

# Rawhide/ Pinnacle Peak Wash Alignment Study

Alluvial Fan Task Force

November 1992

Adopted November 17, 1992

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## City of Scottsdale, Arizona

Parks Department, Planning and Community  
Development Department, Transportation  
Department

A680.921

# Rawhide/Pinnacle Peak Wash Alignment Study

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## EXECUTIVE SUMMARY:

The Rawhide/Pinnacle Peak Wash Alignment study was developed by the Alluvial Fan Task Force due to increased planning and development activity within the floodplains north of the Central Arizona Project (CAP). The primary objective for the task force was to identify and develop a stormwater management plan for the Rawhide and Pinnacle Peak washes and their associated floodplains which will: manage peak flows, partially or completely remove the alluvial fan flooding hazard, utilize and retain as much of the existing environment as possible, effectively integrate with existing infrastructures, and maximize public benefit.

The task force proposes management of the stormwater runoff in a channel alignment which is sensitive to existing desert topography and consistent with planned infrastructures. A conceptual Desert Greenbelt design for stormwater management integrates a variety of environmentally sensitive and passive recreational opportunities.

The task force examined existing Sonoran Desert conditions and engineering standards to develop channel alignments for each of the washes. For Rawhide Wash these are divided into two tributary channel alignments and three main channel alignment alternatives:

- North Tributary Alignment      •South Tributary Alignment
- North Channel Alignment      •Central Channel Alignment      •South Channel Alignment

To meet the goals of the report, both a tributary alignment and a channel alignment were required. A No Action alternative was also examined.

Due to an existing stormwater management system, three alternatives were examined for Pinnacle Peak Wash :

- No Action Alternative
- Enhanced Existing Alignment
- Alternative Alignment.

Based on the goals and objectives identified by the task force these alternatives and alignments were rated according to their impacts in the following categories: Land use, Right-of-way acquisition, Hydraulic considerations, Environmental impacts, Cost.

For Rawhide Wash, the North Tributary Alignment in conjunction with the Central Channel Alignment were identified as the preferred alternative based upon the evaluation criteria and preliminary cost analysis of the various alignments. Both alignments were considered favorable due to their environmental sensitivity, consistency with the Desert Greenbelt concept and the goals and objectives identified by the study. The task force recommends a preliminary design study be prepared for the recommended Rawhide alignments. Performed by an outside consultant, this study would determine a basis for engineering design and cost feasibility of the recommended alignments.

The Pinnacle Peak Wash was complicated due to the inability of the alternatives to resolve the flood hazard with improvements only within the existing AO zone. Cost analysis was difficult to ascertain as well, and comparison ineffective. For these reasons, staff recommends that this flood zone be analyzed as a "sub-regional" study with the design of the Pima Road Channel to resolve the various flooding concerns of residents of the area (particularly those west of Pima Road) and including the goal of removing the AO designation from the Pinnacle Peak Wash Floodplain.

# Rawhide/Pinnacle Peak Wash Alignment Study

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Available for review from the City of Scottsdale Transportation Department.	

# Rawhide/Pinnacle Peak Wash Alignment Study

## 1.0 INTRODUCTION

In the 1960's the City of Scottsdale was confronted with increasing development upon the Indian Bend Wash Floodplain. Due to the flood hazards associated with this, the City began reviewing alternatives for a stormwater management plan. Faced with the possibility of a concrete lined channel running through the heart of the City, the citizens of Scottsdale proposed a Greenbelt concept form of flood control. In place of the proposed concrete channel, a lush vegetated system of parks would be used to not only provide stormwater control, but as an asset to the City and its citizens by providing a center for recreational activities and cultural events year round.

Following severe flooding along the wash in the early 1970's, the citizens of Scottsdale approved a bond for the construction of the Indian Bend Wash Greenbelt. The resulting system has proven to be an award winning method of effectively managing floodwaters while maintaining and providing cultural and recreational benefits to the entire community.

Following growth in the 1980's, Scottsdale again finds itself with similar issues of expansion and proposed development in the floodplains north of the Central Arizona Project (CAP). Described as alluvial fans, these floodplains are fundamentally different from familiar riverine floodplains and impose difficult drainage conditions for development. Because of these conditions and the desire to conserve and protect as much of the natural Sonoran Desert resource as possible, the City is once again exploring alternative methods of managing floodwaters. The goals of such management would be to reduce the flood hazard, reduce/remove the need for high cost flood insurance, protect the existing environment, and benefit the community by integrating planned recreational and cultural facilities.

Since the natural Sonoran Desert character and the amount of floodwater make a lush Greenbelt concept inappropriate, a new Desert Greenbelt concept is being considered. This type of greenbelt differs significantly from the standard Greenbelt concept used on the lower Indian Bend Wash. Instead of constructing a wash with grass and trees, native areas will be left as unchanged as possible, and improved areas will use native plants and materials to maintain the character of the natural surrounding Sonoran Desert. Once again, in place of a concrete lined drainage channel, a stormwater management facility within the natural desert environment will be integrated with adjoining land uses and amenities for recreation and cultural activities.

The purpose of this study is to review the flooding hazards, identify goals and objectives for stormwater management, review conceptual channel cross sections, and recommend potential channel alignments that will be integrated as part of an overall Regional Stormwater Management Plan. This report is not intended as a design report, but instead focuses on identifying a conceptual channel alignment for Rawhide and Pinnacle Peak washes.

## 2.0 PROBLEM STATEMENT

After the adoption of the drainage element of the City of Scottsdale General Plan for the area north of the CAP, the Federal Emergency Management Agency (FEMA) identified boundaries of potentially hazardous flooding conditions by delineating flood hazard zones. Generally in the floodplains north of the CAP, these flood zones occur on alluvial fans created by the erosion of upstream mountain ranges; the "AO" zone being the most hazardous of these zones.

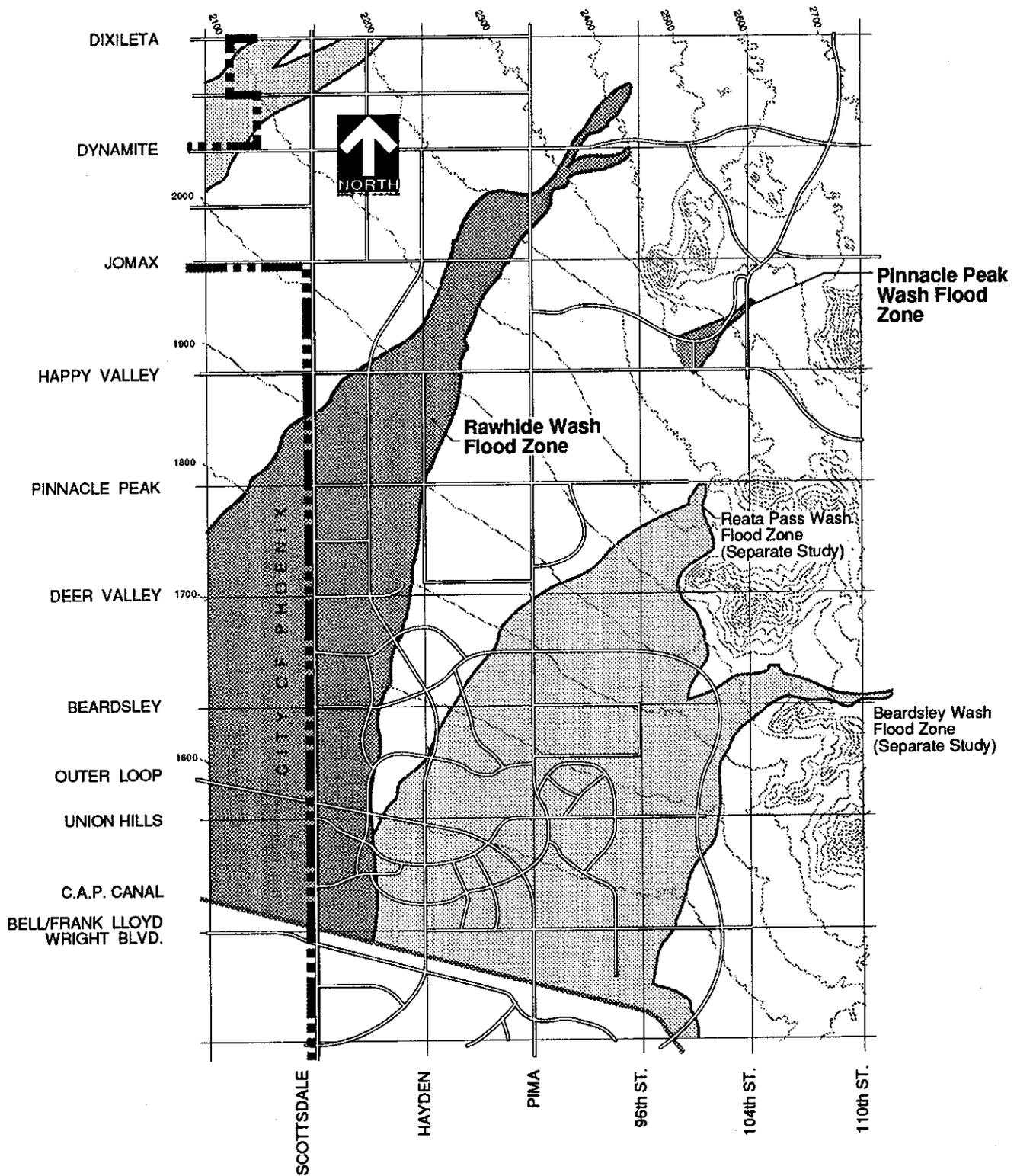
Constraints have been placed on development occurring in AO zones designated by FEMA that require property owners to elevate building pads to protect the structure from flooding. Further constraints mandate that lending organizations require the purchase of flood insurance to mitigate their risk. Large portions of currently undeveloped and low intensity land north of the CAP have been identified by FEMA as an alluvial fan AO zone and are subject to these requirements. The areas effected are shown in Figure 1.

Results of investigations of actual alluvial fan flooding events throughout the arid southwestern portion of the United States indicate alluvial fans do not have predictable drainage patterns, even when some defined natural watercourses exist (Figure 2). Most natural channels are only capable of containing more frequent two to five year flood events from bank to bank, larger less frequent events are not confined within these channels. This lack of confinement, as well as the loose sediment of the alluvial fan, creates the problem of major floodwaters quickly establishing new flow paths quite unpredictably during each new flood event and is the cause for most flooding hazards.

In typical riverine systems the overbank flows that occur in larger flood events are usually contained within adjacent land formations such as river terraces or valley side slopes which parallel the main channel. In alluvial fan situations such as north of the CAP, once the channels emerge from the McDowell Mountains on to the alluvial fan slopes there are no confining land formations to contain larger overbank flood flows. Due to this lack of confinement, it is not appropriate to rely on the location of previous flow paths to predict future flow paths and hazardous locations.

Since the flows from the apex of the Rawhide and Pinnacle Peak washes have the potential of moving across the entire fan area unpredictably, large areas of land are affected and subject to potential flooding, requiring elevated building pads and flood insurance (Figure 1). Such potential flooding imposes a threat to life and property for any level of existing or proposed development. Severely elevated building pads adversely impact the Sonoran Desert environment, and flood insurance creates an additional obstacle to cost effective development and places an economic burden on existing and future residents.

To remove these problems and to encourage sensitive development anticipated by the General Plan, stormwater management must be provided.

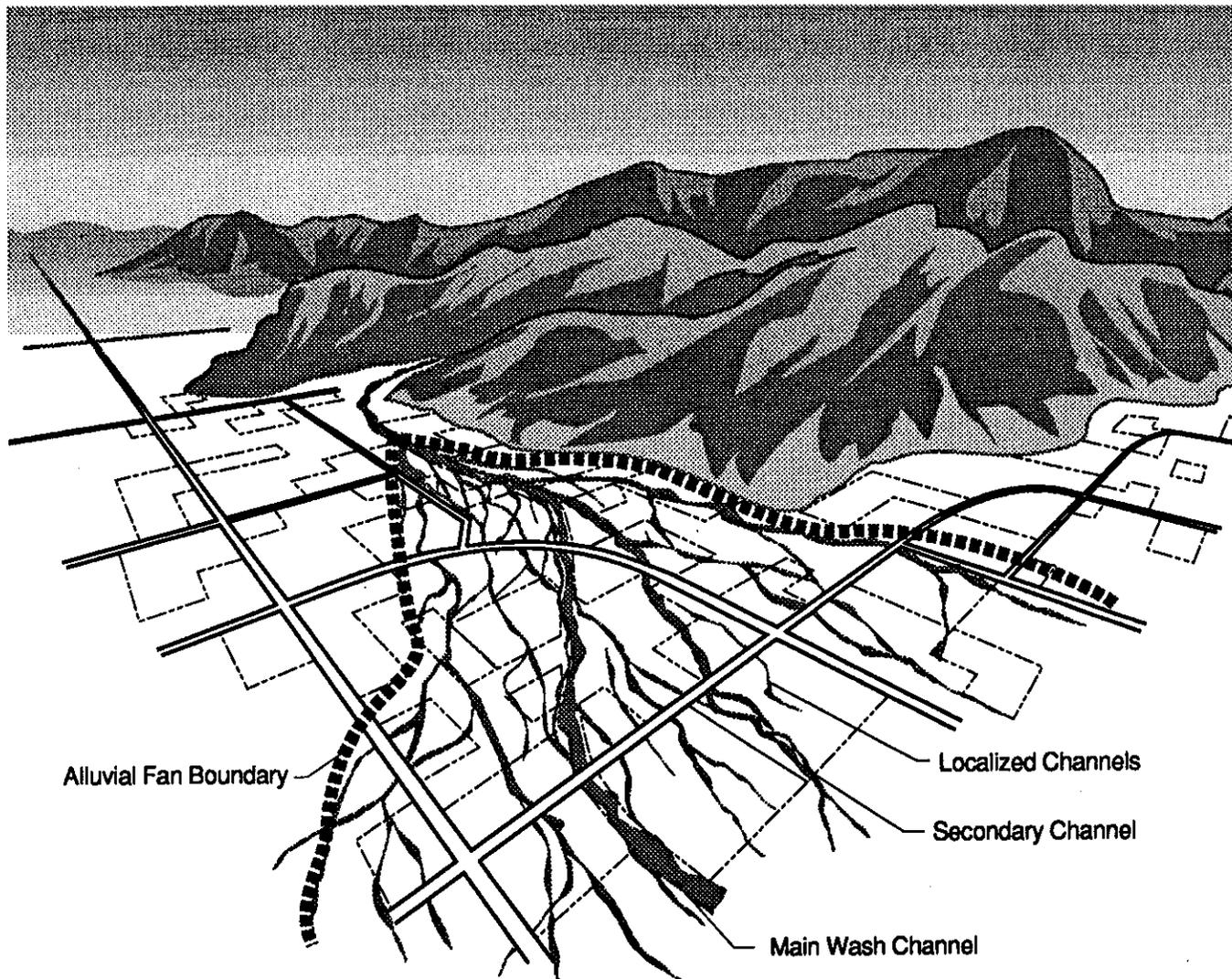


**Legend**

- Rawhide/Pinnacle Peak Alluvial Fan Flood Zones
- Additional Alluvial Fan Flood Zones

Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

**Figure #1:**  
Alluvial Fan Flood Zones



**Figure #2:**  
Conceptual Alluvial Fan Channel Distribution

### 3.0 GOALS

The following goals were established to research, develop, and select a stormwater management system for the alluvial fan hazards of Rawhide and Pinnacle Peak washes.

- Identify channel alignments which will:
  - Manage peak flows of Rawhide and Pinnacle Peak washes.
  - Partially or completely remove the threat of property damage or loss of life due to alluvial fan flooding.
  - Utilize and retain as much of the existing natural desert channels and environment as possible.
  - Effectively integrate with land ownerships, planned land uses, and transportation networks.
  - Maximize public benefits, including recreational, aesthetic, and cultural.
  
- Remove the "AO" designation from the fans, thus removing the need for flood insurance and reducing the height of building pads.

Such a system would be a significant component of a stormwater management plan for each individual fan, which would be integral to a regional stormwater management plan for the areas of Scottsdale north of the CAP.

#### 4.0 THE DESERT GREENBELT AND STORMWATER MANAGEMENT

Managing alluvial fan stormwater hazards in the Sonoran Desert setting of Rawhide and Pinnacle Peak washes offers some unique challenges. Taking into consideration the area's natural attributes, as well as the engineering and hydraulic restrictions, it has become apparent that the type of Greenbelt seen in the Lower Indian Bend Wash area would be incompatible with the Sonoran Desert and unachievable in this area. However, by combining the Greenbelt approach to stormwater management with sensitivity to the natural environment, a "Desert Greenbelt" would provide a drainage solution that combines the advantages of an Indian Bend Greenbelt with the existing Sonoran Desert environment.

Unlike the Indian Bend Wash facilities, the majority of the Desert Greenbelt would be native or revegetated to native appearance and provide passive recreational facilities within the drainage channel. Passive activities and facilities, such as multi-use trails, nature areas, and picnic facilities, have minimal impact on existing or proposed land uses surrounding the channel. Activity hubs are envisioned where park dedication sites adjoin the channel. Although no park sites are currently planned for either of these washes, such hubs could offer the more traditional park/ recreational facilities such as ball fields, courts, and playgrounds. In either passive or traditional recreational facilities, the right-of-way associated with the drainage facilities necessary for a stormwater management plan would be utilized.

When discussing a stormwater management plan for a specific watershed in conjunction with the Desert Greenbelt System, certain differences between the two should be made clear. The Desert Greenbelt System attempts to protect the alluvial fan areas of a major wash from flooding caused primarily by runoff generated upstream of the apex. This protection then removes the fan from a FEMA "AO" zone, thereby eliminating the need for costly flood insurance and severely elevated building pads. A stormwater management plan must deal with the upstream runoff as well as flows generated downstream of the apex and the increase in flows due to development.

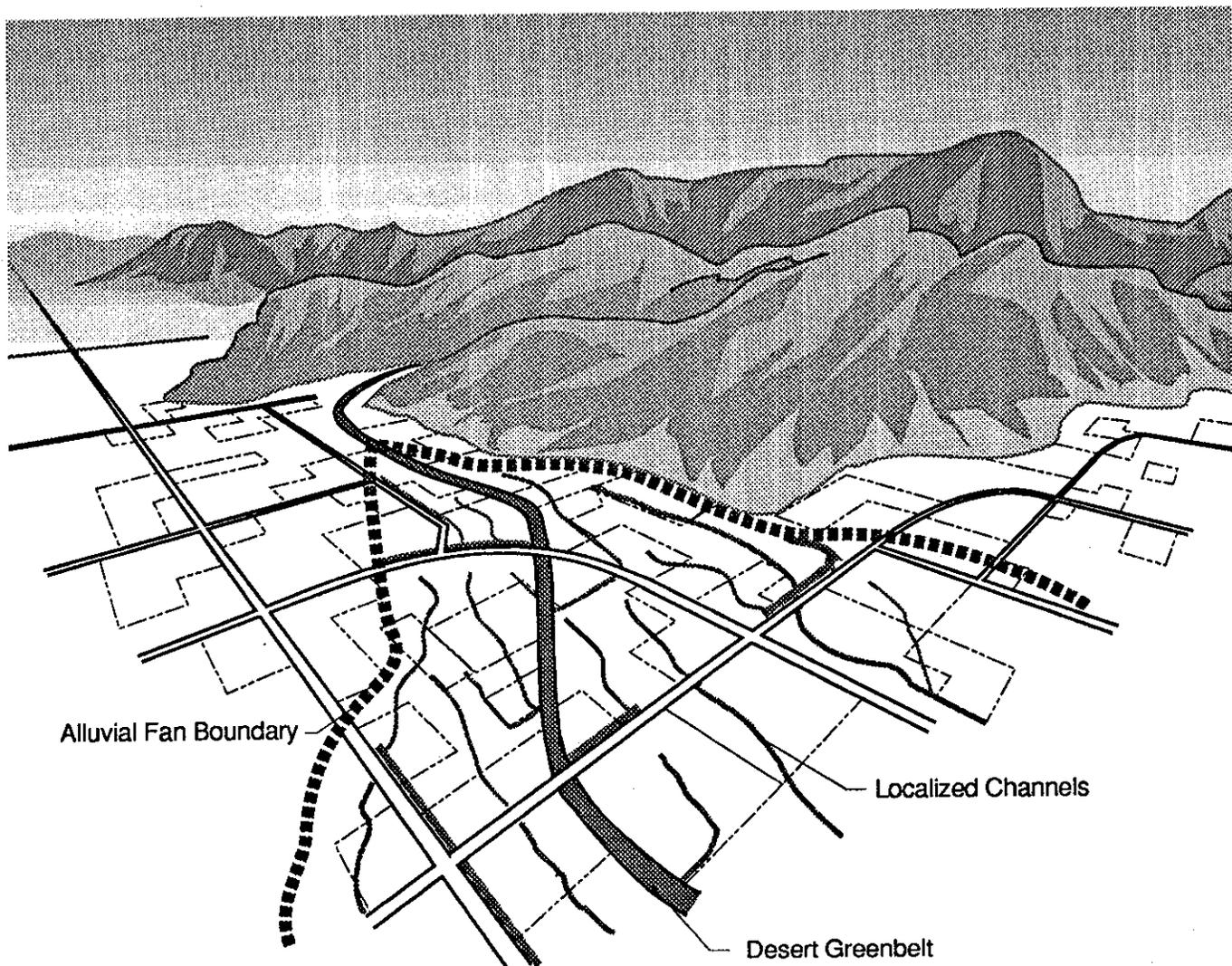
By dealing with runoff generated from mountain ranges and high desert areas to the north, or off-site runoff, the Desert Greenbelt System provides the "backbone" of a system for conducting stormwaters from the point where they are no longer naturally contained, safely through inhabited areas, to an area where they can be detained or retained (Figure 3).

Just as the major natural washes rely on smaller localized channels to convey stormwater generated locally, or on-site runoff, so to does a stormwater management plan. Under such a plan, the Desert Greenbelt System, in conjunction with existing washes and other drainage facilities such as channels, storage facilities, levees, etc., would form the backbone of a stormwater management plan. Smaller channels and existing natural channels would be required to remove on-site generated runoff to the Desert Greenbelt System safely and reliably.

Although the goals of the two overlap, the Desert Greenbelt System functions as only a part of an overall stormwater management plan, focusing primarily on off-site runoff. As development continues in the desert areas north of the CAP, the problem of increased on-site runoff will continue to grow. Currently, each individual development must provide storage or direct stormwater through or around their property to existing outlet points downstream. Without the

direction and guidance a stormwater management plan provides, these individual solutions are often harmful to the environment and compound drainage problems downstream.

Even though having the Desert Greenbelt System in place would remove the threat of flooding capable of property damage and hazardous conditions on alluvial fans, it would not remove the threat of localized flooding from on-site runoff. Establishing the Desert Greenbelt System as a "backbone", development, with a planned direction and guidance could occur within the desert resulting in less disruption to the environment and be the foundation for a unified, reliable drainage network.



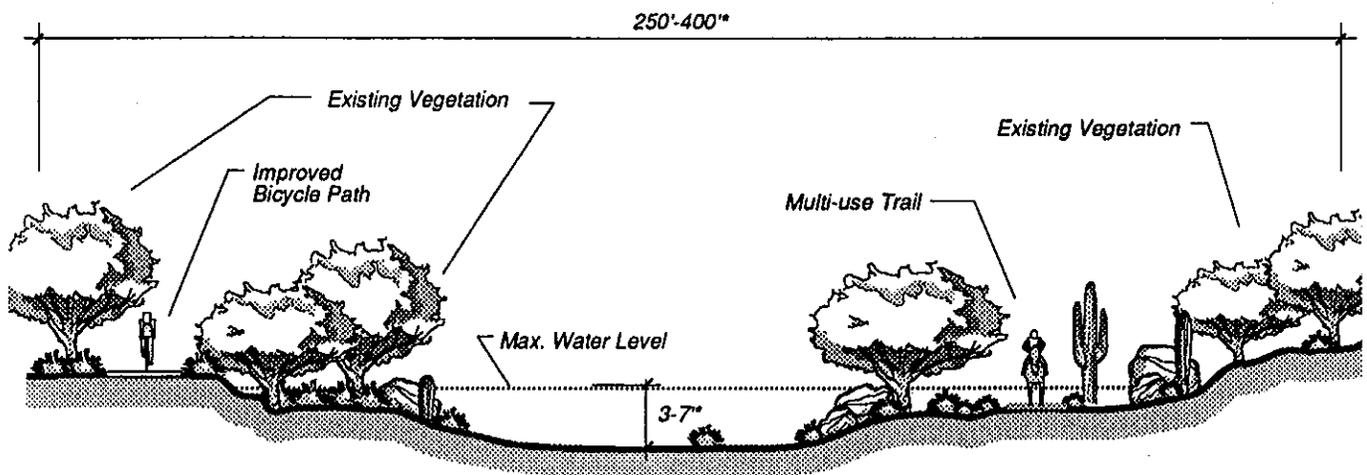
**Figure #3:**  
Conceptual Stormwater Management Plan

## 5.0 CONCEPTUAL CHANNEL CROSS SECTIONS

Each of the alignment alternatives identified have locations where varying degrees of improvements would be required to assure that floodwaters would remain within the existing or planned channels. For the sake of illustration, the typical cross sections of these various configurations have been separated into the four most commonly needed improvements. The exact design of each individual cross section will vary depending upon engineering requirements, with the most commonly occurring cross sections as follows: Natural Containment, Partial Containment, Uncontained Flow, and Cut Sections.

### 5.1 NATURAL CONTAINMENT

Areas of natural containment are where the existing natural channel is able to contain floodwaters with nominal improvements and/or structural modifications. This results in minimal disruption to the channel and the surrounding vegetation. Improved bicycle paths and non-paved multi-use trails would be established with limited disruption to existing channel vegetation along either side as topography allows.



#### **Typical Characteristics:**

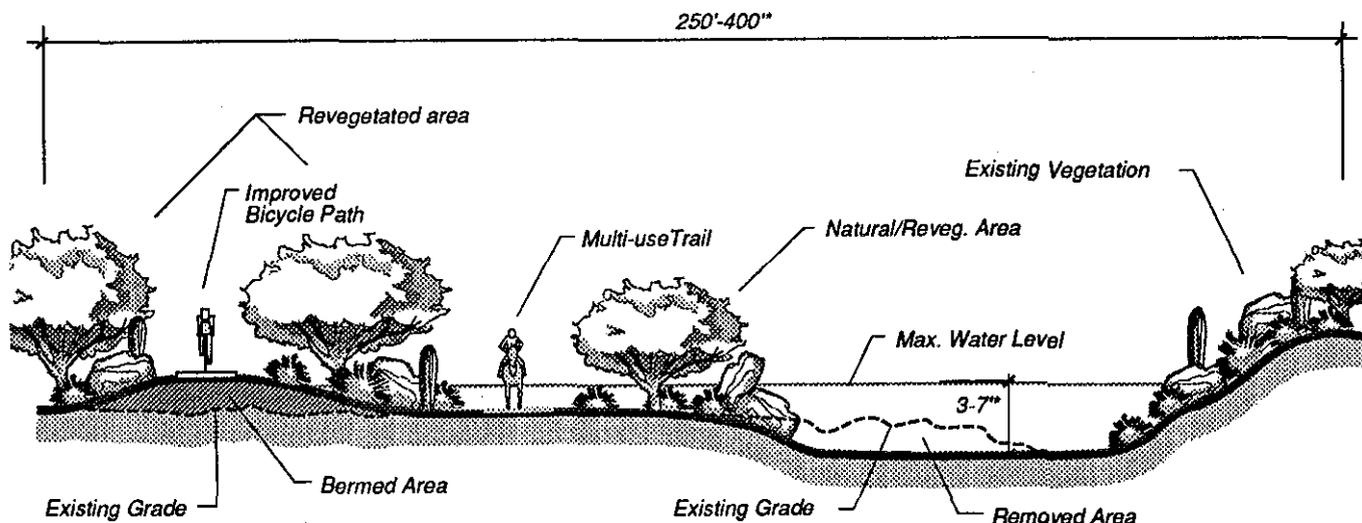
- 3'-7' deep X 250'-400' wide existing, natural channel.
- Provides for multi-use trails and bicycle paths on either side of channel.
- Minimal disruption of existing channel and vegetation.
- Sufficient capacity exists within the natural channel for floodwaters.

Not To Scale

\*Width and depth are dependent upon hydraulics, existing capacity and planned improvements.

## 5.2 PARTIAL CONTAINMENT

Used in areas where the natural channel has the ability to contain some, but not all of the floodwaters, a partial containment channel would maintain the natural channel and vegetation where possible. The existing channel might be partially excavated to provide a low flow channel within the existing wash, and small berms may be added to ensure containment of floodwaters. The existing natural channel and vegetation would be retained where possible, with disturbed areas revegetated to blend with the existing surroundings. Once again multi-use trails and bicycle paths would be established.



### **Typical Characteristics:**

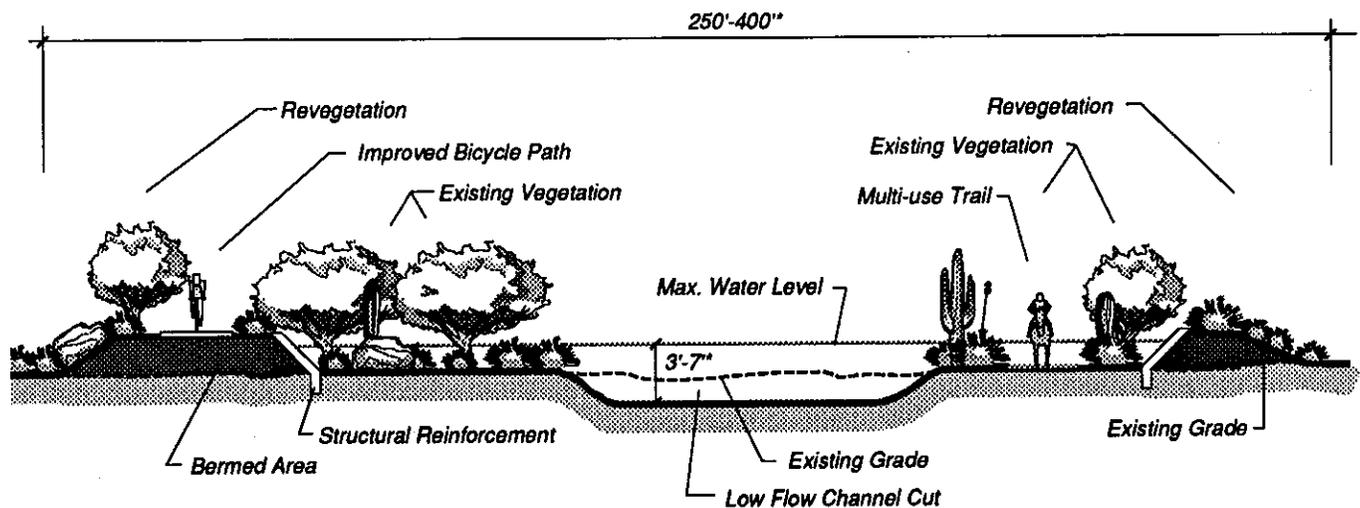
- 3'-7' deep X 250'-400' wide existing, natural channel.
- Provides for multi-use trails and bicycle paths on either side of channel.
- Partial improvement required to natural channel through berming and/or excavation.
- Existing vegetation blended with revegetated areas.
- Used in areas where natural channel has the ability to contain some but not all floodwaters.

\*Width and depth are dependent upon hydraulics, existing capacity and planned improvements.

Not To Scale

### 5.3 UNCONTAINED FLOW

In areas where little or no existing channel is evident, generally the flatter slopes of the alluvial fan, extensive improvements are required to contain flood waters. In areas where right of way concerns are evident, and space is limited, an entirely man-made channel would have to be constructed to enclose the floodwaters. Such a channel would require structural reinforcement to meet with federal standards and would require significant revegetation as much of the existing vegetation would be disturbed during the construction process. Existing vegetation would be salvaged and reused. Amenties would include multi-use trails and bicycle paths.



#### Typical Characteristics:

- 3'-7' deep X 250'-400' wide structurally reinforced channel
- Provides for multi-use trails and bicycle paths on either side of channel.
- For use in areas where little or no channel is in existence.

Not To Scale

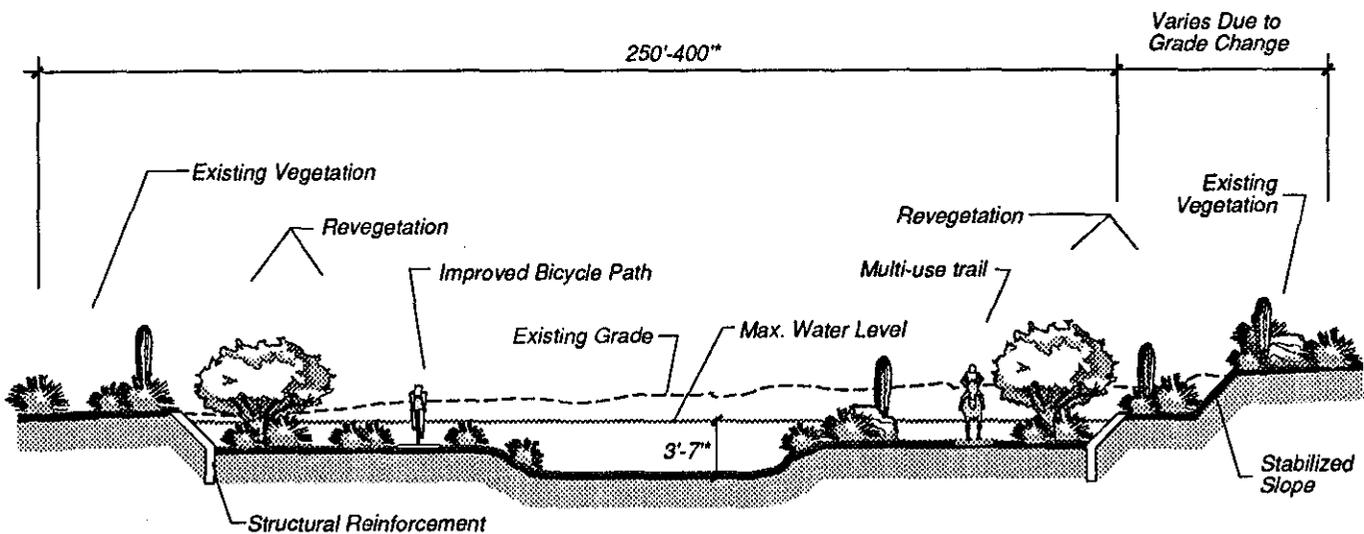
\*Width and depth are dependent upon hydraulics, existing capacity and planned improvements.

## 5.4 CUT SECTIONS (shown below)

In areas where the channel must be removed from existing washes a cut section must be excavated to maintain flow of the floodwaters. Since the entire channel is being created by removing the existing landscape, the channel must be structurally reinforced and completely revegetated at significant cost.

## 5.5 TRIBUTARY CHANNEL

For all Rawhide Wash alignment options, tributary channel improvements will be required in addition to the main channel improvements listed. In some of these areas the existing natural wash will be capable of containing the floodwaters that are not being conveyed in the main channel. Where the existing natural washes need to be improved it is estimated that approximately 110 foot of right-of-way would be required as well as structural reinforcement for bank protection. The channel would be landscaped to appear as natural as possible and passive recreational amenities would be encouraged where appropriate.



### Typical Characteristics:

- 3'-7' deep X 250'-400' wide man made channel.
- Provides for multi-use trails and bicycle paths on either side of channel.
- Major disruption of surrounding desert.

\*Width and depth are dependent upon hydraulics, existing capacity and planned improvements.

Not To Scale

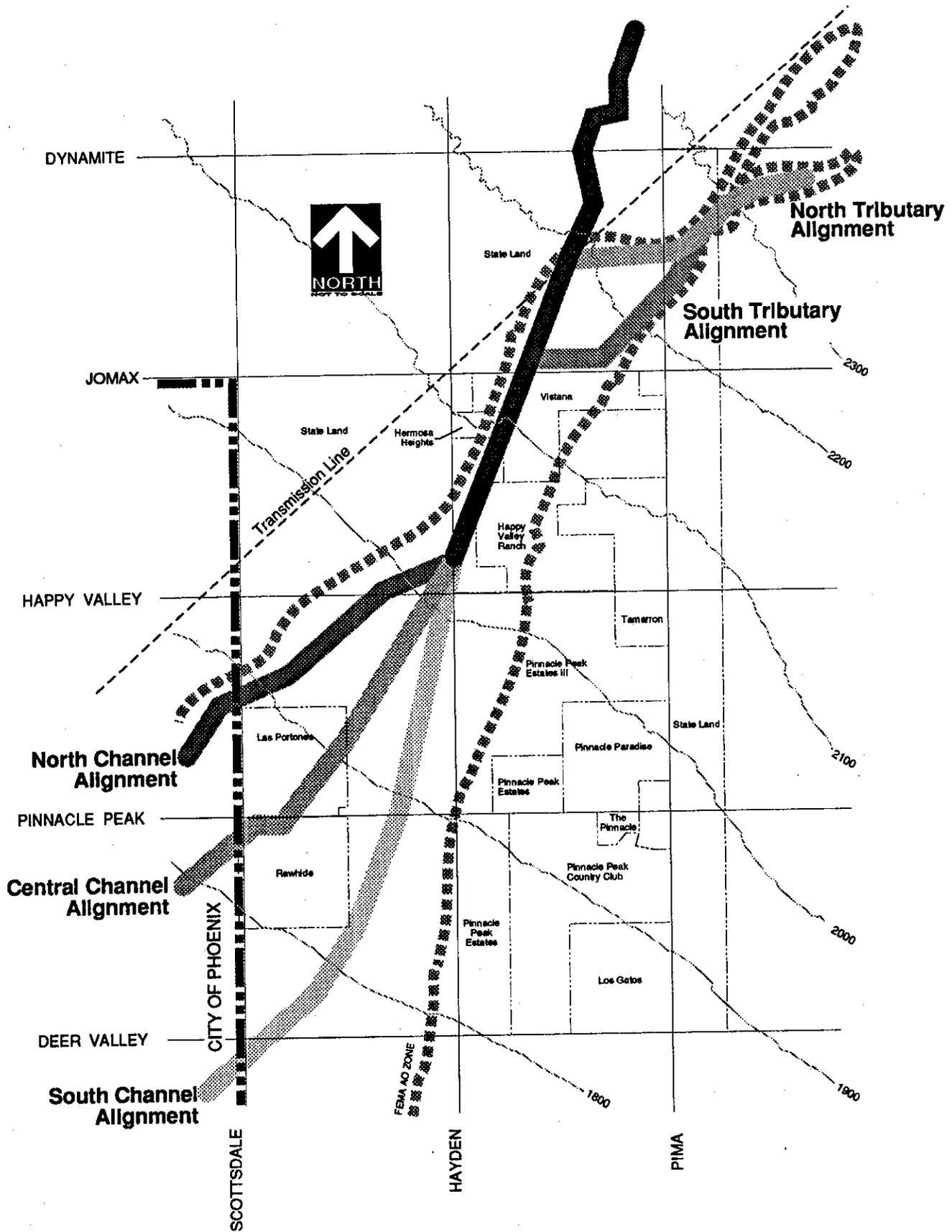
## 6.0 DESCRIPTION OF RAWHIDE AND PINNACLE PEAK WASH AND DOWNSTREAM ALLUVIAL FAN AREA

### 6.1 RAWHIDE WASH (Figure 4):

Originating in the high desert of north Scottsdale, Rawhide Wash travels southwesterly in a large defined channel until reaching its primary apex and forming an alluvial fan one quarter mile north of Happy Valley Road near the Hayden Road alignment. From here, a system of shallow braided channels typical of alluvial fans spreads out to the south and southwest crossing into the City of Phoenix and reaching its southern boundary north of the CAP.

The centermost "braid" of this system is significantly wider and more well defined than others channels in the system. This pathway represents where the majority of stormwater runoff from Rawhide Wash has been concentrated during recent events. This path passes through a well defined channelization and containment system of berms and dikes constructed by the Los Portones developments, exiting near the northeast corner of the Rawhide theme park property. From this point, stormwater passes through Rawhide's parking lot by a series of man made dikes and channels, eventually crossing Scottsdale Road approximately one quarter mile south of Pinnacle Peak Road.

Upstream of the major apex, the wash is fed by a series of braided tributaries north of Jomax Road. Large areas along many of these tributaries have been classified by FEMA as "AO" flood zones and are included within the overall Rawhide "AO" zone because of their braided unstable characteristics.



**Figure #4:**  
**Potential Alignments-Rawhide Wash**

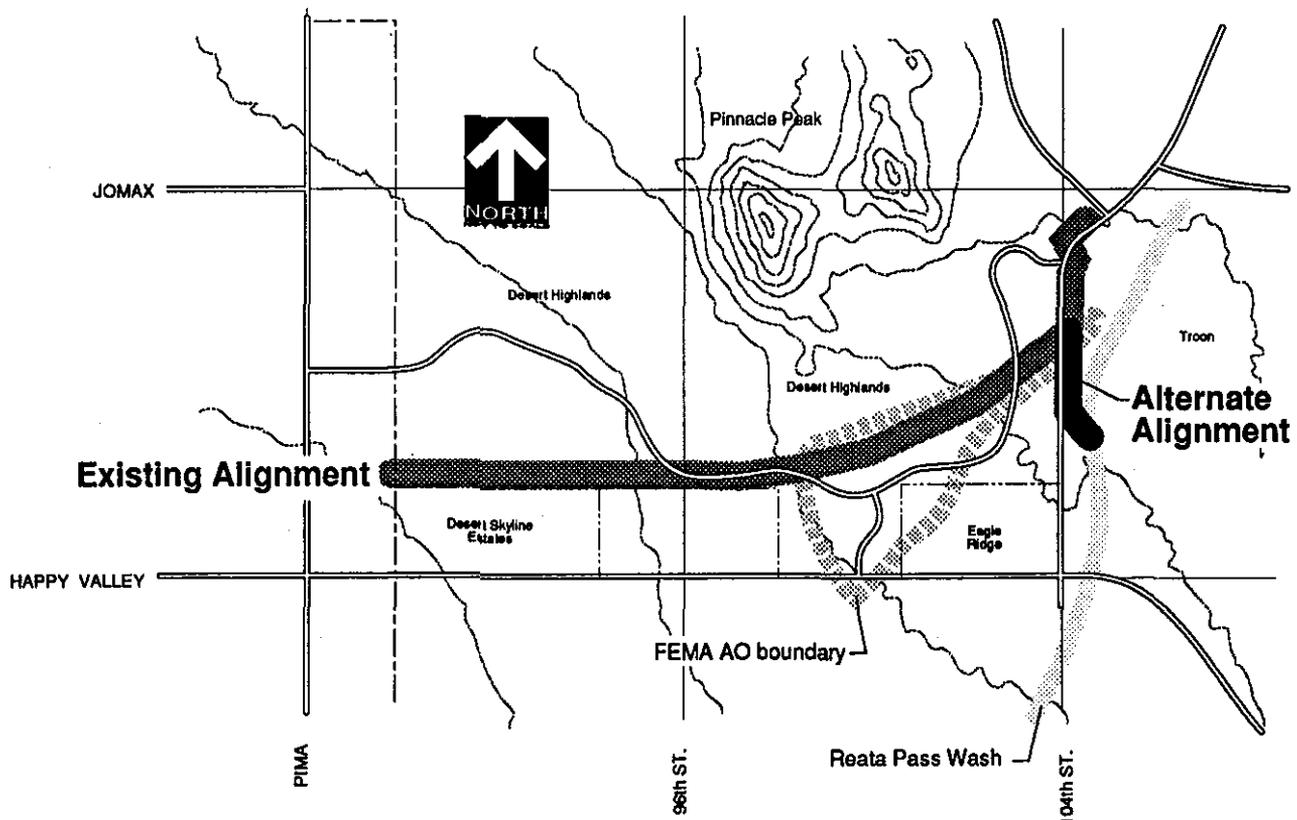
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

## 6.2 PINNACLE PEAK WASH:

Originating on the eastern side of Pinnacle Peak, Pinnacle Peak Wash travels to the south where it has been diverted to follow 114th Street (Alma School Road) until reaching its apex approximately two thirds of a mile north of Happy Valley Road. From this point an alluvial fan exists whose boundaries included properties in Desert Highlands, Eagles Glen, and some individual land ownerships. These portions of the fan have been designated by FEMA as an "AO" flood zone.

Developments in this area have been subdivided and all the required streets, water lines, sewer lines, etc., have been put in place. Construction of residences within these subdivisions, however, is not complete.

The southern boundary of the "AO" zone has been delineated by FEMA as an arc approximately one mile downstream of the apex. FEMA has determined that downstream of this arc, the potential for sheet flooding still exists, however, the depth of flooding is less than one foot which is the minimum requirement of an "AO" zone.



Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

## 7.0 DESCRIPTION OF POTENTIAL STORMWATER MANAGEMENT ALTERNATIVES

One of the primary goals of this report was to focus on identification of a conceptual channel alignment for Rawhide and Pinnacle Peak washes. Through site examination, engineering principles, and planning concerns, alternatives were selected. Each of the alternatives was selected with the purpose of developing a conceptual stormwater management system sensitive to the existing desert topography, land ownership and consistent with the proposed land uses and planned infrastructure networks. Alignment selection also considered maximizing public benefits within the spirit of the City of Scottsdale and the Desert Greenbelt concept.

### 7.1 RAWHIDE WASH ALTERNATIVES

The alternatives for Rawhide Wash have been broken down into two groups of alternatives and a no action alternative. In the first group of alternatives, two tributary alignments have been chosen to deal with flooding concerns in the northern boundaries of the Rawhide AO zone. The second group of alternatives deals with where to bring the flood waters into the City of Phoenix. This group consists of three alignments, each of which branches off from approximately the same point along Rawhide Wash just north of Happy Valley Road. Either of the tributary alignments may be used with any of the Rawhide alignments to the south and visa versa.

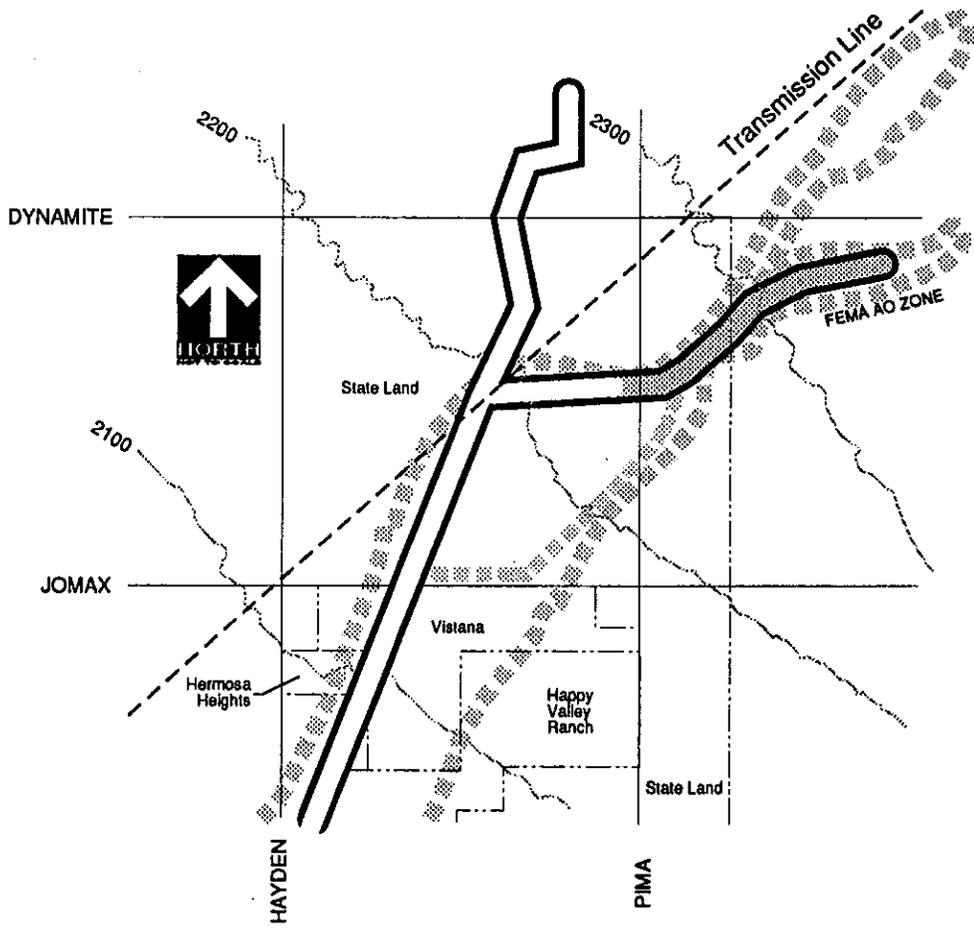
#### 7.1.1 NO ACTION ALTERNATIVE

Without a structurally managed solution, development on the fans will be mandated by FEMA regulations which require the elevation of structures. Development intensities identified in the Scottsdale Land Use Element would be difficult to obtain and expensive to build. Elevated subdivisions, raised building pads, and mass graded subdivision plans would be required to protect property and lives from existing flood hazards. Even with such potentially inefficient improvements, homeowners would still be required to purchase flood insurance from the National Flood Insurance Program. Little if any public benefit would be obtained from such measures, and the Sonoran Desert would be severely impacted.

In order to remove areas from special flood hazard areas, FEMA will only consider major flood mitigation measures supported by appropriate engineering analysis. These mitigation measures may include channels protected by dikes (berms) and detention basins.

### 7.1.2 NORTH TRIBUTARY ALIGNMENT

The North Tributary alignment begins east of Pima Road and just south of Dynamite Road in a series of small braided chanel with capability of partial containment. Following a westerly path, the alignment crosses Pima Road approximately one half mile south of Dynamite and joins with a portion of wash where channel capacity increases enough to reach a naturally confined state. From here the alignment joins with the main Rawhide Wash approximately one half mile north of Jomax Road.



### North Tributary Alignment

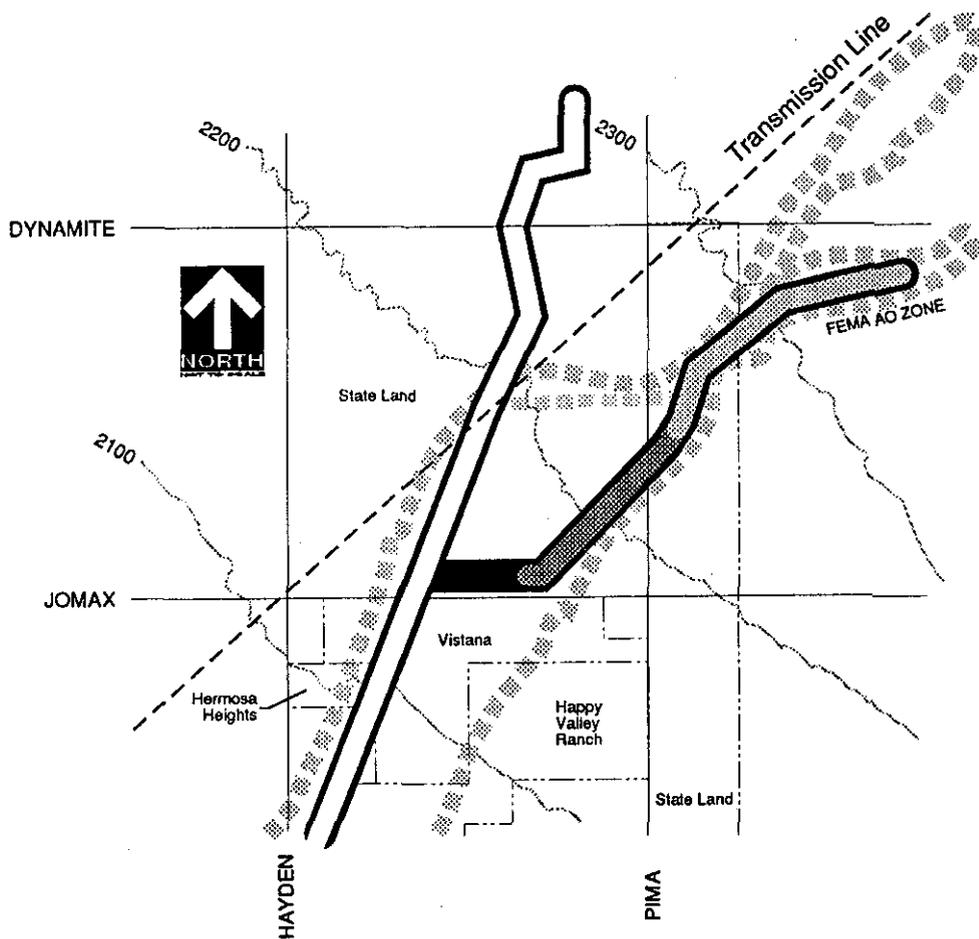
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

#### Containment Level



### 7.1.3 SOUTH TRIBUTARY ALIGNMENT

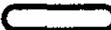
The South Tributary alignment begins just as the North Tributary alignment, east of Pima Road and just south of Dynamite Road. After following braided channels to the west, the alignment then follows one of the major braids to the southwest, still capable of maintaining partial containment of floodwaters. From here, the alignment crosses Pima Road approximately one third mile north of Jomax Road and loses containment of floodwaters. The alignment continues to the southwest this way until reaching Jomax Road where a cut section will be required to direct the floodwaters away from existing development south of Jomax, and carry the flows to the main Rawhide channel.



### South Tributary Alignment

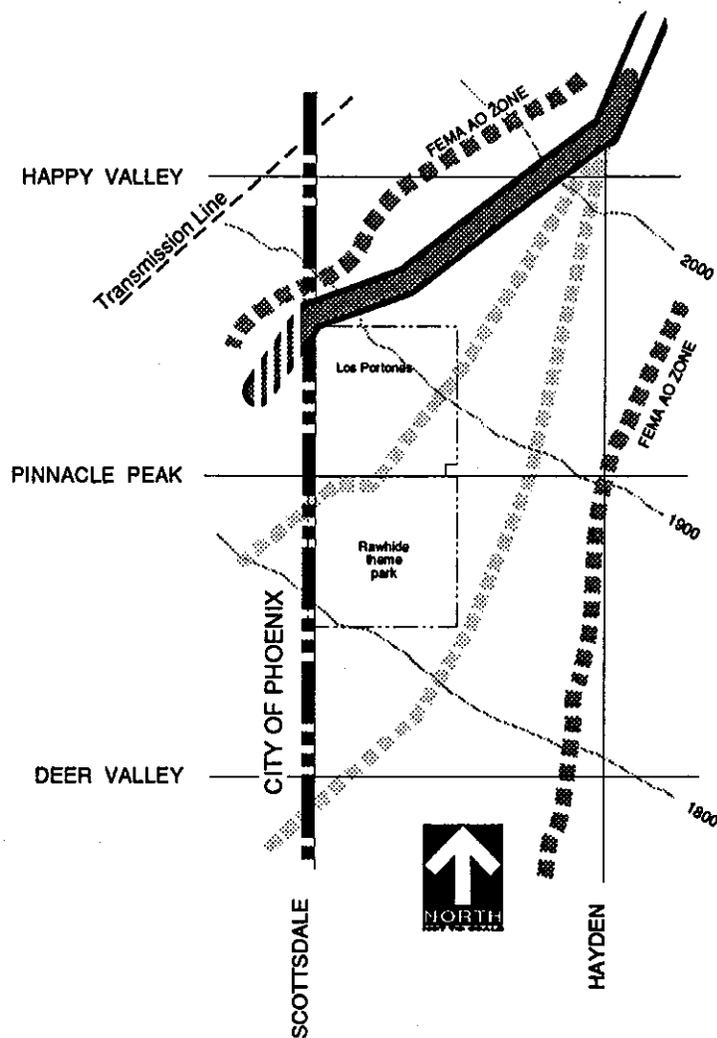
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

#### Containment Level

-  Natural
-  Partial
-  Uncontained flow
-  Cut section

### 7.1.4 NORTH CHANNEL ALIGNMENT

The North Channel alignment begins at the primary apex of Rawhide Wash one quarter mile north of Happy Valley Road. From this point, floodwaters are directed in a southwesterly direction following existing braided channels in an uncontained condition. The alignment proceeds to a point at the northwest corner of the Los Portones subdivision, entering the City of Phoenix approximately one half mile north of Pinnacle Peak Road.



### North Channel Alignment

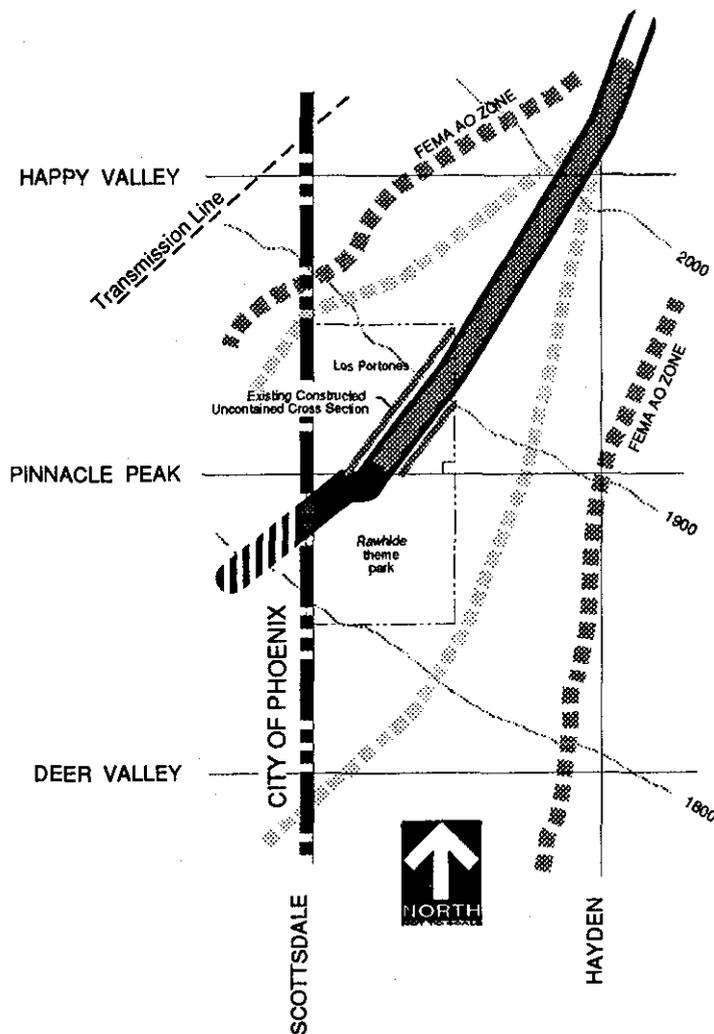
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

#### Containment Level



### 7.1.5 CENTRAL CHANNEL ALIGNMENT

Beginning at the primary apex one quarter mile north of Happy Valley Road, this alignment follows the central braid of Rawhide Wash southwest until reaching the northeast corner of the Los Portones subdivision. Until reaching the subdivision, the channel is wide with a sandy bottom, yet uncontained in nature. Once within the subdivision, the channel is contained by an existing constructed channel similar to the Uncontained Channel Cross section shown in section 5.3. The outlet point of this channel is at Pinnacle Peak Road approximately one third mile east of Scottsdale Road. The alignment then requires some modification to this outlet point, and directs the flows to the south side of Pinnacle Peak Road where a cut section would be used. The alignment would then follow Pinnacle Peak Road for a short distance west, then to the southwest through Rawhide theme park's parking lot, entering the City of Phoenix just south of Pinnacle Peak Road.



### Central Channel Alignment

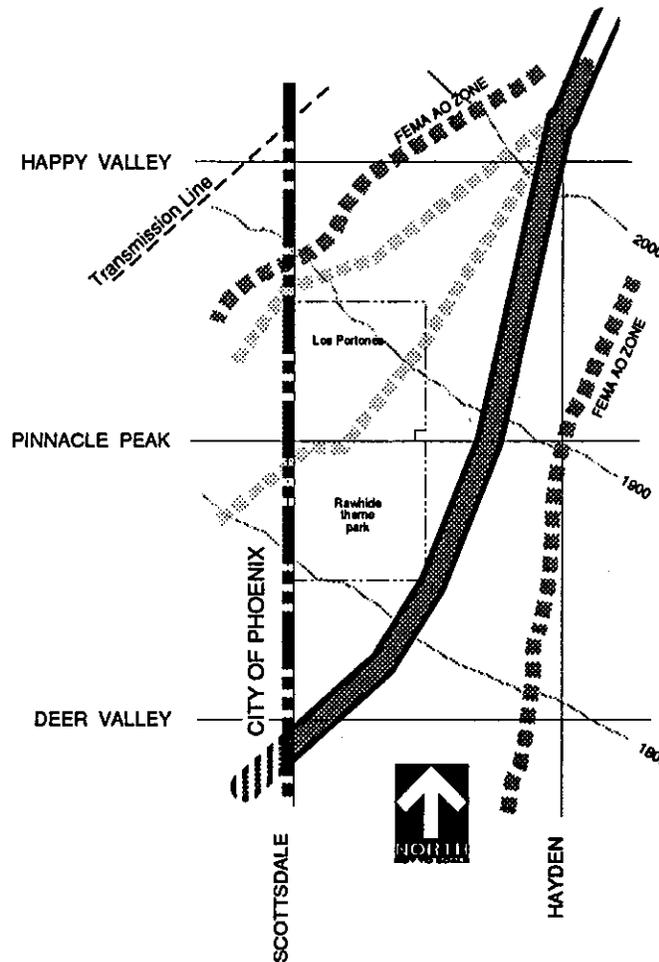
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

#### Containment Level

- Natural
- Partial
- Uncontained flow
- Cut section

## 7.1.5 SOUTH CHANNEL ALIGNMENT

Beginning at the primary apex one quarter mile north of Happy Valley Road, this alignment follows various braided channels to the south/southwest in an uncontained condition. The alignment crosses Pinnacle Peak Road approximately one third mile west of the Hayden Road alignment. From here, it turns more southwesterly approximately at the southeast corner of Rawhide theme park, and continues on to Deer Valley Road. Here the alignment crosses Deer Valley Road and Scottsdale Road just south of their intersection and enters the City of Phoenix.



### South Channel Alignment

Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

#### Containment Level



## 7.2 PINNACLE PEAK WASH ALTERNATIVES

Due to the unique nature of Pinnacle Peak Wash and the existing drainage system already in place within Desert Highlands subdivision, the alignment alternatives were broken down into three choices: No Action Alternative, Enhanced Existing Alignment, and an Alternative Alignment.

### 7.2.1 NO ACTION ALTERNATIVE

Under the No Action Alternative, the existing golf course, street crossings, and drainage system would remain undisturbed. Development intensities specified in the Scottsdale Land Use Element, typically one acre lots or larger, would be obtainable yet expensive. Without a structurally managed solution, development on the fans will be mandated by FEMA regulations which require more severe elevation of structures. Elevated building pads and on-lot drainage re-routing would be required. Under such an approach an inefficient drainage system may result regardless of the small scale of flows/depths. Also, since the flood hazard will remain, flood insurance will still be required.

However, there is only a limited benefit to an overall stormwater management plan for this specific watershed. Some disadvantages of an overall plan are the lack of specific containment areas and the lack of an outlet to planned drainage facilities and the amount of existing development.

### 7.2.2 ENHANCED EXISTING ALIGNMENT

This alignment would follow the existing alignment in place through Desert Highlands. However, in places where for hydraulic or hazard reasons the alignment is incapable of conveying floodwaters, increased channel sizes and street crossings would be implemented.

This alternative would provide benefits to residents of the area such as relieving owners in designated AO zones from flood hazards, severely raised building pads, and mandated flood insurance.

However, this alternative would create a new AO zone below the outlet of the enhanced drainage system unless complete containment is provided to the CAP storage basins (via existing or constructed drainage facilities). The benefits of this alternative are dependent upon identifying and integrating with a specific outlet point.

### 7.2.3 ALTERNATIVE ALIGNMENT

A further alternative was examined that removed the floodwaters from the existing drainage system and re-directed them via a man-made channel into nearby Reata Pass Wash (and watershed). This alternative requires potential increases in Reata Pass channel capacity and crossing structures of existing and planned drainage system and basins.

This alternative would remove the Pinnacle Peak AO zone and relieve property owners from flood hazard, severely elevated building pads, and flood insurance.

## 8.0 EVALUATION CRITERIA

In order to determine which proposed channel alignment best meets the identified goals and objectives the alignments were rated by members of the City staff task force according to their impacts in the following categories:

### Land Use:

- existing land uses
- proposed land uses
- major utility corridors
- transportation system
- recreational/open space
- existing drainage facilities

### Right-of-Way Acquisition

- number of affected property owners
- degree of existing improvements within right-of-way
- relative cost of right-of-way acquisition
- availability of existing right-of-way and/or easements

### Environmental Impacts

- cuts and fills
- vegetation
- wildlife
- archeology
- viewshed
- geology

### Hydraulic Considerations

- effects on existing drainage facilities
- channel cross section characteristics
- erosion and sedimentation

## 8.1 SPECIAL CONSIDERATIONS FOR PINNACLE PEAK WATERSHED

Due to the limited area of this floodplain and disparity between the alternative solutions, evaluation criteria and cost analysis are difficult to establish. Each alternative results in different AO zone resolutions, with additional floodplain management issues left unresolved. In the No Action alternative raised pads and individual drainage diversions must be considered. In the Enhanced Existing alternative, the AO zone is merely relocated and additional containment must be examined. Finally, the Alternative alignment impacts new watersheds and does not lead to a resolution of downstream on-site runoff.

This inconsistency of evaluation criteria and costs considerations makes apex to outlet resolution costs and benefit/detriments difficult to fairly compare when reviewing this AO zone only.

## 8.2 EVALUATION OF RAWHIDE WASH ALTERNATIVES

The figures below are an average of the responses of the city staff task force members using the following evaluation criteria:

Rank:1-5

Accurately describes=5

Various Accuracy levels=2-4

Inaccurately describes=1

	North Channel	Central Channel	South Channel	North Tributary	South Tributary
<b>LAND USE</b>					
The proposed alignment causes minimal disruption to the existing land uses.	5.0	4.0	4.9	5.0	5.0
The proposed alignment does not hinder or prohibit future and proposed land uses.	4.0	4.8	2.8	4.9	4.6
The proposed alignment does not impact or excessively cross any existing or planned major utility corridors.	3.8	3.3	2.4	3.4	4.0
The proposed alignment does not impact or excessively cross any existing or planned transportation routes.	3.9	3.1	1.9	3.8	3.4
The proposed alignment provides opportunities for the inclusion of open space tracts, with passive rec. facilities.	3.5	4.5	4.0	4.1	4.0
The proposed alignment takes advantage of existing drainage facilities such as culverts and channels.	2.4	4.8	1.8	4.0	2.8
<b>Average Land Use Rating:</b>	<b>3.77</b>	<b>4.08</b>	<b>2.97</b>	<b>4.20</b>	<b>3.97</b>
<b>RIGHT-OF-WAY ACQUISITION</b>					
The proposed alignment has few property owners who must be negotiated with to acquire necessary right-of-way.	3.5	3.3	1.4	4.9	5.0
The proposed alignment requires no removal and demolition of existing improvements or developments.	4.6	3.0	3.8	4.8	4.8

	North Channel	Central Channel	South Channel	North Trib.	South Trib.
Rank:1-5					
Accurately describes=5					
Various Accuracy levels=2-4					
Inaccurately describes=1					
<b>RIGHT-OF-WAY ACQUISITION</b>					
The proposed alignment's right-of-way is made up of predominately low cost land.	3.3	3.4	2.3	4.1	4.1
The proposed alignment takes advantage of existing or stipulated right-of-ways, easements, and/or open space tracts.	1.5	3.9	2.5	1.4	1.8
<b>Average ROW Acquisition Rating:</b>	<b>3.23</b>	<b>3.40</b>	<b>2.50</b>	<b>3.80</b>	<b>3.93</b>
<b>ENVIRONMENTAL IMPACTS</b>					
The proposed alignment minimizes the extent of disturbance associated with the construction of improvements.	3.0	4.0	1.6	3.4	2.1
The proposed alignment does not disturb significant stands of natural vegetation.	2.3	2.6	2.0	3.0	2.1
The proposed alignment imposes no threat upon any significant wildlife sanctuaries or habitats.	3.0	3.8	3.2	2.8	3.0
The proposed alignment does not disrupt or disturb any known archeological sites.	3.8	3.8	3.8	3.8	3.8
The proposed alignment and associated improvements do not affect the surrounding viewshed.	2.7	3.6	3.0	3.6	3.0
The proposed alignment does not significantly disrupt any known geological features such as major rock outcroppings.	4.6	4.7	4.7	4.6	4.6
<b>Average Enviromental Impact Rating:</b>	<b>3.23</b>	<b>3.75</b>	<b>3.05</b>	<b>3.53</b>	<b>3.10</b>
<b>HYDRAULIC CONSIDERATIONS</b>					
The proposed alignment does not require any modification or retrofitting of existing drainage facilities.	4.7	4.0	4.7	5.0	5.0

	North Channel	Central Channel	South Channel	North Trib.	South Trib.
Rank:1-5 Accurately describes=5 Various Accuracy levels=2-4 Inaccurately describes=1					
<b>HYDRAULIC CONSIDERATIONS</b>					
The proposed alignment facilitates the construction of a channel cross-section which provides reasonable depths of flow, flow velocities, and widths of flow during various storm events up to and including a 100 year event.	4.2	4.8	4.2	4.8	4.2
The proposed alignment minimizes erosion and sedimentation problems.	3.8	4.5	3.0	3.4	2.8
<b>Average Hydraulic Consideration Rating:</b>	<b>4.23</b>	<b>4.43</b>	<b>3.97</b>	<b>4.40</b>	<b>4.00</b>
<b>Overall Average Rating:</b>	<b>14.46</b>	<b>15.66</b>	<b>12.49</b>	<b>15.93</b>	<b>15.00</b>

**NOTE:**

The no action alternative was not ranked because the evaluation criteria specifically related to the alternative alignments. The task force is not recommending the no action alternative for the following reasons:

- Building pads would need to be severely elevated, thereby impacting the desert environment
- The areas could not be removed from special flood hazard areas and flood insurance would be required
- Development intensities identified in the General Plan would be difficult to obtain
- Sporadic drainage improvements created would be:
  - Inadequate in that drainage problems are transferred to other sites and;
  - Inefficient compared to an integrated regional plan which links the entire watershed and realizes an associated economy of scale
- Costs of approximately 100 million dollars would be required for flood protection construction, and flood insurance over a 30 year time frame in a "no action" alternative for the Rawhide Wash AO zone.

## 8.3 COSTS

### 8.3.1 RAWHIDE TRIBUTARY ALIGNMENT COST DATA

	North Tributary	South Tributary
Length	13,800 ft	13,200 ft.
Excavation <sup>1</sup>	\$ 27,800	\$ 161,400
Berms	\$84,800	\$ 240,400
Soil Cement	\$ 312,900	\$ 1,129,200
Grade Control Struct.	\$ 47,800	\$ 93,400
Bridges	\$ 745,900	\$ 858,400
Sub-Total	\$ 1,219,200	\$ 2,482,800
Clear and Grub <sup>2</sup>	\$ 38,000	\$ 109,600
Salvage/Reveg <sup>3</sup>	\$266,000	\$ 1,236,700
Sub-Total	\$ 304,000	\$ 1,346,300
Bike Paths <sup>4</sup>	\$ 207,000	\$ 198,000
Multi-Use Trails	\$ 2,800	\$ 2,600
Sub-Total	\$ 209,800	\$ 200,600
Construction Total	\$ 1,733,000	\$ 4,029,731
25% Contingency	\$ 443,300	\$ 1,007,433
Total Construction Cost	\$ 2,176,300	\$ 5,037,100
Right-of-Way <sup>5</sup>	\$ 711,400	\$ 1,216,000
Total Cost	\$ 2,887,700	\$ 6,253,100

Note: All cost data is reflected in 1992 dollars.

- 1: Channel excavation includes the excavation for the soil cement berm protection. Soil cement berm protection is installed to a depth of 4' below channel invert. Grade control structures placed every 1320', 2' width, 6' depth, length equals channel top width plus 10'.
- 2: Clear and grub includes the cost to clear and grub areas of channel cut and berms.
- 3: Revegetation/salvage costs assume the area calculated as channel length times the entire right-of-way width. All native plants sufficient to be salvaged are included in this cost. Channel revegetation factors: Natural containment .01, Partial containment .25 Uncontained flow .60, and cut section 1.00.
- 4: Bike paths are 10' wide. Multi-use trails assume a minor improvement within the proposed channel.
- 5: Right-of-way widths assume full channel width and berm width (both at grade) plus an additional 8' per side for maintenance.

### 8.3.2 RAWHIDE CHANNEL ALIGNMENT COST DATA

	North Alignment	Central Alignment	South Alignment
Length	6,600 ft.	9,300 ft.	14,800 ft.
Excavation <sup>1</sup>	\$ 138,100	\$ 336,700	\$ 309,700
Berms	\$ 249,000	\$ 209,400	\$ 558,300
Soil Cement	\$ 1,032,500	\$ 1,390,900	\$ 2,315,400
Grade Control Struct.	\$ 129,100	\$ 218,900	\$ 279,000
Bridges	\$ 1,693,100	\$ 2,193,800	\$ 2,930,600
<b>Sub-Total</b>	<b>\$ 3,241,800</b>	<b>\$ 4,349,700</b>	<b>\$ 6,393,000</b>
Clear and Grub <sup>2</sup>	\$ 117,300	\$ 220,900	\$ 263,100
Salvage/Reveg <sup>3</sup>	\$ 1,906,700	\$ 2,458,700	\$ 4,475,500
<b>Sub-Total</b>	<b>\$ 2,024,000</b>	<b>\$ 2,679,600</b>	<b>\$ 4,738,600</b>
Bike Paths <sup>4</sup>	\$ 99,000	\$ 139,500	\$ 222,000
Multi-Use Trails	\$ 1,320	\$ 1,900	\$ 3,000
<b>Sub-Total</b>	<b>\$ 100,300</b>	<b>\$ 141,400</b>	<b>225,000</b>
Construction Total	\$ 5,366,100	\$ 7,170,700	\$ 11,356,600
25% Contingency	\$ 1,341,500	\$ 1,792,700	\$ 2,839,200
<b>Total Construction Cost</b>	<b>\$ 6,707,600</b>	<b>\$ 8,963,400</b>	<b>\$ 14,195,800</b>
Right-of-Way <sup>5</sup>	\$ 1,215,900	\$ 1,204,900	\$ 2,854,000
<b>Total Cost</b>	<b>\$ 7,923,500</b>	<b>\$ 10,168,300</b>	<b>\$ 17,049,800</b>

Note: All cost data is reflected in 1992 dollars.

1: Channel excavation includes the excavation for the soil cement berm protection. Soil cement berm protection is installed to a depth of 4' below channel invert. Grade control structures placed every 1320', 2' width, 6' depth, length equals channel top width plus 10'.

2: Clear and grub includes the cost to clear and grub areas of channel cut and berms.

3: Revegetation/salvage costs assume the area calculated as channel length times the entire right-of-way width. All native plants sufficient to be salvaged are included in this cost. Channel revegetation factors: Natural containment .01, Partial containment .25 Uncontained flow .60, and cut section 1.00.

4: Bike paths are 10' wide. Multi-use trails assume a minor improvement within the proposed channel.

5: Right-of-way widths assume full channel width and berm width (both at grade) plus an additional 8' per side for maintenance.

## 9.0 RECOMMENDATION

### 9.1 RAWHIDE WASH RECOMMENDATION

After reviewing the results of the task force evaluation, it became clear that the North Tributary Alignment combined with the Central Channel Alignment were favorable in the majority of comparison categories and consistently achieved higher rankings than any other of the alternatives.

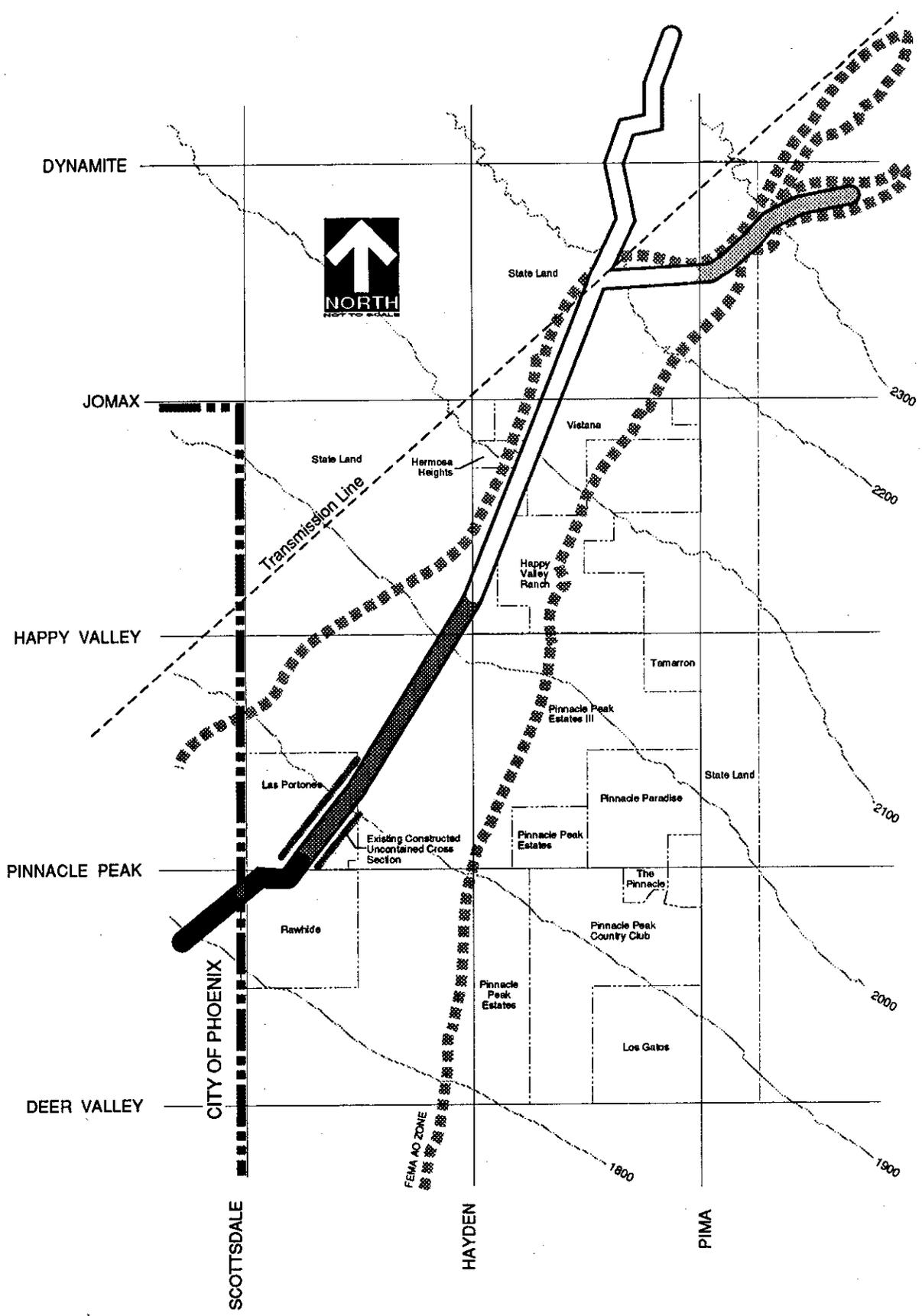
Estimated costs identified the North Tributary as less than the Southern Tributary. Of the three channel alignments, the North Channel Alignment was shown to be the least costly as it is the shortest of the channel alternatives. However, the Central Channel Alignment takes advantage of existing improvements within the wash, and therefore, remains comparative in overall cost. Additionally, the Central Channel Alignment incorporates the existing vegetation and sandy bottom of the natural wash which minimizes the environmental impact. Maintenance requirements and costs for each alternative are consistent in a "per mile" comparison and, due to the relatively minor yearly cost impacts, were not a significant determinant in identifying a preferred alignment (see technical appendix for maintenance cost data).

Based on the evaluations, the task force has identified the Central Channel Alignment in conjunction with the Northern Tributary Alignment as the most favorable due to their greater overall environmental sensitivity, cost efficiency, consistency with the Desert Greenbelt concept, and the goals and objectives identified by this report. In addition, the Central Channel Alignment is supported by the City of Phoenix and State Land Department, whose land this outlets onto. This alignment alternative has also been identified by the Upper Indian Bend Wash Intergovernmental Task Force as the preferred alignment (Figure 5).

As the intent of this report was to identify a potential alignment for stormwater management and not to create a design plan, the task force recommends a preliminary design study be prepared for this recommended alternative. Performed by an outside consultant, the purpose of this design study would be to determine a basis for engineering design and cost feasibility of this recommended stormwater management plan.

### 9.11 COST OF RECOMMENDED ALIGNMENT

North Tributary Construction Cost:	\$ 2,176,300
Central Alignment Construction Cost:	\$ 8,963,400
Construction Total:	<u>\$11,139,700</u>
North Tributary Right-of-Way:	\$ 711,400
Central Alignment Right-of-Way:	\$ 1,204,900
Right-of-Way Total:	<u>\$ 1,916,300</u>
Total Recommended Alignment Cost:	\$13,056,000



**Figure #5:**  
**Recommended Alignment-Rawhide Wash**

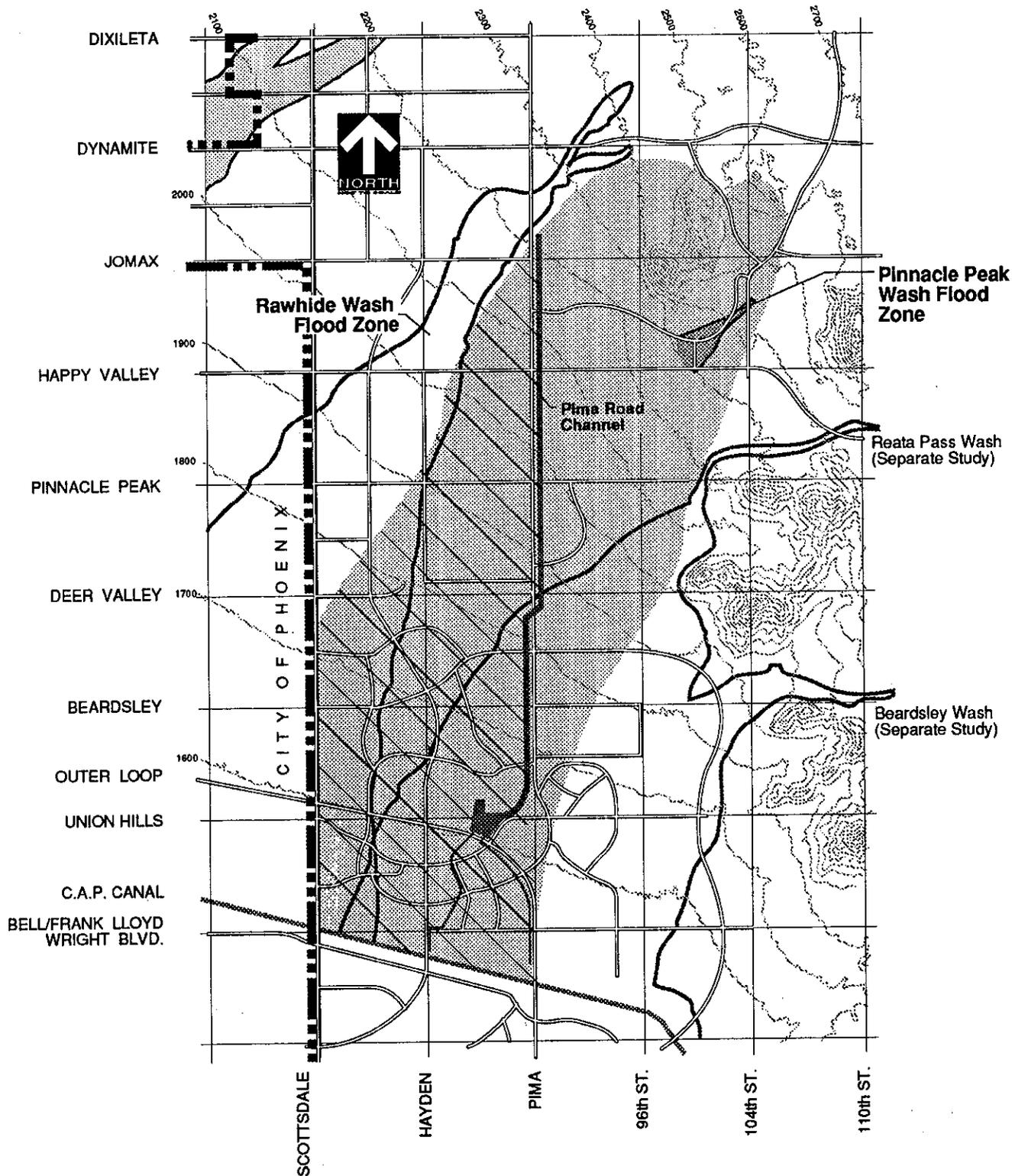
Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

## 9.2 PINNACLE PEAK WASH RECOMMENDATION/IMPLEMENTATION

Review of the alternatives was complicated due to the inability to remove the AO designation with improvement only from within the existing AO zone. The alternatives either would leave the AO designation (and hazard) in place, relocate the AO designation (and hazard) downstream from a new apex, or transfer the flows into another watershed where existing drainage structures and facilities would need modification to accommodate the increased volume.

Due to the complicated and unique nature of the alternatives, and the variety of resolution and improvements for only the designated AO zone, cost analysis was difficult to ascertain and comparison ineffective.

Several on going "Sub-Regional" stormwater management solutions have been proposed, discussed and studied for the area of the Pinnacle Peak watershed (Figure 6). As the Pinnacle Peak Wash AO zone is only a small fraction of this area, staff recommends that a concentrated study be initiated on this "sub-region" to resolve the various flooding concerns of residents of the area (particularly those west of Pima Road) and include the goals of removing the AO designation from the Pinnacle Peak Wash floodplain.



**Legend**

- Pinnacle Peak Watershed
- Area of watershed impacted by Pima Road Channel

**Figure #6:**  
Pinnacle Peak Watershed Impacts

Note: The purpose of these figures is completely illustrative only. For more detailed information, contact the City of Scottsdale.

## 10.0 IMPLEMENTATION

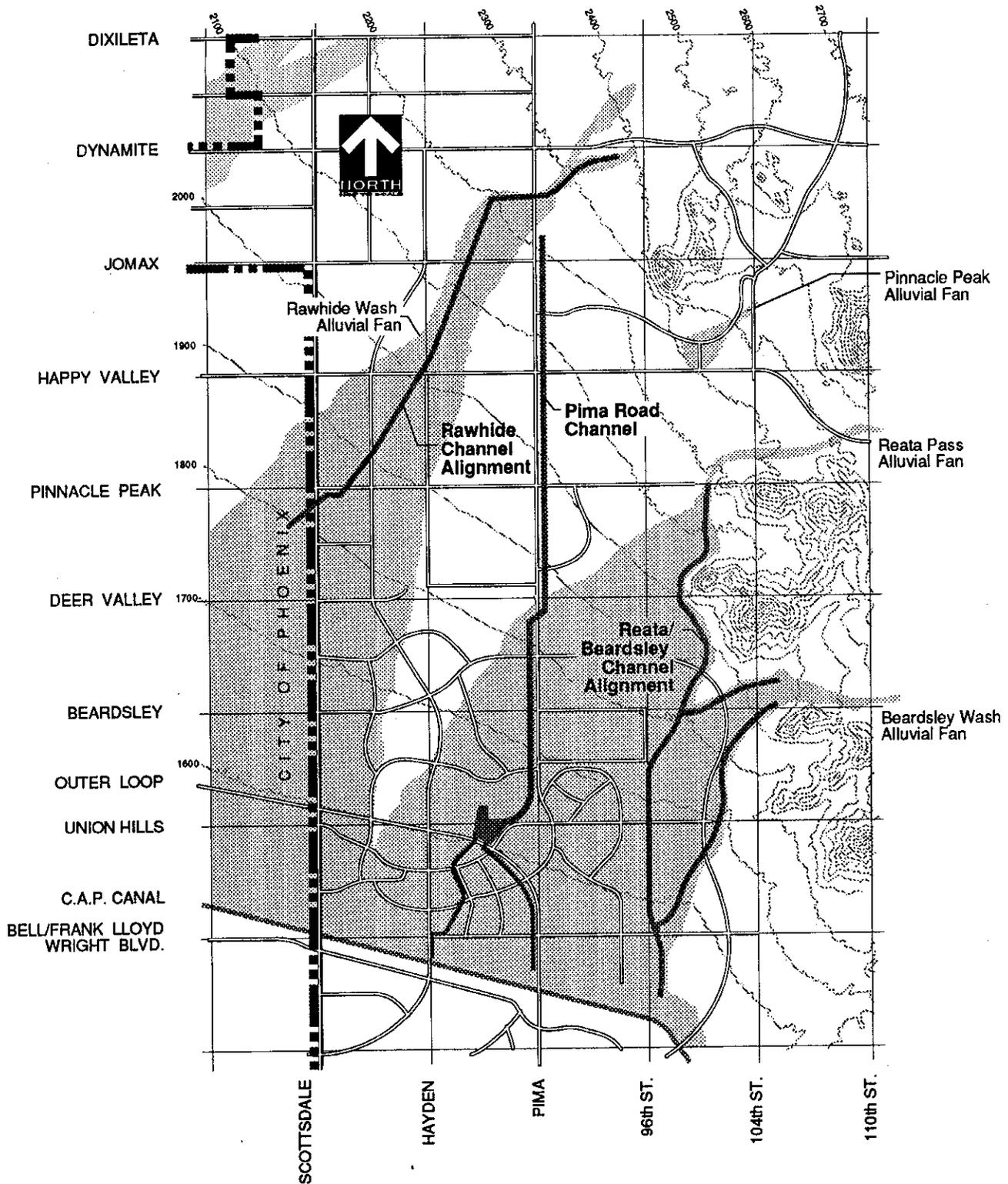
The information in this report is not intended to represent all of the potential concerns or engineering analysis required to construct a stormwater management channel for the Rawhide Alluvial Fan. However, this report does present general channel alignment concepts which attempt to maximize the uses of the existing natural channels, and multi-use amenities; as well as minimize the width of land required for improvements and the number of road crossing structures (Figure 7).

It is recommended the preferred alternative be further studied to determine final engineering and cost feasibility. This study should examine the proposed alignment under a specific set of engineering design guidelines including, but not limited to, the following:

- Consistency with the Desert Greenbelt concept
- Hydraulic and Sediment Transport Analysis
- Construction Phasing
- Channel Design and Treatments
- Impacts of the channel enhancements through Rawhide theme park parking lots and potential multi-objective design solutions
- Impacts of the outlet on the City of Phoenix (coordination with the City of Phoenix)
- Landscaping and amenities within channel
- Opportunities for groundwater recharge
- Detailed Cost/Benefit Analysis

Implementation of the stormwater management channel should also establish and coordinate the following items:

- Public Meetings
- Public Information Program
- Discussion with affected property owners
- Ordinance and Regulations
- Coordination Efforts with other Agencies
- Review and Approval Process
- Additional Environmental Assessment Requirements
- Funding Sources
- Risk Assessment



### Legend

 Flood Zones

**Figure #7:**  
**Recommended Conceptual Regional Stormwater Management Plan**

Note: The purpose of these figures is completely illustrative only. For more detailed information, consult the Upper Indian Bend Wash Regional Drainage & Flood Control Plan, July 1992.

## 11.0 FINANCIAL STRATEGIES

It is anticipated that the cost of the drainage facilities installed to implement the recommended stormwater management plan for the Rawhide Wash alluvial fan is in the order of \$13 million.

It is recommended that other governmental agencies be approached with a view to contributing to the required funds. These agencies should include:

- Arizona Department of Transportation
- City of Phoenix
- Maricopa County Flood Control District
- United States Bureau of Reclamation (USBR)
- United States Army Corp of Engineers

It is also recommended that property owners who benefit from the improvements contribute to the cost. The City of Scottsdale could also contribute a portion from approved Capital Improvement Projects.

Funding mechanisms that should be explored should include:

- Improvement Districts (ID)
- Community Facilities Districts (CFD). This funding mechanism is preferable because under the CFD legislation it is possible to fund the maintenance of the constructed system. The system will have a considerable maintenance requirement because of the nature of the improvements.

It is recommended that a benefit analysis study be initiated to develop a cost apportionment methodology for distributing the costs of the recommended Conceptual Regional Stormwater Management Plan (Figure 7). It is anticipated that benefits for assessment may include, but not be limited to, the following:

- Removal of 'AO' flood hazard.
- Relief from mandatory flood insurance costs.
- Relief from required individual stormwater protection (ie. raised building pads).
- Potential waiver of on site retention.
- Provision of access during a 100 year event.
- Savings through efficiency of infrastructure, planning and construction.
- Recreation benefits of joint use stormwater structures.
- Environmental preservation/management.

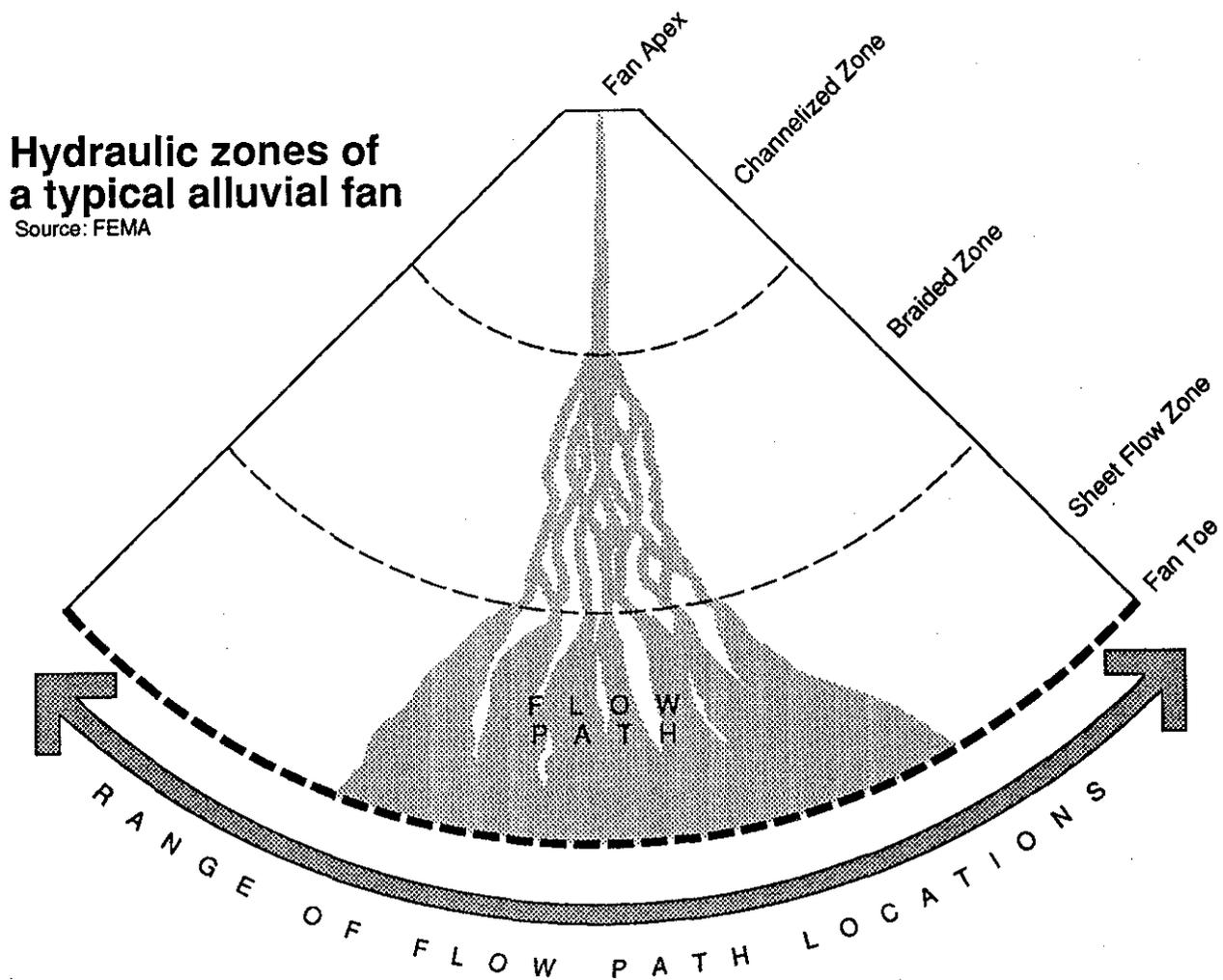
## 12.0 GLOSSARY

**Alluvial Fan:** a landform or geologic structure, conical or fan like in shape which is formed by sediments deposited by flowing water.

**Alluvial Fan Flooding:** flooding occurring on the surface of an alluvial fan originating at the apex and characterized by high-velocity flows; active processes of erosion, sediment transport and deposition, and unpredictable flow paths.

**AO Zone:** Area of special flood hazards having shallow water depths and/or unpredictable flow paths between one and three feet.

**Apex:** a point on an alluvial fan below which the flow path of the major stream that formed the fan becomes unpredictable and generally multi-pathed.



**Berm:** an embankment raised to contain waters within a watercourse to prevent flooding.

**CAP:** The Central Arizona Project, a U.S. Bureau of Reclamation aqueduct which delivers domestic and agricultural water from the Colorado River along the western boundary of Arizona to the metropolitan area of Phoenix and Tucson. A flood levee which protects the CAP canal forms the boundary between the Upper and the Lower Indian Bend Wash watersheds.

**FEMA:** The Federal Emergency Management Agency, an instrumentality of the executive branch whose director answers directly to the President of the United States, with the prime responsibility of being the central point of contact for all emergency situation management, for natural and man-caused disasters and with other responsibilities which include providing resources, guidance and assistance to local governments and the management of the National Flood Insurance Program.

**Flood:** water flowing over the land which exceeds the capacity of a watercourse having a defined bed and banks or a closed container such as a storm drain.

**Floodplain:** the area of a watercourse and the adjacent land areas that are required to convey the peak discharge of a flood.

**Indian Bend Wash:** the major stormwater channel in Scottsdale which drains into the Salt River in Tempe.

**Lower Indian Bend Wash:** refers to the 120 square mile watershed tributary to the Salt River downstream from the CAP protective levee.

**Stormwater:** water flowing across the land, either contained or not contained, resulting from a rainfall event.

**Topography:** the detailed and precise physical description of a place and the graphic technique of representing the exact physical features of that place on a map.

**Upper Indian Bend Wash:** refers to the 86 square mile watershed tributary to the CAP protective levee.

**Watercourse:** a lake, river, creek, stream, wash, arroyo, channel or other topographic feature on or over which waters flow at least periodically. Watercourses include specifically designated areas in which substantial flood damage may occur.