City of Scottsdale
Desert Greenbelt Project

EXECUTIVE SUMMARY AND BASELINE CONDITIONS REPORT IN SUPPORT OF A 404 PERMIT APPLICATION REATA PASS/BEARDSLEY WASH PIMA FLOODPLAIN

The Desert Greenbelt
SCOTTSDALE, ARIZONA

Main Report
Volume 1 of 5
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Prepared by:
Simons, Li & Associates, Inc.
Costa Mesa, California

EXECUTIVE SUMMARY

AND

BASELINE CONDITIONS REPORT

IN SUPPORT OF A 404 PERMIT APPLICATION

PREPARED FOR THE CITY OF SCOTTSDALE

DESERT GREENBELT PROJECT

Prepared by

Simons, Li & Associates, Inc.
San Diego, California

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EXECUTIVE SUMMARY

This report provides baseline conditions and alternatives analysis for a regional flood-control project proposed by the City of Scottsdale for the Reata Pass/Beardsley Wash and Pima Floodplain in northern Scottsdale. The flood-control system will impact waters of the U.S. and is subject to the jurisdiction of the United States Army Corps of Engineers under Section 404 of the Clean Water Act.

The Reata Pass / Beardsley Wash alluvial fans and the Pima floodplain in northern Scottsdale, Arizona are subject to a severe flooding potential. In 1993, The Federal Emergency Management Agency (FEMA)completed mapping of approximately nine square miles of flood-prone area with 100-year flood depths ranging from one to four feet. Alluvial fan flooding is unpredictable, difficult to quantify and is potentially catastrophic to human life, homes and businesses on the Reata Pass / Beardsley Wash alluvial fans. Flood flows tend to be high velocity and laden with sediment and debris. Alluvial fan stream channels are unstable and highly subject to shifting out of their banks to form new channels. Structures located directly in the path of a new channel can be subject to severe damage whether elevated to the regulatory flood level or not.

The National Research Council (NRC) describes alluvial fan flooding as "ultrahazardous." The Reata Pass Wash, in particular, was singled out by the NRC to illustrate the potential for large, kilometer-scale changes in the positions of flow paths that can occur on alluvial fans. In addition, the U.S. Geological Survey rated the Reata Pass Wash as a flood-hazard degree nine, out of ten possible.

The Pima Floodplain, located west of and partially overlapping the Reata Pass/Beardsley Wash regulatory floodplain, is not mapped by FEMA but is subject to extensive flooding and channel bank and bed erosion during heavy rainstorms. The study area consists of the developed portion of the Reata Pass/Beardsley Wash regulatory floodplain, and all of the Pima Floodplain west of Pima Road.

Over the past ten years, the Reata Pass/Beardsley Wash and Pima Floodplains have experienced extensive development. In terms of area permitted and disturbed, approximately 67% of the Reata Pass/Beardsley Wash and 75% of the Pima floodplain study areas have been altered from their natural state through the construction of buildings, roads, golf courses and other graded areas. There are now more than 2,100 residences on the Reata Pass/Beardsley Wash alluvial fan, and more than 2,400 on the Pima Floodplain. Approved but not yet constructed residences are approximately 650 on the Reata Pass/Beardsley Wash alluvial fan and 1,000 on the Pima Floodplain. Total units constructed or approved for construction for all development including resort and non-residential are 3,859 on the Reata Pass/Beardsley Wash alluvial fan and 4,541 on the Pima Floodplain. The value of current development, with contents, is estimated at $645,240,000 for the Reata Pass/Beardsley Wash and $589,950,000 for the Pima Floodplain.

Permits will continue to be granted in the future with or without a regional flood-control system. New structures are allowed within the regulatory Reata Pass/Beardsley Wash floodplain provided that they are elevated above the regulatory 100-year flood depth. There is no regulatory flood depth on the Pima Floodplain. By the year 2030, the Reata Pass/Beardsley Wash alluvial fan is expected to have 6,776 residences, and 5,644 to exist on the Pima Floodplain (not counting resort and non-residential development). Structure and content values will be more than $2,000,000,000 dollars for the Reata Pass/Beardsley Wash floodplain and $1,360,000,000 for the Pima Floodplain.

Alluvial fan flooding is so hazardous that elevating structures to the regulatory flood level does not eliminate flood damage. Elevating building pads above the regulatory flood level is the minimum FEMA requirement that only allows structures to be legally constructed and the local community to participate in the National Flood Insurance Program. Elevation on fill does not reliably mitigate the risk. According to FEMA: ". . . elevations of a parcel of land or a structure by fill or other means, will not serve as a basis for removing areas subject to alluvial fan flooding from an area of special flood hazards. FEMA will credit on NFIP maps [i.e. remove the Zone AO designation] only major structural flood control measures whose design and construction are supported by sound engineering analyses which demonstrate that the measures will effectively eliminate alluvial fan flood hazards from the area protected by such measures."

As a result of the "ultrahazardous" flooding condition on the alluvial fan, the potential for flood damage is high even though structures built since the 1993 FEMA map designation have been elevated to the regulatory flood level. The current annualized flood damage potential from all floods is estimated at $3,890,800 per year for the Reata Pass/Beardsley Wash and Pima Floodplain. A single 100-year flood is expected to cause nearly $30,000,000 damage to residential structures and contents under current conditions. This does not include any potential damage to infrastructure and the City of Scottsdale's Water Campus. By the year 2030, the damage potential from all floods is expected to rise to $11,025,500 per year, with $120,000,000 damage to structures and contents during a 100-year flood.

The project area is typical of alluvial fan desert wash drainage systems, consisting of vein-like networks of stream channels that are capable of containing small to moderate flows. Vegetation is generally distributed according to water availability. Along the washes, vegetation is characterized by a corridor of larger and/or greater density trees and shrubs. Species closely associated with washes generally have greater water requirements, while species more tolerant of drier soil conditions occur both along the washes and across the adjacent terraces. The corridors of wash vegetation generally become more closely aligned with the active channels with increasing distance down the alluvial fan.

The most common Sonoran Desert vegetation type in the project area is the Paloverde-Cacti Mixed Scrub Series of the Arizona Upland Subdivision. Most of the northern and eastern portions of the project area, along the McDowell Mountains front, supports this vegetation type. Typical of this Series, the dominant overstory species are foothill palo verde and Saguaro cactus.

Along the washes, the most common overstory species in the project area is foothill palo verde, with ironwood, blue palo verde, cat-claw acacia, and an occasional velvet mesquite also present. On the upper alluvial fan, these species are most common, and attain the greatest size, along the wash channels; however, they may also occur on the adjacent terraces and, occasionally, on hillsides.

Dominant upland species of the Paloverde-Cactus Mixed Scrub Series include creosote, jojoba, and triangle-leaf bursage.

The Lower Colorado River Valley Subdivision of the Sonoran Desert is characteristic of the drier, finer textured soils of the lower alluvial fan. This plant community is best represented near the CAP canal and in the southwestern portion of the project area. This subdivision is dominated by creosote and bursage with sparsely scattered cacti; larger trees, including foothill palo verde and ironwood, are typically limited to the washes. Interwashes are barren of understory most of the year; however, after the rainy seasons, many annual species occupy these areas.

The disturbed/developed areas are characterized by residential uses, unpaved and paved roads, drainage culverts and structures, recreational facilities, and commercial developments. Residential lots are common on the alluvial fan surface, outside of the main channels, throughout the length of the project area. Three golf courses are located in the central project area. Many of the developed areas have been landscaped with native and nonnative drought tolerant species including mesquite, ocotillo, palo verde, and several species of cacti. While landscaping is typical of developed areas, some projects have retained natural Sonoran Desert vegetation withing the developments.

The area is located within the northern end of the historic range of the cactus ferruginous pygmy owl and the lesser long-nosed bat, both Federally-listed and state-listed endangered species. Results of a previous survey indicate that the pygmy owl is not present on the site. The lesser long-nosed bat has been observed in the vicinity of the McDowell Mountains.

Waters of the U.S. in the 8,550-acre study area total 160.7 acres, including 63.4 acres of waters connected to the alluvial fan apex, and 97.3 acres not connected to the apex (fed by local runoff). Vegetative habitat shows a similar pattern. The 8,550 acre project area includes about 500 acres of wash habitat. About 185 acres are linked to the Reata Pass Wash apex and about 315 acres are sustained by local watersheds.

The State Historic Preservation Office has indicated that the project site contains no significant cultural resources, and that it is likely the project will have no effect on any properties listed or eligible for inclusion on the National Register of Historic Places.

The City of Scottsdale proposes to build a regional flood-control solution for the Reata Pass/Beardsley Wash and Pima Floodplain. The basic project purpose is to remove the 100-year flood hazard to protect human life, existing and future homes, businesses and public improvements, and enhance recreation.

1. **Flood Hazard Removal**: To provide 100-yr flood protection for existing and future homes, businesses and public improvements within the FEMA designated Special Flood Hazard Area of the Reata Pass Wash and Beardsley Wash alluvial fans and within the Pima Floodplain;

2. **Flood Protection for Public Improvements**: To provide flood protection for Pima Road, Scottsdale Road, Thompson Peak Parkway, other local streets, the City of Scottsdale Water Campus, and local utilities; and,

3. **Enhance Recreation**: To enhance recreational use of the Reata Pass and Beardsley Wash alluvial fans and provide path and trail linkages to the McDowell Mountains and City-wide recreational corridors.

The proposed project consists of two main components. The first is an open channel system extending from the apex of the Reata Pass Wash to the U.S. Bureau of Reclamation (USBR) detention basin on the north side of the Central Arizona Project canal (CAP) east of Pima Road in northern Scottsdale. This open channel follows the alignment of the existing wash with the greatest natural capacity. The channelization has several different cross sections: fully lined with soil cement, levees along natural wash, incised channel with soil cement bank protection and grade control structures. The channel will be contoured and vegetated to appear as natural as possible given the flood-control function. The channel alignment is basically along the alignment of an existing wash that runs north to south along the east side of the developed portion of the Reata Pass/Beardsley Wash alluvial fan. The undeveloped portion of the alluvial fan to the east of the channel alignment will not be protected.

The second component is a series of three detention basins connected by underground storm drains along Pima Road. This system extends from one-quarter mile north of Jomax Road to the USBR detention basin west of Pima Road. This system turns to the southwest at approximately Union Hills Road, and enters the USBR detention basin along the Hayden Road alignment. Two of the detention basins are east of Pima Road. The third basin is west of Pima Road partially within the Loop 101 Freeway right-of-way. This third basin is elongated east to west along the Freeway right-of-way for the purpose of protecting the Princess/TPC/Perimeter Center developments from flooding generated on the Pima Floodplain surface. The Loop 101 Freeway has already been permitted by the Corps of Engineers as a pass-through system and is not a part of this permit application.

Twenty alternatives to the proposed project, including no action, are considered. These alternatives were identified based upon previous analyses prepared by the City of Scottsdale, a request by the Corps of Engineers, and suggestions by the public. Alternatives were evaluated for compliance with the 404(b)(1) guidelines used by the Corps in evaluating discharges of dredged or fill material into waters of the United States under section 404 of the Clean Water Act. The guidelines require that:

1) the discharge be the least environmentally damaging practicable alternative;

2) the discharge not violate any water quality standard or toxic effluent standard, or jeopardize a threatened or endangered species;

3) the discharge not result in a significant degradation of the waters of the United States; and,

4) unavoidable impacts to the aquatic ecosystem must be mitigated.

An alternative was determined to be practicable if it is available and capable of being done after taking into consideration cost, existing technology and logistics in light of overall project purposes.

Alternatives were evaluated for practicability, ability to meet project purpose, and potential environmental impacts. Environmental impacts evaluated included waters of the U.S., plant communities, wildlife, sensitive species, cultural resources, visual resources, hydrology, land use, traffic, public health and safety, and groundwater recharge.

It was determined that the proposed project and alternatives would result in direct impacts to vegetation and waters of the U.S. through construction, and indirect impacts through alteration of the alluvial fan hydrology. Watercourses indirectly impacted will continue to receive local runoff, which is demonstrated by the example of washes not connected to the fan apex to be sufficient to maintain riparian vegetation on most of the alluvial fan. The further downstream the vegetation is from the alluvial fan apex, the more the vegetation relies on rainfall and local runoff rather than flows from the apex. These impacted areas will continue to be subject to permit applications by others under the Corps 404 program after implementation of this project.

The greatest potential for indirect impacts to vegetation is in the upper alluvial fan area, between the apex and Deer Valley Road, and on the east channel of Reata Pass Wash, downstream of North Beardsley Wash. These areas supports some of the most extensive and diverse wash habitat in the project area. The indirect impact is a possible long-term change in habitat caused by the alteration in the hydrologic regime.

Overstory species that may be affected would likely include blue palo verde, velvet mesquite and catclaw acacia. As a result of less moisture availability, individual plants may suffer a decline in health, and recruitment may be reduced. Over the long term, this may result in a reduction in the density of wash species on the upper fan, or even loss of some infrequently occurring species, such as blue palo verde or mesquite, that currently occur in low numbers. A vegetative survey of the alluvial fan found only small numbers of blue palo verde and velvet mesquite on the upper portion of the alluvial fan. Blue palo verde density on the upper alluvial fan was found to average < 1 individual per acre. Velvet mesquite density averaged just 0.2 individuals per acre. No blue palo verde or velvet mesquite was observed during the vegetative survey of the lower alluvial fan area.

The remaining areas of indirect impact are either in areas far removed from apex or other significant tributary flows, or are already affected by diversions associated with existing development. These riparian areas are largely sustained by local watersheds. It is likely that local watersheds would

continue to sustain these areas with the project or alternatives in place. Consequently these areas are not expected to be adversely affected by the project.

The No Action alternative would leave the floodplain subject to potentially catastrophic floods. The current average annual flood damage potential of $3,890,800 per year would continue and rise to $11,025,500 per year by the year 2030.

After consideration of ability to meet project purpose, impacts to waters of the U.S., impacts to biological resources, other environmental impacts, and cost, Alternative 21, Reata Pass Levee and Channel Project, Fan Apex to Westworld Detention Basin with Pima Road Three Basin Project and Low-Flow Diversion, is determined to be the least-damaging practicable alternative. Alternative 21 removes the flood hazard, meets the entire project purpose, and minimizes impacts to vegetation, wildlife and the waters of the U.S. through an 800-cfs flow diversion to water habitat at the upper alluvial fan.

Mitigation would consist of establishment of approximately 40 acres of riparian habitat within the flood-control channel on the lower alluvial fan downstream of the Beardsley Wash confluence. All of the area within the flood-control channel will become waters of the U.S. after construction. Revegetation of the 40-acre restorable portion of the flood control channel will mitigate all of the direct impacts of the waters of the U.S. at a ratio of slightly more than 2:1, and most of the direct impacts (in terms of area) to riparian habitat.

Indirect impacts, which would be characterized by a possible, long-term replacement of blue palo verde, velvet mesquite and catclaw acacia with more upland overstory species tolerant of slightly more xeric conditions (such as foothill paloverde and ironwood) in the affected areas, would be avoided on most of the upper Reata Pass alluvial fan by the 800 cfs diversion on Alternative 21. Indirect impacts along the East Wash and downstream of the Beardsley Wash apex would be mitigated by the establishment of blue palo verde, velvet mesquite and catclaw acacia in the restored channel bottom between the confluence of the Beardsley Wash and the Westworld detention basin.

Long term monitoring of revegetation areas and preserved habitat by qualified biologists is recommended. Contingency mitigation measures, including alternative mitigation sites and/or mitigation strategies would be implemented should monitoring indicate decline of the wash community.

The following table provides a summary of the results of the evaluation.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
1. Scattered Detention/ Retention Facilities	Not feasible	Not feasible	No project purpose met	NE[7]	NE	NE	NE	Not practicable because not feasible from an engineering and logistical standpoint
2. Detention at the Alluvial Fan Apex	Feasible	Not feasible	1,2: Met 3: Not met	NE	NE	NE	$63,000,000	Not practicable because of cost, environmental impact, logistical infeasibility, and failure to fulfill entire project purpose. Negative impact on recreation.
3. Streambank Stabilization	Feasible, but does not remove flood hazard	Feasible	1,2: Not met 3: Possibly met	NE	NE	NE	NE	Not practicable because existing channels do not have capacity for 100-year flood discharges. This alternative does not meet the project purpose
4. Relocation	Feasible	Feasible	1,2: Met 3: Not met	None	None	None	More than $2,000,000,000	Not practicable because of excessive cost and significant social disruption.
5. Environmental Enhancement	Not Feasible	Not Feasible	No project purpose met	NE	NE	NE	NE	An environmental enhancement project is not practicable. The existing habitat is not degraded and there is no opportunity for enhancement. See Alternative 15.
6. Floodproof Existing Structures	Feasible	Feasible	No project purpose met	None	None	None	NE	Not practical because it would not be effective flood protection and is not recognized by FEMA as a means to eliminate alluvial fan flood hazards on residential structures.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
7. Stop Development	Not applicable	Feasible	No project purpose met	None	None	None	$218,000,000	Not practicable because it would cost many times more than the proposed project and not achieve the primary project purpose of protecting existing development.
8. Watershed Management	Not feasible	Not feasible	No project purpose met	NE	NE	NE	NE	Not practicable because it would result in substantial impact to the natural ecosystem without achieving the required level of flood protection. Probable very high cost.
9. Onsite Detention for Each Development	Feasible but not effective	Feasible	No project purpose met	NE	NE	NE	NE	Not practicable because flood discharges are generated upstream of the alluvial fan where there is no opportunity for onsite detention. Onsite detention is ineffective at reducing large, historic flood discharges.
10: No Action	Not Applicable	Not applicable	No project purpose met.	0	0	0	None	Not practicable because it does not meet any project purpose. Leaves the entire area subject to severe flood hazard.
11: Reata Pass Levee and Channel Project, Fan Apex to Westworld Detention Basin	Feasible	Feasible	1, 2: Partially Met 3: Met	64	64	0	$41,237,000	Practicable, except as stand-alone project does not fulfill complete project purpose.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
12: Reata Pass Levee and Channel Project, Fan Apex to Union Hills Drive	Feasible	Feasible with purchase of residual floodplain land.	1, 2, 3,: Partially met	61.7	61.7	0	$70,466,000	Not practicable because of substantially higher total cost than Alternative 11. Less effective than Alternative 11 at meeting project purpose. Avoided impact to waters of the U.S. is small in comparison to the increased cost.
13: Reata Pass Levee and Channel Project, Fan Apex to Union Hills Drive with Detention Basin at Union Hills Drive	Feasible	Feasible	1, 2, 3: Partially met	64.3	64.3	0	$52,192,000 to $69,912,000 depending upon excavation transport costs	Not practicable because of substantially higher total cost than Alternative 11. Impact to waters of the U.S. is higher than that of Alternative 11. Less effective than Alternative 11 at meeting project purpose.
14: Wider Channel	Feasible	Feasible	1,2: Partially Met 3: Met	NE: More than for proposed project	NE: More than for proposed project	NE: More than for proposed project	NE: Higher than proposed project	Practicable, except higher cost and environmental impact than for the proposed project.
15: Reata Pass Wash Partial Levee Project, Fan Apex to Westworld Detention Basin	Feasible	Feasible	1,2: Partially Met. 3: Not Met	64	64	0	$43,179,000	Not practicable because of induced flood hazard on adjacent property resulting in higher cost than the proposed project, significant adverse visual impact to the area, and unsuitability for use as a recreational corridor.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
16: Protect Existing Development Using Levees (Ring Dikes)	Not feasible	Not feasible. Violates Floodways and Floodplains ordinance	No project purpose met because not feasible.	NE[5]	NE[5]	NE[5]	NE: Cost would be many times the cost of the proposed project.	Not practicable because not feasible from an engineering, local regulatory or logistical standpoint. Cannot meet project purpose.
17: Reata Pass Wash Narrow Channel Project, Fan Apex to Westworld Detention Basin	Feasible but not advisable due to safety and maintenance concerns.	Feasible	1, 2: Partially met. 3: Not met	64	64	0	$53,110,000	Not practicable because does not fulfill project purpose. Creates hazardous in-channel condition. Inconsistent with natural open space transition into McDowell Sonoran Preserve. Avoided impact to waters of the U.S. is small in comparison to the increased cost in comparison to proposed project
18: Pima Road Levee/Channel Stand-Alone Project	Feasible but not practical given required design considerations and current land use	Feasible	1, 2: Partially met 3: Not met	7.5	0	7.5	$135,273,000	Not practicable as a stand-alone project because it only partially fulfills the project purpose. Would result in substantial disruption of land use along Pima Road. Substantial increase in cost in comparison to Alternatives I and J.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
19(a): Pima Road Three Basin Stand-Alone Project[6]	Not feasible. Will not function as a stand-alone project.	Feasible	No project purpose met.	10.7	0	10.7	$58,257,000 (Not including $5,500,000 extra cost of Loop 101 Freeway pass-through system)	Not practicable as a stand-alone project because it does not fulfill the project purpose. Practicable if combined with a regional solution on the Reata Pass/Beardsley wash. Not practicable in comparison to 19(b) due to excessive cost in comparison to benefits gained.
19(b): Pima Road Three Basin Stand-Alone Project[7]	Not feasible. Will not function as a stand-alone project.	Feasible	No project purpose met.	12.6	0	12.6	$53,081,000	Not practicable as a stand-alone project because it does not fulfill the project purpose. Practicable if combined with a regional solution on the Reata Pass/Beardsley wash.
20: Reata Pass Levee and Channel Project, fan Apex to Westworld Detention Basin with Pima Road Three Basin Project.	Feasible	Feasible	Entire project purpose met	72.6	64	8.6	$94,318,000	Practicable. Fulfills entire project purpose.

Alternative Summary

Alternative	Engineering Feasibility	Local Regulatory Feasibility	Project Purpose[1]	Impacts to Waters of the U.S.[2] (In acres)			Cost	Conclusion
				Total	RPBW[3]	PF[4]		
21: Reata Pass Levee and Channel Project, Fan Apex to Westworld Detention Basin with Pima Road Three Basin Project and Low-Flow Diversion	Feasible	Feasible	Entire project purpose met	45.6	37	8.6	$94,684,000	Alternative 21 meets the entire project purpose and minimizes impact to vegetation, wildlife and the waters of the U.S. through the 800 cfs diversion. This is the least-damaging practicable alternative.

1 Project purposes are: 1) Flood Hazard Removal; 2) Flood Protection for Public Improvements; and, 3) Enhance Recreation.
2 Includes direct and indirect impacts. See Table 4.3 for detailed impact summary.
3 Reata Pass/Beardsley Wash impacts. These are impacts that occur as a result of flood-control improvements to the Reata Pass/Beardsley wash. Impacts within the Reata Pass/Beardsley Wash floodplain but related to the Pima Road improvements are classified as Pima Floodplain impacts.
4 Pima Road/Pima Floodplain impacts. These are impacts related to the Pima Road/Pima Floodplain improvements.
5 Not possible to estimate. All waters of the U.S. within study area would potentially be impacted.
6 See Table 4.6 for detailed summary of impacts.
7 Not Estimated for the reason that the project is determined to be not feasible or practicable or does not fulfill project purpose.

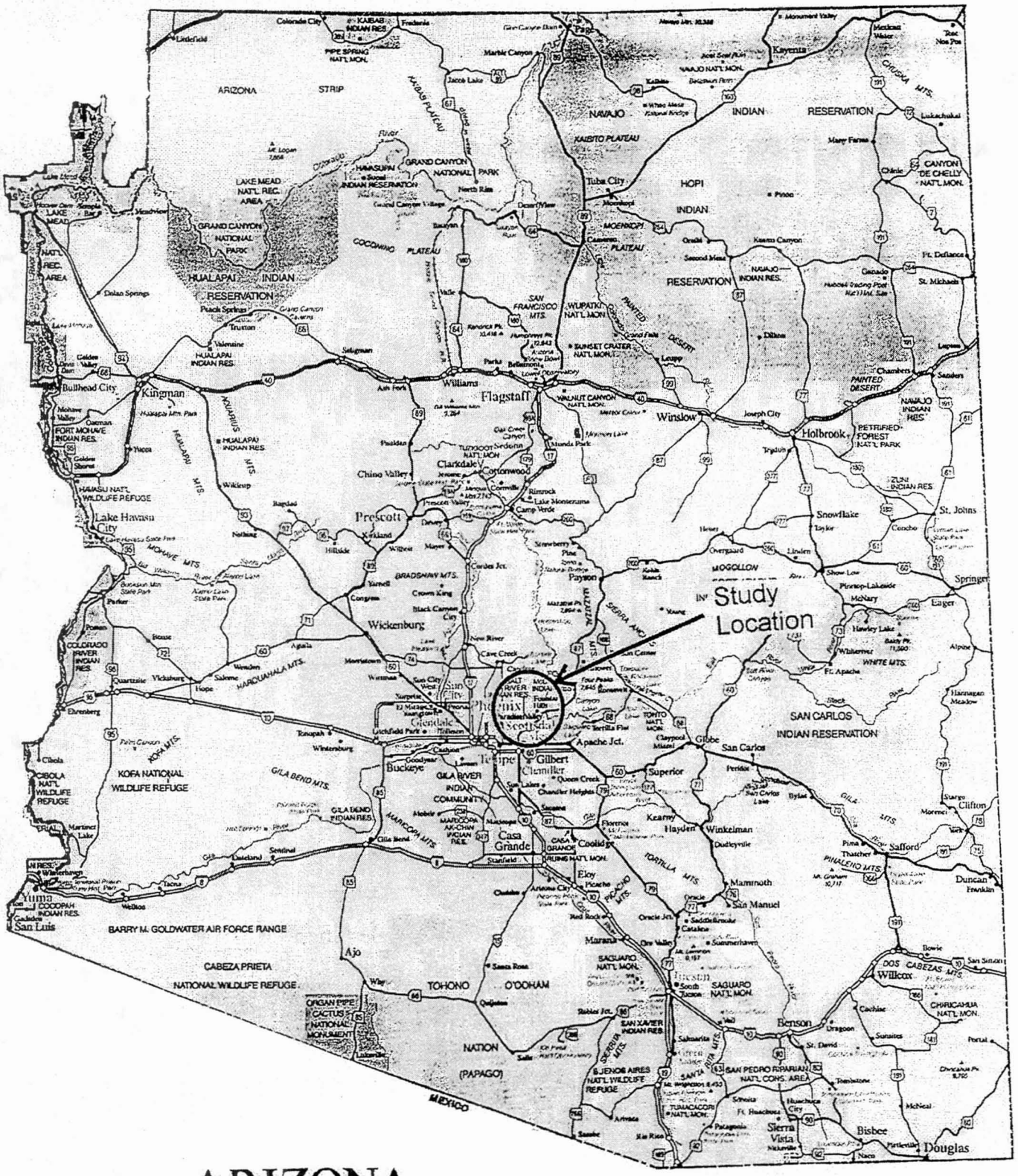
BASELINE CONDITIONS REPORT

I. INTRODUCTION

The Reata Pass / Beardsley Wash alluvial fans and the Pima Floodplain in northern Scottsdale, Arizona (Figure 1.1) are subject to periodic and severe flooding originating in the area of the McDowell Mountains. The Federal Emergency Management Agency (FEMA) in 1993 completed mapping of approximately nine square miles on the Reata Pass / Beardsley Wash alluvial fans of flood-prone area with 100-year flood depths ranging from one to four feet on the average across the surface of the alluvial fan. Recent aerial photographs were examined to determine the extent to which development had disturbed the natural desert ecosystem. A developed area was assumed to be any area where homes, businesses or golf courses are in place or where the drainage and street networks are in place and alterations have been made to the natural desert landscape to the extent that additional structures can be easily constructed. This investigation of the aerial maps shows that the Reata Pass / Beardsley Wash floodplain area is approximately 67% developed, with mainly single-family residences. The FEMA floodplain designation does not prohibit development, which will continue for the foreseeable future. The flood hazard in the Pima floodplain was not mapped by FEMA; however, there is historical evidence of flooding in this area. The aerial maps show that the Pima floodplain area is approximately 75% developed, with mainly single-family residences (Note: these percentages are based on area disturbed where habitat is impacted). Percentages based solely on structure count would be different). Consequently, due to the potential for flood and erosion damage to development, the Reata Pass and Beardsley Wash alluvial fans and the Pima floodplain have become a focus of concern by the City of Scottsdale and the Flood Control District of Maricopa County.

Alluvial fan flooding is unpredictable, difficult to quantify and represents a particularly catastrophic type of flooding for development. According to FEMA (February 1989),

> *"An often-overlooked 'hazard' is the tendency to underestimate both the potential and severity of alluvial fan flood events. The infrequent rainfall, gently-sloping terrain, and often long time spans between successive floods events contribute to a sense of complacency regarding the existence of possible flood hazards. Though the intense rainstorms which produce fan floods occur randomly, they nevertheless can develop very rapidly at any time, and can recur with any frequency."*



ARIZONA

Figure 1.1
Location Map

The State of Arizona Bureau of Geology and Mineral Technology (1979) published a geologic hazards map entitled "Environmental Geology of the McDowell Mountains Area, Maricopa County, Arizona." This map covers a major portion of the Reata Pass/Beardsley Wash alluvial fan. This publication describes the flood hazard on the Reata Pass/Beardsley Wash alluvial fan as follows"

> *"The youngest fan segment is the present day area of deposition. The major washes carry runoff and sediment from the mountains and as the stream channel decreases in depth down fan, the runoff spills over the channel sides and debauches onto the fan surface. The drainage system is braided and channels continually change positions. Flooding is generally severe in major storms and overflowing channels add to the sheetflow problems down fan."*

Due to controversy over development on alluvial fans, and the proper method of evaluating and managing the flood hazard on alluvial fans, FEMA recently asked the National Research Council (NRC), a division of the National Academy of Sciences, for help. The NRC established the Committee on Alluvial Fan Flooding which consisted of eight engineers and earth scientists, all with recognized expertise in alluvial fan morphology and processes. The NRC's 1996 report, entitled "Alluvial Fan Flooding," proposed the following definition of alluvial fan flooding:

> *"Alluvial fan flooding is a type of flood hazard that occurs only on alluvial fans. It is* ***characterized by flow path uncertainty so great that this uncertainty cannot be set aside in realistic assessments of flood risk or in the reliable mitigation of the hazard****. An alluvial fan flooding hazard is indicated by three related criteria: (a) flow path uncertainty below the hydrographic apex, (b) abrupt deposition and ensuing erosion of sediment as a stream or debris flow loses its competence to carry material eroded from a steeper, upstream source area, and (c) an environment where the combination of sediment availability, slope, and topography creates* ***an ultrahazardous condition for which elevation on fill will not reliably mitigate the risk****."* (Emphasis added)

and;

> *"In summary, the committee's revised definition limits alluvial fan flooding to flood hazard on alluvial fans. The committee recognizes that alluvial fan flooding is one type of flood hazard under the wider category of* ***uncertain flow path flooding.*** *Such hazards may have considerable uncertainty associated with their behavior and require means other than fill for reliable mitigation."* (Emphasis in the original)

The Reata Pass/Beardsley Wash alluvial fan is specifically cited in the NRC report as an active streamflow alluvial fan. The crucial issues raised in the NRC report regarding the streamflow fan characteristics for that fan are as follows:

- Rapid erosion of channel bed and banks is possible
- Channel capacity can be altered by a single flood
- Sudden changes in flow paths can occur
- Existing channels can be abandoned
- Small channel shifts at the top of the fan can cause dramatic changes near the bottom of the fan

The NRC report states:

> "*Particularly large,* ***kilometer-scale changes in the positions of flow paths*** *and active sedimentation zones can occur without the channel occupying or shifting across intermediate positions if the channelized and the overbank flow cause sediment to be deposited within and close to the channel, raising the bed and the channel margins above the surrounding fan surface (Figure 2-4).*" (Emphasis added)
>
> "*Small shifts near the fan head can cause dramatic changes in channel position farther down the fan.*"

Figure 2-4 of the NRC report, referred to in the above quotation, is reproduced here as Figure 1.2. This figure shows an aerial view of the Reata Pass Wash fan apex, used by the NRC as an example to illustrate the points made in the quotation.

The NRC report further states:

> "*Stream flooding on alluvial fans differs from most riverine flooding in that the hazard not only derives from the inundation itself, but also is intimately connected with sedimentation processes. These latter have immediate impact during the flood itself, and they have long-term geomorphic influence through the rearrangement of sediment on the fan. High flood stages in channels are accompanied by high flow velocities, and by heavy loads of floating wood, and other debris in some environments. High velocities are promoted by the relatively steep, hydraulically simple nature of the channels. The flood hazard is markedly increased, however, by the potential for channel change during the flood itself. The loose bed material may be scoured several meters deep. On some fans the loose, unconsolidated nature of sediments allows rapid channel widening by bank collapse if the flood persists for*

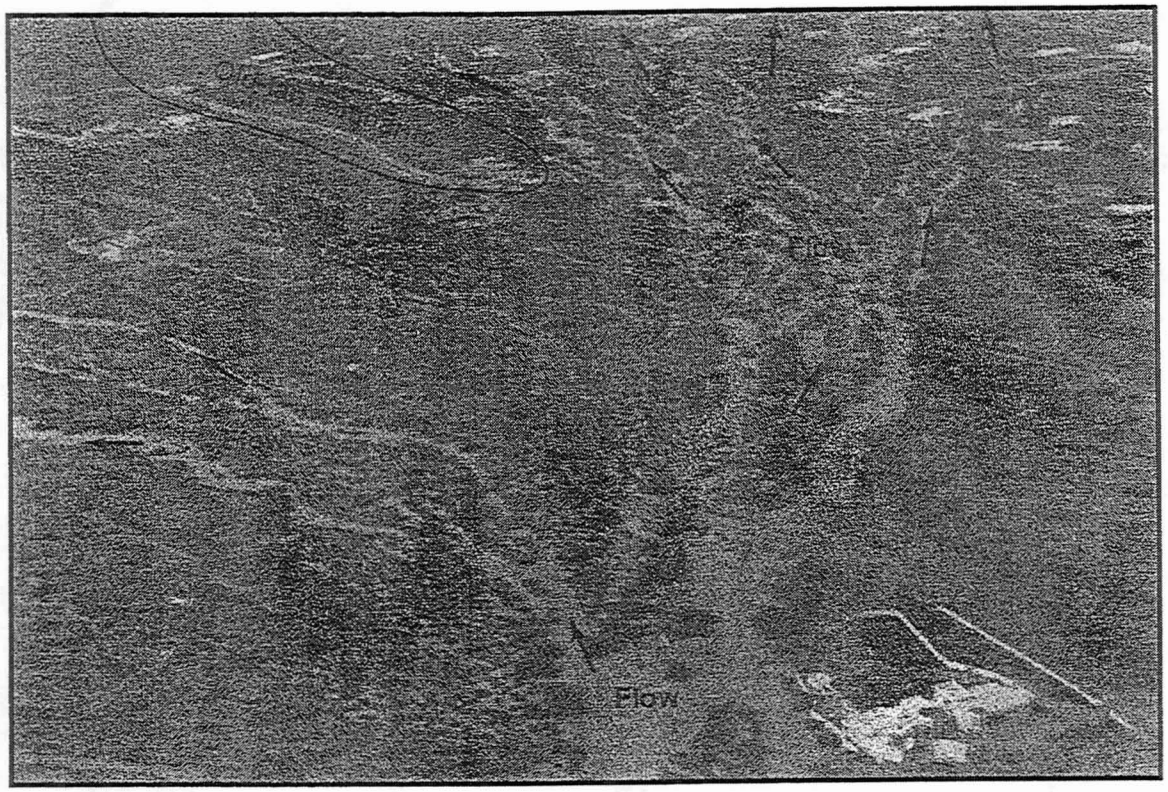


Figure 1.2 Aerial Photograph of the western slopes of the McDowell Mountains. The topographic apex is at the lower edge of the scene. Floodflow can inundate much of the area in the scene except for a few ridges of old-fan remnants.
Source: Alluvial Fan Flooding, NRC 1996.

several hours or days. On others, the deposition of bars along a channel margin causes the channel to shift against the opposite, concave bank at rates of up to tens of meters per flood. Thus, rapid scour and filling of the channel cause changes in the channel conveyance capacity between and during floods.

The largest and most widespread threat arises, however, through the process of avulsion ("tearing away") in which water escapes from a channel by scouring a new path through the bank. This process may begin by sudden bank collapse or by gradual overflow of water from the rising flood. As the relatively dilute surface water flows overbank, it often travels down a gradient that is steeper than the channel (because of the convexity of the fan cross section and the perched nature of some channels above the general fan surface) and so is able to pick up sediment and scour a new path. The water may also take advantage of a former channel, or a series of abandoned channel segments. In the short term, this process may easily be predicted if there are obvious low sections of bank or narrow levees separating the channel from much lower parts of the fan. However, it is difficult to anticipate all such weak sections of the banks and to predict the exact flow path that the diversion is likely to follow across the irregular fan surface. On a time scale of decades, it is virtually impossible, with either field inspection or mathematical modeling of sediment transport, to anticipate the locations of in-channel deposition and bank erosion that might provoke avulsion. The problem is aggravated by the fact that a diversion on the upper part of the fan may alter flow paths on the lower part of the fan in ways that are independent of local fan morphology. Topographic changes in the channel network far upstream of a channel reach have the greatest potential for radically altering the risk of inundation, overtopping channel banks, or undermining a site downfan, but are probably the most difficult threat to anticipate and quantify.

Sheetfloods spread extensively on low-relief lower parts of fan, and as they decelerate they often deposit sheets and low bars of sand or gravel. Even though velocities and depths are low, inundation by turbid water can be very destructive."

and,

". . . major flood control works are necessary to mitigate flood hazards on active alluvial fans "

During the 1970's the City of Scottsdale experienced severe flooding along Indian Bend Wash. A Greenbelt channel was constructed to mitigate these flood hazards. This Indian Bend Wash channel has been very successful as a flood-control and recreational facility. When the North Scottsdale area experienced significant growth in the early 1980's the City of Scottsdale and its citizens were faced

with potential flood damages similar to those sustained along Indian Bend Wash before a flood control system was constructed. The Reata Pass/Beardsley Wash alluvial fan is potentially even more severe due to the ultrahazardous nature of alluvial fan flooding.

The City has been planning a regional flood-control project on the Reata Pass/Beardsley Wash alluvial fan and Pima floodplain for more than 10 years. FEMA states that elevation on fill will not reliably mitigate the risk of alluvial fan flooding (such as on the Reata Pass / Beardsley Wash fan). In early discussions with FEMA it became clear that a regional flood-control system, in the form of a major flood-control structure, is the only possible solution that would be accepted by FEMA as adequate flood control. Major structural flood control means apex to outlet control and conveyance of the entire 100-year flood discharge. A properly-sized detention basin at the alluvial fan apex, with a small outlet discharge or outlet channel, would also be acceptable. The regional system must be capable of collecting and conveying the entire 100-year discharge past developed areas at every point on the alluvial fan. In addition to the flood-control function, the project would provide a permanent, public corridor for recreational use along the foot of the McDowell Mountains.

The basic project purpose is to remove the 100-year flood hazard to protect human life, existing and future homes, businesses and public improvements, and enhance recreation.

1. **Flood Hazard Removal**: To provide 100-yr flood protection for existing and future homes, businesses and public improvements within the FEMA designated Special Flood Hazard Area of the Reata Pass Wash and Beardsley Wash alluvial fans and within the Pima Floodplain;

2. **Flood Protection for Public Improvements**: To provide flood protection for Pima Road, Scottsdale Road, Thompson Peak Parkway, other local streets, the City of Scottsdale Water Campus, and local utilities; and,

3. **Enhance Recreation**: To enhance recreational use of the Reata Pass and Beardsley Wash alluvial fans and provide path and trail linkages to the McDowell Mountains and City-wide recreational corridors.

The proposed regional flood-control project will affect watercourses under the jurisdiction of the U.S. Army Corps of Engineers (USACE) by authority of Section 404 of the Clean Water Act. An

environmental evaluation is required as part of the 404 Permit application. This report provides a description of environmental baseline conditions prior to assessment of impacts and development of mitigation measures. Environmental baseline issue areas covered include Waters of the U.S., vegetative habitat, wildlife, endangered species, hydrology, hydraulics, flooding, erosion, sedimentation, groundwater, land use, traffic and public safety. An assessment of environmental future-without-project conditions is included as part of the baseline conditions analysis.

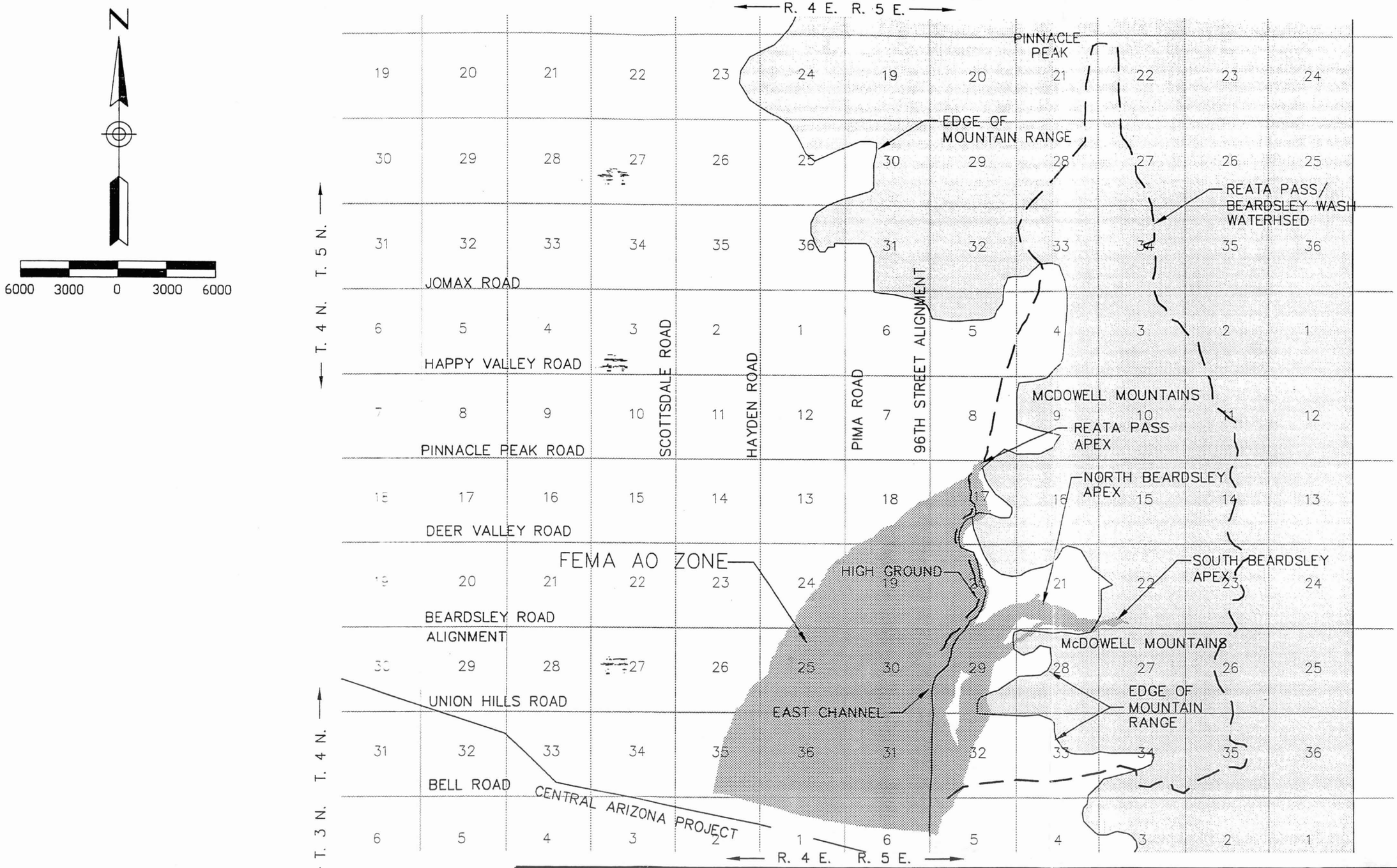
II. STUDY AREA AND PROJECT DESCRIPTION

2.1 Study Area Description

The study area is generally bordered by the Central Arizona Project (CAP) on the south, the McDowell Mountains to the east, Dynamite Boulevard to the north, and Scottsdale Road to the west. The mountain area is characterized by rugged terrain and steep gradients (10 percent or steeper). Elevations range from about 4,034 feet above sea level at McDowell Peak to 1,520 feet at the CAP. The area is typical of the Sonoran Desert in the Phoenix area. The major watercourses originate in the steep mountain canyons and pediment slopes and discharge abruptly onto wide alluvial fans with numerous shallow washes that spread out from the fan apex. General drainage direction is northeast to southwest.

Typical of alluvial fans, there is no single, natural, defined channel extending from the apex to the CAP Aqueduct (the downstream terminus) which can be singled out as carrying all of the apex flow in any given event. Instead, there are a number of channels each of which has a potential for carrying flows in any event. Flowpaths are unpredictable and can change during a storm event. Alluvial fan hydrology and hydraulics are discussed in detail in Sections 4.2 and 4.3 of this report.

There are two major flood prone areas in the study area: the Reata Pass/Beardsley Wash alluvial fan (shown in Figure 2.1) and the Pima floodplain (shown in Figure 2.2).



Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

REATA PASS WASH AND NORTH AND SOUTH BEARDSLEY WASH AO ZONE AND WATERSHED AREA

FIGURE 2.1

The Desert Greenbelt
SCOTTSDALE, ARIZONA

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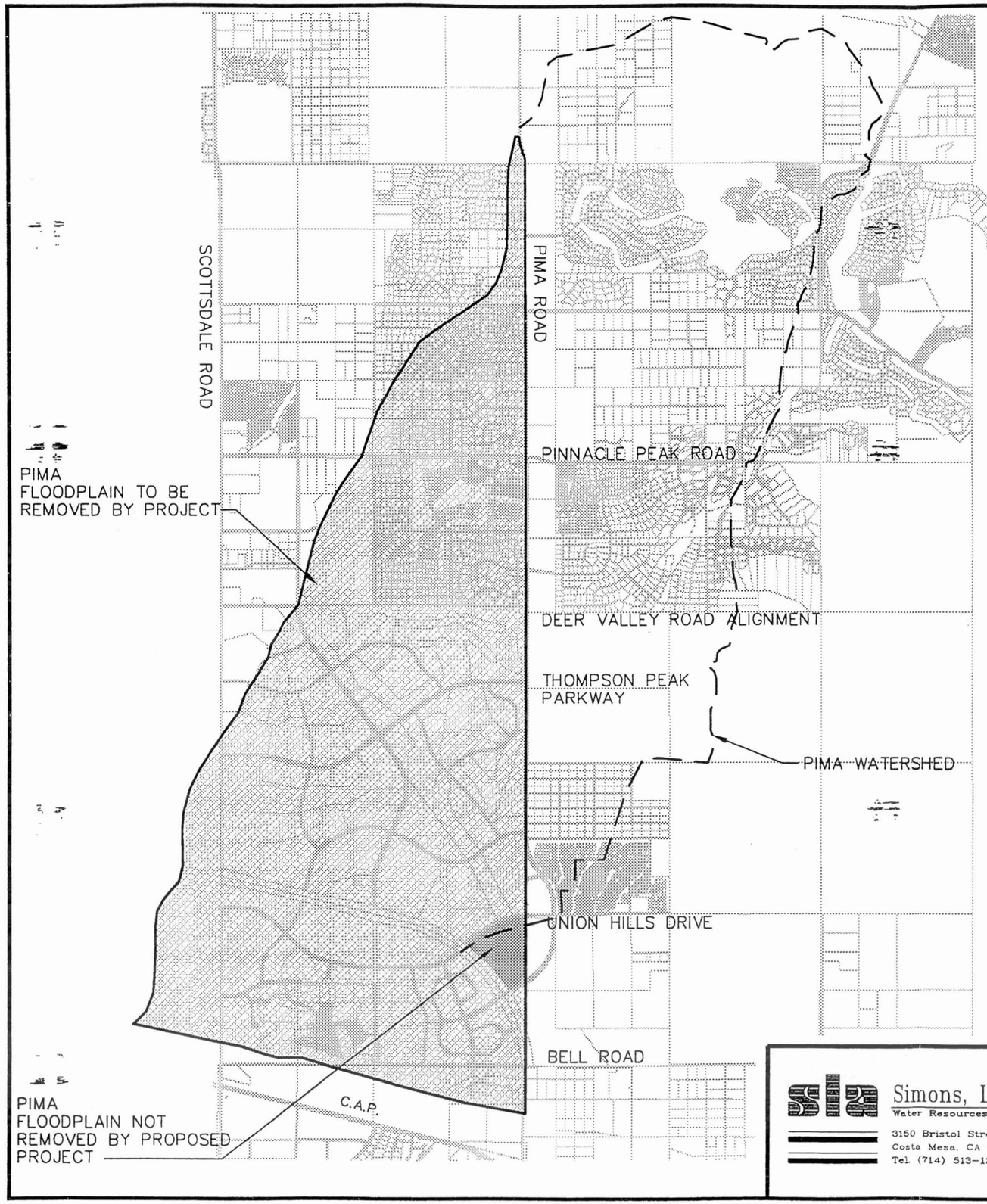


Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

STUDY AREA
PIMA FLOODPLAIN
AND WATERSHED AREA

FIGURE 2.2

The Desert Greenbelt
SCOTTSDALE, ARIZONA

M:\PUBLIC\PROJECTS\AZCOS03\EXHIBITS\SHT-2-2 PW STUDY AREA.DWG, 11/02/98

Reata Pass and Beardsley Wash

The Reata Pass Wash alluvial fan (according to mapping prepared by FEMA) comprises approximately 5,900 acres just south of the east-west alignment of Pinnacle Peak Road and approximately 1.5 miles east of Pima Road. The wash spreads out from the apex in a number of separate channels running toward the south and southwest. The slopes on the alluvial fan are approximately 4 percent along the upper fan and 2 percent along the lower fan. The alluvial fan flows eventually discharge into the Bureau of Reclamation retention basins upstream of the CAP canal.

North and South Beardsley Washes begin in the McDowell Mountains. North Beardsley heads westward through Sections 21 and 20 of Township 4 North, Range 5 East, G&SRBM before turning southwest and meeting the Reata Pass Wash near the Beardsley Road alignment. South Beardsley Wash turns to the southwest in Section 21 of Township 4 North, Range 5 East, G&SRBM and meets the Reata Pass Wash near Bell Road. The slopes on the alluvial fans are approximately 3 percent along the upper fan and 2 percent along the lower fan. The alluvial fan flows eventually discharge into the Bureau of Reclamation retention basins upstream of the CAP canal.

Because these three flooding sources join, they are referred to for purposes of this report as the Reata Pass/Beardsley Wash alluvial fans. The Reata Pass/Beardsley Wash alluvial fans have been delineated by FEMA as a regulatory floodplain (Figure 2.1). This floodplain has been designated by FEMA as Zone AO with depths ranging from 4 feet to 1 foot and velocities ranging from 9 to 3 feet per second.

One major channel in the Reata Pass/Beardsley Wash alluvial fan, referred to in this report as the East Wash, has its origin at the fan apex and heads directly southward along the foot of the McDowell Mountains through Sections 17 and 20 of Township 4 North, Range 5 East, G&SRBM. When the wash reaches an area approximately ½ mile south of the Beardsley Road alignment it heads southwest until reaching the 96th Street alignment. The wash then moves southeast through Sections 30, 31, and 32 of Township 4 North, Range 5 East, G&SRBM until it reaches the Bureau

of Reclamation /WestWorld retention basin. Figure 2.1 shows the location of the East Wash in relation to the Reata Pass/Beardsley Wash floodplain. The East Wash follows the eastern edge of the Reata Pass fan surface for most of the length of the fan.

The East Wash is a partial exception to the alluvial fan rule that all channels have an equal potential to carry flows. At a point approximately 3,000 feet downstream of the apex, the East Wash is confined on the west side by high ground ranging from one to four times the maximum FEMA-delineated depth of flow at the alluvial fan apex. High ground confines the East Wash intermittently for a total distance of 9,500 feet along the 24,000-foot distance from the fan apex to the Bureau of Reclamation detention basins. This channel is well defined from the apex to Ironwood Village and from Bell Road to the Bureau of Reclamation detention basins. As a result flows that enter the East Wash will stay within the channel along the confined area and cannot spread freely over the alluvial fan to the west. The high ground adjacent to the East Wash is subject to flooding from other channels originating at the fan apex, but not from the East Wash.

The East Wash serves as an approximate boundary between that area of the Reata Pass/Beardsley Wash which has been developed and that area which has not been developed. There is no existing development within the FEMA floodplain of the Reata Pass/Beardsley Wash alluvial fan east of the East Wash. The area west of the East Wash has been subject to intense residential development since 1980. Major existing residential developments, described in Section 4.1 of this report, include Pinnacle Peak Heights, DC Ranch, Grayhawk, Ironwood Village and Princess / TPC Area. At present, there are approximately 2,121 residences on the Reata Pass/Beardsley Wash alluvial fan.

Because flood protection for existing development is the primary purpose of the proposed project, the study area is further defined as that portion of the Reata Pass/Beardsley Wash alluvial fan within the FEMA AO Zone and west of the East Wash, and that portion of the Pima floodplain west of Pima Road. That portion of the FEMA AO Zone to the east of the East Wash, although zoned for future residential development, has no existing development. This area is excluded from the study area and will not be protected by the proposed project for the reason that it contains no development

currently subject to flood damage. The study area for the Reata Pass/Beardsley Wash is shown in Figure 2.3. The study area shown in Figure 2.3 comprises an area of approximately 4,800 acres in the Reata Pass/Beardsley Wash alluvial fan AO Zones.

Pima Floodplain

The Pima floodplain is geologically different from the Reata Pass / Beardsley Wash alluvial fan. This floodplain is an inactive fan surface; as such, there is no single apex for this floodplain and the significant flows are generated on the fan surface. Although the area is not included as part of the FEMA regulatory floodplain, there has been historic flooding of existing development on the Pima floodplain downstream (west) of Pima Road.

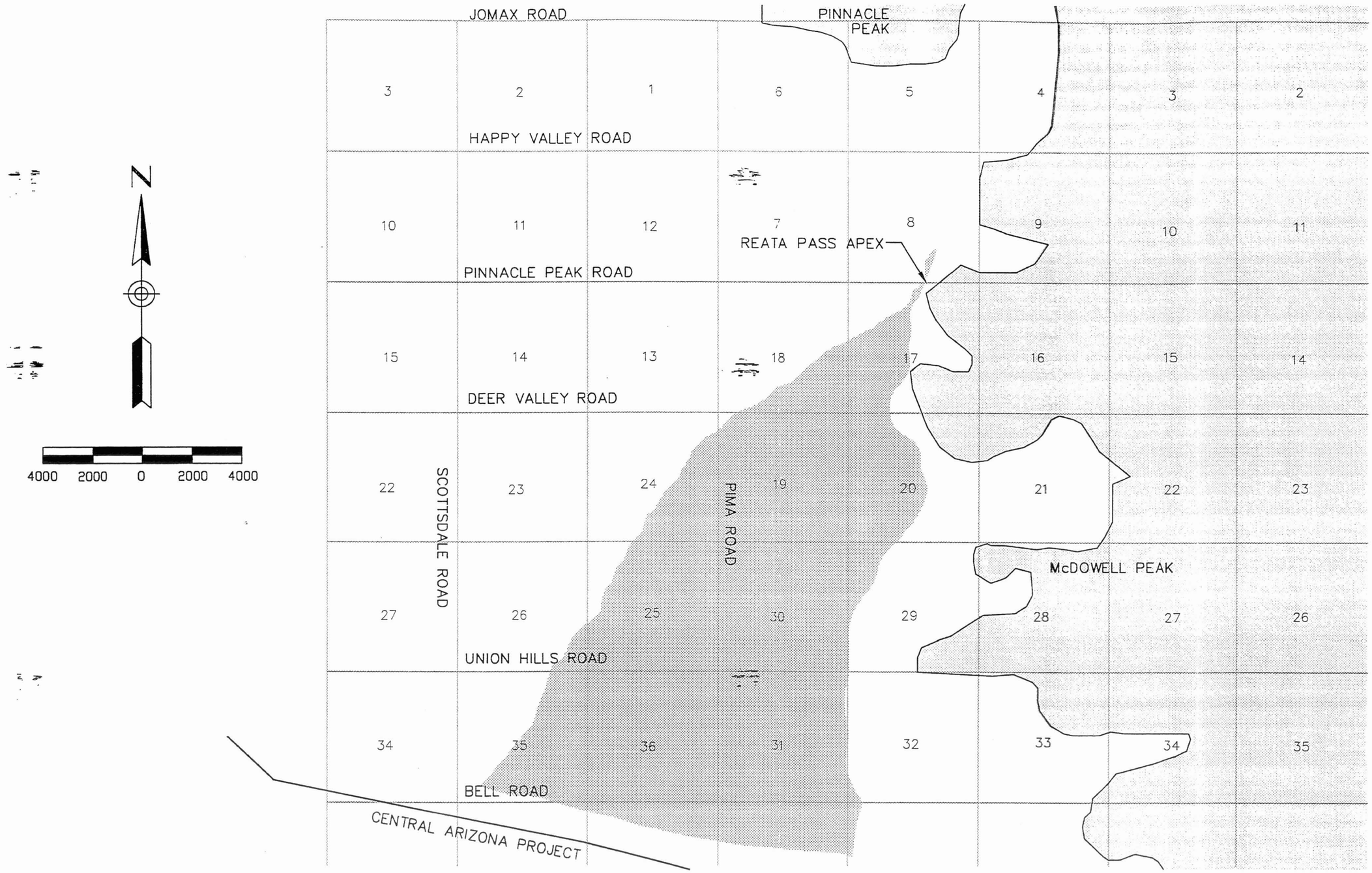
The study area shown in Figure 2.2 comprises an area of approximately 5,750 acres in the Pima floodplain. This area begins north of Jomax Road and is confined to the west side of Pima Road. Downstream of Deer Valley Road alignment and west of Pima Road there is an area that is within both the Reata Pass / Beardsley Wash fan and the Pima floodplain. This area, totaling approximately 2,000 acres, is shown in Figure 2.4.

The Pima floodplain is subject to development similar to the Reata Pass / Beardsley Wash alluvial fan and currently contains approximately 2,409 residences.

2.2 Project Description

Reata Pass / Beardsley Wash

The proposed project, illustrated in Figure 2.5, consists of a levee and channel system that extends along the alignment of the East Wash from upstream of Pinnacle Peak Road to the Bureau of Reclamation /WestWorld retention basin. This system captures flow at the apex of the Reata Pass alluvial fan and conveys it south along the McDowell Mountains. Levees are provided to direct the North Beardsley flows into the main channel. The existing Thompson Peak flood control channel intercepts the South Beardsley flows and directs them into the main channel near Bell Road. Flows from North and South Beardsley Wash are not contained at their respective apexes. Consequently,



Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

STUDY AREA
REATA PASS/BEARDSLEY WASH

FIGURE 2.3

The Desert Greenbelt
SCOTTSDALE, ARIZONA

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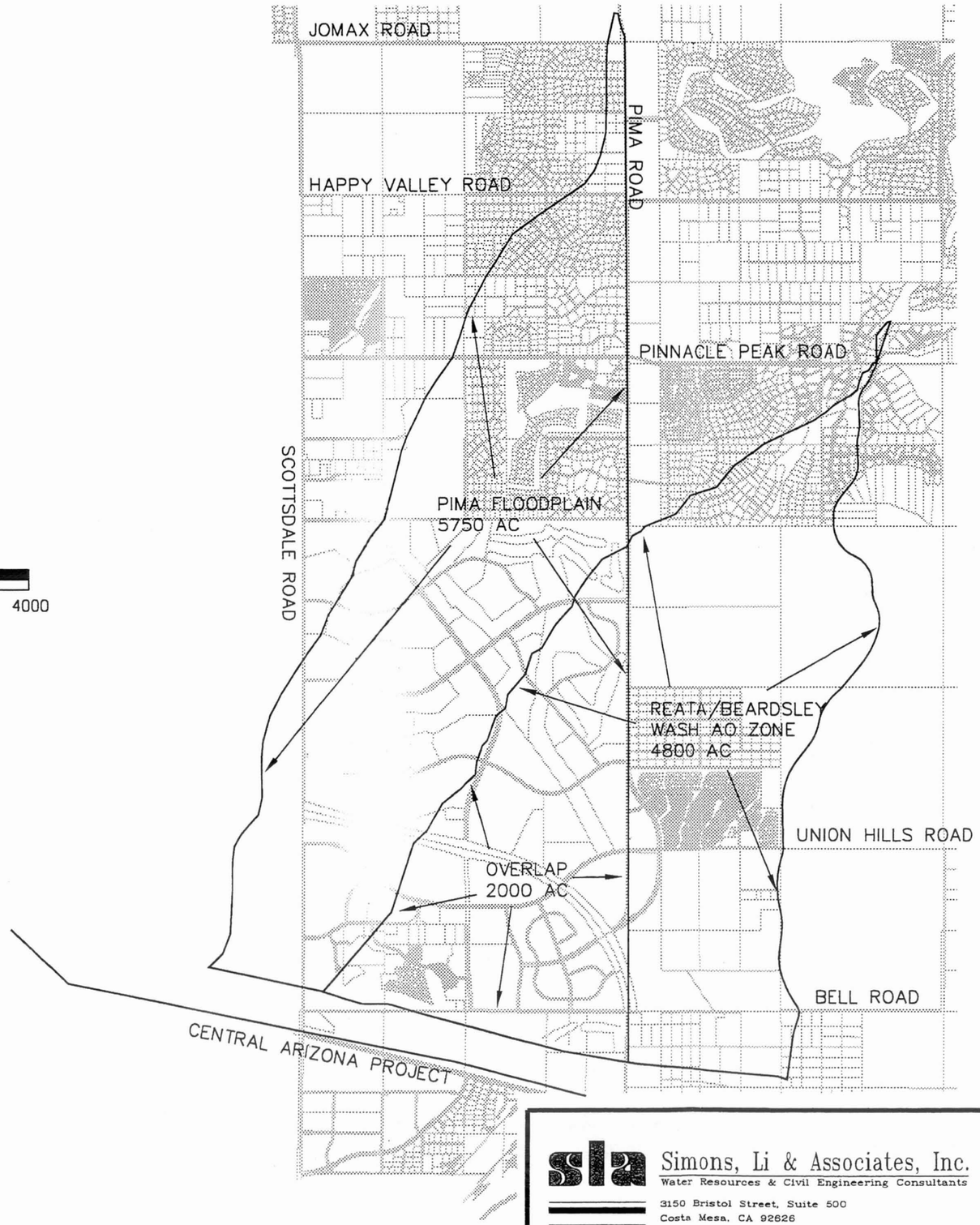

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

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REATA PASS/BEARDSLEY WASH AO ZONE AND PIMA FLOODPLAIN OVERLAP

FIGURE 2.4

The Desert Greenbelt
SCOTTSDALE, ARIZONA

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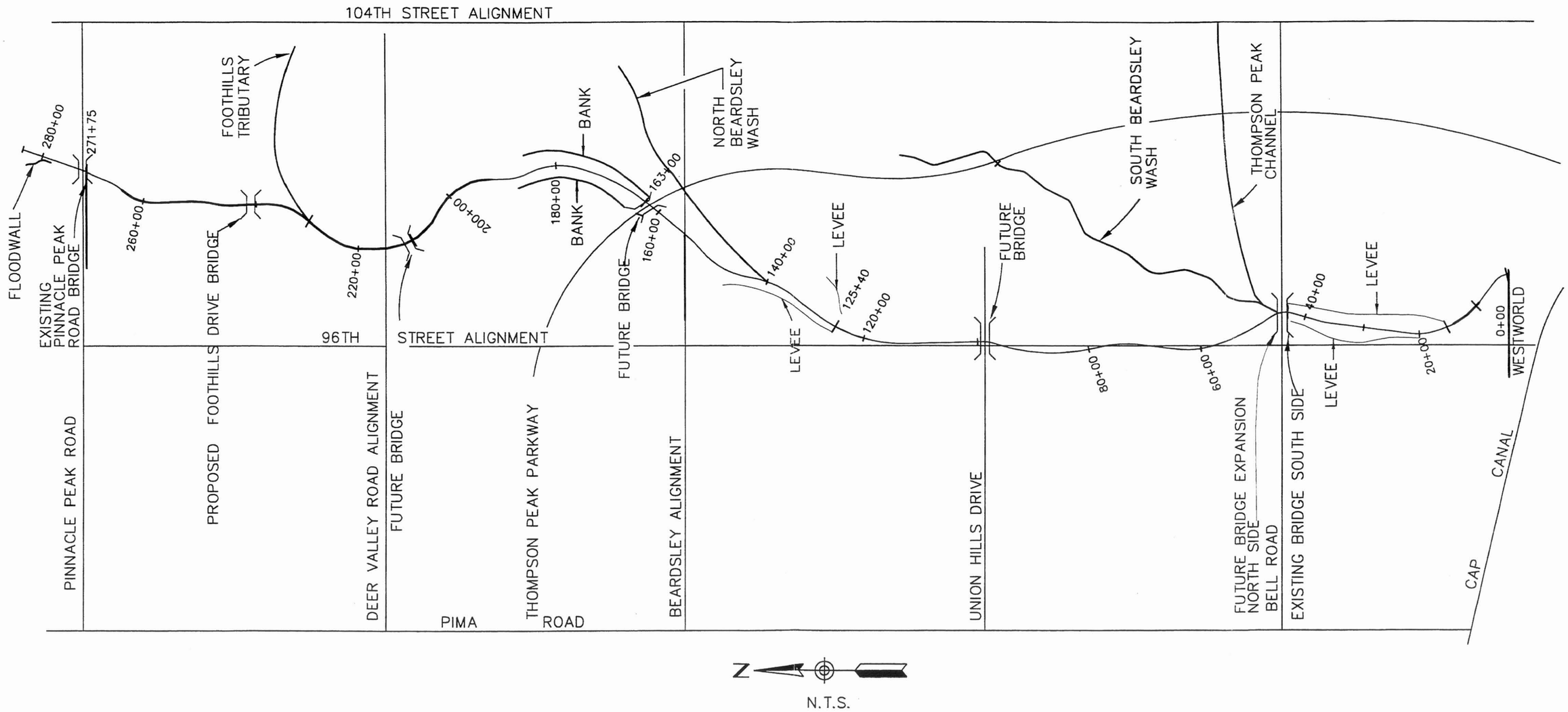


Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

PROPOSED REATA PASS
BEARDSLEY WASH
FLOOD CONTROL PROJECT

FIGURE 2.5

The Desert Greenbelt
SCOTTSDALE, ARIZONA

P:\AZCOS03\EXHIBITS\SHT-2-5 RPBW FLOOD CONTROL.DWG, 12/29/98

flood protection is not provided for the undeveloped area east of the main channel. Table 2.1 provides a summary of key project components.

Exact dimensions of the levee and channel system are described on the plans entitled "Scottsdale Desert Greenbelt Reata Pass Wash", prepared by Simons, Li and Associates, 1998.

Pima Floodplain

The proposed Pima Floodplain project, illustrated in Figure 2.6, is a flood-control system along the alignment of Pima Road from approximately one-quarter mile upstream of Jomax Road to the Bureau of Reclamation retention basins at the CAP. The system consists of underground conduits beneath Pima Road beginning at a point approximately 1/4 mile upstream of Jomax Road and running south to enter the Bureau of Reclamation detention basins at a point approximately one mile west of Pima Road. The storm drain runs under existing Pima Road pavement to Sierra Pinta Drive and then along the east side of Pima Road to a point adjacent to the City's Water Campus. At the Water Campus the storm drain turns toward the southwest then runs along the Hayden Road alignment to the Bureau of Reclamation detention basins.

There are three detention basins. The first two, located at Happy Valley Road and Deer Valley Road, are intended to reduce flood peaks to levels that can be easily conveyed in the underground storm drains proposed in the Pima Road corridor. The third detention basin, located west of Pima Road and upstream of the Princess/TPC/Perimeter Center developments, is elongated in an east-west direction in order to protect the existing Princess/TPC/Perimeter Center from local drainage generated on the Pima Floodplain area upstream of these developments.

Table 2.1. Key Components for Proposed Reata Pass/Beardsley Wash System.

Channel Reach (Approximate)	Reach Length (Approximate)	Key Project Characteristics
Upstream of Pinnacle Peak Road	1,100 feet	A floodwall directs apex flow into a concrete lined channel under Pinnacle Peak Road
Pinnacle Peak Road to 7,300 feet downstream of Pinnacle Peak Road	7,300 feet	Soil cement lined channel (bed and banks) with numerous drop structures and grade control structures. Channel depth eight to twelve feet. Channel bottom width 64 to 130 feet.
7,300 feet downstream of Pinnacle Peak Road to Thompson Peak Parkway alignment	3,000 feet	Open channel with soil cement banks and natural bed with the exception of two grade control structures and a proposed bridge crossing. Channel depth approximately 6 to 12 feet Portions of the west bank are above the existing ground by 1 to 6 feet. Natural channel bottom width ranges from 265 to 450 feet.
Thompson Peak Parkway alignment to approximately 850 feet downstream of the Beardsley Road alignment	1,950 feet	No construction proposed.
850 feet downstream of the Beardsley Road alignment to 3,200 feet downstream of the Beardsley Road alignment	2,350 feet	Levees ranging in height from four to ten feet above adjacent (dry side) natural ground. Levees are protected from erosion by soil cement. Natural channel bed between the levees. The levee toedown ranges from twelve to seventeen feet. Width between the levees ranges from 180 to 680 feet.
3,200 feet downstream of the Beardsley Road alignment to Bell Road	8,000 feet	Open channel with soil cement lined banks, earthen invert and soil cement drop structures. Channel depth eight to twelve feet. Most drop structures are three feet in height. Channel bottom width is 180 feet.
Bell Road to 2,900 feet downstream of Bell Road	2,900 feet	Levees ranging in height above adjacent ground from 3 feet to 9 feet. Width between the levees ranges from 190 to 420 feet. Levee toedown ranges from 12 feet to 17 feet.
2,900 feet downstream of Bell Road to Westworld Detention Basin	1,600 feet	Soil-cement-lined channel with earth bottom. Channel depth 9 feet to 16 feet. Channel width approximately 150 to 190 feet.

96TH ST. ALIGNMENT

JOMAX ROAD

HAPPY VALLEY ROAD

PINNACLE PEAK ROAD

DEER VALLEY ROAD ALIGNMENT

BEARDSLEY ROAD ALIGNMENT

UNION HILLS DRIVE

BELL ROAD

SPURDIKE

PIMA ROAD

HAPPY VALLEY DETENTION BASIN

DEER VALLEY DETENTION BASIN

HAYDEN ROAD OUTLET

OUTER LOOP BASIN

LOOP 101 FWY

SCOTTSDALE ROAD

CULVERT

N

3000 1500 0 1500 3000

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

PROPOSED PIMA ROAD FLOOD CONTROL PROJECT

FIGURE 2.6

The Desert Greenbelt
SCOTTSDALE, ARIZONA

P:\AZCOS03\EXHIBITS\SHT-2-6 PIMA ROAD FLOOD CONTROL.DWG, 12/30/98

III. PREVIOUS STUDIES

The City of Scottsdale, along with other State and County agencies, began to investigate the potential flood hazards in the North Scottsdale area more than 10 years ago. The City had experienced severe flooding in the early 1970's along Indian Bend Wash. A Greenbelt channel was constructed to mitigate these flood hazards. This Indian Bend Wash channel has been very successful as a regional flood-control and recreational facility. When the North Scottsdale area began to experience significant growth in the early 1980's the City of Scottsdale and its citizens were faced with potential flood damages similar to those sustained along Indian Bend Wash before a flood control system was constructed. The following lists the numerous studies that were performed for the City of Scottsdale to quantify the flood potential and determine a plan to control the damages.

- **North Scottsdale Master Plan, prepared by Water Resources Associates, Inc. (WRA), June 1989.**
  This study was developed to formulate a general drainage plan to address hydrology, existing and future flooding potential, and concept plans to address the flooding problems. As a result of this study, four concept plans were developed. The first plan included on-site retention and manmade channels along the east side of certain reaches of Pima and Scottsdale Road. The second plan used detention basins to capture the flow along major washes. The third plan was to construct large channels in areas where detention basins were not feasible. The main channels and interceptor channels would need to be large. In addition to the two channels discussed as part of Plan 1, a third channel aligned along the McDowell Mountains 1 ½ miles east of Pima Road was considered. This channel was proposed to be a combination of natural channel, levees, and manmade channels. This concept plan and alignment are similar to the proposed Reata Pass / Beardsley Wash project. The fourth plan involved channelization and regional detention basins.

- **Final Report - Upper Indian Bend Wash Regional Drainage and Flood Control Plan, prepared by Water Resources Associates, Inc., July 1992.**
  The purpose of this study was to develop a regional drainage plan to address the present and future needs within the watershed, including the drainage needs associated with the Loop 101 Freeway. The City of Scottsdale, the City of Phoenix, the Flood Control District of Maricopa County and the Arizona Department of Transportation participated in the study. The plan proposed channels and detention basins to intercept floodwaters. Approximately 35 miles of channelization were included as part of this study. A number of these channels were east-west collector channels as well as channels to convey Rawhide Wash (a flooding source outside the study area) flows. The proposed alignments for the flood control systems to address Reata Pass / Beardsley Wash flows and Pima floodplain flows are similar to the proposed project alignments.

- **<u>Reata Pass / Beardsley Wash Alignment Study</u>, prepared by the City of Scottsdale, November 1992.**
  This study was developed due to the increase in planning activity and development within the floodplains north of the CAP. The primary objective was to identify and develop a stormwater management plan for the Reata Pass and Beardsley Washes and their floodplains. Four potential channel alignments (which include the Reata Pass, Beardsley Wash, Thompson Peak, and Southwestern Alignments) and a "no action" alternative were investigated. Public involvement was obtained regarding the acceptability of the alignments. Based on the criteria of land use, right-of-way acquisition, hydraulic considerations, environmental impacts, and cost, the Reata Pass Alignment was identified as the preferred alternative and was adopted into the City's General Plan by the City Council as an amendment to the Drainage Element in November of 1992. According to that study, this alignment was preferred because of its environmental sensitivity and consistency with the Desert Greenbelt concept. This alignment was consistent with the alignment used in the proposed project.

- **<u>Rawhide / Pinnacle PeakWash Alignment Study</u>, prepared by the City of Scottsdale, November 1992.**
  This study was developed due to the increase in planning activity and development within the floodplains north of the CAP. The primary objective was to identify and develop a stormwater management plan for the Rawhide and Pinnacle Peak Washes and their floodplains. Three alternatives were examined for Pinnacle Peak Wash. These include no action, enhancing the existing alignment, and an alternative alignment. No alternative to resolve the flood hazards associated with Pinnacle Peak Wash could be found that only involved improvements in the AO Zone. For this reason, the City determined that the best course of action was to resolve the Pinnacle Peak Wash flooding concerns as part of the design of the Pima Road Channel. This study was adopted by the City Council as an amendment to the Drainage Element of the City's General Plan in November of 1992.

- **<u>Preliminary Design Phase I Study Report</u>, prepared by the Greiner Team, June 1994, and <u>City of Scottsdale Desert Greenbelt Project - Final Report</u>, prepared by the Greiner Team, June 1995.**
  This study was performed to develop the initial concepts of three Desert Greenbelt Projects. These projects included Rawhide Wash, Reata Pass / Beardsley Wash, and the Pima Road Channel. This study included a significant amount of public participation for all 3 projects. Opinion-leader interviews were conducted, a 3,000-name mailing list was prepared for distribution of fact sheets and newsletters, small group working sessions were performed, briefings were held with residents, property owners, developers and agencies most directly affected by the projects, and 3 open houses were held to obtain additional public comments. Native plants, wildlife, and cultural resources were inventoried in each project area. The Reata Pass / Beardsley Wash Channel included a low flow channel, levees, and floodwalls. The alignment was similar to the currently proposed channel. The Pima Road Channel consisted of a man-made channel without any detention along Pima Road. The alignment of that channel was the same as the currently proposed Pima Road Project.

- **<u>Desert Greenbelt Project Environmental Guidelines</u>, prepared by the Greiner Team, October 1994 and <u>Environmental Mitigation Plan</u>, prepared by the Greiner Team as written by Dames and Moore, Inc., May 1995.**
  The first report identifies the objectives of the Desert Greenbelt projects in relation to environmental impacts. The results of an environmental inventory were reported and the mitigation plan was presented. A long-term monitoring plan and potential need for project modifications were discussed. The second report further detailed the mitigation objectives and measures and the anticipated results of those measures.

- **<u>Upper Reata Wash Specific Option</u>, September 1994, <u>Reata / Beardsley Washes Specific Option</u>, January 1995, and <u>Reata Pass / Beardsley Wash Preferred Alternative Report</u>, May 1995, all prepared by the Greiner Team.**
  These studies were prepared to further refine the channel design along Reata Pass Wash from Pinnacle Peak Road to the Bureau of Reclamation Retention Basin. Natural washes with bank protection and stabilization, levees and floodwalls, manmade channels, and natural containment areas were proposed. The public participation process included 3 small group workshops and a general community open house. The alignment of the project is the same as the alignment of the proposed project.

- **<u>Pima Road Channel Specific Option</u>, prepared by the Greiner Team, September 1994.**
  This study was performed to investigate different alignments for the Pima Road Channel. Each alignment follows Pima Road from the north to the south; however one is aligned east of the road, the second is aligned to the west, and the third transitions from the west to the east and back to the west side of the road. For each alignment two channel cross sections were investigated - a wider trapezoidal channel with a low flow channel and a narrower trapezoidal channel. As part of this study small group working sessions were conducted with residents and land owners near the project area. Comments were also received from the general public. Recommendations were made regarding the alignment and channel section for each reach of the channel. The overall alignment is similar to the proposed project.

- **<u>Desert Greenbelt Project Pima Road Channel</u>, prepared by George V. Sabol Consulting Engineers, Inc., November 1996.**
  The purpose of this report was to review two concepts for the Pima Road Channel. The first concept had been developed by Greiner and consists of a fully concrete lined trapezoidal channel. The second concept had been developed by Pacific Advanced Civil Engineering, Inc. and consists of 3 detention basins and a smaller channel than the Greiner concept. The design concepts were reviewed based on the hydraulic performance, safety, aesthetics and recreation. It was recommended that the 3 detention basins option be adopted with a soil cement channel and energy dissipator / grade control structures. This concept was used to develop the proposed project along Pima Road.

- **Reata Pass / Beardsley Wash Channel Response Analysis with Ultimate Levee Encroachment, prepared by Simons, Li and Associates (SLA), 1997.**
  This study was performed to define the design requirements based on a conceptual flood control system designed by the Greiner Team (see discussion of Preferred Alternative Report). The alignment of this flood control system is the same as the proposed project.

- **Desert Greenbelt Pima Road Three Basins Project, prepared by Stantech, 1997.**
  In 1996 the City began investigating alternatives to the Pima Road Channel. As a result the name of the project was changed to the Pima Road Three Basins Project to reflect the changes in the concept and design. Additional reports in 1997 and 1998 proposed changes to the design. The overall alignment upstream of the proposed Loop 101 Freeway was not changed. This is the currently proposed project described in Section 2.2.

- **Reata Pass / Beardsley Wash Erosion, Sedimentation Control and Channel Improvement Design, prepared by SLA, 1998.**
  This study was performed to define the design requirements for a regional flood control project aligned along the toe of the McDowell Mountains that included a focus on control of the sedimentation and erosion processes. This study provides the technical basis for the proposed project described in Section 2.2. A Conditional Letter of Map Revision (CLOMR) was issued for this project by FEMA on September 8, 1998. Obtaining a CLOMR is the first step toward eliminating the AO Zone.

Information and correspondence pertaining to public and agency involvement in the above studies is included in Appendix G.

The following studies have been performed by entities other than the City of Scottsdale to investigate the flooding hazard in the area on alluvial fans.

- **FEMA, 1993.**
  In 1993 FEMA published maps defining the flood hazards from Wickenburg to the McDowell Mountains. This information showed that a large area, including the North Scottsdale area, was subject to alluvial fan flooding. While the maps showing this information were published in 1993, the study and analysis that the maps are based on was performed between 1987 and 1993.

- **Potential Flood Hazards and Hydraulic Characteristics of Distributary-Flow Areas in Maricopa County, Arizona, prepared by the U.S. Geological Survey, 1994**
  The purposes of this study were to "*(1) describe the variety of potential flood hazards of distributary-flow areas in Maricopa County, (2) to discuss the stability of the flow paths and stream channels and the sediment transported..., and (3) to present hydraulic-geometry*

relations..." A system to rate the flood-hazard degree was established. A degree of 1 describes a relatively stable system where the extent of flooding can be defined; a degree of 10 describes a system where the flow paths appear random and are subject to changes in location and floodflows are unconfined. The Reata Pass Wash alluvial fan was investigated and was rated as a flood-hazard degree nine.

- **Alluvial Fan Flooding, National Research Council, National Academy of Sciences, 1996.** This report describes the results of the Committee on Alluvial Fan Flooding that was established by the NRC. The committee revised the existing definition of alluvial fan flooding, developed criteria to determine if an area is subject to alluvial fan flooding, and provided examples of the definition and the criteria used.

- **North Scottsdale Drainage Area, Arizona - Reconnaissance Study, Flood Control and Related Purposes, USACE, 1996**
  A reconnaissance level study was performed by the USACE. The results of this study, which concluded that a feasible flood control plan existed for Reata Pass / Beardsley Wash, are described below in further detail.

- **Environmental Geology of the McDowell Mountains Area, Maricopa County, Arizona, State of Arizona Bureau of Geology and Mineral Technology, 1979**
  A map of geologic hazards was made of the McDowell Mountains area by the State of Arizona Bureau of Geology and Mineral Technology. This map defined geologic hazard as "*a normal geologic condition, event or process that threatens man's life or property.*" The map further states: "*Correct evaluation of geologic problems and correct application of geologic and engineering procedures can vastly reduce both dollar and life loss due to geologic hazards. It is the purpose of this map to delineate areas where special precautions in planning and construction should take place because life and/or property could be otherwise endangered.*" The map delineates hazards from flooding, slope instability, boulder rolling, debris movement, rock falls, earthcracks and earthquakes. The Reata Pass/Beardsley Wash alluvial fan was classified as a flood hazard with this description: "*The youngest fan segment is the present day area of deposition. The major washes carry runoff and sediment from the mountains and as the stream channel decreases in depth down fan, the runoff spills over the channel sides and debauches onto the fan surface. The drainage system is braided and channels continually change positions. Flooding is generally severe in major storms and overflowing channels add to the sheetflow problems down fan.*"

The USACE prepared a reconnaissance study in 1996 (listed above) which described the flooding problem on the Reata Pass/Beardsley Wash alluvial fan, Pima floodplain, and Rawhide Wash alluvial fan and recommended Federal participation in a regional flood-control project. A series of alternatives including non-structural measures, improvement of existing natural channels, installation of concrete-lined channels, and detention basins, were investigated. A plan that was determined to

be feasible, illustrated in Figure 3.1, includes a detention basin at the intersection of Jomax and Pima Roads, a flood-control channel along Pima Road, and a flood-control channel along the alignment of the East Wash. The USACE reconnaissance plan included two other flood-control channels to protect the currently-undeveloped portion of the Reata Pass/Beardsley Wash alluvial fan east of the East Wash.

IV. BASELINE CONDITIONS

4.1 Land Use and Population

Reata Pass / Beardsley Wash

Land use on the alluvial fan is primarily residential. The current land use for the Reata Pass/Beardsley Wash alluvial fan study area is summarized in Table 4.1. Figure 4.1 shows the land use in the developed areas and the zoning plan for the undeveloped areas. As shown in this figure, the entire alluvial fan is zoned for development. Residential zoning comprises 85% of the total fan area. Residential zoning ranges from 0.2 to 22 units per acre. Non-residential development with categories such as commercial development, offices, resorts, tourist accommodations, employment and utilities comprises 15% of the area. Any development that is located in the Environmentally Sensitive Lands Ordinance area (see Section 5.1) is required by the City of Scottsdale to leave land as Natural Area Open Space (NAOS). The minimum required NAOS is 15% in the Lower Desert, 20% in the Upper Desert, and 40% in Hillside Landforms.

Table 4.1 Summary of Land Use Plan Designations for Reata Pass/Beardsley Wash Alluvial Fan Study Area

Type of Development	Percent of Total Area
Total Residential (Existing)	60%
Total Residential (Future)	25%
Total Non-residential (Existing)	5%
Total Non-residential (Future)	10%
Total Area	100%

Current developments in the study area are shown in Figure 4.2 and summarized in Table 4.2. In all, 2,776 single-family or apartment residences, and 1,083 commercial units, including the City of Scottsdale Water Campus and approximately 300 acres of golf course, have been constructed or are

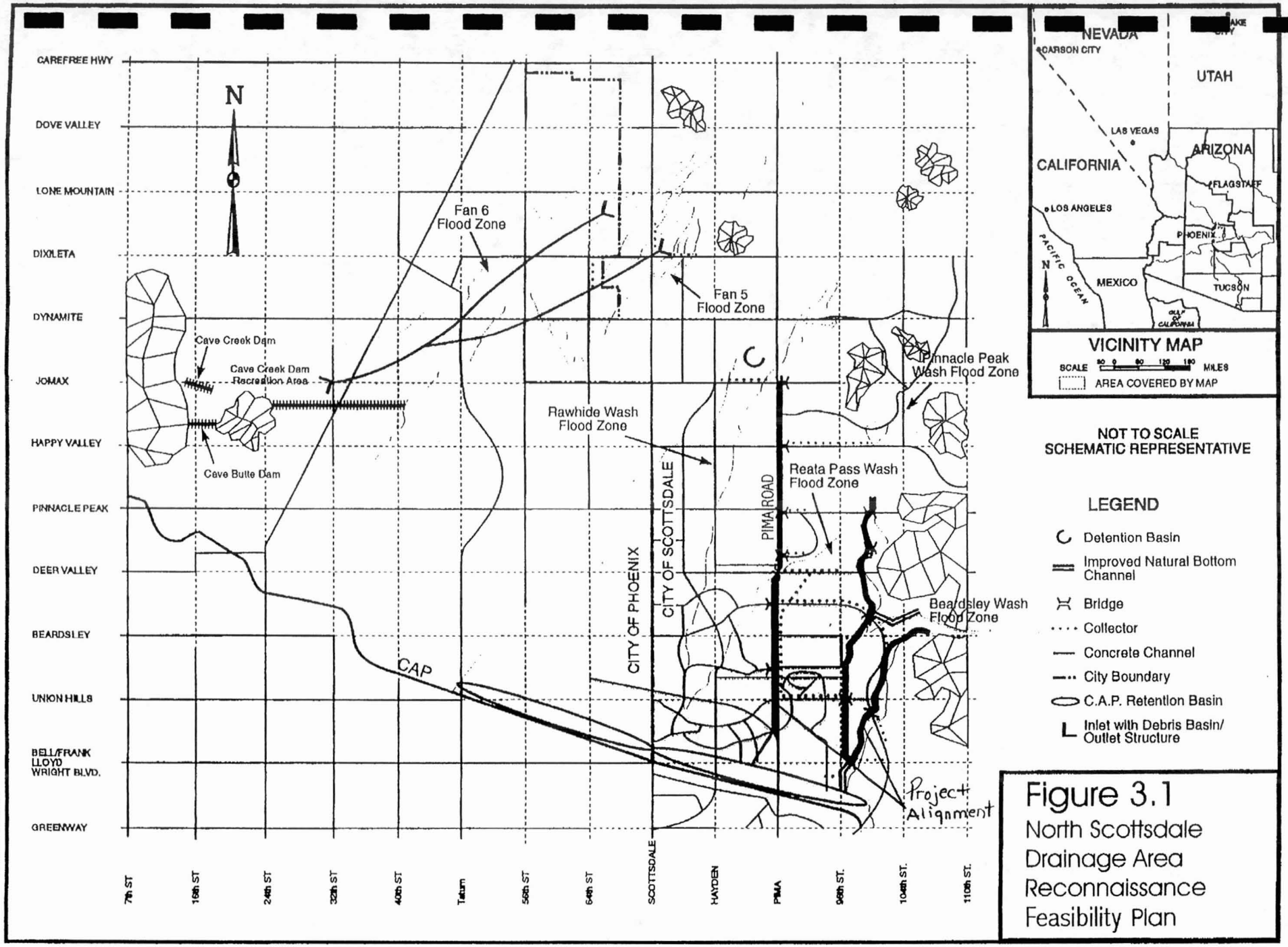


Figure 3.1
North Scottsdale Drainage Area Reconnaissance Feasibility Plan

SOURCE: US Army Corps of Engineers, 1996

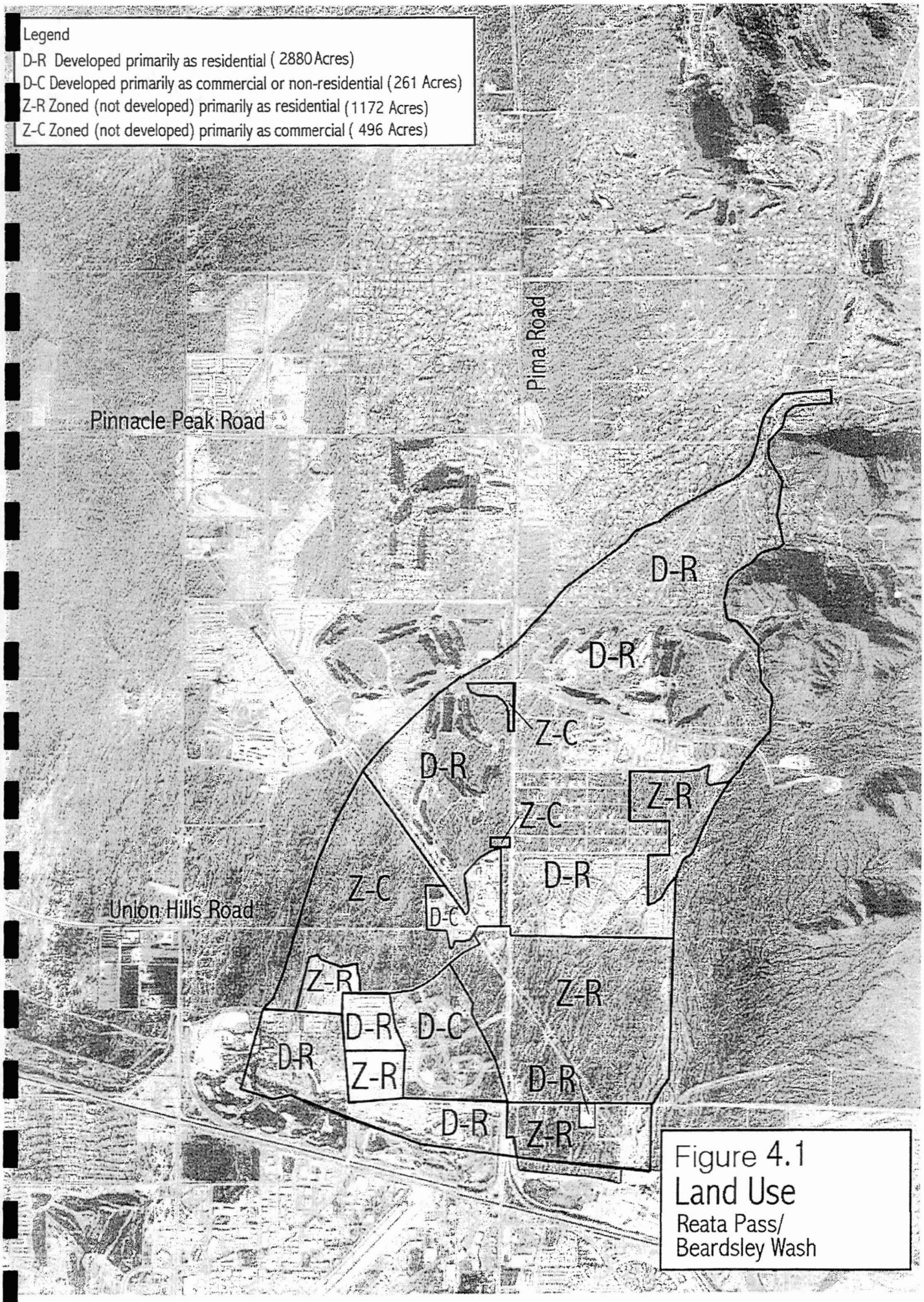
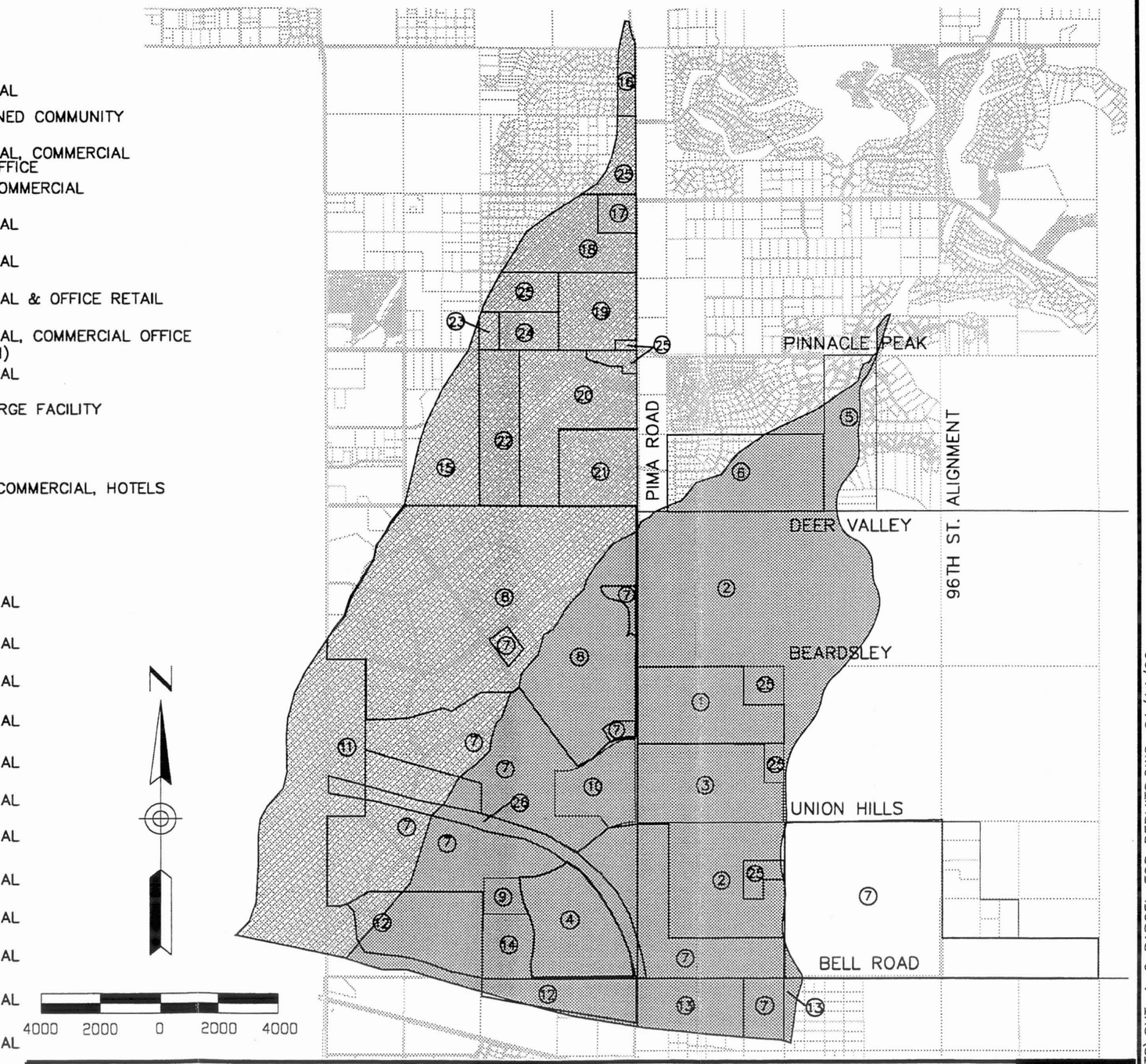


Figure 4.1
Land Use
Reata Pass/
Beardsley Wash

NO.	DEVELOPMENT NAME	YEAR APPROVED	AREA (ACRES)	TYPE
1	PIMA ACRES	1959	298.2	S.F. RESIDENTIAL
2	DC RANCH	1990	1281.2	MASTER PLANNED COMMUNITY (MIXED USE)
3	IRONWOOD VILLAGE	1988	260.0	S.F. RESIDENTIAL, COMMERCIAL INDUSTRIAL, OFFICE
4	PERIMETER CENTER	1985	252.8	INDUSTRIAL, COMMERCIAL
5	PINNACLE PEAK HEIGHTS	1977–1982	94.1	S.F. RESIDENTIAL
6	PINNACLE PEAK VISTAS III	1985	268.0	S.F. RESIDENTIAL
7	STATE LANDS	1992	1542.0	S.F. RESIDENTIAL & OFFICE RETAIL
8	GRAYHAWK	1990	1496.7	S.F. RESIDENTIAL, COMMERCIAL OFFICE (MASTER PLAN)
9	SCOTTSDALE STONEBROOK II 38ZN94	1994	36.9	S.F. RESIDENTIAL
10	WATER CAMPUS/TRANSFER STATION	1988	152.0	WATER RECHARGE FACILITY
11	CORRIGAN MARLEY	1989	155	UNDEVELOPED
12	PRINCESS/ TPC AREA	1986	251.4	SFR, OFFICE, COMMERCIAL, HOTELS
13	HORSEMAN'S PARK	1989	175	UNDEVELOPED
14	CITY LAND	1989	75.2	UNDEVELOPED
15	SONORAN HILLS	1997	212.0	S.F. RESIDENTIAL
16	HAPPY VALLEY RANCH	1977	37	S.F. RESIDENTIAL
17	TAMARRON	1985	40	S.F. RESIDENTIAL
18	PINNACLE PEAK ESTATES III	1979	172	S.F. RESIDENTIAL
19	PINNACLE PARADISE	1969	152	S.F. RESIDENTIAL
20	PINNACLE PEAK COUNTRY CLUB	1976–1984	301	S.F. RESIDENTIAL
21	LOS GATOS	1971–1977	157	S.F. RESIDENTIAL
22	PINNACLE PEAK ESTATES II	1971	166	S.F. RESIDENTIAL
23	DESIERTO VIDA	1995	20	S.F. RESIDENTIAL
24	PINNACLE PEAK ESTATES	1971	60	S.F. RESIDENTIAL
25	OTHER	VARIES	151	S.F. RESIDENTIAL
26	FREEWAY CORRIDOR	1985	151	S.F. RESIDENTIAL



Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

DEVELOPMENTS WITHIN THE STUDY AREAS

FIGURE 4.2

The Desert Greenbelt
SCOTTSDALE, ARIZONA

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approved for construction on the alluvial fan. The existing and approved developments comprise 67% of the total Reata Pass/Beardsley Wash.

"Approved for construction" means all City of Scottsdale ordinance requirements have been met, compliance with Section 404 of the Clean Water Act has been achieved and subdivision plats have been approved. This includes units already constructed as well as units for which individual building permits may still be pending. The Water Campus, located at the intersection of Pima Road and Union Hills Drive, is the site of several regional potable water and wastewater treatment facilities serving the entire City north of Doubletree Ranch Road, including the Scottsdale Airport and surrounding commercial area. Golf courses are included in the developed area because of their importance to the local economy, they would sustain severe damage in a flood due to high flow velocity and sediment deposition, and they represent impacts that have already occurred to the natural environment. It should be noted that the vast majority of the development in the area was approved prior to 1992, when the proposed Reata Pass/ Beardsley Wash proposed project alignment was adopted by the City of Scottsdale as an amendment to the Drainage Element of the General Plan.

The upper alluvial fan north of Sierra Pinta Road (approximately two miles downstream of the apex), comprising an area of approximately 1,600 acres between Sierra Pinta Drive and the Reata Pass apex (one-third of the Reata Pass/Beardsley Wash study area), is currently (1998) at least 83% developed. North of Deer Valley Road, which is approximately one mile downstream of the Reata Pass apex, development covers 100% of the area. This development north of Deer Valley Road consists of large houses at an average density of approximately one home for every 2.5 acres. This 385-acre area supports approximately 186 residences, all of which are located in the interwash areas between the active channels. Figure 1.2 (also Figure 4.6) shows the pattern of development there. Further south on the alluvial fan, below Deer Valley Road, the housing densities are higher in the DC Ranch, Pima Acres and Ironwood Village subdivisions.

Based on an average of 2.54 residents per housing unit (per the City of Scottsdale Community Planning Department), the current population (not including resort occupancy) on the Reata Pass/Beardsley Wash alluvial fan study area is 5,387 assuming 100% occupancy.

Table 4.2 Summary of Development on the Reata Pass/Beardsley Wash Alluvial Fan Study Area

Development Name	Total Approved Lots/Units[1]	Built Lots/Units[2]	Approved Lots Not Yet Built[1]
Residential Development			
Pinnacle Peak Heights	49	14	35
Pinnacle Peak Vistas 3	137	96	41
DC Ranch	543	60	483
Pima Acres	140	43	97
Grayhawk	91	91	0
Ironwood Village	712	712	0
Stonebrook 2	174	174	0
Crown Point	26	26	0
Crown Point 2	44	43	1
Alcazar	38	38	0
Princess Views	76	76	0
Crown Point Apartments	416	416	0
Scottsdale Links Apartments	228	228	0
Montana Del Sol Condominiums	102	102	0
Subtotal	2,776	2,121	655
Commercial/Public Works Development			
Water Campus	1	1	0
Villa Mirage Resort	192	192	0
Resort Suites Hotel	265	265	0
Princess Resort	600	600	0
Perimeter Center	25	10	15
Subtotal	1,083	1,068	15
All Development			
Total	3,859	3,189	670

[1] Approved for construction.
[2] Constructed as of 4/23/1998.

Pima floodplain

Land use on the Pima Floodplain (Table 4.3) is primarily residential. Figure 4.3 shows the land use in the developed areas and the zoning plan for the undeveloped areas. Nearly the entire alluvial fan is zoned for development. Residential zoning ranging 0.4 to 22 units per acre comprises 71% of the total fan area. Non-residential development such as commercial development, offices, resorts, tourist accommodations, employment and utilities comprises 29% of the area. In any development that is located in the Environmentally Sensitive Lands Ordinance area (see Section 5.1), the City of Scottsdale requires area within the development be left as Natural Area

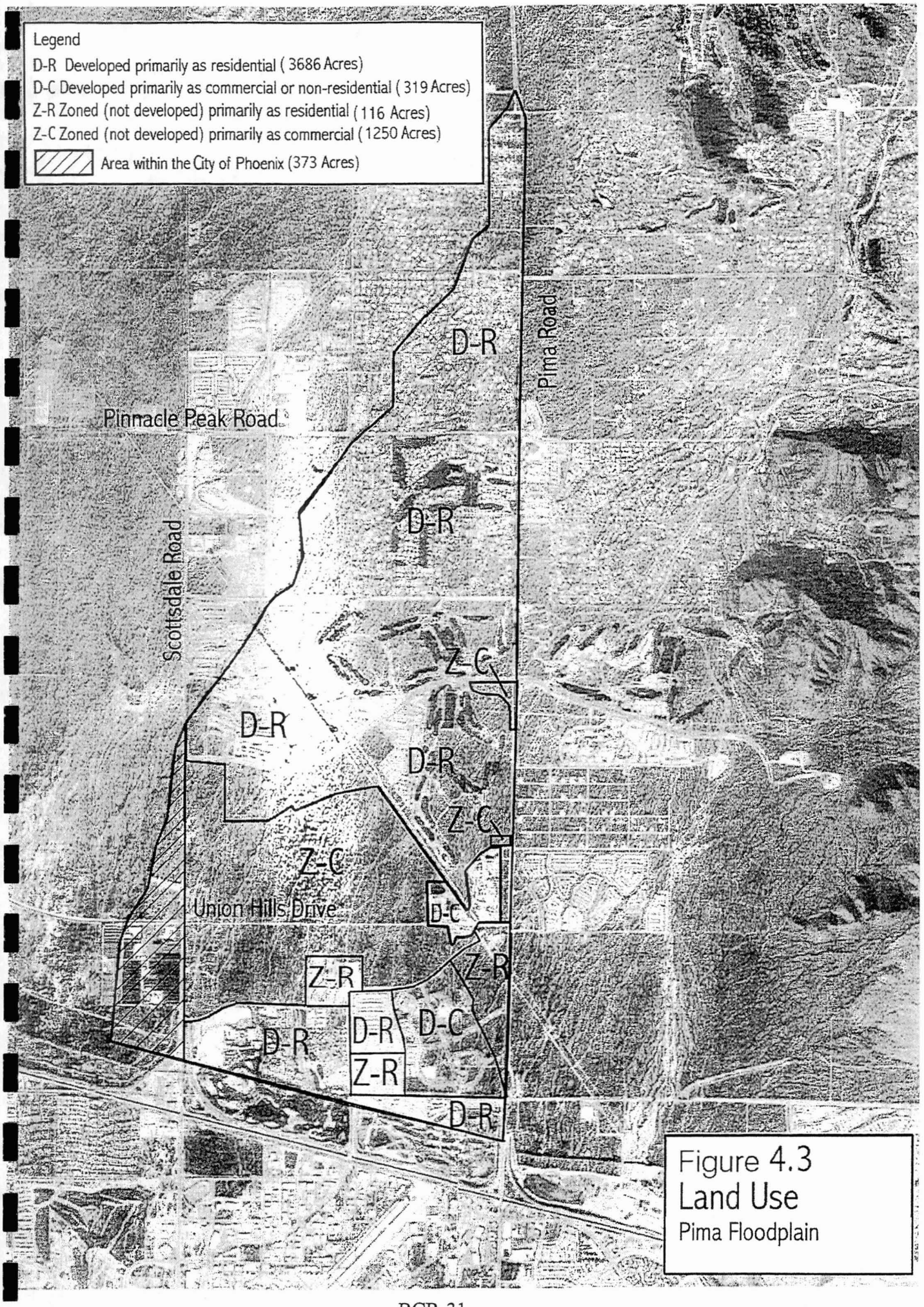


Figure 4.3
Land Use
Pima Floodplain

Open Space (NAOS). The minimum required NAOS is 15% in the Lower Desert, 20% in the Upper Desert, and 40% in Hillside Landforms.

Table 4.3 Summary of Land Use Plan Designations for Pima Floodplain Study Area

Type of Development	Percent of Total Area
Total Residential (Existing)	69%
Total Residential (Future)	2%
Total Non-residential (Existing)	6%
Total Non-residential (Future)	23%
Total Area	100%

Current developments in the study area are shown in Figure 4.2 and summarized in Table 4.4. In all, 3,444 single-family or apartment residences and 1,097 commercial units have been constructed or are approved for construction on the Pima floodplain. The approved developments comprise 75% of the total Pima floodplain study area. Based on an average of 2.54 residents per housing unit (per the City of Scottsdale Community Planning Department), the current population (not including resort occupancy) on the Pima floodplain study area is 6,119 assuming 100% occupancy.

4.2 Hydrology

Four flooding sources have been identified in this study area. These sources are the Reata Pass Wash, North & South Beardsley Washes, and the Pima floodplain.

Reata Pass / Beardsley Washes

As part of the study entitled "Final Report Upper Indian Bend Wash Regional Drainage and Flood Control Plan" (described in Section III) discharges were determined using the USACE HEC-1 rainfall runoff model. During 1992 modifications were made to that HEC-1 model. The results of the modified model at the fan apexes were used by FEMA in the study of these alluvial fans. Table 4.5 lists the contributing drainage areas and the 100-year discharges at the three apexes.

Table 4.4 Summary of Development on the Pima Floodplain Study Area

Development Name	Total Approved Lots/Units[1]	Developed Lots/Units[1]	Approved Lots Not Yet Built[1]
Residential Development			
Happy Valley Ranch	26	16	10
Tammarron	34	28	6
Pinnacle Peak Estates III	143	134	9
Pinnacle Paradise	64	48	16
Pinnacle Peak Estates	49	37	12
Desierto Vida	11	9	2
Pinnacle Peak C.C.	342	333	9
Pinnacle Peak Estates II	125	103	22
Los Gatos	87	61	26
Sonoran Hills	365	0	365
Grayhawk	1,078	521	557
Stonebrook 2	174	174	0
Crown Point	26	26	0
Crown Point 2	44	43	1
Alcazar	38	38	0
Princess Views	76	76	0
Crown Point Apartments	416	416	0
Scottsdale Links Apartments	228	228	0
Montana Del Sol Condominiums	102	102	0
Other	16	16	0
Subtotal	3,444	2,409	1,035
Commercial/Public Works Development			
Commercial	14	14	0
Water Campus	1	1	0
Villa Mirage Resort	192	192	0
Resort Suites Hotel	265	265	0
Princess Resort	600	600	0
Perimeter Center	25	10	15
Subtotal	1,097	1,082	15
All Development			
TOTAL	4,541	3,491	1,050

[1] Approved for construction.
[2] Constructed as of 4/23/1998.

Table 4.5 Apex Discharges

Flooding Source	Drainage Area	100-Year Discharge
Reata Pass apex	7.9 sq.mi.	10,000 cfs
North Beardsley Wash apex	1.8 sq.mi.	3,700 cfs
South Beardsley Wash apex	1.5 sq.mi.	4,100 cfs

The entire flood frequency curve which was used to develop the information shown on the FEMA map for these three flooding sources is shown in Figure 4.4.

Pima Floodplain

As described earlier the Pima floodplain does not have a single source, such as an apex, that contributes to the flooding. Rather the flows generated on the watershed follow numerous paths toward the southwest. As a result any feature that crosses the watershed can be impacted by flows at various locations. For example, Pima Road runs north-south through the watershed. Flows concentrate at intervals along the road; this is supported by the numerous dip crossings along that road. A hydrologic model was prepared by George V. Sabol Consulting Engineers, Inc. and Stantech Consulting, Inc. to determine the location of the flow concentration points and the quantity of flow at those locations along Pima Road. The results of that modeling are presented in the report entitled Desert Greenbelt Pima Road Three Basins Project - Ultimate Design Hydrology Memo, prepared by Stantech Consulting, Inc., March 1998. The results show that the runoff per square mile ranges from 850 cfs in the lower watershed to 1,385 cfs in the upper watershed. The effects of the DC Ranch and Grayhawk developments (imperviousness and channel routing) are included in this model.

4.3 Hydraulics

Reata Pass / Beardsley Wash

The study area is classified by FEMA as an alluvial fan with a Zone AO designation (depths and velocities determined). A report entitled Alluvial Fan Flooding, prepared by the National Research Council (NRC) in 1996 describes alluvial fans as "*gently sloping, fan-shaped landforms created over time by deposition of eroded sediment, ...common at the base of mountain ranges in arid and semiarid regions such as the American West.*" Alluvial fans in western states are subject to infrequent but intense storms typical of arid climates. These rainstorms, combined with abrupt changes in topography, create the necessary conditions for fan formulation.

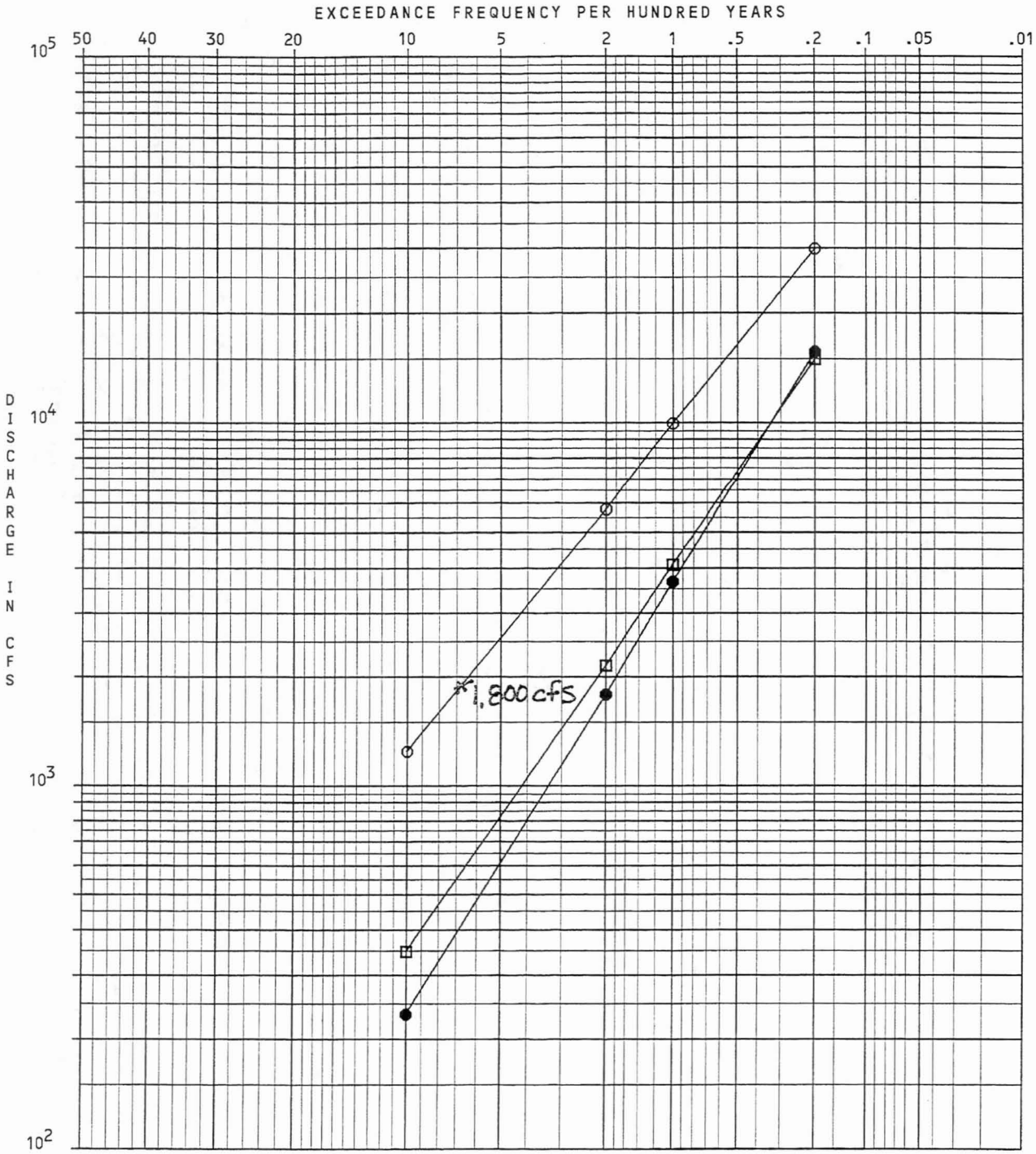


FIGURE 4.4

DISCHARGE-FREQUENCY CURVES

REATA PASS WASH

NORTH BEARDSLEY WASH

SOUTH BEARDSLEY WASH

SOURCE: FEMA FLOOD INSURANCE STUDY

Within the mountains upstream of an alluvial fan, streamflow from intense rainstorms is confined to steep, entrenched channels. Canyon outlets form the apex of each fan, which represents the highest point of elevation on the fan. As described in FEMA's Alluvial Fans: Hazards and Management (February 1989), flow leaving the apex of a fan spreads onto the upper-fan area, where it may either follow a pre-existing path cut from past flood events or cut a new path downslope. As the topography flattens, the channels widen and become shallower, flood flows lose velocity and deposit sediment and debris. The deposition can fill in existing channels, leading to the abrupt development of new channels. Toward the base of the fan, water velocities are reduced as the fan surface becomes more uniform, its slope flattens and water infiltrates the soil surface. In these areas, sheet flow flooding is common.

Alluvial fans represent severe flood hazard areas due to the unpredictable location and high velocity of their flowpaths during flooding, which usually occurs with little or no advance warning time. The NRC's 1996 report, quoted more fully in Section I of this report (the Introduction) describes alluvial fan flooding as "*ultrahazardous . . . for which elevation on fill will not reliably mitigate the risk.*" NRC also states: *"major flood control works are necessary to mitigate flood hazards on active alluvial fans. "*

The Reata Pass/Beardsley Wash alluvial fan is specifically identified in the NRC report (Figure 1.2) as an example of an active streamflow alluvial fan characterized by rapid erosion of channel bed and banks, channel capacity altered in a single flood, and sudden, large-scale changes in flow path.

According to FEMA (February 1989),

> *"An often-overlooked 'hazard' is the tendency to underestimate both the potential and severity of alluvial fan flood events. The infrequent rainfall, gently-sloping terrain, and often long time spans between successive floods events contribute to a sense of complacency regarding the existence of possible flood hazards. Though the intense rainstorms which produce fan floods occur randomly, they nevertheless can develop very rapidly at any time, and can recur with any frequency."*

In a paper entitled "Geometry of an Alluvial Fan," Journal of Earth Surface Processes (1979), Hooke and Rohrer explain that river channels are created by events that occur every year or two. However, alluvial fans are created by events that occur every few *decades*. The largest flow that has been seen recently on the Reata Pass alluvial fan is 1,800 cfs but a significantly larger flood event could occur at any time.

Floodplain limits on an alluvial fan are defined by physical boundaries, such as mountains, which are clearly capable of confining all flows. Due to the unpredictable nature of alluvial fan flows, the probability of occurrence of the 100-year (regulatory) flood event at any point along the entire width of the alluvial fan boundaries is equal. For flood insurance purposes, FEMA uses a procedure that assumes that all structures within the alluvial fan boundaries would be subject to flood damages. According to the National Research Council (1996), this method

> *". . . is quite general and sound for calculations of a conditional risk. This same mathematical approach has been used by the U.S. Army Corps of Engineers to analyze the flood risk of a levee failure while dealing directly with the uncertainties inherent in such an occurrence."*

The following equations for hydraulic parameters along an alluvial fan floor were developed by Dawdy ("Flood Frequency Estimates on Alluvial Fans", Journal of the Hydraulics Division, American Society of Civil Engineers, November 1979) based on field observations.

$$W = 9.5\ Q^{0.4}$$
$$D = .07\ Q^{0.4}$$

Where:	Q	=	Flow discharge, in Cubic Feet Per Second;
	W	=	Flow Width, in Feet; and,
	D	=	Flow depth, in Feet.

Flow velocity (V) can be obtained from Q, D and W using the continuity equation (V = Q/DW). Dawdy demonstrated that discharges on an alluvial fan tend to form a flow path that is approximately defined by the above equations. The Dawdy hydraulic parameters for a 100-year storm event on the Reata Pass/Beardsley Wash alluvial fan are shown in Table 4.6.

Table 4.6 Alluvial Fan 100-year Event using Dawdy Hydraulics at the apex

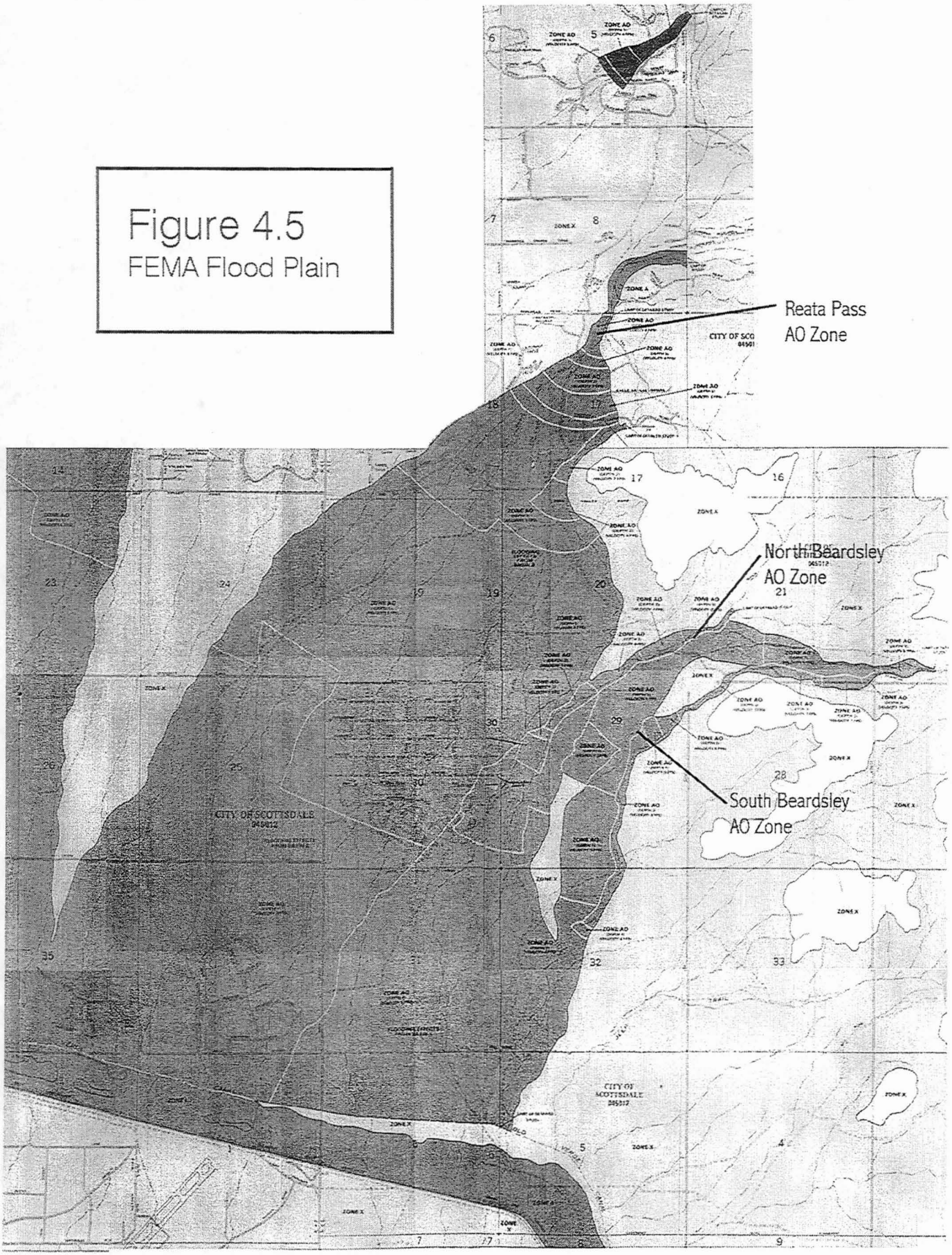
Apex	100-year Discharge	Flow Depth	Flow Width	Flow Velocity
Reata Pass	10,000 cfs	2.8 ft	378 ft	9.5 fps
North Beardsley	3,700 cfs	1.9 ft	254 ft	7.8 fps
South Beardsley	4,100 cfs	2.0 ft	265 ft	7.7 fps

Figure 4.5 shows the floodplain boundaries for the Reata Pass and Beardsley Wash as depicted on the Federal Insurance Rate Maps (FIRM - Panels 04013C1245E, 04013C1255E, and 04013C1265E, effective December 3, 1993) from the Federal Emergency Management Agency (FEMA). The floodplain extends the entire width of the alluvial fan from the fan apex to the CAP Aqueduct. The combined alluvial fan area of Reata Pass and Beardsley Washes is approximately 5,900 acres. The regulatory flood depths on the alluvial fan from the apex to the CAP range from 4 to 1 feet. Regulatory flow velocities range from 9 to 3 feet per second from the apex to the CAP. Regulatory flow depths and velocities decrease as the distance from the apex increases due to increasing width of the alluvial fan in the downstream direction. The floodplain spans a width ranging from 500 feet to 14,000 feet from the apex to the CAP. Direct impact of a 10,000-cfs flow one to four feet deep with velocities up to nine feet per second would be devastating to any existing structure on the alluvial fan.

Pima Floodplain

The Pima floodplain area has not been classified by FEMA as an alluvial fan or a Special Flood Hazard Area. However, structures and roadways have experienced damage as a result of flooding following storm events. The presence of small channels throughout the watershed indicates that during larger storm events the flow will be outside of the banks of those small channels. Based on the concentration points defined in the Stantech hydrology report described in Section 4.2 it was assumed that flow concentrates along 3 flowpaths in each square mile. Using the Dawdy equations described previously, the following hydraulic parameters were determined for the Pima Floodplain.

Figure 4.5
FEMA Flood Plain



Source: FEMA Flood Insurance Rate Maps #04013C1245 E, 04013C1255 E, and 04013C1265 E, 1993

4.4 Sediment

Along an alluvial fan the effect of sediment is usually significant. The stream flow will pick up large quantities of sediment as it travels with a high velocity through the steep mountain reaches. Once the flow leaves the canyon and travels along the valley, the slope and velocity decrease significantly, resulting in massive sediment deposition which could occur at any location throughout the fan downstream of the apex. Uneven sediment deposition downstream of the apex is one of the reasons for the unpredictability of flow paths from flood to flood on an alluvial fan. As one channel fills with sediment another channel opens to convey the flow. A sediment-transport analysis of the Reata Pass and Beardsley Washes using a computer application of the Meyer-Peter-Muller bed-load sediment-transport equation was performed to determine the sediment volume that could be delivered to each of the apexes. It was assumed that the natural watercourses leaving the McDowell Mountains are in sediment equilibrium and that an estimate of transport capacity can be used as an estimate of sediment supply. The results of these analyses are shown in Table 4.7.

A similar sediment-transport analysis of the Pima floodplain could not be performed because there is no location where the 100-year flood event is confined to a single channel or location.

Table 4.7 100-Year Sediment Volumes Delivered to Alluvial Fan Apex

Location	100-year Sediment Volume
Reata Pass Apex	6.9 acre-feet = 13,500 tons
North Beardsley Apex	5.6 acre-feet = 11,000 tons
South Beardsley Apex	5.4 acre-feet = 10,500 tons

* One acre-foot is enough sediment to cover an acre of ground for a depth of one foot. One acre-foot of sand weighs approximately 1,960 tons.

The sediment supply at the apexes of the alluvial fans gives an indication of the total sediment supply available from the Reata Pass and Beardsley Washes. Because the alluvial fan widens and becomes flatter as it leaves the mountains, most of this sediment would be deposited on the alluvial fan under natural conditions.

4.5 Historical Flooding

There are no stream gages to record flood discharges on the alluvial fan. The largest known flood to occur in the past twenty years on the Reata Pass alluvial fan occurred in August 1996 with a discharge estimated using the slope-area method by the USGS as 1,800 cfs at the fan apex. Figure 4.4 shows that this would be approximately a 15-year flood. The USGS determined that this flood, which was 1,800 cfs at the apex split immediately downstream of the apex. Approximately 1,000 cfs flowed directly south along the path of the East Wash, and 800 cfs flowed toward the southwest as shown in Figure 4.6.

This flood caused erosion damage to several properties at the fan apex. In one location the erosion lead to the failure of a large water line, causing a number of residents to lose their water service. During this storm event approximately 55% of the flow went south along the East Wash with the remaining 45% flowing to the southwest. During previous storm events flow primarily went to the south along the East Wash southwest.

Pima Road is the major north-south traffic arterial in the study area. All of the wash crossings of Pima Road are dip crossings subject to periodic flooding. The dip crossings are inundated during storms every summer, creating delays, traffic hazards and causing emergency response, sediment clean-up, and road repair expenses. Flooding and erosion problems exist in the residential area downstream (west) of Pima Road. Damage witnessed by the City includes driveways being washed out, water getting into garages, collapse of block walls, and bank erosion and downcutting. Much of the development on the Pima Floodplain has been in place for over 15 years and was developed in unincorporated Maricopa County, prior to annexation into Scottsdale.

Historical flooding on the Reata Pass / Beardsley Wash alluvial fan should be interpreted in the context of two factors. First, most of the development on the alluvial fan has taken place during the past five years. During this five year period, the probability of occurrence of a large, catastrophic flood such as the 100-year is approximately one in twenty. A 10-year flood has approximately one chance in 2.4 of being exceeded during a five-year period. It is common for a desert flood area to

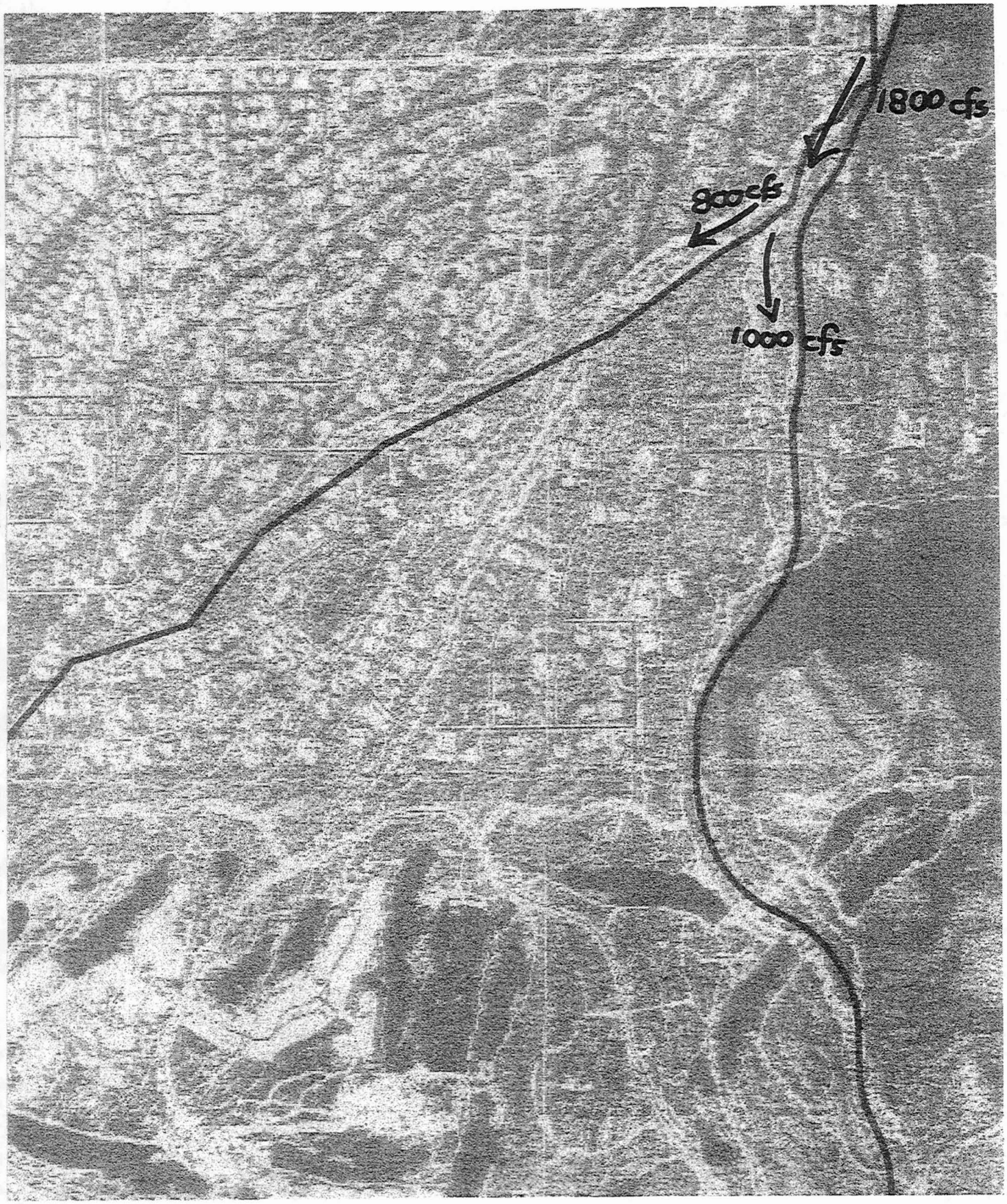


Figure 4.6. 1996 Reata Pass Flow Split.

go five years or more without a significant flooding event. Second, the steepness of the flood frequency curve (Figure 4.4) shows that the frequent floods (say, less than 10-year return period) are of relatively low discharge which are unlikely to cause significant damage.

The NRC recognized the common lack of historical flood data. In a section on reports of flooding on alluvial fans the NRC states:

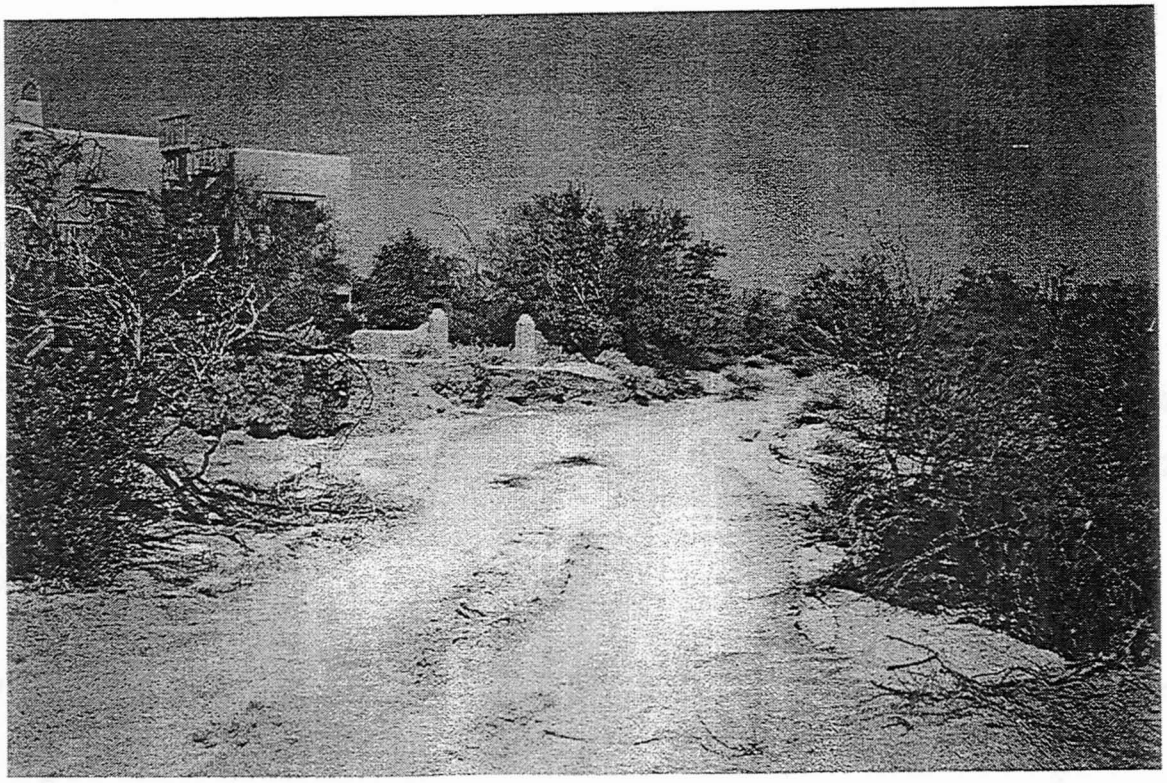
> *"Only a few maps of the extent of flooding are available, and direct measurements of flow depths and velocities on fans are rare. Opportunities for systematic collection of flood data on alluvial fans are also rare."*

Alluvial fan flood damage is compounded by the transport of sand and cobble debris into homes (See Section 4.5). Figure 4.7(a) and Figure 4.7(b) shows the same location along Reata Pass before and after a storm event. Significant amounts of sediment and vegetation were scoured out of the channel and carried downstream. The homeowner lost approximately 15 feet of the channel bank during the August 1996 storm. Figure 4.8 shows the extent of deposition that has occurred along a fan in the North Scottsdale area. Figure 4.9 shows damage that occurred to a home along a fan in California. Figure 4.10 illustrates typical alluvial fan flood damage that occurred to houses constructed on a Nevada alluvial fan. Note the sediment that was deposited outside of the channel adjacent to the structure. The alluvial fan causing this damage was much smaller than the Reata Pass/Beardsley Wash alluvial fan, with peak discharges approximately one-half those expected in Scottsdale.

4.6 Floodplain Risk and Management

As described in the 1996 NRC report, alluvial fan flood conditions on Reata Pass Wash are ultrahazardous. This is due primarily to the uncertainty of the flowpath during a flooding event, and the large amounts of sediment and debris that can be delivered and deposited at random by an alluvial fan. These are flash floods that can arrive suddenly and with little or no advance warning. Every structure and person on the alluvial fan is potentially within the direct path of the full apex flow. During a 100-year event, this flow is expected to be 10,000 cfs for the Reata Pass alluvial fan. To place this in perspective, 10,000 cfs is almost 4 ½ million gallons per minute. This would fill

(A) Reata Pass Wash Before Erosion



(B) Reata Pass Wash After Erosion

Figure 4.7. Reata Pass Channel Erosion

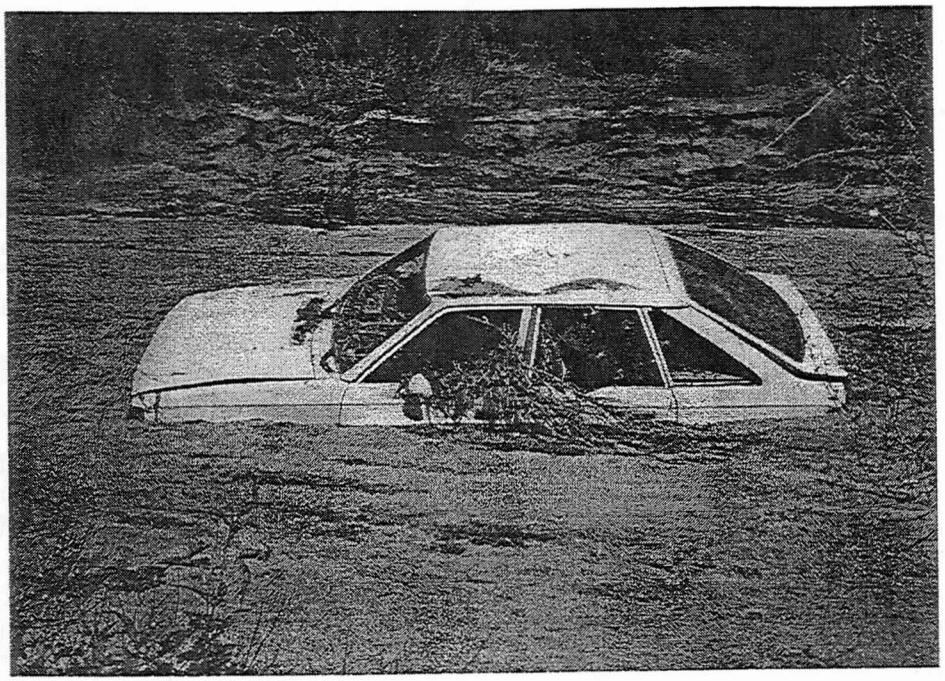


Figure 4.8. Deposition along an Alluvial Fan in North Scottsdale

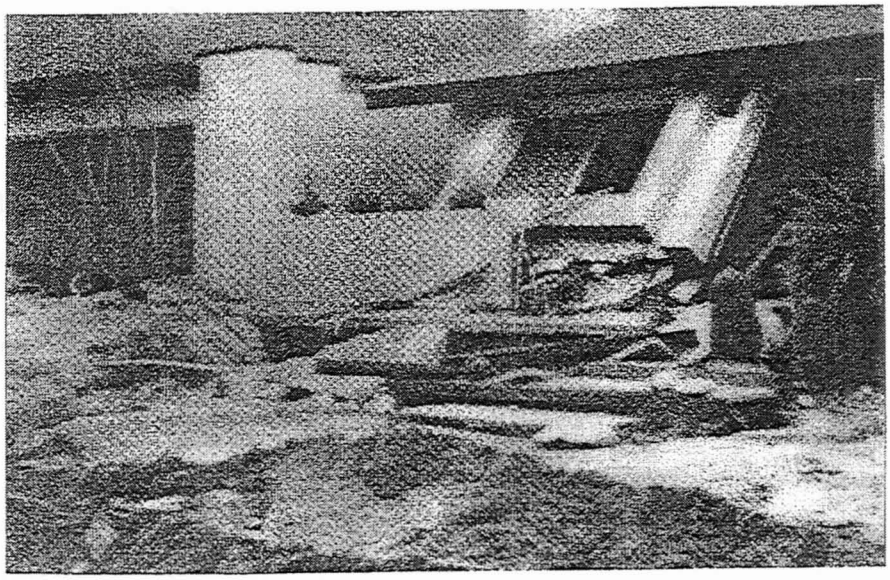


Figure 4.9. Structural Damage along an Alluvial Fan in California

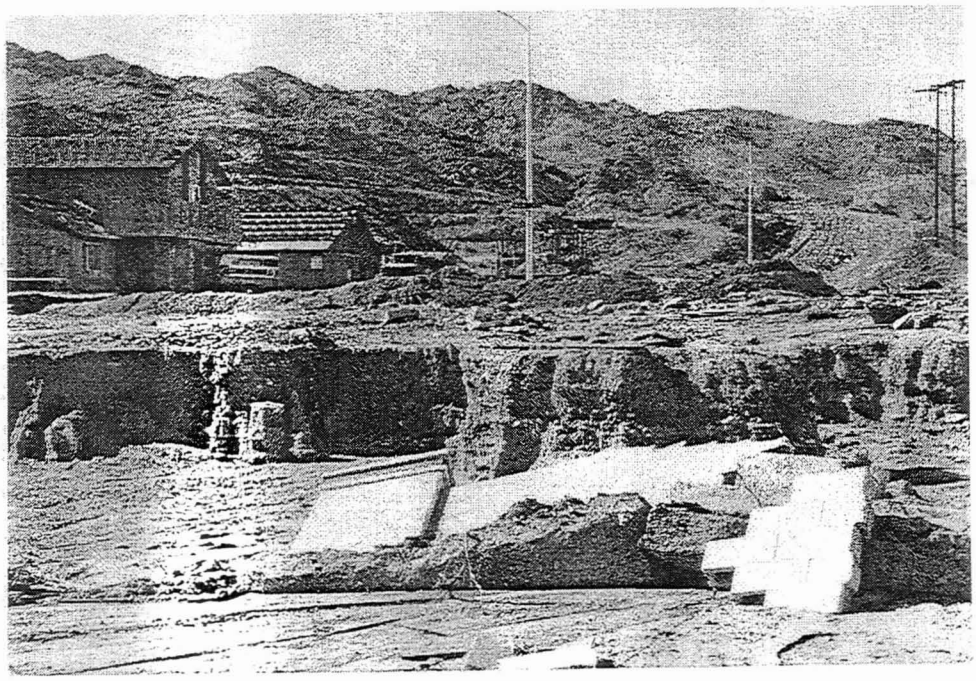


Figure 4.10. Typical Alluvial Fan Flooding Damage. Note the Bulldozer in the Background removing sediment that was deposited outside of the main channel during the flood event.

a 2,000 square-foot, single-story house with 5 feet of water in one second. As discussed previously a flow of 10,000 cfs is expected to have a depth of 2.8 feet and a velocity of 9.5 feet per second (See Table 4.6). At that velocity the flow could hit a 100-foot long side of a structure with a force of 24 tons. Sediment brought down by this flow (nearly 35,000 tons during a 100-year flood) is potentially as damaging as the flow itself. Figures 4.7 through 4.10 show examples of flood damage that has occurred on other alluvial fans in the past, and on the Reata Pass/Beardsley Wash and nearby Rawhide Wash alluvial fan.

4.6.1 FEMA Requirements

The City of Scottsdale is a participant in the National Flood Insurance Program (NFIP). FEMA, which administers the NFIP, identifies and delineates special flood hazard areas on flood insurance rate maps (FIRMs) for communities participating in the NFIP. Final FIRMs were published for the area in 1993.

FEMA has established minimum requirements with which developers in special flood hazard areas must comply in order to meet NFIP regulations and to be eligible for flood insurance coverage. These requirements are addressed in Chapter 44 of the Code of Federal Regulations, Part 60.3. Communities participating in the NFIP must assure that developments within their communities comply with the minimum FEMA requirements to remain eligible for participation in the program. Regarding alluvial fan flooding, these regulations include:

1) The lowest floor must be elevated above the highest adjacent grade to at least the flood depth or elevation specified on the FIRM; and

2) Adequate drainage paths around structures on slopes must be provided, with floodwater guided around and away from proposed structures.

Compliance with these minimum requirements enables developers to build within an alluvial fan AO Zone Special Flood Hazard Area. However, the elevated floor levels do not provide 100-year flood hazard protection. These floor levels have been established assuming a uniform distribution of flood flows across a certain area of the alluvial fan. The FIRM depths are calculated by statistical and

hydraulic methods for management purposes and no not necessarily represent the exact flood depth that can be encountered at any given site on the alluvial fan. Alluvial fan flood flows are extremely unpredictable and are often characterized by concentration of flows in narrow flow paths. These narrow flow paths can contain the entire apex flow at any point on the alluvial fan and result in much greater velocities, flow depths and potential for severe flood damage than shown on the FIRM maps. Therefore, the structures are still considered by FEMA to be susceptible to damage, are still designated as being within the AO Zone Special Flood Hazard Area, and still require flood insurance.

FEMA will credit only major structural measures as eliminating alluvial fan flood hazards. Section 65.13 of FEMA's "National Flood Insurance Program and Related Regulations" (revised October 1, 1994) specifically states: "In general, elevations of a parcel of land or a structure by fill or other means, will not serve as a basis for removing areas subject to alluvial fan flooding from an area of special flood hazards. FEMA will credit on NFIP maps [i.e. remove the Zone AO designation] only major structural flood control measures whose design and construction are supported by sound engineering analyses which demonstrate that the measures will effectively eliminate alluvial fan flood hazards from the area protected by such measures."

Among other things, the engineering analyses must show that the flood control measures are adequate to convey the volumes of water, debris, and sediment that are generated at the fan apex during the 100-year flood. This is key to understanding FEMA's approach to removal of flood hazard zones from alluvial fans. Flood control systems which allow for the safe collection and passage of flood waters, no matter where the systems are located on the alluvial fan, must account for the entire alluvial fan discharge in order to be accepted by FEMA. *This means that unless there is an apex to base regional solution, each developer must construct flood control systems capable of carrying 10,000 cfs or more plus the expected maximum sediment load on the Reata Pass/Beardsley Wash alluvial fan, and the system must be so designed that it will not be bypassed or overtopped by erratic, random flows from the apex.*

The Ironwood Village subdivision on the Reata Pass/Beardsley Wash alluvial fan is one example of a development-related Letter of Map Revision application which was rejected by FEMA (See Appendix F) on the grounds that the flood-control channels were undersized according to the FEMA alluvial fan criteria.

4.6.2 City Requirements

Section 37 of the City of Scottsdale's Revised Code details requirements for developments within special flood hazard areas. Section 37-41 (a) specifies that development is prohibited if it would create hazards to life or property by increasing the potential for flooding either on the property to be developed or to any other property. Further, a watercourse may not be altered unless a professional engineer certifies that the alterations do not increase the flood levels and will not increase flooding hazards within, upstream or downstream of the altered portion of the watercourse.

Section 37-42 states that the developer must submit reports, construction plans and other data to the City as necessary for the floodplain administrator to determine that all proposed building sites will be reasonably safe from flooding.

In accordance with Section 37-42 (6), the lowest floor level of residential structures in FEMA designated AO zones must be elevated above the highest adjacent grade at least as high as the depth number specified on the FIRM. Section 37-42 (7) states that non-residential structures may have lowest-floor elevations lower than the flood depth shown on the FIRM if other floodproofing measures are provided which will result in equivalent protection.

The City of Scottsdale's regulations are consistent with FEMA's minimum requirements for development within an AO Zone. However, they do not meet FEMA's requirements for removal from the floodplain nor do they eliminate the flood hazard. Accordingly, it is possible to develop within the floodplain by elevating the lowest floors of structures without removing the alluvial fan floodplain designation from the FIRM. Those purchasing structures within the special flood hazard area via federally-insured loans, whether the floors are elevated to above the flood elevation or not, would be required to purchase flood insurance.

4.7 Traffic

Pima Road is the main north-south road through the study area. Scottsdale Road, another major north-south arterial, crosses a portion of the lower Pima Floodplain approximately two miles west of Pima Road. The major east-west roads are Pinnacle Peak Road, Thompson Peak Parkway, Union Hills Drive, and Bell Road.

Traffic along major streets has increased significantly as the development has increased. Figure 4.11 shows the past and projected traffic pattern along Pima and Scottsdale Roads from Frank Lloyd Wright Boulevard north to Pinnacle Peak Road and along Pinnacle Peak Road from Pima Road west to Hayden Road. These traffic counts are also summarized in the Table 4.8.

Table 4.8 Traffic Counts and Projections in Vehicles Per Day (VPD)

Road	1990(1)	1992(1)	1994(1)	1996(1)	1998(2)	2020(2)
Pima Road	11,400	14,400	12,900	17,000	28,000	42,000
Scottsdale Road	15,000	12,800	15,700	15,700	26,500	39,000
Pinnacle Peak Road	7,000	9,900	12,800	13,600	16,800	17,000

(1) Actual vehicle count
(2) Projected vehicle count

While there are some bridges and culverts in the study area, the most prevalent type of conveyance for water past a road is a dip crossing. There are numerous dip crossings along Pima Road between Bell Road and Pinnacle Peak Road. During a flood event a hazardous situation is created along the road. Motorists often try to navigate through flooded dip crossings (usually despite posted road warning signs and barricades). As a result, Scottsdale's Emergency Management Department has been required to send emergency teams to assist these motorists.

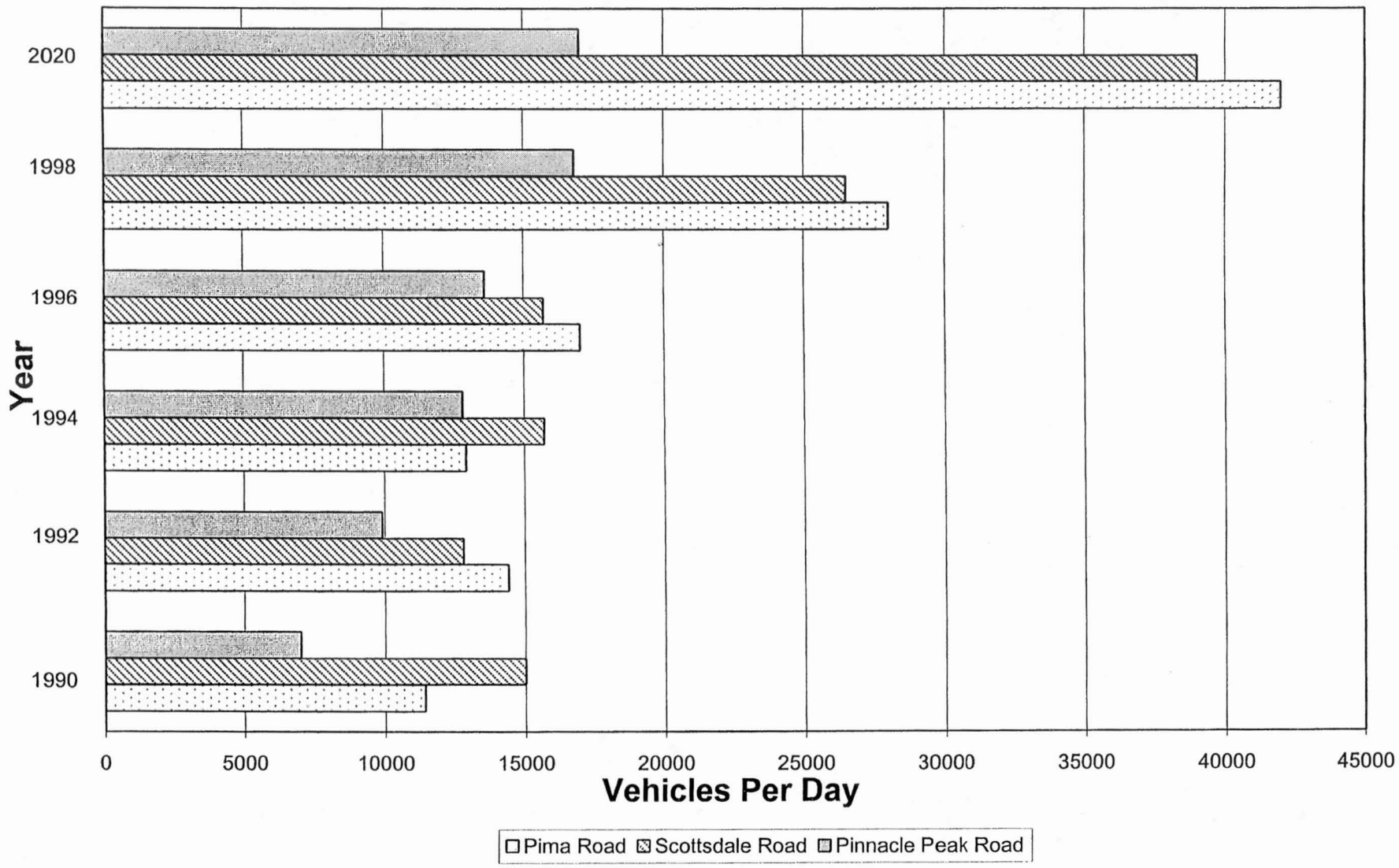


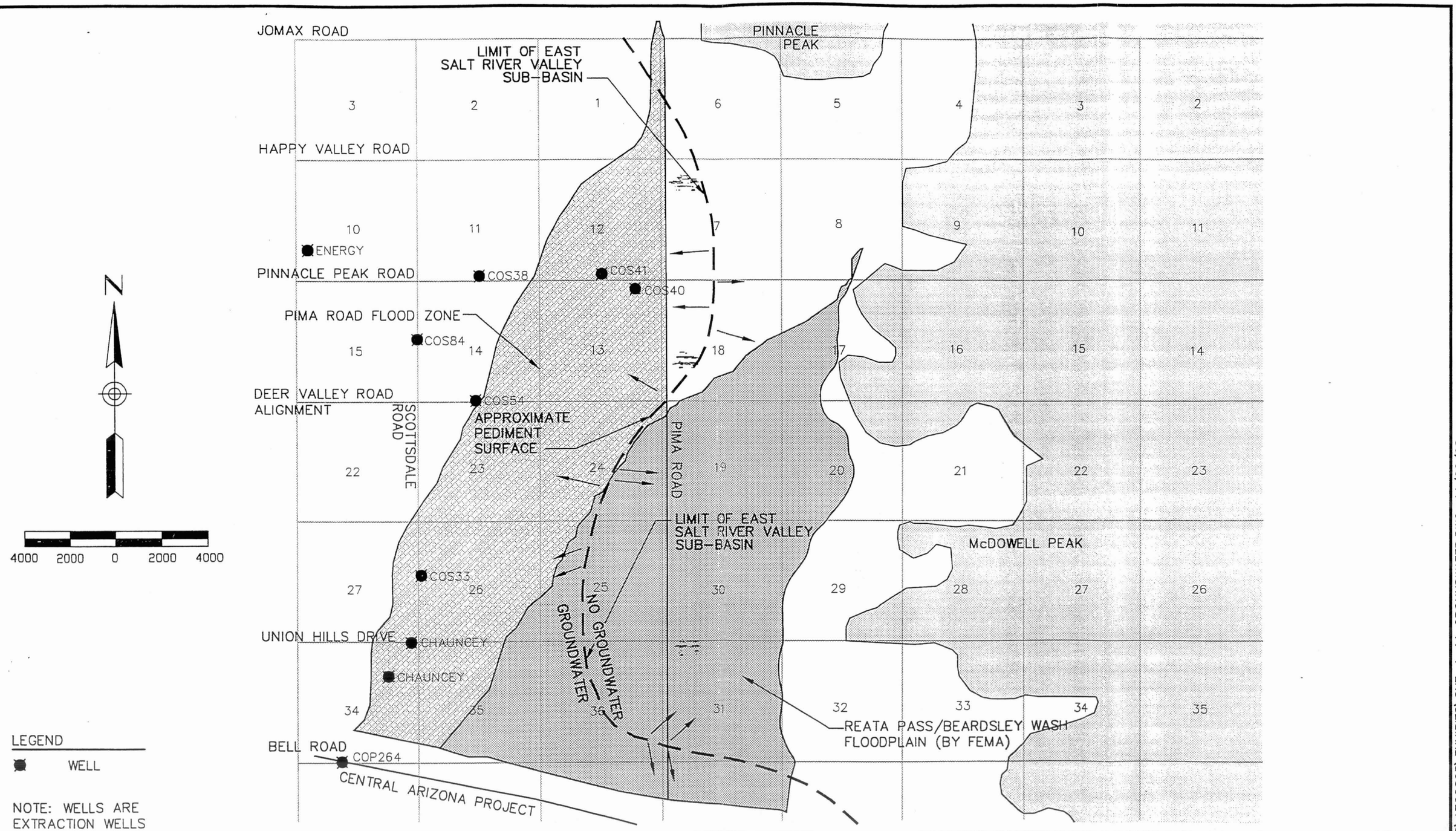
Figure 4.11. Traffic Count

4.8 Groundwater

The hydrogeologic conditions within the study area include portions of two distinct but interconnected alluvial groundwater basins. These basins are referred to as the West Salt River Valley (WSRV) and East Salt River Valley (ESRV). The limits of these basins encompass the Phoenix metropolitan area which includes the City of Scottsdale. In general, the groundwater in these two basins is moving laterally toward extensive and deep depressions in some of the main aquifer systems. The City of Scottsdale lies in the ESRV basin. The 1991 ESRV groundwater level was estimated to be approximately 450 feet below the ground surface in the vicinity of the study area.

The edge of the ESRV in the vicinity of the study area is shown in Figure 4.12. The basin boundary is defined by an abrupt drop in the bedrock pediment sloping away from the McDowell Mountains below the alluvium as illustrated in Figure 4.13. Alluvial deposits to the east of the ESRV limit line shown in Figure 4.12 are shallower than the depth to groundwater in the deeper alluvium west of this line. Consequently, there is no groundwater below approximately 76 percent of the Reata Pass/Beardsley Wash study area. There are no groundwater wells in that part of the study area outside the ESRV other than a few installed by the City of Scottsdale for the Water Campus (Figure 4.14). These are monitoring and recharge wells. There are five groundwater extraction wells within the Pima floodplain study area as shown in Figure 4.12. These wells together pump an average of 1,200 acre feet of water per year.

Recharge to the ESRV and the WSRV is accomplished through groundwater inflow, stream channel recharge and mountain front recharge (Table 4.9). Groundwater inflow, from underground sources outside the ESRV, accounts for approximately 21% of total recharge. In general, groundwater moves east to west through the ESRV towards the lower topographic areas. The major source of recharge is from river and stream channels directly above the ESRV. This accounts for 71% of the total recharge. The final source of groundwater recharge is mountain front recharge. This occurs when water infiltrates into the alluvial material along the interface between mountains and the alluvial groundwater basin. The Arizona Department of Water Resources estimates that mountain



SOURCE: HYDRO-ANALYSIS, INC., 1991

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

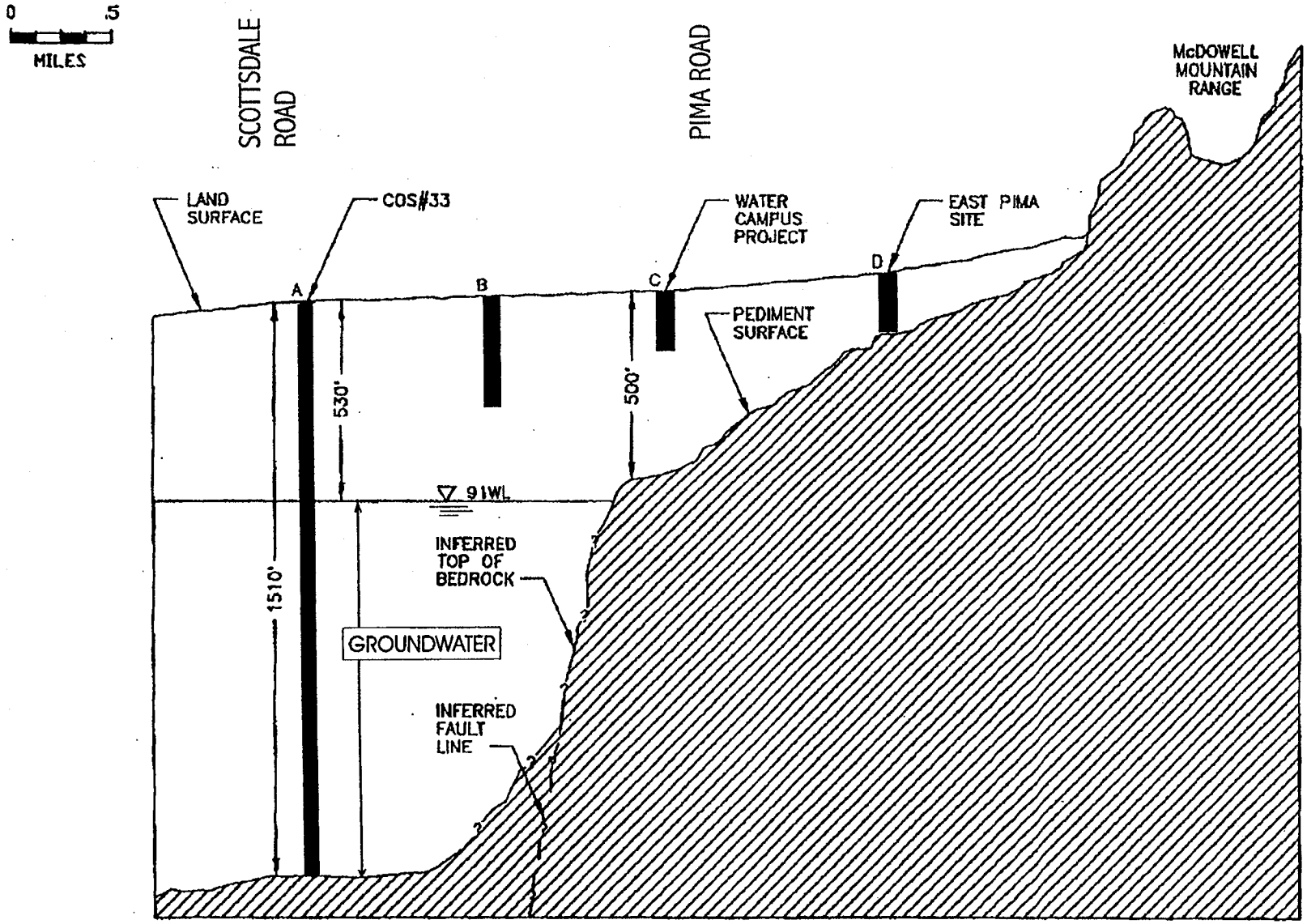
TRANSPORTATION DEPARTMENT

LOCATION OF GROUNDWATER WITHIN STUDY AREA

Figure 4.12

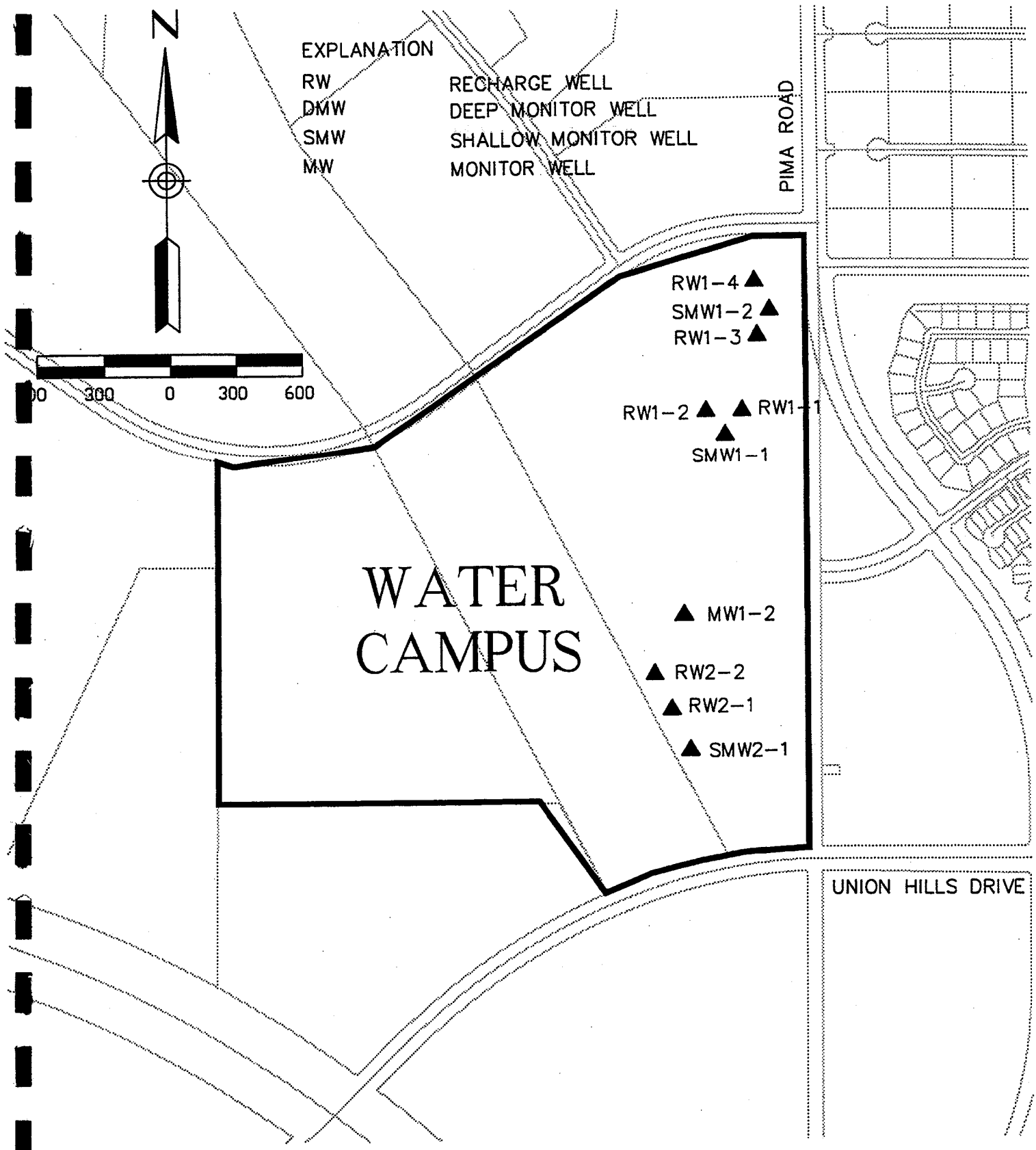
The Desert Greenbelt
SCOTTSDALE, ARIZONA

M:\PUBLIC\PROJECTS\AZCOS03\EXHIBITS\SHT-4-11 GROUNDWATER.DWG, 11/02/98



Source: Hydro-Analysis, Inc., 1995

Figure 4.13
Cross Section of Conceptual Pediment Surface and Recharge Scenarios



WATER WELL LOCATIONS
FOR WATER CAMPUS SITE

Figure 4.14

front recharge for the ESRV is only significant along the McDowell and Superstition Mountains. Recharge from the study area would be classified as mountain front recharge.

Table 4.9 Groundwater Recharge Summary for ESRV Groundwater Basin

Source	Recharge AF/yr	Contribution
Groundwater Inflow	30,000	21%
Stream Channel Recharge	100,000	71%
Mountain Front Recharge	10,000	8%
Source: U.S. Army Corps of Engineers "Rio Salado Salt River, Arizona Draft Feasibility Report" November 1997		

The total McDowell and Superstition mountain front draining toward the ESRV is at least 300 square miles in size. The study area, at 8.6 square miles, constitutes approximately one percent of the total mountain front. Assuming a uniform rate of recharge throughout the entire mountain front area, approximately 0.07 percent (100 acre feet annually) of the average annual recharge to the ESRV originates from the study area.

The City of Scottsdale Water Campus is shown on Figure 4.14. The purpose of this site is to treat potable water for consumption, treat wastewater for reuse, and recharge groundwater. Groundwater recharge begins in 1998. Table 4.10 shows that the Water Campus alone is expected to recharge from 168 to 499 times the total estimated natural recharge.

Table 4.10 Projected Recharge from the City of Scottsdale Water Campus

Phase	Duration	# of Years	Rate of Recharge, AF/yr	Total Volume of Recharge, AF
I	1998-2010	13	16,800	218,400
II	2011-2020	10	33,400	334,000
III	2021-2040	20	41,600	832,000
IV	2041	1	49,900	49,900
Total Projected Volume of Water Recharged (Phases I - IV)				1,430,000

4.9 The Natural Environment

4.9.1 Plant Communities

The Scottsdale Desert Greenbelt project is located near the northern and eastern limit of the Sonoran Desert. The Sonoran Desert extends from northwestern Sonora in Mexico to southeastern California and southwestern Arizona. This desert consists of low, arid plains separated by barren, often detached mountains.

Vegetative communities occurring in the project area include two subdivisions of desert scrub typical of the Sonoran desert: the Arizona Upland Subdivision and the lower Colorado River Valley Subdivision. The project is located in an area that is transitional between the two subdivisions and elements of both are represented on the site.

The project area is typical of alluvial fan desert wash drainage systems, consisting of networks of poorly defined braided channels capable of containing small flows. Soils consist of deep alluvial deposits. As a result of the natural sorting process that occurs as flows move down an alluvial fan, soil particle size decreases relative to distance from the fan apex. The soils of the upper fan are typically more gravelly than the soils of the lower fan, allowing greater water infiltration and storage, and thus making water more readily available to deep rooted plants. This effect is compounded by greater precipitation at higher elevations.

Vegetation in the project area is generally distributed according to water availability. Along the washes, vegetation is characterized by a corridor of larger and/or greater density trees and shrubs. Species closely associated with washes generally have greater water requirements, while species more tolerant of drier soil conditions occur both along the washes and across the adjacent terraces. The corridors of wash vegetation generally become more closely aligned with the active channels with increasing distance down the alluvial fan.

Arizona Upland Subdivision of the Sonoran Desert

The most common Sonoran Desert vegetation type in the project area is the Paloverde-Cacti Mixed Scrub Series of the Arizona Upland Subdivision. Most of the northern and eastern portions of the

project area, along the McDowell Mountains front, supports this vegetation type. Typical of this Series, the dominant overstory species are foothill palo verde (*Cercidium microphyllum*) and Saguaro cactus (*Carnegiea gigantea*).

Along the washes, the most common overstory species in the project area is foothill palo verde, with ironwood (*Olneya tesota*), blue palo verde (*Cercidium floridum*), cat-claw acacia (*Acacia greggii*), and an occasional velvet mesquite (*Prosopis velutina*) also present. On the upper alluvial fan, these species are most common, and attain the greatest size, along the wash channels; however, they may also occur on the adjacent terraces and, occasionally, on hillsides. Burrobrush (*Hymenoclea salsola*) and sweetbush (*Bebbia juncea*)are the most common understory species along the washes.

Dominant upland species of the Paloverde-Cactus Mixed Scrub Series include creosote (*Larrea tridentata*), jojoba (*Simmondsia chinensis*), and triangle-leaf bursage (*Ambrosia deltoidea*). Other upland species include teddy bear cholla (*Opuntia bigelovii*), buckhorn cholla (*Opuntia acanthocarpa*), broom baccharis (*Baccharis sarothroides*), chia (*Salvia columbariae*), and red brome (*Bromus madritensis rubens*).

Lower Colorado River Valley Subdivision of the Sonoran Desert

The Lower Colorado River Valley Subdivision of the Sonoran Desert is characteristic of the drier, finer textured soils of the lower bajada. This plant community is best represented near the CAP canal and in the southwestern portion of the project area. This subdivision is dominated by creosote and bursage with sparsely scattered cacti; larger trees, including foothill palo verde and ironwood, are typically limited to the washes. Interwashes are barren of understory most of the year; however, after the rainy seasons, many annual species occupy these areas.

Disturbed/Developed Areas

The disturbed/developed areas are characterized by residential uses, unpaved and paved roads, drainage culverts and structures, recreational facilities, and commercial developments. Residential lots are common on the alluvial fan surface, outside of the main channels, throughout the length of the project area. Three golf courses are located in the central project area. Many of the developed areas have been landscaped with native and nonnative drought tolerant species including mesquite, ocotillo (*Fouquieria splendens*), palo verde, and several species of cacti. While landscaping is typical of developed areas, some projects have retained natural Sonoran Desert vegetation withing the developments.

Figure 4.15 and 4.16 show typical Arizona Upland and Lower Colorado vegetation occurring in the project area.

Grazing History

The plant communities in the project area were likely affected to some degree by livestock grazing that occurred in the areas from the late 1800's to the early 1900's. Effects of grazing on natural communities include reduction of native grasses, increases in erosion resulting in incised channels, and changes in large tree, shrub and cacti species composition as a result of overgrazing, trampling, and burning. According to the City of Scottsdale, grazing in the project area had largely ceased by the 1970's as residential development began to occur in the area.

Vegetation Ecology

The distribution of desert vegetation on alluvial fans in the Sonoran desert has been studied for over 90 years. These studies have focused on edaphic (soil-related) factors, including moisture, texture, salinity, nutrients and pH, and physical factors, including fluvial and geomorphic processes.

Most studies of vegetation distribution on alluvial fans presume that fans are constructed primarily by fluvial (stream flow) processes operating continuously over time, resulting in a soil texture gradient, and associated moisture gradient, down the fan surface. Coarse soils on the upper fan allow

Figure 4.15 Arizona Upland Vegetation along a wash on the upper Reata Pass Alluvial Fan.

Figure 4.16 Lower Colorado Vegetation along a Wash on the Lower on the Reata Pass Alluvial Fan.

more rapid infiltration of water and hold water less tightly than finer soils further down the fan, thus providing greater moisture availability for vegetation. Consequently, vegetation diversity, in terms of both species richness and growth forms, is usually greatest on the upper fan and declines with distance down the fan.

Fluvial processes contribute to variability on the fan surface. The movement of stream channels across the surface over time causes a shifting of stable and unstable substrates and discontinuities in soil properties. Even relatively infrequent fluvial disturbance may influence the distribution of vegetation.

The distribution of vegetation along washes is affected by additional factors. The distribution of wash vegetation has been found to be strongly influenced by watershed size and the extent of runoff supplied over that supplied by ambient precipitation. Moisture availability and scour, both affected by watershed size, can exert a controlling influence on vegetation.

The root structure of commonly occurring desert trees and shrubs varies with species and their association with the environment in which they occur. Palo verde, cat-claw acacia, and ironwood, all common species of desert wash environments, have deep, extensive root systems that enable them to survive long periods of drought. In contrast, saguaro cactus, generally considered an upland species, has a root system that reaches little more than three feet in depth, but extends laterally near the surface for as much as 100 feet.

Plant species vary in their tolerance to moisture stress. Many shallow rooted species, such as creosote, can tolerate less soil moisture and, due to their shallow root systems, are able to respond quickly to small amounts of precipitation. Wash species, in comparison, generally depend on water at greater soil depths produced by heavy rain events that occur less frequently, and are less responsive to small amounts of precipitation occurring at more frequent intervals.

Temperature is also a limiting factor in the distribution of desert species. Low temperatures appear to limit the northern, eastern and/or upper elevation distribution of many species. Local distribution is also affected by temperature.

Biological adaptations for regeneration have also been studied for many desert species. One common adaptation in species associated with alluvial systems is the requirement of scarification (cutting or softening) of the seed coat to facilitate germination. For most leguminous (pea family) species, including blue palo verde, foothill palo verde, cat-claw acacia, ironwood and mesquite, scarification may increase the number of seed that germinate. Scarification can result from flood events that wash the seeds among suspended sand particles, by digestive juices in the stomachs of animals, through attack by insects or by bacterial action. Blue palo verde and mesquite, species generally associated with washes, have been found to require scarification while foothill palo verde and ironwood do not. Scouring through wash flows as a mode of scarification may be ecologically more reliable for establishment of wash species, since the seed is generally deposited with wash sediments or in a topographic depression and, consequently, may have a better chance of receiving adequate moisture for establishment.

Germination of many desert species is dependent on amount of rainfall. Bowers (1994) found that a minimum rainfall of 17 mm (0.68") triggers germination of foothill palo verde. Temperature also affects the germination of desert wash species. Poole (1958) found that ironwood, mesquite and blue palo verde showed highest germination percentages within optimal temperature ranges, and that low temperature generally inhibited germination. Bowers (1994) reported similar findings for foothill palo verde. Very high temperatures were also found to decrease germination in these species.

Even after germination, many desert species do not readily become established in the harsh desert environment. Soil moisture and depth are a primary influence on seedling survival. Stromberg (1993) noted less survival for mesquite in xeric environments where available water is more than two meters deep. Saguaro cactus seedlings are extremely vulnerable and sensitive to loss by drought, heat, and frost. In a study by Steenbergh and Lowe (1969), 78.8 percent of the saguaro seedlings

died after the first year. Nabhan and Carr (1994) found that most ironwood seedlings that germinate following a rain may die after germinating due to lack of continuous moisture.

Based on the preceding discussions, it is clear that alluvial fans are dynamic environments subject to major perturbations, including scouring of vegetation and redirection of flows, during large flood events. Smaller, more frequent flood events are unlikely to cause significant physical changes to the fan, but are nonetheless important in vegetation ecology. While fluvial processes are an important factor in the regeneration of some wash species, a number of other factors also affect the frequency, timing and success of regeneration. Large flood events may be less important than smaller, more frequent events in sustaining biological communities.

4.9.2 Wildlife

Wildlife in the study area is typical of the Sonoran Desert in the Scottsdale vicinity. In general, wildlife density and diversity are greater along xeroriparian corridors on the Reata Wash floodplain, and in areas closer to the mountains, where vegetation densities and structural complexity of the habitat are greater. Seasonal and diurnal movements of wide ranging species such as coyote, javelina, and mule deer are expected to occur throughout the undisturbed portions of the project area. Long reaches of vegetated wash provide cover and facilitate wildlife movements.

The Sonoran desert scrub wildlife habitat would not appear to offer suitable habitat for amphibians. However, several species of monsoon-active amphibians live in and around the Phoenix metropolitan area (AGFD 1998). With the July and August monsoon rains, these toads emerge and begin breeding activities, using the newly formed rain pools. During the remainder of the year they stay below ground, often using small mammal burrow and woodrat nest mounds. The habitat within and near the study area is known to support the Colorado River (Sonoran Desert) toad (*Bufo alvarius*), Woodhouse's toad (*Bufo woodhousei*), southwestern toad (*Bufo microscaphus*), and red-spotted toad (*Bufo punctatus*). In addition, Couch spadefoot (*Scaphiopus couchii*), western spadefoot (*Scaphiopus hammondii*), and great plains toad (*Bufo cognatus*) likely occur within the study area.

Central Arizona supports a large diversity of native reptiles. The common and characteristic reptiles of Sonoran desert scrub habitat in or near the study area include western banded gecko (*Coleonyx variegatus*), zebra-tailed lizard (*Callisaurus draconoides*), desert spiny lizard (*Sceloporus magister*), side-blotched lizard (*Uta stansburiana*), tree lizard (*Urosaurus ornatus*), western whiptail (*Cnemidophorus tigris*), coachwhip (*Masticophus flagellum*), western diamondback rattlesnake (*Crotalus atrox*), Mojave rattlesnake (*Crotalus scutulatus*), and others. These species could occur throughout the study area, but may be more concentrated along the desert washes due to an increased diversity of vegetation and consequently an increased diversity of prey.

Common and characteristic birds of the Sonoran desert scrub and likely present on the site include red-tailed hawk (*Buteo jamaicensis*), American kestrel (*Falco sparverius*), Gambel's quail (*Callipepla gambelii*), mourning dove (*Zenaida macroura*), greater roadrunner (*Geococcyx californianus*), great horned owl (*Bubo virginianus*), lesser nighthawk (*Chordeiles acutipennis*), Anna's hummingbird (*Calypte anna*), Gila woodpecker (*Melanerpes uropygialis*), ash-throated flycatcher (*Myiarchus cinerascens*), common raven (*Corvus corax*), verdin (*Auriparus flaviceps*), cactus wren (*Campylorhynchus brunneicapillus*), black-tailed gnatcatcher (*Polioptila melanura*), curve-billed thrasher (*Toxostoma curvirostre*), phainopepla (*Phainopepla nitens*), northern cardinal (*Cardinalis cardinalis*), Abert's towhee (*Pipilo aberti*), black-throated sparrow (*Spizella bilineata*), great-tailed grackle (*Quiscalus mexicanus*), house finch (*Carpodacus mexicanus*), and others. The density and diversity of birds tends to be higher in vegetation communities that have a greater amount of structural diversity. The xeroriparian habitat along the desert washes, with its larger blue palo verde trees, ironwood trees, and diverse shrub story, typically supports the greatest bird diversity within the study area.

Common and characteristic mammals of the Sonoran desert scrub habitat include desert cottontail (*Sylivagus audubonii*), black-tailed jackrabbit (*Lepus californicus*), round-tailed ground squirrel (*Spermophilus tereticaudus*), cactus mouse (*Peromyscus eremicus*), deer mouse (*Peromyscus maniculatus*), pocket mice (*Perognathus* spp.), Merriam's kangaroo rat (*Dipodomys merriami*), white-throated woodrat (*Neotoma albigula*), coyote (*Canis latrans*), javelina (*Tayassu tajacu*), mule deer (*Odocoileus hemionus*), and others. The larger mammals present in the area likely use the

undisturbed desert washes as wildlife movement corridors, due to the greater vegetation density and the physical linear characteristics of the washes. Several species of bats likely forage over the Sonoran desert scrub wildlife habitat.

The wash habitat is typically the highest quality wildlife habitat present on the study area. Relative to this type of wash habitat in the region, the habitat in the study area is poor to moderate quality due to the level of previous disturbance from development, off-road vehicle use, and past grazing.

4.9.3 Special Status Species

Special status species include those that are formally listed, or otherwise recognized, at the federal, State and/or local level. A list of special status species potentially occurring in the project area was requested from, and provided by, the U.S. Fish and Wildlife Service (City of Scottsdale 1997). This list includes known federally listed endangered and threatened, proposed, and candidate species and includes all those potentially occurring anywhere in Maricopa County.

Plants

A complete list of special status plant species potentially occurring in the project area is included in Appendix C.

Federally listed plant species known from the general project vicinity include Arizona agave (*Agave arizonica*), Arizona hedgehog cactus (*Echinocereus triglochidiatus arizonicus*), and Arizona cliffrose (*Purshia subintegra*). Suitable habitat is not present for any of the three species in the project area; consequently, no focused surveys were conducted.

The Arizona Native Plant Law (ANPL) protects the most sought after plants in Arizona. The law states that it is unlawful to destroy, dig up or mutilate any protected plant and requires that any person that takes, transports or possess any protected native plant taken from its original growing site obtain a permit from the State of Arizona Department of Agriculture.

Native plant species that occur on the project site, and are protected under the Arizona Native Plant Law, include saguaro and hedgehog cactus (highly safeguarded), barrel cactus (salvage restricted), and desert ironwood and blue and foothill palo verde (harvest restricted). Highly safeguarded plants are species for which prospects for survival are in jeopardy or that are in danger of extinction. Salvage restricted plants are species that are subject to damage by theft or vandalism. Harvest restricted plants are species that have been subject to excessive harvesting or over cutting because of their intrinsic value.

The City of Scottsdale's Native Plant Ordinance (NPO) requires the protection of all salvageable cacti which are six feet or more in height and indigenous trees which are four inches or more in caliper. The City enforces the requirements through its native plant permitting process. Many plants that occur on the project area are subject to the requirements of the NPO.

Wildlife

None of the 11 Federally-listed threatened or endangered wildlife species in Maricopa County is known or expected to regularly occur in the study area, based on a habitat evaluation and results of focused surveys. These 11 species, identified by the USFWS in 1997, are listed in Appendix C. Sensitive species which may potentially be found on the site or use the site on an occasional basis are described in the paragraphs below.

Bald Eagle *(Haliaeetus leucocephalus*). The bald eagle is listed as threatened by the federal government and as wildlife species of special concern by the state of Arizona. Bald eagles occupy Arizona primarily as winter residents and migrants, with 200 to 250 individual eagles typically wintering in the state. A resident population of about 40 pairs nests primarily along the Salt Rive and Verde River, but the nesting population appears to be increasing as nests have also been confirmed along the Gila, Bill Williams, Agua Fria and San Pedro rivers. Because there is no permanent water within the study area, nor rivers with riparian habitat, the bald eagle does not regularly occur. An individual bald eagle may fly over the study area from time to time, but nesting is not expected.

American Peregrine Falcon (*Falco peregrinus anatum*). The peregrine falcon is listed as endangered by the federal government. There are over 200 known peregrine falcon breeding locations in Arizona. However, in the lower elevation deserts of the southwestern quarter of the state, only one is known. While these breeding pairs appear to be year-round residents, peregrine falcons occur throughout Arizona as migrants, transients and wintering birds. Due to a lack of cliffs and steep slopes (suitable nesting habitat) within the study area, the American peregrine falcon is not expected to regularly occur. However, individuals maybe present from time to time in the study area during migration.

Southwestern Willow Flycatcher (*Empidonax traillii extimus*). The southwest willow flycatcher is listed as endangered by the federal government and as wildlife species of special concern by the state of Arizona. The southwestern willow flycatcher occurs in dense riparian habitats along streams, rivers and other wetlands. In Arizona, this bird is known from the upper Gila River, Little Colorado River, the middle Salt River, the lower San Pedro River, Colorado River, San Francisco River, Hassayampa River, the upper Verde River, Big Sandy River, Santa Maria River, Tonto Creek, and the Bill Williams delta. Because the southwestern willow flycatcher is a riparian obligate bird, and there is no riparian habitat within the study area, this species does not occur.

Cactus Ferruginous Pygmy-owl (*Glaucidium brasilianum cactorum*). The cactus ferruginous pygmy-owl is listed as threatened by the federal government and as wildlife species of special concern by the state of Arizona. In central and southern Arizona, the cactus ferruginous pygmy-owl historically occurred in riverbottom woodlands and Sonoran desert scrub habitat. Currently there are fewer than 50 cactus ferruginous pygmy-owls known in Arizona, with the majority occurring in Pima County and southern Pinal County. Prior to 1910, collections indicate that these birds occurred along the New River, in the Cave Creek area, in Phoenix, along the Salt River, and at Agua Caliente in western Maricopa County. Around 1950, a cactus ferruginous pygmy-owl was collected along the Salt River near the confluence with the Verde River. There is a report of an owl identified by calls at this location in 1971, however, there are no additional records from Maricopa County since that time. Based on recent survey results in and around Tucson, it appears that upland areas

characterized by braided wash systems and structurally diverse vegetation are the preferred habitat for cactus ferruginous pygmy-owls.

Since the cactus ferruginous pygmy-owl was listed in March 1997, there have been several seasonal, intensive protocol surveys conducted in and near the study area to evaluate its presence. Within the study area, focused cactus ferruginous pygmy-owl surveys were conducted on 6 and 7 April 1998 along the proposed Reata Pass Wash Channel corridor, located east of 96th Street, west of 104th Street and the McDowell Mountains, south of Pinnacle Peak Road and north of the Central Arizona Project canal (SWCA Inc., Environmental Consultants, 1998a). Additional surveys were conducted on 21, 22, and 27 May 1998 for the proposed Pima Road/Core Area Flood Control Project, on 127 acres at two sites located south of Los Gatos Drive, east of Pima Road and north of Deer Valley Road; and east of Scottsdale Road and north of Union Hills Drive and Princess Boulevard (SWCA Inc., Environmental Consultants, 1998b). A cactus ferruginous pygmy-owl survey was conducted 13 November 1998 for the proposed Pima Road Three Basins-Phase II Project area located along the eastern shoulder of Pima Road, from Los Gatos Drive north to above Jomax Road, as well as a 30-acre basin site at the northeast corner of Pima Road and Happy Valley Road (SWCA Inc., Environmental Consultants, 1998c).

No cactus ferruginous pygmy-owls were recorded during the focused protocol surveys conducted during 1998 within the study area. None has been recorded in other focused protocol surveys conducted to date in Maricopa County. The density of saguaro, and the diversity of other dominant plants in the study area appears low compared to areas where the cactus ferruginous pygmy-owl has been recently recorded in southern Pinal County and Pima County (personal communication, Harris Environmental Group, Inc. 1999). The study area is located in the northern portion of the owl's range, which likely has contracted to the south. Based on the results of recent surveys, cactus ferruginous pygmy-owl do not likely occur within the study area. The study area is not located within proposed Critical Habitat for the cactus ferruginous pygmy-owl.

Mexican Spotted Owl *(Strix occidentalis lucida)*. The Mexican spotted owl is listed as threatened by the federal government and as wildlife species of special concern by the state of Arizona. Habitat

for the Mexican spotted owl includes mature mixed conifer and pine-oak montane forests and woodlands, shady wooded canyons and steep canyons. Due to the lack of appropriate habitat, the Mexican spotted owl does not occur in the study area.

Lesser Long-nosed Bat (*Leptonycteris curasoae yerbabuenae*). The lesser long-nosed bat is listed as endangered by the federal government and as wildlife species of special concern by the state of Arizona. The lesser long-nosed bat is a summer resident (April to September) of Arizona, feeding primarily on nectar and pollen of saguaro, agave and organ pipe. This species has been recorded from immediately north of the Salt River near the confluence with the Gila River in Maricopa County. A tentative identification exists for the Scottsdale area from 1992. No major roost sites have been recorded from near the Phoenix metropolitan area. This species could forage over the study area, but is not expected to roost due to the lack of appropriate roosting sites such as abandoned mines, adits, and caves. The study area is considered marginal foraging habitat due to the relatively low densities of saguaros. However, lesser long-nosed bats could forage on saguaro flowers, particularly in the northern portion of the study area.

In addition to information provided by the USFWS on federally threatened and endangered species, the AGFD's Heritage Data Management System was accessed in 1995 and again in 1998 for current records of special status species within and adjacent to the study area. In addition, the system was accessed in May 1999 for the area adjacent to and west of the study area, bounded by the CAP on the south, Jomax Road on the north, and Cave Creek Road on the west. Special status wildlife species include wildlife of special concern in Arizona, and species classified as sensitive by the U.S. Forest Service. Wildlife of special concern in Arizona includes species whose occurrence in Arizona is or may be in jeopardy, and species with known or perceived threats or population declines. The U.S. Department of Agriculture Regional Forester has classified certain species as 'sensitive' when occurring on lands managed by the U.S. Forest Service. In addition, the USFWS has designated certain wildlife species as federal species of concern. Federal species of concern represent the pool from which future candidates for listing as threatened or endangered may be drawn. None of the categories of special status species is protected under the federal Endangered Species Act. However,

resource agencies encourage the consideration of these sensitive species during project planning efforts.

Special status wildlife species with the greatest potential for occurring in the study area are presented in Appendix C. Harris's hawk (*Parabuteo unicinctus*) and cave myotis (*Myotis velifer*) are the only special status wildlife species that have been recorded during recent biological field surveys in or adjacent to the study area. Harris' hawk were recorded during vegetation sampling surveys conducted during 1998 and 1999, typically associated with saguaro. Surveys of the DC Ranch property on Sections 19 and 20 of Township 4N Range 5E conducted in February 1995 identified a foraging cave myotis (Southwestern Field Biologists 1995).

While the Squaw Peak talus snail (*Sonorella allynsmithi*) is not known from the area, a new subspecies was discovered in McDowell Mountains in 1992 (AGFD 1996). The easternmost portion of the study area may contain appropriate habitat for this potentially sensitive snail. The study area contains suitable habitat for the desert tortoise (*Gopherus agassizii*), common chuckwalla (*Sauromalus obesus*), and Gila monster (*Heloderma suspectum*). Sonoran desert tortoise typically occur on the rocky slopes and bajadas of desert scrub-covered foothills and mountains, chuckwalla are associated with rocky areas, while Gila monster typically occur in shrubby and grassy desert scrub on the lower slopes of mountains and plains. Western burrowing owls (*Athene cunicularia hypugaea*) may also be present. The study area likely is used as foraging habitat for the various sensitive bat species. However, these bats are not expected to roost due to lack of appropriate roost sites.

4.9.4 Waters of the U.S.

The waters of the United States, defined by the ordinary high water mark of a stream or watercourse, fall under the jurisdiction of the U.S. Army Corps of Engineers. The Corps regulates discharges into the waters of the U.S. and adjacent wetlands. The ordinary high water mark is identified according to indicators such as shelving, presence of debris, sedimentation, and vegetation. The width, based on guidance from the Corps of Engineers in this case, is three to five feet or more, but

not greater than the width of the active channel. There are no jurisdictional wetlands on the Reata Pass/Beardsley Wash alluvial fan or Pima Floodplain.

There is habitat associated with the waters of the U.S., which can be used as an indicator, but in this case many of the same plant species found along the channel banks are also found in the interwash areas outside of the waters of the U.S. The habitat and waters of the U.S. are separate, but interrelated components of the alluvial fan system.

Delineation and Characterization

The Waters of the U.S. were determined by the Corps of Engineers for the entire study area. SLA staff assisted in the field work and mapping according to guidance and field oversight provided by the Corps of Engineers. Certain criteria, at the direction of the USACE, were used to determine the Waters of the U.S. These characteristics include:

- minimum normal high water bank to bank width of 3 feet.
- well defined channel.
- evidence of inundation in recent history.
- shelving.
- presence of debris.
- sedimentation.
- vegetation.

Preliminary delineations and mapping were done on 1" = 100' scale aerial photographs by SLA staff.

The area mapped consists of the entire Reata Pass/Beardsley Wash alluvial fan west of the East Wash, and the entire Pima Floodplain (Figure 2.3). The location of the resulting delineated Waters of the U.S. are shown for illustrative purposes on Attachment 2. 100-scale maps showing the actual delineation, with dimensions for regulatory use, are on file with the Corps of Engineers. Attachment 2 differentiates between waters of the U.S. that are directly connected to the Reata Pass/Beardsley Wash apexes, and those that are not. Unconnected waters of the U.S. receive no inflow from the alluvial fan apex. This is important because any project that would cut off or disrupt the flow from

the apex to the alluvial fan would possibly cause an impact to connected washes, but not to unconnected washes.

Table 4.11 summarizes the resulting acreage of the Waters of the U.S. for the different study areas. The total acreage of Waters of the U.S. in the study area is approximately 160.7 acres out of a total 8,550 acres. Approximately 1.9% of the study area is jurisdictional waters. Waters of the U.S. connected to the alluvial fan apex comprise approximately 1.1% of the total land area (63.4 acres). Non-connected waters comprise 61% of the total waters of the U.S. within the study area, and 45% within the Reata Pass/Beardsley Wash floodplain.

Nationwide Permits or Letters of Permission from the U.S. Army Corps of Engineers already cover 26.7 acres (16.6% of the total Waters of the U.S.) within the study area. Table 5.1 provides further information on the areas developed and the type of permit issued. An additional 5.1 acres, 3.1% of the total Waters of the U.S., are in the Ironwood Village area, an area that has been completely built out.

Ordinary High Water Discharge

To determine the amount of flow that feeds the Waters of the U.S. west of the main eastern channel along the McDowell Mountains and downstream of the Reata Pass Wash Apex, the ordinary high water for this section of the alluvial fan was determined. The discharge was determined using the HEC-2 computer program. A cross section at the apex was taken and the flow depth was determined for a number of different discharges until the flow exceeded the top of the defined channel banks. The flow at this point of overflow was determined to be approximately 330 cfs. This flow corresponds to a 2 year flood event at the apex. With this return period determined it was assumed that this return period was applicable for the all washes on the alluvial fan. Using the 2 year event for the North Beardsley Wash results in a 100 cfs flow.

Table 4.11. Waters of United States Summary

Area	Waters of the U.S.			
	Total Area (Acres)	Area Connected to Reata Pass Wash Apex (Acres)	Area Not Connected to Reata Pass Wash Apex (Acres)	Percent Area Not Connected to Reata Pass Wash Apex
Reata Pass/Beardsley Wash Regulatory Floodplain	115.4	63.4	52.1	45
Pima Floodplain	62.1	4.1	57.9	93
Overlap Area	16.8	4.1	12.7	76
Total	160.7	63.4	97.3	61

Waters of the U.S. Compared to Total Land Area					
Area	Total Land Area (Acres)	Total Waters of the U.S. (Acres)	Waters of the U.S. as a Percentage of Total Land Area	Waters of the U.S. Connected to Reata Pass/ Beardsley Wash Apex (Acres)	Connected Waters of the U.S. as a Percentage of Total Land Area
Reata Pass/Beardsley Wash Regulatory Floodplain Study Area	4,800	115.4	2.4	63.4	1.3
Pima Floodplain	5,750	62.1	1.1	4.1	0.1
Overlap Area	2,000	16.8	0.8	4.1	0.2
Total	8,550	160.7	1.9	63.4	0.7

Alluvial Fan Hydrology

Appendix H shows the location of waters of the U.S. connected and not connected to the alluvial fan apex. Washes that are connected to the alluvial fan have a continual downward slope from the apex to the base of the alluvial fan.

Washes that are not connected are hydraulically separated from the apex by high ground. Low flows originating from the apex follow the connected washes and are prevented by banks and this high ground from entering the unconnected waters of the U.S., which do not begin until 2,400 feet

downstream of the apex. Although large floods will overflow the high ground, low flows on the unconnected washes are generated entirely from local runoff and not from the fan apex.

Normal-depth hydraulic capacity analysis of the existing channels shows that the upper Reata Pass channels associated with waters of the U.S. connected to the apex have more than enough capacity for 330 cfs, or the entire waters of the U.S. discharge (a 2-year flood). There is anecdotal evidence from the 1996 flood that a 15-year discharge was confined to the connected channels without overflowing into the unconnected channels. These unconnected washes therefore receive flow from the apex once every two to 15 years or more, so that they are watered almost entirely by local runoff. Qualitative comparison of the vegetation in unconnected washes with washes of similar watershed size adjacent to and outside the alluvial fan indicates that the vegetation in both is similar, indicating that local runoff is sufficient to maintain the vegetation on the unconnected washes. This is consistent with their separation from the connected washes in the waters of the U.S. delineation. In this context, the watershed for the unconnected washes is considered to be that area that collects rainfall and drains to them from downstream of the fan apex. Figure 4.17 illustrates this watershed area for one of the unconnected washes.

The upper Reata Pass alluvial fan receives inflow from tributary watersheds separate from the apex. Within 5.000 feet downstream of the apex there are eight watersheds entering as shown in Figure 4.18. These watersheds, counted separately, deliver a total of 364 cfs to the upper alluvial fan on a two-year flood.

4.10 Cultural Resources

The following information is obtained from specific surveys for the proposed projects as well as for other developments in the area.

In 1985 a cultural survey was performed by Janus Associates, Inc., on State Land property (to be developed as Core South). The results of that survey are included in a report entitled "Forest City Scottsdale Company Cultural Resource Survey", dated February 18, 1996. None of the

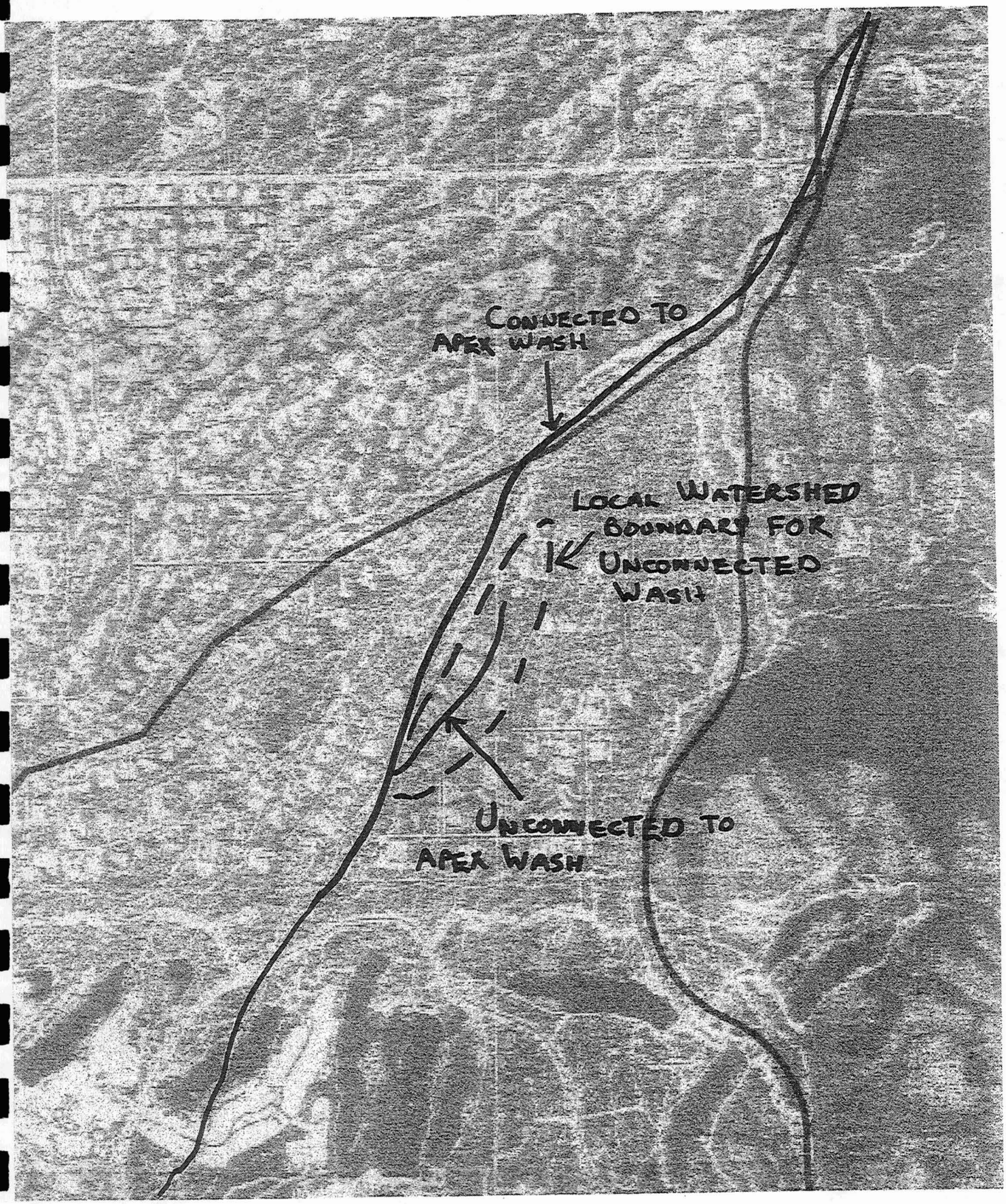


Figure 4.17. Watershed Area for Unconnected Wash.

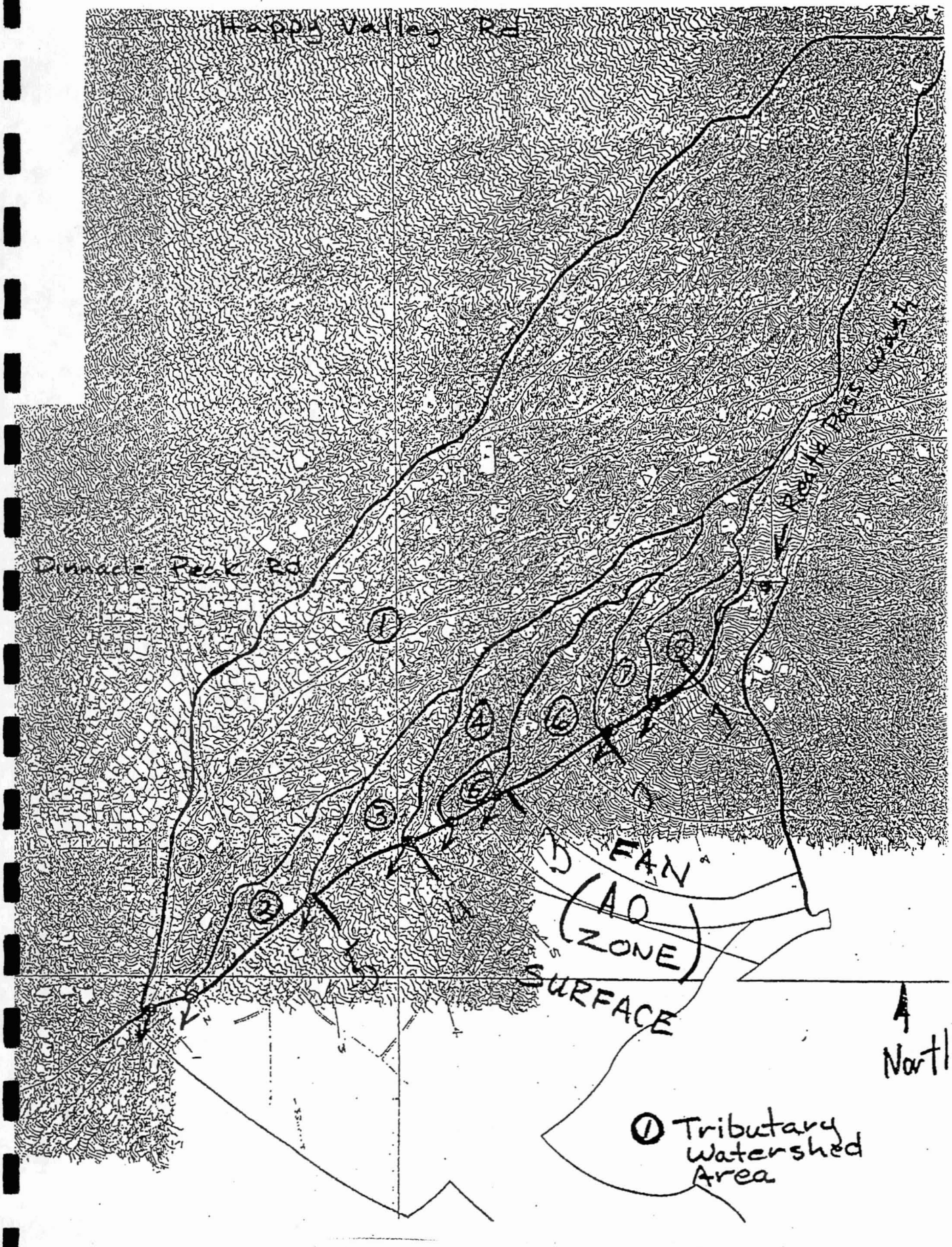


Figure 4.18. Tributary Watersheds to Upper Alluvial Fan.

finds documented as part of this survey were eligible for the National Register of Historic Places (NRHP). Previous survey results were also researched. No eligible sites were found in the study area. However, four nearby sites (AZ U:5:13 and AZ U:5:67 - AZ U:5:69) had been identified as prehistoric sites eligible for the NRHP. These sites are not within the proposed project corridors. In May 1989 Soil Systems, Inc. (SSI) conducted a cultural resources survey on State Land (to be developed as Core North). The results of that survey are included in a report entitled "A Cultural Resources Survey for the Core North Project, North Scottsdale, Maricopa County, Arizona", dated June 1989. No sites were identified and the isolated finds were not eligible for the NRHP. The report includes a map showing the approximate location of the finds.

A report entitled "North Scottsdale Reconnaissance Survey, Scottsdale, Arizona", prepared by Regional Environmental Consultants, dated September 21, 1987, details the results of a survey and planning project funded by the U.S. Department of the Interior, National Park Service, and the City of Scottsdale. The project area included 93 square miles from 56th Street (to the west) to Jenny Lynn Road (to the north) to 136th Street (to the the east) and Deer Valley Road (to the south). The purpose of this project was to document previous archaeological work and historical events related to the project area, conduct surveys to identify cultural resources and evaluate their eligibility for inclusion in the NRHP, and provide the City of Scottsdale with recommendations concerning the future management of cultural resources in North Scottsdale. A total of 15 archaeological sites were identified. Maps within the report show the location of these sites.

In 1989 an archaeological survey was conducted by Archaeological Consulting Services, Ltd., for State Land property located near Bell Road and 104th Street. The records were also searched for other archaeological surveys. The results of the survey are included in a report entitled "An Archaeological Assessment of an 800 Acre State Land Parcel in North Scottsdale for UDC Homes Construction", dated May 22, 1989. Two previously identified sites (AZ U:5:14 and AZ U:5:69) were documented; neither was eligible for the State or National RHP. As part of this survey two new sites were identified (AZ U:5:30 and AZ U:5:31). Neither is eligible for the NRHP. A total of 24 isolated occurrences were identified. The report includes a map showing the approximate location of the sites and occurrences.

A cultural resource inventory investigation performed as part of the May 1996 Reconnaissance Study for the North Scottsdale Area confirmed prehistoric occupation of the area by the Hohokam, a dynamic farming society. Although cultural sites do exist in the region, none are located within any of the corridors (see Figure 3.1) defined by this study as potential project locations.

An archaeological investigation was performed by SSI between September - October 1994 of a portion of the DC Ranch property. The results of this survey are included in the report entitled "A Cultural Resources Survey of Two Sections of the DC Ranch Property, North Scottsdale, Maricopa County, Arizona", dated December 1994. From this survey 5 sites (AZ U 5:149 - AZ U 5:153), and 16 isolated occurrences were documented. Although 3 of the sites may have habitation features, prehistoric use of the surveyed area appears to have been limited and sporadic. It was recommended that the small boulders at site AZ U:5:149 showing rock art be removed or protected prior to any construction. In June 1995 further investigation of four sites (AZ U:5:149 - AZ U:5:152) recorded during the previous survey was performed. The results of that survey are included in the report entitled "Archaeological Test Excavations at AZ U:5:149, AZ U:5:150, AZ U:5:151, and AZ U:5:152 on the DC Ranch Property, North Scottsdale, Maricopa County, Arizona. The conclusion from the data gathered was that the sites do not have sufficient research potential to warrant nomination to the NRHP. The reports include maps showing the approximate location of the sites.

Between February - March 1995 an additional portion of the DC Ranch Property was surveyed. The results of that survey are included in the report entitled "A Cultural Resources Survey of Section 29 and 31 of the DC Ranch Property, North Scottsdale, Maricopa County, Arizona", dated July 1995. A total of 9 sites (AZ U:5:155 - AZ U:5:163) and 18 isolated occurrences of artifacts were documented. Most of these cultural remains are from the Hohokam culture and most of the materials appear to be from the late Colonial and early Classic periods (A.D. 800-1300). At least two of the sites appear to represent complex, heavily occupied areas. Two other sites contain clear evidence of habitation features. Five sites contain rock art. This report concluded that the sites should be avoided during any construction. If this is not feasible the area should be tested and material be removed. The report includes a map showing the approximate location of the sites and occurrences.

These sites would be impacted by the construction of Alternative F (but not the proposed project). This impact is discussed in Section 9.6.14.

Another cultural resource survey and record search of the Reata Pass Channel area was conducted by SSI for Greiner, Inc in March 1996. The results of this survey are included in the report entitled "A Cultural Resources Survey and Records Search of the Desert Greenbelt Project, Reata Pass Channel, North Scottsdale, Maricopa County, Arizona", dated March 1996. The limits of this investigation were from Deer Valley Drive to Pinnacle Peak Road and along a reach south of Union Hills. The record search was conducted for the entire vicinity from Pinnacle Peak Road to the CAP. Eleven isolated occurrences of artifacts from prehistoric and historic cultures were documented. The area around each artifact was searched for any additional occurrences. No further archaeological investigation was recommended based on the findings of this survey. The record search showed that eight cultural resource surveys have been conducted within 1 mile of the project area. As a result of these surveys 21 archaeological sites were identified. These include prehistoric Hohokam sites and sites related to historic mining activities. One of these sites (site AZ U:5:151) is part of the area identified as the proposed project corridor. Additional test excavations were made at this location. Based on data from that excavation it was determined that the site would not qualify for nomination to the NRHP. None of the other sites identified are within the corridor for the proposed Reata Pass / Beardsley Wash project. The report includes a map showing the approximate location of the sites.

A cultural resources overview was performed by SSI in February 1998 for the project corridor of the proposed Pima Road Three Basins Channel. The results are included in the report entitled "A Cultural Resources Overview of the Phase I Desert Greenbelt Project, Pima Road Three Basins Channel, North Scottsdale, Maricopa County, Arizona. The results of the archival search indicated that the entire project area had been surveyed during previous investigations and no archaeological sites have been identified in the project area. Based on the research it appears that no further survey work is necessary.

In November 1995 the State Historic Preservation Office (SHPO) provided the City of Scottsdale with a letter indicating that the Pima Road Channel has been surveyed and no eligible properties were located within this area. This letter is included in Appendix F.

In May of 1996 the SHPO provided the City of Scottsdale with a letter indicating that the survey performed for the Reata Pass Channel was consistent with the Secretary of the Interior's standards and that it located no significant cultural resources. The letter also stated that it is likely that the project will have no effect on any properties listed or eligible for inclusion on the NRHP. This letter is included in Appendix F.

V. FUTURE-WITHOUT-PROJECT CONDITIONS

5.1 Definition of Future-Without-Project Conditions

The future-without-project condition assumes that the proposed regional flood-control project will not be constructed. Based on guidance from the U.S. Army Corps of Engineers Regulatory Branch, the future-without-project condition consists of continued development according to current land use, zoning plans, and FEMA regulations, while leaving the waters of the U.S. intact.

The actual development and the current zoning plan for the undeveloped areas in the Reata Pass / Beardsley Wash area allows for a total of 6,776 residential units on 4,052 acres of land and 757 acres of additional non-residential development (mostly resort, commercial and institutional). Actual development and the current zoning plan for the undeveloped areas (with a development intensity of 2.5 dwelling units per acre per current actual development intensities) in the Pima floodplain area allows for a total of 3,734 residential units on 3,802 acres of land, and 1,569 acres of non-residential development (mostly commercial, employment and institutional). The City's drainage ordinance and ESLO would protect major watercourses and require at least 15% open space in the Lower Desert, 20% open space in the Upper Desert, and 40% open space in Hillside Landforms on piecemeal development within designated environmentally-sensitive lands.

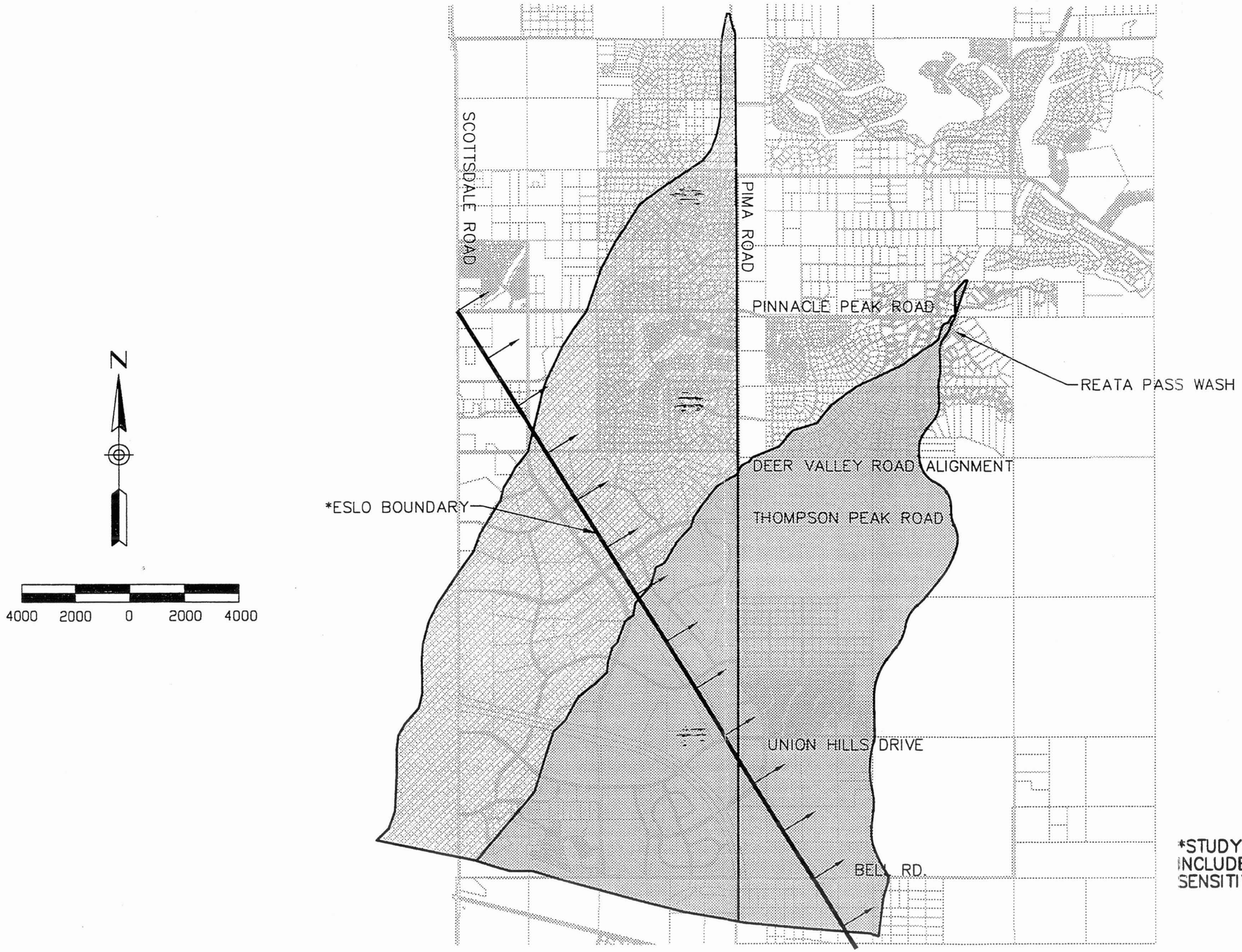
Regarding the waters of the U.S., it is suggested that the assumption of no impact for future-without-project conditions be interpreted based on the following conditions:

- Although the area is described as a regulatory alluvial fan floodplain subject to FEMA regulations, FEMA does not prohibit development. The only restrictions placed by FEMA are that new construction must have the lowest floor elevated at or above the regulatory flood depth described in Section 4.3 and provide adequate flowpaths. As long as new construction is so elevated and flowpaths are provided, development can occur according to the prescribed Land Use Plan without a regional flood-control project.

- Virtually none of the undeveloped property within the study area is owned by the City of Scottsdale. The property is owned by the Arizona State Land Trust or is under private ownership. As such, the City has no control over the property other than to ensure that the development occurs according to the prescribed Land Use Plan and according to City ordinances and standards. The City does have an Environmentally-Sensitive Lands Ordinance (ESLO) which covers most of the project area (Figure 5.1). One purpose of the ESLO is to "protect and conserve ... significant riparian habitats." Another purpose statement reads: "Maintain significant open spaces which provide view corridors and land use buffers, protect landmarks and prime wash habitats, and maintain the City's unique desert setting." The ESLO allows the City to restrict development on any watercourse for which the pre-development 100-year discharge is 250 cfs or more. Major washes with significant riparian resources will be preserved under the ESLO.

- The Corps has allowed impacts to the waters of the U.S. for previous private and public development within the study area. Table 5.1 provides a summary (not necessarily complete) of past permit actions within the alluvial fan. A copy of the relevant permit information is included in Appendix F. It is reasonable to assume that future development projects will be allowed similar impacts provided that they are consistent with 404(b)1 guidelines.

- Aside from current development projects and the proposed regional flood-control project, there are no known applications for 404 Permits on the study area currently under review by the Corps. Until such applications are received and acted upon by the Corps, it is not possible to determine which areas will be impacted and which will be preserved.



*STUDY AREA NORTHEAST OF BOUNDARY INCLUDED IN THE ENVIRONMENTALLY SENSITIVE LAND ORDINANCE (ESLO)

SOURCE: COS. 1991

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants
3150 Bristol Street, Suite 500
Costa Mesa, CA 92626
Tel. (714) 513-1280 Fax. (714) 513-1278

TRANSPORTATION DEPARTMENT

ESLO BOUNDARY

FIGURE 5.1

The Desert Greenbelt
SCOTTSDALE, ARIZONA

M:\PUBLIC\PROJECTS\AZCOS03\EXHIBITS\SHT-5-1 ESLO BOUNDARY .DWG

- The 1996 Corps of Engineers Planning Report assumed continued piecemeal development according to the current pattern without regard to potential impacts to the waters of the U.S. It was assumed in this report that the future-without-project condition consists of complete build-out of the alluvial fan.

Table 5.1 Summary of Past 404 Permit Actions on the Reata Pass/Beardsley Wash Alluvial Fan Study Area

Development Name	Permit Date	Impacted Waters of the US (acres)	Permit Mechanism
DC Ranch	June 7, 1995	39.78	Letter of Permission
Grayhawk	November 18, 1993	<10	Nationwide Permit
Grayhawk	October 17, 1994	<10	Nationwide Permit
Grayhawk	May 15, 1995	<10	Nationwide Permit
Thompson Peak Bridge and Reata Pass Wash Outlet (City of Scottsdale)	June 17, 1997	4.5	Letter of Permission
Pinnacle Peak Road Bridge (City of Scottsdale)	October 24, 1995	2.5	Nationwide Permit
Water Campus (City of Scottsdale)	November 18, 1996 (letter date)	Not subject to jurisdiction (No waters of the U.S. present)	No permit needed
Pima Acres Paving and Drainage Improvement District (City of Scottsdale)	October 8, 1997	Not given	Nationwide permit
Bell Road / Thompson Peak Channel	February 9, 1994	12.2	Letter of Permission

Given the above considerations, the future-without-project condition is further clarified as: Continued piecemeal development to ultimate build-out according to current Land Use Plan and FEMA regulations with waters of the U.S. left intact in terms of no impacts from the proposed project. The project in this case is the proposed regional flood-control system. Intact waters of the

U.S. as defined for this future-without-project condition would still be subject to piecemeal application, review and approval by the Corps of Engineers for impacts related to future development projects.

Certain assumptions can be made regarding the future-without-project drainage pattern and potential impacts to riparian areas. The City's ESLO ordinance requires protection of drainage channels with significant riparian resources. The City has a Floodplain and Drainage ordinance which states: "A development is prohibited if it would create hazards to life or property by increasing the potential for flooding either on the property to be developed or on adjacent property to any other property." Further: "A watercourse may not be altered . . . unless [a] professional engineer certifies that the alterations do not increase the flood levels, and will not increase flooding hazards within, upstream or downstream of the altered portion of the watercourse." This ordinance further states: "Rainfall runoff from storms of all return frequencies should enter and depart from property after its development in substantially the same manner as under pre-development conditions. Any proposals to modify drainage characteristics must be fully justified by engineering data which shall demonstrate to the floodplain administrator that hazards to life and property will not be increased by the proposed modifications."

The general effect of the ESLO and Floodplain and Drainage ordinances will be to preserve the existing drainage pattern. Washes with significant riparian resources will be preserved intact, meaning that there will be no impact to the waters of the U.S. aside from occasional roadway crossings. All washes must enter and leave each development in approximately the same manner as existed prior to development.

5.2 Land Use and Population

The population of the City of Scottsdale has been growing significantly in the past few decades. Table 5.2 summarizes the overall City population growth since 1980. The table shows that the population has been increasing rapidly, and that the rate of growth is increasing.

The growth rate on the Reata Pass/Beardsley Wash and Pima Floodplains is higher than for the City of Scottsdale as a whole. The 1996 Corps of Engineers Reconnaissance Study gave the number of residences on the Reata Pass/Beardsley Wash alluvial fan as 904 in 1995. Assuming 2.54 residents per residence, the population would have been approximately 2,296. By 1998 the number of residential units had increased to 2,121 with a population of 5,387. This is an average annual increase of 33%. An average of 405 residential units, and a population of 1,030 residents, have been added to the Reata Pass/Beardsley Wash alluvial fan each year since 1995.

Table 5.2 City of Scottsdale Population Summary

Year	Population of the City of Scottsdale	Average Annual Percent Increase
1980[1]	88,000	n/a
1990[1]	130,000	4.0%
1995[1]	159,000	4.1%
1998 (July)[2]	196,310	11.1%

1 Information from the U.S. Army Corps of Engineers Reconnaissance Report (North Scottsdale Drainage Area, Arizona Reconnaissance Study Flood Control And Related Purposes)

2 Information provided by the City of Scottsdale Community Planning Department

The rapid growth of development is illustrated in Figures 5.2 to 5.13. Figures 5.2 to 5.7 are aerial photographs showing the Reata Pass/Beardsley Wash and Pima Floodplain study areas in the years 1993 to 1998. Figures 5.8 to 5.13 show developed areas and areas currently being developed. Table 5.3 summarizes land-use developments present on a year-by-year basis. Since 1993 the study area has increased an average of 510 acres of development per year (280 acres per year on Reata Pass/Beardsley Wash alluvial fan and 230 acres per year on Pima floodplain).

Based on the existing development and the current zoning map, a maximum of 6,776 residential units (2,776 approved plus 4,000 zoned. See Table 4.2), with a potential population of 17,211, already exist or will be constructed on the Reata Pass/Beardsley Wash alluvial fan study area.

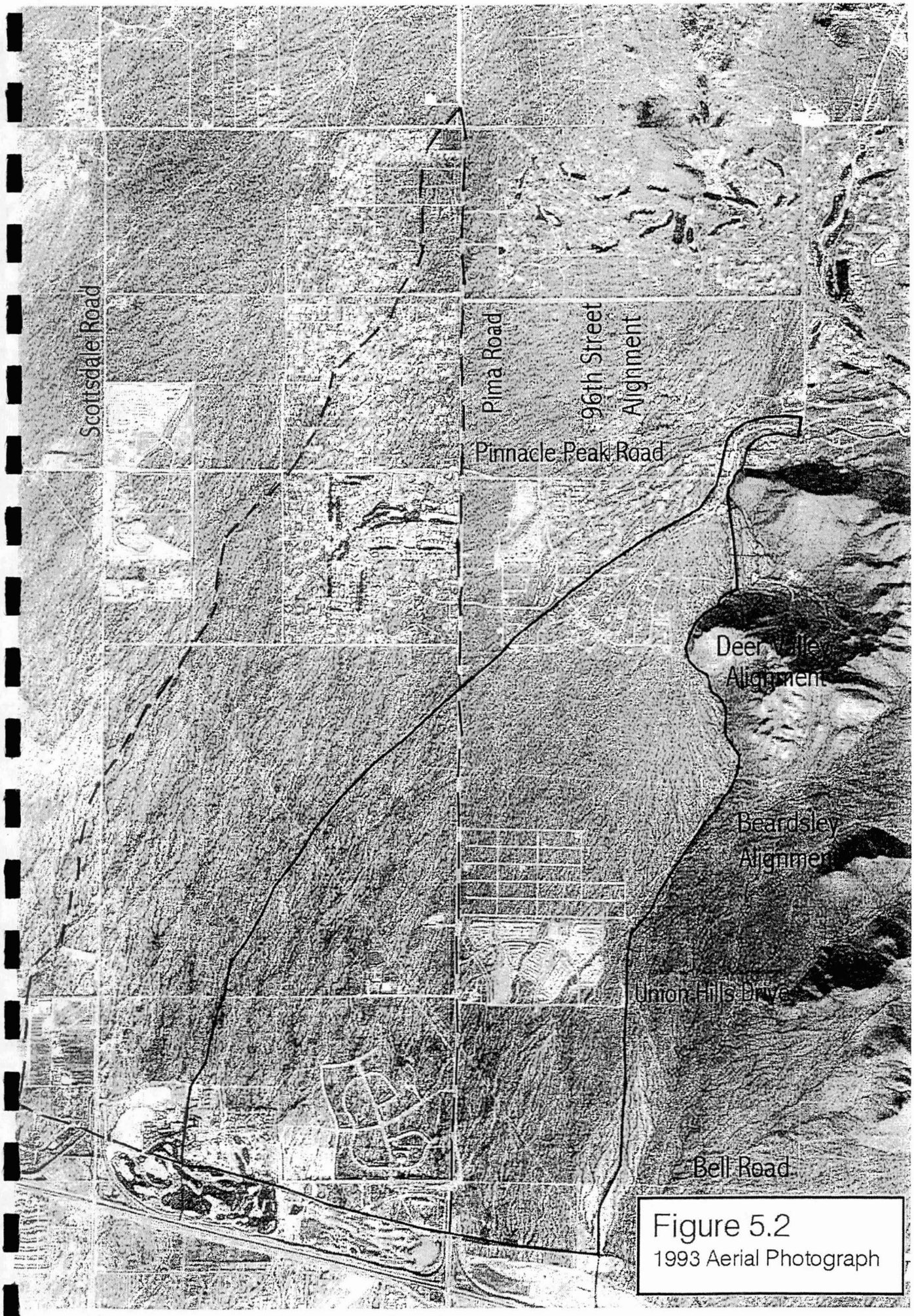


Figure 5.2
1993 Aerial Photograph

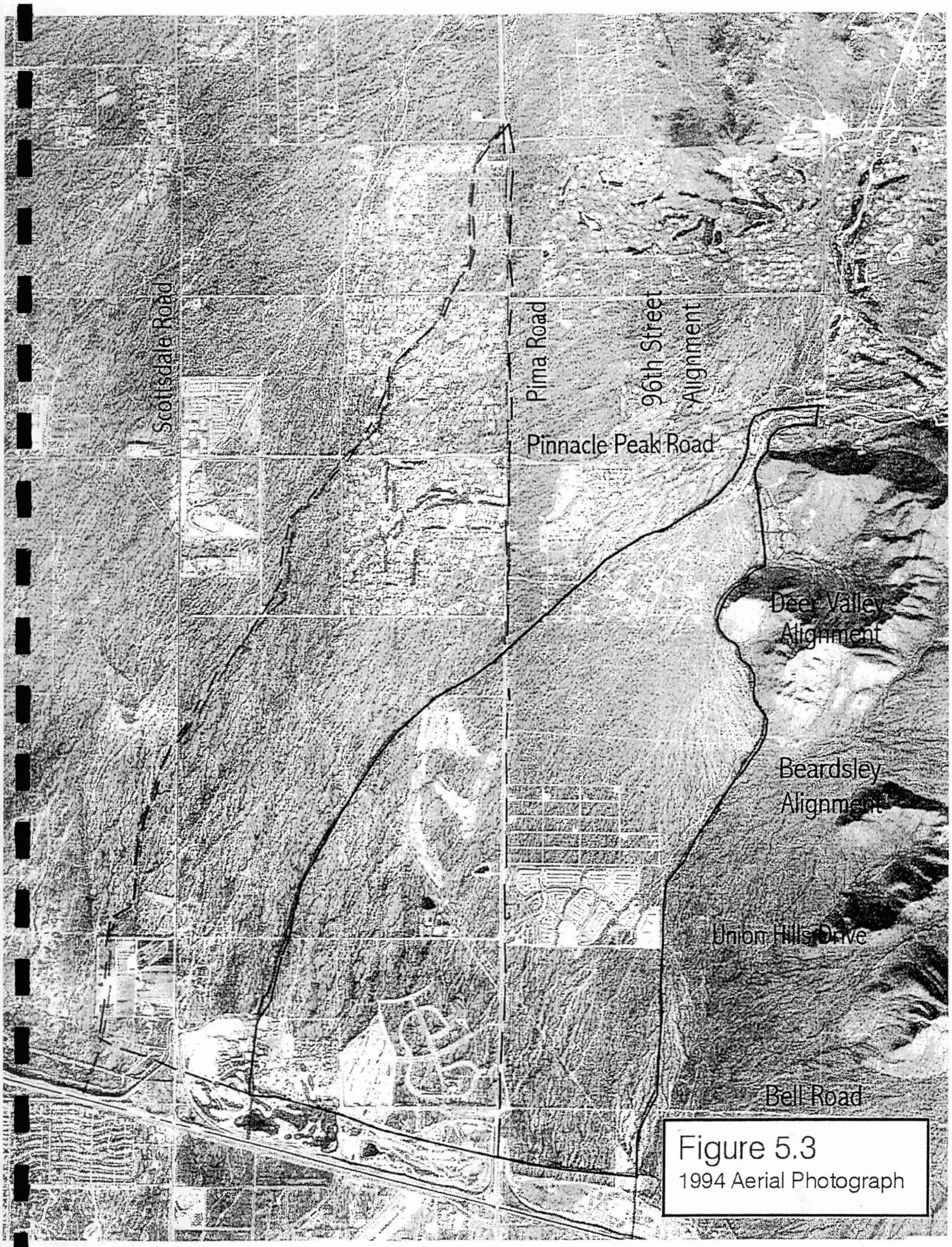


Figure 5.3
1994 Aerial Photograph

Figure 5.4
1995 Aerial Photograph

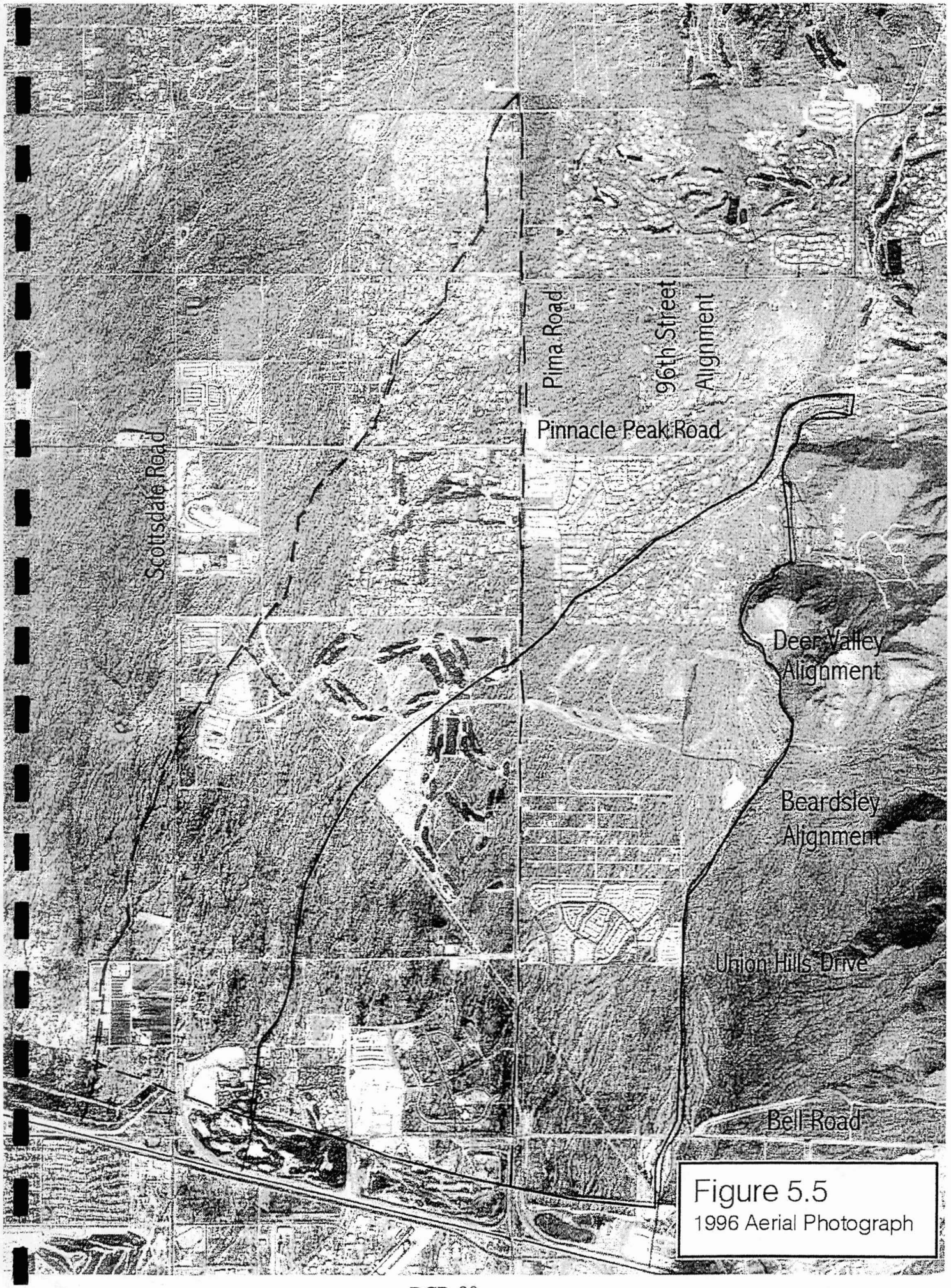
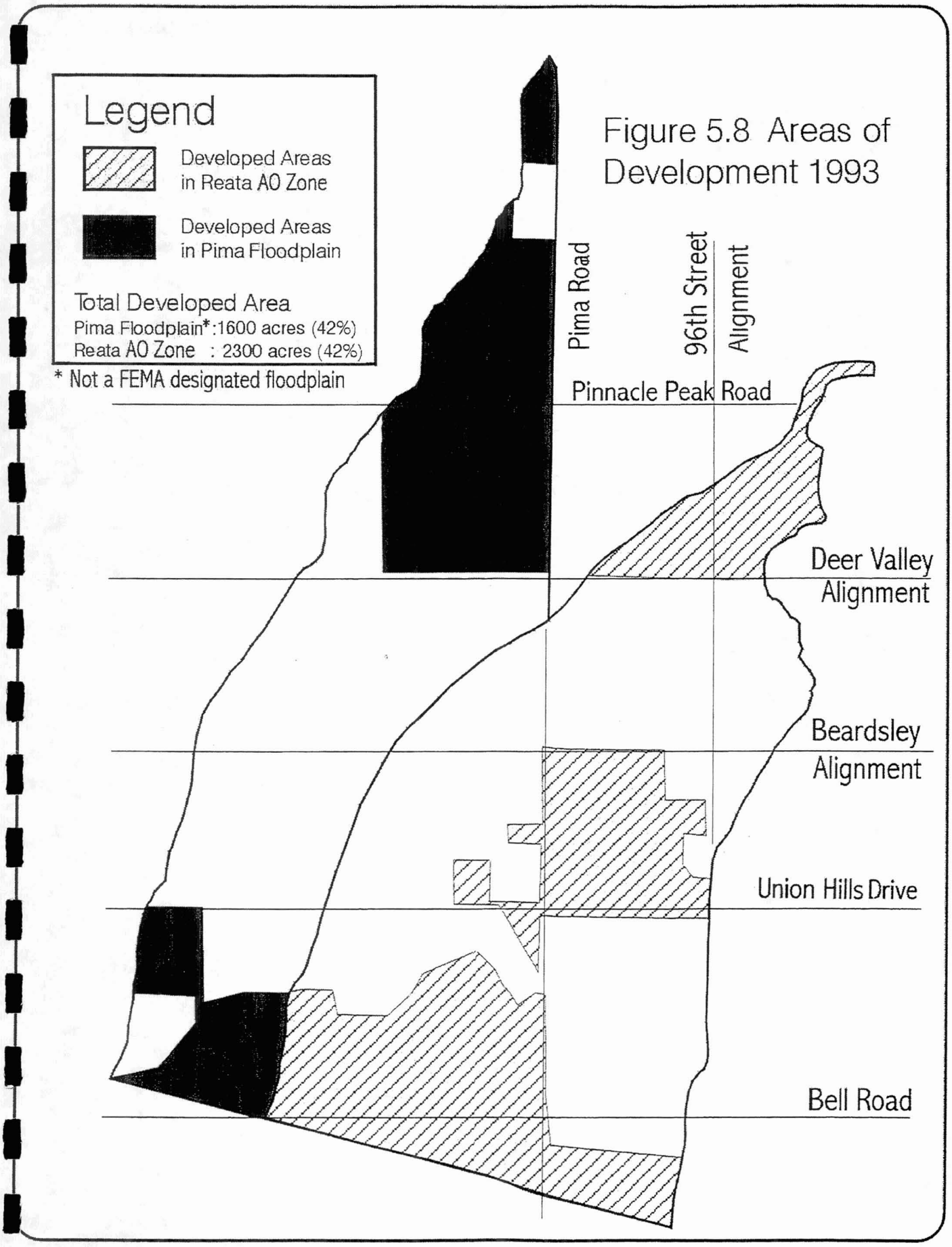
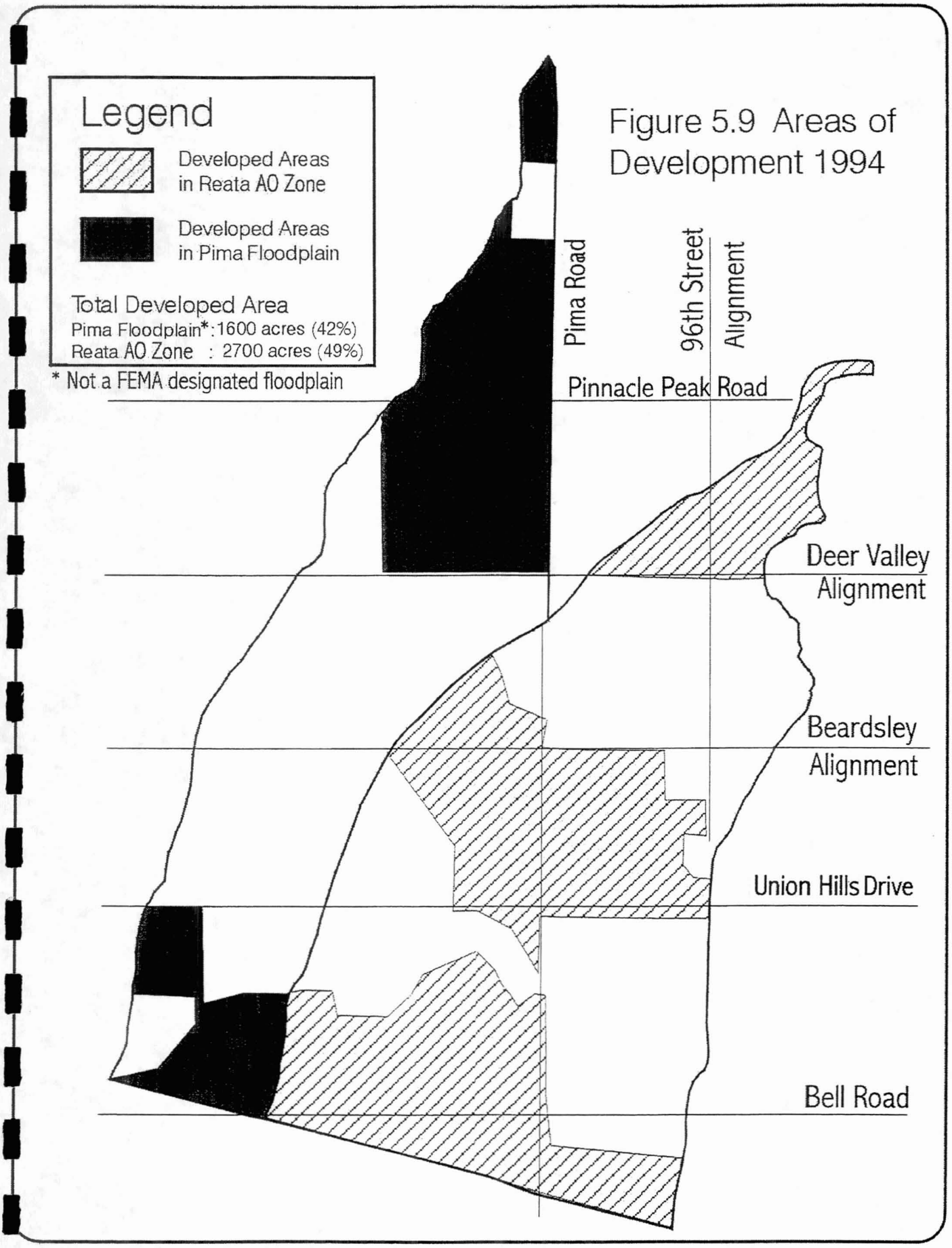


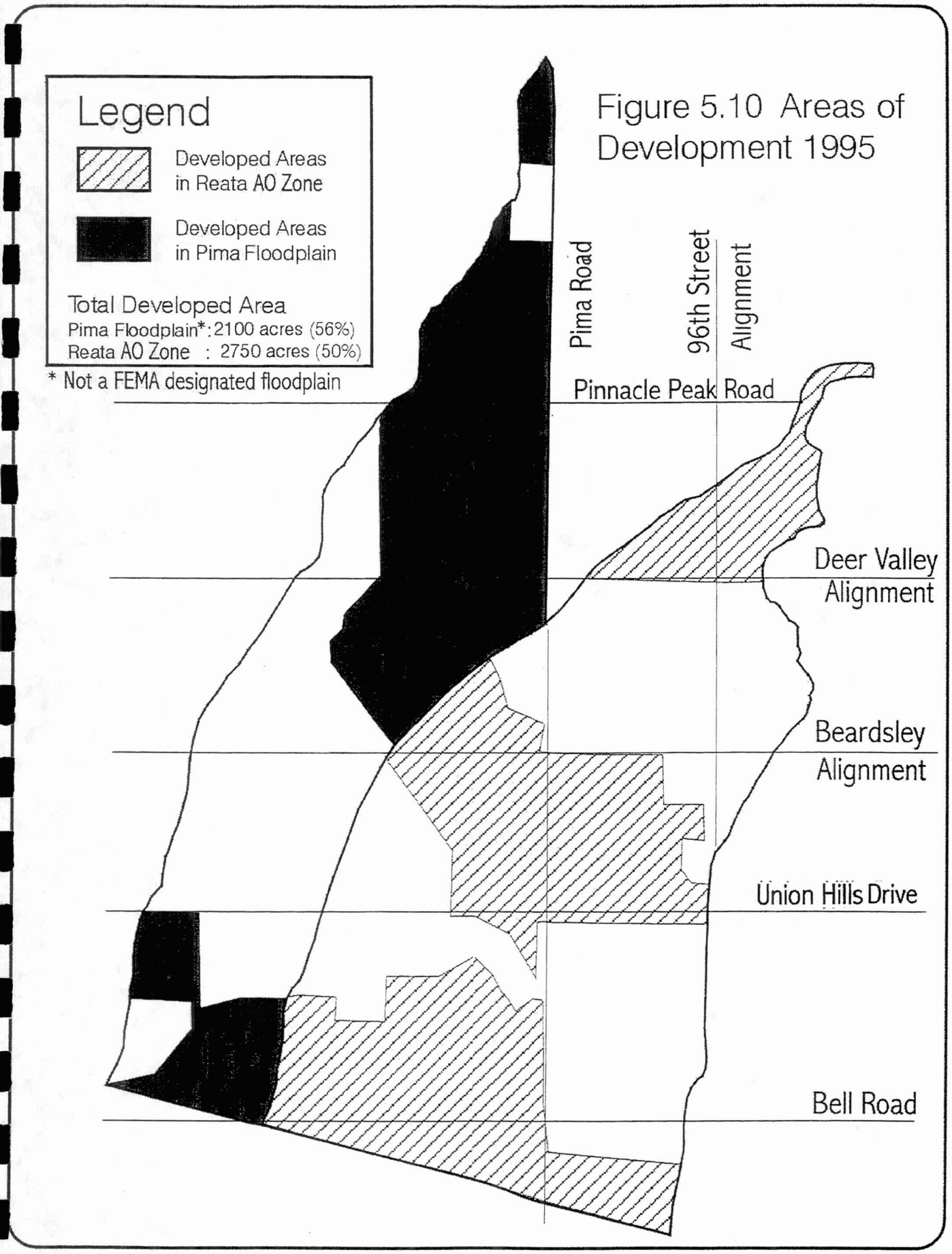
Figure 5.5
1996 Aerial Photograph

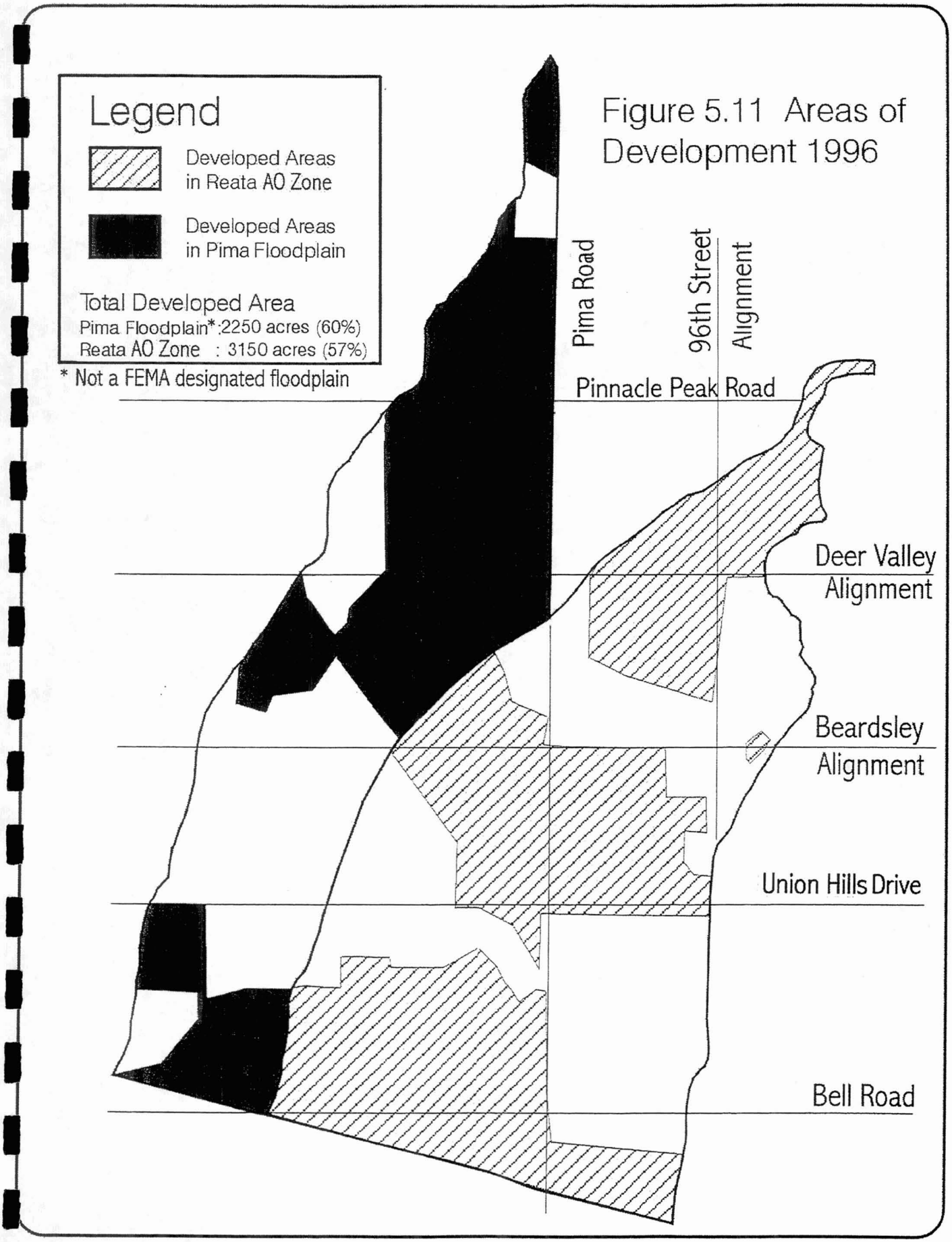
Figure 5.6
1997 Aerial Photograph

Figure 5.7
1998 Aerial Photograph


Legend
Developed Areas in Reata AO Zone
Developed Areas in Pima Floodplain
Total Developed Area
Pima Floodplain*:1600 acres (42%)
Reata AO Zone : 2300 acres (42%)
* Not a FEMA designated floodplain
Figure 5.8 Areas of Development 1993
Pima Road
96th Street Alignment
Pinnacle Peak Road
Deer Valley Alignment
Beardsley Alignment
Union Hills Drive
Bell Road


Legend
Developed Areas in Reata AO Zone
Developed Areas in Pima Floodplain
Total Developed Area
Pima Floodplain*: 1600 acres (42%)
Reata AO Zone : 2700 acres (49%)
* Not a FEMA designated floodplain
Figure 5.9 Areas of Development 1994
Pima Road
96th Street Alignment
Pinnacle Peak Road
Deer Valley Alignment
Beardsley Alignment
Union Hills Drive
Bell Road


Legend
Developed Areas in Reata AO Zone
Developed Areas in Pima Floodplain
Total Developed Area
Pima Floodplain*: 2100 acres (56%)
Reata AO Zone : 2750 acres (50%)
* Not a FEMA designated floodplain
Figure 5.10 Areas of Development 1995
Pima Road
96th Street Alignment
Pinnacle Peak Road
Deer Valley Alignment
Beardsley Alignment
Union Hills Drive
Bell Road


Legend
Developed Areas in Reata AO Zone
Developed Areas in Pima Floodplain
Total Developed Area
Pima Floodplain*:2250 acres (60%)
Reata AO Zone : 3150 acres (57%)
* Not a FEMA designated floodplain
Figure 5.11 Areas of Development 1996
Pima Road
96th Street Alignment
Pinnacle Peak Road
Deer Valley Alignment
Beardsley Alignment
Union Hills Drive
Bell Road

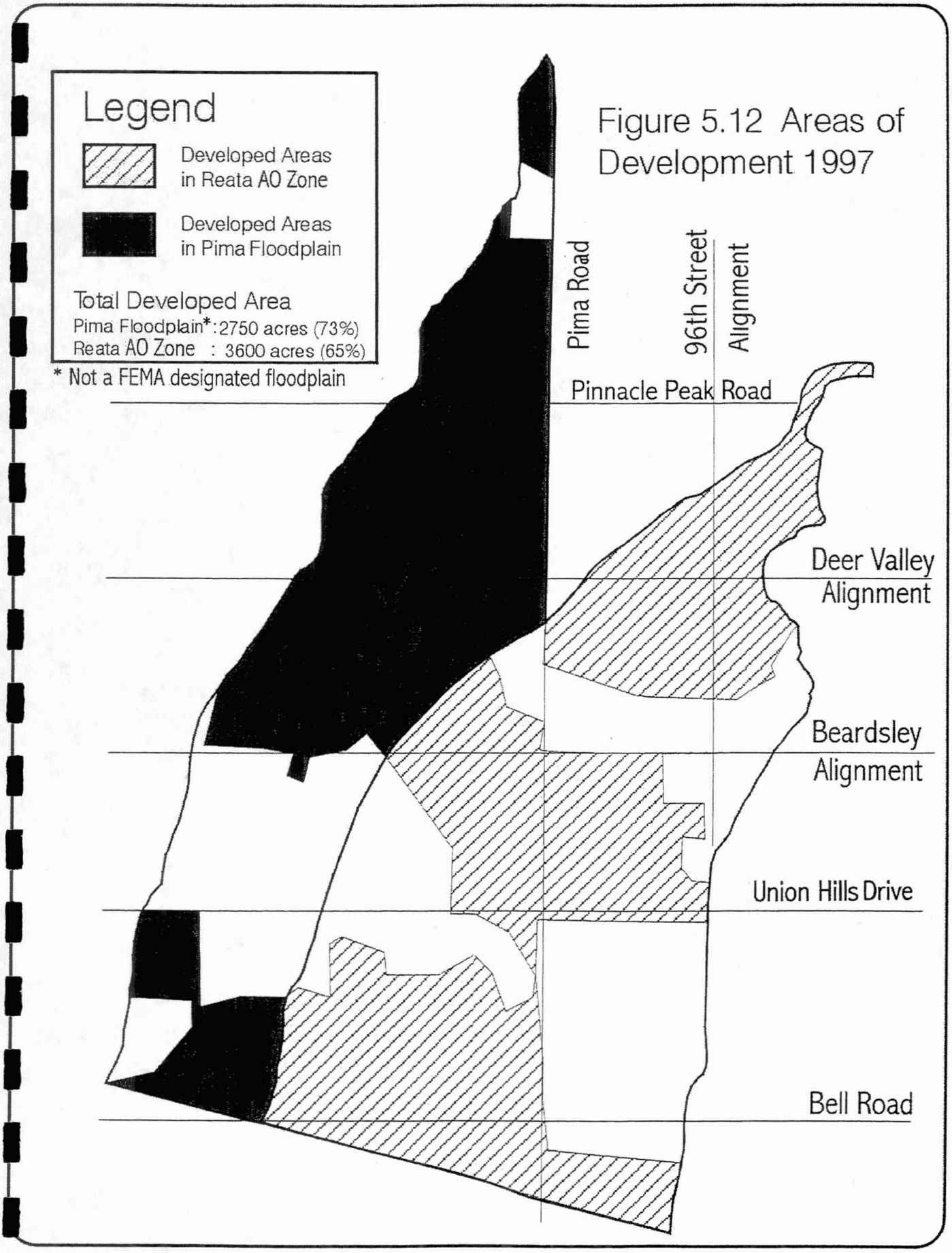
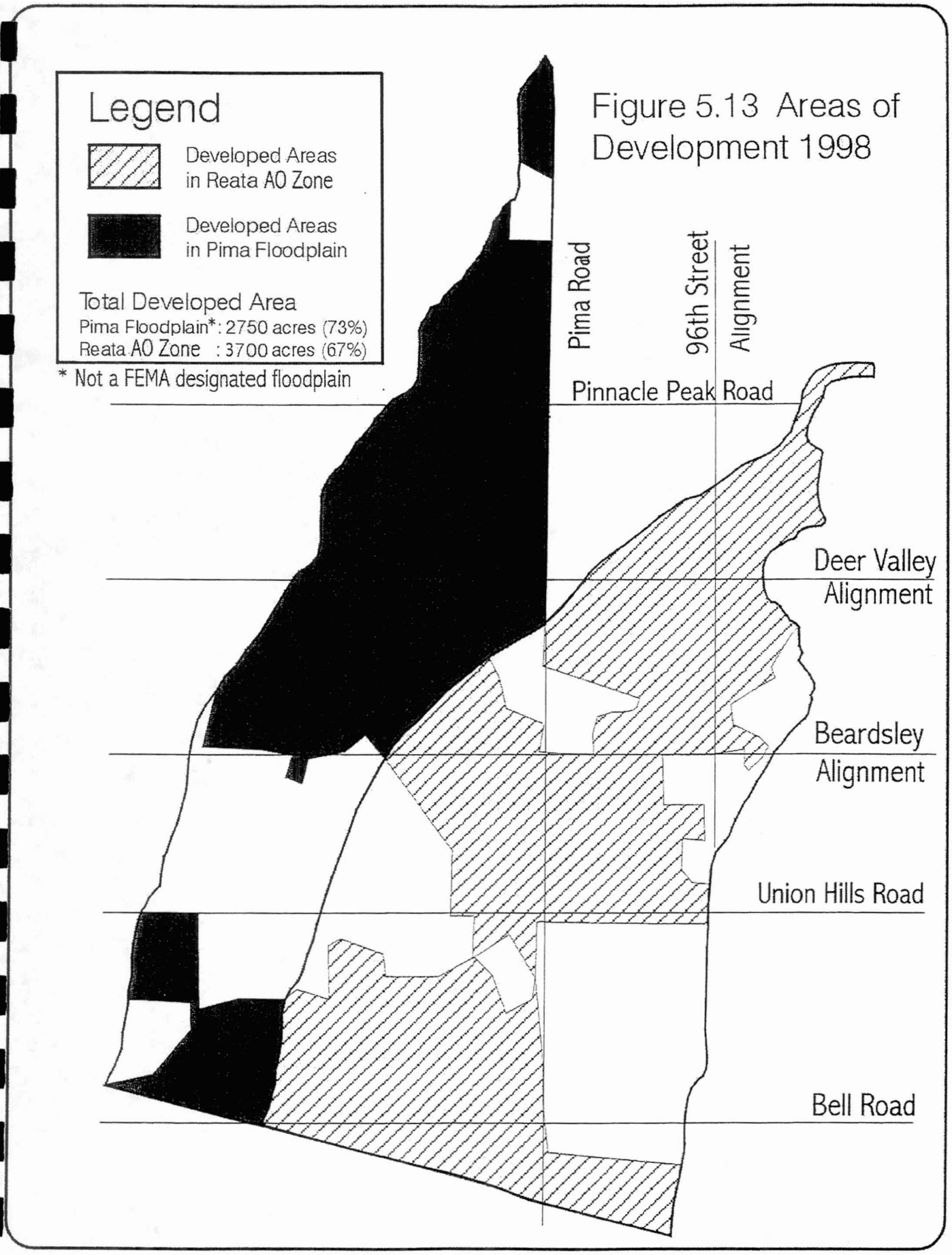


Figure 5.12 Areas of Development 1997


Legend
Developed Areas in Reata AO Zone
Developed Areas in Pima Floodplain
Total Developed Area
Pima Floodplain*: 2750 acres (73%)
Reata AO Zone : 3700 acres (67%)
* Not a FEMA designated floodplain
Figure 5.13 Areas of Development 1998
Pima Road
96th Street Alignment
Pinnacle Peak Road
Deer Valley Alignment
Beardsley Alignment
Union Hills Road
Bell Road

Based on this and the information presented above, three estimates of the amount of time left before maximum build-out can be obtained. A fourth estimate is obtained from information provided in the Corps of Engineers 1996 reconnaissance report. These estimates are listed in Table 5.4. Table 5.4 shows that maximum build-out should occur sometime between the years 2001 and 2025.

Based on the existing approved development (see Table 4.4) and the current zoning map shown on Figure 4.3, a maximum of 5,644 residential units (3,444 approved plus 2,200 zoned), with a potential population of 14,335, exist or will be constructed on the Pima floodplain study area.

5.3 Hydrology

Future without project hydrology upstream of the alluvial fan apex is not expected to change significantly. This area is mountainous and is not conducive to development that could impact the extent of runoff. Other parameters that impact the runoff are not expected to change. The discharges shown in Table 4.5 are still valid for future without project conditions.

Table 5.3 Summary of Historical Development on the Reata Pass/Beardsley Wash and Pima Floodplain Study Area

Year	Area Under Development, in Acres		Percent of Study Area Under Development[1]	
	Reata Pass Alluvial Fan	Pima Floodplain	Reata Pass Alluvial Fan	Pima Floodplain
1993	2,300	1,600	42%	42%
1994	2,700	1,600	49%	42%
1995	2,750	2,100	50%	56%
1996	3,150	2,250	57%	60%
1997	3,600	2,750	65%	75%
1998	3,700	2,750	67%	75%

[1] Based on visible presence on aerial photographs in Figures 5.2 to 5.7.

Table 5.4 Estimates of Remaining Time Until Maximum Build-Out of Reata Pass/Beardsley Wash Alluvial Fan Study Area

Estimating Method	Estimated Year of Maximum Build-Out (Assuming Base Year 1998)
Projection of current annual percent increase in population (33%) to maximum residential population of 17,211.	2002
Projection of current annual increase in residential units (405/year) to a maximum of 6,776	2009
Projection of current annual increase in project area under development (280 acres/year) to a maximum of 4,800 acres.	2003
Corps of Engineers 1996 Reconnaissance Report.	2025

Detailed future without project hydrology is not readily available downstream of the fan apex. The drainage patterns can vary considerably based on the development. As part of a 1998 study for the City of Scottsdale, Stantech prepared a HEC-1 model for the area upstream of Pima Road. This HEC-1 model assumes a Reata Pass project is in place. Future conditions are simulated by assuming the flow is concentrated. This would occur if the land were developed. Soil Conservation Service curve numbers and percent of imperviousness were also adjusted to simulate future developed conditions. SLA modified this model to simulate the difference in estimated discharge between natural land and developed land assuming an impervious area of 35%. The results showed that on a per-square-mile basis, the natural alluvial fan would generate approximately 1,000 cfs in a 100-year flood. The assumed developed area would generate approximately 1,700 cfs per square mile. Using the existing hydrology, and the estimated increase in discharge per square mile for development, and the expected area remaining to be developed on the Reata Pass/Beardsley Wash alluvial fan (approximately 2.8 square miles), the overall, future 100-year discharge at the base of the alluvial fan is estimated to be approximately 14,500 cfs. This is a very general discharge approximation subject to site-specific verification. This discharge would be generated and distributed in several separate washes on the alluvial fan.

5.4 Hydraulics/Sediment/Floodplain Management

The Reata Pass / Beardsley Wash fan will remain classified by FEMA as an alluvial fan in the future-without-project condition. Major flow paths existing in the current condition would remain, but since there would be no control at the apex, any discharge entering the alluvial fan would potentially take any path, even form new channels, with devastating results for existing as well as future development. The entire description of alluvial fan hydraulics, sediment transport and regulations in Sections 4.3, 4.5 and 4.6 of this report applies to the future without project condition.

As a result of the FEMA requirement that alluvial fan development be protected by flood-control structures capable of collecting and carrying the entire alluvial fan flow no matter where located on the alluvial fan, as illustrated by the failure of the Ironwood Village attempt to obtain a Letter of Map Revision, developments on the alluvial fan have been constructed by elevating individual pads. This leaves the developments subject to flooding and flood insurance requirements. Because 67% of the Reata Pass/Beardsley Wash alluvial fan study area is currently developed, and the remaining 33% (Figure 4.2) is owned piecemeal, there will be no opportunity for future developers to protect their property other than by the same method. Elevating individual residences as has been done in the past is the most-likely form of flood control. The Reata Pass/Beardsley Wash alluvial fan will remain within the regulatory floodplain as defined by FEMA.

The Pima floodplain study area will remain subject to flooding hazards. The description of the hydraulics, sediment transport, and regulations in Sections 4.3, 4.5 and 4.6 of this report applies to future without project conditions.

5.5 Traffic

Traffic will continue to increase in the project area as development on the alluvial fan and points north and west increase. Figure 4.11 shows the traffic projections for Pima Road. Using Pima Road as an indicator, by the year 2020 there should be a 50% increase in traffic in the area. The Loop 101 Freeway will be constructed along the lower portion of the alluvial fan to alleviate some of the north-south and east-west congestion anticipated as a result of future development.

5.6 Public Health and Safety

Section IV describes the significant flood-related threat to public health and safety within the study area. Because development will increase in the study area in the future, more people and structures will be affected by this adverse flooding condition. Elevation of structures to the regulatory flood level does not eliminate the risk to life and property.

5.7 Groundwater

Groundwater conditions will remain basically the same for the future, with an increased demand for water resulting from future development on the alluvial fan. There may be a slight decrease in recharge from the study area. This decrease should be negligible or offset given the fact that the entire study area runoff is retained and recharged at the CAP detention basins. Furthermore, any decrease in groundwater recharge would be more than offset by artificial recharge from the Water Campus. The City plans to satisfy the increased demand for water with renewable water supplies such as CAP and reuse of effluent.

5.8 The Natural Environment

Under the future-without-project condition, there would be no project-related impacts to washes, riparian resources, wildlife or sensitive species. The area would continue to develop and be subject to permit applications by others under the Corps Section 404 Program.

Impacts to the natural alluvial fan habitat by future land development will continue to occur until the property is 100% developed, with associated impacts to the natural environment. The City's ESLO and Floodplain and Drainage ordinances will preserve the basic existing drainage pattern. Washes with significant riparian resources will be preserved intact, meaning that there will be no impact to the waters of the U.S. aside from occasional roadway crossings.

Elevating the building pad on fill is the standard method of complying with FEMA regulations on the Reata Pass/Beardsley Wash alluvial fan. Fill must be sloped away from the edge of the structure at a relatively flat slope to be structurally and aesthetically suitable. Assuming one foot of fill with

6:1 side slopes on an average, 2,500-square-foot house, approximately 1.344 square feet of land would be impacted by fill outside the walls of each elevated structure. Since there are approximately 4,000 homes remaining to be built on the Reata Pass/Beardsley Wash alluvial fan, approximately 123 acres of desert habitat would be affected by this fill alone. In addition, some impacts on the waters of the U.S. can be expected as a result of increased building pad construction.

5.9 Cultural Resources

The status of cultural resources is not expected to change for future conditions. Future development may occur in areas where cultural resources currently exist. Individual surveys will be made as development occurs to ensure compliance and proper coordination with the State Historic Preservation Officer.