

BEAR CREEK
DRAINAGE BASIN PLANNING STUDY
LETTER OF PERMISSION
SUBMITTAL
VOL III

Kiowa Engineering Corporation

BEAR CREEK
DRAINAGE BASIN PLANNING STUDY
LETTER OF PERMISSION
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Vol III

Prepared for:

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I. STUDY AREA DESCRIPTION

Location

The Bear Creek Drainage Basin lies in the southwestern portion of Colorado Springs, El Paso County, Colorado. The general location of the basin is shown on Figure 1. Bear Creek is the major drainageway for the basin, flowing in an easterly direction and entering Fountain Creek approximately one-quarter of a mile downstream of the US-24 bridge over Fountain Creek. Portions of the basin lie within Teller County. Approximately two-thirds of the basin lies within the Pike National Forest.

The Bear Creek Basin has two distinct basins, typified by an upper mountain watershed above Gold Camp Road, and a foothills basin below Gold Camp Road. Above Gold Camp Road the watershed is very mountainous and steep, and with the majority of the watershed heavily wooded with pinon pine and juniper. Below Gold Camp Road the basin has a mix of open space, commercial, and residential development. The open space areas are mostly park, and steep hillsides covered with pinon, scrub oak, and juniper. Total area covered by the basin is approximately 10.7 square miles. The average stream slope along Bear Creek is nine percent above Gold Camp Road and two to five percent below Gold Camp Road.

The Drainage Basin Planning Study (DBPS) focused primarily upon the long-term stormwater management of the basin, particularly within the lower basin. Presented on Figure 2 are the planning reaches delineated for the purposes of alternative evaluation.

Environmental Overview

An environmental review of the 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 taken into consideration in the planning of major drainageway facilities. A description of the existing environmental setting follows.

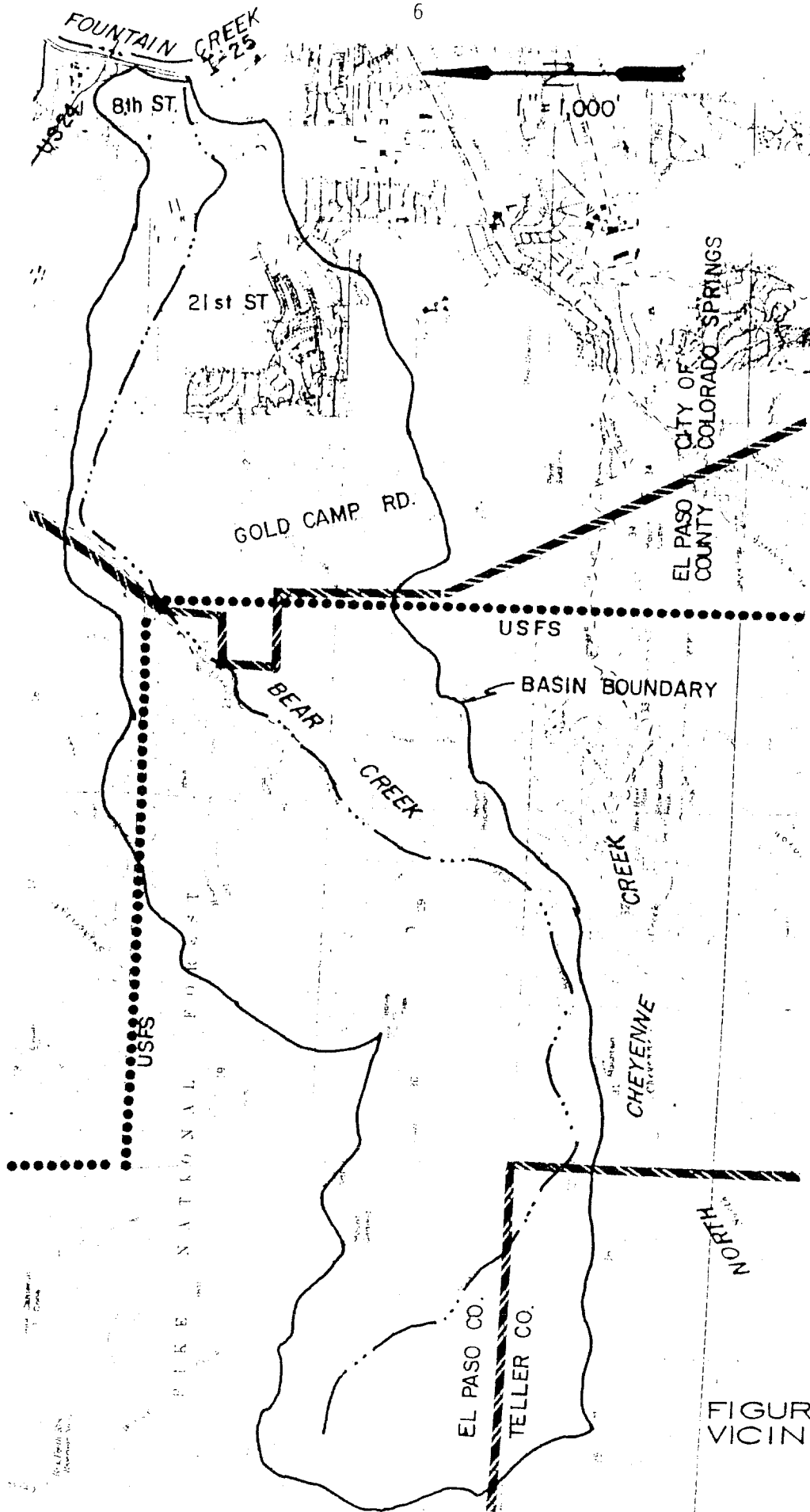
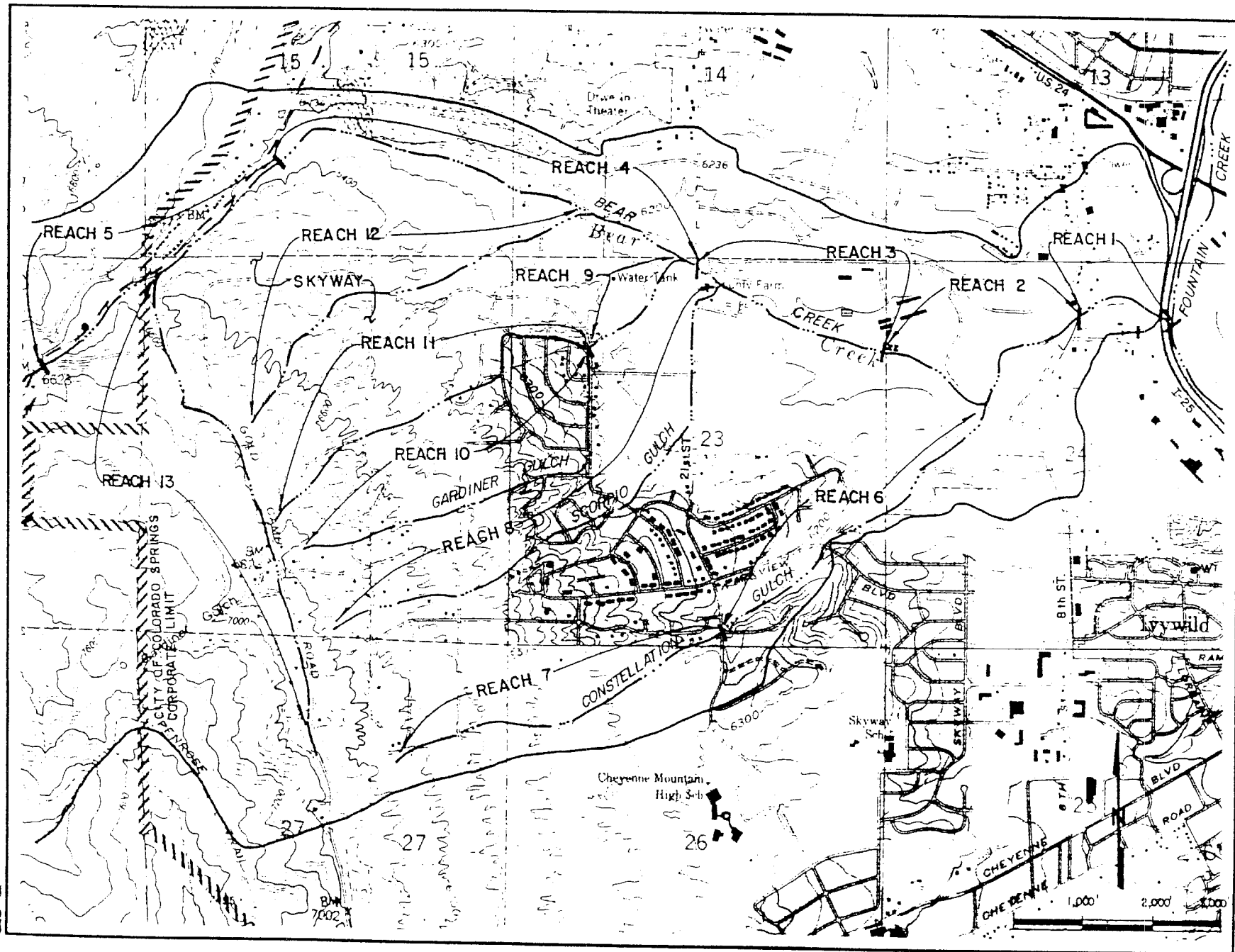


FIGURE 1
VICINITY MAP



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BEAR CREEK DRAINAGE
 BASIN PLANNING STUDY
 REACH DELINEATION MAP

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FIG2

The Bear Creek drainage is located in the foothills and lower mountains to the west of downtown Colorado Springs. The upper drainage basin is within the Pike National Forest and has montane forest and drainages. These montane areas are heavily forested with fir and ponderosa pine trees with scrub oak and junipers on the understory. The forested areas act to control runoff from the upper Bear Creek watershed to a low rate compared to the lower areas of the basin. The study area in the lower drainage basin is within the city limits. Elevations in the study area are at about 5920 feet at the confluence of Bear Creek with Fountain Creek to about 7500 feet at the corporate limits. Within the upper basin, the watershed rises to 11,000 feet.

The topography in the study area is complex and steep in the upper portion to moderately flat in the east, nearer the city. The Bear Creek main channel is confined to a narrow floodplain and is somewhat incised. The vegetation and habitat types are also varied from dry grasslands, scrub, and forests to riparian and subirrigated wetlands. Wildlife species are a mixture of woodland, riparian and forest types at this boundary between the mountains and plains habitats.

Land uses in the lower basin consists of housing and commercial, open space with parks, playing fields, and bridal paths for horseback riding. The land use or vegetation types and associated habitats are listed and described as follows.

Residential/Commercial: Development for housing and commercial businesses are throughout the drainage basin study area. Businesses and a riding stable are concentrated in eastern flat areas, while housing lots are developed on the slopes to the west and up to the National Forest boundary. The parks are maintained mostly as open space and natural areas and are mapped into respective vegetation types.

Grasslands: Open grasslands occur scattered on the dry lower portions of the study area and as small open areas on the upper ridges in the foothills. The grasses are mostly low species of blue grama and western wheatgrass with scattered shrubs and yucca. These grasslands are in fair to good condition due to protection from grazing and other disturbances at the present time. These are small isolated areas of plains habitat cut off from the extensive plains to the east by the City of Colorado Springs.

Pinon-Juniper and Scrub: These areas occur on the upper foothills slopes and north-facing slopes at lower altitudes. The principal plant species are pinon pine and juniper with shrubs of mountain mahogany, scrub oak, and buckbrush. There is an occasional ponderosa pine and Douglas fir scattered in this type, and an understory of grasses and forbs common in the grassland. This is a foothills scrub habitat that has been impacted by housing developments.

Ponderosa Pine Foothills Forest: These open forest occur on north-facing slopes in the foothills and canyons in the study area. There is secondary cover by Douglas fir with understory shrubs of mountain mahogany, snowberry, and oak. This is foothills forest habitat also with some housing development.

Riparian: There is a mixed riparian forest and shrub zone along Bear Creek and tributaries on the floodplain and lower moist slopes. The trees are cottonwood, Douglas fir, ponderosa pine, and with shorter trees and shrubs of willow, alder, scrub oak, snowberry, and mountain mahogany. There is a good ground cover of grasses, sedges, vines, and forbs that grow on the floodplain and lower slopes. This is a riparian habitat type common along streams and drainage throughout the region and is in good condition due to protection and preservation in the parks. The lower portion of the riparian zone near Fountain Creek has been disturbed by commercial development.

Wetlands: Subirrigated wetlands occur in the flat lower drainages that are wet throughout most of the growing season and have typical wetlands plants. These plants include baltic sedge around the drier perimeters with sedges, rushes, and cattails in the wetter interior of the wetlands. This type is well developed in the areas just south and west of Penrose Stadium across Bear Creek. The wetlands along Bear Creek are small and not well developed since the creek is incised and does not have large flat areas next to the channel. The Bear Creek corridor is a productive wetland habitat type in good condition, but covers a small area in the total drainage area. The wetlands have been recently designated for restriction of human and horse access. Two small wetlands exist within Bear Creek Park off of the main stream, which are apparently supported by a groundwater source.

The Colorado Division of Wildlife was consulted for animal species in the Bear Creek Drainage. Most of the information is from their surveys recorded in the Wildlife Resource Information System with some field observations during these surveys. Portions of the study area is within or adjacent to the Pike National Forest, so the whole drainage is described for animal species. Common large animals and herbivores are the white-tailed and mule deer at lower elevations, black bear and elk in

the upper drainages. Other mid-sized and smaller animals include the beaver, coyote, skunks, badger, Abert's squirrel, rabbits, and smaller rodents. The area is listed within the overall range of bald eagles, band-tailed pigeon, golden eagle, and the peregrine and prairie falcons, which have active nests in the upper basin west of the study area. The area has occasional use by waterfowl such as ducks and geese but there are no large bodies of water to attract them. Smaller birds use the area for nests and foraging, especially the wetland and riparian habitats.

The most sensitive areas in the study area are the riparian and wetland habitats, generally found within the floodplain. These areas have the most diverse plant communities and use of habitats by wildlife and other animal species. At the present time these two types are well protected except where already disturbed or developed.

For purposes of analyzing an alternative's relative impact upon the riparian and wetland habitats (i.e., net gains or losses in acreage), the 100-year floodplain was considered to be the primary area where sensitive riparian habitats exist within the lower basin. A tabulation of the floodplain acreage by planning reach for Bear Creek and Constellation Gulch follows. The total floodplain/riparian is 57.2 acres. The wetland zone along Bear Creek averages 20 feet wide throughout the lower basin. This is the low flow channel area, and has a constant base flow which supports the wetland vegetation adjacent to and within the creek bed. For the lower basin, approximately 9 acres of wetland habitat exists along the low flow area of the Bear Creek the drainageway. This represents approximately 16 percent of the floodplain/riparian acreage along the major drainageways.

Table 1. Major Drainageway Floodplain and Riparian/Wetland Characteristics.

Planning Reach	Floodplain Acreage	Quality	Existing Condition
1	2.2	Low	Floodplain confined to riprap channel. Wetland shrubs limited to thalweg of channel.
2	7.6	Low-Fair	Natural channel diverted through Penrose Stadium area. Bank and invert degradation has adversely impacted wetland/riparian zones along low-flow.
3	9.9	Fair-High	Natural stream section altered at road and trail crossings within Bear Creek Park. Riparian areas managed for park uses.
4	11.1	High	Natural stream relatively unaltered. Through park, some disturbances at storm sewer outfalls. Access to creek limited to foot paths.
5	4.6	High	Creek altered adjacent to Bear Creek Road. Access to creek limited to foot paths.
6 Constellation Gulch	21.8	Fair-High	Mostly riparian. No base flow exists along Constellation Gulch. Riparian areas all within Bear Creek Park.

No measurements of wetland and riparian areas were made within Reaches 7 through 13. Field observations revealed that there was little evidence of vegetation, baseflows, or soils which are associated with wetlands. The riparian zones within these reaches are mostly the scruboak, juniper forests which typify the foothills, and mountain zones of the basin. These reaches are subdrainages, and relatively undeveloped and unaltered.

A general description of each reach follows:

Reach 1 Bear Creek, STA 0+00 to 21+00: In this reach the channel is a 10- to 20-foot bottom in width and a 2:1 riprap slope on the north bank. The south bank is mainly 3:1 grass with patches of riprap. The invert is rocked through the lower one-half of the reach, and sandy in the upper one-half of the reach. Willows line the invert for the majority of the reach. The floodplain has split flow due to overtopping of the culvert at 8th Street. Replacement of the 8th Street culvert would allow the flow to remain in the existing channel. One hundred year flow depths range from six- to eight-feet and velocities from 11 to 13 feet per second. A constant baseflow exists within this reach.

Reach 2 Bear Creek, STA 21+00 to 54+00: The channel (STA 21+00 to 26+00) is deeply cut with steep, unprotected eroding banks. Many large cottonwoods line the edge of the low flow channel. The floodplain is approximately 40- to 100-feet wide. The 100-year depth is 9-feet with velocities ranging from 9 to 12 feet per second. The channel has sufficient capacity to carry the 100-year flow, but further bank and invert erosion could occur. Bedrock outcrops have been noted in several locations, which has halted the degradation of the invert.

The channel section from STA 26+00 to 54+00 is narrow, deep and with unvegetated eroding banks; and has been diverted from its historic path. The floodplain is split in this segment with overflows moving east along the historic channel path through the

stadium parking lot. The floodplain along the primary channel is 30- to 50-feet wide, nine to ten-feet deep, and flow at 12 feet per second. Further erosion could occur in this reach as the channel invert drops due to low flow degradation. A constant baseflow exists within this reach.

Reach 3 Bear Creek, STA 54+00 to 85+50: The lower portions of Reach 3 (from STA 54+00 to 78+00) is an undisturbed wide channel, lined with a moderate number of cottonwoods and other vegetation. The floodplain is 80- to 200-feet wide, flowing four to seven-feet deep, and has velocities ranging from 8 to 11 feet per second. In the upper portion of this reach (from STA 78+00 to 85+50) a split flow occurs causing a wide floodplain through the Park area. Near 21st Street the main channel has been narrowed to a very small section and lined with a vertical concrete wall and rocks. A trail crossing exists in the north bay of the culvert. Bank and invert erosion exists at the outlet of the 21st Street culvert, and along the low flow areas of the creek east of Creek Crossing Road. A constant baseflow exists within this reach.

Reach 4 Bear Creek, STA 85+50 to 155+00: This reach is a natural, undisturbed reach of Bear Creek flowing predominantly through Bear Creek Regional Park. A few low flow trail and road crossings are located in this reach. The vegetation in the channel is heavy. The floodplain is 30- to 150-feet wide and flows three- to six-feet deep and seven to ten feet per second. Due to the heavy vegetation in this reach, stream bank erosion is minimal. No habitable structures are within the 100-year floodplain. A constant baseflow exists within this reach.

Reach 5 Bear Creek, STA 155+00 to 190+00: This reach is more typical of a mountain stream. It is in a steep, narrow rocky canyon with a two-lane paved street located on the north bank of the channel (Bear Creek Road). A high quality riparian zone lines the creek. It appears the road has encroached into

the historic drainageway. Several private wood bridges span the creek, and are all generally less than 100-year capacity. The floodplain ranges from 30- to 15-feet wide and has depths from four- to five-feet deep, and velocities of seven to ten feet per second. The channel slope is about 4.5 percent. A constant baseflow exists within this reach.

Reach 6 Constellation Gulch, STA 0+00 to 55+00: The existing channel is a natural drainageway. The upper 3000 feet and the bottom 1000 feet are steep, narrow, eroding channels. The middle 1500 feet is a wide, flat and well-vegetated drainageway. Within Bear Creek Park, the floodplain is 20- to 250-feet wide with depths from 0.5 to five-feet and velocities of four to nine feet per second. Low flows have caused erosion of the invert, and bank sloughing, particularly the outlet of storm sewers. The condition of the existing channel is particularly degraded downstream of the Cresta Drive and Parkview Boulevard crossings. No baseflow exists within this reach.

Reach 7 Constellation Gulch, STA 55+00 to Gold Camp Road: This reach of Constellation Gulch is from Cresta Road along Constellation Drive to Gold Camp Road. In the lower one-third of this reach, from Cresta Drive to Taurus Road, the road forms the invert of the drainageway. Most of the residences abutting Constellation Drive have been constructed below street grade. Sediment and runoff in amounts greater than the street section capacity will move overland through private lots. Structural damage is not expected to occur, however, damage to landscaping and roadside ditches could occur. The drainageways within this reach are largely natural and unimproved.

Reach 8 Scorpio Gulch: This reach begins at Bear Creek STA 79+00, and crosses through Bear Creek Park in a southwesterly direction. South of the park boundary Scorpio Gulch crosses Orion Drive and onto Scorpio Drive. At the intersection of Scorpio Drive and Polaris Drive, Scorpio Gulch is confined by a

steep ravine passing through the Skyway Heights Subdivision. No storm drainage systems exist. The upper ravine(s) is moderately vegetated, and some invert degradation has occurred.

Reach 9: The Orion Drive storm sewer outfall system runs from Bear Creek (STA 90+00), southwest through the park along the existing diversion channel to the low point in Orion Drive. This system outfalls via an 84-inch reinforced concrete pipe (RCP). Local storm drainage has overtopped the existing ditch, and has caused debris and siltation within Bear Creek Park. No defined channels exist in this reach.

Reach 10: Gardiner Gulch runs from Orion Drive to Gold Camp Road. This reach includes the Orion Drive south storm sewer system. At the terminus of the storm sewer system, Gardiner Gulch is within a steep ravine similar to Scorpio Gulch. Bank and invert degradation has occurred in this segment. The gulch is generally dry except during periods of heavy rain. Several detention ponds exist on Gardiner Gulch within the Skyway Heights Subdivision. These ponds are of small capacity, and adversely impacted by frequent siltation. The storm sewer within Orion Drive are of sufficient capacity to contain the 100-year flows.

Reach 11: Orion Drive North runs from Orion Drive west to Gold Camp Road. A proposed storm sewer within Orion Drive running west to Southern Cross will collect storm runoff from the Skyway Heights Subdivision. The upper portions of this reach consist of steep ravines, densely to moderately vegetated with no baseflow.

Reach 12: Skyway Gulch runs from Bear Creek (STA 103+00) westerly up through 2200 feet of 60-inch and 72-inch CMP to the east boundary of the Skyway Northwest Subdivision. Surface overflows would follow the historic drainage path which passes through the County Park and private undeveloped land. Above the storm sewer system, Skyway Gulch is a series of dry, steep

ravines. Sediment deposition has caused local damages near residences within the Skyway Subdivision.

Reach 13: This reach is the Gold Camp Road diversion. It begins at Bear Creek (STA 180+00) and then south through a narrow steep rocky drainageway at an 11 percent slope for about 1800 feet. This first segment is located within the Bear Creek City Park. After crossing under Gold Camp Road a natural depression created by the Gold Camp Road embankment can store approximately ten acre feet until the road would be overtopped. From this point, runoff is conveyed by a roadside ditch along the west side of Gold Camp Road. This reach is sparsely vegetated except at the confluence with Bear Creek.

II. DEVELOPMENT OF ALTERNATIVE PLANS

Introduction

Alternative drainageway improvement concepts have been examined that address the existing and future stormwater management needs of the basin. Alternatives have been identified for each reach of the basin 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 eventually implementation.

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

1. Identify stormwater facilities which may 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 and sedimentation from disturbed 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. Identify facilities which will minimize future operations and maintenance costs; and
5. 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.

Evaluation Parameters

Coordination meetings were held throughout the study to address overall goals and specific concerns of those governmental agencies, individuals, and private community groups asked to participate in the study. One result of this coordination effort

was the development of the following list of parameters which were considered when evaluating an alternative.

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

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 review of the rankings received from the interested agencies and individuals revealed that preservation of existing vegetation, flood control, land use and open space, and erosion control were the more important parameters within the Bear Creek Basin. During the field meeting with representatives from the U.S. Army Corps of Engineers (COE), the Environmental Protection Agency (EPA), and the Colorado Division of Wildlife, subsequent to the evaluation parameter ranking, the importance of the park setting and the riparian areas was again verified. Creek stabilization and floodplain preservation were identified as possible alternatives within the Bear Creek Park. Within the urban areas, a higher ranking of erosion and flood control was indicated in the evaluation parameter ranking. This is primarily because of the erosive soils in the undeveloped upper reaches, which have caused private property to be impacted by sediment being forced out of the street section and onto private property. Site specific erosion control measures combined with local storm sewer systems would probably be effective in addressing these types of problems.

Preliminary Matrix of Alternatives

The alternative planning process began with the evaluation of general drainageway planning alternatives. Alternatives examined for each reach were:

1. Floodplain preservation, with grade control
2. Channelization,
3. Detention, on-site or regional,
4. Diversion between sub-basins, and
5. Closed conduits.

A general description of each concept follows:

Floodplain Preservation: This concept involves the preservation of the existing 100-year floodplain and creek in the same cross-section as currently exists. Localized bank improvements and grade control structures are necessary along the major drainageways and at confluence with tributaries. This concept represents the least disturbance to the vegetative and wildlife habitats which exist along the planning reaches. Concept not applicable in Reaches 7 through 13.

Channelization: In an effort to reduce floodplain widths, channelization was analyzed. Channelization could be accomplished for the full 100-year discharge, or a lesser peak discharge (i.e., the 10-year flow). Materials examined included grasslined and riprap bank linings with natural inverts. Extensive numbers of drop structures and grade controls are required for a grasslined channel alternative in order to reduce velocities to 7 fps or less. Applicable in all reaches except where adequate storm sewer and street capacities exist (i.e., Reaches 7 through 12).

Detention: Detention was examined to determine if reduction in the peak discharges could reduce flooding problems and channel sections downstream of such detention basins. Detention can also be used to enhance the runoff water quality within the watershed by incorporating permanent pools and wetland areas. Two detention concepts were examined: (1) on-site detention which uses ponds storing less than 10 acre-feet, and controlling areas less than 1/4-square mile, and (2) regional detention which incorporates larger basins storing up to 50 acre-feet.

Diversion: This concept utilizes the diversion of runoff from one point within the basin in which facilities are not capable of safely conveying runoff to a point where facilities are adequate. This concept is most applicable within sub-basins where urbanization has blocked the historic path. For the Bear Creek Basin, only Reach 13 was identified where a portion of the total flow could be diverted in order to relieve localized flooding problems downstream. This concept has little impact upon the total flow received by the major drainageways within the Basin.

Closed Conduits: Closed conduits are mostly feasible with the urbanized areas, where surface flows can be conveyed to a street system and then picked by a storm sewer using inlets and catch basins. This concept is usually most practical for conveying runoff for less than the 10-year frequency. This concept is not economically practical along major drainageways where flows exceed 500 cfs for the 10- or 100-year frequencies. Reaches 7 through 12, and a portion of Reach 13, were only reaches where closed conduits are feasible.

Summarized on the following tables are assessments of each concept by reach, along with an estimated of wetland/riparian area impacts and mitigation possibilities. In general, floodplain preservation was determined to be the most feasible concept since the major drainageways are relatively unencroached, lie within park or other dedicated open space, and no habitable structures are currently within the 100-year floodplain. This summary has focused on Reaches 1 through 6 primarily because the majority of the riparian and wetland zones which exist lie within these reaches. Additionally, Reaches 7 through 13 are dry subdrainages and are not anticipated to be altered in the future by development or through the construction of lined channels.

 BEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
 KIDWA ENGINEERING CORPORATION

REACH NUMBER: 1

STATION: 0+00 to 21+00

ALTERNATE	RELATIVE ADVANTAGES/ DISADVANTAGES	MITIGATION REQUIREMENTS
FLOODPLAIN PRESERVATION	Ad: floodplain narrow and con- fined to ex. channel no habitable structures within 100-yr floodplain Dad: overflow area east of 8th street negatively impacts development of property on north overbank	Localized bank im- provements needed at and grade controls needed to protect ex- isting riprap and native grass linings. Wetland shrubs along toe of existing rip- rap banks could be preserved.
CHANNELIZATION RIPRAP	Ad: Provides for more stable bank slopes than currently exists Dad: Natural grasses and shrubs to be lost	Riprap banks needed where unlined banks now exist. Willows along toe of channel should be designed into channel section.
LOW FLOW STAB & FLOOD PLAIN PRESERVATION	Ad: Less costly than full chan- nelization. Dad: Unlined banks above low flow area subject to ero- sion damage.	Willows along channel bottom could enhance vegetative habitat of this reach and pro- vide for stable low flow area.
RETENTION ON-SITE	Ad: Source pollutants from the adjacent developable lands could be controlled Dad: Little impact in peak flow reduction to drainageway	No impact upon vege- tative habitat in this reach.
RETENTION REGIONAL	Ad: Slight reduction in peak flows afforded by region- al pond(s) in upper reaches Dad: No sites available.	No impact upon vege- tative habitat in this reach. No sites in this reach.
DIVERSION	Not applicable in this reach	
CLOSED CONDUIT	Not applicable or economically feasible within this reach	

 BEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
 FLUMA ENGINEERING CORPORATION

REACH NUMBER: 2

STATION: 21+00 to 54+00

ALTERNATE	RELATIVE ADVANTAGES (Ad) / DISADVANTAGES (DAd)	MITIGATION REQUIREMENTS
FLOODPLAIN PRESERVATION	Ad: Riparian areas along creek would not be disturbed Preserves park/open space setting No habitable structures in 100-year floodplain DAd: Overflow through stadium parking areas in 100 yr. Utilities within overflow negatively impacted	Low flow channel im- provements and se- lective bank lining needed to protect ex- vegetation along creek. Trees lost to bank lining a/o grade control const. could be replaced at top of banks.
CHANNELIZATION RIPRAP	Ad: 100-year channel would eliminate overflow in stadium parking areas DAd: Riprap banks would de- grade appearance	Loss of trees due to bank const. could be replaced along top of banks for no net loss Grade controls along invert could restore wetland vegetation
LOW FLOW STAB & FLOOD PLAIN PRESERVATION	Ad: Native grasses and natural side slopes could enhance channel appearance in park Disturbance to existing veg- etative habitat minimal DAd: Overflow in stadium parking area not eliminated.	Willows and trees on banks could replace a/o enhance vegeta- tive habitat along creek low flow
DETENTION ON SITE	Ad: Source pollutants from de- velopable lands within the reach could be controlled DAd: No impact upon peak flows	No impact to habitat in this reach.
DETENTION REGIONAL	Ad: Slight reduction in peak flows afforded by detention in upstream reaches DAd: No sites available	No impact to habitat in this reach.
DIVERSION	Not applicable in this reach	
CLOSED CONDUIT	Not applicable in this reach	

PEAK CREEK DRAINAGE BASIN PLANNING STUDY
SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
CLOWA ENGINEERING CORPORATION

STATION: 54+00 to 95+50

MITIGATION
REQUIREMENTS

Localized bank and invert improvements needed to protect riparian vegetation. Habitat lost to this work could be replaced with trees and shrubs on overbanks.

Willows within inventory could offset a portion of habitat lost to bank const. Barred riprap could offset poor visual appearance of banks. Trees within limits of banks could be replaced for no net loss of habitat.

Loss of trees due to bank grading can be mitigated for by replacing trees within flood plain and willows within invert

No impact to habitat
in this reach.

No impact to habitat
in this reach.

Not applicable in this reach
Not applicable in this reach

 BEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
 KIDWA ENGINEERING CORPORATION

REACH NUMBER: 4 STATION: 85+50 to 155+00

ALTERNATE	RELATIVE ADVANTAGES (Ad)/ DISADVANTAGES (DAd)	MITIGATION REQUIREMENTS
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FLOODPLAIN PRESERVATION	Ad: Preserves open space through Park areas No habitable structures in 100-year floodplain	Channel is stable ex- cept at tributary outfall areas. Vegeta- tion disturbed by localized bank lining could be replaced or protected.
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CHANNELIZATION RIPRAP	DAd: Riprap bank construction would disturb large area of high quality habitat Construction and mainten- ance access limited Costly Disruptive to habitat	Willows within invert could replace a por- tion of the vegetation disturbed by bank con- struction. Trees lost along riprap banks could be replaced in Reach 1 or 2.
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LOW FLOW STAB & FLOOD PLAIN PRESERVATION	Ad: Preserves riparian and wetland vegetation. Provides for erosion protection along low flow areas.	No net loss of habitat. Willows placed at checks and along low flow will stabilize creek bed.
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DETENTION ONSITE	DAd: No areas of extensive urban development trib- utary to this reach which would require on- site detention antici-	No impact to habitat in this reach.
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DETENTION REGIONAL	DAd: Limited availability of sites of suitable size exist which would cause a significant reduction in peak discharges	Site upstream of 21st street could be feasi- ble. Habitat dis- turbed by construction of detention basin could be replaced in detention pond invert.
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DIVERSION	Not applicable in this reach	
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CLOSED CONDUIT	Not applicable in this reach	
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 BEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
 KIOWA ENGINEERING CORPORATION

REACH NUMBER: 5 STATION: 155+00 to 190+00

ALTERNATE	RELATIVE ADVANTAGES (Ad) / DISADVANTAGES (Dad)	MITIGATION REQUIREMENTS
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FLOODPLAIN PRESERVATION	Ad: Preserves open space through Park areas Two habitable structures in 100-year floodplain	Localized riprap bank linings re- quired along Bear Creek Road. Large trees could be a- voided. Willows al- ong toe of improved banks could enhance habitat within low flow areas.
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CHANNELIZATION RIPRAP	Ad: Riprap channel of 100- year capacity could pro- vide higher level of protection to private residences Dad: Capacity of improved channel limited by private bridges over Creek which are not planned to be replaced	Riprap channel con- struction would re- quire that riparian habitat be replaced in downstream chan- nel reaches.
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LOW FLOW STAB & FLOOD PLAIN PRESERVATION	Ad: Preserves existing wetland and riparian habitats Provides for erosion pro- tection along low flow	Temporary dis- turbances only. Vegetation to be preserved.
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DETENTION ONSITE	Dad: No areas anticipated to ur- banize which are tributary to this reach	None required. Al- ternative not prac- tical in this reach.
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DETENTION REGIONAL	Dad: No sites available in this reach along Bear Creek Flows at historic levels and not projected to increase in future	None required. Al- ternative not prac- tical in this reach.
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DIVERSION	Not applicable in this reach	
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CLOSED CONDUIT	Not applicable in this reach	
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 BEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF ALTERNATE DRAINAGEWAY IMPROVEMENT CONCEPTS
 KIDWA ENGINEERING CORPORATION

REACH NUMBER: 6 (CONSTELLATION GULCH) STATION: 0+00 TO 55+00

ALTERNATE	RELATIVE ADVANTAGES (Ad)/ DISADVANTAGES (DAd)	MITIGATION REQUIREMENTS
FLOODPLAIN PRESERVATION	Ad: No habitable structures in 100-year floodplain DAd: Above Parkview Boulevard, channel severely degrading and causing bank sloughing and resulting degradation of water quality downstream	Vegetation dis- turbed by local- ized invert and bank const. could be replaced along low flow and on overbanks resulting in no net loss.
CHANNELIZATION RIPRAP	Ad: In combination with grade control structures, riprap channel could stabilize banks and reduce erosion DAd: Within Park area, riprap channel could degrade vis- ual appearance of Park	Buried riprap and introduction of willows at the toe of riprap banks could result in no net loss of habitat
LOW FLOW STAB & FLOOD PLAIN PRESERVATION	Ad: Better visual appearance through Park areas in comparison to riprap channel alternative DAd: Number of drop and grade control structures dou- bled in comparison to riprap channel	Plantings of native grasses, trees and shrubs could offset habitat loss due due to const. Above Parkview, plantings could re- store habitat which has been damaged by erosion.
DETENTION ONSITE	Ad: Source control of pollutants afforded through onsite de- tention DAd: Basin substantially deve- loped; no sites available Maintenance of onsite ponds of concern to City	No impact to habi- tat in this reach.
REGIONAL	DAd: No sites available large enough to reduce flows to downstream reaches	None required. al- ternative not fea- sible in this reach.
DIVERSION	Diversion not feasible in this reach	
CLOSED CONDUIT	Ad: Low flows could be controlled DAd: High cost of construction	No impact upon habitat if surfaces restored.

 DEAR CREEK DRAINAGE BASIN PLANNING STUDY
 SUMMARY OF SELECTED DRAINAGEWAY IMPROVEMENT CONCEPTS

REACH NUMBER	SELECTED OR PREFERRED DRAINAGEWAY TREATMENT	MITIGATION SUMMARY	COMMENTS
1	ALT 2A: RIPRAP CHANNEL Riprap bank linings, buried and unburied, in combination with grade control and drop structures 12-foot multiple use trail provide at top of channel bank.	Wetland shrubs to be replaced wherever disturbed. New riprap linings to be stabilized at toe using native willow species.	NO NET LOSS OF HABITAT. 1000 LINEAL FEET OF WETLAND SHRUBS GAINED ALONG TOE OF RIPRAP BANKS
2	ALT 2B: LOW FLOW STABILIZATION Riprap low flow channel (10-year maximum capacity), in combination with grade control and drop structures, and vegetated overbanks. Proposed habitable structures to be elevated to one-foot above 100-year water surface, and/or flood proofed.	Riparian areas in floodplain to be preserved. Vegetation disturbed to be replaced. Wetland shrubs to be placed at grade/drops and along low flow.	NO NET LOSS OF HABITAT. TEMPORARY DISTURBANCES DURING CONSTRUCTION.
3	ALT 2B: LOW FLOW STABILIZATION Selected riprap bank linings and low flow channel stabilization, in combination with grade controls at erosion prone locations along the creek low flow area. Proposed habitable structures to be elevated to one foot above 100-year flood plain, and/or flood proofed.	Wetland shrubs to be placed at toe of riprap banks and at grade controls. Vegetation disturbed to be replaced with native species.	SAME AS REACH 2
4	ALT 2B: LOW FLOW STABILIZATION Same as reach 3. Construction of habitable structures should be restricted within 100-year flood plain.	Same as Reach 3	SAME AS REACH 2
5	ALT 2B: LOW FLOW STABILIZATION Same as Reach 4	Same as Reach 3	SAME AS REACH 2
6	ALT 2A: RIPRAP CHANNEL 10-year capacity low flow channel above Parkview Boulevard. Flood plain preservation below Parkview Boulevard. Grade control and drop structures sited throughout reach.	Below Parkview, native vegetation to be preserved and replaced as required to stabilize low flow. Above Parkview, overbanks to be revegetated using native species	VEGETATION ALONG INVERT MAY BE STORED AS A RESULT OF THE GRADE CONTROLS. BANK EROSION REDUCED THEREBY ENHANCING BASIN WATER QUALITY.

III. DESCRIPTION OF SELECTED ALTERNATIVE

Alternative drainageway improvement concepts have been examined that address the existing and future stormwater management needs of the basin. As a result of the planning process, and correspondence with the interested agencies and individuals, a preliminary design plan has been developed for the major reaches of the Bear Creek basin. A brief description of proposed improvements by reach follows:

Reach 1 (0+00 TO 21+00): The selected improvements for this reach includes drop structures and riprap bank linings beginning at the confluence with Fountain Creek to approximately 600 feet upstream of the 8th Street bridge. Bank linings would consist of buried and unburied rock riprap extending to at least one foot above the 100-year water surface. Grade controls would be vertical concrete structures with a maximum height of three feet. Three existing slope drops would remain in place. Willows would be planted along the toe of the riprap bank linings and at the crests of the grade control structures in order to further stabilize the channel. New bridges are proposed at Eighth Street and at proposed Fountain Boulevard. These structures would be clear span and would be constructed to allow for trail crossings to pass beneath them. Along the top of the riprap linings, plantings of trees and shrubs could be considered. With the preservation of the existing willows and the possible planting of additional wetland shrubs along the invert, an increase in vegetative habitat would result. Approximately 900 lineal feet of willows aligned along the toe of the riprap banks would be gained by implementing this alterantive. With the construction of the bridge at Eighth Street, the shallow flooding situation would be eliminated.

Reach 2 (21+00 to 54+00): The preferred channel section within this reach is a low flow riprap stabilized channel combined with grade control and drop structures. The riprap linings would extend to approximately the ten-year water surface

level. As in Reach 1, willows and wetland shrubs are to be preserved and/or planted along the toe of the riprap slopes and at drops and grade controls. This vegetation, once mature, will protect invert from being degraded by the low flows in the Creek. The 100-year flood plain would be slightly reduced from the existing condition however flooding in the Penrose Stadium parking areas would still occur for flows exceeding the 10-year discharge. Construction of the channel and drops should be performed in such a way that disturbances to the existing riparian vegetation is minimized. Because the invert of the existing channel is severely degraded at this time, the introduction of the grade control and drop structures should help to preserve the existing vegetation and protect large trees from being undermined. Trees lost to the construction will be replaced by native species. Maintenance access to the low flow channel will be provided via the parking areas. A 10-year capacity culvert at the parking lot entry road is proposed in this Reach.

Reach 3 (54+00 to 85+50): The preferred alternative in this reach consist of flood plain preservation in combination with selectively sited, intermittent low flow riprap banks, low flow channel and drop structure improvements. These improvements would act to stabilize the low flow area of the Creek, however the majority of the 100-year flood plain would be preserved in roughly the same location(s) as it exists today. The low flow area is currently heavily vegetated, with the more significant erosion problems occurring at outside bends where the low flow has undercut the existing vegetation. Trees which abut the low flow area would be protected from construction disturbances. Maintenance access to the low flow would be restricted to existing Park trails and grassed bench areas along the Creek. A new bridge is proposed at 21st Street over Bear Creek. This bridge would be larger than the existing culvert, and the 100-year flood plain would be confined to the bridge opening.

Reach 4 (85+50 to 155+00): The Creek in this Reach is currently stable, mainly because of the armoring along the low flow and the bank and flood plain vegetation. The preferred alternative is flood plain preservation in combination with selective, intermittent riprap banks linings, and grade control structures. The grade control structures have been sited just downstream of the major side drainage confluences with Bear Creek in order to limit the effects of local scour and the resulting degradation of the water quality within the basin. The construction of improvements within this reach must be carried out to limit the disturbance to the riparian habitat within the flood plain area. The 100-year flood plain would be preserved in its present location.

Reach 5 (155+00 to 190+00): The preferred alternative within this reach includes flood plain preservation in combination with riprap channel linings along the Bear Creek Road side. The riprap linings are needed to protect the roadway embankment in locations where there is little or no bank erosion protection. The trees within the floodplain would be protected and from disturbances caused by the placement of riprap. A new culvert is proposed for Bear Creek Road over Bear Creek at approximately station 190+00. The existing culverts are under capacity and in poor repair. Maintenance to the low flow area would be provided by Bear Creek Road and existing trails within Bear Creek Park. The 100-year flood plain would be preserved in its present location.

Reach 6, Constellation Gulch (0+00 to 55+00): The preferred alternative within this Reach consist of a 10-year capacity riprap channel natural invert in combination with flood plain preservation. Above Parkview Boulevard, the invert would be stabilized using native willows and shrubs and using grade control and drop structures. Within the Bear Creek Park segment of this Reach, native grasses would be restored along the floodplain wherever construction disturbances occurred. Above

Parkview Boulevard, the introduction of the drop structures will help the restore the invert to an elevation higher than currently exists, and return the drainageway to a more acceptable visual appearance.

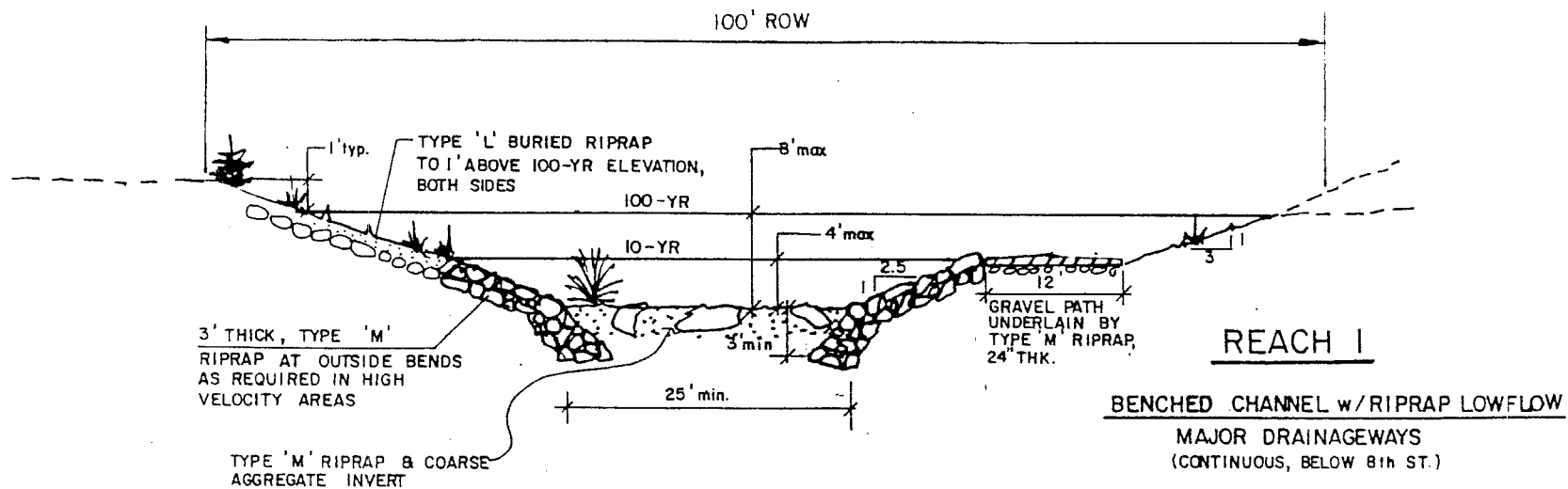
Reaches 7-12: These reaches are the smaller subdrainages which exist within the residentially developed areas of the basin. Currently, storm sewers and streets convey the majority of the runoff from the urbanized areas to the natural drainageways and steep ravines. Many of the natural drainages lie within preservation easements and have little or no access provided to them through the platted lots. The densities of the existing and proposed subdivisions are low enough that the historic flow is not significantly raised in comparison to the historic condition. The preferred improvements for the natural drainages involve localized grade control structures which can be constructed to conform with landscaping treatments used for the lots abutting the natural drainages. Outlet structures at all storm sewer outfall points have been proposed in order to reduce localized erosion which may impact the receiving drainageway(s). It is anticipated that the facilities proposed for these reaches can be constructed with minimal disturbances to the native vegetative habitat.

Reach 13: This reach is the Gold Camp Road outfall channel. The preferred improvements for this reach include the construction of a stabilized roadside ditch and storm sewer to convey runoff to Reach 6 of Bear Creek. Minimal disturbance to the native vegetation within this Reach is anticipated. Grade control structures have also been identified for this Reach in order to stabilize the roadside ditch and limit localized erosion problems.

General Discussion

Presented on the following Figures are typical sections for Reaches 1 through 6. With the exception of Reach 1, the

low flow stabilization
preferred alternative was the flood plain preservation concept. As part of this concept, native riparian and wetland areas are to be preserved. Replacement of vegetation disturbed due to the construction of the proposed improvements has been recommended in the Drainage Basin Planning Study report. Construction of improvements must take into account the limitation of access to a given site by a singular construction access road, siting of drop/check to avoid disturbances to shrubs and trees, and the replacement of grasses, shrubs, and trees with native species wherever disturbances cannot be avoided. In some reaches, stabilization of the low flow area may promote the growth of native riparian and wetland species. Overall, it is anticipated that there would be any net loss of the existing riparian or wetland habitat if the DBPS is implemented as recommended. The stabilization of the low flow area may protect existing vegetation from washouts due to invert and bank erosion. The importance of source erosion control has also been identified as being a key aspect of preserving the water quality of the Bear Creek drainageway. This will be particularly important as the development of the residential areas tributary to Reaches 7 through 12 proceeds.

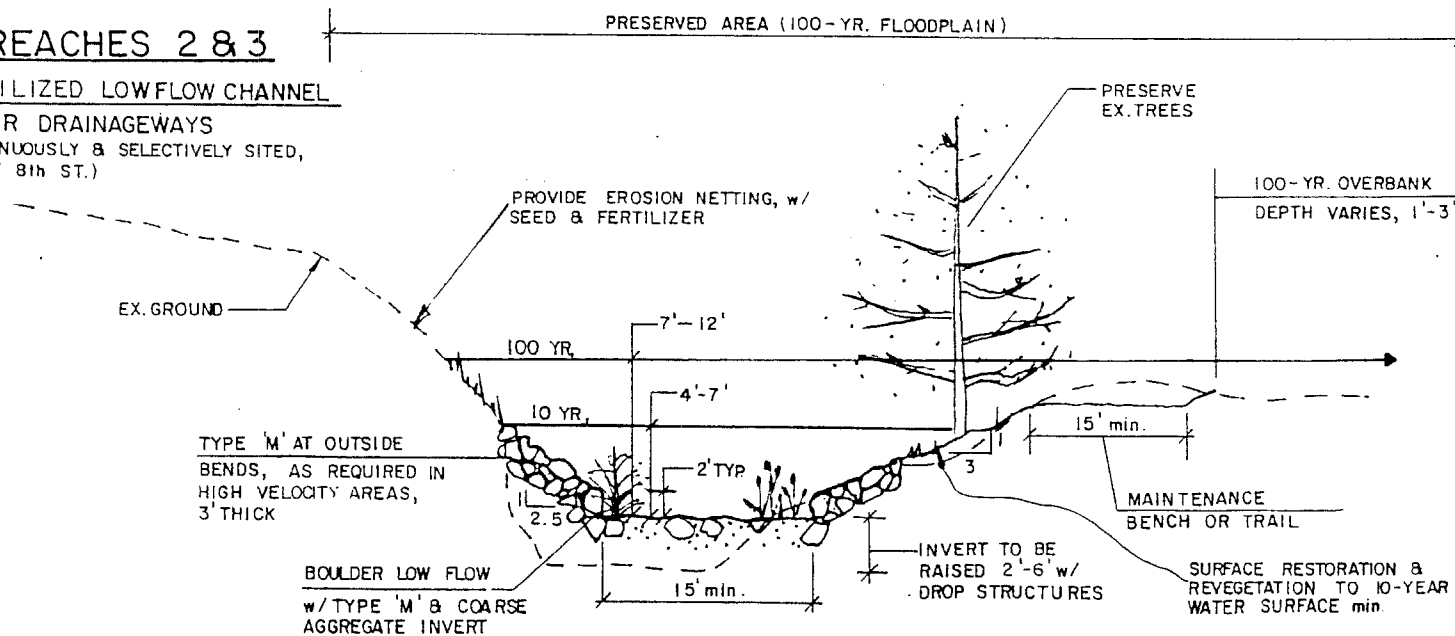


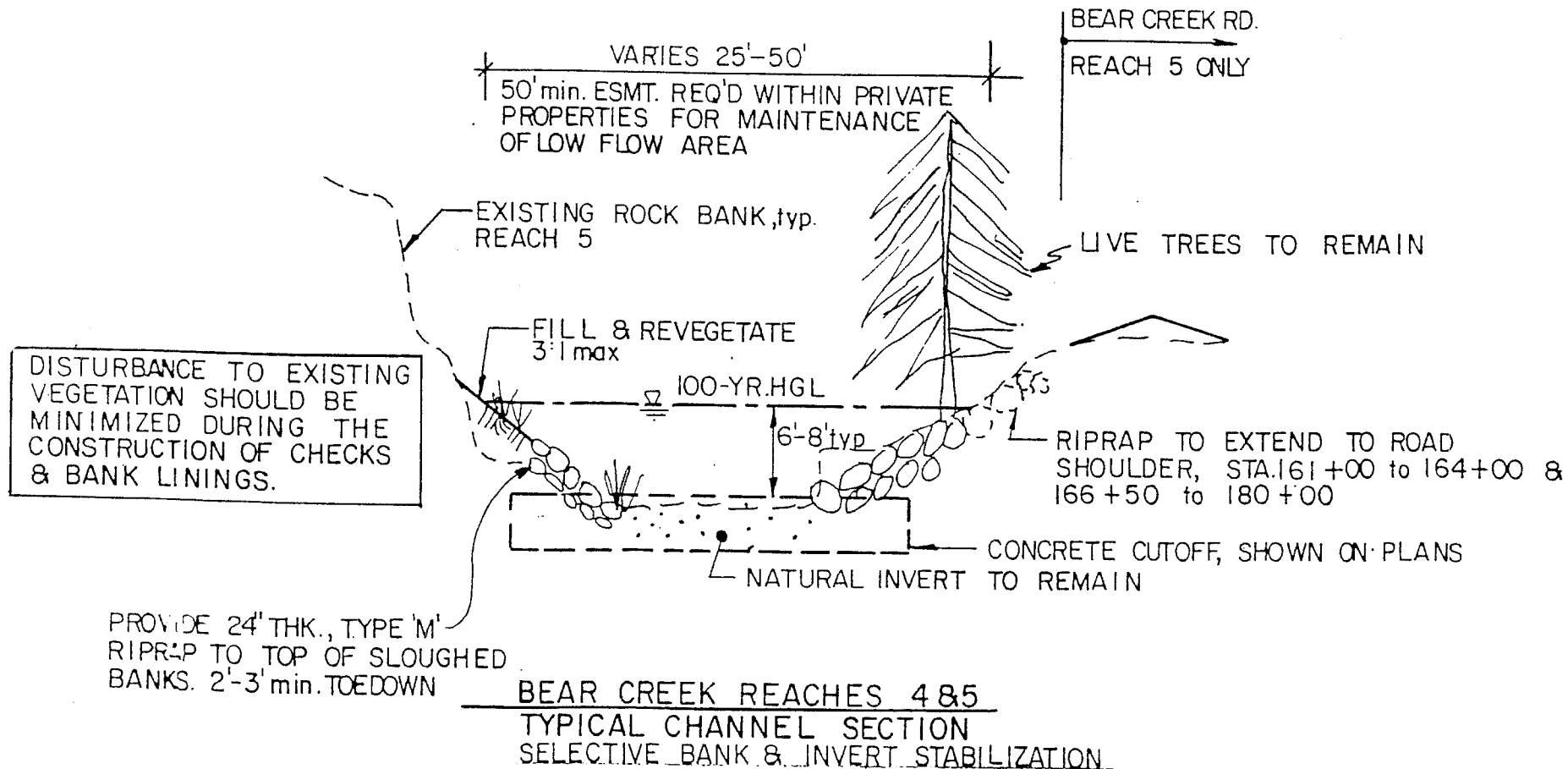
REACHES 2 & 3

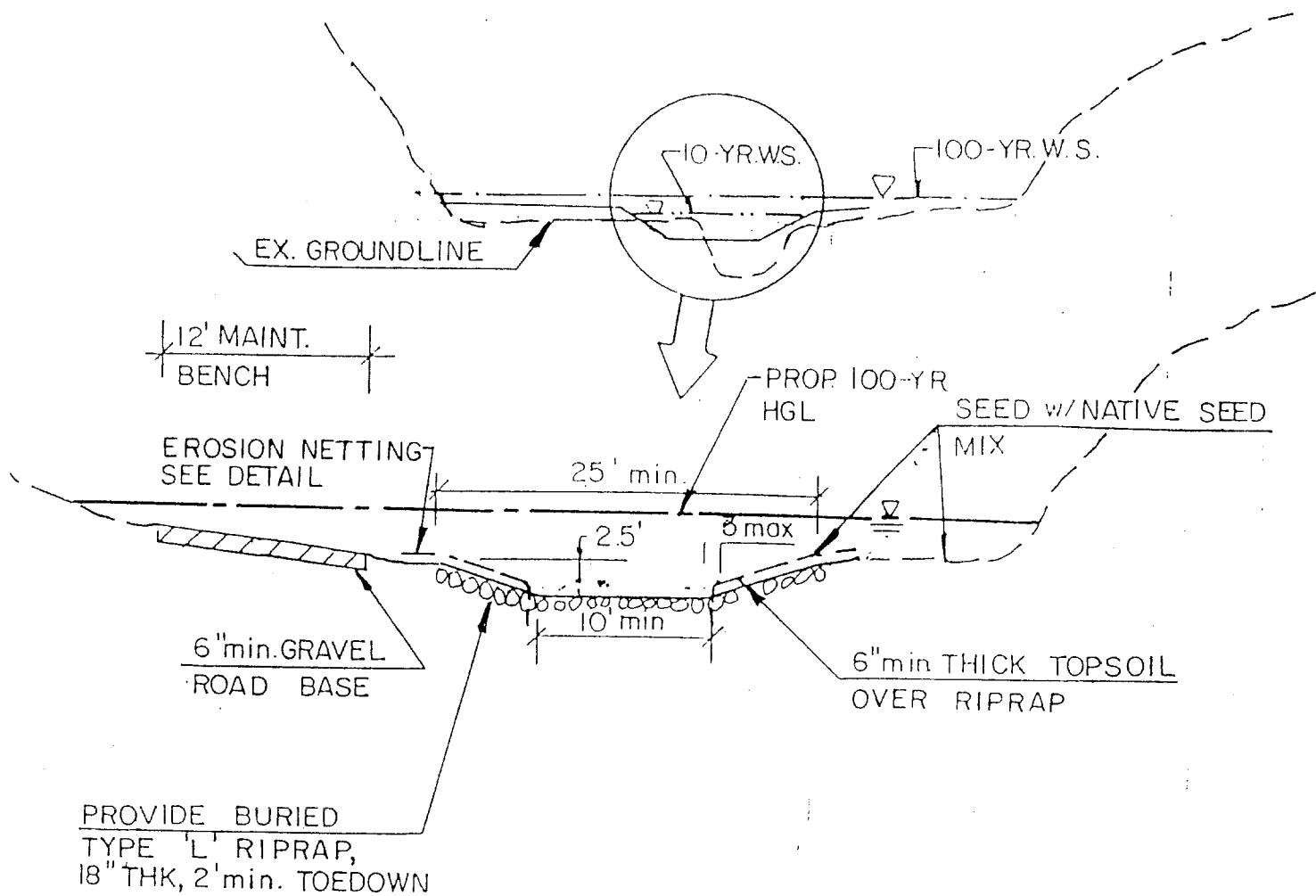
STABILIZED LOWFLOW CHANNEL

MAJOR DRAINAGEWAYS

(CONTINUOUSLY & SELECTIVELY SITED, ABOVE 8th ST.)

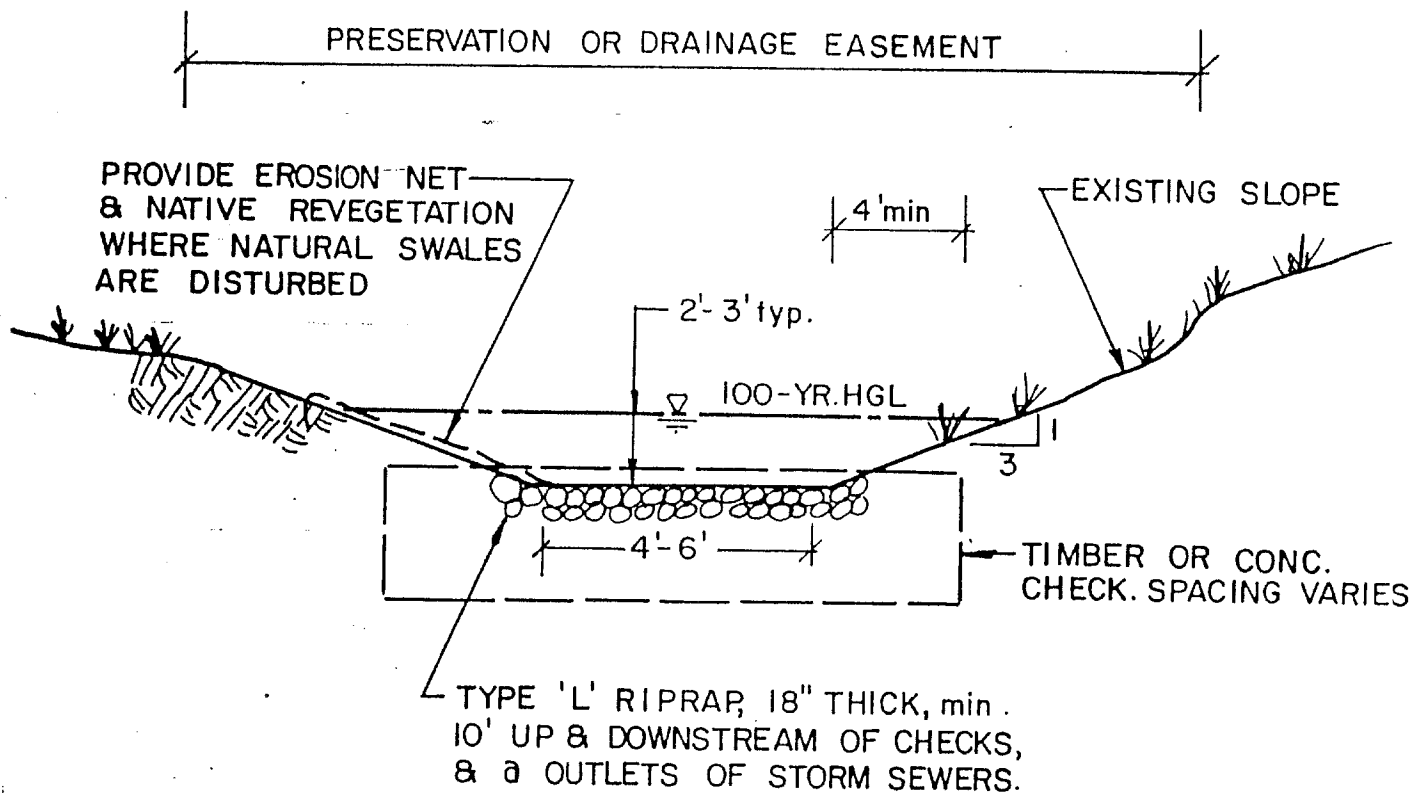






CONSTELLATION GULCH REACH 6 STABILIZED CHANNEL SECTION

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THIS SECTION TO BE USED
WITHIN THE PRIVATELY
MAINTAINED PRESERVATION
EASEMENTS.

TYPICAL SECTION
REACHES 7-12

FIGURE 13