGN POINT 5	138	3,900	NATURAL	NATURAL BOTTOM WITH GRASS/SHRUB BANKS & GRADE CONTROL (WITH 10 DROPS)	20	3.0
32 TO DESIGN POINT 31	5,674	1,500	NATURAL	PROV. TOE OF SLOPE PROTECTION THROUGHOUT & GRADE CONTROL (2 DROPS) & BURIED RIPRAP AT I-25 BRIDGES (400')	20	13.0
31 TO DESIGN POINT 30	5,613	1,600	NATURAL	PROVIDE SUFFICIENT EASEMENT WIDTH FOR NATURAL CHANGES TO THE CHANNEL EXCEPT USE GABIONS BY HOUSES TO EAST	20	13.0
30 TO DESIGN POINT 29	4,981	1,000	NATURAL	PROV. SUFFICIENT WIDTH FOR NATURAL CHANGES TO THE CHANNEL (ON USAFA LAND) EXCEPT USE GABIONS ON EAST (400')	20	13.0
U4B TO DESIGN POINT 31	420	4,500	NATURAL	STORM SEWER	60"/78" RCP	N/A
U4A TO DESIGN POINT 30	400	2,000	NATURAL	NATURAL BOTTOM & PROV. GABIONS (1ST 900') & GRASS LINED (LAST 1,100') FOR BANKS & GRADE CONTROL (5 DROPS)	10	5.0

* SEE FAIRFAX AT BRIARGATE MDDP FOR ALTERNATIVE DESIGN

COTTONWOOD CREEK DBPS - TABLE 3

CHANNEL & CULVERT RECOMMENDATIONS

REACH	HEC-1 FLOW w/det. (CFS)	CHANNEL OR CULVERT LENGTH(FT)	EXISTING IMPROVEMENT	RECOMMENDED IMPROVEMENT	TOTAL BOTTOM WIDTH (FT)	TOTAL DEPTH (FT)
SUM13 TO DESIGN POINT 29	2,949	2,500	P. LINED	NATURAL BOTTOM WITH BURIED RIPRAP BANKS & GRADE CONTROL (WITH 9 DROPS)	120	5.0
28 TO DESIGN POINT 29	2,739	1,800	CONCRETE	NO IMPROVEMENT REQUIRED (RECENTLY REBUILT)	20	6.0
28B TO DESIGN POINT 28	438	1,600	54" PIPE	PARALLEL PIPE (900')	60" RCP	N/A
28A TO DESIGN POINT 28B	430	1,900	48" PIPE	PARALLEL PIPE (800')	72" RCP	N/A
U1 TO DESIGN POINT 28A	125	2,800	42" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
28E TO DESIGN POINT 28F	1,563	1,200	108" PIPE	LINE PIPE FOR LOWER N VALUE	108" LINER	N/A
28D TO DESIGN POINT 28E	404	2,200	84" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
R2 TO DESIGN POINT 28D	356	1,100	66" PIPE	PARALLEL PIPE (250')	42" RCP	N/A
28C TO DESIGN POINT 28E	816	1,450	CONCRETE	REBUILD CONCRETE LINED CHANNEL	7	5.5
R1 TO DESIGN POINT 28C	775	2,700	NATURAL	STORM SEWER (1,300')	72" RCP	N/A
27 TO DESIGN POINT 28G LOW	794	1,700	CONCRETE	NO IMPROVEMENT REQUIRED	3	8.0
26 TO DESIGN POINT 27	518	3,500	78" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
26A TO DESIGN POINT 26B	797	2,800	NATURAL	NATURAL (IN PARK) EXCEPT PROVIDE BURIED RIPRAP & GRADE CONTROL BELOW CONCRETE CHANNEL (600' & 3 DROPS)	15	6.0
N1 TO DESIGN POINT 26A	454	3,100	36" PIPE	PARALLEL PIPE (1,500')	36"/54" RCP	N/A
25 TO DESIGN POINT 26	253/overflow	1,800	54" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
24 TO DESIGN POINT 25	2,201	1,750	CONCRETE	INCREASE DEPTH OF CONCRETE LINING BY 2.5'	8	6.5
23 TO DESIGN POINT 24	1,737	1,150	CONCRETE	NO IMPROVEMENT REQUIRED	6	6.0
23A TO DESIGN POINT 23	766	850	CONCRETE	INCREASE DEPTH OF CONCRETE LINING BY 2'	8	5.0
I4 TO DESIGN POINT 23A	240	3,200	48" PIPE	PARALLEL PIPE (1,900)	30" RCP	N/A
22 TO DESIGN POINT 23	613	4,550	CONCRETE	NO IMPROVEMENT REQUIRED	6	5.0
I2 TO DESIGN POINT 22A	163	1,650	42" PIPE	NO IMPROVEMENT REQUIRED	N/A	N/A
I1 TO DESIGN POINT 22	343	2,400	CONCRETE	NO IMPROVEMENT REQUIRED	6	5.0
28H TO DESIGN POINT 28	2,344	500	CONCRETE	NO IMPROVEMENT REQUIRED	12	6.0
27 TO DESIGN POINT 28G UP	518	1,500	90" PIPE	PARALLEL PIPE	48" RCP	N/A
WALMART CENTER NO. 2	N/A	N/A	N/A	STORM SEWER PER APPROVED SUBDIVISION DRAINAGE REPORT	N/A	N/A
ACADEMY BLVD (DP U4B)	240	150	RCP - 30"	54" REINFORCED CONCRETE PIPE	54" RCP	N/A
DUBLIN BLVD (DP 19F)	1,560	66	CBC - 2 @ 10' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
DUBLIN/TURRET (DP 19F19E)	1,492	50	CBC - 2 @ 9' x 5'	NO IMPROVEMENT REQUIRED	N/A	N/A
DUBLIN/LEMONWOOD (DP 19F19E)	1,423	175	CBC - 2 @ 9' x 5'	NO IMPROVEMENT REQUIRED	N/A	N/A
ACADEMY BLVD (DP 19E)	1,285	300	CBC - 12' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
LEHMAN DRIVE (DP 19E19D)	1,089	80	CBC - 14' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
HOLLOW TREE CT (DP 19D)	893	60	CBC - 12' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
TUCKERMAN LN (DP 19C)	726	70	CBC - 12' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
DUBLIN BLVD (DP 13Q)	1,058	200	CMP - 126"	ADD PARALLEL PIPE	84" CMP	N/A
AUSTIN BLUFFS (DP 13M)	1,116	250	USES 13J CROSSING	DOUBLE 10' X 8' CONCRETE BOX CULVERT	20	8
BALSAM ST (DP 13G)	1,593	150	CMP - 42"	DOUBLE 12' X 8' CONCRETE BOX CULVERT	24	8
POWERS BLVD (DP H5)	908	225	CMP - 3 @ 60"	DOUBLE 9' X 6' CONCRETE BOX CULVERT	18	6
POWERS BLVD (DP H6)	495	400	CMP - 2 @ 42"	14' X 5' CONCRETE BOX CULVERT	14	5
DUBLIN (DP 13B) N. SIDE	980	180	N/A	20' X 6' CONCRETE BOX CULVERT	20	6
DUBLIN (DP 13B) S. SIDE	490	180	N/A	14' X 5' CONCRETE BOX CULVERT	14	5
RANGEWOOD DR (DP 13P)	653	300	RCP - 72"	ADD PARALLEL PIPE	48" RCP	N/A
MEADOW RIDGE DR (DP 12C)	1,289	100	CBC - 10' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
RESEARCH PKWY (DP 12A)	541	220	CBC - 8' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
* POWERS BLVD (DP 11D)	901	400	N/A	12' X 9' CONCRETE BOX CULVERT	12	9

* SEE FAIRFAX AT BRIARGATE MDDP FOR ALTERNATIVE DESIGN

COTTONWOOD CREEK DBPS – TABLE 3

CHANNEL & CULVERT RECOMMENDATIONS

09-Jun-94

LOCATION	HEC-1 FLOW w/det. (CFS)	CHANNEL OR CULVERT LENGTH(FT)	EXISTING IMPROVEMENT	RECOMMENDED IMPROVEMENT	TOTAL BOTTOM WIDTH (FT)	TOTAL DEPTH (FT)
* RESEARCH PKWY (DP 11F)	1,341	250	N/A	12' X 9' CONCRETE BOX CULVERT	12	9
BRIARGATE PKWY (DP 8E)	861	180	N/A	12' X 9' CONCRETE BOX CULVERT	12	9
RESEARCH PKWY (DP 6)	673	180	N/A	10' X 8' CONCRETE BOX CULVERT	10	8
BRIARGATE PKWY (DP 5)	870	180	N/A	12' X 9' CONCRETE BOX CULVERT	12	9
ACADEMY BLVD MIDDLE (DP 28F)	1,563	150	DBL - 6' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
ACADEMY BLVD SOUTH (DP 28G)	794	125	CBC - 8' x 6'	NO IMPROVEMENT REQUIRED	N/A	N/A
UNION BLVD (DP 24)	1,737	125	CBC - 10' x 7'	NO IMPROVEMENT REQUIRED	N/A	N/A
LEXINGTON (DP 23) N. SIDE	1,108	95	CBC - 8' x 4'	NO IMPROVEMENT REQUIRED	N/A	N/A
LEXINGTON (DP 23) S. SIDE	766	225	RCP - 2 @ 48"	REPLACE W/ 10' X 5' CONCRETE BOX CULVERT	10	5
UNION BLVD. (DP 16B)	369	200	RCP - 60"	ADD PARALLEL PIPE	60" RCP	N/A
OAKWOOD (DP 13B)	1,556	70	CMP - 2 @ 30"	TRIPLE 12' X 6' CONCRETE BOX CULVERT	36	N/A
TOBIN RD. (ABOVE DP 5)	870	60	CMP - 2 @ 48"	12' X 9' CONCRETE BOX CULVERT	12	9
MCFERRAN RD. (DP 3)	335	60	CMP - 36"	2 @ 72" REINFORCED CONCRETE PIPE	2@72" RCP	N/A
HUNGATE RD. (ABOVE DP 3)	335	60	CMP - 48"	2 @ 72" REINFORCED CONCRETE PIPE	2@72" RCP	N/A
BURGESS RD. (DP 2)	114	70	N/A	48" REINFORCED CONCRETE PIPE	48" RCP	N/A
HERRING RD. (DP 1)	81	60	N/A	42" REINFORCED CONCRETE PIPE	42" RCP	N/A

* SEE FAIRFAX AT BRIARGATE MDDP FOR ALTERNATIVE DESIGN

COTTONWOOD CREEK DBPS - TABLE 4
BRIDGE RECOMMENDATIONS

LOCATION	HEC-1 FLOW w/det. (CFS)	EXISTING IMPROVEMENT	PROPOSED IMPROVEMENT
CDOT BRIDGES			
I-25 (DP 21)	11,173	BRIDGE, T=137,B=113,D=18	REPL. BRIDGES (8 LANES), 2 @ 70' WIDE X 140' LONG
I-25 (DP 31)	5,613	BRIDGE, T=189,B=39,D=43	REPL. BRIDGES (8 LANES), 2 @ 70' WIDE X 190' LONG

CITY BRIDGES			
CORPORATE DRIVE (DP 21)	11,173	BRIDGE, T=123,B=61,D=15.8	NO IMPROVEMENT REQUIRED
VINCENT DRIVE (DP 20)	11,112	BRIDGE, T=209,B=53,D=33.5	REPL. BRIDGE (6 LANE ART.), 107' WIDE BY 210' LONG
CURRENT ACCESS RD (DP 20)	11,112	HORSESHOE - 2 @ 22' x 22'	NO IMPROVEMENT REQUIRED
ACADEMY BLVD (DP 18)	10,000	CBC - 5 @ 20' x 9'	NO IMPROVEMENT REQUIRED
UNION BLVD (DP 16)	9,416	CBC - 7 @ 12' x 6'	REPL. BRIDGE (6 LANE ART.), 107' WIDE BY 150' LONG
RANGEWOOD DRIVE (DP 13)	7,844	CM ARCH - 4 @ 25.5' x 13'	NO IMPROVEMENT REQUIRED
WOODMEN ROAD (DP 12)	4,026	BRIDGE - 118' x 22'	REPL. BRIDGE (8 LANE ART.), 143' WIDE BY 200' LONG
AUSTIN BLUFFS (DP 12)	4,026	N/A	REPL. BRIDGE (8 LANE ART.), 143' WIDE BY 200' LONG
POWERS BLVD (DP 9)	2,332	N/A	TRIPLE 10' X 9' CBC (360')
DUBLIN BLVD (DP 13O)	2,414	CMP - 2 @ 132"	ADD PARALLEL 108" CMP
AUSTIN BLUFFS (DP 13J)	3,686	CMP - 2@120"	QUADRUPLE 12' X 9' CBC
RESEARCH PKWY (DP 8G)	1,632	N/A	TRIPLE 14' X 6' CBC
PINE CREEK RD (DP 31)	5,613	BRIDGE, T=185,B=45,D=41	NO IMPROVEMENT REQUIRED
OLD RAILOAD GRADE (DP 31)	5,613	HORSESHOE - 2 @ 25' x 21'	NO IMPROVEMENT REQUIRED
ACADEMY BLVD N (DP SUM13)	2,586	CBC - 10' x 6'	REPLACE WITH TRIPLE 12' X 9' CBC

COUNTY BRIDGES			
BLACK FOREST ROAD (DP 7)	854	BRIDGE, T=40,B=26,D=17	REPL. BRIDGE (5 LANE ART.), 70' WIDE BY 110' LONG

COTTONWOOD CREEK DBPS - TABLE 5
MATRIX OF CATAGORIES OF ACTIVITIES

CHANNEL CLASSIFICATION	ACTIVITY						
		CHANNEL BOTTOM				CHANNEL SIDES	
	NO ACTION	GRADE CONTROL /ENERGY DISS.	LINING OR PIPE	DREDGE CHANNEL	RELOCATE CHANNEL	CONCRETE (NON-PLANTED)	GABIONS (PLANTED)
UNCLASSIFIED	1	2	2	2	2	2	2
AGRICULTURAL CHANNEL	1	2	2	2	2	2	2
BACKWATER WETLAND	1	3	5	* 3/5	3	* 3/5	3
STRUCTURAL FLOODWAY	1	1	1	1	1	1	1
HERBACEOUS WETLAND	1	3	5	* 3/5	3	* 3/5	3
MODIFIED CHANNEL	1	2	2	2	2	2	2
OPEN WATER	1	3	5	* 3/5	3	* 3/5	3
RIPARIAN FOREST	1	4	4	4	4	4	4
SHRUB WETLAND	1	3	5	* 3/5	3	* 3/5	3
PRAIRIE SWALE W/O WETLANDS	1	2	2	2	2	2	2
PRAIRIE SWALE W/ WETLANDS	1	3	3	* 3/5	3	* 3/5	3

MITIGATION REQUIREMENTS

1 - NO MITIGATION REQUIRED SINCE THERE IS NO ENVIRONMENTAL DISTURBANCE PLANNED

2 - REVEGETATE DISTURBED AREAS WITH UPLAND VEGETATION AND PROVIDE TEMPORARY/PERMANENT EROSION CONTROL MEASURES

3 - USE 1:1 REPLACEMENT OF WETLANDS IN KIND/ON SITE

4 - RE-ESTABLISH RIPARIAN HABITAT

5 - USE 1:1 REPLACEMENT OF WETLANDS IN KIND/OFF SITE

6 - ESTABLISH NEW WETLAND

* MITIGATION MEASURE 3 IS PREFERRED, USE MITIGATION MEASURE 5 ONLY IF 3 IS NOT FEASIBLE

COTTONWOOD CREEK DBPS - TABLE 5
MATRIX OF CATAGORIES OF ACTIVITIES

CHANNEL CLASSIFICATION	ACTIVITY: CHANNEL SIDES			ACTIVITY: OTHER ACTIVITIES			
	BURIED RIPRAP	GRASS/SHRUB (VEGETATED)	GRASS W/ EROSION MAT	BRIDGE	CULVERTED ROAD CROSSING	DAMS	TEMPORARY CONSTRUCTION
UNCLASSIFIED	2	2/6	2/6	REFER TO TYPE OF BANK PROPOSED	2	6	2
AGRICULTURAL CHANNEL	2	2/6	2/6		2	6	2
BACKWATER WETLAND	3	3	3		2	3	3
STRUCTURAL FLOODWAY	1	N/A	N/A		1	N/A	1
HERBACEOUS WETLAND	3	3	3		2	3	3
MODIFIED CHANNEL	2	2/6	2/6		2	6	2
OPEN WATER	3	3	3		2	3	3
RIPARIAN FOREST	4	4	4		4	4	4
SHRUB WETLAND	3	3	3		2	3	3
PRAIRIE SWALE W/O WETLANDS	2	2/6	2/6		2	6	2
PRAIRIE SWALE W/ WETLANDS	3	3	3		2	3	3

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COTTONWOOD CREEK DBPS - TABLE 5
MATRIX OF CATAGORIES OF ACTIVITIES

CHANNEL CLASSIFICATION	ACTIVITY						
	OTHER ACTIVITIES						
	MAINTENANCE ACTIVITIES	UTILITY CROSSINGS					
UNCLASSIFIED		2					
AGRICULTURAL CHANNEL	REFER	2					
BACKWATER WETLAND	TO	3					
STRUCTURAL FLOODWAY	TYPE	1					
HERBACEOUS WETLAND	OF	3					
MODIFIED CHANNEL	ACTIVITY	2					
OPEN WATER	PROPOSED	3					
RIPARIAN FOREST		4					
SHRUB WETLAND		3					
PRAIRIE SWALE W/O WETLANDS		2					
PRAIRIE SWALE W/ WETLANDS		3					

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