

TREXLER

FLOOD REPAIR AND FLOOD HAZARD MITIGATION PROGRAM

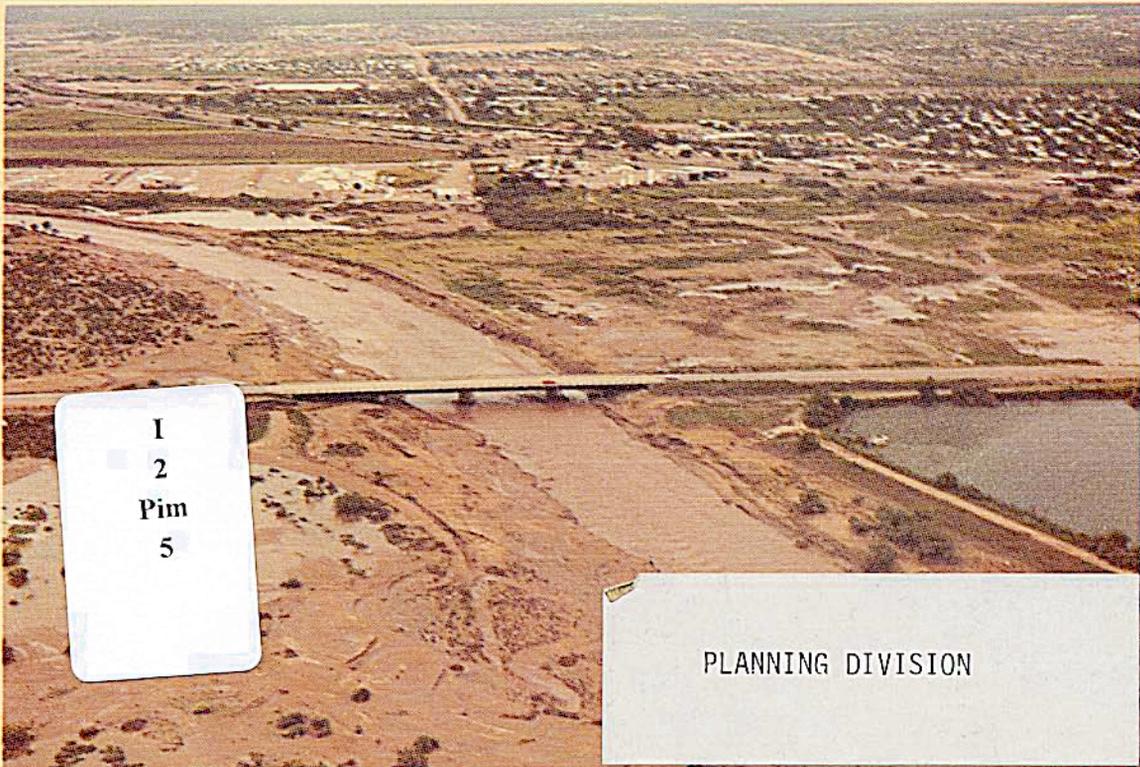
PIMA COUNTY, ARIZONA

El Camino del Cerro Bridge



FLOOD DAMAGE:
TOTAL LOSS

OCTOBER 1977 FLOOD DISCHARGE 20,000 CFS



FEDERAL REPAIR	\$ 471,138
LOCAL MITIGATION	\$1,490,035
TOTAL	\$1,961,173

FLOOD DAMAGE:
MINOR

PLANNING DIVISION

See Page 41

OCTOBER 1983 FLOOD DISCHARGE 45,000 CFS

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CONSULTANT LIST

	DATE/TIME	SIGNATURE
ALPHA ENGINEERING	3/1/84	D. M. Campbell
APM	3/1/84	AZM T.S.
A.R. TURK	3/1/84 9:46	A.R. Turk
BKS ENGINEERS	3/1/84 11:17	Bal K. Saran
BLANTON & COMPANY	3/1/84 1:45 PM	R.E. Smith
BUCK LEWIS	3/1/84 2:05	Buck Lewis
CANNON & ASSOCIATES	3/1/84	Jay O. Cannon
JOHN CAROLLO	3-1-84	John Carollo
CARTER ASSOC., INC.	3/1/84 10:11	John P. Smith
CELLA BARR ASSOC.	3/1/84 11:40	Dennis Bishop
CHEYNE OWEN LTD	3/1/84 10:50	Robert J. Lawson
DAMES & MOORE	3-1-84	Lutz Kuege
DOOLEY-JONES ASSOC	3/2/84	JAMES WISE
FINICAL & DOMBROWSKI	3-1-84	Ray Calman
GREINER ENGINEERING	3-1-84	Bill Greiner
HOLBEN, MARTIN & MEZA	3/1/84	Rand Holben
JOHNSON-BRITTAIN & ASSOC.	3/1/84	Mike Johnson by leg
LIND/JENSEN & ASSOC.	3/5/84	Clare Jeslin
PDS INCORPORATED	3/2/84	Tom Johnson
RG CONSULTING ENGRS	3/1/84 9:45	Michael
RS ENGINEERING	3/1/84 11:40	Mike
RUIZ ENGINEERING	3/2/84 7:50	Bob Swift
SIMON LI & ASSOC	3/1/84 3:10	Gill E. Li
STITZER, JOHNSON & ASSOC	3/2/84 4:03	Frank Stitzer
SVERDRUP & PARCEL	3/1/84 3:24	Burford D. Olcott
THOMPSON-MURPHY	3-2-84 10:55	Tami Thompson
VEA, LTD	3-1-84 9:23	Jon Sella
THE WLB GROUP	3-1-84	Wm. C. Walker

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Property of:
Pima County
Flood Control District Library
740-6350

FLOOD REPAIR AND FLOOD HAZARD MITIGATION PROGRAM

PIMA COUNTY, ARIZONA

A program for

Property of:
Pima County
Flood Control District Library
740-8350

the permanent repairs to flood damaged public facilities to prevent future flood damage

the reduction of private loss and suffering from the September and October, 1983, flood

the reduction of overall community disruption, damage, and inconvenience from future floods

providing a comprehensive and systematic approach to flood protection in Pima County.

Prepared by

The Pima County Department of Transportation
and Flood Control District

Prepared for

Pima County Citizen Bond Committee
and
The Pima County Board of Supervisors
and
The Pima County Flood Control District Board of Directors

INTRODUCTION



INTRODUCTION

Beginning September 29 and continuing through October 2, 1983 flooding occurred in watersheds, affecting Pima County and Southern Arizona. This flooding caused severe erosion damage as well as over bank flooding damage on the Santa Cruz River, Rillito River, Pantano Wash, Tanque Verde Creek, Agua Caliente Wash, Pima Canyon Wash, Canada del Oro Wash and many of the tributary watersheds to the major river system. The estimated flood peaks for the major river system are shown in the following table:

OCTOBER 1983 FLOOD

PIMA COUNTY DEPARTMENT OF TRANSPORTATION AND FLOOD CONTROL DISTRICT

PEAK FLOOD FLOW ESTIMATES

<u>RIVER</u>	<u>QUANTITY (cfs)</u>	<u>RETURN PERIOD</u>
Santa Cruz @ Green Valley	30,000	100 yr
Santa Cruz @ Tucson	40 - 45,000	100+ yr (100 yr = 30,000)
Santa Cruz @ Marana ¹	60,000	100+ yr (100 yr = 40,000)
Rillito ²	25,000	50 yr
Tanque Verde	20,000	50 yr
Pantano	15,000	25 yr
Canada del Oro	10,000	10 yr

Massive flood damages occurred to public facilities from this flood event. Public damages include washed out bridges, damaged flood control works, washed out and damaged arterial highways, collector and local roadways, and damaged or destroyed utilities such as sewer, water, electric and gas lines as well as damaged sanitary land fills.

Early estimates by the Federal Emergency Management Agency indicate that in the Santa Cruz River Basin 154 residential units were destroyed, 160 suffered major damage, and 222 received minor damage. Furthermore, an estimated 19 businesses had major damage while 22 incurred minor damage. More tragically, 13 lives were lost, 221 people were injured and 11 were hospitalized in Arizona, with most victims in Pima and Pinal Counties. Included in the fatalities were two helicopter crew members from the Arizona Department of Public Safety, killed while performing rescue activities. Although the total number of people rescued is unknown, the Picture Rocks Fire District and Rural Metro Fire Department, with the assistance of the Department of Public Safety and the Army National Guard, estimate approximately 400 people were evacuated for medical or personal safety reasons. Pima County Search and Rescue estimates they were involved in 200 rescues during the early stages of the storm.

The American Red Cross reported that in the 16 emergency shelters set up throughout Arizona, 5,852 people were given emergency shelter. Through mid-December, 11,440 people, received some type of assistance. In addition, the Tucson office of the Salvation Army housed about 40 to 45 families temporarily.

In areas isolated by the flood, as well as at temporary shelters, the main concern became that of sustaining victims by providing for their physical and emergency care needs. Food and medical supplies for hundreds of families were air-dropped into isolated area. Over 23 tons of food, as well as clothing, furnishings, bedding, and personal items were distributed in the early days and weeks of the flood disaster.

During the height of flooding, 35 to 42 major bridges were closed. Fifteen bridges suffered sufficient damage to remain closed to traffic from a few days to a few weeks. Four bridges remain closed awaiting major repair or replacement. Today there

are 170,000 vehicle trips traveling over a damaged bridge or approach each day in eastern Pima County. Because of the temporary nature of repairs made to date, the potential for additional damage to nineteen bridges is very high during any additional flooding.

During the flood, severe damage occurred to sanitary sewer interceptor lines ranging in size from 27 inches to 15 inches. Over 8,000 feet of sewer main was washed out resulting in a discharge of 1.5 million gallons of sewage per day into the river system. Minor damage also occurred to the Green Valley and Marana wastewater treatment facilities.

Sanitary landfills were also damaged by flood waters. The Ina Road landfill was the most severely damaged, however, damage also occurred or the potential for damage was high at over a half dozen other abandoned landfill sites.

The water distribution system was also damaged during the flood. Water transmission mains ranging in size from 36 inches to 8 inches were washed out. Many households were temporarily without water service because of flood damage. Several well sites and well fields were also endangered by flood waters and erosion.

Public and private damage from the flood was high. The cost to repair the damage will also be high. Funding for damage repair will come from a variety of federal, state and local sources with the majority of funds coming from local sources.

GENERAL PUBLIC FACILITY DAMAGE AND PRIVATE PROPERTY

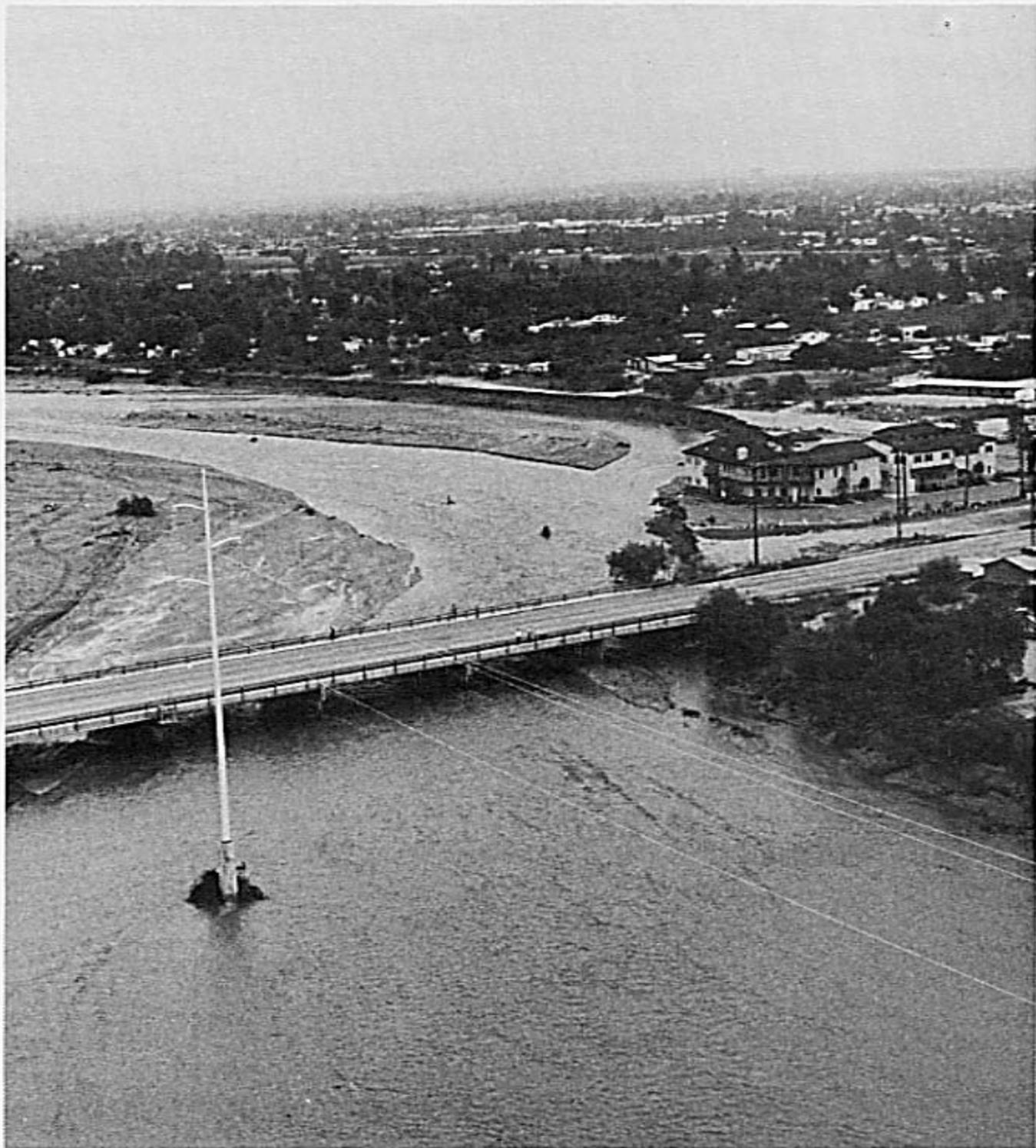
Santa Cruz River

By far the greatest flood damage occurred within the Santa Cruz River Basin. Flood damage was extensive from the Amado Road Bridge immediately south of the County line to beyond the Trico Road Bridge on the north Pima County line. The most severe damages on the Santa Cruz River occurred downstream of the Canada del Oro Wash and Rillito River confluences. Property damages along the Rillito River wa extensive and caused by bank erosion rather than flood water inundation. The flow in the Rillito River came primarily from the Tanque Verde Creek where floodwater inundated the flood plain cause property damages and severely reduced access. Flows within the Pantano Wash and Canada del Oro Wash were of a much reduced magnitude but did contribute to overall flood volumes and flood/erosion damage.

The following pages list a general location and description of the damage to the bridge/highway crossings, flood control works, sewer and water works and private property and of the utilities along the major watercourses.

The list is not intended to be a complete list of all flood damages but is a general list of the larger damage sites and damage categories.

GENERAL PUBLIC FACILITY AND PRIVATE PROPERTY DAMAGE



RIVERLOCATIONDAMAGE DESCRIPTIONSanta CruzBRIDGES/HIGHWAY
CROSSINGS

✓ Continental Road	Erosion damage to west abutment and approach road.
Sahuarita Road	Erosion damage to west approach road and west abutment undermined.
Pima Mine Road	Extensive debris accumulation on bridge with one pier undermined.
I-19	Erosion damage to north abutment; structural damage to bridge.
Sixth Street Extension (San Xavier Loop) Road	Bridge washed out and extensive erosion damage to south approach.
✓ Valencia Road	Erosion damage to west bridge abutment and piers.
Drexel Road	Highway crossing washed out.
Irvington Road	Erosion and settlement of west approach.
Ajo Way	Scour/erosion at northwest corner.
29th Street	Scour/erosion at northwest corner.
✓ 22nd Street	Damage to abutment protection, southwest corner.
✓ Grant Road	Minor erosion at abutments.
○ El Camino del Cerro	Southwest side spur dike breached.
✓ Sunset Road	Bridge washed out.
✓ Ina Road	Severe erosion damage to both bridge approaches.



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CAG 1010 19103

<u>RIVER</u>	<u>LOCATION</u>	<u>DAMAGE DESCRIPTION</u>	
<u>Santa Cruz</u> BRIDGES/HIGHWAY CROSSINGS Cont.	✓ Cortaro Road	Bridge washed out.	
	✓ Avra Valley Road	Erosion damage to bridge approach; structural damage to bridge.	
	✓ Sanders Road	Erosion damage to bridge approach.	
	✓ Trico-Marana Road	Erosion damage to east approach.	
	Trico Road	Bridge clogged by debris and sediment.	
	Trico Road @ Brawley Wash	Severe erosion damage to bridge approaches.	
	FLOOD CONTROL WORKS		
	Green Valley to Sahuarita	Extensive flooding and debris damage to natural channel.	
	Valencia Road to Ajo Road	Severe bank erosion.	
	Grant Road to Avra Valley Road	Overbank flooding and channel meandering; bank erosion exposed landfill cell.	
Marana	Severe flood damage from flood waters and extensive sediment deposition.		
PRIVATE PROPERTY AND UTILITIES			
✓ Green Valley	Minimal flooding of residential properties.		
✓ Upstream of Ajo Way	Loss of homes and property due to severe erosion.		
✓ Vicinity of Cottonwood Lane	Loss of homes and property due to severe erosion.		

RIVER

Santa Cruz

PRIVATE PROPERTY
AND UTILITIES

Cont.

LOCATION

Downstream of Grant Road

✓ Puerta del Norte

✓ Cortaro

✓ Rillito

✓ Marana

✓ Green Valley to Marana

DAMAGE DESCRIPTION

Extensive damage to residential, commercial, and industrial development.

Approximately 75 residences were severely damaged from mud and water flow in excess of 4 feet.

Severe stream meandering and erosion destroyed approximately 20 residences.

Massive flooding of residences and business from flow depths of 2 to 4 feet.

Massive flooding and damages to residences, business and agricultural crops. Major area of evacuation.

Major utility damage to electric and telephone lines, water and sewer pipelines, and gas pipelines.

<u>RIVER</u>	<u>LOCATION</u>	<u>DAMAGE DESCRIPTION</u>	
Santa Cruz SEWER WORKS/SOLID WASTE FACILITIES	Green Valley Trunk Sewer	Up to 4000 feet of the 21" diameter system washed out.	
	Green Valley Wastewater Treatment Facility	Flood water entered site inundating treatment ponds, eroding bank protection and washing our fence.	
	Michigan Street and Kostka Street	Sanitary sewer manhole and segments of an 8" diameter sewer pipe were washed out.	
	Southwest Interceptor (near 22nd Street)	33 inch diameter Southwest Interceptor exposed and undercut.	
	Ina Road Landfill	700 feet of bank protection washed out, and water eroded several thousand cubic feet of old landfill.	
	Tangerine Road Sanitary Landfill	Fencing and entrance road damaged.	
	La Puerta del Norte WWTF Effluent Line	Evaporation pond was damaged and parts of effluent line between treatment plant and the pond were washed out.	
	Marana Wastewater Treatment Facility	Erosion/break through of the pond berms washing out of almost all of the site's fencing, erosion of entrance roadway, mud/debris in the ponds.	
	WATER WORKS	Drexel Road	400 feet of 8" was washed out with Drexel Road erosion.
		Santa Cruz Well Field Transmission lines 12" & 24" (SC-1,9,22,23,25,26)	Damage to 12" and 24"; loss of 1,200 feet from bank erosion in excess of 250 feet

RIVER

LOCATION

DAMAGE DESCRIPTION

Santa Cruz

WATER WORKS
Cont.

Michigan and Kostka

36" main and parts of 8" pipe were washed out with whole intersection total 400 lf.

Ajo Way

Minor damage to 8" distribution system.

29th Street

8" distribution system was exposed.

Alameda

Less than 50 feet of 10" was washed out.

Ina Road

Total 850 feet of 12" piping on both bridge approaches was washed out.

Cortaro Road

16" pipe located in the damaged bridge and eroded east approach was damaged - total 600 feet.

RIVER

LOCATION

DAMAGE DESCRIPTION

Rillito River

BRIDGE/HIGHWAY
CROSSINGS

I-10 Frontage Road	Erosion damage to north abutment.
Southern Pacific Railroad	Erosion damage to spur dike and north abutment .
El Camino de la Tierra	Dip crossing washed out.
Flowing Wells	Upstream failure of rock rip rap protection.
First Avenue	Erosion damage to north approach.
Campbell Avenue	Erosion damage to south abutment.
Dodge Boulevard	Erosion damage to north abutment and approach; structural damage to bridge.
Swan Road	Erosion damage to north approach.

FLOOD CONTROL WORKS

Pegler Wash Channel and Culvert at El Camino de la Tierra	Channel configuration destroyed; box culvert filled with sediment and debris .
✓ Upstream of Flowing Wells Road	Bank protection damage. <i>rock rip-rap</i>
✓ Vicinity of Country Club Road	Bank protection damage. <i>rock rip-rap</i>
✓ Vicinity of Swan Road	Extensive loss of bank protection. <i>rock rip-rap</i>
✓ Craycroft Road to I-10	Major utility damage to electric and telephone lines, and water, sewer, and gas pipelines.

RIVER

LOCATION

DAMAGE DESCRIPTION

Rillito River

PRIVATE PROPERTY
AND UTILITIES

Pueblo Pebbles Sand and
Gravel

Sand and gravel pit flooded.

Residential area in
vicinity of Pegler Wash

Minor residential property
damage.

First Avenue

Structural damage and loss of
residential and commercial
buildings.

Vicinity of Allen Road

Flooding in overbank area;
flood damage to residential
properties.

Country Club Road to
Swan Road

Power lines located within
river damaged.

Prince Road to Country Club

Structural damage and loss of
residential buildings.

SEWER WORKS

Rillito Interceptor near
Swan Road and Rillito Wash

3000 feet of 18" diameter
trunk system wash out.

North Rillito Interceptor
near Lulu Walker School

Manhole on the North Rillito
Interceptor 39" was exposed
and whole lane (I-10 to
Craycroft) was endangered.

Flowing Wells Road

Concrete encased 10" diameter
sewer was undermined and
damaged.

WATER WORKS

Camino de la Tierra

Loss of few hundred feet of
8" diameter water pipe.

First Avenue

Loss of 100 feet of 8"
diameter water pipe with
eroded bridge approach.

Country Club & Prince

Loss of 500 feet of 8"
diameter water pipe with
eroded land.

RIVER

LOCATION

DAMAGE DESCRIPTION

Rillito River

WATER WORKS
Cont.

Dodge Boulevard

150 feet of 8" diameter water pipe was washed out with eroded north bridge approach.

Columbus Road

36" and 12" diameter water pipes were washed out.

Swan Road

Loss of 75 feet of 8" diameter water pipe with eroded north bridge abutment.

<u>RIVER</u>	<u>LOCATION</u>	<u>DAMAGE DESCRIPTION</u>
Tanque Verde Wash		
BRIDGE/HIGHWAY CROSSINGS		
	✓ Tanque Verde Loop Road	Bridge approaches wash out; structural damage to bridge.
	Houghton Road	Dip crossing washed out.
	✓ Wentworth Road	Dip crossing washed out.
FLOOD CONTROL WORKS		
	- N O N E -	
	(No significant flood control works exist along Tanque Verde Creek)	
PRIVATE PROPERTY AND UTILITIES		
	✓ Vicinity of Woodland Road	Flooded residential structures; exposed utility lines.
	✓ Agua Caliente Wash upstream of Tanque Verde Road	Flooding to residential subdivisions.
	✓ 49er's Country Club	Flooded residential structures.
SEWER WORKS		
	Pantano Road	Two manholes on the Tanque Verde (24") Interceptor were exposed.
	Forty-Niner's Trunk Sewer	500 feet of 27" sanitary trunk sewer was washed out.
	Woodland Road	1200 feet of 8" and 12" main have been damaged.
WATER WORKS		
	Tanque Verde Loop	30 feet of 24" diameter water pipe were washed out.
	Soldiers Trail and Agua Caliente Wash	8" diameter pipe was broken at road crossing.

RIVER

LOCATION

DAMAGE DESCRIPTION

Pantano Wash

BRIDGE/HIGHWAY
CROSSINGS

✓ Speedway Boulevard

Erosion damage to west abutment.

✓ 22nd Street

Erosion damage upstream of bridge.

✓ Golf Links Road

Erosion damage at east abutment.

✓ Harrison Road

Dip crossing washed out.

✓ Colossal Cave Road

Dip crossing washed out.

FLOOD CONTROL WORKS

Kennison Lake and Channel

Erosion damage to flood control facilities and roadway crossings.

✓ Upstream of Speedway Boulevard

Erosion damage to bank protection.

PRIVATE PROPERTY
AND UTILITIES

✓ Downstream of Tanque Verde Road

Erosion damage to east bank endangering homes.

✓ Apartments upstream of Speedway Boulevard

Structural damage to residential dwellings.

✓ Mobile Home Park vicinity of Escalante

Loss of mobile homes; flooding to residential structures.

SEWER WORKS

Sahuaro Pressure Main at Glenn Street

Portion of the pressure main system, from the sewage lift station was washed out.

Pantano Interceptor (south of Speedway)

Manhole was exposed.

RIVER

LOCATION

DAMAGE DESCRIPTION

Pantano Wash

SEWER WORKS

Lincoln Ridge Sewer System

800 feet of 12" and 16" sewer pipe were exposed and partially damaged. One manhole was washed out.

Hearthstone Hills Trunk Sewer at Beachwood Street and Creek Street

100 feet of 12" diameter trunk sewer was exposed and washed out.

WATER WORKS

Sarnoff Drive

12" diameter water pipe was damaged.

Golf Links and Camino Seco

Several hundred feet of 8" diameter water pipe was washed out with eroded river bank.

RIVERLOCATIONDAMAGE DESCRIPTIONCanada del Oro WashBRIDGE/HIGHWAY
CROSSINGS

✓ Magee Road

Detour roadway for bridge construction site washed out.

La Cholla Boulevard

Dip crossing washed out.

Overton Road

Dip crossing washed out.

✓ La Canada Drive

Detour roadway for bridge construction site washed out.

✓ Lambert

Dip crossing washed out.

✓ First Avenue

Dip crossing washed out.

✓ U.S. 89

Erosion damage to south abutment and approach.

✓ Vicinity of Catalina

Dip crossings washed out at local roads.

FLOOD CONTROL WORKS

✓ Oro Valley

Erosion damage to dike.

PRIVATE PROPERTY
AND UTILITIES

Upstream of Magee Road

Erosion damage to interceptor sewer.

SEWER WORKS

CDO Interceptor near Tucson National Golf Course Sites

30" diameter interceptor sewer was exposed and joints of ductile iron pipe were separated.

CDO Interceptor near La Cholla Boulevard

One manhole was damaged and second endangered.

DESIGN AND REPAIR PHILOSOPHY

Pima County has adopted the philosophy in repairing flood damaged public facilities or in constructing new public facilities in flood or erosion hazard areas that the facility be protected so that damage is not expected to occur unless the flood frequency exceeds the 100 year recurrence interval. This is essentially a permanent repair philosophy. The following represents the present standards for bridge construction and/or replacement.

BRIDGES - STANDARDS FOR NEW CONSTRUCTION OR REPLACEMENT

1. All bridges shall be designed to convey the 100 year flood discharge with reasonable free board for debris, as well as, long or short term stream bed profile change.
2. Placement of sufficient bank stabilization or channelization as required to prevent lateral river migration and bridge approach wash out.
3. The hydraulic orientation of the bridges structure shall be consistent with sound principles of floodplain management.
4. The traffic carrying capacity of the bridge structure shall be equivalent to the traffic anticipated during the life of the structure except where staged construction will allow for a parallel bridge structure in the future.

The following is a list of bridges constructed using these standards since 1979.

REPAIR PHILOSOPHY



<u>RIVER</u>	<u>LOCATION</u>	<u>DESIGN CRITERIA (FLOOD RETURN FREQUENCY: YEAR)</u>	<u>YEAR BUILT</u>
RILLITO CREEK	La Cholla Boulevard	+100	1981
RILLITO CREEK	Craycroft Road	100	1982
PANTANO WASH	Tanque Verde Road	+100	1978
PANTANO WASH	Houghton Road	100	1981
TANQUE VERDE WASH	Sabino Canyon Road	100	1982
SANTA CRUZ RIVER	El Camino del Cerro	100	1979
SANTA CRUZ RIVER	Twenty-Second Street	+100	1978
SANTA CRUZ RIVER	Irvington Road	+100	1981
CANADA DEL ORO	Thornydale Road	100	1983

Other flood control projects which prevent flood damage are characterized as either bank protection or stabilization projects. Pima County has also adopted strict state of the art standards for bank protection/stabilization construction and installation. These standards are listed below.

BANK PROTECTION/STABILIZATION - STANDARDS FOR NEW CONSTRUCTION OR REPLACEMENT

1. Soil-cement bank protection/stabilization will be provided on major watercourses and shall be herein referred to as "bank protection".
2. The bank protection shall be constructed to a finished thickness of not less than eight feet.
3. All bank protection shall be designed to withstand the 100-year flood discharge with reasonable freeboard, as well as, long or short term stream bed profile change.

4. All bank protection above the natural channel bottom shall be constructed on a slope no steeper than one horizontal to one vertical.
5. The horizontal alignment of all bank protection shall be consistent with sound principles of hydraulic design.
6. Upstream and downstream ends of bank protection shall be properly keyed into the natural banks to prevent erosion behind the bank protection in the advent of natural lateral channel migration.
7. All bank protection shall be designed with proper access provided for maintenance vehicles. Ramps for equestrian and other recreation access to the channel bottom shall be constructed at intervals not to exceed one mile on each bank.
8. All bank protection shall be designed to minimize adverse effects of erosion on property upstream, downstream or adjacent to said protection.

The following is a list of bank protection/stabilization projects using these standards since 1980.

PIMA COUNTY BANK PROTECTION/STABILIZATION PROJECTS

<u>RIVER</u>	<u>LOCATION</u>	<u>YEAR BUILT</u>
RILLITO CREEK	La Cholla Boulevard	1981
RILLITO CREEK	Oracle Highway	1981
SANTA CRUZ RIVER	Ina Road Landfill	1981
SANTA CRUZ RIVER	Irvington Road	1981
PANTANO WASH	Houghton Road	1983
TANQUE VERDE CREEK	Sabino Canyon Road	1983
CANADA DEL ORO WASH	Thornydale Road	1983
CANADA DEL ORO WASH	Thornydale Road to Magee Road	1983

In summary, Pima County has adopted a state of the art design philosophy in the new construction and/or replacement of bridges and flood control facilities. Of those bridges or flood control facilities constructed using these standards, damage from the October 1983 flood was nonexistent. Therefore, it is felt these standards are the minimum flood damage repair standards that should be employed within the community and that by using these standards the community will receive the maximum amount of flood protection at the long-term least cost.

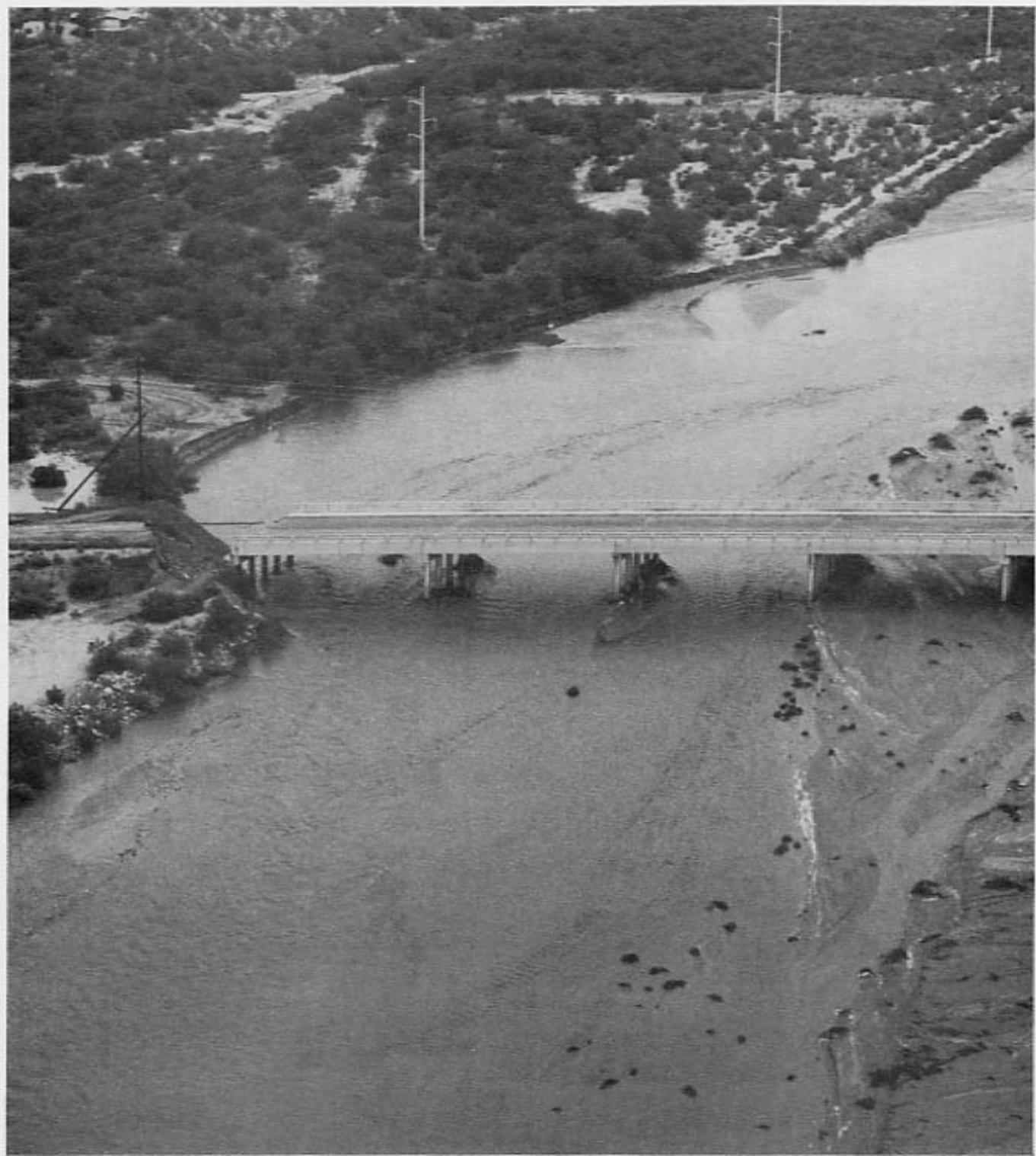
While these standards are more stringent than past design standards it is not intended to imply past bridge construction or bank stabilization was deficient or substandard. All past projects were developed using technology known or available at the time and with limited funding. The growth of the community has necessitated differing design standards as well as provided additional funding to finance more complete improvement.

PUBLIC FACILITY REPAIR AND MITIGATION PROGRAM

The Flood Repair and Flood Hazard Mitigation Program for public facilities basically consists of (a) making permanent repairs to damaged bridges, (b) relocating four damaged or destroyed bridges to lower flood hazard areas consistent with the transportation system, (c) installing bank stabilization and/or channelization where major damage to public facilities, such as sewer and water transmission systems or sanitary landfills, has occurred, (d) installing bank stabilization and/or protection where severe damage to improved private property has occurred or would occur during another flood event on the river system, or (e) installing bank stabilization and/or protection to complement and complete flood control measures installed for bridge protection on the transportation grid.

The following tables list the repair and mitigation improvements planned for the permanent repair of highways, bridges and flood control works which includes the protection of major sewer water and utility works.

PUBLIC FACILITY REPAIR AND MITIGATION PROGRAM



RIVER	PROJECT	COST	REVENUES (\$1,000)				STATE/LOCAL MITIGATION CROSS REFERENCE	REPAIR AND MITIGATION KEY
			FEDERAL	STATE	COUNTY BOND	OTHER		
SANTA CRUZ	Continental Bridge Replacement	2,800	• 96	• 655	• 649	1,400	1	a
SANTA CRUZ	Valencia Bridge Protection	900	113	397	390		2	a
SANTA CRUZ	Irvington to Ajo Way Channelization and Bank Protection	3,700	315	1,815	1,570		20	c,d,e
SANTA CRUZ	29th Street-Bridge Replacement	2,000		1,000	1,000		3	a
SANTA CRUZ	29th Street to Mission Lane Channelization and Bank Protection	3,850	26	1,913	1,911		21	c,e
SANTA CRUZ	22nd Street Bridge Bank Protection	140	6	67	67		4	a
SANTA CRUZ	St. Mary's Road to Speedway Channelization and Bank Protection	1,500		750	750		22	c,e
SANTA CRUZ	Grant Road Bridge Protection	250	30	105	115		5	a
SANTA CRUZ	El Camino del Cerro Bridge Protection	900	• 6	• 447		• 447	6	a,c
SANTA CRUZ	Sunset/Orange Grove Bridge Replacement	3,900	• 708	• 1,620	• 1,572		7	b
SANTA CRUZ	CDO Confluence and Landfill Protection	2,600			1,300	1,300		c
SANTA CRUZ	Ina Road Bridge Protection	3,100	• 1,003	• 1,082	• 1,015		8	a
SANTA CRUZ	Cortaro Bridge Replacement	3,000	• 1,488	• 806	• 706		9	b
SANTA CRUZ	Avra Valley Bridge Replacement	1,500	• 375	• 575	• 550		10	a
SANTA CRUZ	Tangerine Landfill Protection and Channelization Maintenance	500			500			c
SANTA CRUZ	Sanders Bridge Protection	1,200	• 46	• 579	• 575		11	a,b

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RIVER	PROJECT	COST	REVENUES (\$1,000)				STATE/LOCAL MITIGATION CROSS REFERENCE	REPAIR AND MITIGATION KEY
			FEDERAL	STATE	COUNTY BOND	OTHER		
SANTA CRUZ	Trico-Marana Bridge Protection	400	* 105	* 151	* 144		12	a
RILLITO	Pegler Wash Channelization	1,500	230	35	1,235			c,d
RILLITO	Shannon Road to La Cholla Boulevard Bank Stabilization	2,600	110		2,490			c,d,e
RILLITO	La Cholla Boulevard to Flowing Wells Bank Stabilization	4,300	230	35	4,035			a,c,d,e
RILLITO	First Avenue Bridge Protection	2,000	99	954	947		13	a,c,d,e
RILLITO	Campbell to First Avenue Bank Stabilization	2,000	390			1,610		c,e
RILLITO	Campbell Avenue Bridge Protection	700	88	315	297		14	a,c,e
RILLITO	Campbell to Prince/Country Club Bank Stabilization	5,300	160		2,140	3,000		c,d,e
RILLITO	Dodge/Alvernon Bridge Replacement	2,800	30	1,386	1,384		15	b,c,e
RILLITO	Swan Road Bridge Protection	1,800	206	804	790		16	a,c,d,e
RILLITO	Swan Road to Craycroft Bank Stabilization	1,500			1,500			c,d,e
TANQUE VERDE	Sabino Canyon Creek to Tanque Verde Road Bank Stabilization	3,500			3,500			c,d,e
TANQUE VERDE	Tanque Verde Loop Road/Houghton Road Bridge Replacement	7,600	3,800		3,800		17	b

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RIVER	PROJECT	COST	REVENUES (\$1,000)				STATE/LOCAL MITIGATION CROSS REFERENCE	REPAIR AND MITIGATION KEY
			FEDERAL	STATE	COUNTY BOND	OTHER		
PANTANO	Bank Stabilization Downstream of Tanque Verde Road	2,050	250		1,000	800		c,d,e
PANTANO	Speedway Bridge Protection	500		250	250		18	a,c,d,e
PANTANO	Tanque Verde Road to upstream of Speedway Boulevard Bank Stabilization and Grade Control	2,840	540		1,000	1,300		c,d,e
PANTANO	Golf Links Road Bridge Protection	306	36	136	134		19	a,c
PANTANO	22nd Street to upstream of Golf Links Road Bank Stabilization	5,694			4,994	700		c,e
GENERAL	Miscellaneous Highway Repairs	5,718	5,000		718			c
T O T A L S		84,948	11,686	19,677	43,028	10,557		

PRESERVATION OF OVERBANK FLOOD STORAGE AREAS INCLUDING RELOCATION AND ACQUISITION AS AN ALTERNATIVE TO STRUCTURAL FLOOD CONTROL

Flood prone land acquisition and relocation is a method of reducing future flood losses by either removing structures built in a flood plain prior to a flood or by prohibiting rebuilding after flood damage. The National Flood Insurance Act of 1968 requires that any flood plain structure damaged more than 50 percent of its value must, if repaired, comply with the community's Floodplain Management Ordinance. In addition, the Arizona Revised Statutes require the same for any structure which needs anything more than reasonable repair. Often, because of the severity of flood damage and the physical location of the property in a flood hazard area, it is impossible to rebuild or repair in conformance with floodplain management rules and regulations.

Flood prone land acquisition and improvement relocation is a viable method of reducing future flood losses, particularly when the cost of acquisition and relocation is less than the cost of constructing a flood control project to mitigate the flood hazard for the acquired area.

Pima County has reduced the cost and damage from flood hazards by structural flood control projects and aggressive flood plain management. However, there are sites within Pima County which were developed prior to the Flood Plain Management Ordinance and/or were not within a flood or erosion hazard zone when development first occurred. In most of these cases cost effective structure flood control project is not available, however, relocation is cost effective as a flood hazard mitigation measure.

Of major concern in the reduction of future flood losses is the issue of artificial flood control actions which may increase downstream flooding. Flood control improvements cannot be undertaken to protect one area of the community if such an improvement

FLOOD STORAGE, RELOCATION AND ACQUISITION PROGRAM



increases flood hazards for other areas of the community. Perhaps the most serious problem arising out of flood control projects is the increasing of downstream flood peaks by the channelization of large overbank flood storage areas. To promote channelization to protect one area of the community while flooding another area is unwise. The only option for reducing future flood losses under these circumstances is acquisition and relocation.

Pima County has developed the following priorities for acquisition and relocation:

- A. Improved property where there has been a total loss of personal and real property where there is no salvage value or the possibility to reclaim lost property.
- B. Improved property receiving more than 50 percent damage from a flood and no approved or programmed flood control project will remove the threat of future flood or erosion damage.
- C. Improved property with less than 50 percent damage from a flood and no approved or programmed flood control project will remove the threat of future flood or erosion damage.
- D. Improved property which is subject to constant flood hazard with damage occurring in the last three out of five years.
- E. Previously undamaged unimproved property which is subject to severe flood or erosion hazards and is located in a defined floodway.

F. Improved and unimproved property which is flood prone for which there exists an approved open space and recreation plan which is consistent with sound principles of flood plain management.

Using these priorities the following areas are recommended for relocation because of the severity of the flood hazard and because relocation is the most cost effective flood hazard mitigation measure.

<u>SITE</u>	<u>DESCRIPTION</u>	<u>COST</u> <u>(millions)</u>
La Puerta del Norte near Santa Cruz River	Prior to October, 1983 flood this subdivision was located outside 500-year flood plain of the Santa Cruz River. Flood damage to the area was greater than 50 percent and future hazard will remain high due to changes to the stream channel.	\$ 2.1
Avra Valley Road	Extensive damage in October, 1983 flood similar to La Puerta del Norte.	0.33
Linda Vista at I-10 and Santa Cruz River	Severe erosion and flooding extensively damaged the area and increased future flood risks.	1.3
Pegler Wash at Rillito River	Repetitious flooding hazard. Area required excavation during 1978 and 1983 floods.	2.3
Los Reales/Cardinal West Branch of Santa Cruz River	Repetitious flooding hazard.	.5
Miscellaneous Locations		1.7
TOTAL		\$ 8.23

ACCESS IMPROVEMENT PROGRAM

Because of dispersed population centers throughout Pima County, thousands of Pima County residents are isolated from sources of food, fuel, utilities, law enforcement and medical and educational facilities due to flood waters. In addition, these residents are more than likely unable to work during flooding events.

Access improvements for isolated population centers will reduce future public monetary costs by (a) reducing emergency medical and food supply operations, (b) allowing area residents to have continuous employment, (c) allowing full student enrollment at public educational institutions and (d) reducing the risk of accident, injury or death of those persons who will attempt to cross high hazard flood areas.

Actual project details shall be developed through a three step process. The first step shall involve the development of a Preliminary Access Improvement Plan. The Plan shall indicate the proposed improvements in the target area which are designed to provide improved access during floods. The preliminary access improvement plan shall concentrate improvements on one route of access into the isolated area and the plan shall be developed with an emphasis on minimizing cost of improving the selected route. Step two of the process will involve a public meeting in the target area to present the preliminary access improvement plan to those persons in the target area for their review and comment. Step three of the process shall be the development of the final access improvement plan, taking into account the public comments received and presenting the plan to the Board of Supervisors for approval and allocation of funds.

ACCESS IMPROVEMENT PROGRAM



Access improvement funds shall not be spent outside the target areas listed until final access improvement plans have been developed for all target areas and funding for all target areas has been allocated. If funds remain after access improvements have been made in the target areas, access improvements to other areas shall be provided in accordance with the following prioritization system.

The following factors in combination shall be used to establish the relative priority of access improvement projects which are not designated as target areas.

1. Average Daily Traffic Volumes:
The higher the average daily traffic volume carried by the highway facility serving the flood-isolated area, the higher the priority.
2. Duration of Flood Disruption:
Flood disruption is defined as a roadway submerged under flood waters and/or sedimentation remaining on the travel surface preventing vehicles from safe travel. The longer the duration of flood disruption, the higher the priority of the access improvement project.
3. Area Wide Population Density of the Flood-Isolated Area:
The area wide population density of an area can be judged from the extent of urbanization that has occurred in an area, measured from the density of the existing developments in the area. The higher the population density of an area, the higher the priority of the access improvement project desired to serve the area.
4. Estimated Cost of the Access Improvement:
Cost of access improvements depends upon several factors, including, but not limited to, drainageway improvements, cost of designing and constructing the

drainage crossing structures, right-of-way acquisition costs. The lower the estimated cost of the desired access improvement, the higher the relative priority of the project.

Based on the known areas of isolation, the following is a list of Access Improvement Target Areas.

<u>TARGET AREA</u>	<u>PROJECT OR ROUTE</u>	<u>MINIMUM FUNDING (Millions)</u>
1. Vail, Happy Valley Area	Bridge, Colossal Cave Road at Pantano Wash.	2.5
2. Arivaca Area	Arivaca Road between I-19 and Town of Arivaca.	0.5
3. Catalina Area	Wilds Drive, Lago del Oro Parkway	0.5
4. Tanque Verde Valley Area	Redington Road between Tanque Verde Loop Road Soldier Trail across Caliente Hills Wash.	0.6
5. Mission, Twin Buttes, Helmet Peak Area	Pima Mine Road and Red Roan Avenue (Wrangler). Helmet Peak - Sahuarita Road between Tres Avenue and I-19 (Curly Horn). Ocotillo Ranch Road between Avenida Haley and Mission Road. (Ocotillo)	1.4
6. South Continental/ Canoa Area	New all-weather road (6.0 miles long) connecting Canoa Road and Continental Road, located on the east side of Santa Cruz River.	0.7
7. Sahuarita Area	Sahuarita Road, Alvernon Way, Dawson Road.	1.5

(continued on next page)

<u>TARGET AREA</u>	<u>PROJECT OR ROUTE</u>	<u>MINIMUM FUNDING (Millions)</u>
8. Branding Iron Park and Surrounding Area.	Camino Verde between Ajo Way and Valencia Road.	0.4
9. Tucson Estates Area	Tucson Estates Parkway between Ajo Way and Kinney Road.	0.4
10. Green Valley Area	La Canada Drive - from Duval Mine Road to Sahuarita Road and from Esperanza Boulevard to Mission Twin Buttes Road.	0.8
	TOTAL DESIGNATED	<u>9.3</u>

PROGRAM SUMMARY

The total cost of the Flood Repair and Flood Hazard Mitigation Program is 105.7 million dollars. This cost will be paid with 11.7 million dollars of federal funds, 19.7 million dollars of state funds, 10.6 million dollars of other or private funds and 63.8 million dollars of county bonds. Because the federal and state funds require a local fund match, the 63.8 million dollars of county bond will attract 41.9 million dollars of federal, state and other funds. Below is a category breakdown of the county bond portion of the program.

1. Repair of flood damaged highways, bridges, flood control works including mitigation work to prevent future flood damage;

\$43.0 million

2. Acquisition of flood storage areas including relocation of flood damaged residential property;

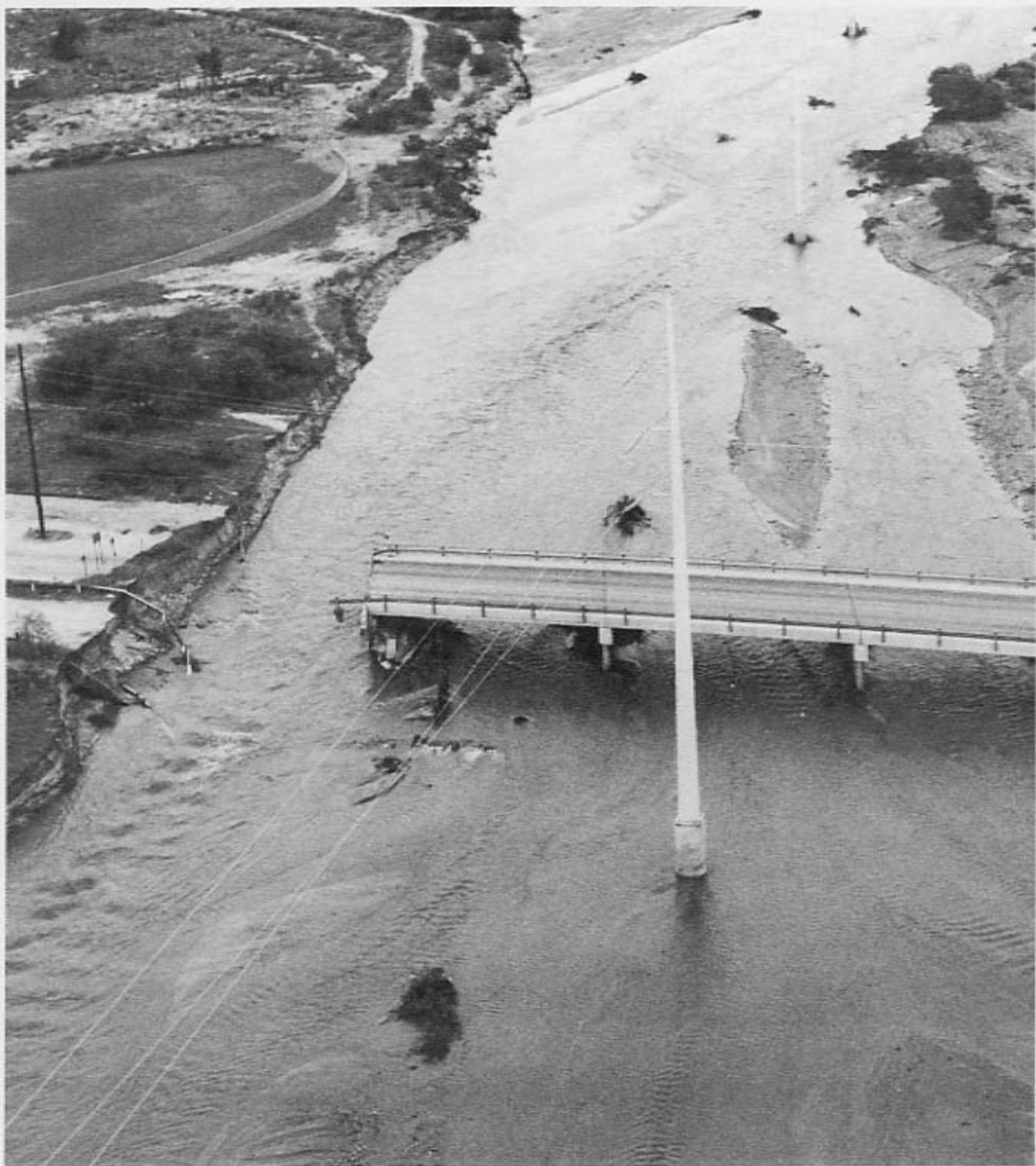
\$8.3 million

3. Access Improvement to prevent isolation during flood events;

\$12.5 million

Total \$63.8 million

PROGRAM SUMMARY



OTHER FEDERAL AND STATE PROGRAMS FOR FLOOD REPAIR

Various other studies are now or have been under way by the Federal and State government to solve the most complex and difficult flooding problems in the community. At this time, there is no indication as to whether or not these studies will lead to an actual project. For this reason, funding of such projects has not been included in the Flood Repair and Flood Hazard Mitigation Program.

The most important federal program for reducing future flood losses is through the United States Army Corps of Engineers. In 1980, the Corps of Engineers sponsored the Tucson Urban Study which studied the feasibility of a federally sponsored flood control program for eastern Pima County. The Tucson Urban Study concluded that the only Federally sponsored flood control project which was worthy of additional study was on the Rillito River and its tributaries. This study is now called the Rillito Interim Study. It is in this study that possible solutions lie for the substantial overbank flooding of the Tanque Verde Wash and Agua Caliente Wash in the Tanque Verde Valley, as well as, the complex problem of the junction of the Rillito River with the Southern Pacific Railroad and Interstate 10. The Corps has also been requested to study the long standing and recurring erosion and sedimentation problems of the lower reaches of the Santa Cruz River downstream of the confluence of the Canada del Oro and Rillito River to the north Pima County line. Hopefully, the federal studies by the Corps of Engineers will lead to flood protection for the Tanque Verde Valley residences, as well as, those in Marana.

OTHER FEDERAL AND STATE FLOOD CONTROL PROGRAMS



GENERAL AND SPECIFIC BENEFITS OF REPAIR AND MITIGATION PROGRAM

The Flood Repair and Flood Hazard Mitigation Program will result in the replacement of seven structurally or hydraulically deficient bridges, the protection of thirteen flood damaged bridges or bridge approaches, the protection to two active sanitary landfill operations and the protection of four inactive sanitary landfills, installation of approximately 12 miles of river bank stabilization, the protection of major utility systems, acquisition and public ownership of flood storage areas and the river bank and bed wherever stabilization is provided, and finally, improved access for all population centers or urban areas in Pima County to prevent isolation from sources of food and fuel, medical, law enforcement and educational institutions. These are very direct and obvious benefits of the program. The program also provides other benefits which are general in nature and less obvious, but are just as important, and in some cases, more important, than the direct benefits of the program. General benefits include: (a) Elimination of transportation system disruption caused by the temporary closing of 35 of 42 bridges over the major river system during the flood and the closure of 19 bridges for a period of days after the flood; (b) enhancement of recreation and open space opportunities through the acquisition of flood storage areas and the acquisition of river bank and river bed in areas of bank stabilization to allow the development of walking, jogging, hiking, and equestrian trails; (c) landscaping and buffering of the river to improve the riverine environment; (d) water quality benefits of public ownership and control over our most important groundwater recharge system, the major river beds of Pima County; and (e) maintenance of a reasonable sediment balance in the major river system through erosion control thereby minimizing the loss of natural river flood conveyance through deposition and sedimentation.

GENERAL AND SPECIFIC BENEFITS OF REPAIR AND MITIGATION PROGRAMS



To summarize, the general and specific benefits of the Flood Repair and Flood Hazard Mitigation Program by functional element are listed below. Following this listing will be a detailed discussion of some general or specific benefits where necessary or appropriate.

Flood Control

- Erosion and sedimentation control through bank stabilization.
- Flood storage area protection through acquisition.
- Sand and gravel mining control through public ownership of the streambed and/or regulation.

Transportation

- An arterial highway network capable of withstanding a 100-year flood on any part of the major river system.
- Protection of the economic investment in major bridges through bank stabilization.
- Substantial highway user cost benefits from decreased detour mileage, reduced congestion and accidents.
- Access improvement for all citizens of Pima County.

Recreation/Open Space

- Flood storage areas to remain natural open space.
- Sufficient right-of-way for the provision of jogging, hiking, walking, and equestrian trails.

- Where possible, jogging, hiking, walking, and equestrian trails will be constructed with bank stabilization.
- Where possible, natural landscaping will be provided along the river bank to enhance the riverine environment.

Essential Utility Functions

- Sanitary interceptor sewers are protected, major water transmission mains are protected, water well sites and well fields are protected.
- Sanitary landfills are protected.
- Electrical, natural gas, and communication facilities are also protected.

Water Quality and Water Supply

- Water quality is protected by the public ownership and control of the regions, most important, ground water recharge area.
- Water supply is enhanced through improved infiltration through wider river sand beds and the installation of grade control structures.

Flood Control

The obvious benefits of flood control through bank stabilization and channelization need little further explanation. The benefits of erosion control and sedimentation control need further discussion in order to become evident. Erosion and sedimentation is a natural river process which does not need control unless urbanization encroaches in the river environment. Erosion hazards to urban uses are quite apparent; however, the accom-

panying downstream deposition is not. Down stream natural sedimentation and/or deposition can reduce the natural flood carrying capacity of stream channels. To the extent that bank stabilization prevents substantial erosion, downstream sedimentation or deposition should be reduced, thereby, preserving, in some degree, the natural flood carrying capacity of the drainage system.

The benefits of flood storage area acquisition also needs explanation. Naturally occurring flood storage areas act as flood peak attenuation devices. Artificial channelization of the river system which removes these flood storage areas can be extremely detrimental to existing urban encroachments in the river environment. In all cases, downstream flood peaks are increased in direct proportion to the volume rate of overbank flood storage area removed by artificial channelization. Therefore, in order to protect the public investments in bridges and flood control works, as well as, private development on the river system, flood storage areas should be preserved.

Transportation

Every day in Pima County, 478,000 vehicle trips cross a major bridge structure. During the flood peak, 35 of the 42 bridges that carry these daily vehicle trips were closed. On the day after the flood peak, October 3, 19 bridges remained closed. In the days and weeks that followed, 15 bridges were temporarily repaired and open for traffic. Considering the average daily traffic on the closed bridges, the probable detour routing for each closed bridge, the level of congestion on available open bridge routes, the total aggregate community costs in terms of transportation for detour mileage, congestion, and accidents were \$600,000 per day. Immediately after the flood these costs decreased at a rate equivalent to the reopening of closed bridges.

MOST COMMONLY ASKED QUESTIONS ABOUT FLOOD REPAIR
AND FLOOD HAZARD MITIGATION

Q. What is flood hazard mitigation?

Flood hazard mitigation is the repair, or reconstruction of flood damaged public facilities to a state or condition where future floods will not damage or destroy the public facility. Quite simply, it is repairing flood damage so that the same damage does not occur again in the next flood.

Q. Why weren't our streets/bridges and other public facilities originally built to resist flood damage?

First, almost all of the major public facilities which received flood damage during the recent floods in October of 1983 were constructed during the period of 1930 to 1965. The design standards during this period for the construction of these facilities were less stringent than they are today. Pima County has adopted a policy, which has been in effect since 1979, to construct all public facilities required for essential public services to remain in service and without damage during a 100 year flood event.

Second, major flood events have occurred with more regularity in the last 5 years than they have in the previous 50 years. Pima County has experienced 4 Presidentially declared flood disasters since 1978 (October 1977, March 1978, December 1978, and October 1983).

Q. Why are state and local funds required for flood hazard mitigation?

The disaster relief programs administered through either the Federal Emergency Management Agency or the Federal Highway

MOST COMMONLY ASKED QUESTIONS ABOUT PROGRAMS



Administration simply pay to repair flood damaged public facilities to their condition immediately prior to the flood. Any additional work to prevent future flood damage must be paid for by either the state or local government or a combination of both. For example, the El Camino del Cerro bridge crossing the Santa Cruz River was completely destroyed in the flood of October 1977 (flood magnitude 20,000 cubic feet of water per second). The Federal Emergency Management Agency paid Pima County \$471,138 to repair and/or replace the El Camino del Cerro bridge to a condition which would have been similar to its physical condition immediately prior to the October 1977 flood. Pima County decided not to repair the El Camino del Cerro bridge to its pre-October 1977 flood condition but to build a new bridge which would withstand future Santa Cruz River flooding. The additional cost which Pima County had to pay for this flood hazard mitigation was \$1,490,035. This bridge withstood the October 1983 flood (flood magnitude 45,000 cubic feet of water per second) without damage. Had Pima County only spent the Federal Disaster Relief funds received of \$471,138 the El Camino del Cerro bridge would not have survived the October 1983 flood.

Q. What are the benefits of flood hazard mitigation?

Flood hazard mitigation provides three general benefits, these are:

- a. Reduction in future flood damage and the cost to repair such damage.
- b. Reduction in personal injury or the loss of life due to flooding.
- c. Reduction in community disruption due to a flooding event.

The benefits of reducing future flood damage cost and flood repair cost are obvious. It makes little if any sense to

repair flood damaged facilities only to have the monetary value of those repairs washed down the river with the next flood event.

In any flood event, as has been the case in the October 1977, March 1978, December 1978, and the October 1983 flood, any personal injury or loss of life which flood related is a tragedy; and even more so, if such could have been prevented with flood hazard mitigation. In the previous floods most of the lives which were lost were a result of motorists driving into a flooded river, stream or arroyo. The Pima County mitigation response to this type of loss was to build seven new bridges financed by the citizens of Pima County through a bond election in 1979. The region is very fortunate that more lives were not lost during the floods of late September and early October 1983 from citizens driving into the washed out bridge approaches of Tanque Verde Loop Road, Swan Road, Dodge Boulevard, First Avenue, Continental Road, Sunset Road, Ina Road, Cortaro Road, Trico Marana Road, or Trico Road.

Community disruption due to flooding probably affects almost every member of the community. While private property damage, personal injury or death, or public facility damage is a direct and recognizable result of the flood, community disruption is not as obvious but is perhaps more important. The lack of access to medical facilities, law enforcement, food, fuel, typically taken for granted is disruption. Over crowded streets and traffic jams due to only a few bridges being passible is disruption. Emergency operations which takes away from normal public services is disruption.

Q. What has Pima County done in the past as flood hazard mitigation and how has it worked in subsequent floods?

Since the formation of the Pima County Flood Control District in 1978, several flood control projects as well as bridges have been built. Since 1979, 8 bridges have been built or are under construction using flood control bonds or taxes. Six of these bridges have been completed and were not damaged from the October 1983 flood. Had these bridges not been installed, La Cholla Boulevard at the Rillito River would have been closed; Houghton Road at the Pantano Wash would have been closed; Craycroft Road at Rillito River would have been closed; the Sabino Canyon Bridge over the Tanque Verde Wash would have been destroyed. At these locations alone, over 60,000 vehicles per day would have been detoured to alternate routes.

In addition, the District has constructed two channelization and bank stabilization projects, Rio Nuevo and Rillito River west of Oracle Road. These two flood control projects suffered very minor damage during the October 1983 flood and while preventing private and public property damage in the range of 15 to 25 million dollars at a cost to the local taxpayers of only 3.5 to 4 million dollars.

Q. How are we assured the new bridges or flood control works will not be damaged in the next flood?

Since 1979, Pima County has employed design principles and construction techniques which greatly increase the flood damage resistance of bridges and flood control works. These techniques include the pioneering use of deep-drilled and cast-in-place concrete caissons for bridge foundations and the use of soil-cement as a method of bank stabilization to prevent lateral river mitigation. These two elements together with a conservative design philosophy makes future damage extremely remote.

Q. Are floods coming more often?

Several factors, natural and manmade, influence flooding conditions.

In recent years the Tucson area climate has been in a more humid cycle with greater rainfall being received than normal. The average annual rainfall is 11 inches per year, but in 1978, 1981, 1982, and 1983 the measured rainfall was 16, 14, 14, and 22 inches respectively. The degree of flooding in October 1983, was influenced by rainfall in September 1983, set up by high soil moisture conditions which increased the potential for storm runoff and by an unusually high rainfall amount of 6 1/2 to 8 inches over a period of 4 days.

Flooding may also appear to be increasing due to increases in flood damages. Development and population influx in the 1960's to 1970's, prior to flood plain management regulations, has increased the potential for flood damages within the Tucson area. Stated simply, there may be more things to be damaged rather than more floods.

Q. Isn't it better and cheaper to design our bridges so that their approaches washout once every ten to twenty years?

It is true that it is easier and cheaper to make temporary repairs to washed out bridge approaches rather than permanent repairs. Two things make temporary and cheaper solutions unsound.

First, the temporary repair cost is not simply the cost of plugging the hole where the roadway approach has washed out. In most cases the washed out approach is due to a substantial change in direction of the river for some distance upstream

of the washed out area. Therefore, in order to repair the area to a preflood condition, substantially more earth and fill would have to be placed in the eroded area. Therefore, the actual cost of preflood repair is substantially more than simply filling the washed out roadway approach.

Second, the increasing expansion of the Tucson Metropolitan area requires a transportation system which is flood damage resistant so that massive community wide disruption is avoided in the future. To have major traffic arteries which carry in the aggregate 478,000 vehicles a day affecting the daily lives of 287,000 people subject to flood destruction is unwise. It is even more unwise to risk the potential tragedy of personal injury or death of those persons who unknowingly drive into washed out bridge approaches.

Q. What has Pima County done to prevent unwise land use in flood plains and how effective has that been?

Pima County in 1974, was the first County in the State of Arizona to enact flood plain land use regulations. The State only enacted enabling legislation for its political subdivisions to enact such land use regulations in 1973. Many other jurisdictions and Counties throughout the State still today do not have flood plain land use regulations. A majority of the regulations which are in effect today only have been law since 1980. Pima County has been very aggressive in its enforcement of the flood plain ordinance. Through this aggressive enforcement, Pima County was the first County in the State of Arizona to go to the Arizona Supreme Court and win a case involving its flood plain management ordinance. The effectiveness of the ordinance is measured in the damages prevented to private property during flooding. In the October, 1983 flood, over ninety percent, perhaps close to 100 percent, of private property damage

occurred to property which was developed or occupied prior to the effective date of Pima County's flood plain ordinance.

Q. Won't all of this flood control work increase downstream flooding for somebody else?

The flood repair and flood hazard mitigation program has been formulated with that potential in mind. The most serious effects on downstream flood plain dwellers or public facilities, which are constructed across the river system or adjacent to it, occurs when large overbank flood storage areas which occur naturally are removed through artificial river channelization. The program does not, at any location propose channelization where such would remove these flood overbank storage areas from the river system. The non-stabilization or channelization of the Santa Cruz River in the Green Valley area, the non-channelization of the Tanque Verde Wash in the Tanque Verde Valley, the optimum location of the Alvernon Bridge upstream of a major Rillito River flood overbank storage breakout area, the flood storage land acquisition in leau of channelization elements of the program are all examples of how sensitively the program deals with the equilibrium of the river system.

Q. Why should local government pay for flood control when the federal government, through the Corps of Engineers, has all the money we need to solve our problems?

Pima County is probably not in line for any immediate major grants of Federal funds for flood control works. In order to qualify for such funding, certain artificial economic tests must be met. These tests are based on classical overbank flood hydrology and does not represent the type of bank erosion that actually occurs during floods in the arid southwest. For this reason, it is highly unlikely that any

Federal funds for flood control will be received by Pima County in the near future. The Corps studied the Rillito River in 1964, in addition, in 1980 they conducted the Tucson Urban Study. The results of all of these studies indicate that the only potential for a federally sponsored flood control project is on the Rillito River and its tributaries. Another study is now underway by the Corps of Engineers to determine the feasibility of flood control works on the Rillito River and its tributaries. This study is called the Rillito Interim Study. If it is successful, it is highly unlikely that any Federal flood control dollars will be spent in Pima County before the end of this decade.

Q. Won't channelization and/or bank stabilization decrease groundwater recharge and our water supply?

Bank stabilization does not reduce groundwater recharge. Reduction in the recharge potential is possible if channels were narrowed or if the bottom was to be lined. No existing or proposed flood control work has included the lining of the natural stream sand beds. Rather, the increase in channel capacity and/or the addition of grade control structures slows the flood water flow and allows a greater potential for infiltration and groundwater recharge.

IMPLEMENTATION

The Flood Repair and Flood Hazard Mitigation Program is designed to be implemented over a three to four year period. Public facilities which received damage during the flood and are now exposed to more severe damage if another flood occurs are given priority for repair and protection. The revenue stream from state mitigation funding is also spaced over a three year period by legislation. Given the previous and design time for the more complex projects, the following table represents the planned implementation of the program and the bond fund requirements by fiscal year.

COUNTY BOND REQUIREMENTS (in millions)

	<u>83/84</u>	<u>84/85</u>	<u>85/86</u>	<u>86/87</u>
Access Improvements	1.0	3.0	4.0	4.5
Flood Plain Management Acquisition	5.0	3.3		
Capital Improvements	<u>5.9</u>	<u>11.1</u>	<u>11.3</u>	<u>14.8</u>
TOTAL	11.9	17.4	15.3	19.3

The distribution of bond requirements by fiscal year does not imply specific project priority but is intended for financial planning purposes given known project needs, design complexity and right-of-way availability. All projects will be implemented as soon as possible and it is possible unforeseen conditions could either delay or accelerate specific projects or programs.

IMPLEMENTATION



<u>RIVER</u>	<u>PROJECT</u>	<u>TOTAL BOND COST</u>	<u>83/84</u>	<u>84/85</u>	<u>85/86</u>	<u>86/87</u>	<u>REMARKS</u>
SANTA CRUZ	Continental Bridge Replacement	649		325	324		
SANTA CRUZ	Valencia Bridge Protection	390	390				
SANTA CRUZ	Irvington to Ajo Way Channelization and Bank Protection	1,570	500	1,070			
SANTA CRUZ	29th Street Bridge Replacement	1,000		500	500		
SANTA CRUZ	29th Street to Mission Lane Channelization and Bank Protection	1,911	1,000	911			
SANTA CRUZ	22nd Street Bridge Bank Protection	67	67				
SANTA CRUZ	St. Mary's Road to Speedway Channelization and Bank Protection	750		750			
SANTA CRUZ	Grant Road Bridge Protection	109	109				
SANTA CRUZ	El Camino del Cerro Bridge Protection	0	0	0	0	0	Other: \$447 (WWM)
SANTA CRUZ	Sunset/Orange Grove Bridge Replacement	1,572			572	1,000	
SANTA CRUZ	CDO Confluence and Landfill Protection	1,300	1,300				
SANTA CRUZ	Ina Road Bridge Protection	1,015		515	500		
SANTA CRUZ	Cortaro Bridge Replacement	706			300	406	
SANTA CRUZ	Avra Valley Bridge Replacement	550		250	300		
SANTA CRUZ	Tangerine Landfill Protection and Channelization Maintenance	500	500				
SANTA CRUZ	Sanders Bridge Protection	575		575			

RIVER	PROJECT	TOTAL BOND COST	TOTAL BOND COST				REMARKS
			83/84	84/85	85/86	86/87	
SANTA CRUZ	Trico-Marana Bridge Protection	144		144			
RILLITO	Pegler Wash Channelization	1,235			1,235		
RILLITO	Shannon Road to La Cholla Boulevard Bank Stabilization	2,490	200		1,145	1,145	
RILLITO	La Cholla Boulevard to Flowing Wells Bank Stabilization	4,035		2,000	2,035		
RILLITO	First Avenue Bridge Protection	947	947				
RILLITO	Campbell to First Avenue Bank Stabilization	0	0	0	0	0	Other: \$1,610
RILLITO	Campbell Avenue Bridge Protection	303	303				
RILLITO	Campbell to Prince/Country Club Bank Stabilization	2,140	240			1,900	
RILLITO	Dodge/Alvernon Bridge Replacement	1,384			692	692	
RILLITO	Swan Road Bridge Protection	790		790			
RILLITO	Swan Road to Craycroft Bank Stabilization	1,500		1,500			
TANQUE VERDE	Sabino Canyon Creek to Tanque Verde Road Bank Stabilization	3,500			1,750	1,750	
TANQUE VERDE	Tanque Verde Loop Road/Houghton Road Bridge Replacement	3,800			1,900	1,900	

<u>RIVER</u>	<u>PROJECT</u>	<u>TOTAL BOND COST</u>	<u>83/84</u>	<u>84/85</u>	<u>85/86</u>	<u>86/87</u>	<u>REMARKS</u>
PANTANO	Bank Stabilization Downstream of Tanque Verde Road	1,000				1,000	
PANTANO	Speedway Bridge Protection	250	250				
PANTANO	Tanque Verde Road to upstream of Speedway Boulevard Bank Stabilization and Grade Control	1,000		1,000			
PANTANO	Golf Links Road Bridge Protection	134	134				
PANTANO	22nd Street to upstream of Golf Links Road Bank Stabilization	4,994				4,994	
GENERAL	Miscellaneous Highway Repairs	718		718			
	SUB-TOTALS	43,028	5,940	11,048	11,253	14,787	
	RELOCATION	8,300	5,000	3,300			
	ACCESS	12,500	1,000	3,000	4,000	4,500	
	T O T A L S	<u>63,828</u>	<u>11,940</u>	<u>17,348</u>	<u>15,253</u>	<u>19,287</u>	