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# BIG JOHNSON RESERVOIR/CREWS GULCH

## DRAINAGE BASIN PLANNING STUDY

Prepared for:
El Paso County
Department of Public Works
3105 North Stone Avenue
Colorado Springs, Colorado 80907

Prepared by:
Kiowa Engineering Corporation
419 West Bijou Street
Colorado Springs, Colorado 80905-1308

KIOWA Project No. 88.05.09

September 1991

Approved
El Paso County
Planning Commission
This 16th day of July 1991
Chairman
Secretary

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Revised September 1991

EXECUTIVE SUMMARY
BIG JOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN
PLANNING STUDY

Background

The Planning Commission, on December 17, 1984, approved, as an amendment to the County's master plan for development, a plan for the development of drainage basins in El Paso County which have been determined to be of mutual concern for El Paso County and the City of Colorado Springs. The plan, as approved, allowed for specific drainage basin studies or restudies to occur with the corresponding adjustments in fees. The Big Johnson Reservoir/Crews Gulch Drainage Basin Planning Study is one such study with accompanying fee changes. This study has been reviewed by City and County staffs and was initially presented to the City/County Drainage Board on March 16, 1989. The Drainage Board approved the study on June 20, 1991. Recommendations made by the El Paso County Planning Commission have been incorporated into the report. The Planning Commission approved the Report on July 16, 1991. The study was presented to the Board of County Commissioners (BOCC), for their consideration on September 5, 1991. The BOCC approved the plan and the associated fees on this same date.

Location

The Big Johnson Drainage Basin lies in central El Paso County, north of the City of Fountain, and east of the unincorporated area of Widefield. The area of the basin is approximately 5.3 square miles. The basin is drained by natural and manmade drainageways, the mainstem of which is known as Crews Gulch. The Basin is bounded by the Jimmy Camp Creek Basin on the east, Windmill Gulch Basin along the northwest, and the Little Johnson/Security Creek Basin on the southwest.

Major irrigation facilities lie within the basin, which plays a major role in determining the hydrologic characteristics of the basin. The water surface of Big Johnson Reservoir covers approximately 300 acres in the upper portion of the watershed. The Reservoir has the volume to adequately store developed runoff from a major storm event without overtopping of the spillway. The total storage volume of the reservoir is approximately 3950 acre feet. The Reservoir spillway has been rated at approximately 50 percent of the probable maximum flood. An inspection completed by the State Engineers Office in May, 1988, rated the Reservoir as satisfactory. The Reservoir is owned and operated by the FMIC.

The McRae Reservoir lies in the central portion of the basin, and abuts Fontaine Boulevard. This reservoir has mainly captured irrigation seepage, and has a permanent pool surface area of approximately 14 acres. Wetland vegetation has developed along some banks of the reservoir. Over the years, the reservoir has been impacted by siltation, which has significantly reduced the storage volume and mean depth of the reservoir.

The basin has both urban and rural development. The urbanized areas lie mainly south of Fontaine Boulevard. The Fountain Valley School property covers the majority of the drainage area between Fontaine Boulevard and Goldfield Drive. The FMIC owns Big Johnson Reservoir. North and east of the Big Johnson Reservoir is the Waterview property. The area north of Powers Boulevard is within the City of Colorado Springs, and is within the boundary of the Colorado Springs Municipal Airport.

Two El Paso County Parks lie along Crews Gulch. They are Fountain Creek Regional Park, and Widefield Park. Near the outlet of the basin the City of Fountain Ceresa Park lies within the Crews Gulch floodplain. Crews Gulch is a major feature in each of the County Parks. The primary areas of potential development are within the areas directly tributary to the Big Johnson Reservoir. This includes the Waterview property, and the Colorado Springs Municipal Airport property. Both of these properties are proposed for commercial/business development.

## Environmental Review

An environmental review of the study area was conducted in order to identify the basin's environmental features. The sensitivity of wetland and riparian areas to stormwater runoff, sedimentation and erosion was evaluated and planned for in the study. Both McRae and Big Johnson reservoirs were constructed for irrigation storage and control purposes, but they have also played a significant role in flood control. These reservoirs are used by waterfowl and shorebirds and contain some fish. These reservoirs are a good habitat resource for this area for use by aquatic biota and water birds.

Riparian wetlands occurs mainly as a narrow fringe in places around Big Johnson Reservoir, and on a wider zone in the Crews Gulch floodplain between Big Johnson and McRae reservoirs. This is a diverse and highly productive habitat for vegetation and wildlife, especially birds. At the present time, the floodplain area is used as grazing and pasture, and as an open space and riparian zone. Small wetlands exist around Big Johnson Reservoir, which periodically dry up during periods of lowered groundwater and/or reservoir storage levels.

South of Fontaine Boulevard Crews Gulch flows through Widefield Park. This Park has irrigated lawns and playing fields, adjacent to the drainageway. The Gulch within the Park has a frequently occurring base flow. Along the drainageway, planted trees with stands of cottonwoods and elm exist. The open stream through the Park has some wetland vegetation along it, and could be maintained as an open stream channel for use by aquatic plants.

## Hydrologic Analysis

A hydrologic analysis was conducted in order to determine peak discharges and runoff volumes for various storm types, and basin development conditions. This data was used in the evaluation of flood problems, identification of feasible plans, and in the preliminary design of the selected drainage facilities.

The runoff model used to determine the peak flows and volumes within the study area is the SCS Computer Program for the Project Formulation Hydrology (TR-20). The use of this hydrological model was in compliance with the City of Colorado Springs/El Paso County Drainage Criteria Manual at the time of project initiation.

A total of 71 sub-basins were delineated within the study area for the purposes of determining flow rates and volumes at various key locations. The drainage flow from the Little Johnson/Security Creek Basin was accounted for at the confluence of Crews Gulch and Security Creek near U.S. Highway 85/87.

Land use for existing and future basin conditions were determined from the available County land use, tax assessor, and zoning maps, aerial photos, and conversations with County staff and private land owners. Land use density and the corresponding curve numbers were determined from the City/County Drainage Criteria Manual. Hydrology from the Little Johnson/Security Creek Drainage Basin Planning Study was used to supply peak flow data for Security Creek. A summary of peak flow rates for the 2- and 24-hour storms are shown below:

Comparison of 2-Hour and 24-Hour Storm
for Regional Basins.

| Design Point | Local Description | Future Condition: 24-Hour Storm 100-Yr. | 24-Hour Storm 10-Yr. | 2-Hour Storm 100-Yr. | 2-Hour Storm 10-Yr |
|---|---|---|---|---|---|
| 31 | Big Johnson Basin | | | | |
| | Peak Flow (CFS) | 4850 | 2790 | 4340 | 2510 |
| | Peak Volume (AF) | 570 | 340 | 440 | 260 |
| 26* | McRae Basin | | | | |
| | Peak Flow (CFS) | 1360 | 440 | 1700 | 580 |
| | Peak Volume (AF) | 130 | 50 | 130 | 60 |
| 3* | Above Confluence of Security Creek and Crews Gulch | | | | |
| | Peak Flow (CFS) | 3550 | 1370 | 3850 | 1510 |
| | Peak Volume (AF) | 310 | 150 | 290 | 150 |

The results of the hydrologic analysis have been presented in several formats. A basin hydrologic map which shows the basin boundary, channel routing scheme, sub-basin locations, and design points is contained within the Map Pocket at the rear of the report. The results of the hydrologic analysis show that in the absence of detention storage, the impact of urban development in the basin would be to increase peak flow rates and volumes being conveyed by the major drainageways.

Hydraulic Analysis and Floodplain Delineation

A hydraulic analysis along the major drainageways was conducted to establish the flow capacities of existing structures, and to identify areas of flooding. The major drainageways were divided into reaches in order to better organize the planning effort. The reaches were selected based upon their particular drainageway characteristics and/or problems.

As part of the hydraulic evaluation, the existing major drainageway facilities were inspected in the field. Measurements of bridges, culverts, channels, inlets and other storm drainage facilities were taken in order to estimate the capacity of the existing storm drainage system(s).

Using the peak flow data developed in the Hydrology Analysis, water surface profiles were determined for each of the major drainageways. The COE HEC-2 water surface profile program was used to define 100-year floodplains for the existing and future basin conditions. Floodplain boundaries are presented on the preliminary design drawings contained in this report and the Technical Addendum. A 100-year floodway was also determined for the existing basin and drainageway conditions.

Development of Alternative Plans

Alternative drainageway plans have been examined that address the existing and future stormwater management needs of the basin. Alternatives have been identified for each reach of the drainageway on a conceptual level. Quantitative and qualitative comparisons are presented, and a recommendation made as to which plan is most feasible to advance to preliminary design and eventual implementation. The general planning goals followed during the alternative plan development phase were:

(1) Identify stormwater facilities which will reduce existing floodplains and flooding problems within urbanized areas;

(2) Provide stormwater management within developing areas of the basin in order to reduce the detrimental effects of runoff from urbanized areas;

(3) Provide stormwater facilities which preserve and/or enhance the existing drainageway and areas adjacent to the drainageway which provide an environmental resource in the area;

(4) Provide for separation of stormwater runoff from irrigation canals;

(5) Identify facilities which will minimize future operations and maintenance costs; and

(6) Provide stormwater management facilities which will at least maintain and/or enhance the water quality characteristics of the basin.

The alternative planning process began with the evaluation of general drainageway planning alternatives. Alternatives which are generally available in the majority of urban drainage basins include:

(1) Do nothing, and/or floodplain regulation,

(2) Channelization,

(3) Detention, on-site or off-site, and

(4) Diversion between sub-basins.

(5) Combinations of the above.

These concepts were evaluated for each reach of the basin. Alternatives ruled out for further consideration were the "do nothing", and the full conveyance of future runoff via improved channels. The "do-nothing" alternative was eliminated from further consideration because of the long-term need for localized invert and bank stabilization which is needed to protect the drainageways from erosion caused by increasing base and low flows. Both of these alternatives are unfeasible because of the large increase in peak flows due to urbanization and the resulting impact on the existing drainage channels, sensitive habitats, and roadway crossings. The undetained scenario could cause significant negative impacts to the drainageway areas south of Big Johnson Reservoir. Floodplain preservation with low flow stabilization is most feasible within Reaches 3 and 4.

Water quality is an important aspect of urban stormwater management. The question of water quality is particularly important within the Big Johnson Reservoir/Crews Gulch Basin because of possible negative impacts upon the irrigation waters stored within Big Johnson Reservoir created by urban stormwater. During the planning effort FMIC expressed a willingness to allow the detention of stormwater within Big Johnson Reservoir, if the quality of the runoff could be handled in such a way that the runoff will not degrade in the functioning of the Reservoir and canal system with respect to the their intended purpose. For this reason, detention/water quality basins were compared to the alternative of diverting future stormwater runoff around the Big Johnson Reservoir.

Alternative Plans

Based upon the information compiled, and comments from agencies and individuals which have been involved in the project, alternatives were developed for further technical evaluation. Three alternatives were developed for Reaches 1 through 3, which are based upon varying detention configurations at McRae Reservoir. For Reaches 4 and 5, three alternatives were developed. Channel sections, drops, and other facility sizes for each alternative were evaluated and the costs compared.

Within Reach 5, two subalternatives were developed for Alternate 1. Sub-alternate 1-1 is a water quality/detention concept whereby future flows would be maintained at historic levels before entering the Big Johnson Reservoir by using combined water quality/detention basins. Alternate 1-2 assumes water quality basins only (sited on Big Johnson Reservoir property), however, the future peak flows would enter Big Johnson Reservoir without any attenuation. For all of the alternatives evaluated in Reach 5, detention on the Colorado Springs Airport property was assumed.

During the preparation of the study, several government agencies were routinely involved in the coordination activities. Representatives from the Colorado Division of Wildlife, U.S. Army Corps of Engineers (COE), and the U.S.D.A. Soil Conservation Service (SCS) provided valuable commentary during the development of the alternative plans. The goal of the coordination process was to achieve a consensus on the types of alternatives which would best fit within the environmental constraints of the basin. Coordination meetings were held throughout the study to address overall goals and specific concerns of those agencies and individuals asked to participate in the study. One result of this coordination effort was the development of the following list of factors which were considered when evaluating an alternatives.

- Flood Control
- Erosion Control
- Operation and Maintenance
- Water Quality
- Wildlife Habitat
- Construction Cost
- Preserve Existing Vegetation
- Administration and Implementation
- Open Space
- Land Use
- Constructability
- Recreation
- Aesthetics
- Water Rights
- Transportation

The alternatives were evaluated on a reach-by-reach basis taking into account each of the factors presented above. Construction and operation and maintenance cost estimates for each of the conceptual plans were developed.

From the evaluation, it was determined that Alternative 3, the mid-level flow attenuation at McRae Reservoir, was the preferred alternative. For Reaches 4 and 5 the "preferred" plan is Alternative 1-2. Water quality basins with 100-year overflow facilities would be constructed on Big Johnson Reservoir property. The peak flow attenuation to areas below Big Johnson

Reservoir would be accomplished through storage within the Reservoir itself.

Preliminary Design

The results of the preliminary design analysis are summarized on the preliminary design drawings, Sheets 1 through 17, which are contained at the rear of this report. A description of the improvements follows:

**Reach 1 - Fountain Creek to Harvard Street**

The channel improvements within this reach are primarily rehabilitative in nature, with exception of the segment between State Highway 16 and US 85/87, which is new channel construction. The existing stream banks downstream of State Highway 16 should be lined with riprap where the existing bank protection has failed or is non-existent. Maintenance access in this reach would be through gravel trails along the top of the riprap bank. Upstream of the railroad bridges, the existing concrete channel is of adequate capacity to convey to 100-year flow with the provision of the fill along the south overbank from Station 33+50 to Station 35+40.

**Reach 2 - Harvard Street to Quebec Street**

Within this reach it is proposed that a 10-year, riprap-lined channel be constructed within the existing greenbelt extending to Kilgore Street. These improvements, in combination with the replacement of the Harvard and Quebec Street culverts are sufficient to reduce the potential for flood damages in comparison with the existing 100-year floodplain. The existing grasslined overbanks and trees should be preserved to the greatest extent possible. A gravel maintenance trail has been proposed within the greenbelt from Kilgore Street to Quebec Street.

**Reach 3 - Quebec Street to Fontaine Boulevard**

This reach is within Widefield Park. A floodplain preservation concept, in combination with the stabilization of the existing low flow channel, is proposed. A new box culvert is proposed at Quebec Street to eliminate the overtopping of the roadway. This concept if implemented would result in a zero net loss of habitat values.

**Reach 3A - Fountain Mesa Tributary**

This reach involves the stabilization of the existing drainageway from Widefield Park to Goldfield Drive. At Widefield Park, an additional 48-inch pipe has been proposed to supplement the existing 42-inch culverts which currently convey stormwater from areas upstream of Drury Lane, as well as augmentation water from the Fountain Mutual Canal. A residual floodplain would remain within the street section of Drury Lane, and would enter the park opposite Ciello Vista Street. Upstream of Drury Lane a stabilized grasslined channel is proposed. Drop structures are required upstream of Bella Vista Lane, and at Metropolitan Drive to facilitate the crossing of roads and the Fountain Mutual Irrigation Canal. Upstream of Goldfield Drive a detention pond has been sited to control runoff from the Waterview Property. Right-of-way acquisitions may be required for the channel upstream of Fontaine Boulevard to Goldfield Drive.

**Reach 4 - Fontaine Boulevard to Big Johnson Reservoir**

The primary stormwater management facility in this reach is McRae Reservoir. The improvements to the existing embankment are required to prevent the overtopping of the roadway. A new outlet structure is proposed, with an energy dissipator. Riprap embankment protection is to be provided along Fontaine Boulevard, downstream of the emergency overflow weir. The emergency outlet has been sized to pass the 100-year inflow (future condition) in accordance with State Engineer's regulations for a Class II, Minor Dam. McRae Reservoir represents a major environmental resource within the basin. Wetland and riparian habitat currently exist. The improvements shown on the preliminary design plans have been developed in order to improve the Reservoir's flood handling capabilities, while preserving and/or enhancing the Reservoir's existing habitat. Upstream of McRae Reservoir, a meandering boulder low flow channel extends from the Reservoir to Station 122+20. Disturbance to existing vegetation should be minimized. At Station 122+20 the 36-inch stormwater outlet from Big Johnson Reservoir would enter the boulder flow. Right-of-way acquisition or easements are required along the low flow path (and 36-inch conduit) from McRae Reservoir, north to Goldfield Drive.

**Reach 5 - Big Johnson Reservoir to Powers Boulevard**

The preliminary design concept for this reach relies upon detention and water quality basins to provide the long-term maintenance of stormwater runoff rates and water quality within Big Johnson Reservoir basin. Water quality ponds above the Big Johnson Reservoir, in combination with the stringent enforcement of County Erosion Control standards, are proposed to manage impacts of sedimentation as the area develops. Various other improvements at Big Johnson Reservoir include the enlargement of the existing spillway to meet the State Engineer's requirements, regrading of the dam embankment road, and an inlet structure for the 36-inch stormwater outlet pipe.

Upstream of Big Johnson Reservoir, riprap-lined channels and closed conduits are proposed. The actual channel section(s) to be constructed should be designed taking into account the land use adjacent to a drainageway. Major road crossings have been considered and box culverts sized to convey the 100-year design frequency. North of Powers Boulevard, the drainage area is within the City of Colorado Springs, and more specifically, part of the Colorado Springs Municipal Airport property. Detention basins have been sited north of Powers Boulevard. The ponds should incorporate water quality control features into their design, similar in concept to those proposed south of Powers Boulevard within Reach 5.

Right-of-way and/or easements acquisition is required for the water quality control ponds which are sited within the Big Johnson Reservoir property. Right-of-way for the public drainage facilities within the Waterview Property can be obtained through plat dedication as the property develops.

Preliminary Cost Estimate

Presented below are the total cost estimates for the preliminary design improvements. Unit costs used in developing the preliminary estimate were determined using bid tabulation data from recent drainageway construction projects in the area. Costs for initial systems are not included in the total costs. It is recommended that no reimbursement via the basin drainage fund be allowed for initial systems in this basin except as shown on the preliminary design plans.

| | |
|---|---|
| Total Cost of Drainageway Improvements | $7,448,253 |
| Total Cost of Roadway Crossings | $ 786,584 |

Of the total drainageway costs, approximately $5,400,000 can be funded via the drainage basin fee system. Total reimbursable bridge replacement costs is estimated at $495,376.

Basin Fee Determination

Within the basin approximately 977 acres of unplatted ground are available for fee assessment. Using the methods approved by El Paso County, a drainage fee of $6,178/acre has been calculated. The bridge fee has been calculated at $507 per acre. Land fees for detention basin land acquisition have been calculated at $43 per acre.

The balance of the drainage and bridge improvement costs for the basin (i.e., non-reimbursable costs) total $2,048,400 and $291,200, respectively. The costs, which have been termed non-reimbursable, represent improvements to channels and bridges which have inadequate capacity for the existing basin condition. A suggested allocation of these costs has been presented in the report. Public and private entities have been suggested to share the costs of these improvements.

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# I. INTRODUCTION

## Authorization

This evaluation of the stormwater management facilities within the Big Johnson Reservoir/Crews Gulch Drainage Basin was authorized under the terms of the agreement between El Paso County (County) and Kiowa Engineering Corporation by the El Paso County Board of County Commissioners, July 11, 1988.

## Purpose and Scope

The purpose of the study is to identify feasible stormwater management plans to satisfy the existing and future needs within the Big Johnson Reservoir/Crews Gulch Basin. The specific scope of work for this study included the following tasks:

1. Meet monthly with the County to: insure compliance with the services required by this agreement, obtain existing data and general information from participating entities, solicit desires of participating entities and other interested agencies or groups in order to develop alternate plans, procure current information relative to development plans in the basin, procure information relative to right-of-way limitations, proposed County projects, potential hazards due to flooding, and avoid duplication of effort whenever possible by utilizing existing information available from other agencies.

2. Contact the County, individuals, and other agencies who have knowledge and/or interest in the study area.

3. Utilize County policies and criteria and applicable information wherever possible.

4. Perform hydraulic and hydrologic analyses within the study area.

5. Identify existing and potential drainage and/or flooding problems.

6. Develop improvement alternatives to reduce existing and potential flooding problems.

7. Examine the operation and maintenance aspects of feasible alternatives.

8. Conduct an economic analysis of each alternative.

9. Recommend and prepare a preliminary design for a selected alternative plan.

10. Prepare a written report discussing all items examined in the study.

11. Conduct presentations to public and private entities in order to define project goals, and to involve agencies with specific interest to help define feasible alternatives.

Summary of Data Obtained

Listed below is the technical report collected for the use in this study:

1. Soil Survey for El Paso County, Colorado, dated June 1981.

2. "City of Colorado Springs/El Paso County Drainage Criteria Manual", prepared by City of Colorado Springs, El Paso County, and HDR Infrastructure, Inc., dated May 1987.

3. "Flood Insurance Studies for Colorado Springs, and El Paso County, Colorado", prepared by the Federal Emergency Management Agency (FEMA), 1986.

4. "Windmill Gulch Master Drainage Study", prepared by Finn & Associates, Ltd., dated July 1984.

5. Cruse Gulch Augmentation Line Design, prepared by Wheeler & Associates, 1987.

6. Division of Water Resources, State of Colorado, Rules and Regulations for Dam Safety and Dam Construction, September, 1988.

In addition to the above listed reports there were a number of drainage study reports, sketch plans, preliminary and final design drawings, land use maps, proposed development plans, and existing drainage facility maps that were provided by the County, local agencies, private entities, and individuals for the use of the project.

Mapping and Surveying

As part of the agreement, detailed mapping for the study area at a scale of 1" = 200' with 2-foot contour intervals was prepared by Landmark Mapping in July 1988, with the exception of the area lying north of Big Johnson Reservoir. Mapping for the basin above Big Johnson Reservoir area dated November, 1986, was obtained from URS, Inc., on behalf of the Centennial Land Development Corporation.

Stream cross-section data for Crews Gulch was obtained from the 1986 FEMA Flood Insurance Study (FIS) for Widefield Creek. These sections were verified against the new topographic mapping, and revised as necessary.

A detailed site inspection of the study area was conducted, and photographs were taken documenting the key drainage features. This data is contained in Section IV.

Acknowledgements

During the course of the preparation of this study, officials from El Paso County and others provided technical input and guidance. Specifically, we would like to thank the El Paso County Department of Public Works, the County Attorney's Office, the El Paso Parks and Land Use Departments for their time and assistance in providing technical information.

We would also like to thank the City of Colorado Springs; City of Fountain; Fountain Mutual Irrigation Co.; MVE, Inc.; URS, Inc.; the Fountain Valley School; Centennial Land Development Corporation; and Gilbert Meyer and Sams, Inc., for providing planning and technical documents relevant to the project.

During the preparation of the study, several government agencies were routinely involved in the coordination activities. Representatives from the Colorado Division of Wildlife, U. S. Army Corps of Engineers (COE), and the U.S.D.A. Soil Conservation Service provided valuable commentary during the development of the alternative plans. A listing of the individuals and agencies routinely coordinated with during the study has been presented below:

| Name | Agency |
|---|---|
| Alan Morrice | El Paso County Department of Public Works |
| John Kempfer | Centennial Land Development |
| Patrick Wheeler | El Paso County Attorneys Office |
| Rick O'Connor | El Paso County Land Use Department |
| Jeff Brauer | El Paso County Parks Department |
| Sue Johnson | El Paso County Parks Department |
| Micky Carter | El Paso County Parks Department |
| Ray Brown | Colorado Department of Highways |
| Gary Haynes | City of Colorado Springs Engineering Division |
| Dave Lethbridge | City of Colorado Springs Engineering Division |
| Bruce Goforth | Colorado Division of Wildlife |
| Lawrence Hecox | Fountain Mutual Irrigation Co./ Fountain Valley School |
| Ann Marshall | Fountain Mutual Irrigation Co. |
| Gary Steen | Monument Valley Engineering, Inc. |
| Frank Bustamento | City of Fountain |
| Dan Bunting | Regional Building Department |
| Brad Miller | Environmental Protection Agency |
| John Liou | Federal Emergency Management Agency |
| Don Lohrmeyer | Widefield Homes/Fountain Mutual Irrigation Company |
| Anita Culp | U.S. Army Corps of Engineers |
| John Maynard | NES, Inc. |

| | |
|---|---|
| Ed Spence | Soil Conservation Service |
| Bob Searns | Urban Edges |
| Roger Sams | Gilbert, Meyer & Sams, Inc. |
| Joe Peters | URS, Inc. |

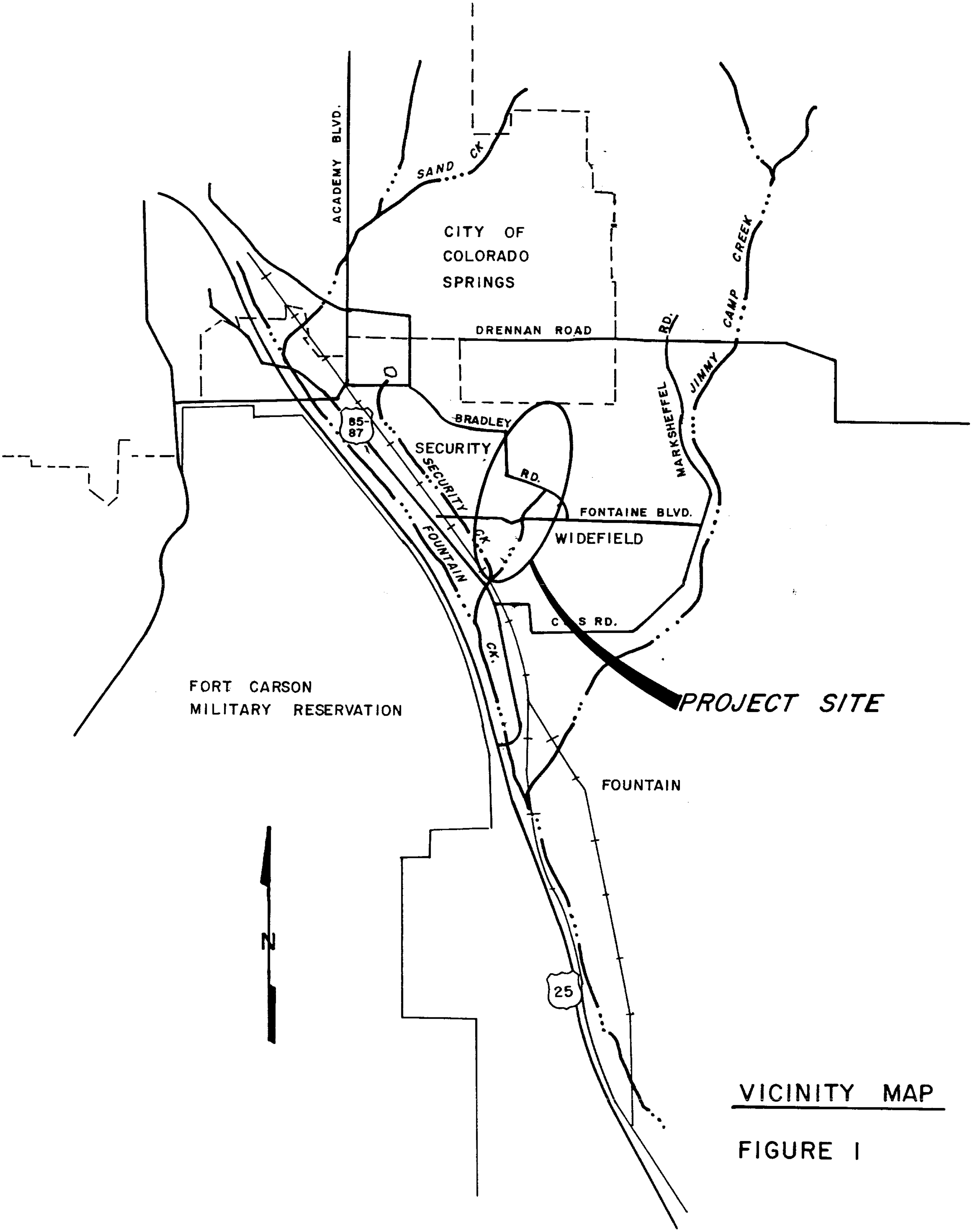
## II. STUDY AREA DESCRIPTION

### Location

The Big Johnson Drainage Basin lies in central El Paso County, north of the City of Fountain, and east of the unincorporated area of Widefield. The location of the basin is shown on Figure 1. The basin is drained by natural and manmade drainageways, the mainstem of which is known as Crews Gulch. The Basin is bounded by the Jimmy Camp Creek Basin on the east, Windmill Gulch Basin along the northwest, and the Little Johnson/Security Creek Basin on the southwest.

Major irrigation facilties lie within the basin, which plays a major role in determining the hydrologic characteristics of the basin. The water surface of Big Johnson Reservoir covers approximately 300 acres in the upper portion of the watershed. The reservoir has the volume to adequately store developed runoff from a major storm event without overtopping of the spillway. The total storage volume of the reservoir is approximately 3950 acre feet, however, the actual volume is suspected to be at best one-half of this number because of sedimentation which has occurred through the years. The primary source of sediment reaching the Reservoir is via the Fountain Mutual Canal and from the portion of the watershed area north of the Reservoir (i.e., the Big Johnson Reservoir Basin). The spillway has been rated at approximately 50 percent of the probable maximum flood. An inspection completed by the State Engineers office in May, 1988, rated the facility as satisfactory. The reservoir is owned and operated by the Fountain Mutual Irrigation Company. In accordance with the office of the State Engineer, Dam Safety Regulations, the Big Johnson Reservoir is rated as a Class II, Intermediate Dam. The existing emergency spillway can pass 50 percent of the Probable Maximum Flood (PMF). The PMF has been estimated at 11,300 cubic feet per second.

The Fountain Mutual Canal enters the Big Johnson Reservoir from the west. This canal crosses several drainage basins between the diversion point on Fountain Creek and Big Johnson Reservoir. The irrigation outlet at Goldfield Drive feeds the




VICINITY MAP

FIGURE I

Kiowa Engineering Corporation

Fountain Mutual Canal which flows southeast, traversing the basin below the Reservoir. The canal crosses the Fountain Mesa Tributary near Metropolitan Drive before exiting the basin. Unless storm water separation is provided, the canal can capture surface runoff, and divert flow out of the basin. Storm drainage entering the Fountain Mutual Canal has caused the canal to breach in the past. The area above Big Johnson Reservoir is primarily open rangeland, with poor to fair vegetative cover consisting of native rangeland grasses. The land south of Powers Boulevard is being used for grazing, which has caused the sedimentation rates from this area to be increased (in comparison to an undisturbed condition).

The McRae Reservoir lies in the central portion of the basin, and abuts Fontaine Boulevard. This reservoir has mainly captured irrigation seepage, and has a permanent pool surface area of approximately 14 acres. Wetland vegetation has developed along some banks of the reservoir. Over the years, the reservoir has been impacted by siltation, which has significantly reduced the storage volume and mean depth of the reservoir. Maximum depths range from five to six feet at the outlet, with an average of three to four feet. In 1965, the reservoir embankment breached after several successive days of heavy rain. The ensuing flood caused significant damage to roadways and bridges along Crews Gulch. The existing embankment and sheet pile wall was constructed in 1972 by El Paso County forces. The McRae Reservoir has not been inspected recently by the State Engineer's Office. Using the State's Dam Safety Regulations, McRae Reservoir would be classified as a Class II, Minor Dam. Because of this, a spillway for McRae Reservoir must be able to pass a 100-year flow with the principal outlet totally plugged.

Property Ownership

The basin covers a total of 5.3 square miles, and has both urban and rural development. The urbanized areas lie mainly south of Fontaine Boulevard. The Fountain Valley School property covers the majority of the drainage area between Fontaine

Boulevard and Goldfield Drive. The Fountain Mutual Irrigation Company owns Big Johnson Reservoir. North and east of the Big Johnson Reservoir is the Waterview Development property. North of Powers Boulevard is within the City of Colorado Springs, and more specifically within the boundary of the Colorado Springs Municipal Airport.

Two El Paso County Parks lie along Crews Gulch; Fountain Creek Regional Park, and Widefield Park. Near the outlet of the basin the City of Fountain Ceresa Park lies within the Crews Gulch floodplain. Crews Gulch is a major feature in each of the County Parks. Along the major drainageways, below Fontaine Boulevard (i.e., Crews Gulch and the Fountain Mesa Tributary), property adjacent to the stream is either publically owned, within a greenbelt, or within a dedicated drainage easement or tract. In general, the acquisition or dedication right-of-way will be required along all major drainageways upstream of Fontaine Boulevard.

Future Development

The primary areas of potential development are within the areas directly tributary to the Big Johnson Reservoir. This includes the Waterview Development, and the Colorado Springs Municipal Airport property. Both of these properties are proposed for commercial/business development, which has been accounted for in the hydrologic modelling of the future basin condition. During the hydrologic evaluation, the land use assumptions to follow for the Fountain Valley School property were discussed with representatives of the school. As a result of these discussions, the Fountain Valley School property was assumed to remain in its existing state, for the purposes of the future condition hydrologic and hydraulic modelling.

Future roadway projects will impact the drainage planning. The roadway projects considered during the drainageway planning included:

-- Southmoor Drive Bridge Improvements

-- Fontaine Boulevard Widening (El Paso County)

-- US 85/87 Improvements (CDOH)
-- Goldfield Road Realignment
-- Bradley Road (Private)
-- Major/Minor Arterials within the Waterview property

The location of future arterials and major realignments were obtained from the El Paso County Major Transportation Plan, updated 1988.

Climate

The study area has a climate typical of the high plains, with total precipitation amounts typical of a semi-arid region. Winters are generally cold and dry, and summers relatively cool and dry. Precipitation ranges from 14 to 16 inches per year, with the majority of this precipitation occurring in spring and summer in the form of rainfall. Thunderstorms are common during the summer months, and are typified by quick-moving low pressure cells which draw moisture from the Gulf of Mexico into the region. Average temperatures range from about 30°F in the winter to 75°F in the summer. The relative humidity ranges from about 25 percent in the summer to 45 percent in the winter.

## III. ENVIRONMENTAL REVIEW OF BASIN

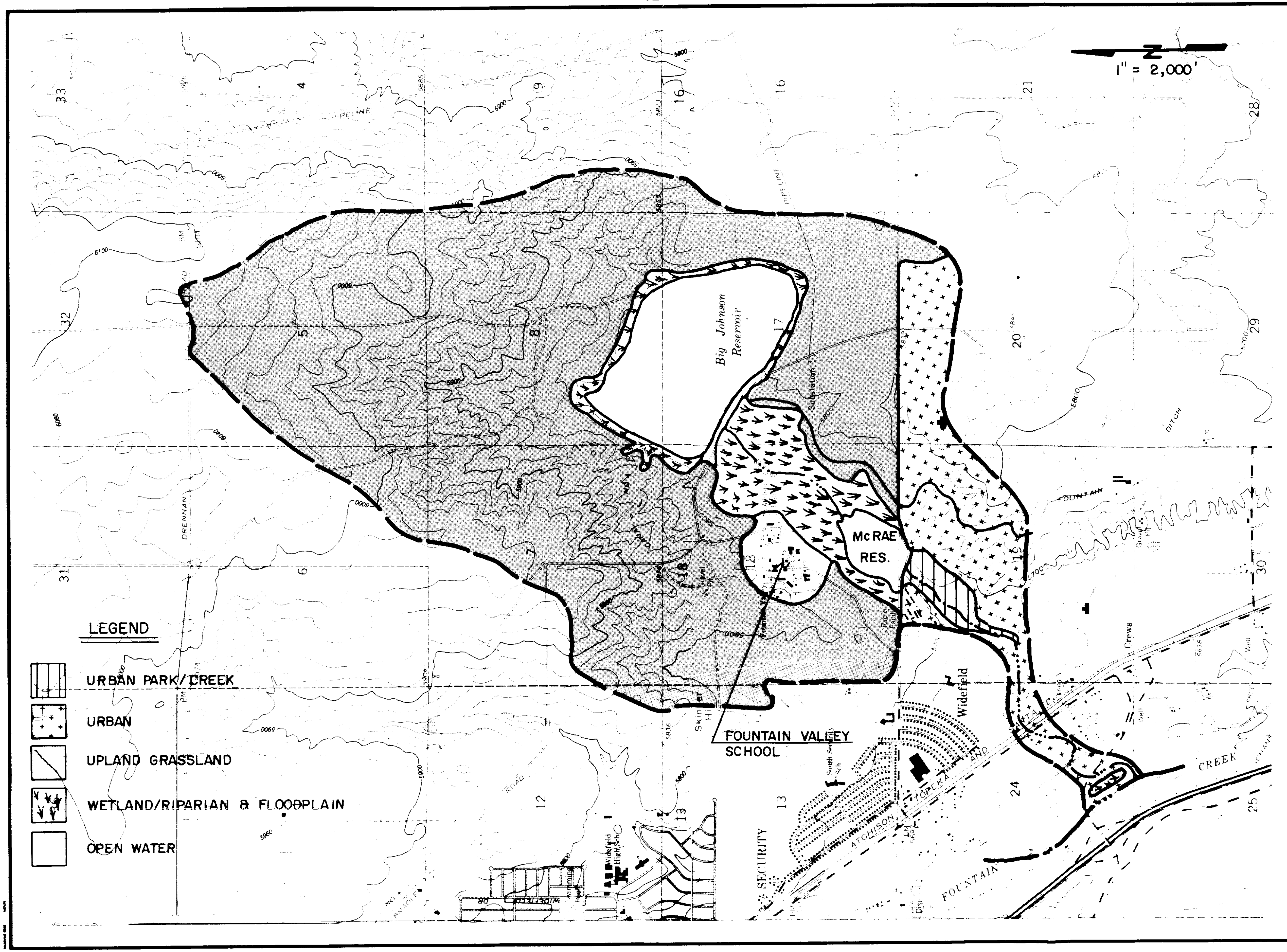
An environmental review of the study area was conducted in order to identify the existing environmental features. The sensitivity of wetland and riparian areas to stormwater runoff, sedimentation and erosion must be evaluated and planned for in a reasonable way. A description of the existing environmental setting follows. Presented on Figure 2 is the environmental setting for the existing basin.

### Open Water

In the basin there are two open bodies of water; the larger Big Johnson Reservoir and the smaller McRae Reservoir. Both reservoirs were constructed for irrigation storage and control purposes, but they have also played a significant role in flood control. These reservoirs are used by waterfowl and shorebirds and contain some fish. These reservoirs are a fairly good habitat resource for this area for use by aquatic biota and water birds. This type of open water habitat is not common in the region.

### Riparian/Floodplain and Wetlands

This type of water body occurs mainly as a narrow fringe in places around Big Johnson Reservoir, and on a wider zone in the area between Big Johnson and McRae Reservoirs (Reach 4). This is a diverse and highly productive habitat for vegetation and wildlife, especially birds. This is the most significant area for wildlife habitat preservation and possible enhancement. At the present time, this area is used as grazing and pasture for horses by the Fountain Valley School, and as open space wetlands and riparian zone. With proper management, this area could be enhanced and tied into the lower drainages of the upland grassland to enlarge a wildlife habitat resource base. Small wetlands exist around Big Johnson Reservoir, which periodically dry up during periods of lowered groundwater and/or reservoir storage levels.

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BIG JOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN PLANNING STUDY

ENVIRONMENTAL INVENTORY MAP

| | |
|---|---|
| Project No. | 88.05.09 |
| Date: | 2/89 |
| Design: | SB |
| Drawn: | LK |
| Check: | RW |
| Revisions: | |

FIGURE 2

Drainages

Drainages in the basin consist of intermittent flows in upper and lower swales in the upland grassland to a well-defined channel and frequent flow in the stream from below McRae Reservoir to Fountain Creek. Canals for taking water into and out of Big Johnson Reservoir flow from north into and south out of the Big Johnson Reservoir. These drainages and stream channels have narrow strips of better plant productivity and wetlands, and are a minor but important habitat type that can enhance the wetlands and riparian zones in Reach 3 and at Fountain Creek.

Upland Grassland

This is a high plains grassland (short-grass prairie) vegetation and habitat type. This area in the basin has been heavily grazed by cattle and horses, and as a result the range is in poor condition with lower plant productivity, increases in weedy species, and an increased rate of soil erosion. With proper management, such as reducing or eliminating grazing and erosion control, the value of this large upland area could be enhanced as a habitat resource for upland birds and small mammals.

Urban Development

Those areas in the lower basin south of Fountain Boulevard are residential housing and some commercial development. As such, the area is mainly roads, houses, and lots. The lower drainage basin is crossed by roads and railroads through which most of the stream has been channelized. Some birds and mammals, such as squirrel, are adapted to an urban environment and live in this area of the basin; but in general, this is not a part of the basin that can be managed to contribute to a resource base.

Urban Park

El Paso County has established a park south of Fontaine Boulevard, with irrigated lawns and playing fields, along the main basin drainage area (Crews Gulch). This park has a frequently flowing stream and planted trees with stands of cottonwoods and elm trees. This area provided some habitat for birds and animals in Reach 3 since it is contiguous and provides some elements of the riparian and wetland habitats. The open stream through this park has wetland vegetation along it, and could be maintained as an open stream channel for use by aquatic plants and animals.

## IV. HYDROLOGIC ANALYSIS

The hydrologic analysis portion of the Drainage Basin Planning Study was conducted in order to determine peak discharges and runoff volumes for various storm types, and basin development conditions. This data was used in the evaluation of flood problems, identification of feasible plans, and in the preliminary design of the selected drainage facilities. Detailed computer printouts of input data and output are contained within the Technical Addendum to this report.

### Runoff Model

The runoff model used to determine the peak flows and volumes within the study area is the Soil Conservation Service (SCS) Computer Program for the Project Formulation Hydrology (TR-20). The version is available for the IBM personal computer (PC) "XT" and "AT" or a compatible PC. The use of this hydrological model is in compliance with the City of Colorado Springs/El Paso County Drainage Criteria Manual (Manual).

### Basin Hydrologic Characteristics

For analysis purposes, the study area was divided into three regional basins which include: (1) the Big Johnson Reservoir Basin, (2) the McRae Reservoir Basin, and (3) South Fontaine Basin as shown on Figure 3 (in Map Pocket). A total of 71 sub-basins were delineated within the study area for the purposes of determining flow rates and volumes at various key locations. The drainage flow from the Little Johnson/Security Creek Basin was accounted for at the confluence of Crews Gulch and Security Creek near U.S. Highway 85/87. The basin characteristics such as basin size, curve numbers (CN), basin slope, flow path, flow time, channel type, slope and size, channel routing coefficient "X" and "m" values, and velocity were determined from available topographic mapping, land use maps, soil maps, field investigation and personal conversations with County staff and local agencies. Summary tables for the time of concentration ($T_C$) and "X" and "m" values for both existing and future basin conditions are included in the Technical Addendum. Figure 4 shows the soil distribution and their types based on the El Paso County soil survey report.

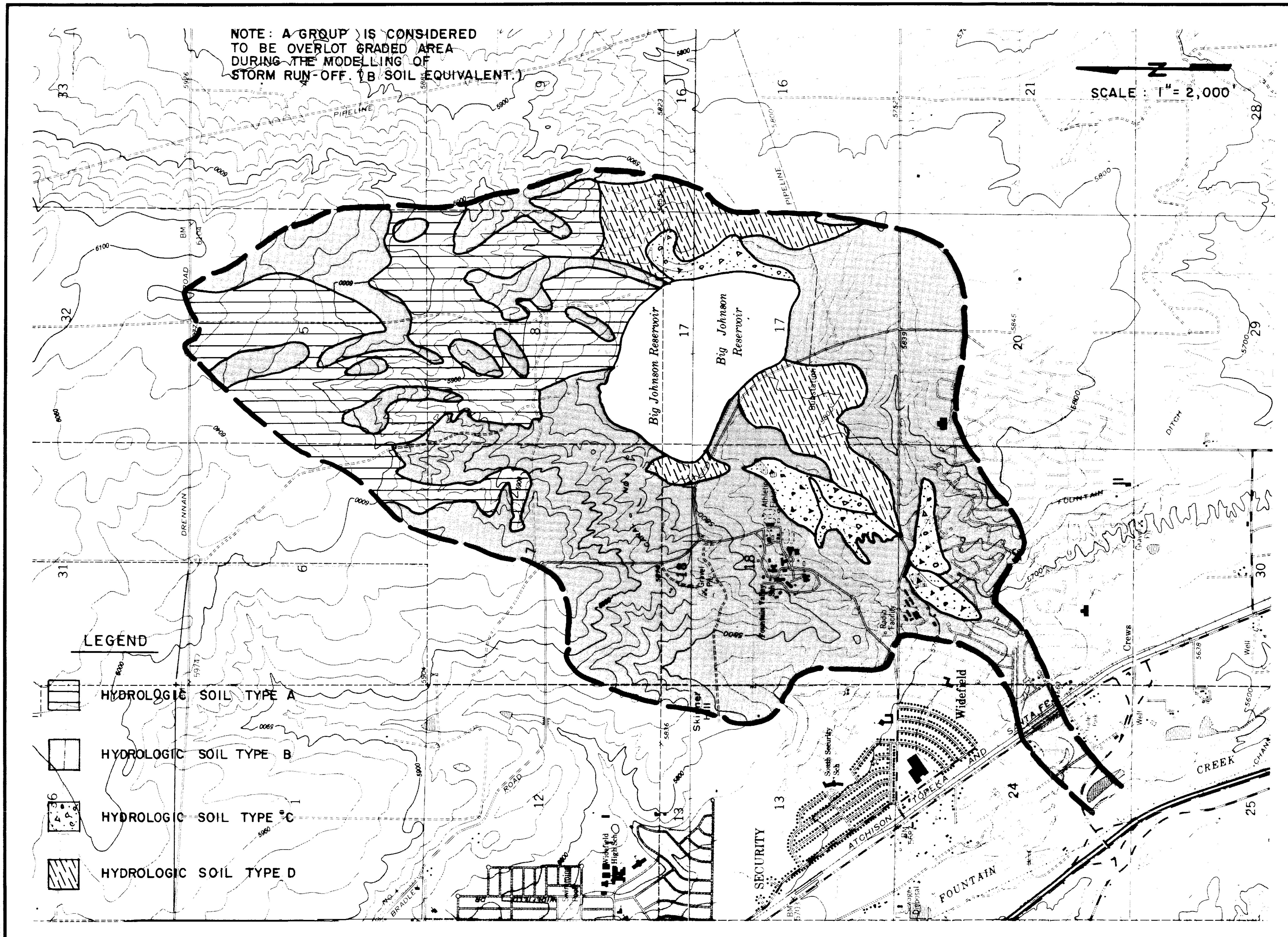
Impervious Land Density

Land use for existing and future basin conditions were determined from the available County land use, tax assessor, and zoning maps, aerial photos, and conversations with County staff and private land owners. Land use density and the corresponding curve numbers were determined from the City/County Drainage Criteria Manual. Figure 5 depicts the future land use map for the study area. Table 1 summarizes the curve numbers for both the existing and future conditions. The land use map presented was used solely for the determination of hydrologic characteristics within the basin, and are not intended to be used for any other purpose.

Design Rainfall

In accordance with the City/County Drainage Criteria Manual, two types of storm distributions were evaluated in order to determine a controlling storm for the sizing of drainage structures. The first type of storm is the 24-hour Type II-A storm with antecedent moisture condition (AMC) of two (2). The second type of storm is a 2-hour distribution with an AMC of three (3). The storm events for the 10-year and 100-year recurrence intervals were evaluated. Rainfall depths for the 24-hour storm are 4.5 inches and 3.0 inches for the 100-year and 10-year frequencies, respectively. Rainfall depths for the 2-hour storm are 3.0 inches for the 100-year frequency, and 2.1 inches for the 10-year frequency. A comparison of the results for the 24-hour and 2-hour storms revealed that in most cases the 2-hour storm controls the peak runoff and the 24-hour storm controls for runoff volume. (In some areas above Big Johnson Reservoir, the 24-hour peak flows are higher than the 2-hour flows.)

The Little Johnson/Security Creek Drainage Basin Planning Study was used to supply peak flow data for Security Creek. The

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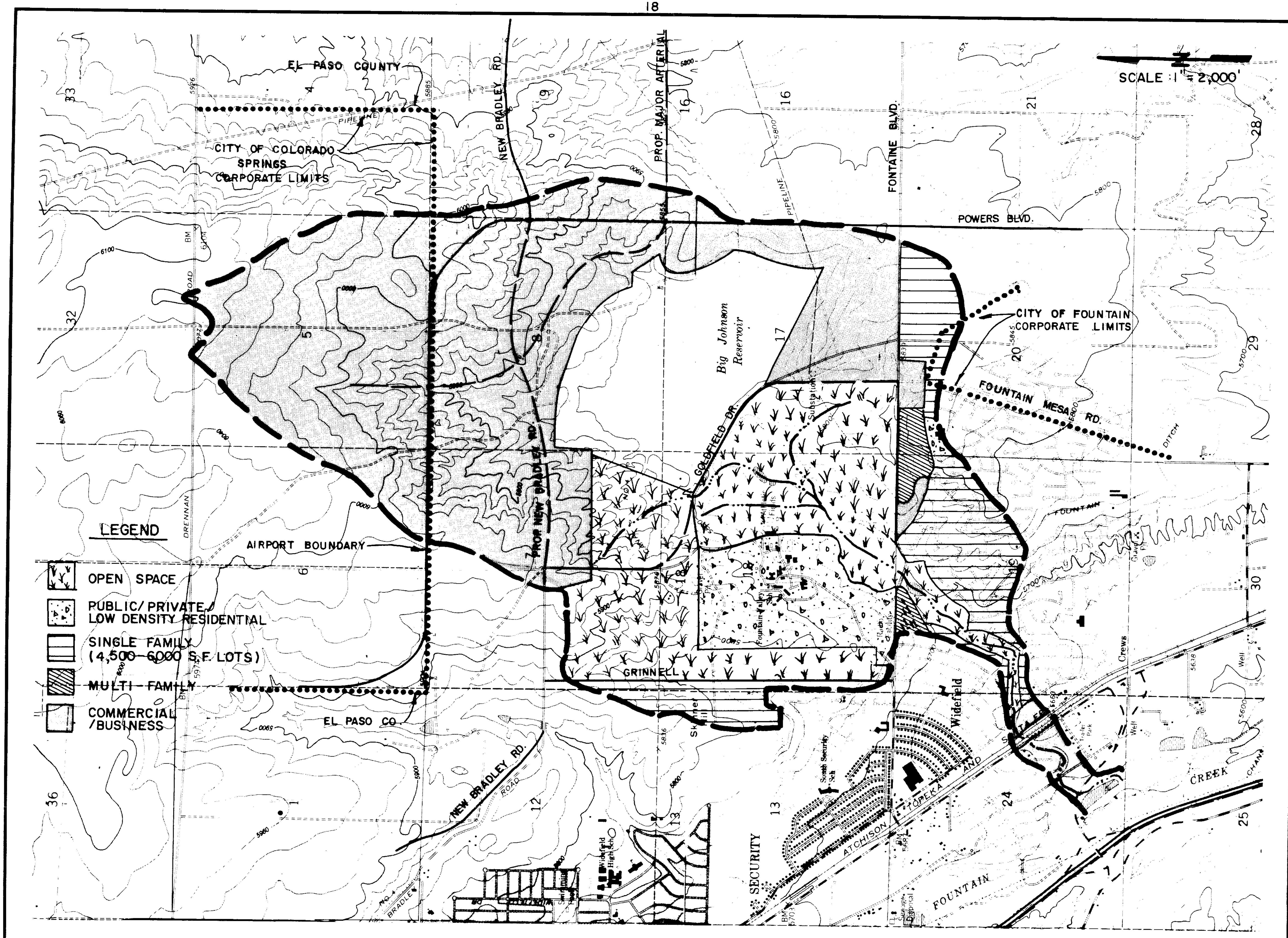
BIG JOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN PLANNING STUDY

SOILS MAP

| | |
|---|---|
| Project No. | 88.05.09 |
| Date: | 2/89 |
| Design: | |
| Drawn: | EK |
| Check: | RW |
| Revisions: | |

FIGURE 4

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BIG JOHNSON RESERVOIR / CREWS GULCH DRAINAGE BASIN PLANNING STUDY

LAND USE MAP

| | |
|---|---|
| Project No. | 88-05-09 |
| Date: | 8-88 |
| Design: | RNW |
| Drawn: | EAK |
| Check: | RNW |
| Revisions: | |

FIGURE 5

Table 1: Summary of SCS Curve Numbers

KIOWA ENGINEERING CORPORATION

TR-20 SOIL CURVE CALCULATION SPREADSHEET

DATE: 09-Mar-89
TIME: 06:26 PM

NOTE: SOIL GROUP A = 1 SOIL GROUP C = 3
SOIL GROUP B = 2 SOIL GROUP D = 4

PROJECT: BIG JOHNSON HYDROLOGY

| <---- S-O-I-L G-R-O-U-P I-N-F-O-R-M-A-T-I-O-N ----> | | | | | | | | | ** ANTECEDENT MOISTURE CONDITION = 2 ** | | | | | | | | ** AMC = 3 ** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ** FIRST GROUP ** | | ** SECOND GROUP ** | | ** THIRD GROUP ** | | | | EXISTING CONDITIONS | | | | FUTURE CONDITIONS | | | | EXISTING | FUTURE |
| BASIN ID NUMBER | GROUP NUMBER | PERCENT OF GROUP | GROUP NUMBER | PERCENT OF GROUP | GROUP NUMBER | PERCENT OF GROUP | % IMP. EXISTING | % IMP. FUTURE | 1ST GROUP CURVE # | 2ND GROUP CURVE # | 3RD GROUP CURVE # | WEIGHTED CURVE | 1ST GROUP CURVE # | 2ND GROUP CURVE # | 3RD GROUP CURVE # | WEIGHTED CURVE | COMPUTED CURVE # | COMPUTED CURVE # |
| 1 | 2 | 100 | 0 | 0 | 0 | 0 | 5 | 5 | 62.9 | 0.0 | 0.0 | 63 | 62.9 | 0.0 | 0.0 | 63 | 80 | 80 |
| 2 | 2 | 100 | 0 | 0 | 0 | 0 | 55 | 55 | 80.9 | 0.0 | 0.0 | 81 | 80.9 | 0.0 | 0.0 | 81 | 92 | 92 |
| 3 | 2 | 100 | 0 | 0 | 0 | 0 | 30 | 76 | 71.9 | 0.0 | 0.0 | 72 | 88.4 | 0.0 | 0.0 | 88 | 86 | 95 |
| 4 | 2 | 100 | 0 | 0 | 0 | 0 | 3 | 3 | 62.2 | 0.0 | 0.0 | 62 | 62.2 | 0.0 | 0.0 | 62 | 80 | 80 |
| 5 | 2 | 100 | 0 | 0 | 0 | 0 | 10 | 85 | 64.7 | 0.0 | 0.0 | 65 | 91.7 | 0.0 | 0.0 | 92 | 82 | 97 |
| 6 | 2 | 100 | 0 | 0 | 0 | 0 | 45 | 45 | 77.3 | 0.0 | 0.0 | 77 | 77.3 | 0.0 | 0.0 | 77 | 89 | 89 |
| 7 | 2 | 100 | 0 | 0 | 0 | 0 | 10 | 10 | 64.7 | 0.0 | 0.0 | 65 | 64.7 | 0.0 | 0.0 | 65 | 82 | 82 |
| 8 | 2 | 100 | 0 | 0 | 0 | 0 | 8 | 8 | 64.0 | 0.0 | 0.0 | 64 | 64.0 | 0.0 | 0.0 | 64 | 81 | 81 |
| 9 | 2 | 100 | 0 | 0 | 0 | 0 | 45 | 45 | 77.3 | 0.0 | 0.0 | 77 | 77.3 | 0.0 | 0.0 | 77 | 89 | 89 |
| 10 | 2 | 100 | 0 | 0 | 0 | 0 | 30 | 30 | 71.9 | 0.0 | 0.0 | 72 | 71.9 | 0.0 | 0.0 | 72 | 86 | 86 |
| 11 | 3 | 45 | 2 | 55 | 0 | 0 | 7 | 7 | 34.1 | 35.1 | 0.0 | 69 | 34.1 | 35.1 | 0.0 | 69 | 84 | 84 |
| 12 | 3 | 5 | 2 | 95 | 0 | 0 | 80 | 80 | 5.1 | 85.0 | 0.0 | 90 | 5.1 | 85.0 | 0.0 | 90 | 96 | 96 |
| 13 | 2 | 7 | 3 | 93 | 0 | 0 | 5 | 5 | 4.3 | 70.6 | 0.0 | 75 | 4.3 | 70.6 | 0.0 | 75 | 88 | 88 |
| 14 | 2 | 8 | 3 | 92 | 0 | 0 | 20 | 20 | 5.7 | 72.5 | 0.0 | 78 | 5.7 | 72.5 | 0.0 | 78 | 90 | 90 |
| 15 | 2 | 22 | 3 | 78 | 0 | 0 | 10 | 10 | 13.9 | 60.3 | 0.0 | 74 | 13.9 | 60.3 | 0.0 | 74 | 87 | 87 |
| 16 | 3 | 16 | 2 | 84 | 0 | 0 | 45 | 45 | 13.7 | 64.8 | 0.0 | 79 | 13.7 | 64.8 | 0.0 | 79 | 90 | 90 |
| 17 | 3 | 57 | 2 | 43 | 0 | 0 | 45 | 45 | 48.6 | 33.1 | 0.0 | 82 | 48.6 | 33.1 | 0.0 | 82 | 92 | 92 |
| 18 | 3 | 19 | 2 | 81 | 0 | 0 | 35 | 35 | 15.5 | 59.9 | 0.0 | 75 | 15.5 | 59.9 | 0.0 | 75 | 88 | 88 |
| 19 | 2 | 100 | 0 | 0 | 0 | 0 | 25 | 25 | 70.1 | 0.0 | 0.0 | 70 | 70.1 | 0.0 | 0.0 | 70 | 85 | 85 |
| 20 | 2 | 100 | 0 | 0 | 0 | 0 | 50 | 50 | 79.1 | 0.0 | 0.0 | 79 | 79.1 | 0.0 | 0.0 | 79 | 90 | 90 |
| 21 | 2 | 100 | 0 | 0 | 0 | 0 | 5 | 59 | 62.9 | 0.0 | 0.0 | 63 | 82.3 | 0.0 | 0.0 | 82 | 80 | 92 |
| 22 | 2 | 100 | 0 | 0 | 0 | 0 | 8 | 69 | 64.0 | 0.0 | 0.0 | 64 | 85.9 | 0.0 | 0.0 | 86 | 81 | 94 |
| 23 | 2 | 100 | 0 | 0 | 0 | 0 | 45 | 45 | 77.3 | 0.0 | 0.0 | 77 | 77.3 | 0.0 | 0.0 | 77 | 89 | 89 |
| 24 | 2 | 100 | 0 | 0 | 0 | 0 | 30 | 30 | 71.9 | 0.0 | 0.0 | 72 | 71.9 | 0.0 | 0.0 | 72 | 86 | 86 |
| 25 | 2 | 100 | 0 | 0 | 0 | 0 | 24 | 24 | 69.7 | 0.0 | 0.0 | 70 | 69.7 | 0.0 | 0.0 | 70 | 85 | 85 |
| 26 | 2 | 100 | 0 | 0 | 0 | 0 | 5 | 45 | 62.9 | 0.0 | 0.0 | 63 | 77.3 | 0.0 | 0.0 | 77 | 80 | 89 |
| 27 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 85 | 61.8 | 0.0 | 0.0 | 62 | 91.7 | 0.0 | 0.0 | 92 | 80 | 97 |
| 28 | 2 | 100 | 0 | 0 | 0 | 0 | 4 | 40 | 62.5 | 0.0 | 0.0 | 63 | 75.5 | 0.0 | 0.0 | 75 | 80 | 88 |
| 29 | 2 | 28 | 3 | 72 | 0 | 0 | 2 | 19 | 17.1 | 54.2 | 0.0 | 71 | 18.8 | 57.0 | 0.0 | 76 | 86 | 89 |
| 30 | 2 | 5 | 3 | 19 | 3 | 77 | 2 | 2 | 3.1 | 13.9 | 57.4 | 74 | 3.1 | 13.9 | 57.4 | 74 | 87 | 87 |
| 31 | 3 | 11 | 2 | 44 | 3 | 45 | 2 | 2 | 8.1 | 27.4 | 33.6 | 69 | 8.1 | 27.4 | 33.6 | 69 | 84 | 84 |
| 32 | 4 | 58 | 2 | 42 | 0 | 0 | 2 | 2 | 47.2 | 25.8 | 0.0 | 73 | 47.2 | 25.8 | 0.0 | 73 | 87 | 87 |
| 33 | 2 | 51 | 3 | 38 | 3 | 12 | 4 | 4 | 31.9 | 28.3 | 8.7 | 69 | 31.9 | 28.3 | 8.7 | 69 | 84 | 84 |
| 34 | 3 | 3 | 3 | 37 | 2 | 60 | 5 | 5 | 2.0 | 28.0 | 38.0 | 68 | 2.0 | 28.0 | 38.0 | 68 | 84 | 84 |
| 35 | 2 | 100 | 0 | 0 | 0 | 0 | 15 | 15 | 66.5 | 0.0 | 0.0 | 66 | 66.5 | 0.0 | 0.0 | 66 | 83 | 83 |

## Table 1 cont'd:  Summary of SCS Curve Numbers

KIOWA ENGINEERING CORPORATION

TR-20 SOIL CURVE CALCULATION SPREADSHEET

DATE: 09-Mar-89
TIME: 06:26 PM

NOTE: SOIL GROUP A = 1  SOIL GROUP C = 3
SOIL GROUP B = 2  SOIL GROUP D = 4

PROJECT: BIG JOHNSON HYDROLOGY

| | <---- S-O-I-L G-R-O-U-P I-N-F-O-R-M-A-T-I-O-N ----> | | | | | | | | ** ANTECEDENT MOISTURE CONDITION = 2 ** | | | | | | | | ** AMC = 3 ** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ** FIRST GROUP ** | | ** SECOND GROUP ** | | ** THIRD GROUP ** | | | | EXISTING CONDITIONS | | | | FUTURE CONDITIONS | | | | EXISTING | FUTURE |
| BASIN ID NUMBER | GROUP NUMBER | PERCENT OF GROUP | GROUP NUMBER | PERCENT OF GROUP | GROUP NUMBER | PERCENT OF GROUP | % IMP. EXISTING | % IMP. FUTURE | 1ST GROUP CURVE # | 2ND GROUP CURVE # | 3RD GROUP CURVE # | WEIGHTED CURVE | 1ST GROUP CURVE # | 2ND GROUP CURVE # | 3RD GROUP CURVE # | WEIGHTED CURVE | COMPUTED CURVE # | COMPUTED CURVE # |
| 36 | 2 | 100 | 0 | 0 | 0 | 0 | 4 | 4 | 62.5 | 0.0 | 0.0 | 63 | 62.5 | 0.0 | 0.0 | 63 | 80 | 80 |
| 37 | 2 | 100 | 0 | 0 | 0 | 0 | 10 | 10 | 64.7 | 0.0 | 0.0 | 65 | 64.7 | 0.0 | 0.0 | 65 | 82 | 82 |
| 38 | 3 | 13 | 2 | 87 | 0 | 0 | 10 | 10 | 9.7 | 56.5 | 0.0 | 66 | 9.7 | 56.5 | 0.0 | 66 | 83 | 83 |
| 39 | 3 | 10 | 2 | 90 | 0 | 0 | 2 | 2 | 7.1 | 55.9 | 0.0 | 63 | 7.1 | 55.9 | 0.0 | 63 | 80 | 80 |
| 40 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 61.8 | 0.0 | 0.0 | 62 | 61.8 | 0.0 | 0.0 | 62 | 80 | 80 |
| 41 | 3 | 3 | 2 | 97 | 0 | 0 | 2 | 2 | 1.9 | 60.2 | 0.0 | 62 | 1.9 | 60.2 | 0.0 | 62 | 80 | 80 |
| 42 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 61.8 | 0.0 | 0.0 | 62 | 61.8 | 0.0 | 0.0 | 62 | 80 | 80 |
| 43 | 2 | 100 | 0 | 0 | 0 | 0 | 5 | 5 | 62.9 | 0.0 | 0.0 | 63 | 62.9 | 0.0 | 0.0 | 63 | 80 | 80 |
| 44 * | - | - | - | - | - | - | 100 | 100 | - | - | - | 100 | - | - | - | 100 | 100 | 100 |
| 45 | 3 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 75.0 | 0.0 | 0.0 | 75 | 75.0 | 0.0 | 0.0 | 75 | 88 | 88 |
| 46 | 3 | 24 | 3 | 46 | 2 | 31 | 4 | 4 | 17.9 | 34.5 | 19.2 | 71 | 17.9 | 34.5 | 19.2 | 71 | 86 | 86 |
| 47 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 85 | 61.8 | 0.0 | 0.0 | 62 | 91.7 | 0.0 | 0.0 | 92 | 80 | 97 |
| 48 | 3 | 23 | 2 | 77 | 0 | 0 | 2 | 61 | 17.2 | 47.6 | 0.0 | 65 | 20.3 | 64.0 | 0.0 | 84 | 82 | 93 |
| 49 | 3 | 26 | 2 | 45 | 3 | 28 | 2 | 44 | 19.8 | 28.0 | 21.3 | 69 | 22.3 | 34.8 | 24.0 | 81 | 84 | 92 |
| 50 | 2 | 4 | 3 | 27 | 3 | 69 | 2 | 65 | 2.6 | 20.2 | 51.7 | 74 | 3.5 | 24.1 | 61.7 | 89 | 87 | 96 |
| 51 | 3 | 60 | 3 | 40 | 0 | 0 | 2 | 75 | 44.9 | 30.1 | 0.0 | 75 | 55.0 | 36.8 | 0.0 | 92 | 88 | 97 |
| 52 | 3 | 18 | 3 | 82 | 0 | 0 | 2 | 73 | 13.3 | 61.7 | 0.0 | 75 | 16.2 | 75.1 | 0.0 | 91 | 88 | 96 |
| 53 | 3 | 18 | 1 | 47 | 2 | 35 | 2 | 85 | 13.2 | 19.0 | 21.7 | 54 | 16.5 | 43.4 | 32.1 | 92 | 73 | 97 |
| 54 | 1 | 72 | 2 | 28 | 0 | 0 | 2 | 44 | 29.0 | 17.0 | 0.0 | 46 | 55.7 | 21.2 | 0.0 | 77 | 66 | 89 |
| 55 | 2 | 25 | 1 | 75 | 0 | 0 | 2 | 64 | 15.5 | 30.0 | 0.0 | 45 | 21.0 | 63.1 | 0.0 | 84 | 65 | 93 |
| 56 | 2 | 40 | 1 | 60 | 0 | 0 | 2 | 85 | 24.7 | 24.0 | 0.0 | 49 | 36.7 | 55.0 | 0.0 | 92 | 69 | 97 |
| 57 | 2 | 73 | 1 | 27 | 0 | 0 | 2 | 85 | 44.9 | 10.9 | 0.0 | 56 | 66.7 | 25.0 | 0.0 | 92 | 75 | 97 |
| 58 | 2 | 50 | 1 | 50 | 0 | 0 | 2 | 85 | 30.9 | 20.0 | 0.0 | 51 | 45.8 | 45.8 | 0.0 | 92 | 71 | 97 |
| 59 | 2 | 59 | 1 | 41 | 0 | 0 | 2 | 85 | 36.3 | 16.5 | 0.0 | 53 | 53.8 | 37.9 | 0.0 | 92 | 72 | 97 |
| 60 | 2 | 35 | 1 | 65 | 0 | 0 | 2 | 85 | 21.6 | 26.0 | 0.0 | 48 | 32.1 | 59.6 | 0.0 | 92 | 68 | 97 |
| 61 | 1 | 50 | 2 | 50 | 0 | 0 | 2 | 85 | 20.0 | 30.9 | 0.0 | 51 | 45.8 | 45.8 | 0.0 | 92 | 71 | 97 |
| 62 | 1 | 25 | 2 | 75 | 0 | 0 | 2 | 85 | 10.0 | 46.4 | 0.0 | 56 | 22.9 | 68.8 | 0.0 | 92 | 75 | 97 |
| 63 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 44 | 61.8 | 0.0 | 0.0 | 62 | 76.9 | 0.0 | 0.0 | 77 | 80 | 89 |
| 64 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 44 | 61.8 | 0.0 | 0.0 | 62 | 76.9 | 0.0 | 0.0 | 77 | 80 | 89 |
| 65 | 3 | 7 | 2 | 93 | 0 | 0 | 2 | 31 | 5.5 | 57.2 | 0.0 | 63 | 6.0 | 66.9 | 0.0 | 73 | 80 | 87 |
| 66 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 61.8 | 0.0 | 0.0 | 62 | 61.8 | 0.0 | 0.0 | 62 | 80 | 80 |
| 67 | 2 | 100 | 0 | 0 | 0 | 0 | 2 | 2 | 61.8 | 0.0 | 0.0 | 62 | 61.8 | 0.0 | 0.0 | 62 | 80 | 80 |
| 68 | 2 | 100 | 0 | 0 | 0 | 0 | 45 | 45 | 77.3 | 0.0 | 0.0 | 77 | 77.3 | 0.0 | 0.0 | 77 | 89 | 89 |
| 69 | 2 | 100 | 0 | 0 | 0 | 0 | 20 | 20 | 68.3 | 0.0 | 0.0 | 68 | 68.3 | 0.0 | 0.0 | 68 | 84 | 84 |
| 70 ** | - | - | - | - | - | - | 100 | 100 | - | - | - | 100 | - | - | - | 100 | 100 | 100 |
| 71 | 2 | 100 | 0 | 0 | 0 | 0 | 60 | 60 | 82.7 | 0.0 | 0.0 | 83 | 82.7 | 0.0 | 0.0 | 83 | 93 | 93 |

* McRae Reservoir
** Big Johnson Reservoir

24-hour storm was modeled in the Little Johnson/Security Creek study, however, the 2-hour storm was not. As part of this study the 2-hour storm distribution was applied to the Little Johnson/Security Creek basin hydrologic model, for both existing and future drainage basin conditions. The 2-hour storm was found to control, however, the variance from the 24-hour storm as presented in the Little Johnson/Security Creek basin study is less than ten percent.

A summary of peak flow rates for the 2-hour and 24-hour storms are shown on Table 2.

Table 2. Comparison of 2-Hour and 24-Hour Storm for Regional Basins.

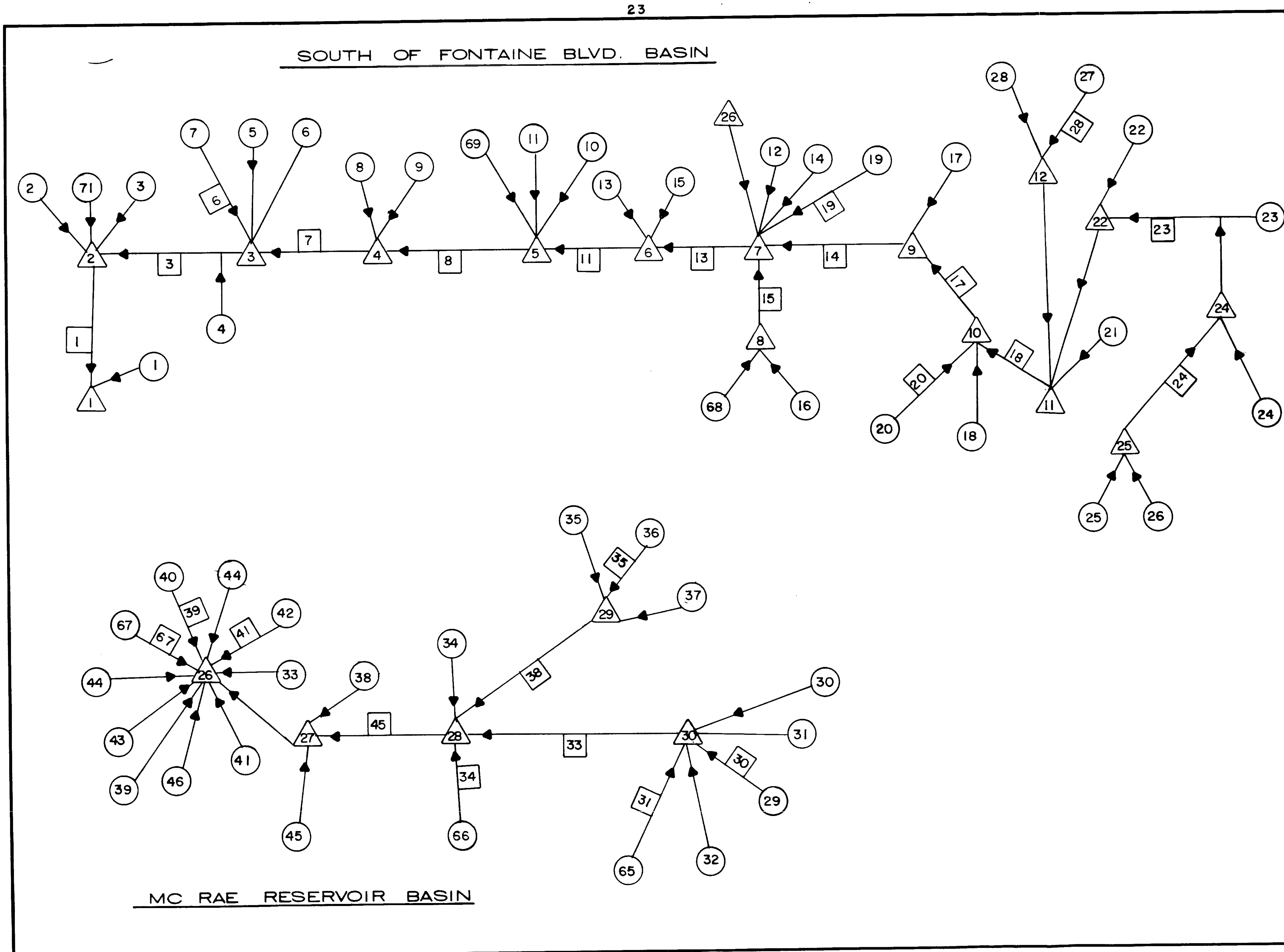
| Design Point | Location Description | | Future Condition 24-Hour Storm 100-Yr. | 24-Hour Storm 10-Yr. | 2-Hour Storm 100-Yr. | 2-Hour Storm 10-Yr. |
|---|---|---|---|---|---|---|
| 31 | Big Johnson Basin | Peak Flow (CFS) | 4850 | 2790 | 4340 | 2510 |
| | | Peak Volume (AF) | 570 | 340 | 440 | 260 |
| 26* | McRae Basin | Peak Flow (CFS) | 1360 | 440 | 1700 | 580 |
| | | Peak Volume (AF) | 130 | 50 | 130 | 60 |
| 3* | Above Confluence of Security Creek and Crews Gulch | Peak Flow (CFS) | 3550 | 1370 | 3850 | 1510 |
| | | Peak Volume (AF) | 310 | 150 | 290 | 150 |

* Big Johnson Basin was assumed to be hydrologically unconnected to the basins lying below Big Johnson Reservoir.

Results

The results of the hydrologic analysis have been presented in several formats. A basin hydrologic map which contains the basin boundary, channel routing scheme, sub-basin locations, and design points is shown in Figure 3 (See Map Pocket). A TR-20 flow diagram for each of the three major regional basins are shown on Figures 6 and 7. A summary of flow rates for all the sub-basins and design points is shown in Table 3. Selected regional basin hydrographs for the existing and future basin conditions for both 2-hour duration 10- and 100-year storms are shown in Figures 8 through 13. Hydrographs for the 24-hour storm are included in the Technical Addendum. A Technical Addendum with the TR-20 computer program input and output is on file with the El Paso County Department of Public Works.

The results of the hydrologic analysis show that the impact of urban development in the basin will be to increase peak flow rates and volumes being conveyed by the major drainageways. Natural storage at McRae Reservoir was not accounted for in the routing model. No hydrologic connection was made between the Big Johnson Basin(s) and the lower tributary areas.

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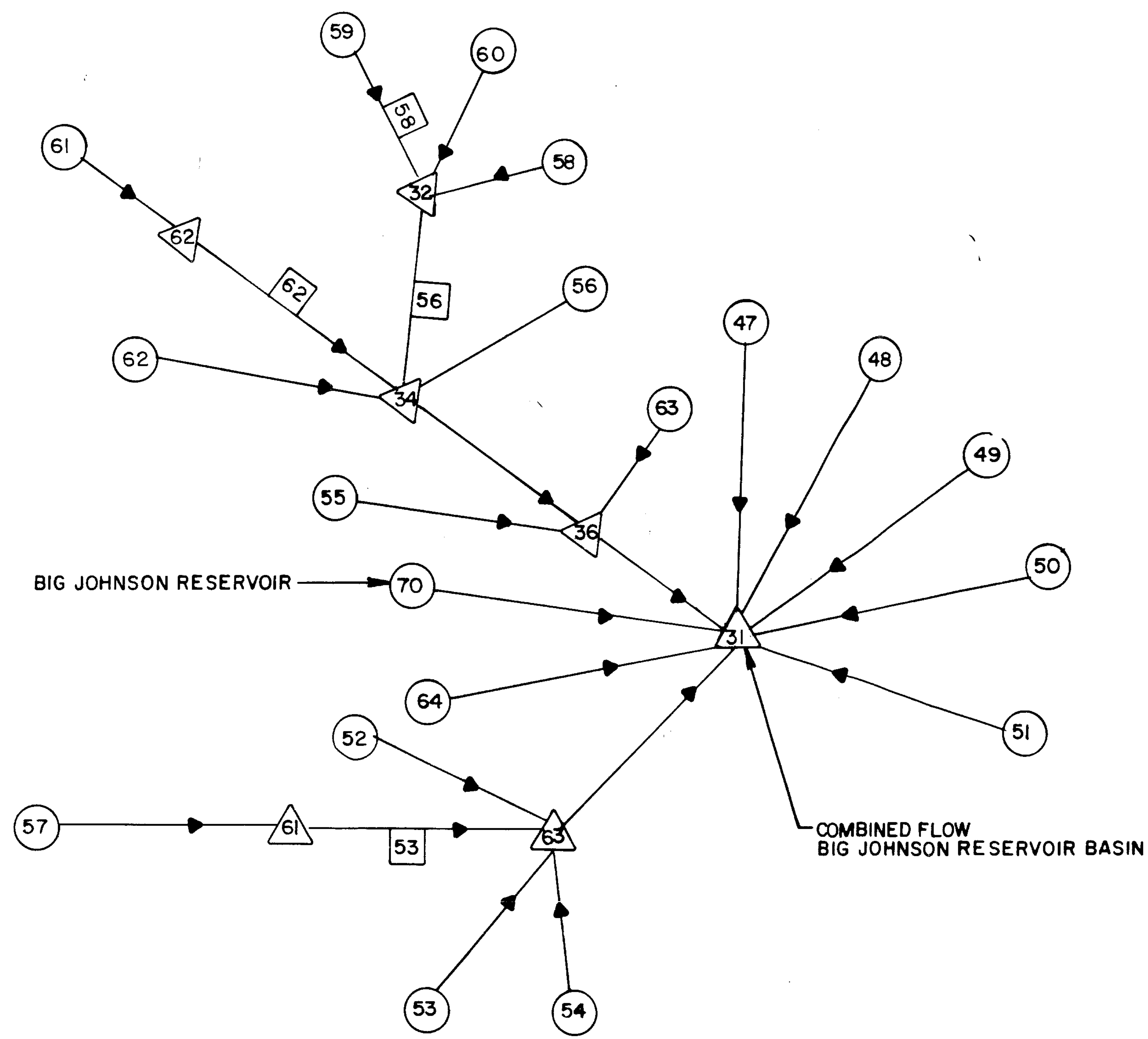
BIGJOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN PLANNING STUDY

TR-20 SCHEMATIC DIAGRAM

| | |
|---|---|
| Project No. | 88.05.09 |
| Date: | 12/88 |
| Design: | JYC |
| Drawn: | EAK |
| Check: | RNW |
| Revisions: | |

FIGURE 6

## BIG JOHNSON RESERVOIR BASIN

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80905-1308

BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY

TR-20 SCHEMATIC DIAGRAM

| | |
|---|---|
| Project No. | 88.06.05 |
| Date: | 12/88 |
| Design: | JYC |
| Drawn: | EAK |
| Check: | |
| Revisions: | |

7

KIOWA ENGINEERING CORPORATION BIG JOHNSON HYDROLOGY

DATE: 25-Apr-91 TIME: 01:12 PM

TABLE 3
SUMMARY OF PEAK DISCHARGES (CFS) (1)

| | | EXISTING CONDITION | | | | FUTURE CONDITION (1) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 24 HOUR STORM | | 2 HOUR STORM | | 24 HOUR STORM | | 2 HOUR STORM | |
| DESIGN POINT | DRAINAGE AREA (SQ MI) | 100 YR. | 10 YR. | 100 YR. | 10 YR. | 100 YR. | 10 YR. | 100 YR. | 10 YR. |
| 1* | 2.37 | 4398 | 1742 | 4881 | 1983 | 3676 | 1372 | 3989 | 1524 |
| 2* | 2.35 | 4400 | 1771 | 4866 | 1984 | 3656 | 1379 | 3971 | 1528 |
| 3* | 2.29 | 4374 | 1780 | 4814 | 1966 | 3554 | 1372 | 3853 | 1508 |
| 4 | 2.24 | 1503 | 464 | 1962 | 664 | 2471 | 842 | 2770 | 979 |
| 5 | 2.20 | 1456 | 444 | 1930 | 653 | 2412 | 834 | 2713 | 966 |
| 6 | 2.17 | 1428 | 433 | 1903 | 644 | 2379 | 827 | 2678 | 956 |
| 7 | 2.14 | 1391 | 428 | 1874 | 635 | 2331 | 818 | 2631 | 946 |
| 8 | 0.07 | 145 | 70 | 141 | 69 | 145 | 70 | 141 | 69 |
| 9 | 0.47 | 469 | 172 | 566 | 196 | 885 | 422 | 875 | 390 |
| 10 | 0.45 | 426 | 145 | 524 | 186 | 843 | 408 | 838 | 377 |
| 11 | 0.37 | 350 | 114 | 440 | 147 | 727 | 361 | 699 | 331 |
| 12 | 0.15 | 110 | 27 | 151 | 45 | 331 | 178 | 299 | 150 |
| 13 | 0.15 | 198 | 81 | 223 | 95 | 259 | 119 | 268 | 125 |
| 24 | 0.09 | 104 | 39 | 121 | 47 | 129 | 54 | 141 | 59 |
| 25 | 0.08 | 90 | 33 | 105 | 39 | 116 | 49 | 125 | 51 |
| 26 | 1.56 | 946 | 282 | 1324 | 450 | 1356 | 437 | 1692 | 577 |
| 27 | 0.87 | 557 | 177 | 754 | 262 | 880 | 318 | 1056 | 383 |
| 28 | 0.78 | 509 | 168 | 682 | 237 | 820 | 303 | 974 | 357 |
| 29 | 0.11 | 72 | 21 | 97 | 33 | 72 | 21 | 97 | 33 |
| 30 | 0.46 | 341 | 116 | 427 | 154 | 600 | 239 | 657 | 266 |
| 31 | 3.07 | 795 | 307 | 1351 | 503 | 4851 | 2786 | 4337 | 2510 ** |
| 32 | 0.79 | 85 | 5 | 295 | 73 | 2140 | 1300 | 2070 | 1070 ** |
| 34 | 1.33 | 146 | 14 | 483 | 122 | 1511 | 914 | 1397 | 836 ** |
| 36 | 1.66 | 200 | 27 | 604 | 151 | 2227 | 1281 | 2118 | 1215 ** |
| 61 | 0.07 | 25 | 4 | 44 | 11 | 220 | 130 | 210 | 125 |
| 62 | 0.08 | 22 | 1 | 48 | 9 | 270 | 170 | 250 | 160 |
| 63 | 0.61 | 221 | 71 | 349 | 98 | 1499 | 873 | 1404 | 799 ** |

* - Includes flow from Little Johnson/Security Creek Basin

(1) - Reference Table 14, Chapter VII, for design flows for selected plan.

**- Peak flow rates from Colorado Springs Airport property assumed to be detained to historic conditions.

TABLE 3 (Continued)
SUMMARY OF PEAK DISCHARGES (CFS)

| BASIN NUMBER | DRAINAGE AREA (SQ MI) | ** EXISTING CONDITION ** 24 HOUR STORM 100 YR. | 10 YR. | 2 HOUR STORM 100 YR. | 10 YR. | ** FUTURE CONDITION ** 24 HOUR STORM 100 YR. | 10 YR. | 2 HOUR STORM 100 YR. | 10 YR. |
|---|---|---|---|---|---|---|---|---|---|
| 36 | 0.02 | 21 | 6 | 27 | 10 | 21 | 6 | 27 | 10 |
| 37 | 0.07 | 44 | 14 | 62 | 21 | 44 | 14 | 62 | 21 |
| 38 | 0.08 | 61 | 20 | 80 | 28 | 61 | 20 | 80 | 28 |
| 39 | 0.03 | 27 | 7 | 35 | 11 | 21 | 6 | 26 | 10 |
| 40 | 0.03 | 28 | 8 | 36 | 12 | 28 | 8 | 36 | 12 |
| 41 | 0.02 | 18 | 5 | 24 | 8 | 18 | 5 | 24 | 8 |
| 42 | 0.01 | 11 | 3 | 14 | 5 | 11 | 3 | 14 | 6 |
| 43 | 0.05 | 44 | 13 | 57 | 19 | 44 | 13 | 57 | 19 |
| 44 | 0.02 | 56 | 37 | 46 | 28 | 56 | 37 | 46 | 28 |
| 45 | 0.01 | 24 | 12 | 26 | 14 | 24 | 12 | 26 | 14 |
| 46 | 0.03 | 57 | 25 | 60 | 30 | 62 | 28 | 67 | 35 |
| 47 | 0.05 | 59 | 18 | 70 | 24 | 176 | 110 | 180 | 116 |
| 48 | 0.13 | 144 | 48 | 179 | 67 | 406 | 230 | 439 | 273 |
| 49 | 0.04 | 63 | 25 | 70 | 29 | 108 | 57 | 112 | 64 |
| 50 | 0.04 | 78 | 35 | 81 | 39 | 132 | 79 | 136 | 84 |
| 51 | 0.03 | 63 | 29 | 62 | 33 | 106 | 66 | 108 | 69 |
| 52 | 0.11 | 156 | 68 | 167 | 72 | 361 | 220 | 359 | 223 |
| 53 | 0.31 | 78 | 8 | 166 | 40 | 914 | 553 | 836 | 510 |
| 54 | 0.12 | 9 | 0 | 42 | 8 | 234 | 111 | 249 | 122 |
| 55 | 0.26 | 26 | 1 | 97 | 19 | 606 | 329 | 605 | 334 |
| 56 | 0.22 | 32 | 1 | 94 | 20 | 699 | 427 | 661 | 397 |
| 57 | 0.07 | 25 | 4 | 44 | 11 | 220 | 134 | 209 | 125 |
| 58 | 0.18 | 24 | 2 | 73 | 18 | 505 | 305 | 445 | 256 |
| 59 | 0.17 | 29 | 3 | 75 | 19 | 467 | 281 | 416 | 237 |
| 60 | 0.44 | 52 | 2 | 176 | 37 | 1323 | 803 | 1238 | 740 |
| 61 | 0.08 | 22 | 1 | 48 | 9 | 270 | 166 | 252 | 162 |
| 62 | 0.24 | 92 | 13 | 159 | 39 | 753 | 460 | 716 | 430 |
| 63 | 0.07 | 64 | 18 | 82 | 25 | 130 | 63 | 136 | 66 |
| 64 | 0.11 | 50 | 13 | 80 | 25 | 188 | 87 | 195 | 88 |
| 65 | 0.17 | 128 | 36 | 175 | 56 | 292 | 127 | 321 | 146 |
| 66 | 0.08 | 50 | 13 | 70 | 22 | 75 | 22 | 97 | 33 |
| 67 | 0.43 | 252 | 66 | 370 | 114 | 252 | 66 | 370 | 114 |
| 68 | 0.03 | 72 | 35 | 74 | 40 | 72 | 35 | 74 | 40 |
| 69 | 0.01 | 13 | 5 | 15 | 6 | 13 | 5 | 15 | 6 |
| 70 | 0.40 | 401 | 268 | 356 | 215 | 401 | 268 | 356 | 215 |
| 71 | 0.01 | 29 | 16 | 31 | 19 | 29 | 16 | 31 | 19 |
| ** 72 | 0.08 | 70 | 21 | 90 | 29 | 148 | 73 | 152 | 75 |

** - Flows in excess of the 5-year storm runoff pass to the Widefield Basin.

TABLE 3 (Continued)
SUMMARY OF PEAK DISCHARGES (CFS)

| BASIN | DRAINAGE | ** EXISTING CONDITION ** | | | | ** FUTURE CONDITION ** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 24 HOUR STORM | | 2 HOUR STORM | | 24 HOUR STORM | | 2 HOUR STORM | |
| NUMBER | AREA (SQ MI) | 100 YR. | 10 YR. | 100 YR. | 10 YR. | 100 YR. | 10 YR. | 100 YR. | 10 YR. |
| 1 | 0.02 | 30 | 10 | 34 | 16 | 30 | 10 | 34 | 16 |
| 2 | 0.01 | 27 | 15 | 29 | 17 | 27 | 15 | 29 | 17 |
| 3 | 0.03 | 66 | 31 | 73 | 39 | 102 | 61 | 109 | 70 |
| 4 | 0.01 | 8 | 2 | 11 | 3 | 8 | 2 | 11 | 3 |
| 5 | 0.01 | 11 | 4 | 13 | 5 | 34 | 21 | 33 | 21 |
| 6 | 0.03 | 53 | 25 | 55 | 25 | 52 | 24 | 54 | 24 |
| 7 | 0.01 | 10 | 3 | 13 | 4 | 10 | 3 | 13 | 4 |
| 8 | 0.01 | 11 | 3 | 13 | 5 | 11 | 3 | 13 | 5 |
| 9 | 0.03 | 64 | 31 | 66 | 32 | 64 | 31 | 66 | 32 |
| 10 | 0.01 | 18 | 8 | 19 | 8 | 18 | 8 | 19 | 8 |
| 11 | 0.01 | 9 | 3 | 11 | 4 | 9 | 3 | 11 | 4 |
| 12 | 0.02 | 60 | 35 | 58 | 34 | 60 | 35 | 58 | 34 |
| 13 | 0.02 | 37 | 17 | 40 | 19 | 37 | 17 | 40 | 19 |
| 14 | 0.01 | 24 | 12 | 25 | 14 | 24 | 12 | 25 | 14 |
| 15 | 0.01 | 15 | 6 | 16 | 7 | 15 | 6 | 16 | 7 |
| 16 | 0.04 | 79 | 39 | 81 | 40 | 79 | 39 | 81 | 41 |
| 17 | 0.02 | 56 | 31 | 59 | 35 | 56 | 31 | 59 | 35 |
| 18 | 0.05 | 107 | 50 | 103 | 57 | 107 | 50 | 103 | 57 |
| 19 | 0.01 | 16 | 6 | 18 | 8 | 16 | 6 | 18 | 8 |
| 20 | 0.03 | 71 | 36 | 70 | 39 | 71 | 36 | 70 | 39 |
| 21 | 0.07 | 66 | 20 | 84 | 27 | 154 | 81 | 155 | 83 |
| 22 | 0.02 | 19 | 6 | 24 | 8 | 58 | 33 | 59 | 35 |
| 23 | 0.04 | 81 | 38 | 85 | 42 | 81 | 38 | 85 | 42 |
| 24 | 0.01 | 18 | 8 | 19 | 8 | 18 | 8 | 19 | 4 |
| 25 | 0.05 | 70 | 28 | 79 | 33 | 70 | 28 | 79 | 33 |
| 26 | 0.03 | 22 | 6 | 30 | 10 | 47 | 21 | 49 | 22 |
| 27 | 0.09 | 75 | 20 | 97 | 31 | 259 | 156 | 235 | 140 |
| 28 | 0.06 | 45 | 13 | 62 | 20 | 112 | 51 | 121 | 57 |
| 29 | 0.09 | 132 | 55 | 150 | 65 | 177 | 82 | 188 | 91 |
| 30 | 0.06 | 56 | 23 | 64 | 26 | 84 | 36 | 91 | 39 |
| 31 | 0.11 | 71 | 25 | 97 | 36 | 89 | 32 | 113 | 42 |
| 32 | 0.03 | 48 | 21 | 53 | 24 | 55 | 24 | 59 | 26 |
| 33 | 0.08 | 85 | 31 | 101 | 38 | 109 | 43 | 126 | 53 |
| 34 | 0.13 | 83 | 29 | 114 | 41 | 137 | 49 | 165 | 62 |
| 35 | 0.02 | 24 | 8 | 29 | 11 | 24 | 8 | 29 | 11 |

# BIG JOHNSON RESERVOIR RUNOFF HYDROGRAPH

## 10 YEAR STORM (DESIGN POINT 31)

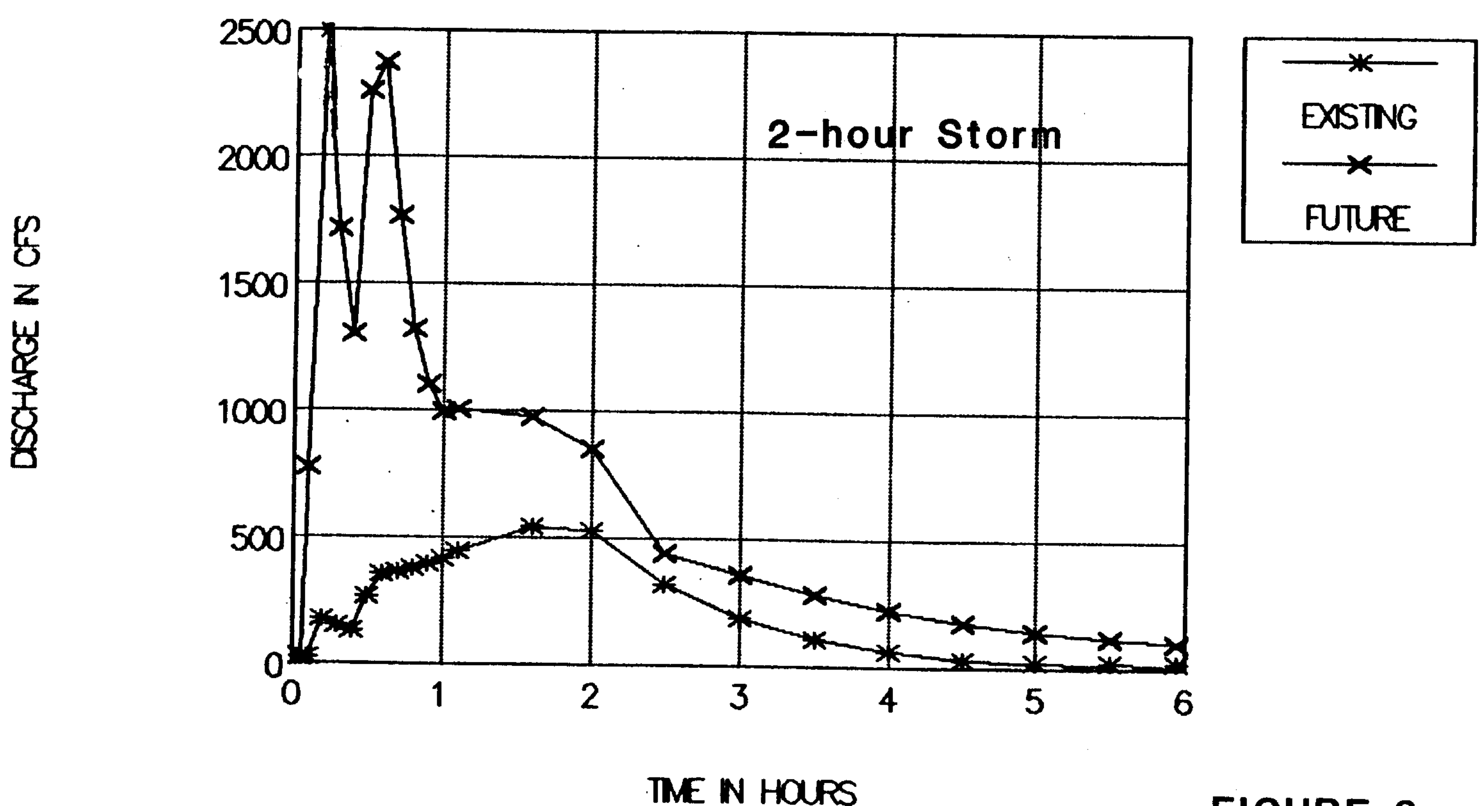



**FIGURE 8**

# BIG JOHNSON RESERVOIR RUNOFF HYDROGRAPH

# 100 YEAR STORM (DESIGN POINT 31)

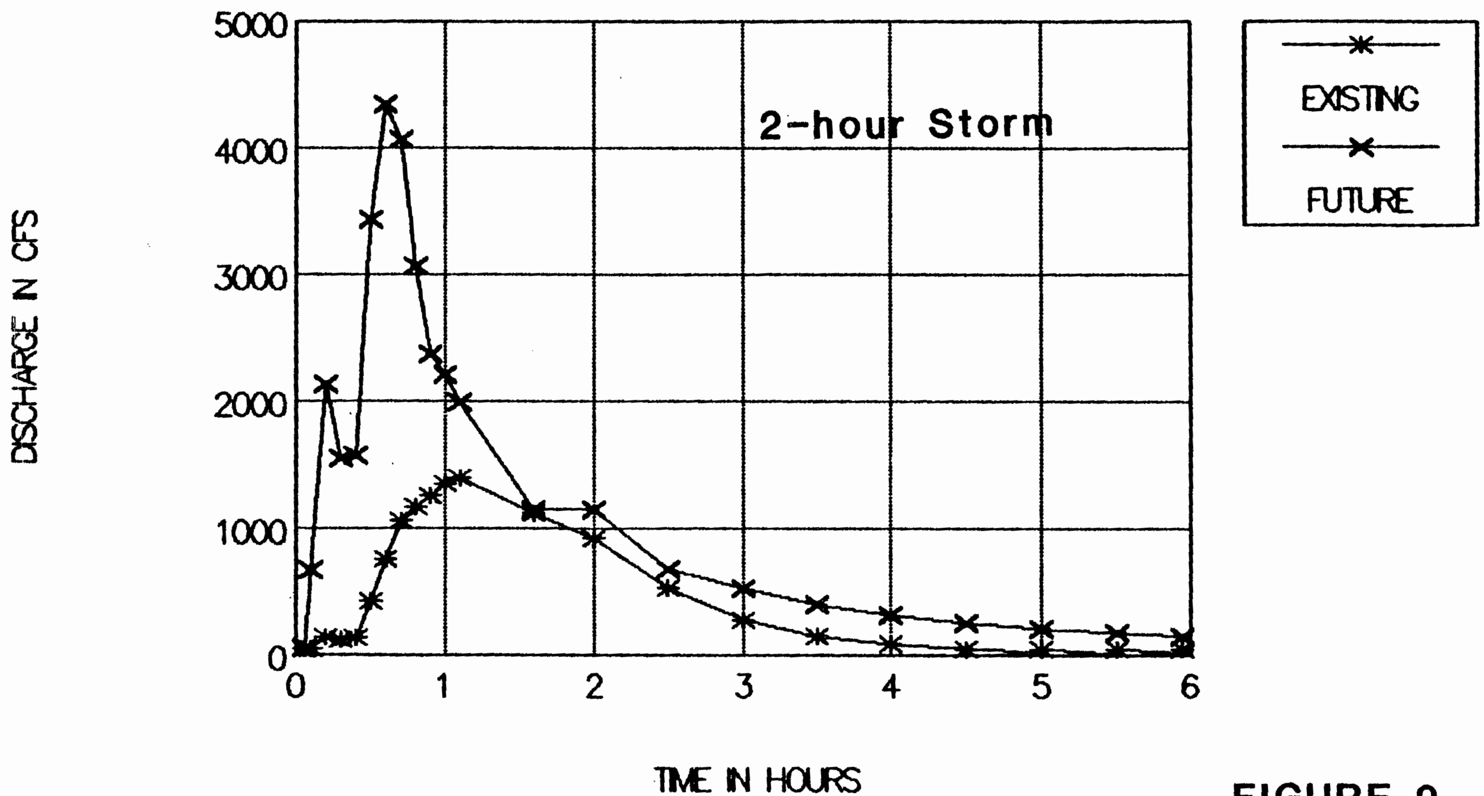



FIGURE 9

# McRAE RESERVOIR RUNOFF HYDROGRAPH

## 10 YEAR STORM (DESIGN POINT 26)

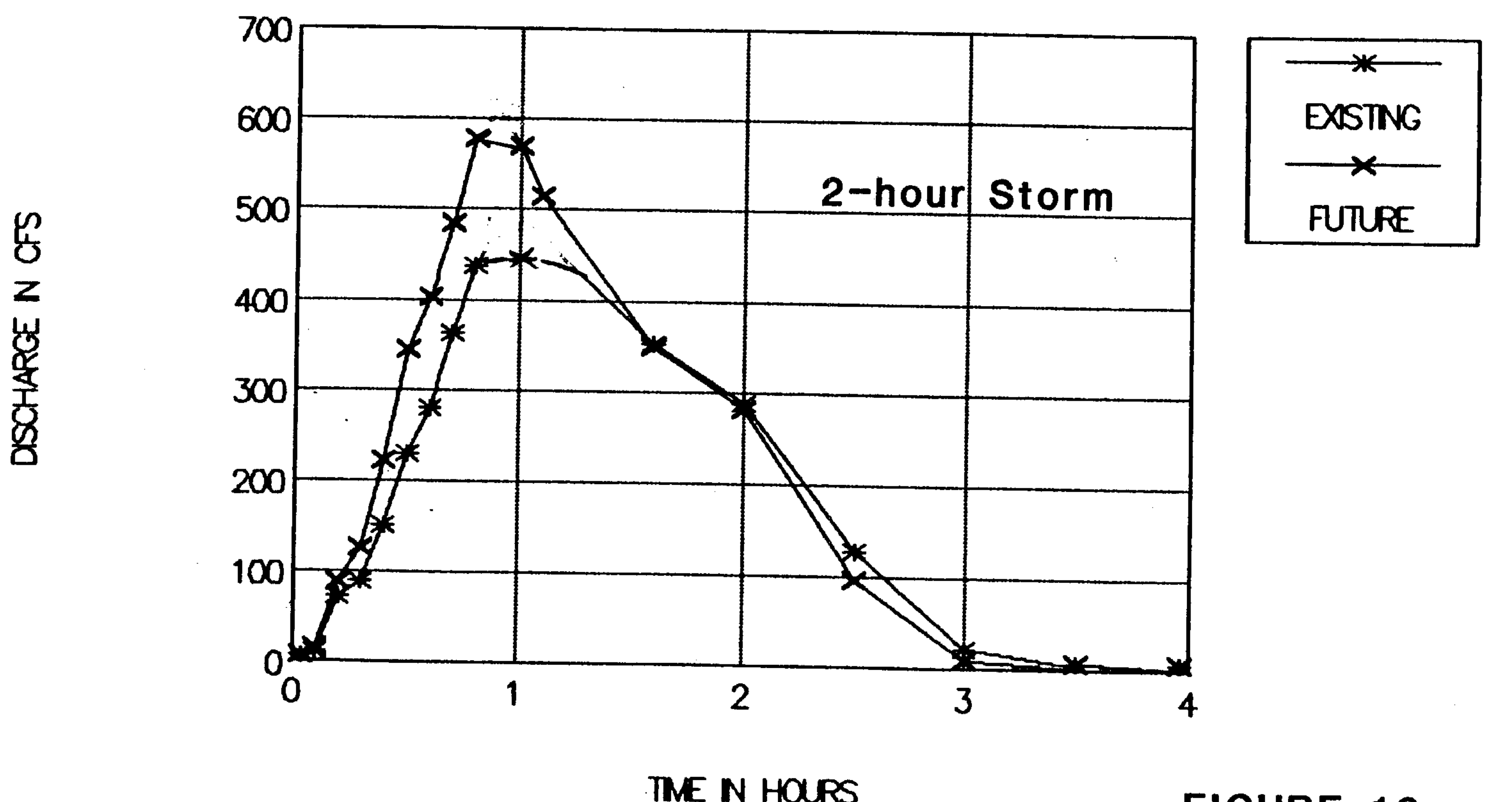



**FIGURE 10**

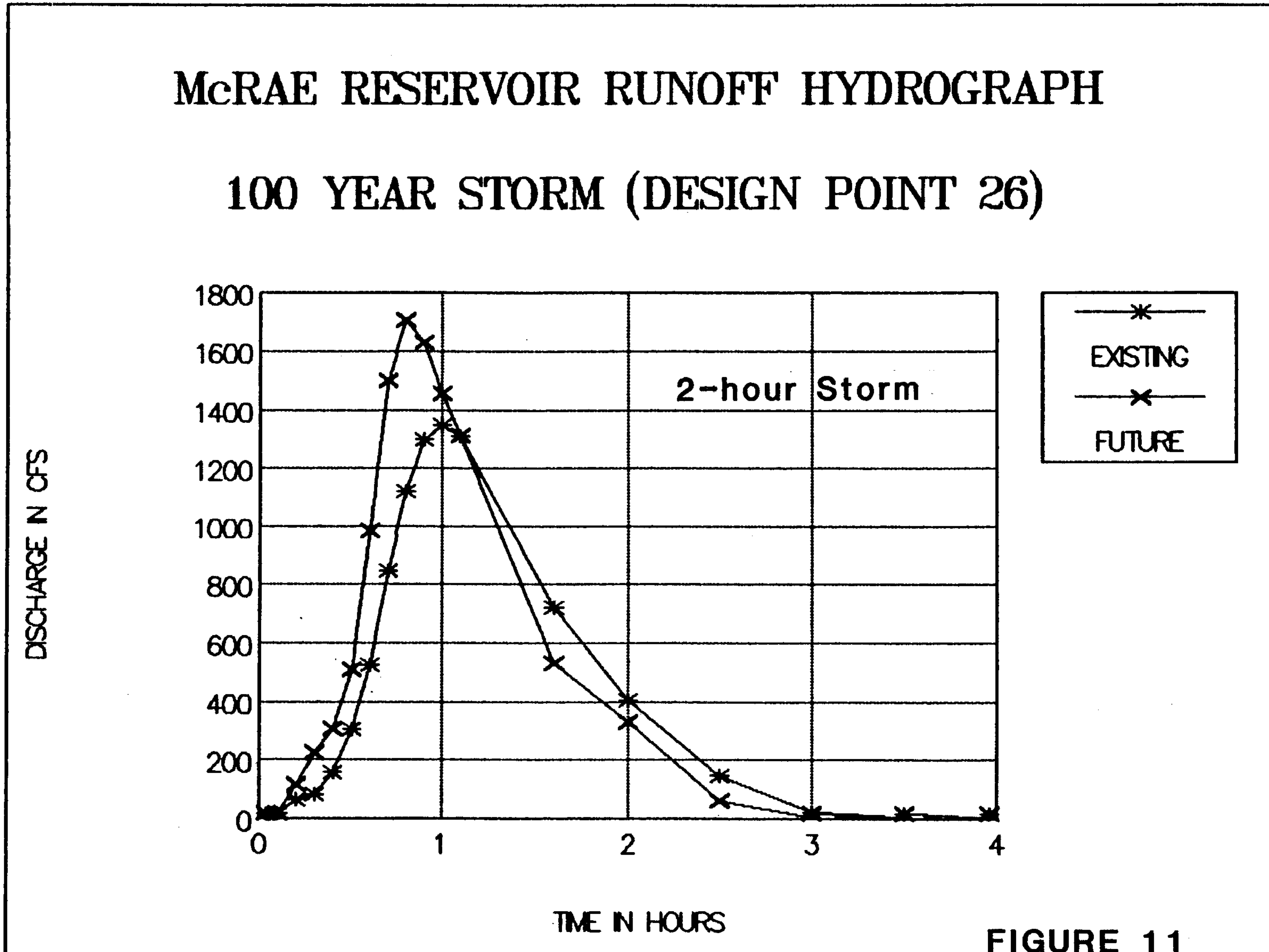

MCRAE RESERVOIR RUNOFF HYDROGRAPH
100 YEAR STORM (DESIGN POINT 26)
DISCHARGE IN CFS
0
200
400
600
800
1000
1200
1400
1600
1800
TIME IN HOURS
0
1
2
3
4
2-hour Storm
EXISTING
FUTURE

FIGURE 11

# CREWS GULCH & WIDEFIELD BASIN COMBINED

# 10 YR RUNOFF HYDROGRAPH (DESIGN PT 3)

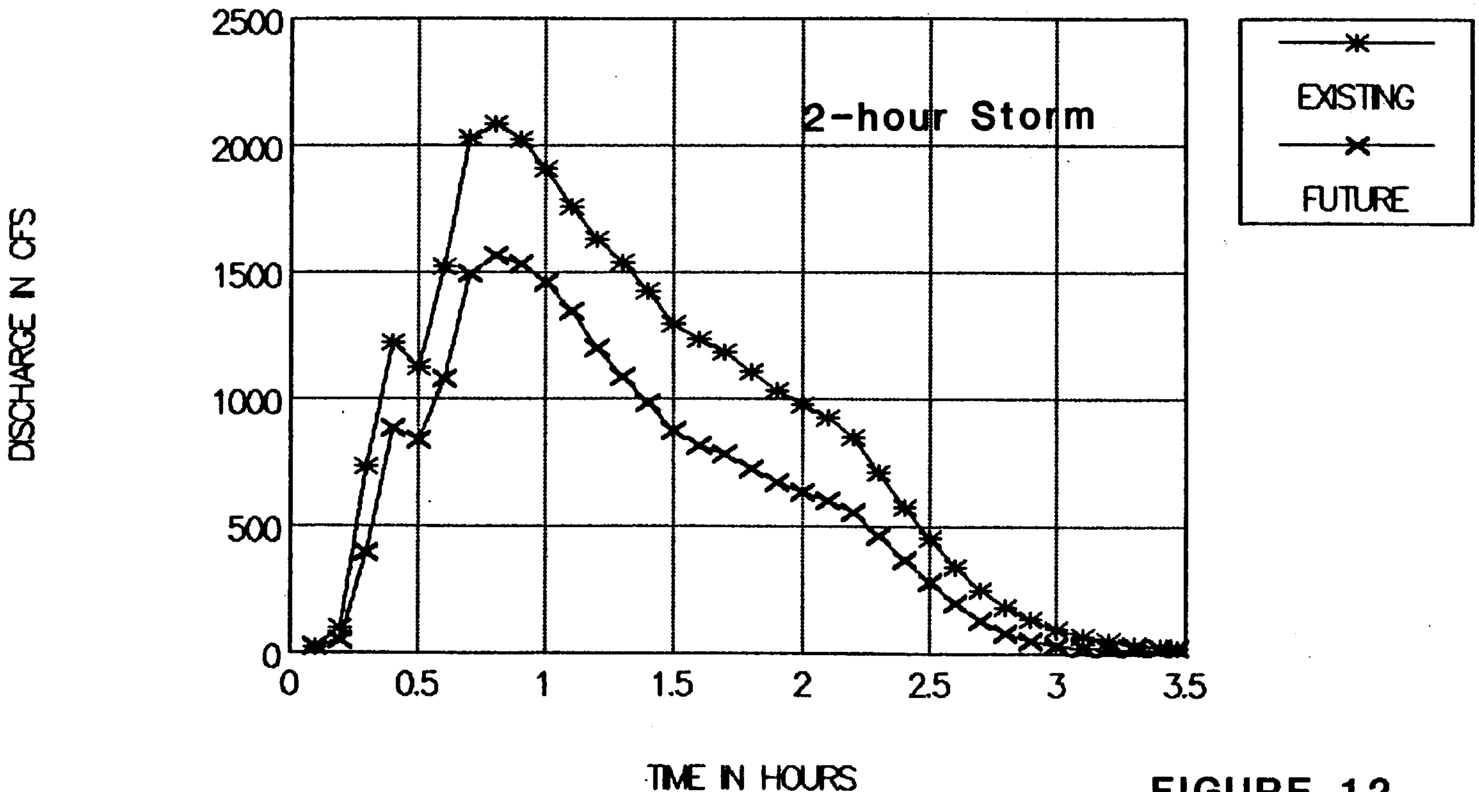



**FIGURE 12**

## V. HYDRAULIC ANALYSIS AND FLOODPLAIN DELINEATION

A hydraulic analysis along the major drainageways was conducted to establish the flow capacities of existing structures, and to identify areas of flooding. The major drainageways were divided into reaches in order to better organize the planning effort. Presented on Table 4 are the stream reaches. The reaches were selected based upon their particular drainageway characteristics and/or problems. Brief descriptions of each reach are included.

### Structure Inventory

As part of the hydraulic evaluation, the existing major drainageway facilities were inspected in the field. Measurements of bridges, culverts, channels, inlets and other storm drainage facilities were taken in order to estimate the capacity of the existing storm drainage system(s). The inventory of structures is presented on Table 5, for bridges, drainageways, and other key drainage features. Capacity estimates of initial systems were made whenever the system could be adequately located in the field.

### Flood History

The Crews Gulch has experienced storm events which have caused the stream to overtop. The most severe event occurred in June of 1965. Heavy rains caused the McRae Reservoir to burst, sending floodwaters along Crews Gulch. The Denver and Rio Grande Western Railroad Bridge, as well as the US 85/87 bridge, were washed out. Shallow flooding of residences occurred near Harvard Street. Several eyewitness accounts were recorded in local newspapers.

Table 4. Reach Descriptions.

| Reach Number | Location | Comments |
|---|---|---|
| 1 | Fountain Creek to Harvard Street | Channel degraded severely downstream of US 85/87. Limited channel capacity within Fountain Creek Regional Park |
| 2 | Harvard Street to Quebec Street | Channel has natural grass overbanks in poor to fair condition. Low flow area degrading. Residential flooding upstream of Harvard. |
| 3 | Quebec Street to Fontaine Boulevard | Mostly park and greenbelt along drainageway. Limited structure encroachment except at Quebec. |
| 3A | Fountain Mesa Tributary | Deep and steep drainageway downstream of Metropolitan. Development pressure in area upstream of Fontaine Blvd. |
| 4 | Fontaine Blvd. to Big Johnson Reservoir | No substantial runoff from urban areas exists. Poorly defined flow paths upstream of McRae. |
| 4A | Grinnell Street Channel | Hard-lined channel conveys flow to McRae. |
| 5 | Big Johnson Reservoir to Study Limit | Poor to moderately defined flow paths. Majority of area within City of Colorado Springs Municipal Airport property. |

# CREWS GULCH & WIDEFIELD BASIN COMBINED

# 100 YR RUNOFF HYDROGRAPH (DESIGN PT 3)

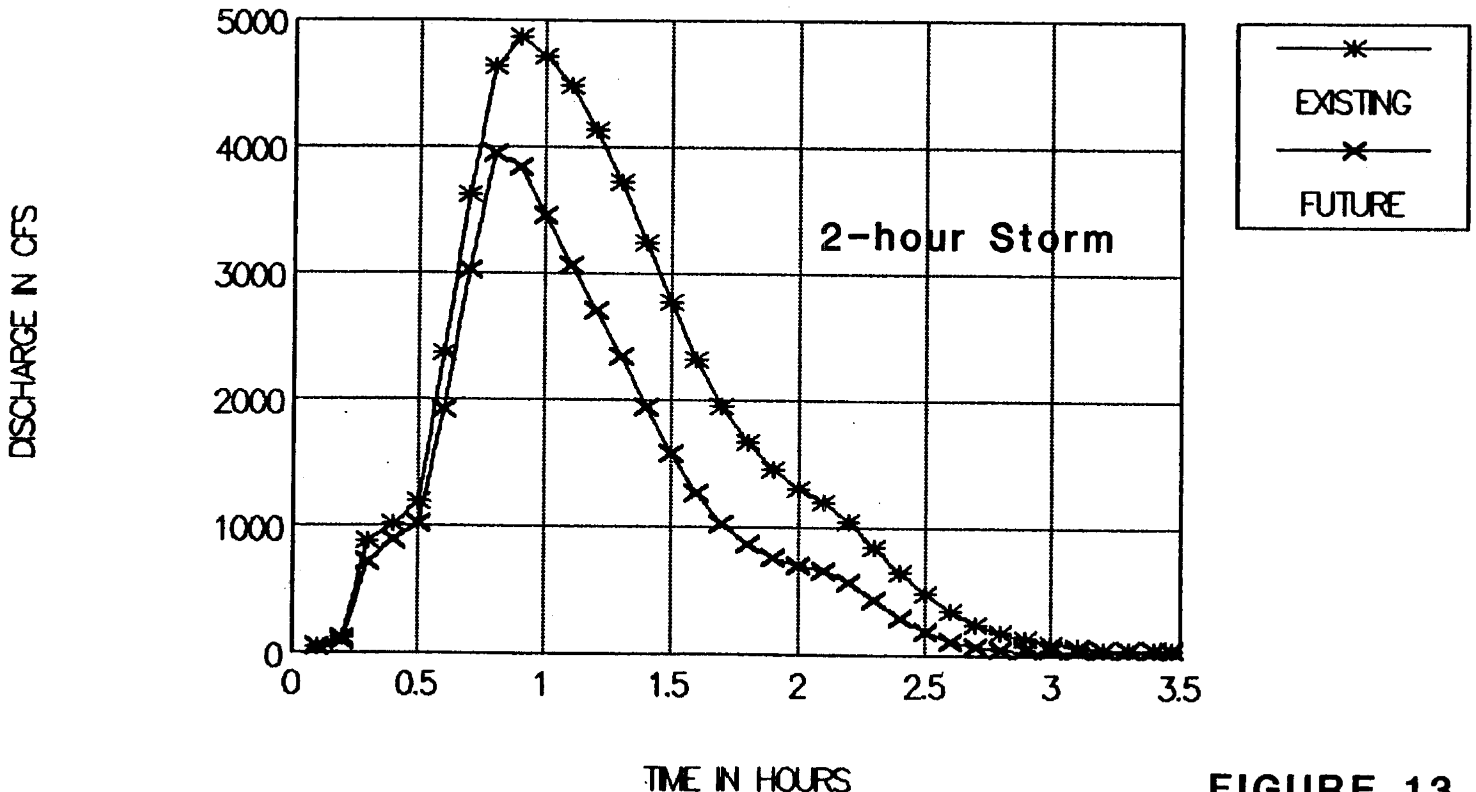



FIGURE 13

TABLE 5

STRUCTURE INVENTORY
ROADWAY CROSSINGS

BIG JOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN PLANNING STUDY

STREAM: CREWS GULCH REACHES 1 -4

| LOCATION | DESCRIPTION | SIZE | CAPACITY (cfs) | GENERAL COMMMENTS |
|---|---|---|---|---|
| STATE HIGHWAY 16 RAMP | CONCRETE BRIDGE | 3-SPAN, 220` 2 PIERS | >100 YR | STRUCTURE IN GOOD CONDITION |
| SOUTHMOOR DRIVE | CONCRETE BOX CULVERT | 13-16-13 8' HEIGHT | 100-YR | BRIDGE RECENTLY REPLACED BY CITY OF FOUNTAIN |
| US 85/87 | CONCRETE BRIDGE | 2-SPAN, 65' 2 PIERS | >100 YR | STREAM DEGRADATION HAS EXPOSED THE STEEL PILES SUPPORTING THE BRIDGE PIERS |
| D & RGW RAILROAD (2) | STEEL BRIDGE | 2-SPAN, 90' 2 PIERS | >100 YR | STREAM DEGRADTION ON DOWNSTREAM SIDE OF BRIDGES. HEAVY DEBRIS BUILDUP IN NEED OF REMOVAL. EXISTING BANK PROTECTION INADEQUATE |
| HARVARD STREET | CONCRETE BOX | FOUR 8' X 4' | 1300 | BANK PROTECTION ON UPSTREAM AND DOWNSTREAM BANKS IN POOR CONDITION. OPENING BLOCKED BY VEGETATION. |
| QUEBEC STREET | CMP | TRIPLE 36" | 140 | STREAM DEGRADATION AND SCOUR AT CULVERT OUTLET UNDERMINING BANKS AND GUNNITE OUTLET PROTECTION |
| FONTAINE BOULEVARD | CMP | TWIN 48" 24" 18" | 350 | OUTLET STRUCTURE INADEQUATE. NO EMERGENCY SPILLWAY. DOWNSTREAM CHANNEL BANK PROTECTION IN POOR CONDITION |

TABLE 5 CONTINUED

STRUCTURE INVENTORY
ROADWAY CROSSINGS

BIG JOHNSON RESERVOIR/CREWS GULCH DRAINAGE BASIN PLANNING STUDY

STREAM: FOUNTAIN MESA TRIBUTARY (REACH 3A)

| LOCATION | DESCRIPTION | SIZE | CAPACITY (cfs) | GENERAL COMMMENTS |
|---|---|---|---|---|
| DRURY LANE | CMPA | TWIN 27"X42" | 100 | SYSTEM PARTIALLY PLUGGED. AUGMENTATION LINE CONNECTED TO SOUTH CULVERT |
| BELLE VISTA | CMP | TRIPLE 36" | 30 | CULVERT PLUGGED |
| METROPOLITAN DRIVE | CMP | TWIN 36" | 100 | UPSTREAM CHANNEL POORLY VEGETATED AND CLOGGED WITH DEBRIS |
| FOUNTAIN MUTUAL CANAL | CONCRETE FLUME | | NA | IRRIGATION CANAL CROSSES FOUNTAIN MESA TRIBUTARY DOWNSTREAM OF METROPOLITAN DRIVE. |
| PACK TRAIN LOOP | - | - | - | PROPOSED ROADWAY |
| FONTAINE BOULEVARD | CMPA | 30"x87" | 70 | CULVERT IN FAIR CONDITION |
| GOLDFIELD DRIVE (PROPOSED) | - | - | - | PROPOSED ROADWAY |
| FONTAINE BLVD & FOUNTAIN MESA RD | CMP | 24" | 30 | PARTIALLY PLUGGED |
| FONTAINE BLVD & GOLDFIELD ROAD | CMP | 24" | 30 | PARTIALLY PLUGGED |

Floodplain Delineation

Using the peak flow data summarized in Section IV, a water surface profile analysis was conducted along the major drainageways. Floodplains were drawn for the Crews Gulch, and for the Fountain Mesa Tributary. The U.S. Army Corps of Engineers (COE) HEC-2 water surface profile program was used to define 100-year floodplains for the existing and future basin conditions. Existing 100-year floodplain and floodway analyses were performed considering no improvements to the major drainageway facilities. Floodplain boundaries have been placed on the preliminary design drawings contained in this report and the technical addendum.

The Federal Emergency Management Agency (FEMA) has a detailed flood insurance study (FIS) for Widefield Creek (a.k.a. Crews Gulch). Peak flow data for this report was obtained using the methods described in Technical Manual No. 1, Procedures for Determining Runoff from Natural Streams in Colorado, published by the U.S. Geological Survey (USGS) in 1976. Since the basin in its existing condition is greatly affected by irrigation canals and reservoirs, the use of TM-1 is somewhat inappropriate. Additionally, the planning effort undertaken requires that a hydrograph method be used, which can more closely simulate urban runoff patterns. A floodway has also been delineated within the FEMA study for El Paso County. Floodplain data which has been prepared for the purposes of evaluating alternative drainage plans will be made available to FEMA for incorporation into the FIS.

Existing Floodplain Description - Crews Gulch

**Reach 1:** In this reach the 100-year floodplain is mainly limited to the existing channel banks. Within the Fountain Creek Regional Park area, the restricted channel cross section downstream of State Highway 16 would cause the existing west pond embankment to be overtopped. Backwater effects from this constriction would cause flood waters to slow and overtop a small berm along the west bank of Crews Gulch, and sending floodwaters west along the State Highway 16 embankment, through Ceresa Park, and into Fountain Creek. Assuming that no embankment failure could occur downstream of State Highway 16, approximately 1,800 cfs could pass into Ceresa Park during a 100-year flood on Crews Gulch.

Heavy bank erosion and potential roadway and utility damages could occur in Reach 1 during a 100-year event. Residential flooding near Harvard Street could also occur. The existing railroad bridge foundations are currently exposed as a result of ongoing stream invert degradation within this portion of Reach 1. Sufficient capacity is available to pass the 100-year flows at all bridges within Reach 1.

**Reach 2:** Because of the restricted culvert at Harvard Street, and insufficient channel capacity for approximately 1,000 feet upstream of Harvard, flood waters would cause inundation of several residences whose rear lot lines abut the drainageway. Some of the houses have basements which would increase the dollar loss due to flooding. Flood depths on the order of one to three feet are anticipated in a 100-year event adjacent to these residences in Reach 2. Quebec Street would be overtopped which would cause some of the flows from Crews Gulch to split and flow within local streets such as Kilgore and Fairfax Streets. Mostly debris damage would be anticipated within Reach 2, and damages to storm sewer outfalls and low-flow channels.

**Reach 3:** This is the reach of Crews Gulch within Widefield Park. The average overbank depth in a 100-year event is between two and three feet, with velocities generally below five feet per second. The existing low-flow channel would be overtopped, and small foot bridges could be washed out. The shallow and low velocity nature of the floodplain within Reach 3 lends itself well to floodplain management and low-flow channel stabilization, as a means of addressing stormwater management within this reach.

**Reach 3A:** The Fountain Mesa Tributary floodplain is shallow in general, with ponding occurring at street crossings. Street flooding could occur at Drury and Belle Vista Lanes, and Metropolitan Drive. Downstream of Metropolitan Drive, the Fountain Mutual Canal crosses the drainageway. Because of the limited irrigation ditch capacity available to intercept stormwater, the majority of the surface flow along the drainageway would pass over the canal. Invert and bank erosion would be the predominant type of flood-resulting damage, with a substantial portion of debris flow outfalling to Widefield Park.

**Reach 4:** The McRae Reservoir, for the purposes of floodplain modelling, was assumed full to the crest of the existing outlet culverts at the time of a 100-year event. This is probably a reasonable assumption in light of the 1965 flood, which was a long duration rainfall event, culminating in the eventual overtopping and failure of the Reservoir embankment. Using this assumption, and survey data collected as part of this study, the location where the McRae Reservoir would overtop was determined. Flood water would overtop in the vicinity of Drury Lane, and would immediately flow into Widefield Park. Damages to the Fontaine Boulevard roadway embankment, park facilities, and local residential flooding could occur. The floodplains depicted on the preliminary design drawings do not reflect areas of potential flooding in the event of a breach in the Reservoir occurring. Should the McRae Reservoir be utilized for stormwater management, an emergency spillway should be provided to better manage an overtopping of McRae.

Upstream of McRae Reservoir, the floodplain is wide and shallow, and little damage would occur in a 100-year runoff.

**Reach 5:** Floodplains have not been delineated for the drainageways above Big Johnson Reservoir. It is anticipated that future development will be required to provide adequate stormwater management facilities to safely convey storm flows in residential and business areas.

Basis of Analysis and Design

In general, the City/County Drainage Criteria Manual was used as a technical guide to the evaluation, and design of existing and future drainage facilities. Summarized on Table 6 is a partial listing of technical criteria used in the evaluation of channels, roadway crossings, and ponds along the major drainageways. A consistent application of these criteria was used for comparing the feasible alternative drainageway plans, and during the preliminary design phase.

Table 6. Summary of Technical Criteria.

| Facility | Criteria | |
|---|---|---|
| Channels | | |
| Grasslined | Maximum Velocity | 5 feet per second |
| | Maximum Flow Depth | 5 feet |
| | Minimum Roughness | .035 |
| | Maximum Radius of Curvature | 200 feet |
| | Design Capacities | 10 yr and 100 yr |
| | Maximum Side Slope | 4H:1V |
| Riprap | Maximum Velocity | 7 feet per second |
| | Maximum Flow Depth | 7 feet |
| | Minimum Roughness (with natural bottom) | .030 - .040 |
| | Design Capacity | 100-year |
| | Maximum Side Slope | 2.5H:1V |
| Low Flow Sections | Maximum Velocity | 5 feet per second |
| | Maximum Flow Depth | 2 feet |
| | Design Capacity | 3% of 100 yr discharge (minimum) |
| | Minimum Roughness | .035 |
| Regional Detention | | |
| | Minimum Surface Area | 5 acres |
| | Maximum Average Depth | 7 feet |
| | Discharge Rates | "Historic" 10 & 100 yr. |
| | Maximum Storage Time | 48 hours |
| | Storm Duration | 24 hours |
| Roadway Crossings | | |
| | Design Capacity | 100-year |
| | Concrete Culvert Roughness | .013 |
| | Corrugated Metal Pipe Roughness | .024 |

# VI. DEVELOPMENT OF ALTERNATIVE PLANS

## Introduction

Alternative drainageway plans have been examined that address the existing and future stormwater management needs of the basin. Alternatives have been identified for each reach of the drainageway on a conceptual level. Quantitative and qualitative comparisons are presented, and a recommendation made as to which plan is most feasible to advance to preliminary design and eventual implementation.

During the alternative analysis, it became evident that the basin had two general characteristics which have influenced the existing drainageway form and function. In the lower Reaches (1 through 3) the drainageways are more typical of an urbanized area, and have a base flow which is mostly irrigation seepage. In the upper Reaches (4 and 5) areas around the existing reservoirs are largely undeveloped. Within Reaches 4 and 5, the drainageways are more indistinct and in the case of Reach 4, very well vegetated.

The general planning goals followed during the alternative plan development phase were:

(1) Identify stormwater facilities which will reduce existing floodplains and flooding problems within urbanized areas;

(2) Provide stormwater management within developing areas of the basin in order to reduce the detrimental effects of runoff from urbanized areas;

(3) Provide stormwater facilities which preserve and/or enhance the existing drainageway and areas adjacent to the drainageway which provide an environmental resource in the area;

(4) Provide for separation of stormwater runoff from irrigation canals;

(5) Identify facilities which will minimize future operations and maintenance costs; and

(6) Provide stormwater management facilities which will at least maintain and/or enhance the water quality characteristics of the basin.

The City/County Drainage Criteria Manual was used to estimate rates of runoff and size facilities. Other planning goals were developed through the coordination process, and common or mutual goals of the interested agencies identified prior to the initiation of the alternative development phase.

Preliminary Matrix of Alternatives

The alternative planning process began with the evaluation of general drainageway planning alternatives. Alternatives which are generally available in the majority of urban drainage basins include:

(1) Do nothing, and/or floodplain regulation,

(2) Channelization,

(3) Detention, on-site or off-site, and

(4) Diversion between sub-basins.

(5) Combinations of the above.

These concepts were evaluated for each reach of the basin. The results are summarized on Table 7. Alternatives ruled out for further consideration were the "do nothing", and the full conveyance of future runoff via improved channels. Both of these alternatives are unfeasible because of the large increase in peak flows due to urbanization and the resulting impact on the existing drainage channels, sensitive habitats, and roadway crossings. The feasibility of regional detention is most evident within Reaches 4 and 5. Since its construction, the Big Johnson Reservoir has acted to maintain flow to the lower basins at very low levels. This flow control in combination with the groundwater recharge the Reservoir provides has resulted in stable drainageways and wetland habitats along Crews Gulch particularly at McRae Reservoir. Regional detention within Reach 5 would benefit the downstream areas through decreased culvert and channel sections, as compared to a full conveyance or undetained scenario. The undetained scenario could cause significant negative impacts to the drainageway areas south of

Table 7: Preliminary Matrix of Alternatives

| REACH | FLOODPLAIN PRESERVATION WITH REGULATION (DO NOTHING) | DETENTION ON-SITE | DETENTION REGIONAL | CHANNELIZATION "SOFT" | CHANNELIZATION "HARD" | DIVERSION |
|---|---|---|---|---|---|---|
| 1. FOUNTAIN CREEK TO HARVARD STREET | DEGRADED CHANNELS & BRIDGES UNABLE TO SAFELY CONVEY EXISTING OR FUTURE FLOWS | TOO LOW IN THE BASIN TO HAVE AN IMPACT ON FLOW REDUCTION | TOO LOW IN THE BASIN TO IMPACT | NATURAL BOTTOMS FEASIBLE WITH GRADE CONTROL AND/ OR LOW FLOW STABILIZATION RIGHT OF WAY INADEQUATE FOR UNDETAINED OPTION | HARD LINING NOT COMPATIBLE WITH PARK | TOO LOW IN THE BASIN TO HAVE IMPACT. OVERFLOW TO FOUNTAIN CREEK U/S OF SH 16 RAMP FEASIBLE TO REDUCE D/S CHANNEL REQUIREMENTS |
| 2. HARVARD STREET TO QUEBEC STREET | INADEQUATE CROSSING CAPACITY CAUSES WIDE FLOOD PLAIN EFFECTING RESIDENCES FOR EXISTING AND FUTURE CONDITIONS | TOO LOW IN THE BASIN TO HAVE EFFECT. NO AREA AVAILABLE | NO AREA AVAILABLE FOR REGIONAL DETENTION | EXISTING CHANNELS GRASS LINED, LOW FLOW STABILIZATION NEEDED FOR EXISTING AND FUTURE CONDITIONS | FULL 100-YR CONVEYANCE WOULD REQUIRE HARD LINING TO CONFINE FLOW WITHIN EXISTING R.O.W. | NOT FEASIBLE IN THIS REACH |
| 3. QUEBEC STREET TO FONTAINE BOULEVARD | FLOOD PLAIN CONFINED TO PARK AREAS FOR EXISTING AND FUTURE CONDITIONS. NO ENCROACHMENTS CURRENTLY EXIST. LOW FLOW STABILIZATION REQD. | TOO LOW IN THE BASIN TO HAVE EFFECT. NO AREA AVAILABLE | NO AREA AVAILABLE FOR REGIONAL DETENTION | EXISTING CHANNELS GRASS LINED, LOW FLOW STABILIZATION NEEDED FOR EXISTING AND FUTURE CONDITIONS | HARD LINING INCOMPATIBLE WITH EXISTING CROSS SECTION AND PARK SETTING | NOT FEASIBLE IN THIS REACH |
| 3A. FOUNTAIN MESA TRIBUTARY | LOW FLOW STABILIZATION REQUIRED | FEASIBLE FOR AREAS EAST OF GOLDFIELD DRIVE AND NORTH OF FONTAINE BLVD. | FEASIBLE FOR AREAS EAST OF GOLDFIELD DRIVE AND NORTH OF FONTAINE BLVD. | LOW FLOW STABILIZATION REQUIRED DOWNSTREAM OF FONTAINE | HARD LINING FEASIBLE WITHIN COMMERCIAL AND BUSINESS AREAS | DIVERSION OF LOW FLOWS FROM DEVELOPING AREAS TO McRAE FEASIBLE |
| 4. FONTAINE BOULDVARD TO BIG JOHNSON RESERVOIR | FEASIBLE IF LOW AND PEAK FLOWS ARE CONTROLLED TO PRESENT LEVELS. FEASIBILITY DEPENDENT UPON DETENTION IN REACH 5 | DEVELOPMENT PRESSURE NOT SIGNIFICANT IN THIS REACH (NO DETENTION REQUIRED) | MC RAE RES. HAS EXISTING FLOW ATTENUATION CAPABILITIES. STORAGE AMPLE WITHOUT OUTLET IMPROVEMENTS IF DETENTION IMPLEMENTED IN REACH 5. | LOW FLOW STABILIZATION REQUIRED. FEASIBLE IF DETENTION IMPLEMENTED IN REACH 5. | HARD LINING INCOMPATIBLE WITH EXISTING ENVIRONMENTAL SETTING | DIVERSION FEASIBLE AROUND MC RAE RES. FOR LOW FLOWS ONLY. 100-YR FLOWS TOO LARGE TO DIVERT FROM HISTORIC PATHS. COSTLY. |
| 5. BIG JOHNSON RESERVOIR TO STUDY LIMIT | FEASIBLE AT EXISTING RUNOFF RATES, HOWEVER NOT DESIRABLE IN LIGHT OF PROJECTED LAND USES. | SMALL PONDS NOT DESIRABLE FROM LONG TERM COST AND OPERATION/MAINTENANCE REQUIREMENTS. TEMPORARY ONSITE DETENTION COULD BENEFIT WQ AS UPPER BASIN DEVELOPS. | INCIDENTAL STORAGE AT POWERS AND/OR FUTURE ARTERIALS AVAILABLE | LOW FLOW STABILIZATION . | HARDLINING CAN BE FEASIBLE WITHIN COMMERCIAL/ BUSINESS AREAS | FLOW DIVERSION TO REGIONAL PONDS FEASIBLE U/S OF POWERS. STABLE OUTFALL CHANNELS TO BIG JOHNSON REQUIRED THROUGH THE WATERVI PROPERTY. |

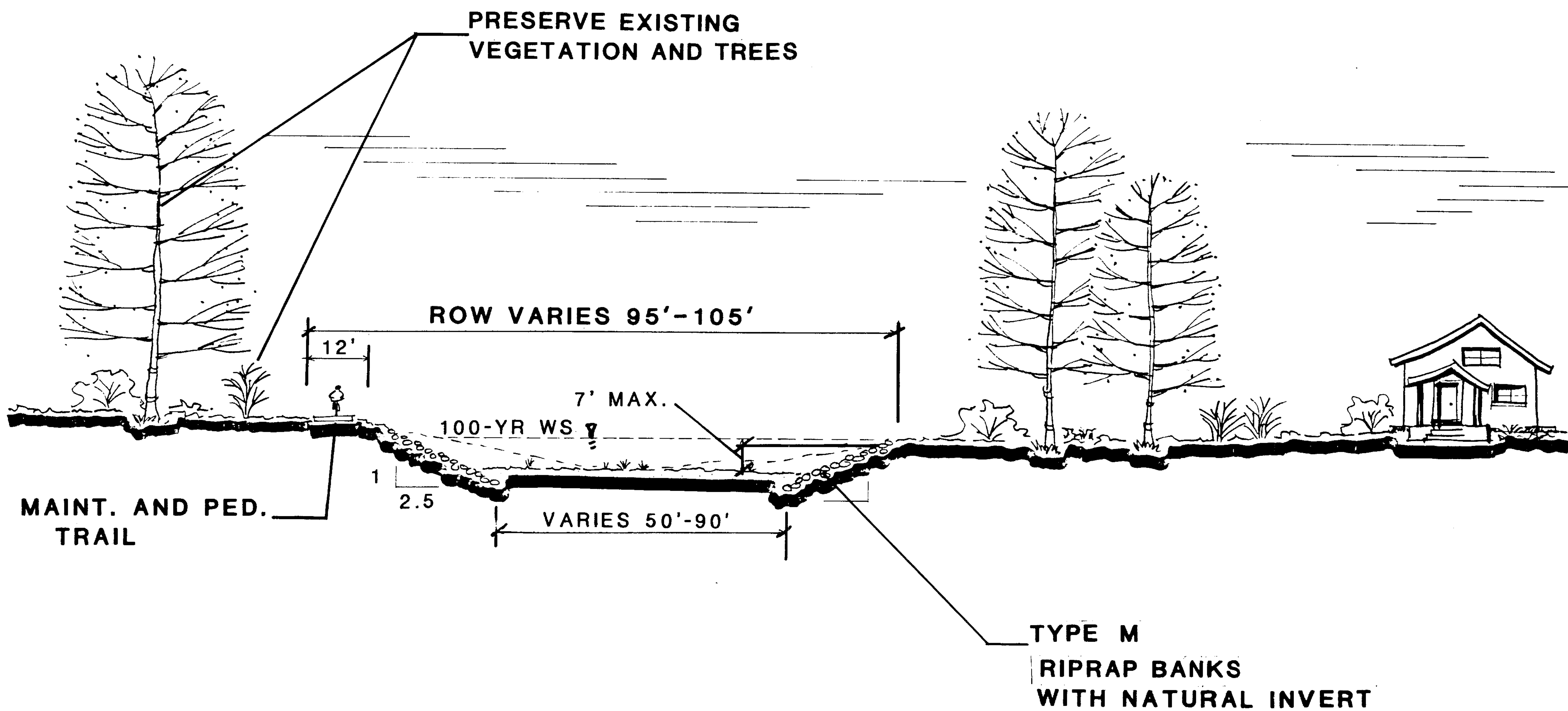
Big Johnson Reservoir. Floodplain preservation with low flow stabilization is most feasible within Reaches 3 and 4. However, in the undetained runoff scenario (full conveyance) floodplain preservation is not considered feasible because of the anticipated large increases in peak flow and duration, wide channel sections, erosion concerns, and possible habitat degradation.

Drainage System Alternatives

The handling of stormwater can be accomplished by the use of pipes, channels, detention/retention basins, bridges, culverts and various other physical improvements. The use of any one or a combination of the above improvements is dependent upon the level of flow, topography, right-of-way and the character of the areas adjacent to the drainageway. A qualitative discussion of the feasibility of the general drainage alternatives within each segment, is summarized below:

Channels: Shown on Figures 14 through 16 are the typical sections for riprap, grasslined and low flow channel sections, which are recommended for use along the major drainageways within the study area. The application of each section will vary by reach and by detention alternative under consideration. In general, the riprap section is feasible within Reaches 1 and 3. A grasslined channel with a low flow section is feasible within Reaches 2 and 3. A low flow section in combination with floodplain preservation/regulation is feasible within Reaches 2, 3 and 4.

Detention/Retention: As with channels, the type of detention or retention basin will be dependent upon the volume and rate of flow, however right-of-way and the characteristics of the area adjacent to a proposed detention/retention basin plays a large role in this alternative's feasibility. In the case of retention, water rights can be an important design constraint. Water quality is an important convern in light of the stormwater discharge regulations, and a retention/detention scheme has distinct advantages in this regard in comparison to an undetained

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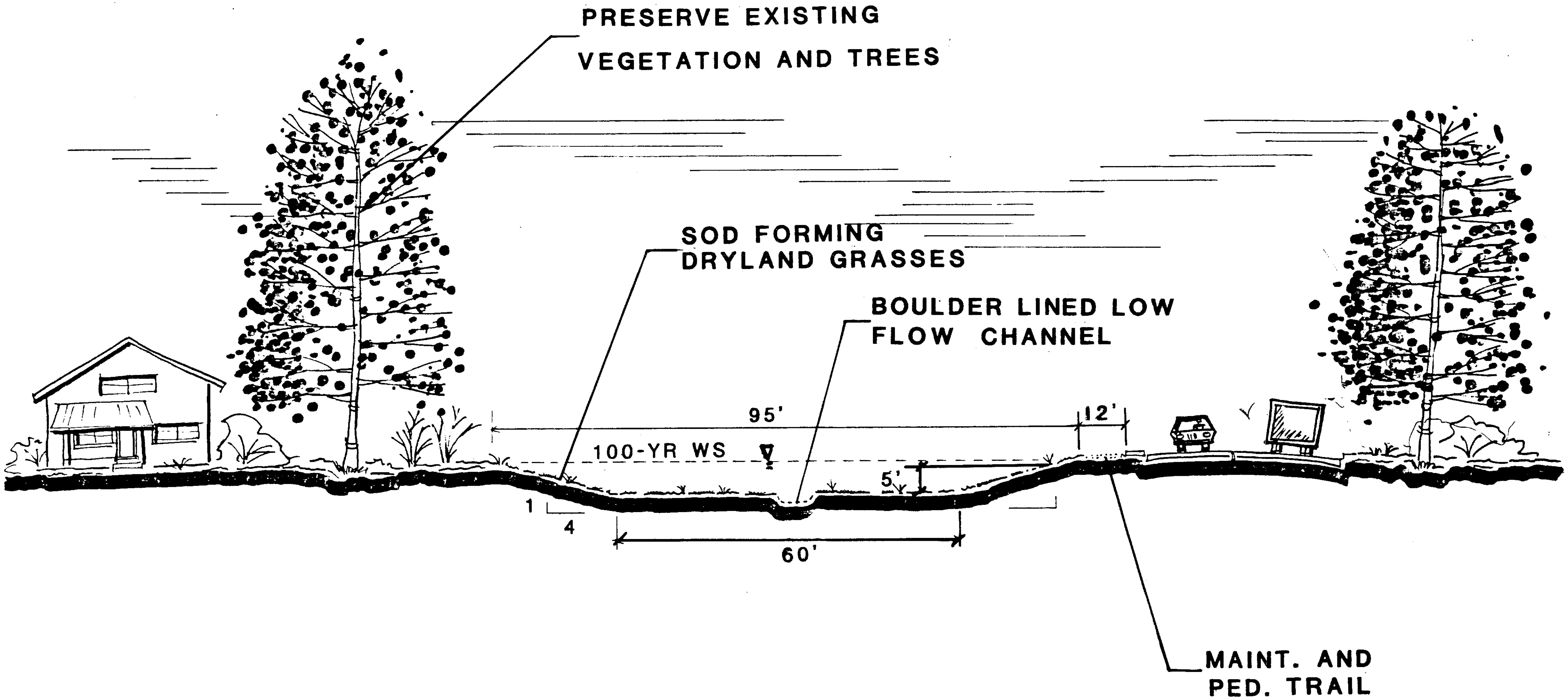
80905-1308

BIG JOHNSON RESERVOIR/
CREWS GULCH DRAINAGE
BASIN PLANNING STUDY
**TYPICAL RIPRAP CHANNEL SECTION**

Project No. 68.05.09
Date: 10/86
Design:
Drawn:
Check:
Revisions:

FIGURE 14

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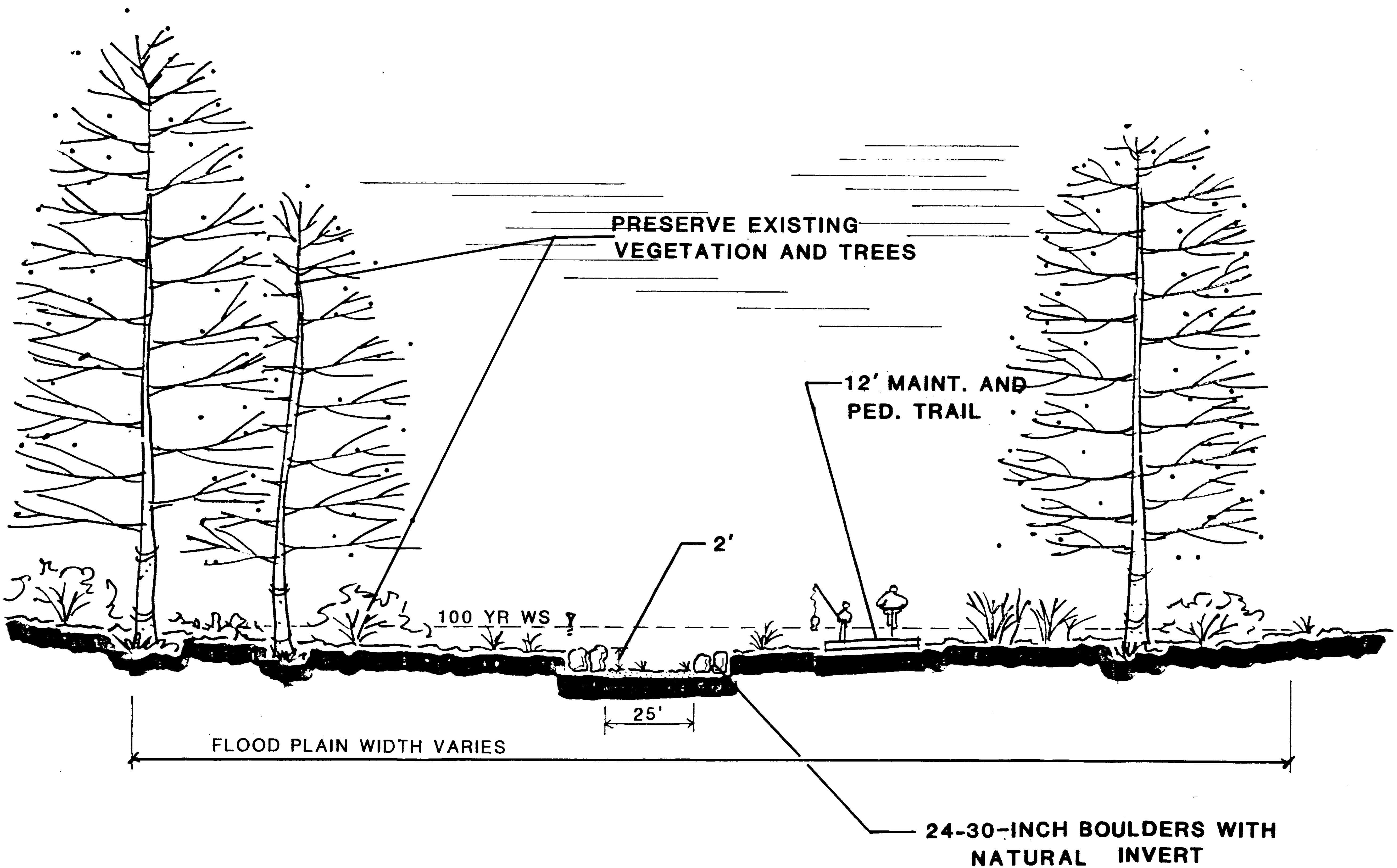
419 W. Bijou Street
Colorado Springs, Colorado
80905-1308

BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY

TYPICAL GRASSLINED CHANNEL
W/LOW FLOW CHANNEL

Project No. [illegible].05.09
Date: [illegible]
Design:
Drawn:
Check:
Revisions:

FIGURE 15

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Colorado Springs, Colorado
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BIG JOHNSON RESERVOIR/
CREWS GULCH DRAINAGE
BASIN PLANNING STUDY
**TYPICAL LOWFLOW CHANNEL SECTION**
**W/FLOODPLAIN PRESERVATION**

Project No. 88.05.09
Date: 10/88
Design:
Drawn:
Check:
Revisions:

FIGURE 16

scenario. Finally, operations and maintenance is a mandatory requirement of a stormwater detention/retention basin if the overall system is to function properly.

For the Big Johnson Reservoir/Crews Gulch Basin, the absence of area available for detention within Reaches 1 through 3 renders detention/retention undesirable. Within Reaches 4 and 5, peak flow attenuation and storage is provided by both McRae and Big Johnson Reservoirs. In addition to these existing facilities, the incidental storage created by the Powers Boulevard embankment provides ample storage volume to control runoff from the Colorado Springs Municipal Airport to historic levels. For cost estimation purposes it has been assumed that a new embankment would be constructed separate from the roadway embankment for the ponds north of Powers Boulevard. The actual location of these ponds may be dependent upon the City boundaries at the time of airport development.

Water quality is an important aspect of urban stormwater management. The question of water quality is particularly important within the Big Johnson Reservoir/Crews Gulch Basin because of possible negative impacts upon the irrigation waters stored within Big Johnson Reservoir created by urban stormwater. The Fountain Mutual Irrigation Company has expressed a willingness to allow the detention of stormwater within Big Johnson Reservoir, if the quality of the runoff will not degrade in the functioning of the reservoir and canal system with respect to the their intended purpose. For this reason, detention/water quality basins were compared to the alternative of diverting future stormwater runoff around the Big Johnson Reservoir. Detention basins upstream of the Reservoir would provide a mechanism to better control the quality of stormwater which could enter the Reservoir, and provide for peak flow attenuation as well. Permanent pools within water quality detention basins are in general more effective in reducing the total suspended solids (and other pollutants) conveyed by stormwater runoff, as compared to dry ponds. In the Big Johnson Reservoir/Crews Gulch Basin, McRae Reservoir has a permanent pool, however the outlet facilities are in need of rehabilitation. Detention/water quality basins within Reach 5 may over time develop a permanent pool. As well as increasing the efficiency of pollutant removal, water qualtiy basins may have a side benefit of enhancing the vegetative and wildlife habitat, which is particularly true within Reach 4. With respect to water quality basins within Reach 5, the basins may also be an area for the mitigation of lost habitat elsewhere in the watershed. Water quality basins must be used in conjunction with onsite erosion control measures whenever areas are disturbed by grading and other types of construction, and not just as singular points to control the deposition of sediment from disturbed sites.

In terms of storage capabilities, the Big Johnson Reservoir can totally store the 100-year future condition runoff from the areas tributary to the Reservoir. Assuming full development, approximately a one-foot rise in the water level would be anticipated in a future condition 100-year event. An outlet to drain any temporarily stored stormwater should be constructed at Big Johnson Reservoir in order to separate the storm and irrigation water. At McRae Reservoir, very little storage exists which can effectively reduce peak flows to the downstream reaches without modifications to the existing outlet works and/or the embankment. Various outlet and storage alternatives for McRae Reservoir have been examined to reduce the size of channels and crossings within Reaches 1 through 3 of Crews Gulch.

Alternative Plans

Based upon the information compiled, and comments from agencies and individuals which have been involved in the project, the following alternatives were developed for further technical evaluation. Three alternatives were developed for Reaches 1 through 3, which are based upon three outlet configurations at McRae Reservoir. These three alternatives are shown conceptually on Figures 1 through 3 in the Technical Addendum to this report. For Reaches 4 and 5, three alternatives were developed. These alternatives are shown conceptually on Figures 4 through 7, also in the Technical Addendum. A brief description of each alternative is presented on the Figure. Included within the Technical Addendum is selected design data for the various channel segments. The channel sections, drops, and other facility sizes for each alternative were evaluated and the costs compared.

Within Reach 5, two subalternatives were developed for detention alternate 1. These alternatives have been designated as alternates 1-1 and 1-2. Alternate 1-1 in Reach 5 is a water quality/detention concept whereby future flows would be maintained at historic levels before entering the Big Johnson Reservoir. Alternative 1-2 is similar, however, the water quality/detention basins would be sited completely off Big Johnson Reservoir property. Alternate 1-2 in Reach 5 considers water quality basins on Big Johnson Reservoir property, however, the future peak flows would enter Big Johnson Reservoir without any attenuation. That is, Big Johnson Reservoir would be used to detain future flows to historic levels.

### Alternative Hydrologic Analysis

The conceptual alternatives developed were each modelled hydrologically to assess the impact on peak flow rates. In general, the historic peak flow condition downstream of Fontaine Boulevard was a primary goal of the alternative planning. Various detention schemes were evaluated at McRae Reservoir in order to optimize the flow to downstream drainageways. A flood frequency discharge profile for Reaches 1 through 4 is presented on Figure 17. Alternative 3 best simulates the historic flow conditions along Crews Gulch downstream of Fontaine Boulevard. It should be noted that the discharge profiles have been developed assuming that a detention alternative would be implemented within Reaches 4 and 5 of the Basin.

### Evaluation Parameters

Coordination meetings were held throughout the study to address overall goals and specific concerns of those agencies and

# 100 YEAR DISCHARGE PROBABILITY PROFILES

## ALTERNATIVE EVALUATION – REACHES 1 – 4

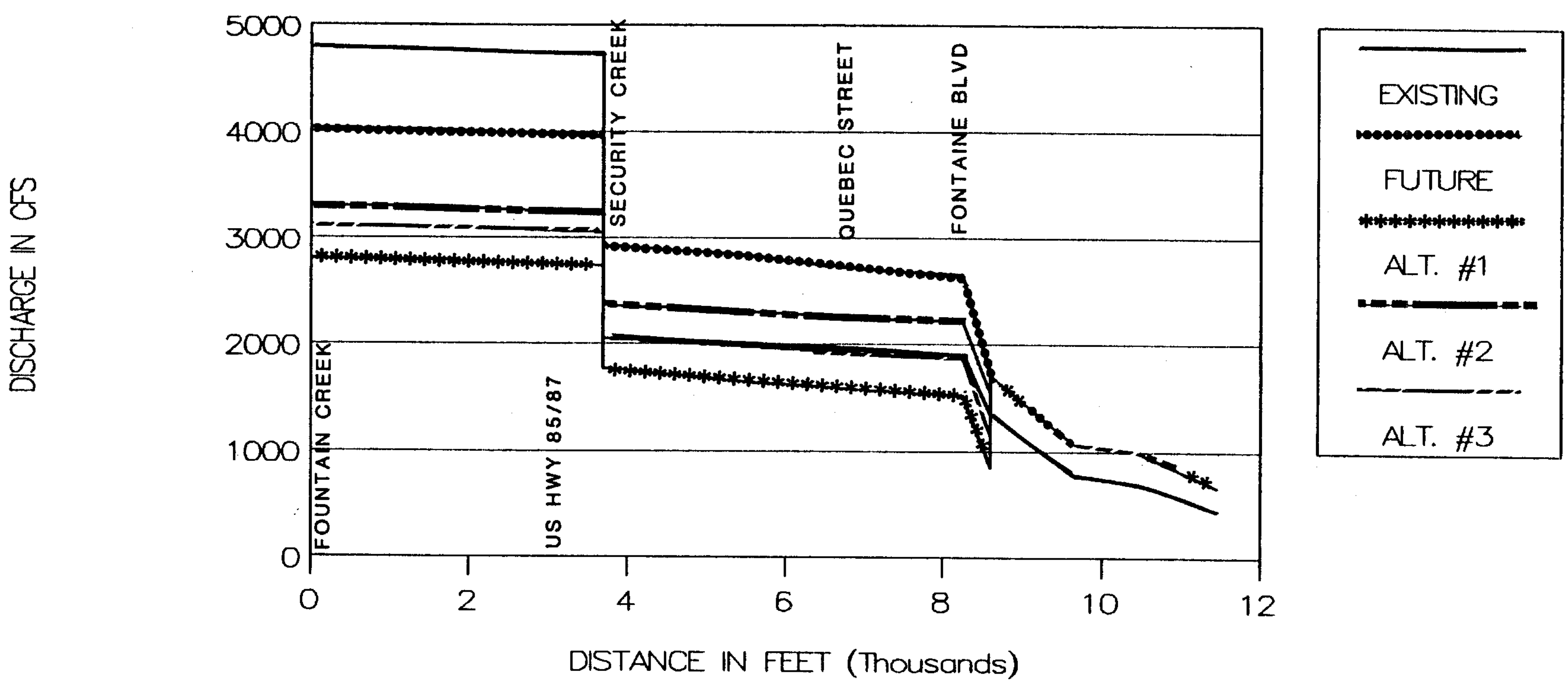


FIGURE 17

individuals asked to participate in the study. One result of this coordination effort was the following list of factors which were considered when evaluating each of the alternatives.

- Flood Control
- Erosion Control
- Operation and Maintenance
- Water Quality
- Wildlife Habitat
- Construction Cost
- Preserve Existing Vegetation
- Administration and Implementation
- Open Space
- Land Use
- Constructability
- Recreation
- Aesthetics
- Water Rights
- Transportation

The list of evaluation parameters was sent out to the persons on the mailing list, and each person was asked to rank their top seven to eight parameters, based upon the technical information presented to date, and from their own point of view. The list presented above is the result of this ranking, with flood control representing the most important parameter. It should be noted that the relative ranking of the first five to six parameters will change within each reach.

### Evaluation Procedures

The alternatives were evaluated on a reach-by-reach basis using the factors presented above. The evaluation parameters were assigned a value from 1 (lowest) to 3 (highest) based on the relative importance within each reach. Each drainage alternative was then ranked from 1 (lowest) to 5 (highest) for each evaluation parameter. If alternatives were considered equal, each was assigned the same score. As an example, water quality and erosion control are relatively more important parameters within Reach 5 because of potential impacts upon Big Johnson Reservoir.

Tables 8 and 9 give the alternative evaluation scores for each alternative for each reach.

### Alternative Cost Estimates

Cost estimates for each of the conceptual plans were developed for comparison purposes. Unit costs used to develop the conceptual cost estimates are shown on Table 10. Operations

TABLE 8 BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY
ALTERNATIVE EVALUATION MATRIX

REACH 1 - 3
FOUNTAIN CREEK TO FONTAINE BLVD.

| EVALUATION PARAMETER | WEIGHING FACTOR | ALTERNATIVES: MAXIMUM ATTENUATION AT MC RAE RESEVOIR | ALTERNATIVES: MINIMUM ATTENUATION AT MC RAE RESEVOIR | ALTERNATIVES: MID LEVEL ATTENUATION AT MC RAE RESEVOIR |
|---|---|---|---|---|
| FLOOD CONTROL | 3 | 4 | 4 | 4 |
| EROSION CONTROL | 2 | 4 | 4 | 4 |
| OPERATION & MAINTENANCE | 3 | 5 | 3 | 4 |
| WATER QUALITY | 2 | 4 | 2 | 3 |
| WILDLIFE HABITAT | 2 | 3 | 3 | 3 |
| CONSTRUCTION COST | 3 | 3 | 4 | 5 |
| PRESERVE EXIST. VEGETATION | 2 | 4 | 3 | 3 |
| OPEN SPACE | 1 | 3 | 3 | 3 |
| ADMIN./IMPLEMENTATION | 2 | 4 | 3 | 5 |
| | TOTAL: | 77 | 66 | 78 |

HIGH TOTAL INDICATES THE PREFERRED ALTERNATIVE.

TABLE 9 BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY
ALTERNATIVE EVALUATION MATRIX

REACH 4 - 5
MC RAE RESERVOIR TO STUDY LIMIT

| EVALUATION PARAMETER | WEIGHING FACTOR | ALTERNATIVES: WATER QUALITY BASINS AT BIG JOHNSON RES. | ALTERNATIVES: DIVERSION AROUND BIG JOHNSON RES. | ALTERNATIVES: COMB. WQ BASINS AND DIVERSION |
|---|---|---|---|---|
| FLOOD CONTROL | 2 | 5 | 3 | 4 |
| EROSION CONTROL | 3 | 5 | 5 | 5 |
| OPERATION & MAINTENANCE | 3 | 4 | 3 | 2 |
| WATER QUALITY | 3 | 4 | 4 | 3 |
| WILDLIFE HABITAT | 2 | 3 | 3 | 3 |
| CONSTRUCTION COST | 2 | 4 | 3 | 2 |
| PRESERVE EXIST. VEGETATION | 3 | 4 | 3 | 3 |
| OPEN SPACE | 2 | 3 | 3 | 3 |
| ADMIN./IMPLEMENTATION | 3 | 4 | 3 | 3 |
| | TOTAL: | 93 | 78 | 72 |

HIGH TOTAL INDICATES THE PREFERRED ALTERNATIVE.

Table 10. Unit Costs.

| Item | Unit Cost |
|---|---|
| <u>Channel Construction</u> | |
| Structural Concrete | \$350.00/CY |
| Excavation | \$ 3.00/CY |
| Boulder Low Flow Channel | \$58.00/LF |
| Riprap 18-inch $D_{50}$, w/filter fabric | \$24.00/CY |
| Riprap 24-inch $D_{50}$, w/filter fabric | \$35.00/CY |
| Gravel Maintenance Trail | \$18.00/LF |
| Surface Restoration (Seed, Erosion Mattress, Fertilizer, Topsoil) | \$ 8.00/SY |
| Grouted Riprap | \$50.00/CY |
| <u>Pipe/Culvert/Inlet Construction</u> | |
| 18-inch Reinforced Concrete Pipe (RCP) | \$35.00/LF |
| 24-inch RCP | \$40.00/LF |
| 30-inch RCP | \$50.00/LF |
| 36-inch RCP | \$75.00/LF |
| 48-inch RCP | \$100.00/LF |
| 60-inch RCP | \$145.00/LF |
| Structural Concrete | \$350.00/CY |
| 5-foot CO Inlet | \$2,000/EA |
| 10-foot CO Inlet | \$3,000/EA |
| 20-foot CO Inlet | \$4,000/EA |
| <u>Detention and Water Quality Basin</u> | |
| Detention/Water Quality Basin and Overflow Facilities (Excavated) | \$10,000/AF |
| Land Acquisition (Detention Ponds only) | \$14,000/AC |
| Detention/Water Quality Basin and Overflow Facilities (Embankment) | \$8,000/AF |
| <u>Annual Operation and Maintenance</u> | |
| Grass Channel | \$ 4.50/LF |
| Concrete Channel | \$ 3.00/LF |
| Storm Sewer | \$ 1.00/LF |
| Riprap Protection | \$ 2.00/LF |
| Detention Areas - Passive Park | \$750.00/AC |
| Detention Areas - Non-Recreational | \$400.00/AC |
| Hydraulic Structures - Culverts, Etc. | \$750.00/Ea. |
| Hydraulic Structures - Check Drops | \$400.00/Ea. |
| Low Flow Channel | \$ 2.00/LF |
| Engineering | 10% of Construction Cost and Contingency |
| Contingencies | 5% of Construction Cost |

and maintenance costs have also been evaluated. Cost tables for each of the alternatives are contained within the Technical Addendum.

Discussion

In addition to the channels and crossings identified for each of the alternatives, drainage improvements common to each alternative are required. These improvements are summarized on Table 11. Comparisons of the costs for alternatives 1-3 are provided on Tables 12 and 13. Cost comparisons for alternative 1, 1-1, and 1-2 are presented on a later table. A discussion of the conceptual alternatives follows.

REACHES 1 - 3

The evaluation matrix presented previously indicates that the "preferred" alternative is Alternative 3, the mid-level flow attenuation at McRae Reservoir. This alternative involves the raising of the control elevation at McRae to elevation 22.0, which can be accommodated by expanding the existing embankment to the east. A riprap channel is needed in Reach 2 in order to confine the 100-year flows to the existing right-of-way; however, a 10-year riprap pilot channel in combination with the 100-year roadway crossings may be sufficient to take the existing residential structures out of the 100-year floodplain.

Within Reach 1, a 10-year riprap channel is proposed through Fountain Creek Regional Park. This channel section would be needed where Crews Gulch passes between the existing pond embankments. Upstream of this section, selective bank lining could be considered to protect the pond embankments.

The overflow structure upstream of the State Highway 16 ramp must be constructed to provide 100-year flood conveyance around Fountain Creek Regional Park as an alternative to modifying the pond embankments to accommodate a wider channel. This overflow structure would not affect facilities within the City of Fountain's Ceresa Park. No formal channel section is proposed, due to the mild grades and slow velocity which would occur

Table 11. Common Drainageway Improvements.

| Reach No. | Segment | Description |
|---|---|---|
| 1 | A | Outlet structure at Fountain Creek on Crews Gulch |
| 1 | B | Overflow structure to Ceresa Park Creek, upstream of State Highway 16 ramp |
| 1 | C | Clear rubble and debris beneath RR and US 85/87 bridges |
| 1 | C | Provide fill or levee on east over bank, downstream of Harvard Street |
| 2 | A | Channel transition structure between Reaches 2 and 3 |
| 4 | 4 | Stormwater outlet at Big Johnson Reservoir |
| 4 | 4 | Rehabilitate spillway at Big Johnson Reservoir to meet State Regulations |
| 5 | 5A, 5B | Detention basins north of Powers Boulevard |

TABLE 12 BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY
ALTERNATIVE COST SUMMARY

REACH 1 - 3
FOUNTAIN CREEK TO FONTAINE BLVD.

| ITEM | ALTERNATIVES | | |
|---|---|---|---|
| | MAXIMUM ATTENUATION AT MC RAE RESEVOIR | MINIMUM ATTENUATION AT MC RAE RESEVOIR | MID LEVEL ATTENUATION AT MC RAE RESEVOIR |
| CHANNELS AND DROPS | $1,645,200 | $1,881,500 | $1,931,400 |
| MCRAE RESERVOIR EMBANKMENT IMP | $1,200,000 | $400,000 | $560,000 |
| CULVERTS | $248,700 | $346,800 | $293,500 |
| OPERATIONS AND MAINTENANCE (CHANNELS) | $232,400 | $195,100 | $195,100 |
| RIGHT OF WAY | $0 | $0 | $0 |
| TOTAL: | $3,326,300 | $2,823,400 | $2,980,000 |

NOTES:
1. O & M COSTS ARE NET PRESENT WORTH ASSUMING AN 8.5 PERCENT INTEREST RATE AND A 40 YEAR DESIGN LIFE.
2. CULVERTS ARE FOR HARVARD STREET, QUEBEC STREET, AND FONTAINE BOULEVARD.
3. THESE ESTIMATES DO NOT INCLUDE IMPROVEMENTS FOR ENGINEERING AND CONTINGENCIES, OR COSTS FOR THE COMMON IMPROVEMENTS SHOWN ON TABLE 19.

TABLE 13 BIG JOHNSON RESERVOIR/CREWS GULCH
DRAINAGE BASIN PLANNING STUDY
ALTERNATIVE COST SUMMARY

REACH 4 - 5
MCRAE RESERVOIR TO STUDY LIMIT

| ITEM | ALTERNATIVE 1<br>WQ BASINS AT BIG JOHNSON RESEVOIR | ALTERNATIVE 2<br>DIVERSION AROUND BIG JOHNSON RESEVOIR | ALTERNATIVE 3<br>WQ BASINS AND DIVERSION AROUND BIG JOHNSON RES. |
|---|---|---|---|
| CHANNELS AND DROPS | $4,521,300 | $7,283,800 | $6,086,900 |
| DETENTION/WATER QUALITY IMP. | $147,000 | $0 | $347,000 |
| CULVERTS | $0 | $70,000 | $10,000 |
| OPERATIONS AND MAINTENANCE | | | |
| CHANNELS | $748,900 | $1,647,400 | $1,159,100 |
| WQ IMPROVEMENTS | $100,200 | $0 | $100,000 |
| RIGHT OF WAY | | | |
| CHANNELS | $41,600 | $184,000 | $308,000 |
| WQ IMPROVEMENTS | $327,600 | $0 | $280,800 |
| TOTAL: | $5,886,600 | $9,185,200 | $8,291,800 |

NOTES:
1. O & M COSTS ARE NET PRESENT WORTH ASSUMING AN 8.5 PERCENT INTEREST RATE AND A 40 YEAR DESIGN LIFE.
2. NO CULVERTS HAVE BEEN ESTIMATED FOR REACH 5.
3. THESE ESTIMATES DO NOT INCLUDE IMPROVEMENTS FOR THE COMMON IMPROVEMENTS SHOWN ON TABLE 11.

through Ceresa Park during a 100-year event. Velocities are anticipated to be less than 5 feet per second within the floodplain. Further consideration to the design of the overflow facilities was undertaken during the preliminary design phase.

REACHES 4 - 5

The apparent "preferred" alternative in these Reaches is Alternative 1, the Water Quality Basin scenario. Water quality basins with 100-year overflow facilities would be constructed on Big Johnson Reservoir property. The peak flow attenuation would be accomplished through storage within the Reservoir itself. This alternative would maintain the existing flow situation for basins below Big Johnson Reservoir which is a key aspect when considered with the selected improvements within Reaches 1 through 4. Construction costs, operations and maintenance cost, impacts upon private property, and floodplain preservation downstream of Big Johnson for Alternative 2 and 3 is the major detractor of these plans. Sub-alternative 1-1 assumed that the detention/water quality basins would be constructed on Big Johnson Reservoir property. Sub-alternative 1-2 assumed that detention/water quality basins in the Big Johnson Reservoir Basin would be constructed within the Waterview property. Both sub-alternatives 1-1 and 1-2 maintain peak flows entering Big Johnson Reservoir at historic levels. All of the sub-alternatives would include the detention basins upstream of Powers Boulevard as do alternatives 2 and 3. A relative cost and acreage comparison between Sub-Alternatives 1, 1-1, and 1-2 is presented below. The primary reason for the lower cost of construction between Alternative 1, and Alternatives 1-1 and 1-2 is the fact that Big Johnson Reservoir is being used to store developed flow.

| Sub-Alternative No. | Storage Volume (1) (AF) | Estimated Detention/Water Quality Basin Construction Cost |
|---|---|---|
| 1 | 187 AF | 1,630,000 |
| 1-1 | 314 AF | 2,318,000 |
| 1-2 | 254 AF | 2,300,000 |

(1) Storage above Powers Boulevard is common to each of the sub-alternatives (120 AF).

Water quality design features are common to all sub-alternatives. Should property within the Big Johnson Reservoir boundary be considered for development, water quality measures must be implemented so that runoff from developed areas does not negatively impact the Reservoir itself.

Within Reach 5, alternatives to grasslined channels may have to be considered because of the numerous drop structures which would be needed to control the flow velocity to five feet per second or less. Closed conduits or riprap-lined channels may be just as cost effective and fit in with the commercial/industrial land use proposed within Reach 5. Culverts in Reach 5 under the proposed arterials have not been included on the conceptual plans; however, these facilities would be the same for each of the alternatives. Closed conduits in place of diversion channels around Big Johnson as proposed in Alternatives 2 and 3 may be feasible, but because of the anticipated mild slopes, siltation of the closed conduit would be an important operation and maintenance consideration. The mild slope would also require large diameter storm sewers, greatly impacting costs.

The installation of a stormwater outlet at Big Johnson Reservoir is a common improvement for all alternatives. This outlet would allow storm flows originating in areas upstream of Big Johnson Reservoir to drain from the Reservoir in approximately a 48-hour period. This outlet could be provided for by modifying the existing irrigation outlet, however the irrigation function of this structure must not be negatively impaired. Consultation with the Fountain Mutual Irrigation

Company is recommended during the design of a stormwater outlet. Meetings have been held with the Board of Directors of the Fountain Mutual Irrigation Company (FMIC) in order to present the alternative evaluation. Fountain Mutual Irrigation Company key concerns related to the selected drainage planning in Reach 5 were siltation control, water quality impacts, and long-term maintenance aspects related to the proposed detention/water quality basins. In general, the FMIC Board supported the concept of using Big Johnson Reservoir for stormwater purposes, provided that the water quality improvement construction be funded by the drainage fee system, and long-term maintenance of these improvements be provided by the County following formal acceptance by the Board of County Commissioners. Of the sub-alternatives evaluated, FMIC indicated a preference for Alternative 1, as long as a mutually agreeable plan for implementation and operation can be developed between FMIC and the Board of County Commissioners.

## VII. PRELIMINARY DESIGN

The results of the preliminary design analysis are summarized in this chapter. The "preferred" alternative within each of the stream reaches has been designed keeping the evaluation parameters developed earlier in the project in mind. The preliminary design drawings, Sheets 1 through 17, are contained at the rear of this report. Presented on Table 14 is a summary of the "selected design" peak discharges for the basin. A description of the improvements follows:

### Reach 1 - Fountain Creek to Harvard Street

The channel improvements within this reach are primarily rehabilitative in nature, with exception of the segment between State Highway 16 and US 85/87, which is new channel construction. The existing stream banks downstream of State Highway 16 should be lined with riprap where the existing bank protection has failed or is non-existent. Riprap should be placed at the outlet of the State Highway bridge and at the outside bend at Station 3+50 to protect the pond embankments which also serve as the Crews Gulch channel banks. Large trees and other native vegetation should be protected to the greatest extent possible within Fountain Creek Regional Park.

Upstream of State Highway 16 a 10-year capacity culvert has been designed to maintain the "historic" peak flow conditions along Crews Gulch. This culvert in combination with an overflow structure at Ceresa Park will control the 100-year future condition flows to the limits shown on the preliminary design drawings. Flooding depths within Ceresa Park would be roughly the same in the future condition as they exist today. Disturbance to the existing facilities within Ceresa Park is not anticipated. The drainageway could accommodate a trail to link both parks, and also to serve as a maintenance access.

The design approach taken during the sizing of the overflow structure(s) adjacent to Fountain Creek Regional Park and Ceresa Park, was to limit the discharge to the capacity (1,100 cfs) of the existing channel downstream of the State Highway 16 bridge.

KIOWA ENGINEERING CORPORATION BIG JOHNSON HYDROLOGY

DATE: 05-Jun-91 TIME: 02:52 AM

TABLE 14

Summary of "Selected Design" Peak Discharges*

| DESIGN POINT | DRAINAGE AREA (SQ MI) | EXISTING CONDITION 2 HOUR STORM 100 YR. | EXISTING CONDITION 2 HOUR STORM 10 YR. | SELECTED PLAN 2 HOUR STORM ** 100 YR. | SELECTED PLAN 2 HOUR STORM ** 10 YR. | COMMENTS |
|---|---|---|---|---|---|---|
| 1* | 2.37 | 4831 | 1983 | 2997 | 1146 | FOUNTAIN CREEK |
| 2* | 2.35 | 4866 | 1984 | 2982 | 1149 | |
| 3* | 2.29 | 4814 | 1966 | 2926 | 1132 | |
| 4 | 2.24 | 1962 | 664 | 1864 | 607 | |
| 5 | 2.20 | 1930 | 653 | 1832 | 597 | |
| 6 | 2.17 | 1903 | 644 | 1805 | 569 | |
| 7 | 2.14 | 1874 | 635 | 1775 | 582 | D/S McRAE RESERVOIR |
| 8 | 0.07 | 141 | 69 | 141 | 69 | |
| 9 | 0.47 | 566 | 196 | 875 | 390 | |
| 10 | 0.45 | 524 | 186 | 838 | 377 | |
| 11 | 0.37 | 440 | 147 | 699 | 331 | |
| 12 | 0.15 | 151 | 45 | 299 | 150 | |
| 13 | 0.15 | 223 | 95 | 268 | 125 | |
| 24 | 0.09 | 121 | 47 | 141 | 59 | |
| 25 | 0.08 | 105 | 39 | 125 | 51 | |
| 26 | 1.56 | 1324 | 450 | 1692 | 577 | |
| 27 | 0.87 | 754 | 262 | 1056 | 383 | |
| 28 | 0.78 | 682 | 237 | 974 | 357 | |
| 29 | 0.11 | 97 | 33 | 97 | 33 | |
| 30 | 0.46 | 427 | 154 | 657 | 266 | |
| 31 | 3.07 | 1351 | 503 | 2120 | 770 | INFLOW TO BIG JOHNSON |
| 32 | 0.79 | 295 | 73 | 85 | 80 | OUTFLOW FROM DET. BASIN 5A-2 |
| 34 | 1.66 | 483 | 122 | 2110 | 1210 | INFLOW TO WQ BASIN 5A-1 |
| 61 | 0.07 | 44 | 11 | 36 | 20 | OUTFLOW FROM DET. BASIN 5B-2 |
| 62 | 0.05 | 48 | 9 | 45 | 25 | OUTFLOW FROM DET. BASIN 5A-3 |
| 63 | 0.61 | 350 | 100 | 1400 | 900 | INFLOW TO WQ BASIN 5B-1 |

* - Includes flow from Widefield/Security Creek Basin

**- Design flows for the 24-hour storm duration is contained within the Technical Addendum to this report.

This approach is influenced primarily upon cost and flood damage reduction factors for this segment of Crews Gulch. For the existing basin conditions (accounting for inflow from the Little Johnson/Security Creek basin), the flow estimated to pass into Ceresa Park in a 100-year event is 3,800 cfs. For the future basin condition (assuming improvements within the Little Johnson/Security Creek basin and Crews Gulch basin are in place), the flow estimated to pass to Ceresa Park is 1,900 cfs for the 100-year event. The reduction between the existing and future conditions is primarily attributable to the improvements proposed at McRae Reservoir and in the Little Johnson/Security Creek Basins.

Upstream of Station 12+50, a new riprap bank/sand invert channel is proposed, which has been constructed with the Southmoor Drive Bridge Improvement Project. Filling of the existing channel, and the extension of the existing Southmoor Drive storm sewer is still required. The right channel bank (looking downstream) is sized to convey the 10-year peak design flow to the flow control culvert at Station 12+50, and to overtop in the 100-year event. The overbank area could be used as additional open space and an enhancement of the existing riparian areas along this segment of Crews Gulch. Maintenance access in this area would be through gravel trails along the top of the riprap bank.

Drop structures have been proposed at US 85/87 in order to stabilize the existing invert at a higher elevation. This will serve to protect the existing bridge and channel lining foundations, provide better maintenance access, and help the area visually by eliminating the degraded invert. The existing concrete blocks and rubble should be removed or buried where possible within the channel invert. The existing banks should be lined with riprap from Station 30+50 to Station 33+50, where the Security Creek channel enters Crews Gulch. Some grouted riprap may be needed to transition to the existing concrete channel lining upstream of the railroad bridge.

A trail under the US 85/87 and railroad bridges is feasible along the south bank, however, easements would need to be obtained from the State Highway Department and the Denver and Rio Grande Western Railroad Company. In this case, the trail shown on the north bank of Crews Gulch, downstream of US 85/87, could be placed on the south bank thereby linking the Widefield area to the lower segments of Crews Gulch. The US 85/87 Improvement Project being planned by the Colorado Department of Highways may eventually require the modification (possibly substantial) of the existing structure. Bank improvements under the structure could be done most cost effectively at that time.

Upstream of the railroad bridges, the existing concrete channel is of adequate capacity to convey to 100-year flow with the provision of the fill along the south overbank from Station 33+50 to Station 35+40. At Station 35+40, a concrete-lined channel has been proposed, which would provide a transition to a riprap section at Station 37+00.

Right-of-way acquisition is not anticipated within Reach 1. The channel sections have been laid out to fit within the existing public ownership(s) throughout. Easements for maintenance access, or operations and maintenance agreements, must be developed between the El Paso County Department of Public Works, City of Fountain, the El Paso County Parks Department, the Denver and Rio Grande Western Railroad, and the Colorado Department of Highways.

It has been calculated that the improvements, if constructed, will result in no net loss of habitat. The segment from Ceresa Park to US85 offers an excellent opportunity to restore habitat values which have been lost to erosion and could be used as a future mitigation area for other projects.

Reach 2 - Harvard Street to Quebec Street

Within this reach it is proposed that a 10-year, riprap-lined channel be constructed within the existing greenbelt extending to Kilgore Street. From this point, a boulder low flow section extending to Quebec Street has been proposed. These improvements, in combination with the replacement of the Harvard and Quebec Street culverts are sufficient to reduce the potential for flood damages in comparison with the existing 100-year floodplain. The low-flow channel will also provide for long-term bank and invert stabilization. The boulder low flow (and riprap channel) will be able to adequately convey the average runoff which will increase in frequency and duration as a result of upstream urban development. The existing grasslined overbanks and trees should be preserved to the greatest extent possible. A gravel maintenance trail has been proposed within the greenbelt from Kilgore Street to Quebec Street. Grade control structures along the 10-year channel have been proposed to retard channel degradation due to low flows. Right-of-way acquisition is not anticipated within this reach, however, maintenance activities and responsibilities will have to be coordinated between the El Paso County Department of Public Works and the City of Fountain. As in Reach 1, the proposed improvements, if constructed, would result in no net loss of habitat values.

Reach 3 - Quebec Street to Fontaine Boulevard

This reach is within Widefield Park. The park is presently maintained by the El Paso County Parks Department. A floodplain preservation concept, in combination with the stabilization of the existing low flow channel, is proposed. A new box culvert is proposed at Quebec Street to eliminate the overtopping of the roadway. Drop structures at Stations 64+00 and 65+00 are proposed in order to gain headroom for the proposed culvert at Quebec Street. The drop structures have been shown as vertical drops, however, they could be constructed to include boulders or grouted rock in order to better blend with the park setting. A three-foot high sodded berm is proposed along Quebec Street to eliminate potential for street flooding. The floodplain preservation concept, if implemented, would result in a zero net loss of habitat values.

Upstream of the drop structures, a boulder low flow channel is proposed. Meandering of the low flow channel is desirable in order to match the existing banks and to minimize utility relocation and disturbance to trees, however, the maximum radius of curvature should be limited to 100-feet. Check structures are proposed to retard invert degradation. The existing footbridges within Widefield Park should be reset as part of the low flow channel construction.

A maintenance bench has been proposed along the boulder low flow. This bench should be sodded, except at footbridge crossings where gravel base should be used. As an option to the maintenance bench, a 12-foot wide gravel trail as proposed elsewhere along Crews Gulch could be constructed. Agreements between El Paso County Department of Public Works and El Paso County Parks Department could be developed to define maintenance responsibilities within Reach 3. No right-of-way acquisition is anticipated within Reach 3 for the construction of the proposed improvements.

Reach 3A - Fountain Mesa Tributary

This reach involves the stabilization of the existing draingeway from Widefield Park to Goldfield Drive. At Widefield Park, an additional 48-inch pipe has been proposed to supplement the existing 42-inch culverts which currently convey stormwater from areas upstream of Drury Lane, as well as augmentation water from the Fountain Mutual Canal. This system, in combination with the proposed box culvert and inlet at Drury Lane, can convey approximately 75 percent of the design 100-year flow. The residual floodplain would be within the street section of Drury Lane, and would enter the park opposite Ciello Vista Street. The existing headwall at the outlet of the 42-inch culverts would need reconstruction. The Crews Gulch augmentation line would need relocation at Drury Lane into the south 42-inch pipe.

Upstream of Drury Lane a stabilized grasslined channel is proposed, in combination with grade control structures. Drop structures are required upstream of Bella Vista Lane, and at Metropolitan Drive to facilitate the crossing of roads and the Fountain Mutual Irrigation Canal. A stormwater/irrigation separation structure is proposed at Metropolitan Drive in order to safely pass the design 100-year flow over the canal.

Upstream of Goldfield Drive a stormwater detention pond has been sited to control runoff from the Waterview Property to historic conditions. The location of this pond may be dependent upon the ultimate location of Goldfield Drive. This pond should also be designed with water quality control features. Improved culverts have been sized for Fontaine Boulevard and Goldfield Drive, as well as for two other proposed roadways.

Right-of-way acquisition may be required for the channel upstream of Fontaine Boulevard to Goldfield Drive, within the Fountain Valley School property. Downstream of Fontaine Boulevard, the Fountain Mesa Tributary passes through privately owned drainageway tracts and County Park property.

Reach 4 - Fontaine Boulevard to Big Johnson Reservoir

The primary stormwater management facility in this reach is McRae Reservoir. The improvements to the existing embankment are required to prevent the overtopping of the reservoir. Modification of the existing embankment may also be required to accommodate the widening of Fontaine Boulevard. A new outlet structure is proposed, with an energy dissipator. The energy dissipator serves to transition the 100-year flow into Widefield Park. The dissipator should be constructed to blend with the park setting to the greatest extent practical. It is proposed that the existing outlet pipe be abandoned. (The existing 18-inch culvert would be diverted into the 8-foot by 12-foot concrete box culvert, as well as used for the dewatering of McRae Reservoir during construction and maintenance projects.) The existing 48-inch culverts should be extended and a drop inlet constructed to provide emergency overflow capacity in addition to the overflow section along Fontaine Boulevard. The existing concrete swale at the outlet of the twin 48-inch corrugated metal pipes should be removed, and the area reclaimed for park use. Riprap embankment protection has been provided along Fontaine Boulevard, downstream of the emergency overflow weir. The emergency outlet has been sized to pass the 100-year inflow (future condition) in accordance with State Engineer's regulations for a Class II, Minor Dam.

The future widening of Fontaine Boulevard was considered when siting the sheet pile wall at McRae Reservoir. The existing curb cuts and collector street grades make the raising of Fontaine Boulevard difficult, particularly at Drury Lane. Shifting of the roadway to the south is also difficult because of the steep embankment which exists already. Therefore, for the purposes of evaluating the stormwater improvements for McRae Reservoir, it was assumed that any future road width would be gained by encroaching into the reservoir. In this case the stormwater improvements, and in particular the sheet pile wall, can serve two purposes.

McRae Reservoir represents a major environmental resource within the basin. Wetland and riparian habitat currently exist. The Reservoir has been impacted by siltation, which has rendered the Reservoir as unsuitable as a fishery, without the removal of a substantial portion of the sediment and muck. The flood control facilities have been sized assuming that the current water level is maintained, and that no flood storage is offered within the permanent pool volume. The improvements shown on the preliminary design plans have been developed in order to improve the Reservoir's flood handling capabilities, while preserving and/or enhancing the Reservoir's existing habitat. Dredging of the Reservoir could help in reestablishing a fish habitat at McRae Reservoir, and provide for better operation of the facilities. At a minimum, the wetland values would be preserved as they exist today.

The current owner of McRae Reservoir is the Fountain Valley School with easement possessed by the Fountain Mutual Irrigation Company. Since it appears that the future purpose of the Reservoir would primarily be for stormwater management, it is recommended that the facility be owned and operated by El Paso County. Inter-agency agreements to promote the multiple-use aspects of the area could be developed in order to ensure that

McRae Reservoir's high quality habitat and open space can be preserved and enhanced while still providing for public safety with respect to flood control. Multiple use of the area may also broaden the sources of funding for improvements at the reservoir. The concepts in this reach would result in a zero net loss of habitat, if implemented.

Upstream of McRae Reservoir, a boulder low flow channel extends from the Reservoir to Station 122+20. The low flow channel should meander to meet existing banks. Disturbance to existing vegetation should be minimized. At Station 122+20 the 36-inch stormwater outlet from Big Johnson Reservoir would enter the boulder flow. Grade control structures are proposed along the low flow channel. This channel is only required when the stormwater outlet at Big Johnson Reservoir has been constructed, or as other site conditions would warrant.

During the formulation of the basin plan, the Fountain Valley School indicated that no residential or commercial land development activities are envisioned within the school property in the foreseeable future. Accordingly, limited storm drainage improvements have been shown for the Fountain Valley School property. Should land development be proposed for the School property, stormwater facilities which will maintain the peak discharges to existing condition levels as estimated herein would be required.

Right-of-way acquisition or easements are required along the low flow path (and 36-inch conduit) from McRae Reservoir, north to Goldfield Drive. Currently, the property through which the low flow passes is owned by the Fountain Valley School. A 50-foot right-of-way or easement would be adequate for the trail and low flow channel through the School property.

Reach 5 - Big Johnson Reservoir to Powers Boulevard

The preliminary design concept for this reach relies upon detention and water quality basins to provide the long-term maintenance of stormwater runoff rates and water quality within Big Johnson Reservoir basin. Specifically, Sub-alternative 1 (discussed in the previous section) has been determined to be the preferred detention/water quality plan in Reach 5. Big Johnson Reservoir, owned and operated by the Fountain Mutual Irrigation Company, has lost a considerable amount of storage volume due to sedimentation. Land development activities can increase sedimentation rates if erosion control facilities are not constructed. Water quality ponds above the Big Johnson Reservoir, in combination with the stringent enforcement of County Erosion Control standards, are proposed to manage impacts of sedimentation as the area develops. For the purposes of this report, the water quality volume has been sized for each detention basin using the methodology contained within Appendix A of this report. The methodology is based upon an analysis of rainfall data for the Peterson Air Field rain gage. This methodology is currently being used by the Urban Drainage and Flood Control District (UDFCD) for the sizing of water quality basins.

The length and breadth of the ponds have been sized to facilitate the dropping out of an assumed predominant sediment size of .01 millimeters and greater. In the long term, when the areas tributary to the Big Johnson Reservoir have been fully developed and stable drainageway constructed, the functioning of the water quality ponds will be less impacted by sedimentation and impacted to a greater degree by the urban pollutants conveyed in the runoff.

There is a potential that the basins shown on the plans will develop a permanent pool. This has a distinct advantage over dry ponds with respect to the removal of suspended sediments. In general, a "wet" basin will have a greater removal rate over a relatively shorter period of time in comparison with a "dry" basin. However, the basins shown on the plans have been sized assuming a dry basin, and therefore the estimated storage volume is considered to be conservative for the purposes of this planning study. Clearing or dredging of the basins can be facilitated primarily within the forebay. A dewatering system has also been proposed for maintenance purposes. The frequency