CELLA BARR
ASSOCIATES

4911 EAST BROADWAY
TUCSON, ARIZONA 85711
[602] 750-7474
FAX [602] 750-7470

TORTOLITA AREA BASIN MANAGEMENT PLAN

PHASE IIB

FORMULATE BASIN MANAGEMENT ALTERNATIVES FOR FUTURE DEVELOPMENT CONDITIONS

Registered Professional Engineer (Civil)
CERTIFICATE NO.
16738
JOHN S.
WISE
Date Signed 8/3/93
ARIZONA, U.S.A.

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CELLA BARR ASSOCIATES
4911 East Broadway Boulevard
Tucson, Arizona 85711

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Registered Professional Engineer (Civil)
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JOHN S. WISE
Date Signed 8/3/93
ARIZONA, U.S.A.

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INTRODUCTION

The Tortolita Area has been extensively studied during recent years, identifying watershed characteristics and associated floodplain issues relative to development in the area. Basin Management alternatives incorporating structural and non-structural solutions have been formulated and modeled with the goal of alleviating existing and future flooding conditions, while incorporating alternative concepts for dealing with the effects of future development. Analysis of alternatives has resulted in specific recommendations and proposed implementation strategy.

The study area for development of Basin Management alternatives includes all major watersheds which impact Tangerine Road, specifically Ruelas Canyon, Prospect Canyon, Cañada Agua, North Ranch and those portions of Wild Burro Canyon which impact Tangerine Road.

The Basin Management Alternative project has focused on two program areas: 1) floodplain management through revised floodplain delineations and assessment of subsequent FEMA mapping revisions; and 2) basin-wide planning issues involving both short- and long-term drainage infrastructure and regulatory needs.

SECTION 1. GENERAL DATA COLLECTION

The following is a summary of research implemented to assist in developing whole basin alternatives:

A. The following agencies prepared case studies which were reviewed for their applicability to the Tortolita area:

1. *Arizona Geological Survey*.

   "Paleoflood Hydrology of the Major Southern Tortolita Mountain Canyons, Northern Pima County, Arizona" by P. Kyle House, September 1990, Revised 1991. A detailed paleoflood investigation was performed in five canyons in the piedmont of the Tortolita Mountains. This study reveals discrepancies between various theoretical estimates of 100-year peak discharges and maximum apparent paleoflood discharge estimates derived from geologic effects of flooding.

   "A Geomorphic Assessment of Flood-Prone Areas on the Southern Piedmont of the Tortolita Mountains, Pima County," Arizona Geological Survey Open-File Report 91-11, Philip A. Pearthree, et al, June 1992. Geomorphic and geologic analyses were utilized to assess extent of alluvial fan flooding on the southern piedmont of the Tortolitas. Compares geomorphic assessment of alluvial fan activity with areas of alluvial fans predicted using FEMA alluvial fan methodology.

2. *Arizona Department of Water Resources*.

   "Design Manual for Engineering Analysis of Fluvial Systems," Simons, Li & Associates, Inc., March 1985. This manual addresses the dynamics of watershed and channel systems considering hydrologic, hydraulic, geomorphic, erosion and sedimentation aspects. The emphasis is placed upon practical implementation of state-of-the-art technology in identifying, evaluating and designing for the natural processes associated with major fluvial systems.

3. *Arizona Department of Transportation*.

"Present Status of Management and Technical Practices on Alluvial Fan Areas in Arizona," Robert L. Ward, November 1988. A primary purpose of this report is to examine flooding problems on alluvial fans in Arizona. A review is made of state-of-the-art technical procedures and floodplain management practices that are presently available. The report includes research recommendations.

"Analysis of Flows on Alluvial Fans," Simons, Li & Associates, Inc., October 1988. A state-of-the-art study of the characteristics, capabilities and applicability of several of the more promising methods for planning and designing drainage for highway crossings on alluvial fans, and to determine an appropriate direction for future research on this topic.

4. *Arizona Floodplain Management Association*.

"Symposium on Alluvial Fan Management," January 23, 1986. A collection of papers on alluvial fan flooding including current approaches to flood control, regulations, and diffusion modeling of alluvial fan processes.

5. *Anderson-Nichols Company, Inc.*

"Floodplain Management Tools for Alluvial Fans," December 23, 1990. This report examines the nature of flooding on fans, identification and quantification of fan flood hazard, and floodplain management tools on alluvial fans.

6. *Association of State Floodplain Managers, Inc.*

"Improving the Effectiveness of Floodplain Management in Western State High-Risks Areas, Alluvial Fans, Mud Flows, Mud Floods," February 1984. This work includes the cultural, physical and meteorological characteristics of the west and the particulars of the status of flood plain management. Other areas discussed are flood plain management opportunities, general and specific requirements and alluvial cones evaluation.

"High Risk Hazards, Movable Bed Models and Alluvial Fan Analysis," Dave Smutzer, June 1986. General discussion of problems associated with quantifying channel migration and bank erosion, moveable-bed boundary models and alluvial fan analysis.

"Proceedings of the Conference on Arid West Floodplain Management Issues," October 1988. The major topics of the conference were mapping and modeling, management of unique hazard areas, information dissemination, data needs and legal issues. It also includes history and nature of floodplain problems in the arid west and discusses trends in western floodplain management.

"Improving the Effectiveness of Floodplain Management in Arid and Semi-Arid Regions," March 1986. This symposium was the first to comprehensively examine flood hazards and damage reduction techniques for arid and semi-arid regions, to identify deficiencies in existing management approaches, and to suggest problem-solving approaches and research needs.

7. *Federal Emergency Management Agency (FEMA)*.

"Alluvial Fan Flooding Methodology, an Analysis," DMA Consulting Engineers, October 1985. This study focuses on the development of a historical data base of floods on alluvial fans. The methodology is based on two key assumptions which have not been verified in the past. The first of these is that the location of any stream channel on a fan is random; that it has an equal probability of occurring anywhere across the fan. The second is that the flow forms its own channel and remains in one channel throughout the event, except that the location of the channel can change through avulsion. The study was conducted to verify the appropriateness of these assumptions and if needed, to modify the method.

"Floodproofing Non-Residential Structures," May 1986. Manual illustrates a broad range of flood proofing techniques to reduce flood damages to existing and proposed non-residential structures.

"Design Manual for Retrofitting Flood-Prone Residential Structures," September 1986. Manual presents several methods for retrofitting a house along with the process of selecting a method and ways of implementing the method.

8. *Nevada Division of Emergency Management*.

"Floodplain Management Techniques for Alluvial Fans, Arid and Semi-Arid Environments," S. A. Santarcangelo, September 1984. The purpose of this publication is to pull together existing technical information which addresses the physical aspects of flooding and discuss some of the floodplain management techniques which might be used to implement them.

9. *Pima County Department of Transportation and Flood Control District*

"Guideline for the Development of Regional Multiple Use Detention/ Retention Basins in Pima County, Arizona," January 1986. Guidelines developed as a tool to be used in planning, programming and designing basins.

10. *U.S. Army Corps of Engineers*

"Engineering Standards for Flood Protection of Single Lot Developments on Alluvial Fans," Draft Report. A study performed by the Corps at the request of FEMA, to provide specific engineering standards for areas subject to alluvial fan flooding. Includes equations which predict velocity and depth of flooding and methods to armor fill and determine local scour.

"Estimating Sediment Delivery and Yield on Alluvial Fans," Technical Paper No. 130, June 1990. This paper summarizes the procedures used for computing the basinwide annual yields and single event sediment production for ephemeral channels located on an incised alluvial fan in central California.

B. A request was made to FEMA to provide examples of structural alternatives on alluvial fans in other communities. FEMA was unable to provide this data.

C. The document entitled "Regional Long Range Transportation and Air Quality Plan and Ten-year Transportation and Expenditure Plan 'The Baja

Project'," BRW Inc., August 1990 is generally accepted as the transportation plan for Pima County. In this report Tangerine Road is indicated as an Arterial Upgrade in 0-10 years and Moore Road (west as far as Tortolita Road) and Camino de Mañana are indicated as arterial upgrades in 11-30 years.

D. Two major roadway improvements are anticipated in the Tortolita Area:

1. *Tangerine Road*. The report entitled "Location and Design Study for Tangerine Road, Avra Valley Road to 1st Avenue," Parsons Brinckerhoff, June 1988, indicates that 100- and 50-year peak discharges were determined by the Pima County method for several crossings. Three alternatives were considered to address drainage conveyance: cross-drainage to match existing; intercept all flow and convey, west to I-10; and intercept runoff in detention basins and convey west to I-10. The most viable option was determined to be allowing flow to occur in same general pattern as existing.

2. *Interstate 10*. The I-10 General Plan, Ruthrauff to Tangerine is in the process of being completed by JHK and Associates. A drainage report by Johnson Brittain and Associates, Inc. entitled "Hydrologic and Hydraulic Report for I-10 Corridor Study - Pima County Ruthrauff to Tangerine Road," (March 1991) utilizes peak discharges and HEC-1 models generated in the Tortolita Basin Management Study, Phase IIA, to design cross-drainage structures for the 50-year event and evaluating 100-year event.

E. The Tortolita Area Plan and Tortolita Community Plan (current Zoning Map for the Tortolita area) were reviewed.

F. The Marana General Plan (June, 1987) was reviewed and the Zonal Land Use Map was utilized to determined Curve Number (CN) values for future developed conditions. The Plan encourages preservation of existing, natural drainage conveyance. An overlay exhibit of the plan was developed to assist in the evaluation of impacts of proposed solutions (Section 5) and is included as an overlay map in Appendix A.

G. Problem areas with respect to operations and maintenance were identified in 1987 (Phase I report). A summary is included as Table 1.

H. The draft version of the Comprehensive Plan (PADs) for the Tortolita/Avra Valley area was reviewed. One theme of interest classifies areas north of Tangerine Road for rural uses. South of Tangerine Road, areas are classified for urban uses.

I. A Pima County Waste Management Landfill Project is being proposed in the Tortolita Area, north of Tangerine Road. Rick Engineering has prepared a concept report addressing drainage. This report was reviewed and the landfill is not within the Phase IIB Study area.

J. Currently effective (September 6, 1989) FEMA Flood Insurance Rate Maps (FIRM) were compiled and reviewed. The FIRMs have been incorporated as an overlay map exhibit and are contained in Appendix A. Revised maps were published (September 30, 1992) during the course of this study. However, the floodplain delineations and zone designations shown on the attached overlay maps are unchanged.

TABLE 1

FLOODING COMPLAINTS

Township, Range, Section	Date	Nature of the Complaint
T12S R13E sec 29	7/22/85	Bad access into a subdivision, almost flooded two homes. A dike will be installed on Club Drive to divert the water into an old channel.
T12S R13E sec 31	10/8/85	Culverts under Magee Road causing erosion and scouring of a wall on private property
T12S R12E sec 1	2/11/82	5 CMP's need cleaning, 900 ft. west of Naranja Road and 1st Avenue
T12S R12E sec 6	2/5/85	I-10 and Buena Vista - Buena Vista does not drain due to right-of-way slope problems and no culverts in area.
T12S R12E sec 6	10/3/84	Tangerine Road, water ponds in a dip.
* T12S R12E sec 24	10/20/83	Camino de Oeste at Hardy Wash - culvert clogged with vegetation.
T12S R12E sec 26	since 1977	Oshrin Park Subdivision - residents complain the County caused flooding. Maintenance complaints numerous.
T12S R12E sec 36	10/3/84	Mars Road west of Camino de Oeste - pavement ends at 4800 West Mars causing substantial erosion and flooding there.
T12S R12E sec 36	9/30/83	Camino de Oeste and Massingale Road - reservoir owned by County leaks. The Massingale detention basin will solve the problem.
T12S R13E sec 8	12/82	3605 West Potvin Lane - wash avulsion occurring.
T12S R13E sec 8	12/80	Camino Christie and Camino Centrell - erosion at the corner caused by development.

* This culvert has been replaced with 26-36" CMP's.

FLOODING COMPLAINTS

Township, Range, Section	Date	Nature of the Complaint
T12S R13E sec 15	11/10/82	9900 North Cholla Blvd. - channel erodes and migrates into property (no bank protection), County has re-established original alignment and/or stabilized.
T12S R13E sec 15	10/23/84	Canyon Shadow Estates - drainageway headcuts into adjacent properties and causes sedimentation in the channel.
T12S R13E sec 22		1841 Overton, east of La Cholla Blvd. - erosion due to channel braiding.
T12S R13E sec 29	9/23/80	Magee Road - (400 feet east of Shannon Road) - pipe culvert under road has experienced headwall erosion on downstream side, exposing phone cable.
T12S R13E sec 31	10/23/85	Gatewood Ranch - inadequate capacity of 2-CMP's under Basque Drive, get clogged with debris/sediment.
T12S R13E sec 31	8/24/82	Gatewood Ranch - 7524 North Shirley - severe erosion around pipe culvert outlet.
	3/7/83	Gatewood Ranch - erosion in alley-poor grading.

SECTION 2. REVIEW OF CURRENT PIMA COUNTY FLOOD CONTROL ALTERNATIVES IN TORTOLITA AREA

The following Pima County specific items were reviewed for relevancy to currently utilized structural and non-structural flood control concepts:

A. Interim Guidelines were developed for the Tortolita Area under the Phase I study. These guidelines provide the basis for the spine wash criteria. The Town of Marana, Floodplain and Erosion Hazard Management Code does not address the Pima County Interim Guidelines. Marana's code has regulatory discharges from the Flood Insurance Study for the major canyons. The code requires a 20% increase in discharges for design.

B. Current Pima County detention/retention Regulations' applicability to the Tortolita area were reviewed and is discussed in later sections. The Town of Marana has adopted the Pima County Detention/Retention Manual.

C. A report entitled "Drainage Alternatives for Tortolita Mountain Properties, Phase I" (Simons, Li & Associates, April 1989) was reviewed. This report proposes a regional detention plan consisting of five regional detention basin sites in the Prospect Canyon, Ruelas Canyon, and Wild Burro Canyon.

   A report entitled "Report on Alignment and Cross-Section Alternatives for Tributary Drainage - The Lower Santa Cruz River Flood Control Project," (December 2, 1987) was prepared by CMG Drainage Engineering, Inc., for the Pima County Flood Control District. This report evaluates three alternative alignments and two alternative cross-sections of tributary channels to collect Tortolita Mountain runoff at the Southern Pacific Railroad and Interstate 10 and convey it to the Santa Cruz River.

D. No rezonings with significant impact to the Tortolita area were discovered by the Pima County Flood Control District.

E. A master drainage study for the existing North Ranch subdivision has been developed by CBA. Specific plans (Marana) developed for proposed development include The Tortolita Mountain Properties (Westinghouse by SLA) impacted by Prospect and Ruelas Canyons, Acacia Hills (Estes) impacted by Cañada Agua and Prospect Canyons, Northgate (WLB) impacted by Cañada Agua and Prospect Canyons, Hartman Hills (CBA) and Tangerine Hills (CBA) both impacted by Cañada Agua Canyon. The location of each specific plan is shown on the overlay exhibits, Appendix A.

F. Arizona Department of Transportation (ADOT) seems to be the only agency pursuing improvements (I-10, Tangerine Road) in the area at this time. The Southern Pacific Railroad (SPRR) has no plans for improvements in the Tortolita area.

G. Pima County Riparian Ordinance - The proposed Riparian Habitat Protection Amendment to the Floodplain and Erosion Hazard Management Ordinance is being implemented in order to adopt legislation which will protect riparian habitat or green belt areas along major water courses and enable comprehensive long-term protection of designated riparian areas. If adopted by the Board of Supervisors, the amendment will apply to watercourses with 100-year peak discharges of 2000 cfs or more and will apply to several watercourses in the Tortolita Study area.

SECTION 3. DEVELOPED FUTURE CONDITIONS HYDROLOGIC AND HYDRAULIC MODELS

A. HYDROLOGIC MODEL

The 24-hour HEC-1 model generated in Phase IIA of the Tortolita Area Basin Management Plan (CBA, January 24, 1991) were revised to simulate developed conditions. The Marana Zonal Land Use Map (Figure 1) was utilized to determine Curve Number (CN) values for future developed conditions. Sub-watershed delineations and concentration points are shown in Appendix A, Overlay Maps. Table 2 presents a comparison of existing condition HEC-1 curve numbers and curve numbers for the zones indicated on Figure 1, Zonal Land Use Map.

Table 2
CURVE NUMBERS

	Curve Numbers		
Soil Groups	A	B	C
Existing Conditions, Zone C (Moderate to Low Density Residential), Zone D (Low Density/Sensitive areas), Zone I (Open Space - Spine Washes), Zone J (Special Opportunities Plan Area)	82	82	90
Zone A (Commercial)	89	92	95
Zone B (High Residential)	82	85	92
Zone E (High Urbanized/Commercial)	89	92	95

In addition, the Phase IIA existing condition HEC-1 models were revised. The revision consisted of revising the HEC-1 hydrograph ordinates to insure that the number of minutes for the tabulation interval multiplied by the number of hydrograph ordinates is at least as long as the 24-hour storm duration.

The future and existing HEC-1 input data is provided in Appendix B. The resulting existing 100-year peak discharges have decreased approximately 10-15% from Phase IIA. Existing and future 100-year peak discharges at select concentration points are tabulated in Table 3.

Table 3
EXISTING AND FUTURE
100-YEAR PEAK DISCHARGES

BASIN	SUB-BASIN CONCENTRATION POINT	100-YEAR PEAK DISCHARGE (cfs) EXISTING	FUTURE	WATERSHED AREA (SQ.MI.)
North Ranch	A2	1,123	1,123	1.03
	A3	427	427	0.38
	A4	1,606	1,606	1.75
	A5	107	107	0.09
	A6	1,662	1,662	1.98
	A7	64	64	0.05
	A8	1,653	1,653	2.23
	A9	1,647	1,647	2.28
	A10	1,588	1,588	1.48
	A11	283	298	0.27
	A12	1,700	1,701	2.68
	A13	433	474	0.38
	A14	524	563	0.59
	A15	1,919	1,929	3.55
	A16	132	193	0.09
	A17	53	56	0.04
	A18	311	361	0.27
	A19	45	43	0.03
	A20	648	700	1.01
	A21	932	975	0.89
	A2021	1,406	1,519	1.90
	A22	1,645	1,735	2.18
	A23	110	110	0.09
	A	3,108	3,259	5.73
Cañada Agua	B3	3,623	3,702	1.73
	B4	4,060	4,258	2.07
	B5	4,103	4,341	3.42
	B6	3,840	4,107	3.75
Cañada Agua	C8	1,922	1,952	1.75
	C10	249	299	0.22
	C11	380	388	0.27
	C13	2,590	2,717	2.83
	C14	138	138	0.09
	C15	3,282	3,420	3.66
	C16	3,587	3,753	5.63
Prospect Canyon	D6	1,779	1,779	0.95
	D11	6,716	7,096	5.39
	D13*	779	923	0.99
	D14*	6,706	7,216	9.83

* Indicates "floating concentration point," i.e., exact location is undefinable.

TABLE 3 *(Continued)*
EXISTING AND FUTURE
100-YEAR PEAK DISCHARGES

BASIN	SUB-BASIN CONCENTRATION POINT	100-YEAR PEAK DISCHARGE (cfs) EXISTING	FUTURE	WATERSHED AREA (SQ.MI.)
Cañada Agua	E1	53	55	0.04
	E3	241	271	0.22
	E4	665	764	0.58
	E6	253	278	0.18
	E7	413	455	0.35
	E8*	1,473	1,665	1.73
Cañada Agua	F1	124	136	0.08
	F2*	862	997	1.16
Cañada Agua	G1	56	60	0.04
	G2	418	446	0.31
	G3	98	113	0.07
	G4	560	783	0.59
	G5	285	325	0.81
	G6	281	319	0.22
	G7	61	72	0.04
	G8	128	150	0.12
	G9	164	225	0.19
	G10	494	494	0.34
	G11	840	904	0.68
	G12	171	215	0.14
	G13	46	53	0.03
	G16	1,151	1,285	1.02
	G19*	2,347	2,833	3.71
	G20	4,500	4,898	5.15
	G21*	4,337	4,769	5.99
Cañada Agua	H1	287	307	0.24
	H2	584	633	0.66
	I1	164	175	0.13
	I3	202	300	0.27
	I5	595	645	0.60
	I6	50	54	0.04
	I7	192	205	0.19
	I8	834	900	0.88
	I9	858	950	0.93
North Ranch (Massingale)	J4	205	214	0.12
	J10	1,136	1,136	1.36

* Indicates "floating concentration point," i.e., exact location is undefinable.

TABLE 3 *(Continued)*
EXISTING AND FUTURE
100-YEAR PEAK DISCHARGES

BASIN	SUB-BASIN CONCENTRATION POINT	100-YEAR PEAK DISCHARGE (cfs) EXISTING	FUTURE	WATERSHED AREA (SQ.MI.)
	J-IN	2,307	3,141	2.49
	J-OUT	2,226	3,122	2.49
North Ranch	K1	293	327	0.24
	K3	426	458	0.46
	K4	423	454	0.46
North Ranch	L1	67	83	0.06
	L2	547	628	0.53
	L3	502	570	0.43
	L4	326	350	0.28
North Ranch	L5	1,445	1,623	1.34
	L6	1,401	1,585	1.52
	L7	1,786	2,001	1.98
	LK	1,653	1,890	1.98
Prospect	M1	1,186	1,490	0.98
	M2*	1,189	1,655	1.61
Ruelas Canyon	N7	5,615	5,623	3.39
	N8	595	595	0.38
	N9*	8,031	8,607	8.03
	N10*	8,076	8,734	8.99
Wild Burro	O7	9,495	9,500	7.13
	O9*	9,258	9,351	9.01
North Ranch	P1	115	123	0.09
	P2	31	32	0.02
	P3	356	405	0.30
	P4	115	123	0.09
	P	493	520	0.50
Wild Burro	Q1	363	363	
	Q2*	944	959	0.70
	Q3*	1,820	1,856	1.53
	Q4	2,398	2,595	3.65
North Ranch	R1	14	15	0.01
	R2	191	204	0.15
	R3	171	171	0.14
	R4	345	357	0.29

* Indicates "floating concentration point," i.e., exact location is undefinable.

B. HYDRAULIC MODEL

Spine wash 100-year floodplains were redelineated on the Phase IIA floodplain maps (200-scale) utilizing developed condition discharges and revised existing condition discharges.

Manning's ratings of representative cross-sections along the spine washes were used to evaluate and determine the approximate 100-year floodplains. Due to future 100-year peak discharges, the water surface elevations increased from 0.01 foot to as much as 2 feet.

Roughness coefficients for the Manning's ratings range from 0.025 to 0.70. For sandy washes, free of most vegetation, a roughness coefficient of 0.035 was selected. For washes with a greater percentage of vegetation, the roughness coefficients ranged from 0.040 to 0.050. For the overbank areas, a roughness coefficient of 0.050 to 0.070 was used. The cross-section locations and the existing and future 100-year water surface elevations are shown on the 200-scale aerial topographic maps in Appendix C. Tables 4a and 4b summarize the Manning's rating parameters for each cross-section.

Table 4a
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR FUTURE CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
North Ranch								
J10	T12S, R13E, Sec. 21 1	225	234	1,136	1.1	4.9	1.25	0.035
J10	T12S, R13E, Sec. 29 2	581	478	1,136	1.7	2.4	1.30	0.070
J10	T12S, R13E, Sec. 29 3	556	475	1,136	3.3	2.4	1.60	0.070
L2	T12S, R13E, Sec. 8 1	205	149	628	1.5	4.4	2.00	0.040, 0.050
L5	T12S, R13E, Sec. 17 2	430	352	1,623	1.2	5.0	2.00	0.042, 0.040
L6	T12S, R13E, Sec. 18 3	309	325	1,585	3.1	5.0	2.00	0.044, 0.050
L6	T12S, R13E, Sec. 18 4	445	391	1,585	2.1	4.1	1.70	0.044, 0.050
L2	T12S, R13E, Sec. 8 5	123	114	628	2.1	5.6	2.35	0.040, 0.050
L2	T12S, R13E, Sec. 5 6	92	112	628	2.1	5.6	1.70	0.040
L6	T12S, R12E, Sec. 24 7	145	247	1,585	2.1	6.5	1.80	0.044
I3	T12S, R13E, Sec. 7 2	232	133	300	1.7	2.3	1.00	0.045
I5	T12S, R13E, Sec. 18 3	378	210	645	0.7	3.2	1.90	0.045
I8	T12S, R12E, Sec. 13 4	471	208	900	1.8	4.7	3.00	0.050
A2	T11S, R13E, Sec. 27 1	133	207	1,123	4.9	5.4	1.21	0.040
A10	T11S, R13E, Sec. 34 2	290	344	1,588	3.3	4.6	1.36	0.042
A6	T12S, R13E, Sec. 4 3	143	270	1,662	3.1	6.1	1.50	0.045
A8	T12S, R13E, Sec. 8 4	590	473	1,653	2.2	3.5	1.54	0.045
A12	T12S, R13E, Sec. 17 5	424	415	1,701	1.3	4.1	2.00	0.050
A15	T12S, R13E, Sec. 19 6	93	254	1,929	4.6	7.6	1.72	0.050
A22	T12S, R13E, Sec. 19 7	283	355	1,735	2.8	5.0	1.31	0.042

TABLE 4a *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR FUTURE CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
Cañada Agua								
B2	T11S, R13E, Sec. 21 1	63	178	3,072	5.0	17.1	2.1	0.025
B3	T11S, R13E, Sec. 21 2	502	532	3,072	1.6	7.0	1.3	0.025
B3	T11S, R13E, Sec. 28 3	122	283	3,072	4.5	13.1	1.6	0.025
B3	T11S, R13E, Sec. 28 4	557	689	3,702	1.9	5.4	2.0	0.045
B4	T11S, R13E, Sec. 33 5	671	685	4,258	2.6	6.4	1.3	0.025, 0.030
G21	T12S, R12E, Sec. 13 6	909	773	4,769	2.9	6.4	2.3	0.045
G21	T12S, R12E, Sec. 14 7	237	572	4,769	4.3	8.4	2.0	0.045
G21	T12S, R12E, Sec. 23 8	566	644	4,769	2.4	7.8	2.9	0.040, 0.030
G10	T11S, R13E, Sec. 29 1	147	149	494	2.2	3.3	1.0	0.045
G11	T11S, R13E, Sec. 32 2	171	210	904	1.7	4.3	1.3	0.045
G16	T12S, R13E, Sec. 6 3	409	333	1,285	1.8	4.1	1.6	0.045
G2	T11S, R12E, Sec. 32 1	93	101	446	2.5	4.4	2.0	0.050
G4	T11S, R13E, Sec. 31 2	196	218	783	4.0	3.6	1.3	0.050
G5	T12S, R13E, Sec. 6 3	195	183	867	2.4	4.8	2.0	0.042
G5	T12S, R12E, Sec. 12 4	279	273	867	3.1	3.5	2.1	0.070
G19	T12S, R12E, Sec. 12 5	516	733	2,833	2.3	3.9	2.1	0.070
G18	T12S, R13E, Sec. 7 7	455	148	621	2.2	4.6	2.0	0.050, 0.045
G19	T12S, R12E, Sec. 22 9	330	480	2,833	3.9	5.9	2.4	0.050
Prospect								
D6	T11S, R13E, Sec. 30 1	200	257	1,779	1.4	7.0	2.6	0.040
D7 & D8	T11S, R13E, Sec. 30 2	794	968	5,912	4.0	6.6	1.6	0.040
D9 & D10	T11S, R12E, Sec. 36 3	930	1,280	6,951	4.8	5.4	1.4	0.040

TABLE 4a *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR FUTURE CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
Ruelas								
N7	T11S, R12E, Sec. 24 2	617	665	5,623	2.3	8.5	3.6	0.035
N9	T11S, R12E, Sec. 23 3	581	452	6,455	3.1	15.0	3.9	0.050, 0.035
N9	T11S, R12E, Sec. 27 4	441	769	8,607	2.3	11.3	3.2	0.050, 0.035
N9	T11S, R12E, Sec. 28 5	631	1,346	8,607	3.6	6.4	3.3	0.070, 0.035
N9	T11S, R12E, Sec. 23 6	689	988	8,607	4.6	10.0	2.7	0.070, 0.040
Wild Burro								
O3	T11S, R12E, Sec. 14 1	330	728	7,919	3.9	10.9	3.0	0.040
O5	T11S, R12E, Sec. 14 2	260	514	8,346	4.6	16.2	3.0	0.025
O7	T11S, R12E, Sec. 22 3	672	1,079	9,500	4.7	8.8	3.0	0.040
O8	T11S, R12E, Sec. 28 4	781	883	9,494	3.5	11.9	3.0	0.060, 0.032
O9	T11S, R12E, Sec. 28 5	1,361	1,975	9,351	2.3	4.8	3.1	0.070
O9	T11S, R12E, Sec. 32 6	1,097	1,539	9,351	5.9	6.5	2.6	0.050
Q1	T11S, R12E, Sec. 14 1	63	69	363	1.4	5.3	2.9	0.050
Q2	T11S, R12E, Sec. 22 2	79	87	959	1.7	11.4	3.2	0.050, 0.025
Q3	T11S, R12E, Sec. 21 3	268	284	1,856	2.3	6.7	3.0	0.050, 0.040
Q3	T11S, R12E, Sec. 29 4	403	381	1,856	1.7	5.1	2.0	0.050, 0.040
Q4	T11S, R12E, Sec. 29 5	658	519	2,595	3.1	5.2	2.5	0.050, 0.040
Q4	T11S, R12E, Sec. 31 6	799	548	2,595	2.8	5.9	1.8	0.050, 0.040
Cañada Agua								
C1	T11S, R13E, Sec. 21 1	54	95	723	2.9	7.7	2.6	0.045
C3	T11S, R13E, Sec. 29 2	42	115	1,030	4.7	8.9	2.0	0.045
C4	T11S, R13E, Sec. 29 3	473	354	1,208	1.5	3.5	2.0	0.050
C5	T11S, R13E, Sec. 31 4	244	391	1,761	3.5	4.5	1.2	0.050

TABLE 4a *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR FUTURE CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
C8	T11S, R13E, Sec. 31 5	386	461	1,952	2.5	4.2	1.6	0.050
C13	T12S, R13E, Sec. 6 6	437	384	2,717	3.0	4.7	1.7	0.050
C13	T12S, R12E, Sec. 1 7	1,594	716	2,717	2.2	4.0	2.2	0.065
C16	T12S, R12E, Sec. 11 8	1,461	1,050	3,753	2.5	3.8	2.3	0.070
C16	T12S, R12E, Sec. 15 9	968	1,172	3,753	2.1	3.9	2.0	0.070

Table 4b
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR EXISTING CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
North Ranch								
J10	T12S, R13E, Sec. 21 1	225	234	1,136	1.1	4.9	1.25	0.035
J10	T12S, R13E, Sec. 29 2	581	478	1,136	1.7	2.4	1.30	0.070
J10	T12S, R13E, Sec. 29 3	556	475	1,136	3.3	2.4	1.60	0.070
L2	T12S, R13E, Sec. 8 1	195	135	547	1.4	4.3	2.00	0.040, 0.050
L5	T12S, R13E, Sec. 17 2	422	326	1,445	1.1	4.9	2.00	0.042, 0.040
L6	T12S, R13E, Sec. 18 3	302	309	1,401	3.0	4.9	2.00	0.044, 0.050
L6	T12S, R13E, Sec. 18 4	436	360	1,401	2.0	3.9	1.70	0.044, 0.050
L2	T12S, R13E, Sec. 8 5	116	103	547	2.0	5.3	2.35	0.040, 0.050
L2	T12S, R13E, Sec. 5 6	88	102	547	2.0	5.4	1.70	0.040
L6	T12S, R12E, Sec. 24 7	143	229	1,401	2.0	6.2	1.80	0.044
I3	T12S, R13E, Sec. 7 2	185	90	202	1.5	2.3	1.00	0.045
I5	T12S, R13E, Sec. 18 3	370	199	595	0.7	3.1	1.90	0.045
I8	T12S, R12E, Sec. 13 4	469	208	834	1.8	4.7	3.00	0.050
A2	T11S, R13E, Sec. 27 1	133	207	1,123	4.9	5.4	1.21	0.040
A10	T11S, R13E, Sec. 34 2	290	344	1,588	3.3	4.6	1.36	0.042
A6	T12S, R13E, Sec. 4 3	143	270	1,662	3.1	6.1	1.50	0.045
A8	T12S, R13E, Sec. 8 4	590	473	1,653	2.2	3.5	1.54	0.045
A12	T12S, R13E, Sec. 17 5	424	415	1,700	1.3	4.1	2.00	0.050
A15	T12S, R13E, Sec. 19 6	92	253	1,919	4.6	7.6	1.72	0.050
A22	T12S, R13E, Sec. 19 7	274	339	1,645	2.7	5.0	1.31	0.042

TABLE 4b *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR EXISTING CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
Cañada Agua								
B2	T11S, R13E, Sec. 21 1	59	157	2,559	4.7	16.4	2.1	0.025
B3	T11S, R13E, Sec. 21 2	502	522	3,623	1.6	7.0	1.3	0.025
B3	T11S, R13E, Sec. 28 3	121	279	3,623	4.5	13.1	1.6	0.025
B3	T11S, R13E, Sec. 28 4	557	689	3,623	1.9	5.4	2.0	0.045
B4	T11S, R13E, Sec. 33 5	671	665	4,060	2.6	6.4	1.3	0.025, 0.030
G21	T12S, R12E, Sec. 13 6	876	727	4,337	2.8	6.3	2.3	0.045
G21	T12S, R12E, Sec. 14 7	235	537	4,337	4.2	8.1	2.0	0.045
G21	T12S, R12E, Sec. 23 8	682	583	4,337	2.3	8.3	2.9	0.040, 0.030
G10	T11S, R13E, Sec. 29 1	147	149	494	2.2	3.3	1.0	0.045
G11	T11S, R13E, Sec. 32 2	168	200	840	1.6	4.2	1.3	0.045
G16	T12S, R13E, Sec. 6 3	398	309	1,151	1.7	3.9	1.6	0.045
G2	T11S, R12E, Sec. 32 1	92	97	418	2.4	4.3	2.0	0.050
G4	T11S, R13E, Sec. 31 2	164	165	560	3.7	3.4	1.3	0.050
G5	T12S, R13E, Sec. 6 3	143	83	285	1.8	3.5	2.0	0.042
G5	T12S, R12E, Sec. 12 4	155	107	285	2.8	2.8	2.1	0.070
G19	T12S, R12E, Sec. 12 5	572	680	2,347	2.1	3.5	2.1	0.070
G18	T12S, R13E, Sec. 7 7	455	148	621	2.2	4.6	2.0	0.050, 0.045
G19	T12S, R12E, Sec. 22 9	317	422	2,347	3.7	5.6	2.4	0.050

TABLE 4b *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS
FOR EXISTING CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
Prospect								
D6	T11S, R13E, Sec. 30 1	200	257	1,779	1.4	7.0	2.6	0.040
D7 & D8	T11S, R13E, Sec. 30 2	794	968	5,912	4.0	6.6	1.6	0.040
D9 & D10	T11S, R12E, Sec. 36 3	930	1,280	6,915	4.8	5.4	1.4	0.040
Ruelas								
N7	T11S, R12E, Sec. 24 2	617	665	5,623	2.3	8.5	3.6	0.035
N9	T11S, R12E, Sec. 23 3	510	452	6,455	3.0	15.0	3.9	0.050, 0.035
N9	T11S, R12E, Sec. 27 4	437	739	8,031	2.2	11.0	3.2	0.050, 0.035
N9	T11S, R12E, Sec. 28 5	631	763	7,067	3.6	9.8	3.3	0.070, 0.035
Wild Burro								
O3	T11S, R12E, Sec. 14 1	330	728	7,919	3.9	10.9	3.0	0.040
O5	T11S, R12E, Sec. 14 2	260	514	8,346	4.6	16.2	3.0	0.025
O7	T11S, R12E, Sec. 22 3	672	1,079	9,500	4.7	8.8	3.0	0.040
O8	T11S, R12E, Sec. 28 4	781	883	9,494	3.5	11.9	3.0	0.060, 0.032
O9	T11S, R12E, Sec. 28 5	1,361	1,975	9,351	2.3	4.8	3.1	0.070
O9	T11S, R12E, Sec. 32 6	1,097	1,539	9,351	5.9	6.5	2.6	0.050
Q1	T11S, R12E, Sec. 14 1	63	69	363	1.4	5.3	2.9	0.050
Q2	T11S, R12E, Sec. 22 2	79	87	959	1.7	11.4	3.2	0.050, 0.025
Q3	T11S, R12E, Sec. 21 3	268	284	1,856	2.3	6.7	3.0	0.050, 0.040
Q3	T11S, R12E, Sec. 29 4	403	381	1,856	1.7	5.1	2.0	0.050, 0.040
Q4	T11S, R12E, Sec. 29 5	652	487	2,398	3.0	5.1	2.5	0.050, 0.040
Q4	T11S, R12E, Sec. 31 6	799	548	2,398	2.8	5.9	1.8	0.050, 0.040

TABLE 4b *(Continued)*
HYDROLOGIC DATA FOR SPINE WASH FLOODPLAIN DELINEATIONS FOR EXISTING CONDITIONS

(Manning's Ratings)

Drainage Basin	Cross-section	Floodplain Width (ft)	Area (sq ft)	Q100 (cfs)	Max Depth (ft)	Max Velocity (ft/sec)	Channel Slope(%)	n-values
Cañada Agua								
C1	T11S, R13E, Sec. 21 1	54	95	723	2.9	7.7	2.6	0.045
C3	T11S, R13E, Sec. 29 2	42	115	1,030	4.7	8.9	2.0	0.045
C4	T11S, R13E, Sec. 29 3	473	354	1,208	1.5	3.5	2.0	0.050
C5	T11S, R13E, Sec. 31 4	244	391	1,761	3.5	4.5	1.2	0.050
C8	T11S, R13E, Sec. 31 5	384	458	1,922	2.5	4.2	1.6	0.050
C13	T12S, R13E, Sec. 6 6	431	562	2,590	3.0	4.6	1.7	0.050
C13	T12S, R12E, Sec. 1 7	1,590	689	2,590	2.2	4.0	2.2	0.065
C16	T12S, R12E, Sec. 11 8	1,454	1,014	3,587	2.5	3.8	2.3	0.070
C16	T12S, R12E, Sec. 15 9	959	1,014	3,587	2.1	3.8	2.0	0.070

SECTION 4. FLOOD CONTROL COMPONENTS

INTRODUCTION

In this section, structural and non-structural flood control components are identified for use in developing draft basin management plans for each watershed. Where applicable, cost estimates, on a unit cost basis, have been developed in this section to assist in evaluation of each component and draft basis management plans. Evaluation of each component is conducted in Section 5. Draft basin management plans, incorporating individual or combined components, and evaluation of the plans are presented in subsequent sections.

The components presented below are based on review of current methodologies and floodplain management techniques, development plans, plats, existing drainage facilities, roadway and transportation plans/projects, reports and studies, current regulations and design criteria for the Tortolita and similar areas.

A. *NON-STRUCTURAL COMPONENTS*

The high cost of major capital improvements is one deterrent to implementation of stormwater projects within the Tortolita Area in the near future. Implementation of non-structural measures can reduce or offset the need for some structural improvements. Non-structural measures are described in the following text:

	Unit Cost
Floodplain/Erosion Hazard Property Acquisition (convert to parks, open space, trail systems)	
Preservation of land through purchase, fee ownership, easement or other mechanisms is the most effective way of preventing impacts in sensitive areas and preserving options for system improvements. The locations and types of land acquisitions necessary for stormwater system development and maintenance are identified through the basin planning process, where coordinated approaches including land management and other project concerns can be efficiently developed. Besides fee	$2,000-$50,000/acre

ownership, various types of easements are available, including:

Unit Cost

- Conservation easements to preserve natural vegetation from disturbance;
- Open space easements to preserve natural areas including floodplains and erosion-susceptible slopes;
- General public easements to allow public facilities (including storm sewers) to cross private property, including drainage easements and flowage easements.

Easements are most easily obtained during the plan review process as a condition of approval. Where responsible stormwater stewardship has been demonstrated, easements can sometimes be obtained at little or no cost.

Floodproofing/Erosion Proofing

Floodproofing consists of structure-specific improvements to reduce or eliminate flood damage in known floodprone areas.

- Structures	
Sealants	$0.45-1.00/SF
Closures (special treatments for openings such as doors, windows, driveways, etc.)	$45.00/SF
Elevation (raise structure above flood hazard, via fill, piers)	$4.00-15.00/SF
Floodwalls and Levees	$300-350/CY - concrete and $4-10/CY - fill
Cutoff walls	$300-500/CY - concrete
Pier replacement/deepening	$30k to $60k per house
Slope stabilization	$1 to 3/per SY

	Unit Cost
Peripheral landscaping for erosion mitigation	$0.50/FT^2
- Lots	
Elevation via fill, piers	$4-10/CY - fill
Floodwalls and Levees	$300-350/CY - concrete

New Development Design Criteria

Establishing and applying design criteria to new development proposals is one of the most effective non-structural means by which the County can control the drainage impacts of growth. However, design criteria must be carefully developed and applied utilizing a full understanding of the drainage systems throughout the County and the specific needs of individual basins and sub-basins. This understanding is usually gained through basin planning efforts and long-term system observation.

Drainage Plan Review/Approval

The plan review and approval process is another key element in effective management of stormwater systems for new developments. The demands on the plan reviewer include the following: a thorough familiarity with County requirements; sound understanding of basic hydrologic and hydraulic principles; working knowledge of the basins; understanding of constraints on developers; and a willingness to be creative in attaining goals within the framework of County requirements. In addition, the nature of the development review process requires an ongoing vigilance and attention to detail. Once the plans are approved, the opportunities to effect desirable storm drainage management measures are lost.

Building/Floodplain Permitting

Requirement for permits for individual, site specific properties, identified to be located in designated floodplain zones, allows the County to ensure the proposed use of the property is compatible with current floodplain ordinance and design criteria. Appropriate criteria and drainage solutions will need to be presented in order for a permit to be issued. The process would involve much the same elements as identified above for drainage plan review/approval.

Maintenance/Operation

Drainage maintenance, including maintenance of detention facilities, is currently the responsibility of the Operations Division of the Pima County Department of Transportation and Flood Control District. The majority of drainage maintenance generally occurs as a result of a citizen complaint or a flooding event.

There are many benefits of a well operated and maintained stormwater system. First, the useful life of capital facilities will be extended with proper maintenance. Second, well maintained systems should have fewer emergencies associated with system operation under extreme conditions (major storms), thereby reducing the County's liabilities for flood damage. Third, the maintenance staff will understand the system better by virtue of systematic maintenance and may be better able to fend off emergency situations.

Enforcement

Many flooding and water quality problems can be linked to lack of knowledge or are the by-products of current lifestyles. Public education is the appropriate response to lack of knowledge. However, there are people who, knowing the harmful results of their actions, choose to dispose of material in washes or channels, place obstructions in drainage facilities or pour hazardous substances into the stormwater system. For these situations, enforcement mechanisms need to be in place which fully convey the seriousness of the offense. Examples of typical enforcement options include citations, fines and penalties.

Public Education/Involvement

One of the more critical components of a comprehensive approach to storm drainage management is public education and involvement. Basin residents who understand their role in the watershed will not only reduce the potential for hazardous substance spills in the system, but will also be more likely to report spills or other changes they observe. The dual role of awareness and active involvement can go a long way in preserving and protecting watersheds, thus lowering the degree of dependence on "structural solutions". There are a variety of opportunities for public involvement which could greatly enhance stormwater management by raising resident awareness as to the importance of individual actions. It is the jurisdiction's responsibility to coordinate and sponsor public involvement in the stormwater program. Public education opportunities include public involvement programs connected to individual wash improvements, neighborhood associations near existing natural washes, and the construction industry through trade organizations.

Educational displays can provide ongoing reminders of the values of natural drainage systems. The displays can be shown in schools, libraries, shopping centers, community centers and other public gathering places to reach as many residents as possible.

A Best Management Practices (BMP) manual can be developed for distribution to watershed residents. Such a manual would describe actions which residents could take to maintain and improve conditions in the watershed.

There are many project-oriented programs which solicit public involvement and develop a sense of public identification and ownership of washes and other drainage system components. Following are examples of public involvement projects which the community can sponsor both to aid in preserving the systems and to encourage public support for drainage related issues.

- Wash Clean-up Days: Periodically, volunteer groups could be organized to remove debris and provide general clean-up of a specific wash. The effort could be coordinated with regional and local political figures to broaden awareness among different sectors of the watershed residents.

- Signing: Designing and installing signs identifying the washes would regularly remind residents of the washes' presence and trigger greater understanding of their condition during subsequent County preservation or enhancement efforts. Local service organizations (i.e., Kiwanis, Boy Scouts) are often eager to assist in manufacturing, placing and maintaining such signs.

Ordinances/Policies

- Zoning restriction regulations
- Maintain existing floodplain limits via regulations
- Basin Management Plans

Through the proper use of ordinances and land-use planning, several stormwater goals can be achieved. By controlling the location, extent and density of land-use and related activities, the quantity and quality of storm runoff can be influenced and capacities of the existing drainage system preserved. Brief discussions of the types of ordinances in general use are presented below.

- Stormwater Management Ordinances are typically used to limit runoff from a developing site to pre-development characteristics. Approval of drainage plans which include runoff-control facilities (onsite retention/detention) is typically required as a centerpiece of such ordinances. Implementation of the ordinance is predicated upon the development of design standards by the jurisdiction.

- Clearing/Filling/Grading Ordinances recognize the need to manage efforts associated with removal of vegetation and movement of soils. They may include restrictions on clearing, filling or stockpiling of soils on a site, or movement of soils or fill to other than naturally occurring elevations (grading).

- Erosion/Sediment Control Ordinances have been used by some jurisdictions instead of, or as a supplement to, a clearing/filling/grading ordinance to ensure that, from the start of vegetation removal through completion of construction, the loss of sediment from a site is limited.

- Floodplain Management Ordinances are typically developed in compliance with Federal flood insurance requirements and include restrictions on development within the 100-year floodplain associated with major bodies of water. The availability of and ability to purchase flood insurance is one of the most effective inducements for encouraging community adoption of a floodplain management ordinance.

- Sensitive Areas Ordinances include a variety of measures to prevent degradation of washes, steep slopes, riparian habitats and other vicinity-specific features. Most typically such ordinances limit the uses of sensitive areas and reserve an undisturbed "buffer zone" adjacent to the areas.

- Zoning Ordinances can be used to protect critical areas such as floodplains and steep slopes from impacts due to unplanned development. These ordinances can also be used to regulate the density of population and intensity of land use.

- Subdivision regulations may complement, but not supersede the zoning ordinance. Whereas zoning regulations describe where different types of land use shall occur, subdivision regulations describe <u>how</u> the development shall occur to ensure proper functioning of the development.

Organization/Management

An organizational structure which provides the staffing and authority to implement stormwater policies and regulatory requirements for a proactive stormwater management program.

Planning

Components of the physical storm drainage system may be constructed by various agencies and jurisdictions such as highway/road departments, Town of Marana and developers. Stormwater control efficiency can be better achieved through planning processes which can be readily followed and implemented by all agencies.

Intergovernment/Interagency Interaction

There must be a clear delineation of responsibilities for drainage system improvements and maintenance within each watershed, particularly when a watershed crosses jurisdictional boundaries. Responsibilities must also be made clear when a jurisdiction is crossed by a facility maintained by another agency (such as a state highway). Intergovernmental Agreements (IGA) should identify responsibilities of each participating entity and the maintenance standards and frequencies to be used.

Development Inspection

The critical link between establishment of sound design criteria, plan review and stormwater protection is field inspection. Inspectors must understand stormwater issues and communicate with others involved in stormwater management. Inspectors are key to identification of problem areas, erosion control and compliance with design plans.

Monitoring

Monitoring of physical system characteristics, such as rainfall, water quantity, slope and channel stability, increases the understanding of the hydrologic characteristics of the area, thus increasing the ability to design facilities and implement measures to address problems and make best use of available resources.

Data-Base Management

Data-base management includes the collection, recording and cataloging of data pertaining to the stormwater system such as as-built drawings, complaints, reports, easements and fee title properties and construction documents. A good data-base aids in system design and analysis and increases the efficiency of maintenance efforts.

Complaint/Emergency Response

Awareness of a stormwater program comes when residents observe a problem with the storm drainage system. The community's response to a complaint often forms the basis for that resident's subsequent opinion of the community's effectiveness. Thus, a well managed complaint and emergency response program can be a foundational element of a community-supported stormwater management program.

Flood Warning/Monitoring

Collection of water quantity and quality data is integral to system analysis. In the absence of data, conservative assumptions are made to assess the range of outcomes from a given action or event. An increase in understanding of the hydrologic and water quality characteristics of an area increases the ability to design facilities and implement measures which both address the problems and make the best use of available resources.

Monitoring of physical system characteristics, such as water quantity, water quality, groundwater, and slope stability, may include the following:

- Baseline monitoring to determine the "background" characteristics.

- Storm event monitoring to determine the impacts of storms on the physical system such as rainfall measurements, locations of flooding, peak flows and volumes, and levels of pollutants.

- Enforcement monitoring to identify the source of a hazardous substance spill into the stormwater system.

- Emergency response system which will notify local jurisdiction/agency of impending storm/high water level potential, and means to notify residents to implement flood control measures or evacuation procedures.

- Pima County has a flood warning system, ALERT (Automated Local Evaluation in Real Time) system which includes over 50 sensors and has been operating continuously over 10 years. Data generated is available to certain users such as Department of Environmental Quality, City of Tucson and National Weather Service.

- Intergovernmental agreements can be executed to benefit both water quantity and quality control. Such agreements should identify responsibilities of each participating entity and the maintenance standards and frequencies to be used. In this regard, an agreement has been pending between Pima County and the City of Tucson for some time.

Financing

Available financial resources largely determine the community's ability to attain its stated goals. The level of funding is critical in determining whether structural or non-structural solutions should be applied to a particular problem.

Do Nothing

Based on existing land use, future land use, drainage conditions, existing and proposed infrastructure; a "do-nothing" component will be evaluated as to feasibility and impacts to the specific watershed area(s).

B. *STRUCTURAL COMPONENTS*

Structural improvements are defined as constructed drainage facilities or physical alterations to the existing conveyance system to control flows. These improvements can be classified as "hard" or "soft," examples of which are listed below:

Hard Improvements	Soft Improvements
Storm Drains	Landscaped storage facilities
Culverts	Vegetated and unlined channels
Lined channels	

The traditional response to correcting stormwater problems has been to construct structural improvements to control flows. The most effective and economical structural drainage system is a mix of hard and soft elements. Finding the optimal mix of elements is one goal of the Tortolita Area Basin Management Plan and will be accomplished through preparation of draft basin management plans for each basin.

For purposes of the Tortolita Area Basin Management Plan, there exist six general types of structural improvements commonly used to mitigate flood damage. These include channels, storm drains/culverts, stormwater storage facilities designed to release stormwater at a controlled rate and/or permanently store runoff, grade control structures/energy dissipators, and levees. Channels include various options such as vegetation-lined channels, use of natural channels with some clearing and erosion-control works, channels lined with artificial materials, and hybrid channel designs that include such features as natural inverts with retaining walls. Storm drains and culverts are utilized primarily to convey design flows beneath structures and roadways. Storage refers to the concept of the temporary storage of stormwater for subsequent release, at controlled rates into downstream conveyance systems (detention) or into the subsurface (retention). Grade control structures and energy dissipators are site specific erosion control methods. Levees are utilized to confine flow to specific areas such as channels or areas of ponding.

Soft improvements may be more economical than hard improvements when acquisition of land for right-of-way purposes is not a constraint and when developed in conjunction with master drainage plans. As previously indicated, soft improvements include such items as natural drainageways, artificial lakes and channels lined with vegetation. Aesthetic and open space considerations can be incorporated relatively easily into soft improvements, and environmental benefits may also be derived through the contact of runoff with vegetative linings along channels and detention basins. The water quality of runoff is generally improved by contact with natural surfaces at relatively low velocities, and temporary storage in detention ponds permits suspended sediments to settle. Control of water quality is essential to full realization of the potential benefits to be realized from stormwater management. Costs associated with soft improvements may include additional right-of-way needed to construct less hydraulically efficient channels, landscaping and irrigation systems, and long-term maintenance.

Design of soft improvements must also include implementation of adequate operation and maintenance procedures. The design of such improvements should, therefore, be maintenance-oriented. For example, the inclusion of a vegetation lining in the design of a channel or detention/retention facility should consider such items as the need for irrigation, regrading, reseeding, replacement of shrubs or trees; and periodic trimming and mowing.

Typical structural measures are described in the following text with associated Unit Cost:

	Unit Cost
Structure Relocation Structure relocation consists of physical relocation of existing structures within a flood- or erosion-hazard area as a means of reducing or eliminating personal flood risks and potential damages to existing properties and structures.	$30,000-$60,000/ structure
Improved Drainage Channels/Corridors	
Bank Protection	
Riprap	$40-75/CY
Rock and Rail	$170/LF
Soil Cement	$90-200/LF
Concrete	$25/SY
Geotextiles	$15-20/SY
Modular Lining	$45/SY

	Unit Cost
Flexible Lining (unit cost may vary depending on excavation cost and supplemental slope stabilization)	$ 15/SY
Concrete (fully lined)	$180/CY
Channelization	
Encroachment	
Channel Parkways	$.50/SF (Landscaping)
Vegetated/Unlined Channels	$4/CY (Excavation)

- Many natural channels in the Tortolita Area generally have mild slopes and are not seriously agrading or degrading. However, if a natural channel is to be utilized to carry storm runoff from a newly urbanized area, erosion will occur due to the altered nature of the runoff peaks, volumes, and sediment load. Without upstream diversion of runoff away from the channel or storage as a means of reducing levels of runoff and, thus, protecting existing natural conditions, this phenomenon often results in a need for some modifications to the channel to assure stabilized conditions. This scenario has occurred repeatedly throughout the study area as the area has become increasingly developed.

Therefore, as urbanization continues throughout the Tortolita Area, stabilization of channels is likely to be an accompanying process depending upon the level of protection desired by the community. In addition to the option of preserving channels in their current state, several choices of channel stabilization designs are available to the community. These include vegetation, rock, synthetic fabrics, soil cement, gunite, and concrete. The choice of channel lining is generally a function of aesthetics, the desired capacity of the channel, availability of land for right-of-way needs, hydraulic parameters such as existing land slopes, and desired level of operation and maintenance for the life of the channel. The choice of channel lining should also be a function of wildlife benefits, local neighborhood and adjacent property owner needs, existing condition of the resource, and community visibility of the project.

Establishing vegetation in a channel increases the channel's resistance to erosion, thereby contributing to water quality preservation and the structural stability of the channel. Vegetated channels are also aesthetically pleasing in comparison to some other structural improvements. Establishment of vegetation must be accounted for in the hydraulic design of the channel, and sufficient right-of-way must exist to accommodate the channel and maintenance accesses. The vegetation must also be maintained regularly to avoid obstruction of flows, to minimize weed infestations and to ensure desired plant establishment. Revegetation and management approaches must be continually tested and updated to improve success rates.

"Hard" channel stabilization methods protect channel banks and floors from the erosive forces of runoff. These measures include rock lining, gabions, revet mattresses, and gunite or concrete lining. Some of these measures also serve to increase both the flow capacity of the channel and downstream flood peaks by creating more uniform and efficient hydraulic sections. An additional benefit is a relatively narrow cross section, which may allow for the preservation of existing vegetation and space for trails, if sensitively designed. Drawbacks to these measures are high cost, hazards associated with high flow velocities, little or no water quality benefits, and lower aesthetic value. Maintenance requirements are typically lower, however, than for comparable vegetated channels.

Dip Crossings

Roadway dip crossings are at-grade crossings of washes primarily used in rural or suburban areas where all-weather access is neither necessary nor economically feasible.

Unit Cost

$30/LF - concrete cutoff wall

Culverts/Storm Drains

Storm drains and culverts are the most commonly used method of stormwater conveyance in urbanizing areas. They are particularly well suited to developed areas where available land area is restricted. In less intensely developed areas, culverts are widely used to pass storm flows under roadways. Storm drains are used to convey flows to major natural drainages and to divert excess runoff from erodible or floodprone locations.

$300-350/CY - cast in place concrete
$1-1.50/inch of diameter - CMP
$2-3/inch of diameter - RCP/Aluminum
$1.50-$2.50/inch of diameter - spiral rib

Proper sizing of storm drains and culverts to meet flow demands throughout their expected service life is achieved through careful basin planning and specific site analysis during design. Storm drains serve to accelerate the flow rate of stormwater and may in turn contribute to faster concentration of runoff within a basin and greater downstream flooding. Routine maintenance of storm drains, culverts (especially those with flatter slopes) and associated catch basins is necessary to preserve design capacity and ensure proper functioning during flow events.

	Unit cost
Bridges	
Bridges would be employed where a significant wash, or system of braided washes, would need to be spanned, primarily along a major roadway alignment. Bridges would be employed when the peak discharge becomes greater than the conveyance capacity of standard culverts, or if erosion/sedimentation would clog culverts.	$65/SF
Detention/Retention Facilities	$4/CY (excavation only)
Regional	
Local	
Constructed storage facilities, used to supplement natural storage created by channels and topographic depressions, can consist of: short-term detention of runoff, on-line or off-line of conveyance facilities, and longer-term retention of runoff. The primary purpose of these facilities is to lower peak flow rates so as to reduce downstream flooding. However, they may also be designed to meet multiple objectives including: reduce onsite flooding; capture sediments; reduce water pollution; enhance the appearance of the community by promoting vegetation and use of the facility by wildlife; replenish groundwater; and provide recreational benefits.	

Stormwater detention facilities may take a variety of forms with regard to the existing drainage system. If feasible, natural areas such as channels and topographic depressions can be modified to meet stormwater management objectives. Constructed facilities may be designed as a continuation of a natural or constructed channel ("on-line") or as separate from the channel ("off-line"). Six locations are typically considered for detention: 1) subsurface storage; 2) rooftop storage; 3) parking lot storage; 4) recreational area storage; 5) storage in ponds or lakes; and 6) underground storage in seepage pits and groundwater recharge facilities. Storage facilities may occur as small, onsite basins designed to serve individual developments or as larger-scale, regional facilities designed to serve a large watershed area. Because of the volume of stormwater required, "regional" facilities are often integrated with other uses requiring large land areas or having other common attributes. Recreational facilities such as parks, ballfields, golf courses, trails, and open space uses are often incorporated into the design of regional detention facilities. Detention facilities can also be designed to provide enhanced sediment removal. Because many pollutants within stormwater attach themselves to and are transported by sediment particles, sediment removal often provides a large benefit in terms of water quality. Inflatable structures can be utilized to impound runoff during high frequency events. The structure can then be deflated during major flow events to allow flow to pass unobstructed.

Retention systems preclude the passage of runoff downstream by collecting and storing the entire volume of a runoff event. The runoff is released through evaporation and percolation into the underlying soils. Groundwater recharge may be incorporated into retention facilities; however, the potential for groundwater pollution must be considered in this option. Groundwater recharge systems include drywells and engineered infiltration beds. Perforated pipes and permeable paving materials may also be utilized for infiltration purposes within urban settings where small retention systems are desired.

	Unit Cost
Sediment Basins These are structures which may be utilized to collect incoming sediment loads to prevent clogging, siltation, agradation, and are usually implemented in conjunction with detention/retention facilities, culverts, and channels; as required.	$4/CY (excavation only)
Erosion Protection/Energy Dissipation Structures/Grade-Control Structures (Check Dams) Measures to protect channel bottom, channel sides, fill slopes, inlets/outlets to drainage structures, natural surfaces exposed to runoff are employed to prevent erosion of native/placed material. Grade-control structures, dams and energy dissipators are used to decrease the velocity of concentrated flows, thereby reducing erosion in a channel, and can also be employed to stabilize stream beds. Grade control structures and energy dissipators are constructed of both	$75-350/CY - concrete/ soil cement

natural and man-made materials and often have a low capital cost. They must be inspected and maintained regularly to ensure stability.

Levees/Dikes/Dams/Floodwalls/Diversion Structures (Potentially effective at apices and avulsion zones)	Unit Cost
These are structures designed to contain and control stormwater within specific areas or limits.	$300-350 CY concrete and $4-10/CY fill
Improvement to I-10/Southern Pacific Railroad	
Culverts	$300-350/CY - cast in place concrete
Channels/Collector systems	
Soil Cement	$90-200/LF
Concrete	$25/CY
Detention/Retention Facilities	$4/CY (excavation only)

Undersized Conveyance Systems (culverts) under I-10 and the Southern Pacific Railroad create ponding and flooding upstream of these structures. Improvements to I-10 and Southern Pacific Railroad drainage facilities and inherent physical features may be utilized to improve drainage conditions for properties east and west of I-10 as runoff is conveyed out of the Tortolita Area.

Roadway Improvements	Unit Cost
Detention/Retention Facilities	$4/CY (excavation only)
Collector Systems/Channels	$90-200/LF (soil cement)
	$25/CY (concrete)
Culverts	$300-350/CY cast in place concrete
Bridges	$65/SF
Storm Drains	$1-1.50/diameter inch - CMP

$2-3/diameter inch - RCP
$4-10/CY fill

Roadway Levees

As roads are improved/constructed in the Tortolita Area, they provide a unique opportunity to concentrate, collect, divert and convey runoff which may improve/mitigate adjacent drainage conditions.

Street (Parking Lot) Conveyance $15-$25/SY

Street design consists of street planning on two levels: design of streets to convey stormwater runoff and layout of streets within developing areas according to natural terrain.

Pima County has utilized streets to convey storm runoff in the past. In general, the design criteria for street conveyance has generally been the 10-year event or less, particularly in conjunction with use of storm drains. In some instances, however, streets have been designed to convey runoff resulting from events as large as the 100-year as long as depths and velocities of flow did not exceed certain limits.

Layout of streets in developing areas according to natural terrain allows the existing, natural drainage system to be protected. It also minimizes the need for roadway crossings of the existing washes.

SECTION 5. EVALUATION OF COMPONENTS

Flood control components identified in Section 4 have been evaluated for their individual effectiveness on a watershed basis to determine the components that most effectively mitigate drainage/flooding concerns identified in each of the watersheds investigated in this study. Structural and non-structural components were evaluated utilizing a selection matrix. The selection matrices (Tables 5,5A through 9,9A) evaluate effectiveness/value/compliance with regulations for each flood control component relative to specific evaluation criteria, while taking into consideration existing and proposed watershed characteristics. If a component was considered effective relative to a given evaluation criteria, the component was considered to be positive and was rated between a range of 7 and 12, with 12 being highly effective, 8 moderately effective and 7 neutral (i.e., component has no impact on evaluation criteria). If a component was considered noneffective relative to a given evaluation criteria, the component was considered to be negative and was rated between a range of 7 and 0, with 0 being highly negative (i.e., does not mitigate drainage/flooding concerns or is a noneffective component for the given watershed relative to the specific evaluation criteria).

To aid in the evaluation of structural and non-structural components, watershed characteristics (existing and future) and future proposed capital improvements projects were identified (Tangerine Road an I-10 [ADOT] and Santa Cruz River Tributaries Study [CMG Engineering]). In addition, associated hydraulic/hydrologic assessments were conducted for each watershed.

Hydraulic/hydrologic assessments consisted of:

1. Hydraulic/hydrologic evaluation of proposed regional detention/retention facilities to determine the required size and volume needed to reduce the 100-year peak discharge and associated flooding at selected locations, i.e. regulatory floodplains (HEC-1 model, Appendix B).

2. Hydraulic/hydrologic evaluation of channel improvements consisting of a possible 100-year floodplain encroachment (total width of floodplain) utilizing regulations established for spine washes (HEC-1 Model, Appendix B and Floodplain Maps, Appendix C).

TABLE 5

Flood Control Components Selection Criteria Matrix

NORTH RANCH BASIN

NON-STRUCTURAL

	EVALUATION CRITERIA	FLDPLN ACQ.	FLOOD-PROOFING	DESIGN CRITERIA	PLAN REVIEW	FLDPLN PERMITTNG	MAINT. OPERATION	ENFORCE-MENT	EDUCATION	ORDS. POLICIES	ORG/ MGMT	PLANNING	INTER GOV AGENCY INTERACTN	DEV. INSPEC.	FLOOD MONITOR-ING	DATA BASE MGMT.	COMPLAINT EMERG. RESPONSE	POLLUTION MONITORNG	DO NOTHING	WEIGHT FACTOR
1	Engineering Feasibility	8	10	8	12	8	10	8	12	8	10	8	8	8	12	10	10	10	12	2
2	Acceptability to Public	12	7	7	8	7	10	10	12	10	10	12	12	10	10	10	10	10	2	2
3	Implementation Cost	2	2	8	8	6	8	8	10	8	4	6	6	4	4	4	4	4	12	2
4	Effectiveness	8	10	12	12	12	12	12	10	10	12	12	12	12	10	10	10	8	2	3
5	Transportation	8	8	10	12	8	10	8	8	10	10	10	10	10	8	10	8	8	2	1
6	Short Term vs. Long Term Effects	12	10	10	12	12	10	8	10	12	12	12	12	10	10	12	10	8	2	1
7	Benefit Area vs. Impact Area	10	2	8	10	8	12	12	12	12	12	12	12	10	10	10	8	12	2	2
8	ROW Restrictions/Requirements	2	10	8	12	8	12	12	12	8	10	10	10	10	10	10	8	10	12	1
10	Maintenance Requirements	10	2	10	8	10	12	8	10	10	10	10	10	10	8	10	6	8	12	1
9	Multiple Use Potential	12	2	10	10	8	8	8	10	8	10	10	10	10	8	8	8	8	8	1
10	Impact on Infiltration	12	8	8	8	8	10	10	8	8	10	10	10	10	8	8	8	8	4	1
12	Loss of Flow Attenuation	12	8	8	8	8	12	10	8	8	10	10	10	10	8	8	8	8	4	1
13	Env. Considerations	12	8	10	10	10	12	10	12	10	10	10	10	10	8	10	8	10	4	2
14	Water Quality	10	8	8	8	8	8	10	10	10	10	10	10	10	8	10	8	10	4	2
15	Aesthetics	12	4	10	8	8	12	12	12	10	10	10	10	10	8	10	8	10	4	2
16	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	1
17	Pima Co., State, Fed. Regs. (General)	8	10	8	8	8	10	12	10	12	10	10	10	10	10	10	12	10	2	1
18	FEMA Criteria/Regulations	10	8	8	8	8	10	12	10	12	10	10	10	10	12	12	12	12	2	3
19	Compat. with Existing Land Uses	10	12	10	12	8	8	8	10	10	10	10	10	10	12	10	10	10	8	3
20	Compat. with Proposed Land Uses	10	12	10	12	10	10	10	10	10	10	10	10	10	10	10	10	10	4	3
21	Riparian Habitat Protection	12	10	12	12	6	8	10	10	12	10	10	10	10	10	10	10	8	12	3
	OVERALL EVALUATION	8.8	7.3	8.5	9.1	7.7	9.1	9.1	9.4	9.1	9.0	9.1	9.1	8.8	8.6	8.8	8.2	8.4	5.2	38.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 5A

Flood Control Components Selection Criteria Matrix

NORTH RANCH BASIN

STRUCTURAL

	EVALUATION CRITERIA	STRUC RELOC	IMPR CHANNELS	DIP CROSSINGS	BRIDGES	DET/RET FACILITY REGIONAL	SEDMNT BASINS	ENRGY DSP GRADE CONTROL	EROSION PROTCT	LEVEES DIKES FLDWLLS	DIVRSN STRCTRS	I-10 SPRR	RDWAY IMPR	STREET CONVEY	CULVERTS STRM DRNS					WEIGHT FACTOR
1	Engineering Feasibility	8	10	12	12	10	10	12	12	8	2	8	8	4	12					2
2	Acceptability to Public	6	10	6	10	8	8	10	8	6	2	10	10	4	12					2
3	Construction Cost (Design)	2	6	12	6	8	8	10	6	8	2	8	6	6	10					2
4	Effectiveness	10	10	6	12	10	8	12	12	12	12	10	6	4	12					3
5	Transportation	8	10	6	12	10	10	10	10	10	10	10	12	4	12					1
6	Short Term vs. Long Term Effects	10	12	10	12	10	6	8	12	12	6	8	12	8	8					1
7	Phased Constr. Potential	12	12	12	10	12	10	12	6	12	2	12	12	12	12					1
8	Benefit Area vs. Impact Area	2	10	7	7	10	10	8	8	6	2	6	4	2	7					2
9	ROW Restrictions/Requirements	2	2	12	8	2	2	2	2	6	2	4	10	12	7					1
10	Utility Conflicts	10	2	6	6	10	10	10	8	6	6	2	2	6	4					1
11	Maintenance Requirements	12	8	10	10	8	4	10	10	8	2	8	10	8	6					1
12	Multiple Use Potential	2	12	4	6	12	6	2	2	4	2	2	8	2	4					1
13	Impact on Infiltration	8	6	7	7	12	12	10	8	8	10	8	6	2	7					1
14	Loss of Flow Attenuation	8	2	7	7	12	12	8	6	7	10	8	8	6	10					1
15	Env. Considerations	8	6	10	10	8	8	10	6	7	4	6	8	2	7					2
16	Water Quality	8	7	8	10	8	6	10	8	8	2	6	6	4	7					2
17	Aesthetics	10	10	10	12	12	6	8	2	2	2	8	8	6	10					2
18	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	8	8	8	10					1
19	Pima Co., State, Fed. Regs. (General)	12	8	12	8	8	8	10	8	8	8	8	12	8	8					1
20	FEMA Criteria/Regulations	8	8	12	8	8	12	10	8	8	8	12	12	12	12					3
21	Compat. with Exist.	10	8	12	8	12	7	10	10	6	2	12	12	2	8					3
22	Compat. with Proposed Land Uses	8	10	2	8	12	12	12	12	10	2	12	12	6	12					3
23	Financing	6	6	10	6	4	4	8	4	4	4	8	10	10	10					3
24	Riparian Habitat Protection	12	12	12	12	12	12	12	12	12	12	12	12	12	12					2
	OVERALL EVALUATION	7.9	8.4	9.0	9.0	9.4	8.5	9.7	8.2	7.7	5.0	8.8	9.0	6.1	9.6	0.0	0.0	0.0	0.0	42.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 6

Flood Control Components Selection Criteria Matrix

CANADA AGUA BASIN

NON-STRUCTURAL

	EVALUATION CRITERIA	FLDPLN ACQ.	FLOOD-PROOFING	DESIGN CRITERIA	PLAN REVIEW	FLDPLN PERMITTNG	MAINT. OPERATION	ENFORCE-MENT	EDUCATION	ORDS. POLICIES	ORG/ MGMT	PLANNING	INTER GOV AGENCY INTERACTN	DEV. INSPEC.	FLOOD MONITOR-ING	DATA BASE MGMT.	COMPLAINT EMERG. RESPONSE	POLLUTION MONITORNG	DO NOTHING	WEIGHT FACTOR
1	Engineering Feasibility	8	10	8	12	8	10	8	12	8	10	8	8	8	12	10	10	10	12	2
2	Acceptability to Public	12	7	7	8	7	10	10	12	10	10	12	12	10	10	10	10	10	2	2
3	Implementation Cost	2	2	8	8	6	8	8	10	8	4	6	6	4	4	4	4	4	12	2
4	Effectiveness	8	10	12	12	12	12	12	10	10	12	12	12	12	10	10	10	8	2	3
5	Transportation	8	8	10	12	8	10	8	8	10	10	10	10	10	8	10	8	8	2	1
6	Short Term vs. Long Term Effects	12	10	10	12	12	10	8	10	12	12	12	12	10	10	12	10	8	2	1
7	Benefit Area vs. Impact Area	10	2	8	10	8	12	12	12	12	12	12	12	10	10	10	8	12	2	2
8	ROW Restrictions/Requirements	2	10	8	12	8	12	12	12	8	10	10	10	10	10	10	8	10	12	1
9	Maintenance Requirements	10	2	10	8	10	12	8	10	10	10	10	10	10	8	10	6	8	12	1
10	Multiple Use Potential	12	2	10	10	8	8	8	10	8	10	10	10	10	8	8	8	8	8	1
11	Impact on Infiltration	12	8	8	8	8	10	10	8	8	10	10	10	10	8	8	8	8	4	1
12	Loss of Flow Attenuation	12	8	8	8	8	12	10	8	8	10	10	10	10	8	8	8	8	4	1
13	Env. Considerations	12	8	10	10	10	12	10	12	10	10	10	10	10	8	10	8	10	4	2
14	Water Quality	10	8	8	8	8	8	10	10	10	10	10	10	10	8	10	8	10	4	2
15	Aesthetics	12	4	10	8	8	12	12	12	10	10	10	10	10	8	10	8	10	4	2
16	Jurisdictional Boundaries	8	10	8	8	10	8	8	10	8	10	10	10	8	8	8	8	8	8	1
17	Pima Co., State, Fed. Regs. (General)	8	10	8	8	8	10	12	10	12	10	10	10	10	10	10	12	10	2	1
18	FEMA Criteria/Regulations	10	8	8	8	8	10	12	10	12	10	10	10	10	12	12	12	12	2	3
19	Compat. with Existing Land Uses	10	12	10	12	8	8	8	10	10	10	10	10	10	12	10	10	10	8	3
20	Compat. with Proposed Land Uses	10	12	10	12	10	10	10	10	10	10	10	10	10	10	10	10	10	4	3
21	Riparian Habitat Protection	12	10	12	12	8	8	10	10	12	10	10	10	10	10	10	10	8	12	3
	OVERALL EVALUATION	8.7	7.3	8.4	9.1	7.8	9.0	9.0	9.4	9.1	9.0	9.1	9.1	8.8	8.6	8.8	8.2	8.4	5.2	38.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 6A

Flood Control Components Selection Criteria Matrix

CANADA AGUA BASIN

STRUCTURAL

	EVALUATION CRITERIA	STRUC RELOC	IMPR CHANNELS	DIP CROSSINGS	BRIDGES	DET/RET FACILITY REGIONAL	SEDMNT BASINS	ENRGY DSP GRADE CONTROL	EROSION PROTCT	LEVEES DIKES FLDWLLS	DIVRSN STRCTRS	I-10 SPRR	RDWAY IMPR	STREET CONVEY	CULVERTS STRM DRNS					WEIGHT FACTOR
1	Engineering Feasibility	8	10	12	12	10	10	12	12	8	2	8	8	4	12					2
2	Acceptability to Public	6	10	6	10	8	6	10	8	6	2	10	10	4	12					2
3	Construction Cost (Design)	2	6	12	6	8	8	10	6	8	2	8	6	6	10					2
4	Effectiveness	10	10	6	12	10	8	12	12	12	12	10	6	4	12					3
5	Transportation	8	10	6	12	10	10	10	10	10	10	10	12	4	12					1
6	Short Term vs. Long Term Effects	10	12	10	12	10	6	8	12	12	6	8	12	8	8					1
7	Phased Constr. Potential	12	12	12	10	12	10	12	6	12	2	12	12	12	12					1
8	Benefit Area vs. Impact Area	2	10	7	7	10	10	8	8	6	2	6	4	2	7					2
9	ROW Restrictions/Requirements	2	2	12	8	2	2	2	2	6	2	4	10	12	7					1
10	Utility Conflicts	10	2	6	6	10	10	10	8	6	6	2	2	6	4					1
11	Maintenance Requirements	12	8	10	10	8	4	10	10	8	2	8	10	8	6					1
12	Multiple Use Potential	2	12	4	6	12	6	2	2	4	2	2	8	2	4					1
13	Impact on Infiltration	8	6	7	7	12	12	10	8	8	10	8	6	2	7					1
14	Loss of Flow Attenuation	8	2	7	7	12	12	8	6	7	10	8	8	6	10					1
15	Env. Considerations	8	6	10	10	8	8	10	6	7	4	6	8	2	7					2
16	Water Quality	8	7	8	10	8	6	10	8	8	2	6	6	4	7					2
17	Aesthetics	10	10	10	12	12	6	8	2	2	2	8	8	6	10					2
18	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	8	8	8	10					1
19	Pima Co., State, Fed. Regs. (General)	12	8	12	8	8	8	10	8	8	8	8	12	8	8					1
20	FEMA Criteria/Regulations	8	8	12	8	8	12	10	8	8	8	12	12	12	12					3
21	Compat. with Exist.	10	8	12	8	12	7	10	10	6	2	12	12	2	8					3
22	Compat. with Proposed Land Uses	8	10	2	8	12	12	12	12	10	2	12	12	6	12					3
23	Financing	6	6	10	6	4	4	8	4	4	4	8	10	10	10					3
24	Riparian Habitat Protection	12	6	6	8	10	10	8	6	6	6	10	10	12	12					2
	OVERALL EVALUATION	7.9	8.1	8.7	8.9	9.3	8.3	9.5	7.9	7.5	4.7	8.7	9.0	6.1	9.6	0.0	0.0	0.0	0.0	42.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 7

Flood Control Components Selection Criteria Matrix

PROSPECT BASIN

NON-STRUCTURAL

	EVALUATION CRITERIA	FLDPLN ACQ.	FLOOD-PROOFING	DESIGN CRITERIA	PLAN REVIEW	FLDPLN PERMITTNG	MAINT. OPERATION	ENFORCE-MENT	EDUCATION	ORDS. POLICIES	ORG/ MGMT	PLANNING	INTER GOV AGENCY INTERACTN	DEV. INSPEC.	FLOOD MONITOR-ING	DATA BASE MGMT.	COMPLAINT EMERG. RESPONSE	POLLUTION MONITORNG	DO NOTHING	WEIGHT FACTOR
1	Engineering Feasibility	8	12	8	12	6	8	8	12	8	10	8	8	8	8	10	10	8	12	2
2	Acceptability to Public	12	7	7	8	7	10	10	12	10	10	12	12	10	10	10	10	10	2	2
3	Implementation Cost	2	2	8	8	6	6	8	10	8	4	6	6	4	4	4	4	4	12	2
4	Effectiveness	8	10	12	12	12	12	12	10	10	12	12	12	12	10	10	10	8	2	3
5	Transportation	8	8	10	12	8	10	8	8	10	10	10	10	10	8	10	8	8	2	1
6	Short Term vs. Long Term Effects	12	12	10	12	12	10	8	10	12	12	12	12	10	10	12	10	8	2	1
7	Benefit Area vs. Impact Area	10	2	8	10	8	12	12	12	12	12	12	12	10	10	10	8	12	2	2
8	ROW Restrictions/Requirements	2	10	8	12	8	12	12	12	8	10	10	10	10	10	10	8	10	12	1
9	Maintenance Requirements	10	2	10	8	10	12	8	10	10	10	10	10	10	8	10	6	8	12	1
10	Multiple Use Potential	12	2	10	10	8	8	8	10	8	10	10	10	10	8	8	8	8	8	1
11	Impact on Infiltration	12	8	8	8	8	10	10	8	8	10	10	10	10	8	8	8	8	4	1
12	Loss of Flow Attenuation	12	8	8	8	8	12	10	8	8	10	10	10	10	8	8	8	8	4	1
13	Env. Considerations	12	8	10	10	10	12	10	12	10	10	10	10	10	8	10	8	10	4	2
14	Water Quality	10	8	8	8	8	8	10	10	10	10	10	10	10	8	10	8	10	4	2
15	Aesthetics	12	4	10	8	8	12	12	12	10	10	10	10	10	8	10	8	10	4	2
16	Jurisdictional Boundaries	8	10	8	8	10	6	8	10	8	10	10	10	6	8	8	8	8	8	1
17	Pima Co., State, Fed. Regs. (General)	8	10	8	8	8	10	12	10	12	10	10	10	10	10	10	12	10	2	1
18	FEMA Criteria/Regulations	10	8	8	8	8	10	12	10	12	10	10	10	10	12	12	12	12	2	3
19	Compat. with Existing Land Uses	10	12	10	12	8	8	8	10	10	10	10	10	10	12	10	10	10	8	3
20	Compat. with Proposed Land Uses	10	12	10	12	10	10	10	10	10	10	10	10	10	10	10	10	10	4	3
21	Riparian Habitat Protection	12	10	12	12	8	8	10	10	12	10	10	10	10	10	10	10	8	12	3
	OVERALL EVALUATION	8.7	7.4	8.4	9.1	7.7	8.8	9.0	9.4	9.1	9.0	9.1	9.1	8.7	8.4	8.8	8.2	8.3	5.2	38.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 7A

Flood Control Components Selection Criteria Matrix

PROSPECT BASIN

STRUCTURAL

	EVALUATION CRITERIA	STRUC RELOC	IMPR CHANNELS	DIP CROSSINGS	BRIDGES	DET/RET FACILITY REGIONAL	SEDMNT BASINS	ENRGY DSP GRADE CONTROL	EROSION PROTCT	LEVEES DIKES FLDWLLS	DIVRSN STRCTRS	I-10 SPRR	RDWAY IMPR	STREET CONVEY	CULVERTS STRM DRNS					WEIGHT FACTOR
1	Engineering Feasibility	8	8	12	6	10	10	12	12	8	2	10	10	4	8					2
2	Acceptability to Public	6	10	6	10	8	8	10	8	6	2	10	10	6	12					2
3	Construction Cost (Design)	2	2	12	8	8	8	10	6	8	2	8	6	6	10					2
4	Effectiveness	10	10	6	12	10	8	12	12	12	12	10	8	6	12					3
5	Transportation	8	10	6	12	10	10	10	10	10	10	10	12	4	12					1
6	Short Term vs. Long Term Effects	10	12	12	12	10	6	8	12	12	6	10	8	10	8					1
7	Phased Constr. Potential	12	8	12	10	10	10	10	6	10	2	10	8	6	12					1
8	Benefit Area vs. Impact Area	2	10	7	7	10	10	8	8	6	2	6	8	8	7					2
9	ROW Restrictions/Requirements	2	2	12	8	2	2	6	2	8	2	4	6	12	7					1
10	Utility Conflicts	10	2	6	6	10	10	10	8	6	6	6	4	6	4					1
11	Maintenance Requirements	12	10	10	10	8	4	8	8	8	2	8	4	10	6					1
12	Multiple Use Potential	2	12	4	7	12	6	2	2	4	2	2	8	2	4					1
13	Impact on Infiltration	8	6	7	7	12	12	8	6	7	10	7	6	2	7					1
14	Loss of Flow Attenuation	8	2	7	7	12	12	8	6	7	10	7	8	2	10					1
15	Env. Considerations	8	6	10	10	8	8	10	6	6	4	7	8	2	8					2
16	Water Quality	8	7	8	8	8	6	10	6	8	2	7	6	2	7					2
17	Aesthetics	10	10	10	10	12	6	8	2	2	2	8	8	6	10					2
18	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	8	10	10	10					1
19	Pima Co., State, Fed. Regs. (General)	12	8	10	8	8	8	8	8	8	8	8	8	8	8					1
20	FEMA Criteria/Regulations	8	8	12	8	8	12	10	8	8	8	12	12	12	12					3
21	Compat. with Exist.	10	8	12	8	12	7	10	10	2	2	12	6	2	8					3
22	Compat. with Proposed Land Uses	8	10	8	8	12	12	12	12	10	2	12	12	6	12					3
23	Financing	6	6	10	6	4	4	8	4	4	4	8	10	10	10					3
24	Riparian Habitat Protection	12	4	6	8	10	10	8	6	8	6	10	7	10	8					2
	OVERALL EVALUATION	7.9	7.7	9.1	8.5	9.3	8.4	9.4	7.7	7.2	4.7	8.9	8.4	6.4	9.3	0.0	0.0	0.0	0.0	42.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 8

Flood Control Components Selection Criteria Matrix

RUELAS BASIN

NON-STRUCTURAL

	EVALUATION CRITERIA	FLDPLN ACQ.	FLOOD-PROOFING	DESIGN CRITERIA	PLAN REVIEW	FLDPLN PERMITTING	MAINT. OPERATION	ENFORCE-MENT	EDUCATION	ORDS. POLICIES	ORG/ MGMT	PLANNING	INTER GOV AGENCY INTERACTN	DEV. INSPEC.	FLOOD MONITOR-ING	DATA BASE MGMT.	COMPLAINT EMERG. RESPONSE	POLLUTION MONITORNG	DO NOTHING	WEIGHT FACTOR
1	Engineering Feasibility	8	12	8	12	6	8	8	12	8	10	8	8	8	8	10	10	8	12	2
2	Acceptability to Public	12	7	7	8	7	10	10	12	10	10	12	12	10	10	10	10	10	2	2
3	Implementation Cost	2	2	8	8	6	6	8	10	8	4	6	6	4	4	4	4	4	12	2
4	Effectiveness	8	10	12	12	12	12	12	10	10	12	12	12	12	10	10	10	8	2	3
5	Transportation	8	8	10	12	8	10	8	8	10	10	10	10	10	8	10	8	8	2	1
6	Short Term vs. Long Term Effects	12	12	10	12	12	10	8	10	12	12	12	12	10	10	12	10	8	2	1
7	Benefit Area vs. Impact Area	10	2	8	10	8	12	12	12	12	12	12	12	10	10	10	8	12	2	2
8	ROW Restrictions/Requirements	2	10	8	12	8	12	12	12	8	10	10	10	10	10	10	8	10	12	1
9	Maintenance Requirements	10	2	10	8	10	12	8	10	10	10	10	10	10	8	10	6	8	12	1
10	Multiple Use Potential	12	2	10	10	8	8	8	10	8	10	10	10	10	8	8	8	8	8	1
11	Impact on Infiltration	12	8	8	8	8	10	10	8	8	10	10	10	10	8	8	8	8	4	1
12	Loss of Flow Attenuation	12	8	8	8	8	12	10	8	8	10	10	10	10	8	8	8	8	4	1
13	Env. Considerations	12	8	10	10	10	12	10	12	10	10	10	10	10	8	10	8	10	4	2
14	Water Quality	10	8	8	8	8	8	10	10	10	10	10	10	10	8	10	8	10	4	2
15	Aesthetics	12	4	10	8	8	12	12	12	10	10	10	10	10	8	10	8	10	4	2
16	Jurisdictional Boundaries	8	10	8	8	10	6	8	10	8	10	10	10	6	8	8	8	8	8	1
17	Pima Co., State, Fed. Regs. (General)	8	10	8	8	8	10	12	10	12	10	10	10	10	10	10	12	10	2	1
18	FEMA Criteria/Regulations	10	8	8	8	8	10	12	10	12	10	10	10	10	12	12	12	12	2	3
19	Compat. with Existing Land Uses	10	12	10	12	8	8	8	10	10	10	10	10	10	12	10	10	10	8	3
20	Compat. with Proposed Land Uses	10	12	10	12	10	10	10	10	10	10	10	10	10	10	10	10	10	4	3
21	Riparian Habitat Protection	12	10	12	12	8	8	10	10	12	10	10	10	10	10	10	10	8	12	3
	OVERALL EVALUATION	8.7	7.4	8.4	9.1	7.7	8.8	9.0	9.4	9.1	9.0	9.1	9.1	8.7	8.4	8.8	8.2	8.3	5.2	38.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 8A

Flood Control Components Selection Criteria Matrix

RUELAS BASIN

STRUCTURAL

	EVALUATION CRITERIA	STRUC RELOC	IMPR CHANNELS	DIP CROSSINGS	BRIDGES	DET/RET FACILITY REGIONAL	SEDMNT BASINS	ENRGY DSP GRADE CONTROL	EROSION PROTCT	LEVEES DIKES FLDWLLS	DIVRSN STRCTRS	I-10 SPRR	RDWAY IMPR	STREET CONVEY	CULVERTS STRM DRNS					WEIGHT FACTOR
1	Engineering Feasibility	8	6	12	6	2	6	12	12	10	10	10	10	4	8					2
2	Acceptability to Public	6	10	8	10	8	8	10	8	6	6	10	10	6	12					2
3	Construction Cost (Design)	2	2	12	8	8	8	10	6	8	6	8	6	6	10					2
4	Effectiveness	10	12	6	12	2	8	12	12	12	12	10	8	6	12					3
5	Transportation	8	12	6	12	7	10	10	10	10	10	10	12	4	12					1
6	Short Term vs. Long Term Effects	10	10	12	12	2	6	8	12	12	6	10	8	10	8					1
7	Phased Constr. Potential	12	6	12	10	2	10	10	6	10	10	10	8	6	12					1
8	Benefit Area vs. Impact Area	2	12	7	7	10	10	8	8	6	12	6	8	8	7					2
9	ROW Restrictions/Requirements	2	2	12	8	2	2	6	2	2	2	4	6	12	7					1
10	Utility Conflicts	10	2	6	6	10	10	10	8	6	10	6	4	6	4					1
11	Maintenance Requirements	12	8	10	10	6	4	8	8	8	2	8	4	10	6					1
12	Multiple Use Potential	2	12	4	7	12	6	2	2	4	10	2	8	2	4					1
13	Impact on Infiltration	8	6	7	7	12	12	8	6	7	12	7	6	2	7					1
14	Loss of Flow Attenuation	8	2	7	7	12	12	8	6	7	12	7	8	2	10					1
15	Env. Considerations	8	6	10	10	8	8	10	6	6	6	7	8	2	8					2
16	Water Quality	8	7	8	10	8	6	10	6	8	6	7	6	2	7					2
17	Aesthetics	10	10	10	12	12	6	8	2	2	8	8	8	6	10					2
18	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	8	10	10	10					1
19	Pima Co., State, Fed. Regs. (General)	12	8	10	8	8	8	8	8	7	7	8	8	8	8					1
20	FEMA Criteria/Regulations	8	8	12	8	8	12	10	8	7	7	12	12	12	12					3
21	Compat. with Exist. Land Uses	10	8	12	8	6	7	10	10	2	2	12	6	2	8					3
22	Compat. with Proposed Land Uses	8	10	8	8	2	12	12	12	10	10	12	12	6	12					3
23	Financing	6	6	10	8	4	4	8	4	4	4	8	10	10	10					3
24	Riparian Habitat Protection	12	4	6	8	10	10	8	6	8	6	10	7	10	8					2
	OVERALL EVALUATION	7.9	7.7	9.2	8.8	6.7	8.2	9.4	7.7	7.0	7.5	8.9	8.4	6.4	9.3	0.0	0.0	0.0	0.0	42.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 9

Flood Control Components Selection Criteria Matrix

WILD BURRO BASIN

NON-STRUCTURAL

	EVALUATION CRITERIA	FLDPLN ACQ.	FLOOD-PROOFING	DESIGN CRITERIA	PLAN REVIEW	FLDPLN PERMITTNG	MAINT. OPERATION	ENFORCE-MENT	EDUCATION	ORDS. POLICIES	ORG/ MGMT	PLANNING	INTER GOV AGENCY INTERACTN	DEV. INSPEC.	FLOOD MONITOR-ING	DATA BASE MGMT.	COMPLAINT EMERG. RESPONSE	POLLUTION MONITORNG	DO NOTHING	WEIGHT FACTOR
1	Engineering Feasibility	8	12	8	12	6	8	8	12	8	10	8	8	8	8	10	10	8	12	2
2	Acceptability to Public	12	7	7	8	7	10	10	12	10	10	12	12	10	10	10	10	10	2	2
3	Implementation Cost	2	2	8	8	6	6	8	10	8	4	6	6	4	4	4	4	4	12	2
4	Effectiveness	8	10	12	12	12	12	12	10	10	12	12	12	12	10	10	10	8	2	3
5	Transportation	8	8	10	12	8	10	8	8	10	10	10	10	10	8	10	8	8	2	1
6	Short Term vs. Long Term Effects	12	12	10	12	12	10	8	10	12	12	12	12	10	10	12	10	8	2	1
7	Benefit Area vs. Impact Area	10	2	8	10	8	12	12	12	12	12	12	12	10	10	10	8	12	2	2
8	ROW Restrictions/Requirements	2	10	8	12	8	12	12	12	8	10	10	10	10	10	10	8	10	12	1
9	Maintenance Requirements	10	2	10	8	10	12	8	10	10	10	10	10	10	8	10	6	8	12	1
10	Multiple Use Potential	12	2	10	10	8	8	8	10	8	10	10	10	10	8	8	8	8	8	1
11	Impact on Infiltration	12	8	8	8	8	10	10	8	8	10	10	10	10	8	8	8	8	4	1
12	Loss of Flow Attenuation	12	8	8	8	8	12	10	8	8	10	10	10	10	8	8	8	8	4	1
13	Env. Considerations	12	8	10	10	10	12	10	12	10	10	10	10	10	8	10	8	10	4	2
14	Water Quality	10	8	8	8	8	8	10	10	10	10	10	10	10	8	10	8	10	4	2
15	Aesthetics	12	4	10	8	8	12	12	12	10	10	10	10	10	8	10	8	10	4	2
16	Jurisdictional Boundaries	8	10	8	8	10	6	8	10	8	10	10	10	6	8	8	8	8	8	1
17	Pima Co., State, Fed. Regs. (General)	8	10	8	8	8	10	12	10	12	10	10	10	10	10	10	12	10	2	1
18	FEMA Criteria/Regulations	10	8	8	8	8	10	12	10	12	10	10	10	10	12	12	12	12	2	3
19	Compat. with Existing Land Uses	10	12	10	12	8	8	8	10	10	10	10	10	10	12	10	10	10	8	3
20	Compat. with Proposed Land Uses	10	12	10	12	10	10	10	10	10	10	10	10	10	10	10	10	10	4	3
21	Riparian Habitat Protection	12	10	12	12	8	8	10	10	12	10	10	10	10	10	10	10	8	12	3
	OVERALL EVALUATION	8.7	7.4	8.4	9.1	7.7	8.8	9.0	9.4	9.1	9.0	9.1	9.1	8.7	8.4	8.8	8.2	8.3	5.2	38.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

TABLE 9A

Flood Control Components Selection Criteria Matrix

WILD BURRO BASIN

STRUCTURAL

	EVALUATION CRITERIA	STRUC RELOC	IMPR CHANNELS	DIP CROSSINGS	BRIDGES	DET/RET FACILITY REGIONAL	SEDMNT BASINS	ENRGY DSP GRADE CONTROL	EROSION PROTCT	LEVEES DIKES FLOWLLS	DIVRSN STRCTRS	I-10 SPRR	ROWAY IMPR	STREET CONVEY	CULVERTS STRM DRNS					WEIGHT FACTOR
1	Engineering Feasibility	8	6	12	6	2	6	12	12	10	10	10	10	4	8					2
2	Acceptability to Public	6	10	8	10	8	8	10	8	6	6	10	10	6	12					2
3	Construction Cost (Design)	2	2	12	8	8	8	10	6	8	6	8	6	6	10					2
4	Effectiveness	10	12	6	12	2	8	12	12	12	12	10	8	6	12					3
5	Transportation	8	12	6	12	7	10	10	10	10	10	10	12	4	12					1
6	Short Term vs. Long Term Effects	10	10	12	12	2	6	8	12	12	6	10	8	10	8					1
7	Phased Constr. Potential	12	6	12	10	2	10	10	6	10	10	10	8	6	12					1
8	Benefit Area vs. Impact Area	2	12	7	7	10	10	8	8	6	12	6	8	8	7					2
9	ROW Restrictions/Requirements	2	2	12	8	2	2	6	2	2	2	4	6	12	7					1
10	Utility Conflicts	10	2	6	6	10	10	10	8	6	10	6	4	6	4					1
11	Maintenance Requirements	12	8	10	10	6	4	8	8	8	2	8	4	10	6					1
12	Multiple Use Potential	2	12	4	7	12	6	2	2	4	10	2	8	2	4					1
13	Impact on Infiltration	8	6	7	7	12	12	8	6	7	12	7	6	2	7					1
14	Loss of Flow Attenuation	8	2	7	7	12	12	8	6	7	12	7	8	2	10					1
15	Env. Considerations	8	6	10	10	8	8	10	6	6	6	7	8	2	8					2
16	Water Quality	8	7	8	10	8	6	10	6	8	6	7	6	2	7					2
17	Aesthetics	10	10	10	12	12	6	8	2	2	8	8	8	6	10					2
18	Jurisdictional Boundaries	10	10	10	10	10	10	10	10	10	10	8	10	10	10					1
19	Pima Co., State, Fed. Regs. (General)	12	8	10	8	8	8	8	8	7	7	8	8	8	8					1
20	FEMA Criteria/Regulations	8	8	12	8	8	12	10	8	7	7	12	12	12	12					3
21	Compat. with Exist. Land Uses	10	8	12	8	6	7	10	10	2	2	12	6	2	8					3
22	Compat. with Proposed Land Uses	8	10	8	8	2	12	12	12	10	10	12	12	6	12					3
23	Financing	6	6	10	6	4	4	8	4	4	4	8	10	10	10					3
24	Riparian Habitat Protection	12	4	6	8	10	10	8	6	8	6	10	7	10	8					2
	OVERALL EVALUATION	7.9	7.7	9.2	8.7	6.7	8.2	9.4	7.7	7.0	7.5	8.9	8.4	6.4	9.3	0.0	0.0	0.0	0.0	42.0

RATING RANGE: HIGH POSITIVE +12, MEDIUM POSITIVE +10, LOW POSITIVE +8, LOW NEGATIVE +6, MEDIUM NEGATIVE +4, HIGH NEGATIVE +2

3. Hydraulic evaluation of culvert type and size in relationship to discharges determined for future conditions for a given watershed (Hydraulic Culvert Performance Evaluation, Appendix D).

4. Erosion/Sedimentation Analysis (Appendix D).

5. Southern Pacific/I-10 Analysis (Appendix F).

EVALUATION CRITERIA

The following definitions for the evaluation criteria were established and utilized in the selection matrix to evaluate structural and non-structural components.

Engineering Feasibility - Structural solutions are limited by difficulty in adequately collecting, conveying and discharging distributary flow, retaining sediment balance and lack of concentrated downstream outlet points. Non-structural solutions are limited by non-tangible elements such as safety, aesthetics, environmental issues, etc.

Acceptability to the Public - Assumes evaluation is conducted without the benefit of public involvement. Evaluation results in ranking the public's perceived acceptability relative to safety, traffic conveyance, costs, land use, esthetics, etc.

Construction/Implementation Cost (including design) - relative cost for construction/design of structural component and implementation of non-structural components (e.g. diversion structure, bridges - high cost; dip sections - low cost).

Effectiveness - Relates hydraulic performance and/or feasibility of specific component to flood control/drainage concerns, and/or ability to assist in regulating/controlling flooding, drainage problems, etc..

Transportation - Evaluates compatibility of component with existing or proposed roadways. No impact to roadway and an increase in safety infers high compatibility. Relocation of roadway and decrease in traffic conveyance infers low compatibility. Processes that facilitate transportation needs with watershed characteristics infers high compatibility.

Short Term versus Long Term - Evaluation of the effectiveness over time of the desirable effect of the specific component on the watershed relative to flood control, sediment balance and component life expectancy. A dip section may have a longer term effect on the watershed than a culvert crossing, due to the fact that the efficiency of the culvert crossing would decrease over time due to sedimentation.

Phased Construction Potential (Structural Components Only) - Construction of component could be completed in phases without major impacts to the hydraulic performance of the basin. Phased construction could be limited by existing, wide dispersed floodplains and existing, low density development.

Benefit Area versus Impact Area - Comparison of the amount of area required to facilitate component to the amount of area of the basin that will realize a positive hydraulic impact from the performance of the component. For non-structural components relating to agency regulations, review, maintenance, operation and education programs an assumption that the impact area for implementation of these components is small (assumes existing agency property/offices are sufficient).

Row Restrictions/Requirements - Evaluated in terms of land acquisition requirements. For non-structural components relating to agency regulations, review, maintenance operation and education programs an assumption that existing agency property/offices are sufficient to implement component.

Utility Conflicts - Evaluated in terms of utility relocation. (Assumes components within or adjacent to roadways will require utility relocation.) Not an evaluation criteria for non-structural components.

Maintenance Requirements - Evaluated in terms of maintenance requirements relative to hydraulic performance (structural components). For non-structural components, component is evaluated in terms of the need to upgrade/update the component as new information/data base is generated.

Multiple Use Potential - Evaluates component relation to multi-use potential such as flood control, transportation, recreation, aesthetics, etc.

Impact on Infiltration - Evaluates component impact on infiltration on a watershed basis (structural component). For non-structural components, the component's potential or indirect impact is evaluated.

Loss of Flow Attenuation - Evaluation of component effect on flow attenuation (structural component). For non-structural components the component's potential or indirect impact is evaluated.

Environmental Considerations - Evaluates component effect on riparian habitats in relation to impact area (structural component). For non-structural components, the component's potential or indirect impact is evaluated.

Water Quality - Evaluation of component impact on water quality (structural component). For non-structural components, the component's potential or indirect impact is evaluated.

Aesthetics - Evaluates whether the component will be compatible with residents' lifestyle, rural/urban setting, architectural issues, etc. For non-structural components, the component's potential or indirect impact is evaluated.

Jurisdictional Boundaries - Refers to governing agency or agencies. The greater the number of agencies involved in the evaluation and/or design of a component, the lower the ranking.

Pima County, State, Federal Regulations (General) - Refers to impact of regulations on component.

FEMA Criteria/Regulations - Impact of regulations on component.

Compatibility with Existing Land Use - Evaluation of component's compatibility with existing land use.

Compatibility with Proposed Land Use - Evaluation of component's compatibility with proposed land use.

Riparian Habitat Protection - Evaluation of component compliance with Pima County's Riparian Habitat and Green Belt Protection Ordinance.

Financing (Structural Components Only) - Evaluation of funds available for engineering/construction of component. It is assumed that the ranking of available funds to be expended is in the order of greatest public need (i.e., projects/components associated with roadway improvements have the greatest need).

WATERSHED CHARACTERISTICS (EXISTING)

North Ranch Basin

This section of the report describes general, existing watershed characteristics for each watershed. Watershed characteristics were used to aid in the evaluation of the structural and non-structural components.

Area: 15.8 mile square

Geology/Geomorphology: Dissected alluvial deposits

Flow Patterns: Primarily concentrated flow within incised channels. Runoff outfalls along the Southern Pacific Railroad and in part, is partially conveyed to the north adjacent to the Southern Pacific Railroad.

Land Use: Majority of basin is currently zoned rural, suburban ranch (SR). High-density, CR-3/CR-5 urban developments occur in the central and lower portions of the watershed. Approximately 20% of the watershed is developed. The watershed primarily lies in unincorporated Pima County.

Existing Drainage Improvements: Channels and detention/retention basins associated with subdivision development and the development for Arthur Pack Golf Course. Drainage improvements are discontinuous on a watershed basis.

Peak Discharges: 100-year peak discharges range between 30 to 3,150 cfs along spine washes and section line roadway crossings of washes.

Floodplain Delineations: Zone A areas associated with spine wash delineations such as Hardy Wash.

Spine Washes: Four spine washes have been identified in the watershed. Development has occurred within spine washes in some areas. Development ranges from high density subdivisions to low density suburban ranches.

Roadway Improvements: Primarily confined to section line roadway alignments.

Interstate 10/Southern Pacific Railroad: Existing capacity of culverts under the Southern Pacific Railroad and Interstate 10 that drain runoff generated in this basin to the Santa Cruz River are partly or completely filled with sediment or they are undersized and do not convey the estimated 50- or 100-year peak discharge respective to a given culvert crossing. Runoff that does not pass through a culvert is conveyed to the north along the eastern edge of the Southern Pacific Railroad.

Cañada Agua Basin

Area: 19.53 square miles

Geology/Geomorphology: Alluvial deposits/piedmonts.

Flow Patterns: Primarily concentrated flow within two well-defined channels. Runoff outfalls from the watershed along the Southern Pacific Railroad, and in part is conveyed to the north adjacent to the Southern Pacific Railroad.

Land Use: Presently zoned rural GR. Approximately 1% or less of the watershed is developed. Portions of the watershed lie within the limits of the Town of Marana.

Existing Drainage Improvements: None

Peak Discharges: 100-year peak discharges range between 30 to 7,000 cfs along spine washes and section line roadway alignments.

Floodplain Delineations: Flood zones associated with alluvial fan floodplains.

Spine Washes: Five spine washes within the upper reaches of the watershed and three spine washes within the lower reaches of the watershed have been identified. Some development (suburban ranch homes) have occurred within spine washes.

Roadway Improvements: Primarily confined to section line alignments.

Interstate 10/Southern Pacific Railroad: Existing capacity of culverts under the Southern Pacific Railroad and Interstate 10 that drain runoff generated in this basin to the Santa Cruz River are partly or completely filled with sediment or they are undersized and do not convey the estimated 50- or 100-year peak discharge respective to a given culvert crossing. Runoff that does not pass through a culvert is conveyed to the north along the eastern edge of the Southern Pacific Railroad.

Prospect Basin

Area: 10.2 square miles

Geology/Geomorphology: Alluvial deposits/piedmonts/bedrock. Approximately 67% of the watershed (lower watershed) lies in a piedmont area.

Flow Patterns: Concentrated flow within a well-defined channel in the upper reaches of the watershed. Within the lower reaches of the watershed, channel reaches are ill-defined and discontinuous - distributary flow dominates. Runoff outfalls from the watershed along the Southern Pacific Railroad, and in part is conveyed to the north adjacent to the Southern Pacific Railroad.

Land Use: Majority of watershed is currently zoned rural GR and lies within the limits of the Town of Marana. No urban developments have taken place in the watershed.

Existing Drainage Improvements: None

Peak Discharges: 100-year peak discharges range between 750 to 6,750 cfs along spine washes and section line roadway crossings of spine washes.

Floodplain Delineations: Flood zones associated with alluvial fan floodplains.

Spine Washes: One spine wash has been identified. No development has occurred within the limits of the spine wash.

Roadway Improvements: Roadway improvements are confined to Tangerine Road.

Interstate 10/Southern Pacific Railroad: Existing capacity of culverts under the Southern Pacific Railroad and Interstate 10 that drain runoff generated in this basin to the Santa Cruz River are partly or completely filled with sediment or they are undersized and do not convey the estimated 50- or 100-year peak discharge respective to a given culvert crossing. Runoff that does not pass through a culvert is conveyed to the north along the eastern edge of the Southern Pacific Railroad.

Ruelas Basin

Area: 10.9 square miles.

Geology/Geomorphology: Alluvial Deposits/Piedmonts/Bedrock. Approximately 67% of the watershed (lower watershed) lies in a piedmont area.

Flow Patterns: Distributary Flow. Runoff ultimately outfalls from the watershed along the Southern Pacific Railroad, and is partially conveyed to the north adjacent to the Southern Pacific Railroad.

Land Use: Essentially all of the Ruelas Basin is zoned rural DGR. A portion of the upper reaches of the watershed lies with the limits of the Town of Marana. The majority of the watershed lies within unincorporated Pima County. Rural/urban development has not occurred.

Existing Drainage Improvements: None.

Peak Discharges: 100-year peak discharges range between 550 and 8,100 cfs along spine washes and section line roadway alignment/spine wash crossings.

Flood Plain: Flood zones associated with alluvial fan flood zones.

Spine Washes: One spine wash has been identified. No development has occurred within the limits of the spine wash.

Roadway Improvements: Roadway improvements are confined to Tangerine Road.

Interstate 10/Southern Pacific Railroad: Existing capacity of culverts under the Southern Pacific Railroad and Interstate 10 that drain runoff generated in this basin to the Santa Cruz River are partly or completely filled with sediment or they are undersized and do not convey the estimated 50- or 100-year peak discharge respective to a given culvert crossing. Runoff that does not pass through a culvert is conveyed to the north along the eastern edge of the Southern Pacific Railroad.

Wild Burro Basin

Area: 13.1 square miles

Geology/Geomorphology: Alluvial deposits/piedmonts/bedrock. Approximately 47% of the watershed consists of alluvial deposits.

Flow Patterns: Concentrated flow within well defined channels in the upper reaches of the watershed, whereas distributary flow dominates in the lower and middle reaches. Runoff ultimately outfalls from the watershed along the Southern Pacific Railroad.

Land Use: All of the watershed is currently zoned rural GR. The majority of the watershed lies in unincorporated Pima County. Rural/urban development has not occurred.

Existing Drainage Improvements: None

Peak Discharges: 100-year peak discharges range from 900 to 9,500 cfs along spine washes and section line roadway alignments/spine wash crossings.

Floodplain Delineations: Flood zones associated with alluvial fan floodplains.

Spine Washes: Two spine washes have been identified. No development has occurred within the limits of the spine washes.

Roadway Improvements: Roadway improvements are confined to Tangerine Road.

Interstate 10/Southern Pacific Railroad: Existing capacity of culverts under the Southern Pacific Railroad and Interstate 10 that drain runoff generated in this basin to the Santa Cruz River are partly or completely filled with sediment or they are undersized and do not convey the estimated 50- or 100-year peak discharge respective to a given culvert crossing. Runoff that does not pass through a culvert is conveyed to the north along the eastern edge of the Southern Pacific Railroad.

PROPOSED CHANGES IN WATERSHED CHARACTERISTICS

This section of the report describes proposed changes in the watershed that would affect runoff and conveyance of runoff. Proposed drainage improvements are limited to improvements proposed in other studies by the Flood Control District or by the Arizona Department of Transportation and proposed zonal land use.

North Ranch Basin

A. Land Use

1. Town of Marana

a. Moderate to high density residential development

b. Highly urbanized

2. Pima County

a. Rural (North of Tangerine Road)

B. Proposed Drainage Improvements

1. Improved drainage structures at the outfall of the watershed along Interstate 10 to SPRR corridor (ADOT's upgrade assumed the Southern Pacific Railroad will upgrade associated culvert/bridge crossings).

C. Peak Discharges

1. 100-year peak discharges range between 40 cfs and 3,300 cfs along spine wash alignments and roadway alignments.

D. Proposed Roadway Improvements

1. Improvements to Tangerine Road (ADOT).

a. Includes culvert structures at wash crossings.

Cañada Agua Basin

A. Land Use.

1. Town of Marana.

a. Moderate to High Density Residential Development.

b. Highly Urbanized.

c. Moderate to Low Density Residential Development.

B. Proposed Drainage Improvements.

1. Improved drainage structures at the outfall of the watershed along. Interstate 10/SPRR corridor (ADOT's upgrade assumes Southern Pacific Railroad will upgrade associated culvert/bridge crossings).

C. Peak Discharges.

1. 100-year peak discharges range between 40 cfs and 7,600 cfs along spine wash alignments and roadway alignments.

D. Proposed roadway Improvements.

1. Improvements to Tangerine Road (ADOT).

a. Includes culvert structures at wash crossings.

Prospect Basin

A. Land Use

1. Town of Marana

a. Moderate to High Density Residential Development.

b. Highly Urbanized.

c. Moderate to Low Density

d. Rural.

2. Pima County

a. Rural (North of Tangerine Road).

B. Proposed Drainage Improvements

1. Interstate 10/SPRR corridor

a. Interceptor Channel adjacent to the Southern Pacific Railroad. (P.C.D.O.T. & F.C.D.)

C. Peak Discharges

1. 100-year peak discharges range between 900 cfs and 7,250 cfs along spine wash alignments and roadway alignments.

D. Proposed Roadway Improvements.

1. Improvements to Tangerine Road (ADOT).

a. Includes bridge structures at spine wash crossing.

Ruelas Basin

A. Land Use.

1. Town of Marana.

a. Moderate to High Density Residential Development.

b. Highly Urbanized.

c. Moderate to Low Density Residential Development.

d. Rural.

2. Pima County.

a. Rural (North of Tangerine Road).

B. Proposed Drainage Improvements.

1. Interstate 10/SPRR corridor

a. Interceptor channel adjacent to the Southern Pacific Railroad (P.C.D.O.T. & F.C.D.).

C. Peak Discharges.

1. 100-year peak discharges range between 550 cfs and 8,750 cfs along spine wash alignments and roadway alignments.

D. Proposed Roadway Improvements.

1. Improvements to Tangerine Road (ADOT).

a. Includes bridge structures at spine wash crossings.

Wild Burro Basin

A. Land Use.

1. Town of Marana.

a. Moderate to High Density Residential Development.

b. Highly Urbanized.

c. Moderate to Low Density Residential Development.

d. Rural.

2. Pima County.

a. Rural (North of Tangerine Road).

B. Proposed Drainage Improvements.

1. Interstate 10/SPRR corridor

a. Interceptor channel adjacent to the Southern Pacific Railroad (P.C.D.O.T. & F.C.D.).

C. Peak Discharges.

1. 100-year peak discharges range between 950 cfs and 9,500 cfs along spine wash alignments and roadway alignments.

D. Proposed Roadway Improvements.

1. Improvements to Tangerine Road (ADOT).

a. Includes bridge structures at spine wash crossings.

SELECTION MATRIX SUMMARY

The evaluation scores for non-structural and structural components analyzed for individual effectiveness in relation to flood/drainage mitigation for North Ranch, Cañada Agua, Prospect, Ruelas and Wild Burrow Basins are presented in Tables 5, 5A, through 9, 9A. The following text summarizes the selection matrix ranking for the components by individual watershed. Due to the fact that majority of the watershed characteristics for the North Ranch and Cañada Agua Basins are similar, these basins are discussed jointly. Watershed characteristics of Prospect, Ruelas and Wild Burrow are similar, and these basins are discussed jointly as well.

North Ranch/Cañada Aqua Basins

With the exception of 100-year peak discharges and floodplain designations for existing and proposed watershed characteristics, the North Ranch and Cañada Aqua Basins are similar. Two of the five spine washes identified in the Cañada Agua Basins carry 100-year discharge exceeding 2,000 cfs (2,000 - 7,600 cfs), whereas the North Ranch Basin peak discharges along the spine washes are 2,000 cfs or less. This difference between the two basins is reflected in the Riparian Habitat Ordinance criteria.

Non-structural Components

The selection matrix ranking for non-structural components of North Ranch and Cañada Agua Basins ranged between 5.2 and 9.4. Components that received positive evaluation rankings between 9 and 9.4 are Maintenance/Operation, Organization/Management, Plan Review, Ordinances/Policies, Planning, Intergovernment/Interagency, Enforcement and Education. Components that received positive evaluation rankings between 8 and 9 are Complaint Emergency Response, Design Criteria, Pollution Monitoring, Flood Monitoring, Floodplain Acquisition, Development Inspection and Data Base Management. Components that received positive evaluation between 7 and 8 are Floodproofing and Floodplain Permitting. The only component to receive a negative ranking is Do Nothing.

Maintenance/Operation, Organization/Management, Plan Review, Ordinances/Policies, Planning, Intergovernment/Interagency, Enforcement and Education are primarily associated with agency evaluation, regulation and maintenance of an efficient flood/drainage management program that informs and protects the public. These components received an overall positive ranking and individually rank positive in all evaluation criteria because 1) they are directly or indirectly related and supportive to each other (highly compatible) and, 2) ensure that policies and regulations established to mitigate flooding/drainage concerns are recognized and adhered to.

Complaint Emergency Response, Design Criteria, Pollution Monitoring, Flood Monitoring, Floodplain Acquisition, Development Inspection and Data Base Management are similar in use, need and evaluation as the components discussed above; however, received a lower ranking because of one of the following reasons: 1) cost to implement the component relative to previously discussed components is high and, 2) the effect of the component on the watershed for some of the evaluation criteria is only indirectly tangible (non-direct).

Flood Proofing and Floodplain Permitting are components that primarily reduce or eliminate flood damage at site specific locations. These components received a lower ranking that previously discussed components primarily because implementation costs are estimated to be higher.

The Do Nothing component is the only non-structural component to receive a negative rating. The overall negative rating is primarily due to the fact there is no benefit if the Do Nothing component is implemented.

Structural Components

The selection matrix ranking for structural components of North Ranch and Cañada Agua Basins ranged between 6.1 and 9.7. Components that received positive evaluation rankings between 9 and 9.7 are Energy Dissipaters/Grade Control, Culverts/Storm Drains, Regional Detention/Retention Facilities, Dip Crossings and Bridges. Components that received positive evaluation rankings between 8 and 9 are Sediment Basins, I-10 SPRR Improvements, Improved Channels and Erosion Protection. Components that received positive evaluation rankings between 7 and 8 are Structure Relocation and Levees/Dikes/Floodwalls. Components that received overall negative ratings (below 7) are Street Conveyance and Diversion Structures.

Energy Dissipators/Grade Control, Culverts/Storm Drains, Dip Crossing and Bridges are primarily associated with roadway/development improvements, are limited to small impact areas, have minor conflicts with other components and are compatible with aesthetics/environmental aspects and proposed land use and, therefore, received high positive ratings. Culverts/Storm Drains received a higher ranking for drainage/roadway crossings than Dip Sections and Bridges because 1) the majority of the watershed is proposed to be developed at moderate to high density residential and commercial (during flooding events dip section would create traffic congestion; and 2) the majority of the 100-year peak discharges could be conveyed at roadways via culverts. In areas of low density development, dip sections may be considered as suitable drainage facilities. In areas of high 100-year peak discharge (primarily Cañada Agua watershed), bridges may be feasible.

Regional Detention/Retention Facilities received positive rankings for these watersheds primarily because such facilities could be engineered so that the whole watershed would benefit. Impacts that would be realized are 1) reduction in 100-year peak discharge down stream; 2) reduction in size of culvert/bridge crossings required; and 3) reduction or elimination of existing FEMA floodplains. With the exception of Right-of-Way/Restrictions/Requirements and Financing, Detention/Retention Facilities rank positive with all other evaluation criteria.

Sediment Basins, Improved Channels and Erosion Protection are primarily associated with flood mitigation measures that would benefit the whole watershed. Sediment Basins would primarily be associated with Detention/Retention Facilities. This component received positive rankings in evaluation criteria that take into consideration the positive impact of sediment basins on the hydraulic performance of other structural components. Evaluation criteria in which sediment basins ranked negative are: Short Term versus Long Term Effects (requires routine maintenance to function properly); Right-of-Way Restrictions/Requirements (requires excavation of accumulated sediment); Multiple Use Potential (limited due to function of component); Water Quality (provides location for potential unauthorized discharge and concentrates suspended solids); Aesthetics (not visually pleasing when filled with sediment) and Financing (relative to the availability of funds). The overall positive ranking of sediment basins is primarily due to its compatibility with regional detention/retention basins. Improved Channels consist of channel construction and floodplain encroachment. Improved channel construction (concrete lined, trapezoidal channels) is not considered feasible in these watersheds because 1) the majority of all major washes are classified spine washes which prohibit full channel construction; 2) within Cañada Agua Basin the 100-year peak discharge for two of the four spine washes exceeds 2,000 cfs, and therefore, the riparian habitat is protected under the Riparian Habitat Protection Ordinance which precludes total channelization. However, tributary washes to spine washes may be channelized; however, an increase in downstream discharges will be realized. Approximately 50% of the floodplain width could be encroached into before a 0.5′ increase in water surface elevation is realized for floodplains in the Cañada Agua and North Ranch Basins. Washes within the Cañada Agua and North Ranch Basins are primarily well defined; therefore, the engineering feasibility of Improved Channels relative to floodplain encroachment is ranked positive.

The evaluation criteria that provided positive ranking for the improved channel component are related to hydraulic effectiveness (basin wide) in relation to flood/drainage mitigation, transportation concerns and public need/acceptability. Due to the extensiveness of the improved channel component if implemented for the entire watershed, and the potential negative effects (such as increase in flow velocity and potential erosion), the following evaluation criteria were rated negative for this component: Right-of-Way Restrictions/Requirements, Utility Conflicts, Loss of Flow Attenuation, Impact on Infiltration, Environmental Considerations, Financing and Riparian Habitat Protection (applies to two of the five spine washes in Cañada Agua Basin only). Erosion Protection is primarily associated with Improved Channels, Levees/Dikes/Floodwalls and components providing drainage crossings of roadways. Evaluation criteria concerning Hydraulic Effectiveness, Transportation, Compatibility with Existing and Proposed Land Uses were rated positive for erosion protection. The evaluation that provided negative ranking for erosion protection are Cost of Construction (should floodplain encroachment be considered, a high cost would be associated with bank protection), Phased Construction Potential (erosion protection would have to be implemented shortly after construction of component that it is functionally part of), Right-of-Way Restrictions/Requirements (requires acquiring right-of-way), Maintenance Requirements (will require a maintenance program), Impact on Infiltration (increase in flow velocity and potential decrease in infiltration), Loss of Flow Attenuation (increase in flow velocity, increase in peak discharge). Aesthetics (not usually pleasing), Financing and Riparian Habitat Ordinance (primarily Cañada Agua Basin for spine washes with a 100-year discharge of 2,000 cfs or greater) and erosion protection would impact riparian habitat.

Proposed improvements for the I-10/SPRR corridor through these watersheds consists of improvements to existing box culverts and construction of new box culverts under Interstate 10 at locations that are consistent with existing Southern Pacific Railroad drainage crossings (ADOT's upgrade assumes Southern

Pacific Railroad will upgrade associated culvert/bridge crossings). The proposed improvements affect a small percentage of the watersheds (area wise, therefore, will have minor affect on other components and evaluation criteria; however, it provides a mitigating solution for identified flooding located at the outfall of the watersheds to the Santa Cruz River and, therefore, receives an overall positive rating).

Structural Relocation relates to the removal of structures located within floodplain boundaries to areas outside the floodplain limits. Currently, there is a small percentage of residences (primarily suburban ranch homes) located within the limits of 100-year flood boundaries delineated for spine washes that may be required (for safety reasons) to relocate their structure; therefore, this component could have a positive hydraulic effect at specific locations in the watersheds.

Levees/Dikes/Floodwalls would primarily be associated with identified breakout areas along spine washes and adjacent to potential culvert/bridge crossings to contain and control drainage/runoff within specific areas. Due to this function, positive ratings were given to evaluation criteria relating to hydraulic effectiveness/concerns and transportation concerns. Because of the potentially limited impact area associated with Levees/Dikes/Floodwalls, this component has minor or no impact on flow attenuation, infiltration and environmental concerns. Levees/Dikes/Floodwalls would require acquiring right-of-way, require a maintenance program, more than likely be in conflict with utilities, have limited function outside of design function, may impact riparian habitat, are aesthetically unpleasing, are not compatible with existing land use and, relative to the availability of funds for other components Levees/Dikes/Floodwalls as stand alone projects would rate low on the order for funds; therefore, the component received negative ratings in the above mentioned evaluation criteria.

Street Conveyance (drainage) received a negative overall value for these basins, primarily due to the fact that proposed roadway alignments are not compatible with existing drainage patterns. Proposed development concepts suggest high to moderate residential and commercial development, which would preclude utilizing major traffic corridors as drainage ways.

Diversion Structures are primarily used to concentrate and divert flow/runoff from its existing flow path to another, which may be natural or man-made constructed channel. This component received an overall negative rating, because it is not compatible with the drainage characteristics of these basins (i.e., no need to divert flow).

Prospect/Ruelas/Wild Burro Basins

With the exception of the spatial distribution of alluvial floodplain designations, the existing and proposed watershed characteristics for Prospect, Ruelas and Will Burro Basins are primarily similar. The alluvial fan floodplain for Prospect Basin covers approximately 20% of the basin, whereas the alluvial fan floodplains for Ruelas and Wild Burro Basins cover approximately 60% of the basins. In addition, the apex of the alluvial fan floodplain for Prospect Basin is located in the foothills of the Tortolita Mountains, whereas the apices of the alluvial fan floodplains in Ruelas and Will Burro Basins are located in the mountain front of the Tortolita Mountains.

Non-Structural Components

The selection matrix ranking for non-structural components for Prospect, Ruelas and Wild Burro Basins are similar to the rankings assigned to North Ranch and Cañada Agua Basins. Floodplain Permitting, Maintenance/Operation, Flood Monitoring and Pollution Monitoring received slightly lower evaluation rankings. This is primarily due to the distributary flow characteristics of Prospect, Ruelas and Wild Burro basins, which increases the difficulty in implementation of these components.

Structural Components

The selection matrix ranking for structural components for Prospect, Ruelas and Wild Burrow Basins ranged between 4.7 and 9.4. Components that received positive evaluation rankings for the three basins that ranged between 9 and 9.4 are energy dissipators/grade control, culverts/storm drains and dip crossings. Detention/retention Facilities for Prospect Basin were rated 9.3. Components that received a positive evaluation ranking between 8 and 9 are I-10/SPRR improvements, Sediment Basins, Bridges and Roadway Improvement. Components that received a positive evaluation ranking that ranged between 7 and 8 are Levees/Dikes/Floodwalls, Diversion Structures (Ruelas and Wild Burro Basins only), Improved Channels, Structure Relocation and Erosion Protection. Components that received overall negative ratings are Street Conveyance, Diversion Structures (Prospect Basin only) and Detention/Retention Facilities (Ruelas and Wild Burro Basins only).

Components that rank in the upper ranges are Energy Dissipators/Grade Control, Culvert/Crossings and Dip Crossings. These components are primarily associated with roadway/development improvements, are limited to small impact areas, have minor conflicts with other components and are compatible with aesthetics/environmental aspects and proposed land use. Dip and culvert/roadway crossing components received similar rankings. In areas of high density development, culvert crossings should be considered because of the safety and traffic conveyance afforded by a culvert crossing versus a dip crossing.

Regional Detention/Retention facilities received positive rankings for Prospect Basin and negative rankings for Ruelas and Wild Burro Basins. This component received positive rankings for Prospect Basin primarily, because the facility could easily be engineered so that the whole watershed would receive a positive impact. Impacts that would be realized are: 1) reduction in 100-year peak discharge downstream; 2) reduction in size of culvert/bridge crossing required and, 3) reduction or elimination of existing FEMA floodplains. With the exception of right-of-way restrictions/requirements and financing, detention/retention facilities rank positive in other evaluation criteria. The ranking received for regional detention/retention facilities for Ruelas and Wild Burro Basins will be discussed later.

Proposed improvements for the I-10/SPRR corridor through these watersheds consists of a channel that would concentrate and convey runoff along the eastern side of the Southern Pacific Railroad. The proposed improvements affect a small percentage of the watersheds (area wise, therefore, will have minor affect on other components and evaluation criteria); however, it provides a mitigating solution for identified flooding located at the outfall of the watershed to the Santa Cruz River and therefore received an overall positive rating.

The components consisting of sediment basins, bridges and roadway improvements are primarily components that are associated with development and traffic conveyance. These components have minor conflicts with other components in the basin. The engineering feasibility of bridges and sediment basins is rated negative due to the distributary flow characteristics and the unpredictability of channel alignment, in other words, potential migration is characteristic of the middle and lower portions of the subject watersheds. Due to the potential for distributary flow, it is difficult for certain components to adequately collect, convey and discharge runoff effectively; however, because of this characteristic, the feasibility for Roadway Improvements as a drainage collection and conveyance network is probable, and therefore rated positive for engineering feasibility. With the exception of potential utility conflicts, bridges ranked positive or neutral relative to other evaluation criteria. Sediment basins ranked negative in the following evaluation criteria: Short Term versus Long Term effects (requires routine maintenance to function properly); ROW Restrictions/Requirements (requires acquiring right-of-way); Maintenance (requires excavation of accumulated sediment); Multiple Use Potential (limited because of function of component); Water Quality (provides location for potential unauthorized discharge and concentrates suspended solids); Aesthetics (not visually pleasing when filled with sediment) and Financing (relative to the availability of funds for other components, sediment basins are considered low). Because of the sediment basin's function, and the direct or indirect impacts of the sediment basins on the watershed relative to hydraulic/hydrologic concerns and impact area. Sediment basins ranked positive for other evaluation criteria. Evaluation criteria that received negative ratings for Roadway Improvements are Construction Cost (high cost because of the extensiveness of improvements needed relative to other components), Impact on Infiltration (paved surfaces reduces infiltration capacity), ROW Restrictions/Requirements (requires acquiring right-of-way), Utility Conflicts (potential conflict with utility alignment), Maintenance Requirements (high cost and personnel to maintain roadway), Water Quality (roadway improvements increases the amount of dissolved and suspended pollutants in a watercourse) and Compatibility With Existing Land Use (area is presently undeveloped).

The structural component Levees/Dikes/Floodwalls would primarily be associated with potential diversion structures, identified breakout areas along spine washes and adjacent to potential culvert/bridge crossings to contain and control drainage/runoff within specific areas. Due to this function, positive ratings were given to evaluation criteria relative to hydraulic effectiveness/concerns (site specific) and transportation concerns. Because of the potentially limited impact area associated with Levees/Dikes/Floodwalls, this component has minimal or no impact on flow attenuation, infiltration and environmental concerns.
Levees/Dikes/Floodwalls would require right-of-way, require a maintenance program, more then likely be in conflict with utilities, have limited function

outside of design function, may impact riparian habitat, are aesthetically unpleasing, are not compatible with existing land use and, relative to the availability of funds for other components, Levees/Dikes/Floodwalls as stand alone projects would rate low in the order for funds. Therefore, this component received negative ratings for those evaluation criteria.

With the exception of evaluation criteria Loss of Flow Attenuation, Impact on Infiltration, Multiple Use Potential, Maintenance Requirements, Benefit Area versus Impact Area and Short Term versus Long Term Effects, Diversion Structures received a similar ranking for evaluation criteria as the ranking for Levees/Dikes/Floodwalls for Ruelas and Wild Burro Basins only. Diversion Structures could provide a multi-use area in which runoff was contained resulting in: 1) higher degrees of infiltration (over existing); 2) flow attenuation, and 3) overall positive impact to watershed by decreasing downstream discharges (positive rankings given for these evaluation criteria); however, maintenance requirements would be high because of the degree of sedimentation that would take place upstream of the diversion structure. Overall, Diversion Structures rank higher than Levees/Dikes/Floodwalls. Diversion structures could also possibly reduce the size of the existing Alluvial Fan Floodplain.

Improved Channels, which consist of floodplain encroachment and channel construction (not feasible in these watersheds because of County regulations), is primarily associated with flood mitigation, which, if implemented, would benefit the feasibility of commercial and residential development under existing agency regulations. Because of existing conditions (distributary flow, unpredictable flow paths) the effect of Improved Channels (increase in peak discharge, decrease in infiltration, increase in flow velocity, increase in potential erosion), relative to Engineering Feasibility, Construction Cost, Phased Construction Potential, Right-of-Way Restrictions/Requirements, Loss of Flow Attenuation, Environmental Considerations and Riparian Habitat Protection Ordinance evaluation criteria is ranked negative. Evaluation criteria that provided a positive ranking for Improved Channels are related to hydraulic effectiveness (basin wide) in relation to flood/drainage mitigation, transportation concerns and public need/acceptability.

Structural Relocation relates to the removal of structures located within floodplain boundaries to areas outside the floodplain limits. Due to the lack of development in these basins, this component does not have an immediate application.

Erosion Protection is primarily associated with the components Improved Channels, Levees/Dikes/Floodwalls and components providing drainage crossings of roadways. This component ranks positive in evaluation criteria associated with hydraulic and transportation concerns. Slightly negative or positive rankings were assigned to the following evaluation criteria: Impact on Infiltration, Loss of Flow Attenuation, Water/Environmental concerns and the general public need/acceptability. This component received low ratings concerning Row Restrictions/Requirements, Multiple Use Potential and Financing.

As a stand-alone structural component proposed Regional Detention/Retention Facilities received negative overall value for these basins (Ruelas and Wild Burro only), because these types of facilities are not compatible with existing alluvial floodplain delineations (Fan Apex Spatial relationship to mountain front), nor are they compatible with the characteristic distributary drainage conditions associated with the lower and middle portions of the basins.

Street Conveyance (drainage) received negative overall value for these basins, primarily because proposed roadway alignments are not compatible with existing drainage patterns.

Diversion Structures (for Prospect Basin only) is primarily used to concentrate and divert flow/runoff from its existing flow path to another path which may be either natural or man-made constructed channels. This component received an overall negative rating because it is not compatible with drainage characteristics of this basin (i.e., no need to divert flow).

SECTION 6. DEVELOPMENT OF DRAFT BASIN MANAGEMENT PLANS

INTRODUCTION

Structural and non-structural components identified in Task 5 have been incorporated into individual plans on a watershed basis. The conceptual Basin Management Plans proposed for the North Ranch, Cañada Agua and Prospect Basins consist of one option that integrates components identified in Section 5, whereas the plans for Wild Burro and Ruelas watershed consist of several options. This section of the report summarizes the recommended structural and non-structural components identified in Task 5 and relates specifics (size, type, etc.) and benefits of proposed structural components for each watershed.

SUMMARY OF RECOMMENDED OPTIONS

Non-Structural Components (for all Basins)

Component ranking in descending order:

1. Education (9.4)
2. Ordinances/Policies (9.1)
3. Planning (9.1)
4. Intergovernment Agency Interaction (9.1)
5. Plan Review (9.1)
6. Maintenance Operation (9.1 - 8.8)
7. Enforcement (9.0)
8. Organization/Management (9.0)
9. Floodplain Acquisition (8.8 - 8.7)

10. Development Inspection (8.8 - 8.7)

There is little variance in non-structural components between basins. However, the high ranking non-structural components would be necessary in order to allow for implementation of the structural components proposed in each basin, and to satisfy conditions for the proposed land use/development in each basin.

Structural Components

North Ranch Basin

Component ranking in descending order:

1. Energy Dissipators/Grade Control (9.7)

    A. At culvert crossings, site specific.

2. Culverts/Storm Drains (9.6)

    A. At roadway crossings of washes below Tangerine Road. Culvert/Storm Drain crossings are suggested in areas of proposed high density development. Culvert crossings are not suggested for the low density rural development proposed above Tangerine Road.

3. Regional Detention/Retention Facilities (9.4)

    A. Located so as to potentially decrease the size of existing floodplains.

    B. Potential decrease in peak discharge, resulting in lower design discharges for roadway crossings.

4. Roadway Improvements (9.0)

    A. Could be designed to convey flow to a drainage crossing and retain flow to obtain suitable head water at a culvert crossing (potentially reducing the number of culverts required).

5. Bridges (9.0)

   A. Bridges may be more feasible than culverts due to the magnitude of the discharge impacting specific crossings.

6. Dip Crossings (9.0)

   A. Potential component at roadway crossing of washes in the watershed area above Tangerine Road due to the proposed low residential density zoning.

7. Interstate 10/Southern Pacific Railroad (8.8)

   A. Concept improvements limited to Interstate 10. Southern Pacific Railroad has not planned to upgrade culvert/bridge crossings. Proposed improvements for Interstate 10 consists of upgrading existing box culverts and construction of new box culverts.

8. Sediment Basins (8.5)

   A. Associated with Detention/Retention Facilities.

9. Improved Channels (8.4)

   The component Improved Channels is site specific. Depending on regulations, zoning and/or development use, the Improved Channel component may consist of one or more of the following:

   A. Wash to remain in natural state.

   B. Encroachment of wash fringes.

   C. Channelization.

Cañada Agua Basin

Component ranking in descending order:

1. Culverts/Storm Drains (9.6)

   A. At roadway crossings of washes below Tangerine Road.

2. Energy Dissipators/Grade Control (9.5)

   A. At culvert crossings, site specific.

3. Regional Detention/Retention Facilities (9.3)

   A. At apex of existing alluvial fan floodplain. Approximately 2100 acres (75% of existing floodplain) potentially could be removed from the floodplain.

4. Roadway Improvements (9.0)

   A. Could be designed to convey flow to a drainage crossing and retain flow to obtain suitable head water at crossing. (Potentially reducing the number of culverts required.)

5. Bridges (8.9)

   A. Bridges may be more feasible than a box culvert due to the magnitude of discharge impacting specific crossings.

6. Dip Crossings (8.7)

   A. Potential at roadway crossings of washes above Tangerine Road due to the proposed low residential density zoning.

7. Interstate 10/Southern Pacific Railroad (8.7)

   A. Concept improvements limited to Interstate 10. Southern Pacific Railroad has not planned to upgrade culvert/bridge crossings. Proposed improvements for Interstate 10 consists of upgrading existing box culverts and construction of new box culverts.

8. Sediment Basins (8.3)

   A. Associated with Detention/Retention Facilities.

9. Improved Channels (8.1)

   The component Improved Channels is site specific. Depending on regulations, zoning and/or development use, the Improved Channel component may consist of one or more of the following:

   A. Wash to remain in natural state.

   B. Encroachment of wash fringes.

   C. Channelization.

Prospect Basin

Component ranking in descending order:

1. Energy Dissipators/Grade Control (9.4)

   A. At culvert crossings, site specific.

2. Regional Detention/Retention Facilities (9.3)

   A. At apex of existing alluvial fan floodplain. Approximately 1800 acres (75% of existing floodplain) could potentially be removed from the floodplain.

   B. Potential decrease in peak discharges resulting in lower design discharges for roadway crossings and other drainage facilities.

3. Culverts/Storm Drains (9.3)

   A. At roadway crossings of washes located below Tangerine Road. Culvert/Storm Drain crossings are suggested in areas of proposed high density development. For some areas located to the north of Tangerine Road, low density rural development has been proposed; culvert crossings are not suggested for these areas.

4. Dip Crossings (9.1)

   A. Potential component at roadway crossings of washes in the upper part of the watershed above Tangerine Road in areas that have been proposed for low density rural development.

5. Interstate 10/Southern Pacific Railroad (8.9)

   A. Concept improvements consist of a collector channel to be located adjacent to the east of the Southern Pacific Railroad. Channel would convey runoff from Prospect, Ruelas and Wild Burro Basins to the Santa Cruz River. Collector channel is proposed by Pima County Department of Transportation and Flood Control District.

6. Bridges (8.5)

   A. Bridges may be more feasible than a box culvert due to the magnitude of the discharge impacting specific crossings. ADOT has proposed a bridge at the Spine Wash crossing with Tangerine Road.

7. Sediment Basins (8.4)

   A. Associated with Detention/Retention Facilities.

8. Roadway Improvements (8.4)

   A. Could be designed to convey flow to a drainage crossing and retain flow to obtain suitable head water at a culvert crossing. Because of the distributary flow characteristics of the watershed below Tangerine Road, roadway improvements could be utilized to concentrate flow (i.e. roadway alignment function as a diversion levee/dike).

9. Improved Channels (8.1)

The component Improved Channels is site specific. Depending on regulations, zoning and/or development use, the Improved Channel component may consist of one or more of the following:

A. Wash to remain in natural state.

B. Encroachment of wash fringes.

C. Channelization.

Ruelas and Wild Burro Basins

Component ranking in descending order:

1. Energy Dissipators/Grade Controls (9.4)

   A. Energy Dissipators are associated with roadway improvements, i.e. culverts.

2. Culverts (9.3)

   A. At roadway crossings in areas of future development.

3. Dip Crossings (9.2)

   A. More beneficial in lower reaches, in distributary flow areas.

4. Interstate 10/Southern Pacific Railroad (8.9)

   A. Control and convey runoff along the eastern side of the Southern Pacific Railroad.

5. Bridges (8.8)

   A. ADOT has proposed bridges at spine wash crossings where large flows make culverts infeasible.

Detention/Retention basins did not rank high in these basins due to the fact that the location of the apices, and associated bedrock, precludes construction of these facilities. Distributary drainage conditions associated with the lower and middle portions of the basins precludes detention/retention basins (without channelization) in these areas.

The alluvial fan designation, and the component rankings for Ruelas and the Wild Burro Basins, indicate that development would be very limited in these basins. Therefore, though rankings are low, a second draft basin management with a channelization scheme, possibly incorporating on-line detention/retention, is proposed to be developed for each of these basins. The channelization scheme would consist of a combination of the following:

1. Wash to remain in natural state.

2. Encroachment of wash fringes.

3. Channelization.

Proposed Structural Components

This section of the report describes details concerning the proposed structural components on a watershed basis.

North Ranch Basin

1. Retention/Detention Facility Located at Concentration Points A6 and A7.

Size:	Approximately 30 acres.
Depth:	Ten feet, 4:1 sideslopes.
Drain:	Outfall located 700 feet downstream (consists of a 36" RCP).
Design:	Designed for the 100-year discharge so that the outflow discharge does not significantly contribute with downstream 100-year peak discharges. (Inflow = 1,797 cfs; Outflow = 166 cfs).

A. Location of facility situated to collect runoff from sub-basins A-6 and A-7.

B. Will require sediment basin associated with detention/retention facility or required sediment volume should be incorporated into the estimated retention/detention volume for the facility.

C. Benefits

1. Reduction of floodplain width by approximately 60%.

2. Removal of structures from floodplain.

3. Reduction of discharges at roadway crossing of downstream spine wash (85% reduction at Lambert, 69% reduction at Thornydale).

4. Onsite detention/retention regulations may not be required for portions of the watershed.

2. Majority of watershed below Tangerine Road is zoned moderate to high density development. Drainage structures at roadway crossings are proposed along section line alignment of roadways.

A. At site specific locations, energy dissipators and/or bank/grade protection may be required.

B. At site specific locations levees/spurdikes may be required to contain runoff so that appropriate head water elevations may be obtained for efficient functioning of the designed drainage structure. In some areas, additional right-of-way may be required.

C. Arizona Department of Transportation has developed concept roadway improvement plans for Tangerine Road. Plans include drainage improvements.

3. All weather dip sections are proposed for section line roadway crossings of washes north of Tangerine Road (low density development proposed). Dip sections should meet local and county standards.

4. At site specific locations, roadway improvements (elevated roadway section, channels, etc.) are proposed to convey minor runoff from small watersheds to a drainage crossing.

5. Arizona Department of Transportation has developed concept improvement plans for drainage crossings under Interstate 10. Proposed improvements consists of upgrading existing box culverts and construction of new box culverts.

6. Proposed channel improvements are limited to encroachment of spine wash fringes, in addition to initial reduction of floodplain width due to reduced discharges from detention/retention facilities. Approximately 70% to 50% of an existing spine wash floodplain could be encroached upon before an average 0.5 foot rise in water surface elevation is realized for the 100-year event. This alternative essentially reduces the width of the floodplain of spine washes by providing a floodway-type encroachment with sideslope protection to contain flows of extreme events, while preserving and/or re-establishing the riparian environment within substantial drainage corridors. Under this recommendation, floodplain encroachment/channelization and combination channel/parkways would be utilized to improve the conveyance and stability of a defined spine wash.

7. In areas where existing development occurs within spine washes, floodproofing and/or structure relocation is proposed.

Cañada Agua Basin

1. Retention/Detention Facilities

Basin 1

Location:	Concentration Point B6.
Size:	55.15 Acres.
Depth:	20 feet.
Drain:	Outfall 1,700 feet downstream (consists of a 36" RCP).
Design:	Designed for the 100-year discharge so that the outflow discharge does not contribute with downstream 100-year peak discharges. (Inflow = 5,388 cfs; Outflow = 147 cfs).

Basin 2

Location:	Concentration Point C10.
Size:	21 Acres.
Depth:	20 feet.
Drain:	Outfall located 1,600 feet downstream (consists of a 36" RCP).

Design: Designed for the 100-year discharge so that the outflow discharge does not contribute with downstream 100-year peak discharges. (Inflow = 2,785 cfs, Outflow = 154 cfs).

A. Channelization along Tangerine Road and Thornydale in the vicinity of the proposed retention/detention facilities will be required to convey runoff to the proposed facilities.

B. Sediment basins will be required or the required sediment volume should be incorporated into the retention/detention estimated volume for the facility.

C. Benefits

1. Approximately 75% of the existing alluvial fan floodplains could be eliminated. Reduction of linear floodplain width by approximately 30% to 80% (includes spine wash encroachment).

2. Removal of structures from floodplain.

3. Reduction of 100-year peak discharges at roadway crossings of downstream spine washes (75% reduction at Concentration Point G21 and 91% reduction at Concentration Point G20 (includes effect of spine wash encroachment).

4. Onsite detention/retention regulations may not be required for portions of the watershed.

2. Majority of watershed below Tangerine Road is zoned moderate to high density development. Drainage structures at roadway crossings are proposed along section line alignment of roadways.

A. At site specific locations, energy dissipators and/or bank protection may be required.

B. At site specific locations, levees/spurdikes may be required to contain runoff so that an appropriate head water elevation may be obtained for efficient functioning of the designed drainage structure. In some areas, additional right-of-way may be required.

C. Arizona Department of Transportation has developed concept improvement plans for Tangerine Road. Plans include drainage improvements.

3. All weather dip sections are proposed for section line roadway/wash crossings north of Tangerine Road (low density development proposed). Dip sections should conform to local and county standards.

4. At site specific locations, roadway improvements (elevated roadway sections, channels, etc.) are proposed to convey minor runoff to a drainage crossing.

5. Arizona Department of Transportation has developed concept improvement plans for drainage crossings under Interstate 10. Proposed improvements consist of upgrading existing box culverts and construction of new box culverts.

6. Proposed channel improvements are limited to encroachment of spine wash floodplain fringes, in addition to initial reduction of floodplain width due to reduced discharges from detention/retention facilities. Approximately 30% to 80% of an existing spine wash floodplain could be encroached upon before a 0.5 foot rise in water surface elevation is realized for the 100-year event. This alternative essentially reduces the width of the floodplain of spine washes by providing a floodway-type encroachment with sideslope protection to contain flows of extreme events, while preserving and/or re-establishing the riparian environment within substantial drainage corridors. Under this recommendation, floodplain encroachment/ channelization and combination channel/parkways would be utilized to improve the conveyance and stability of a defined spine wash.

Prospect Basin

1. Retention/Detention Facility

   Location: Between Concentration Points D11 and D10.
   Size: 48 Acres.

Depth: 20 feet.

Drain: Outfall located approximately 1,000 feet downstream (consists of a 36" RCP).

Design: Designed for the 100-year discharge so that the outflow discharge does not significantly contribute to downstream 100-year peak discharges. (Inflow = 7,111 cfs, Outflow = 365 cfs).

A. Sediment basins will be required or estimated sediment volume should be incorporated into estimated volume of facility.

B. Benefits

1. Approximately 75% of the existing alluvial fan floodplain could be eliminated.

2. Reduction of peak discharges at roadway crossings of downstream spine washes (92% reduction at Concentration Point D11 and 40% reduction at Concentration Point D14).

3. Reduction of downstream existing linear floodplain width by approximately 75%.

4. Onsite detention/retention regulations may not be required for portions of the watershed.

2. Culverts or bridges are proposed at wash crossings of major roads.

A. At site specific locations, energy dissipators and/or bank/grade protection may be required.

B. At site specific locations, levees/spurdikes may be required to contain runoff so that appropriate head water elevation may be obtained at the drainage structure. In some areas, additional right-of-way may be required.

C. Arizona Department of Transportation has developed concept improvement plans for Tangerine Road. Plans include drainage improvements.

3. All weather dip sections are proposed for section line roadway/wash crossings in proposed low density development areas. Dip sections should meet local and county standards.

4. At site specific locations, roadway improvements (elevated roadway sections, channels, etc.) are proposed to convey minor runoff to a drainage crossing.

5. Concept improvements consisting of a collector channel to be located adjacent to the east of the Southern Pacific Railroad has been proposed by the Pima County Department of Transportation and Flood Control District.

6. Proposed channel improvements are limited to encroachment of spine wash fringes, in addition to initial reduction of floodplain width due to reduced discharges from detention/retention facilities. Approximately 40% to 70% of an existing spine wash floodplain could be encroached upon before a 0.5 foot rise in water surface elevation is realized for the 100-year event. This alternative essentially reduces the width of the floodplain of spine washes by providing a floodway-type encroachment with sideslope protection to contain flows of extreme events, while preserving and/or re-establishing the riparian environment within substantial drainage corridors. Under this recommendation, floodplain encroachment/channelization and combination channel/parkways would be utilized to improve the conveyance and stability of a defined spine wash.

Ruelas and Wild Burro Basins

1. Culvert drainage structures or bridges are proposed at wash crossing of major roads in moderate to high density areas.

    A. At site specific locations, energy dissipators and/or bank/grade protection may be required.

    B. At site specific locations, levees/spurdikes may be required to contain runoff so that appropriate head water elevation may be obtained at the drainage structure. In some areas, additional right-of-way may be required.

C. Arizona Department of Transportation has developed concept improvement plans for Tangerine Road. Plans include drainage improvements.

2. All weather dip sections are proposed for section line roadway/wash crossings in proposed low density development areas. Dip sections should meet local and county standards.

3. Concept improvements consisting of a collector channel to be located adjacent to the east of the Southern Pacific Railroad has been proposed by the Pima County Department of Transportation and Flood Control District.

Floodplain Mitigation

4. Option 1

Improved channels consisting of encroachment of spine wash floodplain fringes. Approximately 30% to 50% of an existing spine wash floodplain could be encroached upon before a 0.5 foot rise in water surface elevation is realized for the 100-year event. This alternative essentially reduces the width of the floodplain of spine washes by providing a floodway-type encroachment with sideslope protection to contain flows of extreme events, while preserving and/or re-establishing the riparian environment within substantial drainage corridors. Under this recommendation, floodplain encroachment/channelization and combination channel/parkways would be utilized to improve the conveyance and stability of a defined spine wash.

A. From the apex of the alluvial fans to a downstream point, collector channels are proposed. The collector channel may consist of levees and/or channelized sections of an existing wash. The purpose of the collector channel is to concentrate, contain and convey runoff from the apex to a downstream transition point with the proposed improved channel option.

1. On-line sediment basins will be required as part of the collector channel.

2. Bank protection of encroached and/or collector channel may be required to mitigate/minimize reflective scour.

B. Benefits

Approximately 75% of the existing alluvial fan floodplain could be eliminated.

C. Plan Considerations

1. Reduction in alluvial fan floodplain would not be recognized until completion of entire encroachment option (apex to I-10).

2. Completion of project is dependant upon development activity.

5. Option 2

A. Diversion structures/dams at the apex of the alluvial fans. Dams/reservoir would be designed to the 100-year level. Outflow could be regulated relative to downstream concerns/constraints.

B. Benefits

1. Approximately 75%-100% of the existing alluvial fan floodplain could be eliminated.

2. Reduction of peak discharges at roadway crossings of downstream spine washes.

3. Reduction or elimination of existing linear floodplain associated with spine washes.

4. Onsite detention/retention regulations may not be required for portions of the watershed.

C. Proposed channel improvements are limited to encroachment of spine wash floodplain. Approximately 30% to 70% of a spine wash floodplain could be encroached upon before a 0.5 foot rise in water surface elevations is realized for the 100-year event.

6. Option 3

A. From the apex of the alluvial fans to a downstream point, collector channels are proposed. The collector channel may consist of levees and/or a channelized section of an existing wash. The purpose of the collector channel is to concentrate, contain and convey runoff from the apex to a downstream detention/retention facility.

B. Retention/Detention Facility

Ruelas

Location:	Downstream of Concentration Point N6.
Size:	33 Acres.
Depth:	20 feet.
Drain:	Outfall located approximately 650 feet downstream (consists of a 36" RCP).
Design:	Designed for the 100-year discharge so that the outflow discharge does not significantly contribute to downstream 100-year peak discharges. (Inflow = 6,026 cfs, Outflow = 267 cfs).

Wild Burro

Location:	Downstream of Concentration Point O4.
Size:	75 Acres.
Depth:	20 feet.
Drain:	Outfall located approximately 900 feet downstream (consists of a 36" RCP).
Design:	Designed for the 100-year discharge so that the outflow discharge does not contribute to downstream 100-year peak discharges. (Inflow = 9,151 cfs, Outflow = 151 cfs).

C. Will require sediment basin associated with detention/retention facility or required sediment volume should be incorporated into the estimated retention/detention volume for the facility.

D. Benefits

Same benefits as Option 2, however, design and construction cost may be less.

Proposed structural components for all watersheds are cited on Figures 3A, 3B, 3C and 3D.

A comparison of 100-year peak discharges between developed conditions with improvements and developed conditions without improvements is provided in Table 10.

Table 10

Comparison of 100-Year Peak Discharges Between Developed Conditions with Improvements and Developed Conditions without Improvements

BASIN	SUB-BASIN CONCENTRATION POINT	100-YEAR PEAK DISCHARGES FUTURE CONDITIONS NO IMPROVEMENTS (cfs)	100-YEAR PEAK DISCHARGES FUTURE CONDITIONS IMPROVEMENTS (cfs)	
North Ranch	A4	1,606	1,712	
	A6+A7	1,681	1,797	(167)*
	A8	1,653	245	
	A9	1,647	299	
	A12	1,701	527	
	A15	1,929	1,322	
North Ranch	A33	777	419	
	A20	700	822	
	CPA	3,259	3,143	
	L2	628	635	
	L5	1,512	1,640	
	L6	1,585	1,676	
	I3	300	345	
	I5	645	734	
	I8	900	1,034	
Cañada Agua	B5	4,341	4,278	
	B6 (B-G17)	5,260	5,350	(147)*
	G20	4,898	447	
	G21	4,769	1,168	
Cañada Agua	G4	783	784	
	G5	867	952	
	G19	2,833	3,038	
Cañada Agua	C4	1,208	1,328	
	C8	1,952	1,871	(154)*
	C13	2,717	888	
	C16	3,806	3,061	
Prospect	D8	5,912	5,912	
	D9	6,951	6,928	
	D11	7,096	7,111	(484)*
	D14	7,216	4,323	
Ruelas	N6	5,508	5,508	
	N8	6,154	6,026	
	N9	8,607	4,922	
	N10	8,734	5,725	

TABLE 10 (*continued*)

Comparison of 100-Year Peak Discharges Between Developed Conditions with Improvements and Developed Conditions without Improvements

BASIN	SUB-BASIN CONCENTRATION POINT	100-YEAR PEAK DISCHARGES DEV. CONDITIONS - NO IMPROVEMENTS (cfs)	100-YEAR PEAK DISCHARGES DEV. CONDITIONS - IMPROVEMENTS (cfs)
Wild Burro	05, 06	9,265	9,151 (154)*
	08	9,494	446
	09	9,351	2,176
Wild Burro	Q1	363	363
	Q2	959	934
	Q3	1,856	1,849
	Q4	2,595	2,840

*100-year peak discharge (cfs) at outfall of proposed retention/detention facility.

SECTION 7. EVALUATION OF DRAFT BASIN MANAGEMENT PLANS

The evaluation of Basin Management Plans for watersheds with a three-plan option are presented, along with cost estimates for the implementation of Draft Basin Management Plans for all watersheds. For each watershed, the following cost estimates have been provided:

1. Construction and right-of-way cost.

2. Engineering/administrative costs, as a standard percentage of construction costs (10%).

3. Life-cycle operation and maintenance costs.

4. Property acquisition cost based on an average cost per acre. Unit costs were obtained from the Property Management Section of the Pima County Department of Transportation and Flood Control District.

Selection Matrix Summary

More than one Basin Management Plan option was developed for Ruelas and Wild Burro watersheds concerning floodplain mitigation. The options identified in Section 6 are:

1. Flood mitigation as a result of encroachment of spine wash floodplain fringes.

2. Flood mitigation as a result of diversion structures/dams at the apex of the alluvial fan and encroachment of spine wash floodplain fringes.

3. Flood mitigation as a result of regional detention/retention facilities and encroachment of spine wash floodplain fringes.

The evaluation scores for the different options are listed in Table 11. The evaluation criteria listed in Table 11 are in order of significance. Overall, Option 3 ranked higher or equal to Options 1 and 2 in the majority of the evaluation criteria.

TABLE 11: Basin Management Plan Selection Matrix

TORTOLITA BASIN MANAGEMENT STUDY

PIMA COUNTY FLOOD CONTROL DISTRICT

Ruelas & Wild Burro Basin

	Alternative #1	Alternative #2	Alternative #3
Provide for Flood Control Effectiveness	2	4	4
Protect Public Safety	2	3	4
Minimize Construction Cost	5	1	3
Preserve/Enhance Natural Channels	4	4	2
Provide for Public Acceptability	4	2	4
Minimize Environmental Impacts	4	3	3
Minimize Hydrologic/Sediment Impacts	4	3	3
Compatibility with Drainage	4	4	4
Compatibility with Development	2	4	4
Opportunity for Multiple Use	2	3	5
Provide for Phased Construction Potential	3	4	4
Provide for Flood Insurance Mitigation	1	4	4
Minimize Future Maintenance	4	2	3
Compatibiltiy with Roads	3	4	4
Enhance Visual Quality	4	2	3
Availability of Funding Options	4	4	4
Minimize Disruption to Public	4	4	4
Minimize Displacement of Structures	4	4	4
Protect Areas of Cultural/Historic Significance	3	3	3

Ranking Range: 1 - Low ——➤ 5 - High

Explanation - Alternative #1: Flood mitigation as a result of encroachment of spine wash floodplain fringes. Rank Score = 3.3

Alternative #2: Flood mitigation as a result of diversion structures/dams at the apex of the alluvial fan and encroachment of spine wash floodplain fringes. Rank Score = 3.3

Alternative #3: Flood mitigation as a result of regional detention/retention facilities and encroachment of spine wash floodplain fringes. Rank Score = 3.6

0793/PJE00119.02ZE/103957-04-0282 (4)

Option 3, relative to Options 1 and 2, ranked higher or equal to all evaluation criteria with the exception of the following criteria: Minimize Construction Cost, Preserve/Enhance Natural Channels, Minimize Environmental Impacts, Minimize Hydrologic/Sediment Impacts, Minimize Future Maintenance and Enhance Visual Quality. Options 1 and 2 received higher rankings in the above evaluation criteria over Option 3 due to the following reasons:

1. Construction cost of encroached spine wash floodplains will be at the expense of development.

2. A regional retention/detention facility and associated upstream channelization will not be as compatible with the natural environment as an encroached floodplain because the facility, to some degree, will have a visual, hydrologic and sediment impact that is less favorable.

Cost Estimates

To aid in the evaluation of the Proposed Basin Management Plans, identified in Sections 6 and 7, preliminary cost estimates have been compiled for the major drainage facilities for concept plans which have been developed. Plans are at a level that is consistent with this stage of the Tortolita Basin Management Study. The drainage facilities for which cost estimates are provided are:

1. Regional Retention/Detention Facilities

    A. Acquisition costs

    B. Excavation costs

    C. Spillway, low level outlet cost

2. Roadway Cross-Drainage Structures

3. Channel Excavation Cost

Estimated quantities are consistent with this level of conceptual planning and are preliminary estimates. Costs developed for the retention/detention basins do not include costs that would be incurred if the facilities were developed as multi-use facilities (additional land acquisition, landscaping, etc.).

Cost developed for roadway cross-drainage structures reflect construction cost only. Channel excavation costs reflect excavation of a typical channel cross-section in areas where channelization is proposed. Acquisition costs are average land costs for the area of a propsed retention/detention facility; unit costs were drived from TRW Real Estate Information Services. Tables 12, 13, 14, 15 and 16 represent rough cost estimates as described for the facilities proposed for North Ranch, Cañada Agua, Prospect, Ruelas and Wild Burro respectively.

TABLE 12

COST ESTIMATE STRUCTURAL IMPROVEMENTS

North Ranch Basin

Retention/Detention Facility

Land Acquisition	= $ 483,542
Excavation	= $ 1,880,504
Spillway	= $ 11,111
Low Level Outlet	= $ 50,400[1]
TOTAL	= $2,425,557
Raodway Drainage Structures	= $ 2,938,236
TOTAL	= $5,363,793

[1]Low level outlet consists of the length of an 48" RCP required to daylight downstream.

TABLE 13

COST ESTIMATE STRUCTURAL IMPROVEMENTS

<u>Cañada Agua Basin</u>

Retention/Detention Facility

		Basin 1	Basin 2
Land Acquisition	=	$ 945,515	$ 240,240
Excavation	=	$ 6,559,268	$ 2,319,652
Spillway	=	22,225	$ 22,225
Low Level Outlet	=	$ 122,400[2]	$ 115,200
TOTAL	=	$ 7,649,409	$ 2,697,317

TOTAL = $10,346,724

Raodway Drainage Structures = $ 2,081,918

TOTAL = $12,428,644

[2]Low level outlet consists of the length of an 48" RCP required to daylight downstream.

TABLE 14

COST ESTIMATE STRUCTURAL IMPROVEMENTS

<u>Prospect Basin</u>

Retention/Detention Facility

Land Acquisition	= $ 384,816	
Excavation	= $ 5,797,512	
Spillway	= $ 22,222	
Low Level Outlet	= $ 72,000[3]	
		TOTAL = $6,276,553
Raodway Drainage Structures	= $ 2,742,305	
		TOTAL = $9,018,858

[3]Low level outlet consists of the length of an 48" RCP required to daylight downstream.

TABLE 15

COST ESTIMATE STRUCTURAL IMPROVEMENTS

Ruelas Basin

Retention/Detention Facility

Land Acquisition	= $ 56,900
Excavation	= $ 3,878,816
Spillway	= $ 22,225
Low Level Outlet	= $ 81,606[4]
Channel Excavation	= $ 622,224[5]
TOTAL	= $4,661,665

Roadway drainage structures not applicable at this time.

[4]Low level outlet consists of the length of an 48" RCP required to daylight downstream.

[5]Based on a channel geometry of a bottom width of 288 feet, 3:1 side slopes and a depth of four feet. Cost does not include bank protection.

TABLE 16

COST ESTIMATE STRUCTURAL IMPROVEMENTS

Wild Burro Basin

Retention/Detention Facility

Land Acquisition	= $ 127,670
Excavation	= $ 9,044,512
Spillway	= $ 22,225
Low Level Outlet	= $ 100,800[6]
Channel Excavation	= $ 948,148[7]

TOTAL = $10,243,355

Roadway drainage structures not applicable at this time.

[6] Low level outlet consists of the length of an 48" RCP required to daylight downstream.

[7] Based on a channel geometry of a bottom width of 288 feet, 3:1 side slopes and a depth of four feet. Cost does not include bank protection.

SECTION 8. LOMR FEASIBILITY FOR ALLUVIAL FAN

A preliminary analysis was conducted concerning the feasibility of decreasing the size of the existing alluvial fan flood zone which impacts the Countryside Subdivision, based on developing a watershed model representative of the associated Tortolita Mountain watershed, and compatible with the alluvial fan model. The results of the analysis indicated that a portion of the subdivision could be removed from the flood zone, based on the revised watershed model. Pima County Flood Control District authorized CBA to proceed with an official LOMR request to FEMA. The LOMR request was submitted and approved, with a subsequent FEMA FIRM revision (refer to Appendix G).

SECTION 9. REFERENCES

"A Geomorphic Assessment of Flood-Prone Areas on the Southern Piedmont of the Tortolita Mountains, Pima County," Arizona Geological Survey Open-File Report 91-11, Philip A. Pearthree, et al, June 1992.

"Alluvial Fan Flooding Methodology, an Analysis," DMA Consulting Engineers, October 1985.

"Analysis of Flows on Alluvial Fans," Simons, Li & Associates, Inc., October 1988.

"Design Manual for Engineering Analysis of Fluvial Systems," Simons, Li & Associates, Inc., March 1985.

"Design Manual for Retrofitting Flood-prone Residential Structures," Federal Emergency Management Agency, September 1986.

"Drainage Alternatives for Tortolita Mountain Properties, Phase I," Simons, Li & Associates, April 1989.

"Engineering Standards for Flood Protection of Single Lot Developments on Alluvial Fans," Draft Report by the U.S. Army Corps of Engineers.

"Estimating Sediment Delivery and Yield on Alluvial Fans," Technical Paper No. 130, U.S. Army Corps of Engineers, June 1990.

"Floodplain Management Techniques for Alluvial Fans, Arid and Semi-Arid Environments," Nevada Division of Emergency Management, S.A. Santarcangelo, September 1984.

"Floodplain Management Tools for Alluvial Fans," Anderson-Nichols Company, Inc., December 23, 1990

"Floodproofing Non-Residential Structures," Federal Emergency Management Agency, May 1986.

"Guideline for the Development of Regional Multiple Use Detention/Retention Basins in Pima County, Arizona," Pima County Department of Transportation and Flood Control District, January 1986.

HEC-1 Hydrologic Computer Model developed by the U.S. Army Corps of Engineers.

"Hydrologic and Hydraulic Report for I-10 Corridor Study - Pima County Ruthrauff to Tangerine Road," Johnson Brittain and Associates, Inc., March 1991.

"Hydrology Manual for Engineering Design and Floodplain Management within Pima County, Arizona," Michael E. Zeller, September 1979.

"Improving the Effectiveness of Floodplain Management in Western State High-Risks Areas, Alluvial Fans, Mud Flows, Mud Floods," Association of State Floodplain Managers, February 1984.

"Interim Floodplain Management Policies for the Tortolita Fan Area," Pima County Department of Transportation and Flood Control District, April 1986.

"Location and Design Study for Tangerine Road, Avra Valley Road to 1st Avenue," Parsons Brinckerhoff, June 1988.

"Mannings Rating Computer Program," Cella Barr Associates.

"North Ranch Sub-Basin Management Study," Cella Barr Associates, 1987.

"Paleoflood Hydrology of the Major Southern Tortolita Mountain Canyons, Northern Pima County, Arizona," by P. Kyle House, September 1990, Revised 1991.

"Present Status of Management and Technical Practices on Alluvial Fan Areas in Arizona," Robert L. Ward, November 1988.

"Regional Long Range Transportation and Air Quality Plan and Ten-Year Transportation and Expenditure Plan 'The Baja Project'," BRW, Inc., August 1990.

"Report of Alignment and Cross-Section Alternatives for Tributary Drainage - the Lower Santa Cruz River Flood Control Project," CMG Engineering, December 2, 1987.

"Stormwater Detention/Retention Manual," Pima County Department of Transportation and Flood Control District, City of Tucson, effective September 1, 1987.

"Symposium on Alluvial Fan Management," Arizona Floodplain Management Association, January 23, 1986.

APPENDIX A.
OVERLAY MAPS

(Maps are provided under separate cover)

APPENDIX B.
HEC-1 MODELS - EXISTING/FUTURE PEAK DISCHARGES

(Floppy disks are provided under separate cover)

APPENDIX B.1
HEC-1 MODEL DETENTION/RETENTION

(Floppy disks are provided under separate cover)

APPENDIX B-1. HEC-1 MODELS - EVALUATION OF PROPOSED REGIONAL DETENTION/RETENTION FACILITIES

Appendix B-1 consists of the HEC-1 models developed to evaluate the hydraulic performance of proposed regional retention/detention facilities. The following criteria and assumptions were employed.

1. The 2-year, 10-year and 100-year developed condition discharges were utilized to evaluate proposed regional retention/detention facilities. The 100-year developed discharges included the effects of proposed improved channels (encroachment of existing spine wash floodplains).

2. The criteria for site selection of proposed regional retention/detention facilities are:

    A. To maximize the potential effect of decreasing or eliminating flood hazard zones associated with existing FEMA alluvial floodplains for Cañada Agua and Prospect watersheds, a location upstream of the apex (transition point from concentrated flow to alluvial fan sheet flow) at a point where runoff is concentrated (main flowpath of watershed or basin) was selected.

    B. The location of the apices of FEMA alluvial floodplains mapped for Ruelas and Wild Burro watersheds in relationship to the Tortolita Mountains (at the mountain front underlain by bedrock) precludes construction of retention/detention facilities of or upstream of the alluvial fan apex, therefore, a location downstream of the apex was selected. With this selection, collector channels would be required to concentrate, contain and convey distributary runoff from the apex to the retention/detention facilities.

    C. The site selection for proposed retention/detention facility for the North Ranch Watershed was based on a report entitled "North Ranch Sub-Basin Study."

3. The size of the retention basin reflects the size required to attenuate the 100-year peak discharge so that the outflow discharge does not contribute significantly with downstream 100-year peak discharges.

Because of the multi-use potential of a retention/detention facility (i.e., parks, etc.) the required acreage required to develop the facility will be greater than the acreage used to estimate the detention volume.

4. Volume and required acreage was estimated using the design constraints of 4:1 side slopes and depths from 10 to 20 feet below surface.

The input files for the HEC-1 models (floppy disk) developed for the retention/detention facility, analysis for each watershed, are located in this appendix. Table B-1 lists the watershed and input file designation.

Table B-1

WATERSHED	FILE NAME	REMARKS
North Ranch	BASIN.A.DET002	2-year event
	BASIN.A.DET010	10-year event
	BASIN.A.DET100	100-year event
Cañada Agua	BASIN.G&B.DENT002	2-year event
	BASIN.G&B.DENT010	10-year event
	BASIN.G&B.DENT100	100-year event
Cañada Agua	BASIN.C.DENT002	2-year event
	BASIN.C.DENT010	10-year event
	BASIN.C.DENT100	100-year event
Prospect	BASIN.D.DENT002	2-year event
	BASIN.D.DENT010	10-year event
	BASIN.D.DENT100	100-year event
Ruelas	BASIN.N.DETN8002	2-year event
	BASIN.N.DETN8010	10-year event
	BASIN.N.DETN8100	100-year event
Wild Burro	BASIN.O.DET06002	2-year event
	BASIN.O.DET06010	10-year event
	BASIN.O.DET06100	100-year event

APPENDIX B.2
HEC-1 MODEL - SPINE WASH

(Floppy disks are provided under separate cover)

APPENDIX B-2. HEC-1 MODELS - EVALUATION OF PROPOSED 100-YEAR SPINE WASH ENCROACHMENT

Appendix B-2 consists of the HEC-1 models developed to evaluate the structural component consisting of improved channels. Improved channels consist of floodplain encroachment of spine wash floodplains. The following criteria and assumptions were employed.

1. To conservatively estimate the downstream effect of allowing encroachment (development guidelines) of delineated spine wash floodplains an encroachment analyses utilizing the 100-year developed condition discharges were developed.

2. The encroachment analyses consisted of evaluating existing conditions by determining the 100-year water surface elevation for an average typical cross-section which was representative of the average Spine Wash floodplain width and depth, the typical cross-section was then analyzed to determine the amount of uniform encroachment obtained before the increase in water surface elevation exceed 0.5 feet.

3. An Manning's "n" value of 0.030 was utilized for the bank areas assuming that some type of bank protection would be required. Manning's "n" values for the channel were taken from previous HEC-1 models for existing conditions, values ranged from 0.03 to 0.07.

The input files for the HEC-1 models (floppy disk) developed for the proposed 100-year spine wash encroachment are located in this appendix. Table B-2 lists the watershed and input file designation.

Table B-2

WATERSHED	FILE NAME	REMARKS
North Ranch	BASIN.I.ENCR100	
	BASIN.K-L.ENCR100	
	BASIN.A.DET100	See Appendix B
Cañada Agua	BASIN.G.ENCR100	
	BASIN.G&B.DENT100	See Appendix B
	BASIN.C.DENT100	See Appendix B
Prospect	BASIN.D.DENT100	See Appendix B
Ruelas	BASIN.N.DETN8100	See Appendix B
Wild Burro	BASIN.O.DET06100	See Appendix B
	BASIN.Q.ENCR100	

APPENDIX C
FLOODPLAIN MAPS (200-SCALE)

(Maps are provided under separate cover)

APPENDIX D
CULVERT HYDRAULIC EVALUATION

APPENDIX D. CULVERT HYDRAULIC EVALUATION

Appendix D consists of tables listing locations of culvert roadway crossing and culvert size, and culvert evaluation data sheets.

Hydraulic evaluation of proposed culvert crossings were conducted to estimate the size, type and cost of culvert roadway crossings for each watershed. The following criteria and assumptions were emphasized:

1. At this level of study proposed culvert locations were identified along existing roadway alignments that are consistent with section line alignments.

2. For a given culvert's size required head water conditions can be achieved by roadway improvements (elevating roadway) and/or by containing runoff impacting the crossing by levees and or spurdikes.

3. At site specific locations, energy dissipator and/or bank protection may be required.

4. The 100-year developed condition discharge was used to size culvert crossings. The 100-year developed discharge included the effects of proposed structural components (Regional Detention/Retention Facilities and Channel Improvements).

5. Culverts were evaluated utilizing CBA, in-house culvert hydraulics computer program.

6. Culvert length was estimated to be 150 feet (from typical major artery roadway section).

Table D

PROPOSED CROSS-DRAINAGE STRUCTURES

Watershed	Structure Location	Structure	Q cfs	Head Water Feet	Total Length Feet
North Ranch	A4	3-10′ X 8′ CBC[1]			
	A5	1-60" RCP[1]			
	A16	2-48" RCP	137	3.64	300
	A17	1-48" RCP	56	3.24	150
	A13	4-60" RCP	474	4.53	600
	A23	2-48" RCP	110	3.2	300
	A8	2-60" RCP	245	4.62	300
	L4	3-60" RCP	350	4.48	450
	L2	3-10′ X 4′ CBC	635	3.7	150
	L3	2-10′ X 4′ CBC	570	4.54	150
	L1	3-60" RCP	327	4.31	450
	R1				
	I6	1-48" RCP	54	3.17	150
	I3	2-60" RCP	257	4.76	300
	I4	2-48" RCP	92	2.89	300
	H1	2-60" RCP	307	5.36	300
	I7	3-48" RCP	205	3.64	450
	1,100 feet upstream of R3	3-48" RCP	171	3.27	450
	R2	3-48" RCP	204	3.63	450
	K3	3-60" RCP	458	5.34	450
	L6	4-10′ X 6′ CBC	1,676	5.84	150
	R3	3-48" RCP	171	3.27	450

[1]Proposed by Arizona Department of Transportation (ADOT)

Table D (Cont.)

PROPOSED CROSS-DRAINAGE STRUCTURES

Watershed	Structure Location	Structure	Q cfs	Head Water Feet	Total Length Feet
North Ranch	I8	4-10′ X 4′ CBC	859	3.74	150
	I9	2-48" RCP	76	3.89	300
	H2	3-10′ X 4′ CBC	633	3.70	450
	1,200 feet upstream of K3	3-60" RCP	450	5.27	450
	2,500 feet upstream of L6	4-10′ X 6′ CBC	1,676	5.84	150
	2,000 feet downstream of A6, A7	2-48" RCP	166	4.28	300
	I-1	2-48" RCP	175	4.28	300
	K-1	3-60" RCP	327	4.31	450
	L-5	4-10′ X 6′ CBC	1,640		150
	P-2	2-48" RCP	155	3.94	300
	1,800 feet upstream of A12	2-10′ X 4′ CBC	527	4.30	150
	1,200 feet upstream of A14	2-10′ X 4′ CBC	563	4.5	150
	1,800 feet upstream of A20	3-10′ X 4′ CBC	822	4.42	150
	1,300 feet upstream of A21	4-10′ X 4′ CBC	975	4.07	150
	1,500 feet downstream of H-1	2-60" RCP	307	5.36	300
	I5	3-4′ X 10′ CBC	597	3.55	150

[1]Proposed by Arizona Department of Transportation (ADOT)

Table D (Cont.)

PROPOSED CROSS-DRAINAGE STRUCTURES

Watershed	Structure Location	Structure	Q cfs	Head Water Feet	Total Length Feet
Cañada Agua	F1	1-42" RCP[1]			
	F1	1-42" RCP[1]			
	D11	500-foot Span Bridge[1]			
	G14	1-48" RCP	53	3.14	150
	B6	2-48" RCP	146	3.79	300
	G5	4-10′ X 4′ CBC	952	4.01	600
	G6	2-60" RCP	319	5.51	300
	G18	3-10′ X 4′ CBC	712	4.00	450
	G20	3-60" RCP	447	5.25	450
	500 feet upstream of G19	7-10′ X 6′ CBC	3,038	5.87	150
	2,700 feet upstream of G19	7-10′ X 6; CBC	3,038	5.87	150
	10,000 feet upstream of G19	7-10′ X 6′ CBC	3,038	5.87	150
	6,300 feet upstream of G21	5-10′ X 4′ CBC	1,168	3.96	150
	8,200 feet upstream of G21	5-10′ X 4′ CBC	1,168	3.96	150
	G9	3-48" RCP	225	3.24	150
	G11	1-10′ X 9[1]			
	G8	1-72" RCP[1]			

[1]Proposed by Arizona Department of Transportation (ADOT)

Table D (Cont.)

PROPOSED CROSS-DRAINAGE STRUCTURES

Watershed	Structure Location	Structure	Q cfs	Head Water Feet	Total Length Feet
Cañada Agua	G4	2-72" RCP[1]			
	C14	1-66" RCP[1]			
	C10				
	C11	1-60" RCP[1]			
	E6	2-60" RCP[1]			
	E3	1-36" RCP[1]			
	E3	1-42" RCP[1]			
	E9	1-36" RCP[1]			
Prospect	1,000 feet downstream of D10	Bridge[1]	6,928		400
	1,600 feet downstream of D12	3-10' X 4' CBC	596	3.55	150
	D11	Bridge[1]	365		
Ruelas		Bridge[1]			
Wild Burro		Bridge[1]			

[1]Proposed by Arizona Department of Transportation (ADOT)

APPENDIX E
EROSION/SEDIMENTATION ANALYSIS

APPENDIX E. EROSION/SEDIMENTATION ANALYSIS

Appendix E consists of the sediment analysis conducted to determine the volume of sediment that will be delivered to the proposed sediment basins. The sediment analysis contained in the Pima County/City of Tucson Stormwater Detention/Retention Manual was utilized. Estimated sediment volumes are listed in Table E.

Table E

EROSION/SEDIMENTATION ANALYSIS

Watershed	Retention/ Detention Facility	Location	A Watershed Area (acres)	CP % of Watershed Yielding Sediment	Vsd = 500 ACP Addit. Volume Required for Sediment (CY)
North Ranch	DETA1	CPA7	1,299.0	55	13,230.0
Cañada Agua	C-DETE	Sub C11	1,433.6	55	14,601.0
Cañada Agua	BGDETE	CPB6	3,097.6	55	31,550.0
Prospect	D-DETE	Sub D11	3,667.2	80	54,329.0
Ruelas	N8-DETE	CPN8	2,412.8	80	35,745.2
Wild Burro	O6-DETE	CPO5,6	4,435.0	80	65,703.7

APPENDIX F
SOUTHERN PACIFIC/I-10 ANALYSIS

APPENDIX F. SOUTHERN PACIFIC/I-10 ANALYSIS

Johnson-Brittain & Associates, Inc. prepared a report entitled "HYDROLOGIC AND HYDRAULIC REPORT FOR I-10 CORRIDOR STUDY - PIMA COUNTY RUTHRAUFF ROAD TO TANGERINE ROAD" for the Arizona Department of Transportation in which they evaluated existing drainage conditions along segments of I-10 and the Southern Pacific Railroad which are within the Tortolita Basin Management Study area. The report proposes solutions to upgrade the existing cross-drainage system of I-10 by constructing new culverts and upgrading existing. Table F lists the proposed cross-drainage culverts offered by Johnson-Brittain & Associates, Inc.

TABLE F

FINAL
PROPOSED CROSS DRAINAGE STRUCTURES
FOR
I-10 CORRIDOR

Basin Structure Station	Description	Q50 (cfs)	Q100 (cfs)	Q50 WSE (ft)	Q100 WSE (ft)	PAVEMENT ELEVATION WBFR	PAVEMENT ELEVATION EBFR	Inlet Levee Elev.	Structure Invert Elevation Inlet	Structure Invert Elevation Outlet	Structure Length	Structure Slope	Pavement Elev. I-10
RILLITO RIVER													
RR4 5217+00	1 - 78" RCP (Existing (Q10=304) 1 - 78" RCP X 700' Storm Sewer (New)	560	659										
RR2 5212+75	WBFR & I-10 1 - 8' X 6' X 400' (Existing)	Remove											
Relocate to 5210+20	WBFR, I-10 & EBFR 5 - 8' X 3' CBC (new) Skew=15	628	738	2240.36	2240.77	2242.50	2239.50	2242.70	2237.25	2235.0	450'	0.5%	2250.00
CANADA DEL ORO													
CO1 5098+20	Old Casa Grande Hwy East of WBFR 2 - 8' X 4' CBC	191	225										
	WBFR, I-10 & EBFR 2 - 8' X 5'X 310' CBC (Existing) Extend 155' (new) Skew = 0	191	225	2206.61	2206.89	2209.90	2209.50	2208.00	2204.00	2202.50	465'	0.3%	2222.50
CO2 5090+00	2 - 108" RCP Storm Sewer (Existing)	927	1090										

TABLE F (Continued)

Basin Structure Station	Description	Q50 (cfs)	Q100 (cfs)	Q50 WSE (ft)	Q100 WSE (ft)	PAVEMENT ELEVATION WBFR	PAVEMENT ELEVATION EBFR	Inlet Levee Elev.	Structure Invert Elevation Inlet	Structure Invert Elevation Outlet	Structure Length	Structure Slope	Pavement Elev. I-10
NORTH RANCH													
NR13 5033+22	WBFR, I-10 & EBFR 3 - 10' X 4' CBC (new) Skew = 0	523	615	2203.35	2203.61	2205.70	2205.30	2204.00	2199.70	2199.30	405'	0.25%	2207.50
NR14 5020+14	1 - 60" RCP Storm Sewer (Existing) Q25=180												
	1 - 60" RCP X 4800' (new)	347	408										
* NR12 5015+98	WBFR, I-10 & EBFR 6 - 10' X 3' CBC (new) Skew = 0	582	685	2193.83	2194.09	2196.64	2196.00	2195.00	2191.60	2190.09	460'	0.15%	2211.00
	EBFR 3 - 10' X 3' X 35' (Existing) REMOVE												
NR11 5004+29	WBFR 2 - 6' X 3' X 35' CBC (Existing) REMOVE												
	I-10 2 - 6' X 3' X 275' CBC REMOVE (Existing)												
NR10 4992+85	WBFR, I-10, & EBFR 4 - 10' X 3' CBC (new) Skew = 6	780	918	2182.38	2182.94	2184.40	2183.00	2183.00	2178.70	2176.00	390'	0.7%	2184.30
NR9 4983+00	WBFR, I-10, & EBFR 8 - 10' X 5' CBC (new) Skew = 1	2889	3399	2178.75	2179.50	2180.80	2179.00	2179.50	2173.30	2172.00	390'	0.35%	2180.00
NR8 4973+00	WBFR 2 - 30" X 32'CMPs (Existing) REMOVE												

* Revised 12-06-90

TABLE F (Continued)

Basin Structure Station	Description	Q50 (cfs)	Q100 (cfs)	Q50 WSE (ft)	Q100 WSE (ft)	PAVEMENT ELEVATION WBFR	PAVEMENT ELEVATION EBFR	Inlet Levee Elev.	Structure Invert Elevation Inlet	Structure Invert Elevation Outlet	Structure Length	Structure Slope	Pavement Elev. I-10
NR7 4962+59	WBFR 3 - 10' X 3' X 32' CBC (Existing) Extend 50' (new) Skew = 0	197	231	2167.46	2166.51	2170.10	2168.90	2168.00	2164.60	2164.50	82'	0.3%	—
	I-10 & EBFR 3 - 10' X 3' X 235' CBC (Existing) Extend 40' (new) Skew = 0	197	231	2167.11	2167.17	--	--	2168.00	2164.50	2163.90	275'	0.2%	2170.50
NR6 4950+68	WBFR 2 - 5' X 3' CBC (Existing) CMID Canal Structure	30	35										
NR 5.5 4916+70	WBFR, I-10 & EBFR 4 - 10' X 4' CBC (new) Skew = 0	1319	1551	2152.90	2153.77	2155.00	2152.00	2155.00	2147.59	2146.00	530'	0.3%	2170.30
NR5 4905+00	WBFR I-10, & EBFR 4 - 8' X 5' CBC (new) Skew = 0	1275	1500	2150.58	2151.44	2152.60	2149.00	2151.70	2144.70	2142.00	535'	0.5%	2158.00
NR4 4892+30	WBFR, I-10 & EBFR 5 - 10' X 4' CBC (new) Skew = 2	1275	1500	2144.31	2144.9	2146.80	2144.50	2146.30	2140.00	2137.70	460'	0.5%	2146.50
NR3 4880+82	WBFR, I-10 & EBFR 6 - 10' X 3' CBC (new) Skew = 0	1275	1500	2140.26	2140.90	2142.30	2141.00	2142.30	2136.30	2133.90	410'	0.59%	2142.10
R2 4875 + 20	WBFR, I-10 & EBFR 5 - 8'X 5' CBC (new) Skew = 1	1275	1500	2137.77	2138.31	2139.80	2137.00	2139.50	2132.70	2131.40	425'	0.31%	2139.50
NR1 4868+72	WBFR, 1-10, & EBFR 6 - 10' X 4' CBC (new) Skew = 1	1275	1500	2134.38	2134.85	2136.70	2135.20	2136.00	2130.60	2128.50	412'	0.50%	2136.30

TABLE F (Continued)

Basin Structure Station	Description	Q50 (cfs)	Q100 (cfs)	Q50 WSE (ft)	Q100 WSE (ft)	PAVEMENT ELEVATION WBFR	PAVEMENT ELEVATION EBFR	Inlet Levee Elev.	Structure Invert Elevation Inlet	Structure Invert Elevation Outlet	Structure Length	Structure Slope	Pavement Elev. I-10
CANADA AGUA													
*CA8 4848+12	WBFR, I-10 & EBFR 14 - 8' X 7' CBC (new) Skew = 3	6658	7833	2128.29	2129.33	2130.20	2128.50	2129.50	2120.70	2119.50	400'	0.3%	2129.30
*CA7 4833+00	WBFR 3 - 8' X 4' X 32' CBC (Existing) REMOVE I-10 3 - 9' X 4' x 255' CBC (Existing) REMOVE												
Relocate to 4828+40	WBFR, I-10 & EBFR 12 - 8' X 4' CBC (new) Skew=4°	2420	2848	2118.28	2118.86	2120.30	2117.50	2119.00	2114.00	2111.50	500'	0.5%	2120.00
CA6 4813+00	WBFR, I-10 & EBFR 9 - 8' x 4' CBC (new) Skew=1°	1800	2118	2109.65	2110.23	2111.70	2109.00	2111.0	2105.40	2103.00	480	0.5%	2110.20
**CA5 4795+34	WBFR, I-10 & EBFR 9 - 8' X 4' (new) Skew = 29	1800	2118	2101.55	2102.13	2103.00	2101.50	2102.50	2097.30	2094.80	390'	0.69%	2103.0
**CA4 4768+60	WBFR 6 - 10' X 4' x 32' (Existing) I-10 & EBFR 6 - 10' X 4' X 95' CBC (Existing) Extend 220'(new) Skew = 42	1069	1258	2092.19	2092.59	2094.85	2092.80	2092.00	2088.85	2086.30	477'	0.44%	2095.3
CA3 4751+30	WBFR, I-10 & EBFR 3 - 8' X 3' CBC (new) Skew = -3	357	420	2087.42	2087.84	2089.80	2088.30	2089.80	2084.40	2083.30	450'	0.24%	2089.5

* Revised 2-28-91

TABLE F (Continued)

Basin Structure Station	Description	Q50 (cfs)	Q100 (cfs)	Q50 WSE (ft)	Q100 WSE (ft)	PAVEMENT ELEVATION WBFR	PAVEMENT ELEVATION EBFR	Inlet Levee Elev.	Structure Invert Elevation Inlet	Structure Invert Elevation Outlet	Structure Length	Structure Slope	Paver Elev. I-10
CA2 4745+80	WBFR —												
	I-10 1 - 9' X 5' CBC CMID Canal Structure												
CA1 4744+30	WBFR, I-10 & EBFR 4 - 10' X 4' CBC (new) Skew =25	825	970	2085.20	2085.65	2087.50	2086.10	2086.00	2081.50	2079.85	460'		2097.(
PROSPECT													
P6 4735+30	RR-xing under I-10 (Existing)	0	0										
P5 4721+20	SPRR 1 - 10' X 3' WBFR I-10	2296 – –		2078.18									

Pima County has proposed to build a intercepter channel on the east side of SPRR from P5 t(northwest, to capture runoff and discharge it through a concrete box culvert at Tangerine Ro into the Santa Cruz River. All flow values will be reduced to onsite corridor runoff. All existi Corridor structures can be removed.

* Revised 2-28-91

APPENDIX G
COUNTRYSIDE SUBDIVISION LOMR

Federal Emergency Management Agency
Washington, D.C. 20472

RECEIVED
NOV 10 1992
103957-04-0931
TO FILE FROM SLS
JSW
PJE

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

IN REPLY REFER TO:
102A

The Honorable Reginald Morrison
Chairman, Pima County
Board of Supervisors
130 West Congress Street
Fifth Floor
Tucson, Arizona 85701

Case No.: 92-09-186P
Community: Pima County, Arizona
FIRM Panel Numbers: 040073 1015 C, and 1020 C
Effective Date of This Revision: NOV 6 1992

Dear Mr. Morrison:

This is in response to a letter dated August 24, 1992, from Mr. Steve Casillas, Principal Hydrologist, Pima County, regarding the effective Flood Insurance Rate Map (FIRM) for Pima County, Arizona. In his letter, Mr. Casillas requested that we revise the effective FIRM to show the results of a new hydrologic analysis of Canada Agua East Basin. In support of his request, Mr. Casillas submitted data with his letters dated July 31, 1992, and August 24, 1992.

We have completed our review of the submitted data and the data used to produce the effective FIRM, and have revised the FIRM to modify the floodplain boundary delineations of a flood having a 1-percent probability of being equaled or exceeded in any given year (base flood) along Canada Agua East Basin. This revision is based on a new flood frequency analysis. In particular, the frequency at which a given flood discharge is expected to be exceeded is less than that previously determined. Thus, although the area labeled Zone AO on the FIRM but labeled Zone B on the attachment to this Letter of Map Revision (LOMR) is indeed subject to flooding, the frequency of a given point within that area being flooded is less than previously determined. It should be noted that when realized, the hazards associated with alluvial fan flooding are just as severe in areas designated as Zone B as those in areas designated as Zone AO. The distinction between the zones should be regarded as a distinction between flooding potentials and not a distinction between the severity of damages to be expected in the event of a flood. Therefore, we highly recommend that the owner of any structure located in such an area obtain flood insurance and that those hazards be considered when devising a floodplain management policy.

The modifications are shown on the enclosed annotated copies of FIRM Panels 040073 1015 C, and 1020 C, and the Summary of Discharges Table. This LOMR hereby revises these panels of the effective FIRM dated September 6, 1989.

Because of current funding constraints, we must limit the number of physical map revisions. Consequently, we will not publish a revised FIRM for Pima County to reflect modifications at this time. However, if in the future we revise and republish the FIRM panels affected by this LOMR, we will incorporate the previously described modifications at that time.

These modifications have been made pursuant to Section 206 of the Flood Disaster Protection Act of 1973 (P.L. 93-234) and are in accordance with the National Flood Insurance Act of 1968, as amended (Title XIII of the Housing and Urban Development Act of 1968, P.L. 90-448), 42 U.S.C. 4001-4128, and 44 CFR, Part 65. As required by the legislation, a community must adopt and enforce floodplain management measures to ensure continued eligibility to participate in the National Flood Insurance Program (NFIP). Therefore, your community must enforce these regulations using, at a minimum, the base (100-year) flood elevations, zone designations, and floodways in the Special Flood Hazard Areas shown on the FIRM for your community, including the previously described modifications.

This response to your request is based on minimum floodplain management criteria established under the NFIP. Your community is responsible for approving all proposed floodplain developments, including this request, and for ensuring that necessary permits required by Federal or State law have been received. With knowledge of local conditions and in the interest of safety, State and community officials may set higher standards for construction, or may limit development in floodplain areas. If the State of Arizona or Pima County has adopted more restrictive or comprehensive floodplain management criteria, these criteria take precedence over the minimum NFIP requirements.

The community number and suffix code listed above will be used for all flood insurance policies and renewals issued for your community on and after the effective date listed above.

The modifications described herein are effective as of the date of this letter. However, a review of the modifications and any requests for changes should be made within 30 days. Any request for reconsideration must be based on scientific or technical data.

This LOMR will not be printed and distributed to primary map users such as local insurance agents and mortgage lenders; therefore, the community will serve as a repository for these new data. We encourage you to disseminate the information reflected by this LOMR widely throughout the community in order that interested persons such as property owners, insurance agents, and mortgage lenders may benefit from this information. We also encourage you to consider preparing an article for publication in the community's local newspaper that would describe the changes that have been made and the assistance the community will provide in serving as a clearinghouse for these data and interpreting NFIP maps.

If you have any questions regarding the modifications described herein, please call the Chief, Natural and Technological Hazards Division, Federal Emergency Management Agency, in San Francisco, California, at (415) 923-7175, or Mr. John Magnotti of my staff in Washington, D.C., at (202) 646-3932.

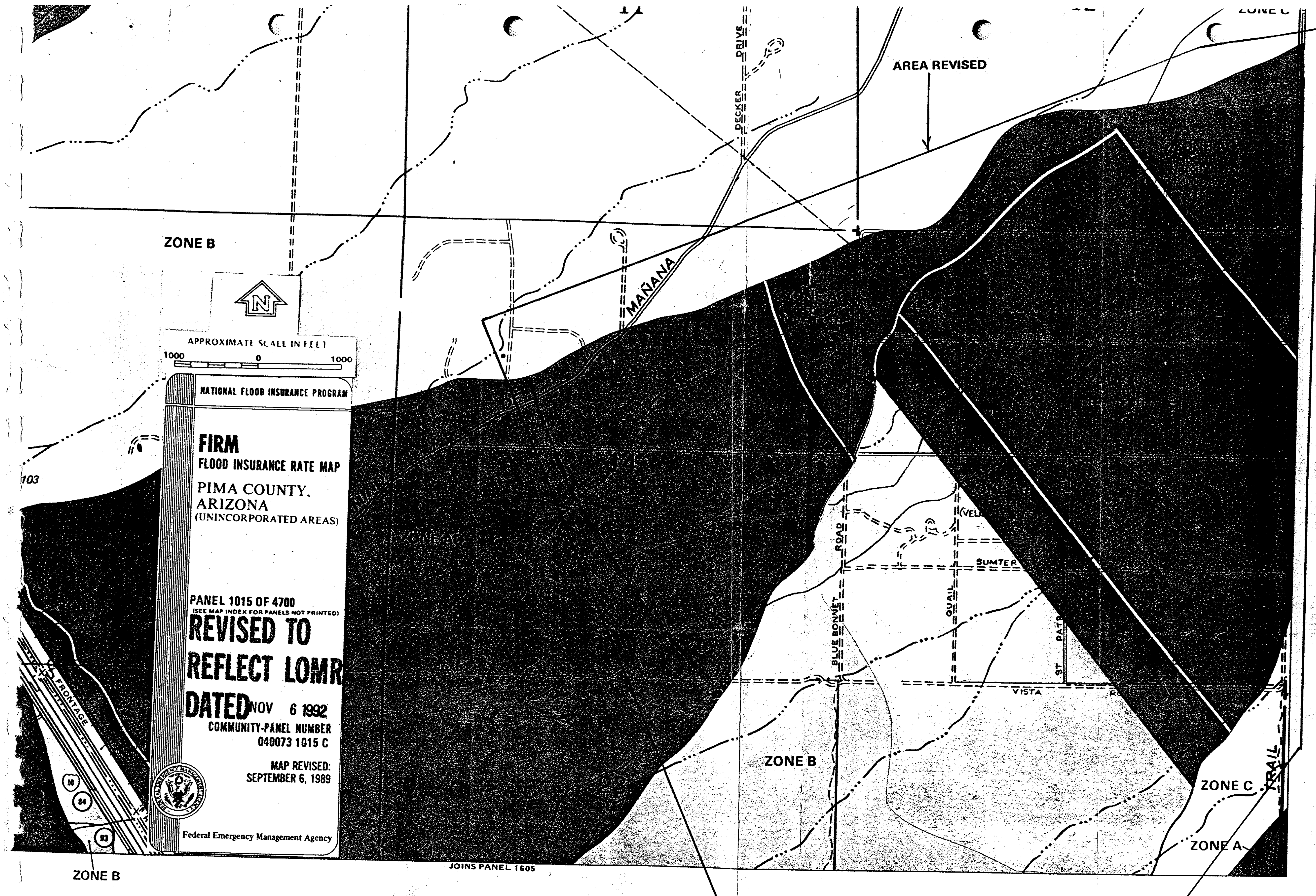
Sincerely,

William R. Locke
Chief, Risk Studies Division
Federal Insurance Administration

Enclosures

cc: Mr. Steve Casillas
Flood Control Planning
and Development Division
Pima County Department of
Transportation and Flood
Control District

Ms. Sandra L. Steichen
Cella Barr Associates



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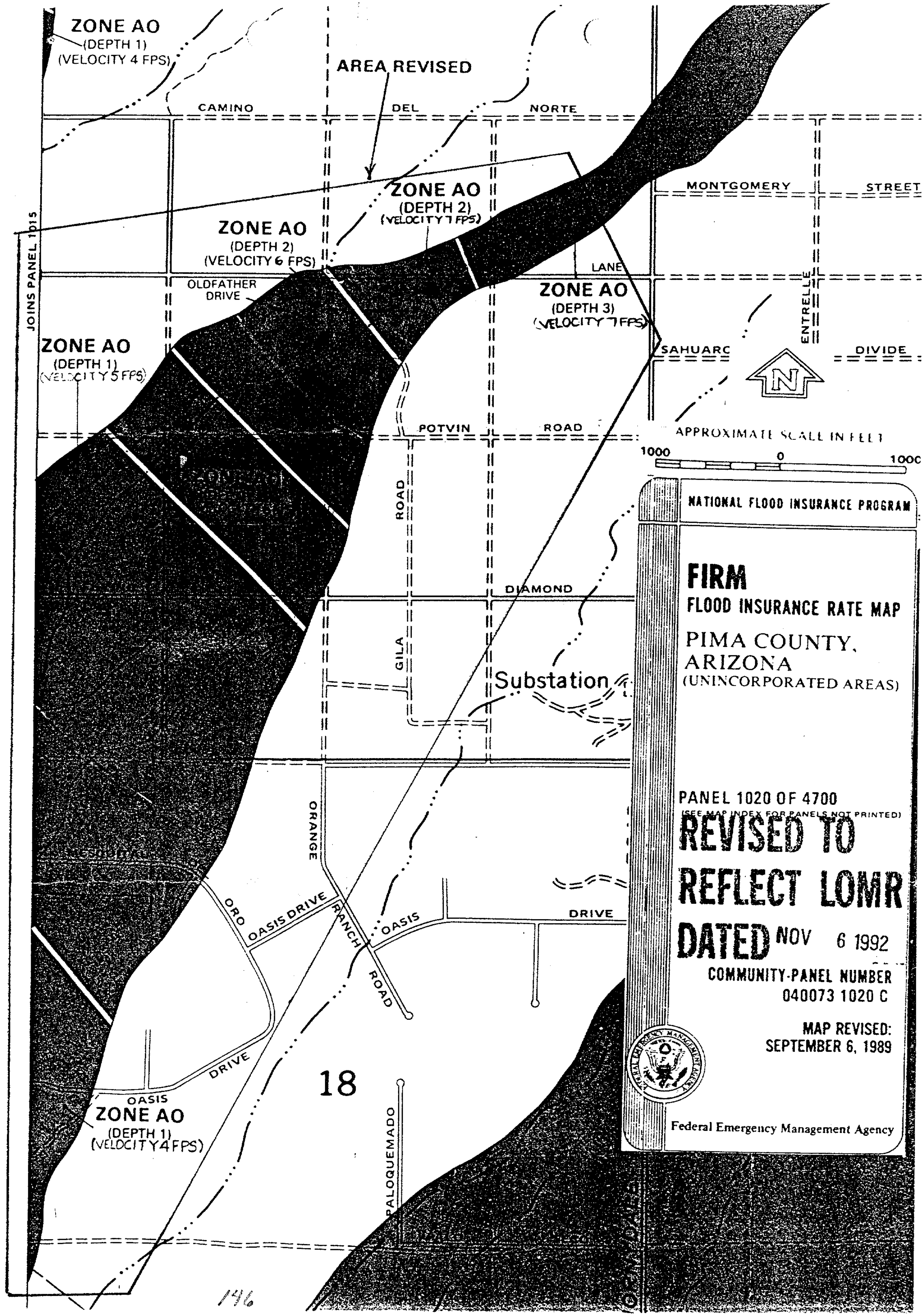
ZONE AO
(DEPTH 1)
(VELOCITY 4 FPS)
AREA REVISED
CAMINO
DEL
NORTE
MONTGOMERY
STREET
ZONE AO
(DEPTH 2)
(VELOCITY 7 FPS)
ZONE AO
(DEPTH 2)
(VELOCITY 6 FPS)
JOINS PANEL 1015
OLDFATHER
DRIVE
LANE
ZONE AO
(DEPTH 3)
(VELOCITY 7 FPS)
ENTRELLE
ZONE AO
(DEPTH 1)
(VELOCITY 5 FPS)
SAHUARO
DIVIDE
N
POTVIN
ROAD
APPROXIMATE SCALE IN FEET
1000
0
1000
ROAD
GILA
DIAMOND
Substation
ORANGE
ORO
OASIS DRIVE
RANCH
ROAD
OASIS
DRIVE
DRIVE
OASIS
18
ZONE AO
(DEPTH 1)
(VELOCITY 4 FPS)
PALOQUEMADO
NATIONAL FLOOD INSURANCE PROGRAM
FIRM
FLOOD INSURANCE RATE MAP
PIMA COUNTY,
ARIZONA
(UNINCORPORATED AREAS)
PANEL 1020 OF 4700
(SEE MAP INDEX FOR PANELS NOT PRINTED)
REVISED TO
REFLECT LOMR
DATED NOV 6 1992
COMMUNITY-PANEL NUMBER
040073 1020 C
MAP REVISED:
SEPTEMBER 6, 1989
Federal Emergency Management Agency
196

Table 2. Summary of Discharges (Cont'd)

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Sopori Wash					
At U.S. Highway 89	164	6,770	14,300	19,900	47,860
At Upstream Limit of Detailed Study	110	6,120	12,960	18,000	43,200
Ventana Canyon Wash					
At Confluence With Tanque Verde Creek	16.7	3,217	N/A	6,800	17,000
Downstream of Confluence With Esperero Canyon Wash	14.6	4,952	11,451	14,775	27,000
Upstream of Confluence With Esperero Canyon Wash	7.9	4,140	8,888	11,082	18,500
At Sunrise Drive	7.0	4,172	8,684	10,770	19,500
At Upstream Limit of Detailed Study	3.9	3,304	6,621	7,836	13,250
Esperero Canyon Wash					
At Confluence With Ventana Canyon Wash	6.2	2,947	6,795	8,440	14,400
At Sunrise Drive	6.1	3,350	7,319	9,116	16,000
At Upstream Limit of Detailed Study	5.9	4,239	8,789	11,037	19,000
Tortolita Alluvial Fans					
Canada Agua Canyon					
At the East Apex	2.06	832	2,398	3,528	7,859
At the West Apex	0.81	640	1,580	2,130	3,720
Prospect Canyon					
At the Apex	3.43	1,960	4,870	6,550	11,450
Ruelas Canyon					
At the Apex	3.58	1,800	4,460	5,990	10,470
Wild Burro Canyon					
At the Apex	6.97	2,850	7,080	9,520	16,630

REVISED TO REFLECT LOMR DATED NOV 6 1992

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APPENDIX H
GLOSSARY OF TERMS AND ACRONYMS

APPENDIX H. GLOSSARY OF TERMS AND ACRONYMS

The following glossary contains terms which may be found throughout this report. In certain instances, the definitions provided represent a specific connotation of the term as it is used within the report.

Balanced Basin - A watershed or sub-watershed which has been identified as having the potential for a severe increase in flood hazards as a result of increased urbanization within the basin.

CFS (Cubic Feet per Second) - A measure of the magnitude of a flood event.

CN (Curve Number) - Abbreviation for watershed curve number.

CBC (Concrete Box Culvert)

CP (Concentration Point) - A hydrologic term which describes any specific point within a watershed where the surface drainage is to be analyzed.

Critical Basin - A watershed or sub-watershed which has been identified as having severe flooding problems as a result of existing watershed conditions.

Culvert - A short, closed conduit, typically designed for conveying flow through an embankment.

Drainage Basin - A geographical area which contributes surface runoff to a particular point of interest. The term "drainage basin" and "watershed" are used interchangeably within this report.

Dry Well - An engineered hole with grated inlet designed to accept stormwater runoff, thereby allowing it to drain into the subsurface strata which lie immediately above the groundwater table.

Embankment - An artificial mound of earth which can act to impound water.

Emergency Spillway - An outflow spillway from a stormwater storage facility which is provided to allow for the safe overflow of floodwaters should situations arise that were not taken into account under normal design assumptions.

FEMA (Federal Emergency Management Agency)

Flood Routing - The mathematical simulation of a flood wave as it moves downstream through a watercourse or detention basin.

Hydrograph - The functional relationship between time and flow discharge, as observed at a particular point within a watershed. Hydrographs are typically represented either graphically or in tabular form.

Infiltration - The movement of water through the surface of the soil. In this report, the terms "percolation" and "infiltration" will be used interchangeably; however, strictly speaking, the term "percolation" is defined as the movement of water through soil strata (i.e., water infiltrates through the soil surface, and then percolates through the underlying strata).

Inflow - Runoff which flows into a stormwater storage facility from the upstream watershed.

Manning's - Manning's Equation for determination of normal depth of flow.

Multi-Purpose Basin - A detention/retention basin which provides benefits in addition to the primary function of flood control. Such benefits may include recreation, water harvesting, visual buffers or parking.

N_b - Watershed basin factor.

Off-Line Detention/Retention Basin - A stormwater storage facility which is located near or adjacent to a watercourse (i.e., the channel does not flow directly into the basin). Inflow to the basin is typically accomplished by means of side weirs.

On-Line Detention/Retention Basin - A stormwater storage facility which is located within the path of a watercourse, and thereby typically intercepts the entire flow from the upstream watershed.

Offsite Drainage - Stormwater runoff emanating from remote areas which affect the site under investigation.

Onsite Drainage - Stormwater runoff which emanates directly from the site under investigation.

Orifice - A small hole designed for draining a stormwater storage facility.

Outflow - Runoff which exits a stormwater storage facility be means of an outlet structure.

Outlet - The point at which stormwater runoff flows out of a detention/ retention facility. Outlets may consist of culverts, weirs, orifices, dry wells, etc., or any combination thereof.

P_1 - One-hour rainfall depth.

Q_{xx} (flood peak) - The largest value of the flow discharge which occurs during a flood event, as observed at a particular point within the watershed.

Return Period - The average interval of time within which a particular magnitude of flood should be equalled or exceeded at least once (e.g., a flood magnitude having a return period of 100 years will be equalled ar exceeded, on the average, once every 100 years).

Rise Time - The time interval from the beginning of runoff to the time of peak discharge, as represented by the flood hydrograph.

Scour - The removal of material from the bed and banks of a channel as a result of flowing water.

Sediment Trap - An area within a stormwater storage facility which is designed to trap the majority of incoming sediments for the purposed of facilitating maintenance.

Stage - The height of water within a stormwater storage facility, as measured above an established datum.

Stormwater Detention Basin - A facility which temporarily stores surface runoff, and then releases it at a controlled rate through a positive outlet.

Stormwater Retention Basin - A facility which stores surface runoff, but is not provided with a positive outlet. No flow is discharged directly into a downstream watercourse from a retention basin, but may be drained into the subsurface by infiltration.