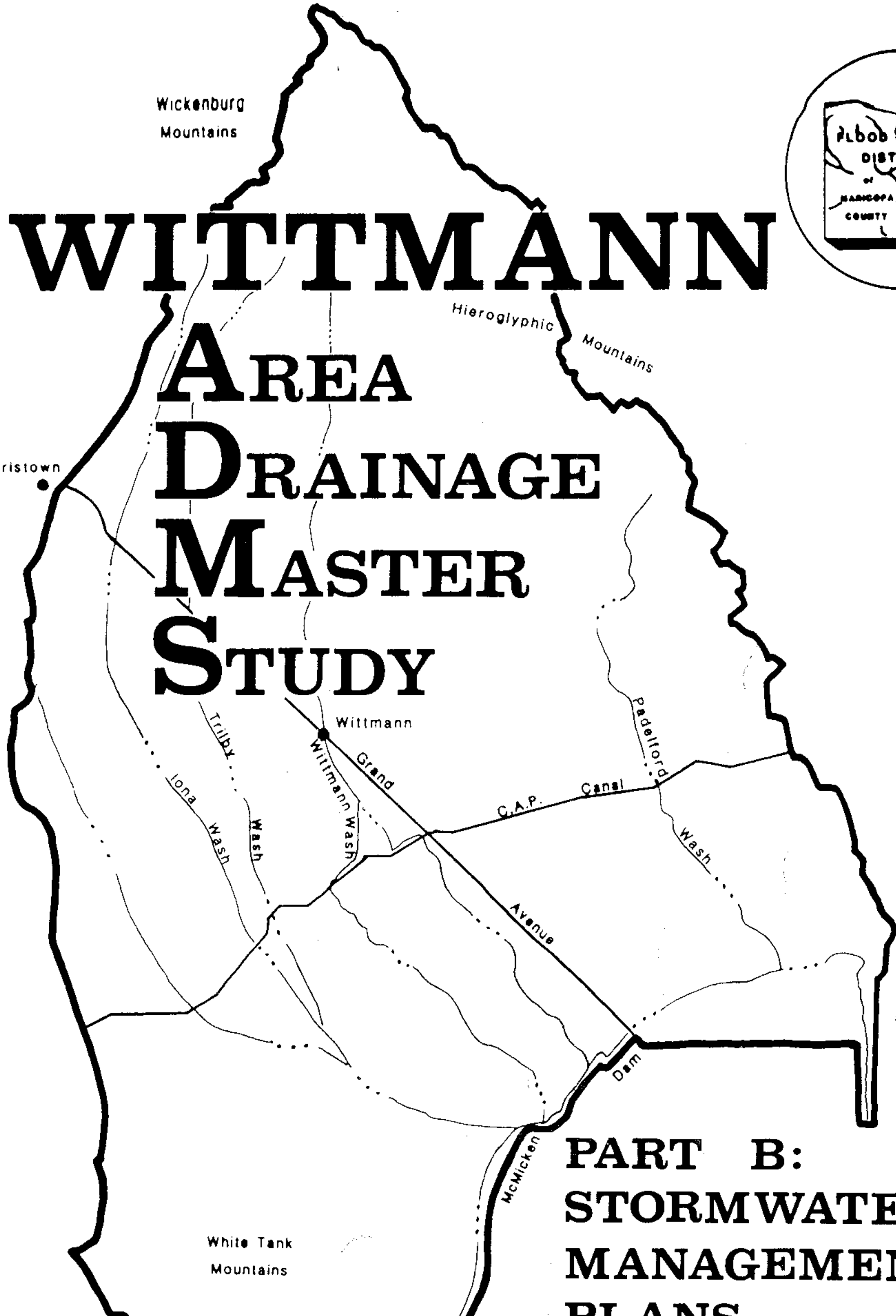
WITTMANN AREA DRAINAGE MASTER STUDY



FLOOD CONTROL DISTRICT of MARICOPA COUNTY

PART B: STORMWATER MANAGEMENT PLANS

The WLB Group Inc.

WLB

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WITTMANN AREA DRAINAGE MASTER STUDY

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PREPARED FOR

The Flood Control District
of Maricopa County

March 10, 1989

PREPARED BY

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The WLB Group Inc.

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The WLB Group Inc.

LIST OF EXHIBITS

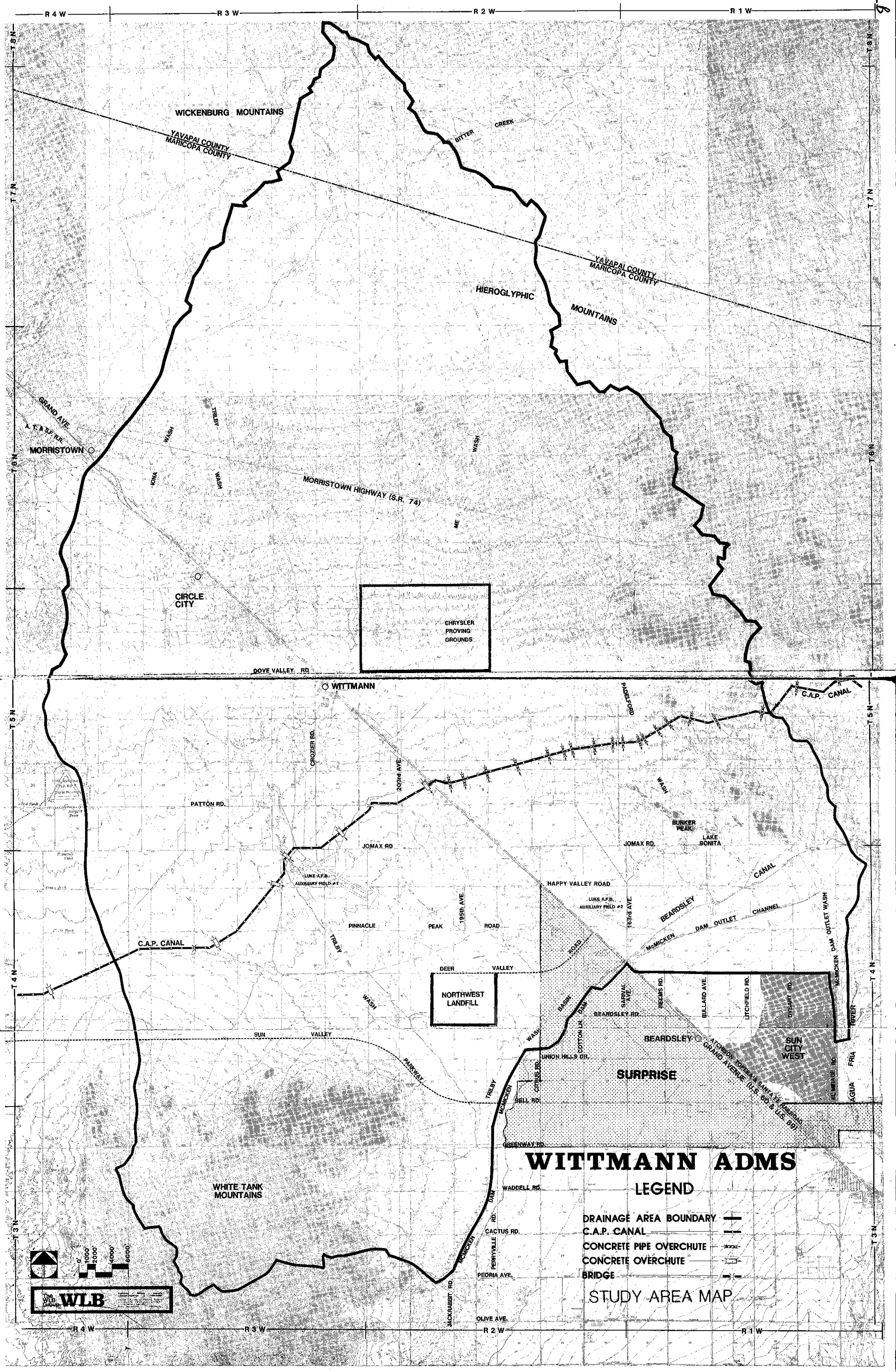
1.0 INTRODUCTION

The Wittmann Area Drainage Master Study (ADMS) covers the largely undeveloped 322 square mile basin that drains to McMicken Dam and the McMicken Dam Outlet Channel. It is one of a number of basin-wide master drainage studies that are being carried out by the Flood Control District of Maricopa County. The purpose of these studies is to identify existing drainage problems and to plan for future development and stormwater management.

The results of the Wittmann Area Drainage Master Study are published as two separate reports. Part A: Hydrology and Hydraulics, summarizes the results of the hydrology study and explains the methods and assumptions used in developing the hydrologic model. In addition, the basic assumptions and methodology used to define the floodplain and floodways are covered in Part A. This report, Part B: Stormwater Management Plans, addresses future development and identifies existing drainage problems. Included are alternative solutions for each identified drainage problem along with cost estimates.

Since the study area is mostly undeveloped, it is envisioned that stormwater management will be primarily non-structural and will utilize the existing washes and adjacent floodplains to form the basis of the drainage infrastructure for the area. The natural washes in the study area should be utilized to maintain existing drainage patterns which will help to preserve natural channel storage.

Stormwater management plans were developed for the Wittmann study area to help address future development and define existing flooding problems. Alternative solutions, preliminary plans, and cost estimates have been prepared for the existing problem areas. The stormwater management plan is to utilize the delineated floodplains, floodways, and ponding areas to manage future development.


WITTMANN ADMS
LEGEND
DRAINAGE AREA BOUNDARY
C.A.P. CANAL
CONCRETE PIPE OVERCHUTE
CONCRETE OVERCHUTE
BRIDGE
STUDY AREA MAP
WICKENBURG MOUNTAINS
HIEROGLYPHIC MOUNTAINS
YAVAPAI COUNTY
MARICOPA COUNTY
BITTER CREEK
MORRISTOWN
GRAND AVE.
A.T.&S.F. RR.
MORRISTOWN HIGHWAY (S.R. 74)
IOWA WASH
TRILBY WASH
CIRCLE CITY
CHRYSLER PROVING GROUNDS
DOVE VALLEY RD.
WITTMANN
PADELFORD WASH
CROZIER RD.
203rd AVE.
PATTON RD.
JOMAX RD.
BUNKER PEAK
LAKE BONITA
HAPPY VALLEY ROAD
LUKE A.F.B. AUXILIARY FIELD #1
LUKE A.F.B. AUXILIARY FIELD #2
PINNACLE PEAK ROAD
195th AVE.
163rd AVE.
BEARDSLEY CANAL
McMICKEN DAM OUTLET CHANNEL
McMICKEN DAM OUTLET WASH
C.A.P. CANAL
DEER VALLEY ROAD
NORTHWEST LANDFILL
TRILBY WASH
SUN VALLEY PARKWAY
BASIN
COTTON LN.
SARIVAL AVE.
REEMS RD.
BULLARD AVE.
LITCHFIELD RD.
DYSART RD.
BEARDSLEY RD.
BEARDSLEY
ATCHISON TOPEKA & SANTA FE RAILROAD
GRAND AVENUE (U.S. 60 & U.S. 89)
SUN CITY WEST
UNION HILLS DR.
CITRUS RD.
SURPRISE
BELL RD.
EL MIRAGE RD.
AGUA FRIA RIVER
GREENWAY RD.
McMICKEN DAM
WADDELL RD.
CACTUS RD.
PERRYVILLE RD.
PEORIA AVE.
JACKRABBIT RD.
OLIVE AVE.
WHITE TANK MOUNTAINS
WLB
R 4 W
R 3 W
R 2 W
R 1 W
T 8 N
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N
0
1000
2000
4000
6000

2.0 STORMWATER MANAGEMENT PLAN FOR FUTURE DEVELOPMENT

The study area is currently undeveloped except for the communities of Wittmann and Circle City and a few scattered residential developments. Consequently, in most cases, the existing washes are in their natural condition. This situation provides the opportunity to direct future development with sound floodplain management and drainage practices and avoid the need for expensive flood control structures.

The floodplain delineations in the study area are based on existing, or undeveloped, conditions. Without good floodplain management practices and stormwater retention requirements, the peak discharges will increase which will add to the flood hazard along the existing washes. Moreover, the entire study area drains to McMicken Dam and any increase in volume and peak rate of runoff could make the dam unsafe.

2.1 Floodplain Management

Future growth should comply with the "Floodplain Regulation for Maricopa County" to eliminate potential flood hazards. Additionally, development should be encouraged to leave the washes in their existing state without encroaching into the floodway fringe. One way that this might be accomplished is by allowing higher densities outside the 100-year floodplain. Thereby providing a "trade off" which would allow the floodplain to remain clear of development.

The benefit derived from preserving the natural desert washes is that the channel storage will be maintained. Channelization and encroachment into the floodplain would result in a decrease in channel storage and an increase in channel travel time. Both of these factors tend to increase the peak rate of runoff and the volume of runoff. By reserving the 100-year floodplain for conveyance of floodwater, channel travel times and storage will be maintained which will help in controlling flooding and preserving the integrity of the McMicken Dam and Outlet Channel.

2.2 Drainage Design

Drainage design should follow the guidelines set forth in the "Uniform Drainage Policies and Standards for Maricopa County". Of particular importance is the requirement to retain stormwater runoff from the 100-year, 2-hour rainfall event. Stormwater retention is important for the same reasons as preserving the channel storage. That is, to control the increased peaks and volumes of runoff so that the flood hazard in the existing floodplains is not increased and McMicken Dam remains safe.

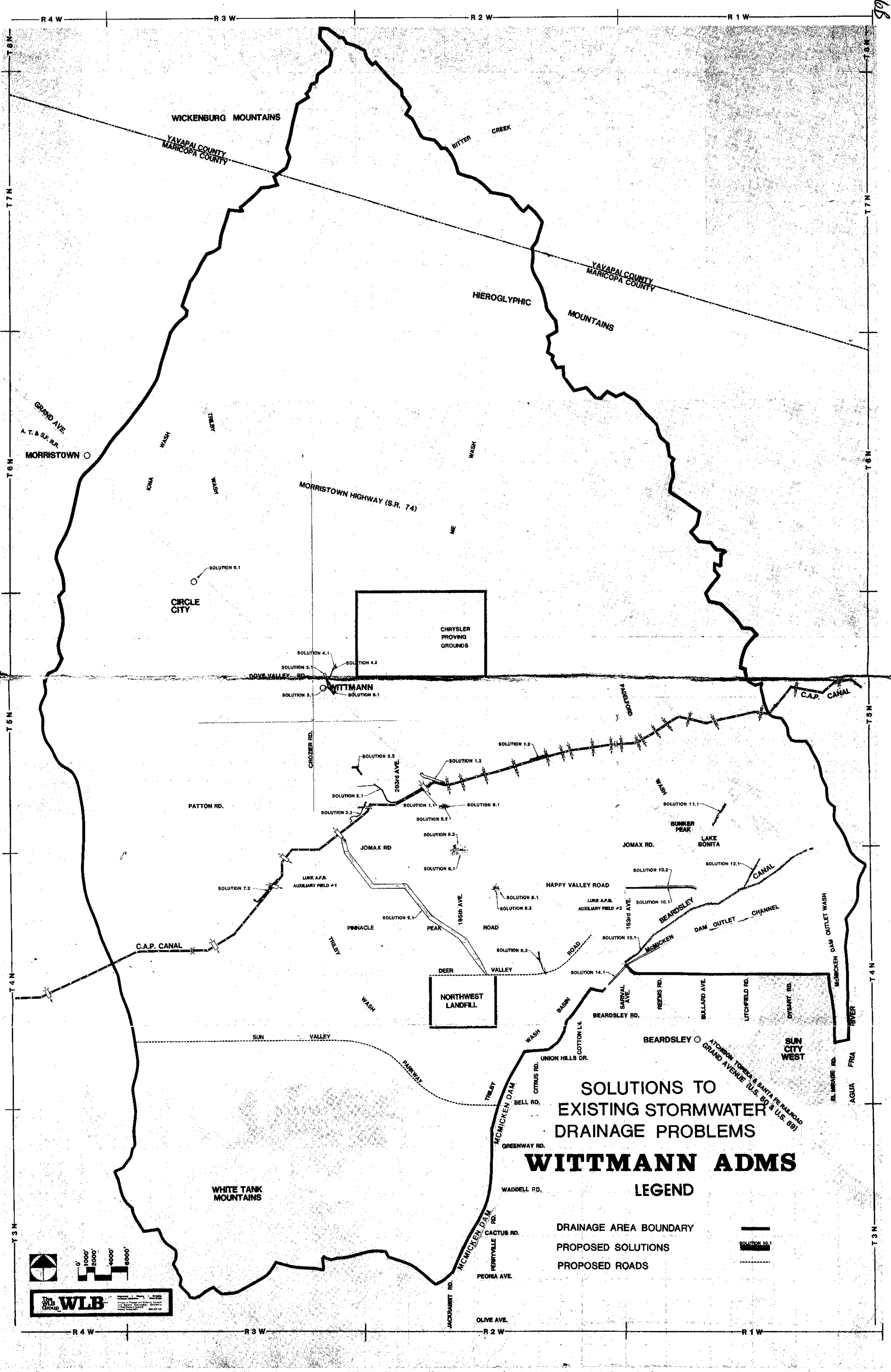
3.0 EXISTING STORMWATER DRAINAGE PROBLEMS AND ALTERNATIVE SOLUTIONS

Part of the Wittmann ADMS was to identify existing flooding problems and develop mitigating solutions. In most cases the hazards are relatively minimal at this time because there is very little development in the study area. However, as development takes place many of these existing flooding problems will become increasingly severe.

A public involvement meeting was held on April 9, 1986 at Nadaburg School in Wittmann, to discuss the Wittmann ADMS. At this meeting, several existing drainage problems were pointed out by the local residents, particularly with respect to vehicular access during major storms. These issues, along with several other flooding problems that were identified through the hydrologic and hydraulic analyses, have been analyzed. Solutions to these drainage problems, including cost estimates and preliminary schematic plans, have been developed for each problem area. The following paragraphs describe the identified drainage problems and their solutions.

3.1 Patton Road and CAP Canal Area

This area has been prone to flooding during large storm events. There are two main problems that have been identified by the local residents. First, water ponds behind the CAP Canal and floods 203rd Avenue at the Wittmann Wash crossing making the roadway impassable. In addition, the HEC-1 rainfall runoff model indicates that the ponding level for the 100-year flood could



SOLUTIONS TO EXISTING STORMWATER DRAINAGE PROBLEMS
WITTMANN ADMS
LEGEND
DRAINAGE AREA BOUNDARY
PROPOSED SOLUTIONS
PROPOSED ROADS
SOLUTION 10.1
R 4 W
R 3 W
R 2 W
R 1 W
T 8 N
T 7 N
T 6 N
T 5 N
T 4 N
T 3 N
WICKENBURG MOUNTAINS
YAVAPAI COUNTY
MARICOPA COUNTY
BITTER CREEK
HIEROGLYPHIC MOUNTAINS
GRAND AVE.
A. T. & S.F. R.R.
MORRISTOWN
IONA WASH
TRILBY WASH
WASH
MORRISTOWN HIGHWAY (S.R. 74)
SOLUTION 6.1
CIRCLE CITY
CHRYSLER PROVING GROUNDS
SOLUTION 4.1
SOLUTION 4.2
SOLUTION 3.1
DOVE VALLEY RD.
WITTMANN
SOLUTION 3.
SOLUTION 5.1
PADELFORD
C.A.P. CANAL
SOLUTION 1.2
SOLUTION 2.2
CROZIER RD.
203rd AVE.
SOLUTION 2.1
PATTON RD.
SOLUTION 1.1
SOLUTION 8.1
SOLUTION 2.3
SOLUTION 8.2
SOLUTION 11.1
BUNKER PEAK
LAKE BONITA
JOMAX RD.
SOLUTION 12.1
CANAL
SOLUTION 10.2
HAPPY VALLEY ROAD
LUKE A.F.B. AUXILIARY FIELD #1
SOLUTION 7.2
LUKE A.F.B. AUXILIARY FIELD #2
163rd AVE.
SOLUTION 10.1
BEARDSLEY
DAM OUTLET CHANNEL
McMICKEN DAM OUTLET WASH
SOLUTION 9.1
PINNACLE PEAK ROAD
195th AVE.
SOLUTION 13.1
McMICKEN
SOLUTION 8.3
ROAD
DEER VALLEY
SOLUTION 14.1
NORTHWEST LANDFILL
SARIVAL AVE.
REEMS RD.
BULLARD AVE.
LITCHFIELD RD.
DYSART RD.
BASIN
BEARDSLEY RD.
RIVER
AGUA FRIA
SUN VALLEY PARKWAY
COTTON LN.
UNION HILLS DR.
BEARDSLEY
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PERRYVILLE RD.
CACTUS RD.
PEORIA AVE.
JACKRABBIT RD.
OLIVE AVE.
0'
1000'
2000'
4000'
6000'
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overtop the CAP Canal in this area. The second problem is that the capacity of the collection ditch and culvert system on the north side of Patton Road, just west of the CAP Canal, is exceeded and causes water to flow over the Patton Road bridge.

Ponding Problems North of the CAP Canal

Ponding behind the CAP Canal floods 203rd Avenue and is caused by two factors. The main reason is the overchute at CAP1WEST is undersized and creates a 100-year water surface elevation behind the canal of 1551.92'. This elevation is based on the assumption that the entire flow in Wittmann Wash would reach the CAP1WEST overchute. In actuality an estimated flow of 550 cfs of the 2300 cfs was discovered to split from the main wash and flow south toward the intersection of Patton Road and the CAP Canal. At the CAP1WEST Overchute, the water ponds above the roadway surface on 203rd Avenue, matching the elevation at the top of the CAP dike (CAP dike elevation = 1552). The overchute was designed for 3,225 cfs, however the HEC-1 model indicates a flow of 6,459 cfs.

The second factor contributing to the ponding problem is that the Wittmann Wash channel that leads to the overchute through the ponding area is undersized and heavily choked with vegetation. This results in an increase in water surface elevation of approximately 0.7 feet from the CAP1WEST overchute, to the Wittmann Wash crossing on 203rd Avenue. Consequently, the lack of conveyance in Wittmann Wash adds to the flooding problem at 203rd Avenue and increases the potential hazard of the CAP dike being overtopped.

In addition, the 203rd Avenue crossing over Wittmann Wash is not adequately sized to pass the 100-year flood. There are 10 - 36" x 24" CMPA culverts that convey only 240 cfs, which is approximately a 2-year flow, while the 100-year flow is 2293 cfs.

The ponding behind the CAP Canal is not only a problem upstream of the canal, but also downstream. Since the CAP dike does not have 3 feet of freeboard, (and in fact is in danger of being overtopped) the area downstream is a flood hazard. This will significantly affect future development downstream.

The following two alternative solutions to this problem have been analyzed. Schematic plans for these solutions can be found on the stormwater management plans and the design data and cost estimates can be found in Appendix A and Appendix B respectively.

<u>Solution 1.1</u> - Widen CAP1WEST Overchute

Schematic Plans:	Sheet PC-1
Design Data:	Appendix A, Page A-1
Cost Estimates:	Appendix B, Page B-1

This alternative is a widening of the existing CAP1WEST overchute to drop the water surface elevation at least 3 feet. Calculations using the Bureau of Public Roads culvert charts were used to create a storage discharge table which was input into the HEC-1 model. The results indicate that an addition of 107.5' in width will lower the water surface elevation from 1551.92' to 1548.21'. The total width of the overchute would be 175'. The cost of this widening was estimated at approximately $1,144,000.

Solution 1.2 - Redirect Flows From CAP1WEST to Ponding Area Behind CAP Canal East of Grand Avenue

Schematic Plans: Sheet G-3 and MC-16
Design Data: Appendix A, Page A-1
Cost Estimate: Appendix B, Page B-1

This alternative would significantly reduce the ponding area behind the overchute at CAP1WEST. The idea would involve redirecting flows that normally cross under the AT&SF Railroad and Grand Avenue bridges 1000' northwest of the CAP Canal. A channel would be constructed to convey flows southeasterly toward the large ponding area behind the CAP Canal east of the Grand Avenue. The HEC-1 computer model was modified to analyze the effect this would have on each ponding area. The 100-year water surface elevation behind CAP1WEST would be reduced 4.17' from 1551.92' to 1547.75'. The water surface elevation behind the CAP Canal, east of Grand Avenue, would rise 2.24' from 1549.88' to 1552.12'.

The peak discharges at the outlet of the pipe culverts associated with the ponding area east of Grand Avenue would increase about 15 to 20 percent which is easily contained in the downstream channels. An example is the peak outlet discharge at CAP1EAST which would increase from 311 cfs to 373 cfs. The HEC-2 analysis for the wash downstream of the CAP1EAST overchute was modified to account for the increased peak discharge and there was very little effect on the water surface elevations. In fact, the greatest increase in peak stage was only 0.2 feet.

The lowest elevation on top of the CAP dike east of Grand Avenue is approximately 1553.5'. This is not acceptable under FEMA criteria and the dike would have to be built up between the CAP4EAST and CAP5EAST overchutes to an elevation of 1556.0' to provide sufficient freeboard. It should be noted that the CAP Canal construction plans intended to have the entire dike constructed to an elevation of 1556'. It should also be noted the existing right-of-way behind the CAP Canal is sufficient to cover the increase in ponding area. The cost of building the channel and raising the CAP dike is approximately $481,400 including the new right-of-way required for the channel.

Providing stormwater detention upstream of the CAP1WEST overchute was also considered to alleviate this problem. A basin of approximately 140 acres would be required with a depth of 9 feet below the invert of the overchute to provide enough storage to drop the water surface elevation 4 feet. This would require an additional 70 - 100 acres of right-of-way and would require a large pump station to drain the basin. Due to very high costs, this alternative was considered impractical. The estimated cost was $3,700,000 including right-of-way acquisition.

Flooding Problem on Patton Road

The flooding problem on Patton Road at the CAP Canal is caused by a split flow situation on Wittmann Wash occurring approximately 1/2 mile upstream of the CAP Canal which diverts about 25% of the 100-year flow (approximately 550 cfs) south to the collection ditch along the north side of Patton Road. The collection ditch outlets into 4 - 50" x 31" CMPA culverts under Patton Road to a small retention basin which has a storage volume of only 6.5 acre-feet. The culverts have a capacity of about 220 cfs when the basin is empty and only about 130 cfs when it is full. At the peak flow of 550 cfs the basin would fill in about 10 minutes. Consequently, the larger stormwater flows from the split on Wittmann Wash flow over Patton Road at the CAP Canal bridge and cause flooding across the bridge.

In addition to flow over the bridge, stormwater spills out of the retention basin and into a small channel which conveys the flow to the CAP2WEST overchute. There aren't any low flow culverts to drain the basin so water stands in it for long periods of time.

Solution 2.1 - Wittmann Wash Channelization North of Patton Road and 203rd Avenue.

Schematic Plan: Sheet PC-1, PC-2
Design Data: Appendix A, Page A-2 and A-3
Cost Estimate: Appendix B, Page B-2

Three channel segments comprise the channelization plan for Wittmann Wash. The first segment starts 1/2 mile north of Patton Road starting at a point 450 feet east of 211th Avenue and continuing to the east for about 2100 feet to meet Wittmann Wash. The purpose of this channel segment is to collect the split flow and convey it east, back to the main wash. One 3' drop would be required to provide a bed slope of .0015 to control the erosion potential.

The second segment of the channelization starts from the point of confluence with the first segment and continues downstream to the culvert crossing at 203rd Avenue. A series of 5 - 3' drops to maintain a slope of .0008 was incorporated into the design for erosion control.

The third segment is from the culvert crossing at 203rd Avenue to the overchute at CAP1WEST along the north side of the CAP Canal. The CAP dike acts as the right bank and the left side would be graded to daylight at a side slope of 10:1. No drop structures are required in this segment of the channel.

The final component of the channelization is a box culvert at 203rd Avenue. The existing 10 - 35" x 25" CMPA pipe culverts can convey only about 240 cfs which is approximately a 2-year flow. Instead, six - 10' x 5' box culverts are proposed to pass the 50-year flow of 1750 cfs. The 100-year flow of 2300 cfs would pond and flow across 203rd Avenue to the east as it currently does now and would not cause increased flooding upstream. This was confirmed by a HEC-2 backwater analysis.

Approximately 30 - 10' x 5' box culverts would be needed to pass the 100-year flow without increasing the flood hazard to the houses upstream. The outflow is controlled by the 100-year water surface elevation north of the CAP1WEST Overchute. The 100-year solution was considered impractical at this location.

The cost of the 50-year box culvert crossing and the three channel segments are as follows:

6 - 10' x 5' Box Culverts	$152,000.00
Channel Segment 1	$138,900.00
Channel Segment 2	$372,600.00
Channel Segment 3	$119,200.00
Total Estimated Cost	$782,700.00

Solution 2.2 - Contain Split Flow in Wittmann Wash With a Dike

Schematic Plan: Sheet PC-1, PC-2
Design Data: Appendix A, Page A-4
Cost Estimate: Appendix B, Page B-3

A dike constructed on the west bank of Wittmann Wash to keep the split flow in the main channel could alleviate the flooding problem at the Patton Road bridge. The top of the dike was set 3 feet above the water surface elevation on Wittmann Wash. The required length of the dike is 1350 feet to assure that the split flow is contained. The estimated cost of the dike is $33,300.

This solution will cause the water surface elevation in Wittmann Wash downstream of the split flow to rise approximately .14 feet. This rise would not greatly affect the width of flooding and would have little impact on the houses already in the floodplain.

Solution 2.3 - Improve Patton Road Drainage to Contain the Split Flow

Schematic Plan: Sheet PC-1, PC-2
Design Data: Appendix A, Page A-4 and A-5
Cost Estimate: Appendix B, Page B-3 and B-4

This alternative is based on allowing the split flow to continue and providing the necessary improvements to Patton Road to convey the flow to the overchute at CAP2WEST. The improvements to Patton Road include three components. First, a berm would be required around the collection ditch on the north side of Patton Road with a top elevation of 1552.0'. Second, 3 - 8' x 5' box culverts would be needed to replace the existing 4 - 50" x 31" CMPA's to convey approximately 550 cfs under Patton Road to the existing retention basin. And last, a channel would be required from the retention basin to the overchute at CAP2WEST. This channel was designed with a bottom width of 50 feet and 3:1 side slopes. It's length is 2800' with a bed slope of .00057. The total estimated cost is $165,100.

This solution will increase the peak outflow from the CAP2WEST overchute approximately 14% from 2,270 CFS to 2,590 CFS. This increase will not significantly impact the CAP2WEST floodplain because it is very wide and shallow downstream of the CAP Canal.

3.2 Wittmann Area

The following existing flooding problems have been identified in the community of Wittmann.

Wittmann Wash

Wittmann Wash flows through town and divides into two channels upstream from Center Street that join back together just prior to crossing under the AT&SF Railroad and Grand Avenue. Flooding is caused by two factors; dense vegetation along the channel banks and undersized culverts under Center Street. Ten to fifteen existing residences are subject to flooding from Wittmann Wash.

Solution 3.1 - Channelization Through the Community of Wittmann

Schematic Plans:	Sheets W-1 and W-2
Design Data:	Appendix A, Page A-5 and A-6
Cost Estimate:	Appendix B, Page B-4, B-5 and B-6

This alternative includes clearing the vegetation from the existing channels, widening the channels in areas, and providing riprap bank protection and drop structures to provide erosion protection and to contain the 100-year flood on Wittmann Wash. Included in this alternative would be new box culverts at the two crossings on Center Street. The existing 6 - 48" concrete pipe culverts are not adequate to pass the flow. The northern crossing would need a 4 barrel - 8' x 5' box culvert to convey 1050 cfs and the southern crossing would need a 6 barrel - 6' x 5' box culvert to pass 1113 cfs. The approximate cost for this alternative is $412,200.

Solution 3.2 - Floodproof in Accordance with Floodplain Regulation for Maricopa County

Floodplains and floodways were delineated on Wittmann Wash as part of this study. This alternative would be to floodproof future development in the flood fringe in accordance with the Floodplain Regulation for Maricopa County. Existing residences located within the floodway fringe may obtain flood insurance through their local insurance company.

Nadaburg High School Flooding

Nadaburg High School is subject to flooding during major storms. There is a channel directly north of the school that flows south to Center Street and then along Center Street and into the school grounds. It was at first thought from aerial photos that there were possibly large flows coming from a split in a major wash north of Wittmann. After a field investigation, however, it was concluded that the split did not occur. The wash that floods the school has a 100-year peak discharge of 406 cfs with an associated drainage area of approximately 1.7 square miles. The major wash that appears to split into the drainage area on aerial photographs, contains the 100-year flood of 1272 cfs and conveys it to the southeast away from Wittmann.

The following alternatives have been developed to prevent the flooding of Nadaburg School.

<u>Solution 4.1</u> - Channelization to Capture Flows North of Nadaburg School

Schematic Plan: Sheet W-1
Design Data: Appendix A, Page A-7
Cost Estimate: Appendix B, Page B-6

The channel would collect flows north of Wittmann and convey them to Wittmann Wash upstream of Center Street. The cost of this channel is approximately $64,800.

<u>Solution 4.2</u> - New Dike to Direct Flows Away From Nadaburg School

Schematic Plan: Sheet W-1
Design Data: Appendix A, Page A-7
Cost Estimate: Appendix B, Page B-6

There is currently a small berm located north of Wittmann that was apparently constructed to direct flows away from Center Street and Nadaburg School. This berm does not contain the flow and does not appear to be structurally sound and therefore is ineffective in protecting the School. This alternative design is a replacement of the berm with a new dike to direct flows to the existing wash west of Center Street. The estimated cost of this dike is $25,200.

In both solutions, downstream residences were not affected. The natural channel has enough capacity to contain the flow and the proposed channelization on Wittmann Wash would also contain the flow. Peak discharges are not affected when this flow is added to Wittmann Wash and, therefore, the residences along the wash will not experience any increased flooding.

Detention/retention was also considered as an alternative solution to reduce flooding at Nadaburg School. A 30-acre basin, approximately 6 feet deep would be required with a 36 inch outlet pipe. The cost of the basin, including right-of-way, would be approximately $1,011,000 which is considerably more expensive than the first two solutions and, therefore does not seem practical.

Bridges at The AT&SF Railroad and Grand Avenue

There is an existing training dike that directs flow from Wittmann Wash to the bridge crossings under the AT&SF Railroad and Grand Avenue. This dike is too short to contain the 100-year flood and therefore a portion of the floodwater will flow around it and continue southeasterly along the Railroad.

Solution 5.1 - Extension of Existing Training Dike on Wittmann Wash to Direct Flows to Bridge Crossing

Schematic Plan:	Sheet W-2
Design Data:	Appendix A, Page A-8
Cost Estimate:	Appendix B, Page B-7

Since the bridges have sufficient capacity to pass the 100-year flood, a simple solution is to extend the training dike 50 feet to the north at an elevation of 1680. The extension would assure that the 100-year flood is contained and directed under the bridges. The approximate cost of the dike extension is $2,300.

Downstream of The AT&SF Railroad and Grand Avenue

The Wittmann Wash floodplain spreads out downstream of Grand Avenue into a large flat area of intermingling channels approximately 1300' wide. There is not a defined channel to convey the flow adequately and the shallow flooding area is densely vegetated. A planned development called Groom Ranch is proposed in this area along with channelization of the wash. Care should be taken to check that this channelization does not adversely affect or increase the flooding potential for the properties upstream and downstream from the development.

3.3 Circle City Area

In general, the Circle City area does not have any major drainage problems. For the most part, the 100-year flood is contained in the existing washes. There are, however, a couple of existing drainage problems that the hydrologic analysis identified.

Insufficient Culvert Capacity Under The Railroad and Grand Avenue

The culverts at the AT&SF Railroad and Grand Avenue are not sized properly to convey the 100-year flow. Runoff exceeds the culverts and is conveyed to the next downstream culvert along the railroad or roadway. Where CCWASH5 crosses Grand Avenue, some runoff may flow across the roadway. The highway culvert can pass the 50-year flood of 93 cfs, however, the 100-year flood of 101 cfs passes through the railroad crossing. Therefore, the culvert is exceeded and a small flow may cross the roadway during a 100-year flood.

Floodways were computed on the northeast side of the railroad where runoff exceeds the culverts and flows downstream along the railroad. Thereby providing an area for conveyance of larger floods. As development occurs along the north side of Grand Avenue, the 100-year, 2-hour retention requirements may reduce peak flows enough to pass the 100-year flood through the culverts.

Circle City Roadway Entrance

The small wash that conveys flow through a dip section in the roadway entrance to Circle City floods to a depth of 1.9'. This problem restricts access into the community.

Solution 6.1 - Box Culvert at Entrance to Circle City

Schematic Plan: Sheet C-1
Design Data: Appendix A, Page A-8
Cost Estimate: Appendix B, Page B-7

The dip section at the Circle City entrance would require 2 - 10' x 3' box culverts to pass the 100-year flood. Training dikes would need to be installed upstream to direct the flows to the culvert. In addition, the channel needs to be cleared of existing vegetation to increase the conveyance around Circle City. The estimated cost of this improvement is $36,100.

3.4. CAP Canal

Overtopping at Iona Wash Overchute

In addition to the problem already discussed at CAP1WEST, there is another area along the CAP Canal that will be overtopped during the 100-year storm. The area in question is at the Iona Wash overchute. The 100-year peak flow on Iona Wash is 5306 cfs. The capacity of the existing overchute is approximately 2460 cfs and it was designed for only 2389 cfs. The consequence is flow over the CAP during the 100-year flood which adversely affects properties downstream.

Solution 7.1 - Widen Iona Wash Overchute

Schematic Plan: Sheet MC-1 and MC-4
Design Data: Appendix A, Page A-8 and A-9
Cost Estimate: Appendix B, Page B-7

Widening of the Iona Wash overchute to convey the 100-year peak discharge is required, along with rebuilding the dike to maintain 3' of freeboard. The overchute would need to be widened 57.7 feet for a total width of 105 feet and the dike would be raised 3 feet to an elevation of 1355.0'. The approximate cost of this addition is $645,600.

Low Point in Dike Between CAP4EAST and CAP5EAST

There is an existing low point in the CAP Dike between CAP4EAST and CAP5EAST at an elevation of about 1,553.5 feet. This area was previously discussed under Section 3.1. As described in that section, if stormwater is diverted from CAP1WEST to the reservoir behind the CAP Canal east of Grand Avenue, the dike will have to be raised to an elevation of 1,556.0 feet to provide 3 feet of freeboard for the 100-year flood. If, however, runoff is not diverted, the existing 100-year water surface elevation is 1,549.88 which allows for over 3 feet of freeboard. Therefore, the dike would not have to be raised to protect against the 100-year flood.

It should be noted, however, that the reservoir behind the CAP Canal is designed to spill at the east end in the event of a major flood that exceeds the 100-year return interval. The elevation of the spill section is 1,554.0 feet. Consequently, the intended flow pattern for floods larger than the 100-year event will not take place. Instead, the large flood events will overtop the CAP dike at the low point between CAP4EAST and CAP5EAST causing a potential flood hazard downstream.

Because of this potential flood hazard, it is recommended that the dike be raised between CAP4EAST and CAP5EAST to elevation 1,556.0; regardless of the diversion from CAP1WEST. The approximate cost is $18,800.

3.5 CAP1WEST Wash Downstream of the CAP Canal

The wash downstream of the CAP1WEST overchute crosses several dirt roads that provide access to the properties west of Grand Avenue. The wash crossings are at grade with dip sections which are not stabilized. The roads are washed out during the major floods which isolates the local residences from access to Grand Avenue. In addition, these wash crossings are maintenance problems for the Highway Department.

The Uniform Drainage Policies and Standards for Maricopa County state that there should be no flow across the street from the 50 year storm and that the flow for the 100-year storm have a maximum depth of 0.5 feet over the crown. Since traffic is relatively minimal on these roads, both 10-year and 50-year alternative designs were considered for the wash crossings.

<u>Solution 8.1</u> - 10-year Design for CAP1WEST Wash Crossings

Schematic Plan: Sheet MC-6, MC-10 and MC-11
Design Data: Appendix A, Page A-9 and A-10
Cost Estimate: Appendix B, Page B-8

Low flow culverts with a stabilized dip section for the 100-year flood were designed to convey the 10-year flow at the road crossings. CAP1WEST Wash crosses Patton Road, 193rd Avenue, Jomax Road, and Happy Valley Road. Culvert sizes and their associated costs are as follows:

Location	Q (10-year)	Size	Cost
Patton Road	2280 cfs	15 - 10' x 4' B.C.	$224,250
193rd Avenue	2346 cfs	6 - 10' x 6' B.C.	$ 96,600
Jomax Road	2346 cfs	8 - 10' x 5' B.C.	$128,800
Happy Valley Rd.	2412 cfs	17 = 10' x 3' B.C.	$254,150
		Total Cost	$703,800

A bridge has already been designed and is in the process of being constructed at Deer Valley Road.

Solution 8.2 - 50-year Design for CAP1WEST Wash Crossings

Schematic Plan: Sheet MC-6, MC-10 and MC-11
Design Data: Appendix A, Page A-10 and A-11
Cost Estimate: Appendix B, Page B-9

The following box culvert designs are based on using County wide criteria of a maximum depth of 0.5' over the crown during the 100-year flood and passing the 50-year peak discharge. Culvert sizes and their associated costs are as follows:

Location	Q (50-year)	Size	Cost
Patton Road	4611 cfs	25 - 10' x 4' B.C.	$ 373,750
193rd Avenue	4707 cfs	9 - 10' x 8' B.C.	$ 152,700
Jomax Road	4707 cfs	11 - 10' x 7' B.C.	$ 183,400
Happy Valley Rd.	4803 cfs	21 - 10' x 4' B.C.	$ 313,950
		Total Cost	$1,023,800

These culverts were designed to convey more than the 50-year flow because the length of the roadway weir section was not sufficiently long to allow the difference between the 50-year and 100-year flood to flow over the road at the maximum depth of 0.5'.

Deer Valley Road Bridge

The training dike at the proposed Deer Valley Bridge does not contain and direct all the flow to the bridge. Upstream flows break out to the east and are conveyed to the southeast where they pond against the roadway.

Solution 8.3 - Extend Training Dike Upstream From Deer Valley Road

Schematic Plan: Sheet MC-19
Design Data: Appendix A, Page A-11
Cost Estimate: Appendix B, Page B-10

The improvement includes extending the dike upstream about 3,350 feet where the flow is contained. The approximate cost is $100,100.

3.6 CAP2WEST Wash Downstream of the CAP Canal

Extremely Wide Floodplain

The CAP2WEST Wash has a very wide, shallow floodplain with no well defined channel. The 100-year floodplain is roughly 1/2 mile wide with depths of 0 to 4 feet. As development occurs in this area, it will probably be very difficult to control with the County's Flood Plain Regulation because smaller developments can encroach into the floodplain without significantly raising the water surface elevation. It is the cumulative effect of several developments that can substantially increase the flood hazard in the area. The floodplain is similar to the East Fork of Cave Creek in Phoenix in which there was no well defined channel and continued development over the years almost entirely eliminated the conveyance in the floodplain.

Solution 9.1 - Channelization Below CAP2WEST Overchute to the Bridge at Deer Valley Road

Schematic Plan: Sheet MC-3, MC-4, MC-6, MC-7, MC-11 and MC-12
Design Data: Appendix A, Page A-12
Cost Estimate: Appendix B, Page B-10

Channelization from the CAP2WEST overchute to the Deer Valley Road bridge is an alternative to regulating development in the wide floodplain. The channel section considered is also wide and shallow to prevent erosive velocities and to provide substantial channel storage as the existing floodplain does. The channel alternative has a 500' bottom width, 3:1 side slopes, and a 3' depth. The total cost including right-of-way is approximately $5,326,000. The cost of just the channel construction is $1,910,500.

Dikes for Livestock Tanks

There are several dikes for livestock tanks that collect flows on CAP2WEST Wash. The dikes should be removed when development occurs. They are structurally unsound and present a flood hazard during a large flood.

3.7 Existing Dike North of Luke Auxiliary Field No. 2, from 163rd Avenue to 7700 Feet East of 163rd Avenue

This dike collects stormwater flow north of the auxiliary field and diverts it to a wash about 2 miles to the east. The Air Force apparently built this dike in the 1940's to protect the airstrip from flooding. The land the dike is located on is individually owned with no drainage easements or right-of-way for the dike. The dike is structurally unsound, it is not maintained and it will be overtopped in areas during the 100-year flood.

Solution 10.1 - Reconstruct Existing Dike

Schematic Plan: Sheet MC-22
Design Data: Appendix A, Page A-12
Cost Estimate: Appendix B, Page B-10

This alternative would involve building up and reinforcing the existing dike to meet FEMA requirements. The dike would require reconstruction with a 10 foot top width and 3:1 side slopes. The top of dike elevations were set at 3 feet above the 100-year water surface elevations. Approximately 800 feet of the dike would require riprap bank protection where the CAP5EAST wash enters (refer to the schematic plans). The cost of this dike would be approximately $351,200.

<u>Solution 10.2</u> - Construct Channel Along Existing Dike Alignment

Schematic Plan: Sheet MC-22
Design Data: Appendix A, Page A-13
Cost Estimate: Appendix B, Page B-11

Another alternative would be to remove the dike and construct a channel. The first reach of channelization would be from 163rd Avenue to the east, 3,500'. The channel section in this reach would require a 60' bottom width with 3:1 side slopes and a bed slope of 0.00337. This segment of the channel would convey the 100-year flow of 584 cfs at a normal depth of 2.23'. One 2' drop structure would be required at the end of the reach.

CAP5EAST joins the channel 3500' east of 163rd Avenue and increases the 100-year peak discharge to 2,025 cfs. The south bank of the channel at this point would require approximately 800' of riprap erosion protection. The bottom width of the remainder of the proposed channel is 135 feet with the same 3:1 side slopes and a channel slope of .0015. Three drop structures, each with a 3' drop, would be required in this reach of the channel. The approximate cost for this alternative including right-of-way is $875,100.

Solution 10.3 - Remove Existing Dike

A third alternative would be to remove the existing dike and let the drainage return to it's natural flow path. However, there are several problems associated with removing the dike.

1. The wash crossings along the Beardsley Canal were apparently constructed after the dike because there are no crossings where the natural drainage courses meet the Canal. Therefore substantial improvements would be required to the Beardsley Canal.

2. Although the dike is a diversion, it has probably been there for 40 to 50 years and scattered development has occurred downstream with the assumption that it will continue to divert flows.

3. The diverted flows have eroded a substantial channel along the dike. Therefore, if the dike were removed only a portion of the floodwater would flow in it's natural flow path with the remainder continuing along the diverted flow path. This would create a very undesirable floodplain problem.

3.8 Lake Bonita

Lake Bonita is located at approximately Bullard Avenue (extended), just north of Jomax Road. The dam was constructed without the Arizona Department of Water Resources (ADWR) permission or supervision and is currently considered to be in violation of ADWR Dam Safety Regulations. It is not known if the dam is structurally sound. From field investigations the dam would appear to be constructed properly, but the ADWR has no records of the construction and was not present during construction.

The reservoir was modeled as part of the hydrologic investigation. The assumption was made that the water surface elevation was at the top of the spillway at the beginning of the 100-year storm. The high water surface elevation for the 100-year event is 1413.0' and the top of the dam is 1416.5'. Therefore the dam adequately controls the 100-year flood.

The Probable Maximum Flood (PMF), on the other hand, will overtop the dam; thereby making the dam unsafe. There are four areas where floodwater can flow out of the lake before going over the top of the dam. The total combined flow through these areas is about 13,000 cfs. The PMF is approximately 42,000 cfs.

In modeling the Probable Maximum Flood, it was assumed that the overflow from behind the CAP will flow out the east end of the storage area and into the washes that contribute to Lake Bonita. This is the flow path that was intended by the design of the CAP. However, the PMF would probably flow over the CAP Canal in several areas and not all of it would reach Lake Bonita. In addition, there is a dike northeast of the dam that directs flows to the lake which is in disrepair and has been breached in at least one place. Therefore, the peak discharge of 42,000 cfs at Lake Bonita is a very conservative estimate of the PMF. Nevertheless, the dam should be designed to be safe under worst case conditions.

Solution 11.1 - Remove Existing Dike Directing Flows to Lake Bonita

Schematic Plan:	Sheet MC-25
Design Data:	Appendix A, Page A-13
Cost Estimate:	Appendix B, Page B-11

To help alleviate the dam overtopping problem, it is recommended to remove the dike northeast of Lake Bonita. This would lower the water surface elevation to 1414.6 during the PMF. This does not meet Arizona Department of Water Resources (ADWR) criteria for minimum freeboard, but it would make the dam safer. Ultimately, the final decision as to the fate of the Lake Bonita Dam is in the hands of the ADWR. The cost of removing the existing dike is approximately $78,700.

The ADWR requires a minimum freeboard of 3 feet or the sum of the wave height and wave runup, whichever is greater. Since Lake Bonita is small, it was assumed that the sum of the wave height and wave runup would be less than 3 feet. (Wave runup is the height that waves will reach upon impact on the dam face.) Therefore, using 3 feet as the required freeboard and with the top of dam at elevation 1416.5', a spillway of length 3,500 feet at an elevation of 1411.0 would be required to pass the PMF of 42,000 cfs. However, a spillway length of 3,500 feet is not physically practical in this area. Therefore, it appears that the only way to meet the State's criteria for dam safety is to raise the height of the dam.

3.9 Beardsley Canal

The following existing drainage problems are associated with the Beardsley Canal.

Training Dike at The Padelford Wash Crossing

The training dike that directs flow to the Padelford Wash crossing over the Beardsley Canal is structurally unsound and does not meet FEMA criteria.

Solution 12.1 - Rebuild Existing Training Dike that Directs Flows to the Padelford Wash Crossing Over the Beardsley Canal

Schematic Plan:	Sheet MC-26
Design Data:	Appendix A, Page A-14
Cost Estimate:	Appendix B, Page B-11

The training dike creates a flood hazard and does not meet FEMA requirements. To meet required specifications it would have to be reconstructed and raised with a top width of 10 feet and side slopes of 3:1. The estimated cost of this dike including right-of-way is $129,700 and without right-of-way it is $49,700.

Ponding Behind The Beardsley Canal

The existing 100-year ponding elevation behind the Beardsley Canal is right at the top of the bank and may overtop the canal. The problem is compounded by dense vegetation along the canal bank that impedes the flow of stormwater to the canal wash crossings. In addition, there are 4 pipe culverts into the canal about 2100 feet east of Grand Avenue that have been crushed and consequently provide very little conveyance.

Solution 13.1 - Raise Canal Bank, Clear Vegetation, and Replace Culverts

Schematic Plan: Sheet MC-22, MC-23 and MC-26
Design Data: Appendix A, Page A-14 and A-15
Cost Estimate: Appendix B, Page B-12

The solution to the ponding problem includes clearing the vegetation from behind the Beardsley Canal and providing a positive slope toward the nearest wash crossing. In addition, the canal bank would have to be raised up about 3 feet and the 4 crushed pipe culverts east of Grand Avenue would need to be replaced. The total estimated cost is $338,200.

3.10 McMicken Dam Outlet Channel

McMicken Dam was designed to contain the Standard Project Flood (SPF) below the crest of the spillway with a peak discharge to the outlet channel of 4,450 cfs. However, the HEC-1 model developed as part of this study indicates that the SPF will overtop the spillway and the total peak discharge to the outlet channel is 15,518 cfs. The increase in peak discharge exceeds the capacity of the outlet channel including the bridge crossings under Grand Avenue and the AT&SF Railroad. The outlet channel widens downstream of the Railroad and can contain the increased flow. The following two alternatives can alleviate the flooding problem.

Solution 14.1 - Increase Capacity of McMicken Dam Outlet Channel

Schematic Plan: Sheet MC-19 and MC-23
Design Data: Appendix A, Page A-15
Cost Estimate: Appendix B, Page B-12

The capacity of the outlet channel from the spillway to 5,200 feet east could be increased and the bridge structures at Grand Avenue and the AT&SF Railroad be enlarged to accommodate the increased flow. The required channel bottom width is 130 feet with 2:1 side slopes and a depth of 14 feet. This includes 1 foot of freeboard for the SPF peak discharge of 15,518 cfs. The estimated cost is $751,300 including bridge widening.

Solution 14.2 - Increase Storage Capacity of McMicken Dam

Another alternative would be to raise both the dam and spillway to contain the volume of the SPF below the spillway and keep the probable maximum flood level below the top of the dam. This would be costly and would need to be studied further as future conditions warrant.

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Dike Data

Height From Channel Invert Varies = 7' - 11'

Dike Elevation = 1563.5 at Start of Channelization

Dike Elevation = 1561.5 at Tie in to Existing CAP Dike

Top Width = 12'

Length = 1,300'

Side Slopes = 3:1

Minimum Freeboard = 3'

Build Up Dike on CAP Canal Between CAP4EAST and CAP5EAST Overchutes

Water Surface Elevation Before Alternative 1.2 = 1549.88

Low Spot on Top of Dike = 1553.0

Water Surface Elevation After Alternative 1.2 = 1552.12

Minimum Freeboard Required = 3'

Dike Data

Top Width = 50'

Length = 2,000'

Side Slopes = 3:1

Dike Volume = 6,555 c.y.

Build up Low Spot to Elevation = 1556.0

SOLUTION 2.1 - Wittmann Wash Channelization North of Patton Road and 203rd Avenue Area

Schematic Plan: Sheet PC-1

Cost Estimate: Appendix B, Page B-2

Trapezoidal Channel Data

CHANNEL SEGMENT 1

Flow Rate = 1,130 cfs	Normal Depth = 4.47'
Slope = .0015 ft/ft	Critical Depth = 3.16'
Mannings "N" = .022	Velocity = 5.83 ft/sec
Left Side Slope = 3:1	1 - 3' Gabion Basket
Right Side Slope = 3:1	Drop Structure -
Bottom Width = 30'	Approximate Gabion Basket
Length = 2,100'	Volume = 138 c.y.

CHANNEL SEGMENT 2

Flow Rate = 2,260 cfs	Normal Depth = 4.70'
Slope = .0008 ft/ft	Critical Depth = 2.75'
Mannings "N" = .022	Velocity = 5.88 ft/sec
Left Side Slope = 5:1	5 - 4' Gabion Basket
Right Side Slope = 5:1	Drop Structures -
Bottom Width = 80'	Approximate Gabion Basket
Length = 2,460'	Volume = 307 c.y. per drop

CHANNEL SEGMENT 3

Flow Rate = 2,260 cfs	Normal Depth = 5.06'
Slope = .00046 ft/ft	Critical Depth = 2.70'
Mannings "N" = .022	Velocity = 3.95 ft/sec
Left Side Slope = 10:1	
Right Side Slope = 3:1	
Bottom Width = 80'	
Length = 5,000'	

6 BARREL 10'X 5' BOX CULVERT

50-year Q = 1,750 cfs	Length = 60'
Maximum Discharge at Headwater	Slope = .0083 ft/ft
Depth = 6.2'= 1,750 cfs	Invert Elevation
	Upstream = 1546.0

SOLUTION 2.2 - Contain Split Flow In Wittmann Wash With a Dike

Schematic Plan: Sheet PC-1

Cost Estimate: Appendix B, Page B-3

Dike Data

Top Width = 12'

Side Slopes = 3:1

Height of Dike = 4' (higher than existing bank elevation)

Minimum Freeboard = 3'

Length = 1,350'

SOLUTION 2.3 - Improve Patton Road Drainage to Contain the Split Flow

Schematic Plan: Sheet PC-1

Cost Estimate: Appendix B, Page B-3

Grouted Riprap Berm Around Collection Ditch

Top Width = 2'	Area of Grouted Riprap = 1,065 s.y.
Side Slopes = 2:1	Length = 1,100'
Elevation = 1552.0	Height Varies 0 - 3 feet

3 Barrel 8' x 5' Box Culvert

100-year Q = 550 cfs	Length = 92'
Maximum Discharge at Headwater	Slope = .0054 ft/ft
Depth = 5.00' = 550 cfs	Invert Elevation Upstream = 1545.5

Trapezoidal Channel Data to CAP2WEST Overchute

Flow Rate = 550 cfs	Normal Depth = 3.64'
Slope = .00057 ft/ft	Critical Depth = 1.51'
Mannings "N" = .03	Velocity = 2.48 ft/sec
Left Side Slope = 3:1	
Right Side Slope = 3:1	
Bottom Width = 50'	
Length = 2,800'	

SOLUTION 3.1 - Channelization Through the Community of Wittmann

Schematic Plan: Sheets W-1 and W-2

Cost Estimate: Appendix B, Page B-4, B-5 and B-6

From Bridges Upstream to Start of Divided Flow - Trapezoidal Channel Data

Flow Rate = 2,202 cfs	Normal Depth = 2.63'
Slope = .0050 ft/ft	Critical Depth = 2.37'
Mannings "N" = .025	Velocity = 7.41 ft/sec
Left Side Slope = 5:1	Riprap Bank Protection Volume = 633 c.y.
Right Side Slope = 5:1	
Bottom Width = 100'	Thickness = 18"
Length = 600'	Toe Down = 3'

Northern Channel of Divided Flow

Flow Rate = 1,050 cfs	Normal Depth = 3.13'
Slope = .005 ft/ft	Critical Depth = 2.85'
Mannings "N" = .025	Velocity = 7.34 ft/sec
Left Side Slope = 5:1	Riprap Bank Protection Volumes = 1,576 c.y.
Right Side Slope = 5:1	
Bottom Width = 30'	Thickness = 18"
Length = 1,610'	Toe Down 3', 10' at upstream end of Island

DESIGN DATA

FOR

SOLUTIONS TO EXISTING DRAINAGE PROBLEMS

SOLUTION 1.1 - Widen CAP1WEST Overchute

Schematic Plan: Sheet PC-1
Cost Estimate: Appendix B, Page B-1

Existing Width = 67.5'
Depth = 8.5'
Additional Width = 107.5'
Water Surface Elevation Prior to Widening = 1551.92
Water Surface Elevation After Widening = 1548.21
Difference = 3.71' (Satisfies FEMA Specifications)

SOLUTION 1.2 - Redirect Flows From CAP1WEST to Ponding Area Behind CAP Canal East of Grand Avenue

Schematic Plan: Sheet G-3 and MC-16
Cost Estimate: Appendix B, Page B-1

Trapezoidal Channel Data

Flow Rate = 4475 cfs	Normal Depth = 5.97'
Slope = .0005 ft/ft	Critical Depth = 2.46'
Mannings "N" = .03	Velocity = 3.44 ft/sec
Left Side Slope = 3:1	3 - 3' Gabion Basket
Right Side Slope = 3:1	Drop Structures -
Bottom Width = 200	Approximate Gabion Basket
Length = 3,000'	Volume Per Drop = 705 c.y.

APPENDIX A

DESIGN DATA

Appendix

The WLB Group Inc. WLB

Southern Channel of Divided Flow

Flow Rate = 1,113 cfs	Normal Depth = 3.03'
Slope = .005	Critical Depth = 2.75'
Mannings "N" = .025	Velocity = 7.33 ft/sec
Left Side Slope = 5:1	Riprap Bank Protection Volume = 1,576 c.y.
Right Side Slope = 5:1	
Bottom Width = 35'	Thickness = 18"
Length = 1,610'	Toe Down = 3', 10' at upstream end of Island

2 - 3' Gabion Basket Drop Structures - Volume = 155 c.y. per drop

Channel Upstream From Divided Flow

Flow Rate = 2,163 cfs	Normal Depth = 2.60'
Slope = .005	Critical Depth = 2.34'
Mannings "N" = .025	Velocity = 7.37 ft/sec
Left Side Slope = 5:1	2 - 3' Gabion Basket Drop Structures - Volume = 406 c.y. per drop
Right Side Slope = 5:1	
Bottom Width = 100'	
Length = 790'	
Riprap Bank Protection	Volume = 823 c.y.
Thickness = 18"	
Toe Down = 3'	

4 - Barrel 8' x 5' Box Culvert - Northern Crossing on Center Street

100-Year Q = 1,050 cfs	Length = 50'
Discharge at Headwater	Slope = .0100 ft/ft
Depth = 5.0 = 1,056 cfs	Upstream Invert Elevation = 1086.0

6 - Barrel 6' x 5' Box Culvert - Southern Crossing on Center Street

100-Year Q = 1,113 cfs	Length = 50 cfs
Discharge at Headwater	Slope = .0100 cfs
Depth = 5.0 = 1,155 cfs	Upstream Invert Elevation = 1086.0

SOLUTION 4.1 - Channelization to Capture Flows North of Nadaburg School

Schematic Plan: Sheet W-1
Cost Estimate: Appendix B, Page B-6

Trapezoidal Channel Data

Flow Rate = 406 cfs	North Depth = 2.86'
Slope = .0065 ft/ft	Critical Depth = 2.50'
Mannings "N" = .03	Velocity = 5.85 ft/sec
Left Side Slope = 5:1	4 - 3' Gabion Basket Drop Structures -
Right Side Slope = 5:1	Approximate Gabion Basket Volume =
Bottom Width = 10'	40 C.Y./Drop
Length = 2,000'	

SOLUTION 4.2 - Dike Directing Flows Away From Nadaburg School

Schematic Plan: Sheet W-1
Cost Estimate: Appendix B, Page B-6

Dike Data

Top Width = 10'
Side Slopes = 3:1
Height of Dike = 4' (higher than existing bank elevation)
Minimum Freeboard = 3'
Length = 1,100'

SOLUTION 5.1 - Extension of Existing Training Dike on Wittmann Wash to Direct Flows to Bridge Crossing

Schematic Plan: Sheet W-2
Cost Estimate: Appendix B, Page B-7

Dike Data
- Top Width = 20'
- Side Slopes = 4:1
- Height of Dike = 2'
- Elevation = 1680.0
- Length = 60'

SOLUTION 6.1 - Box Culvert at Circle City Entrance Road

Schematic Plan: Sheet C-1
Cost Estimate: Appendix B, Page B-7

2 - 10' x 3' Box Culverts

100-year Q = 276 cfs	Length = 60'
Headwater Depth = 3.0'	Slope = .0133 ft/ft
= Discharge at 300 cfs	

SOLUTION 7.1 - Widen Iona Wash Overchute

Schematic Plan: Sheet MC-1 and MC-4
Cost Estimate: Appendix B, Page B-7

100-year Water Surface Elevation = 1,552.12'
Low Spot on Top of Dike = 1,552.0'

Dike Data

Top Width = 25'
Side Slopes = 3:1
Length = 5,850'
Dike Volume = 17,546 c.y.
Elevation = 1550.0
Minimum Freeboard = 3'

Widening of Iona Wash Overchute

Existing Width = 47.5'
Depth = 6.8'
Aditional Width Needed = 57.5'
New Width = 105'
100-year Water Surface Elevation = 1550.73
Difference = 4.27' (Satisfies FEMA Specifications)

SOLUTION 8.1 - 10-Year Design for CAP1WEST Wash Crossings

Schematic Plan: Sheet MC-6, MC-10 and MC-11
Cost Estimate: Appendix B, Page B-8

Patton Road - 15 - 10' x 4' Box Culverts

10-year Q = 2,280 cfs
Discharge at Headwater
Depth = 3.0' = 2,325 cfs
Length = 50'
Slope = .0100 ft/ft
Upstream Invert Elevation = 1520.0

193rd Avenue - 6 - 10' x 6' Box Culverts

10-year Q = 2,346 cfs
Discharge at Headwater
Depth = 6.0' = 2,580 cfs
Length = 50'
Slope = .0100 ft/ft
Upstream Invert Elevation = 1470.0

Jomax Road - 8 - 10' x 5' Box Culverts

10-year Q = 2,346 cfs
Discharge at Headwater
Depth = 5.0' = 2,560 cfs
Length = 50'
Slope = .0100 ft/ft
Upstream Invert Elevation = 1465.5

Happy Valley Road - 17 - 10' x 3' Box Culverts

10-year Q = 2,412 cfs

Discharge at Headwater

Depth = 3.0' = 2,550 cfs

Length = 50'

Slope = .0100 ft/ft

Upstream Invert Elevation = 1432.0

SOLUTION 8.2 - 50-Year Design for CAP1WEST Wash Crossings

Schematic Plan: Sheet MC-6, MC-10 and MC-11

Cost Estimate: Appendix B, Page B-9

Patton Road - 25 - 10' x 4' Box Culverts

50-year Q = 4,611 cfs

100-year Q = 6,455 cfs

Discharge at Headwater

Depth = 4.0' = 5,750 cfs

Weir Coefficient = 3.0

Road Weir Length = 700'

Flow Over Road = 705 cfs

Depth at Crown = .48'

Culvert Length = 50'

Slope = .0100 ft/ft

Upstream Invert Elevation = 1520.0

193rd Avenue - 9 - 10' x 8' Box Culverts

50-year Q = 4,707 cfs

100-year Q = 6,342 cfs

Discharge at Headwater

Depth = 8.5' = 6,300 cfs

Weir Coefficient = 3.0

Road Weir Length = 180'

Flow Over Road = 42 cfs

Depth at Crown = .18'

Culvert Length = 50'

Slope = .0100 ft/ft

Upstream Invert Elevation = 1465.6

Jomax Road - 11 - 10' x 7' Box Culverts

50-year Q = 4,707 cfs

100-year Q = 6,342 cfs

Discharge at Headwater

Depth = 7.01' = 6,050 cfs

Weir Coefficient = 3.0

Road Weir Length = 360'

Flow Over Road = 292'

Depth at Crown = .42'

Culvert Length = 50'

Slope = .0100 ft/ft

Upstream Invert Elevation = 1465.6

Happy Valley Road = 21 - 10' x 4' Box Culverts

50-year Q = 4,803 cfs

100-year Q = 6,228 cfs

Discharge at Headwater

Depth = 4.5 = 5,670 cfs

Weir Coefficient = 3.0

Road Weir Length = 700'

Flow Over Road = 558 cfs

Depth at Crown = .41'

Culvert Length = 50'

Slope = .0100 ft/ft

Upstream Invert Elevation = 1432.0

SOLUTION 8.3 - Extend Training Dike Upstream From Deer Valley Road

Schematic Plan: Sheet MC-19

Cost Estimate: Appendix B, Page B-10

Dike Data

Top Width = 12'

Side Slopes = 3:1

Dike Height = 5'

Minimum Freeboard = 3'

Length = 3,350'

SOLUTION 9.1 - Channelization Below CAP2WEST Overchute to Bridge at Deer Valley Road

Schematic Plan: Sheet MC-3, MC-4, MC-6, MC-7, MC-11 and MC-12
Cost Estimate: Appendix B, Page B-10

Trapezoidal Channel Data

Flow Rate = 2,500 cfs	Normal Depth = 1.3'
Slope = .00591 ft/ft	Critical Depth = .92'
Mannings "N" = .035	Velocity = 3.85 ft/sec
Left Side Slope = 3:1	
Right Side Slope = 3:1	
Bottom Width = 500'	
Length = 25,300'	

SOLUTION 10.1 - Reconstruct Existing Dike

Schematic Plan: Sheet MC-22
Cost Estimate: Appendix B, Page B-10

Dike Data

Elevation From Top of Existing Dike Varies 0 - 3 feet
Elevation = 1389.6 at 163rd Avenue to 1359.0 at Outlet

Top Width = 10'	Dike Volume = 9,809 c.y.
Side Slopes = 3:1	Minimum Freeboard = 3'
Length = 7,700'	

SOLUTION 10.2 - Construct Channel Along Existing Dike Alignment

Schematic Plan: Sheet MC-22
Cost Estimate: Appendix B, Page B-11

163rd Avenue to 3,500' East

Flow Rate = 584 cfs	Normal Depth = 1.70'
Slope = .00337 ft/ft	Critical Depth = 1.40'
Mannings "N" = .022	Velocity = 5.28 ft/sec
Left Side Slope = 3:1	1 - 2' Gabion Basket Drop
Right Side Slope = 3:1	Structure - Approximate
Bottom Width = 60'	Gabion Basket Volume =
Length = 3,500'	157 c.y.

From 3,500 Feet East, to CAP5EAST Wash

Flow Rate = 2,025 cfs	Normal Depth = 2.82'
Slope = .0015 ft/ft	Critical Depth =
Mannings "N" = .022	Velocity = 5.01 ft/sec
Left Side Slope = 3:1	3 - 3' Gabion Basket Drop
Right Side Slope = 3:1	Structures - Approximate
Bottom Width = 135'	Gabion Basket Volume Per Drop
Length = 4,200'	= 430 c.y.

SOLUTION 11.1 - Remove Existing Dike Directing FLows to Lake Bonita

Schematic Plan: Sheet MC-25
Cost Estimate: Appendix B, Page B-11

Total Quantity of Dike to be Removed = 27,391 c.y.

From Spillway to Breach in Dike

Begin at Elevation = 1411.0
End at Elevation = 1411.0 Length = 1,200'

From Breach in Dike Northeast to Mountain

Begin at Elevation = 1411.0

End at Elevation = 1414.0 Flow Over Section = 42,622 cfs

Length = 1,600' At Elevation = 1414.6

This will aleviate the problem at the Lake Bonita Dam, but it still does not meet ADWR freeboard requirements.

SOLUTION 12.1 - Rebuild Existing Training Dike That Directs Flows to Padelford Wash Crossing Over Beardsley Canal

Schematic Plan: Sheet MC-26

Cost Estimate: Appendix B, Page B-11

Dike Data

Top Width = 10' Dike Volume = 14,074 c.y.

Side Slope = 3:1 Elevation Varies

Dike Height = 5' Minimum Freeboard = 3'

Length = 4,000'

SOLUTION 13.1 - Raise Beardsley Canal Bank, Clear Vegetation, and Replace Culverts

Schematic Plan: Sheet MC-22, MC-23 and MC-26

Cost Estimate: Appendix B, Page B-12

Road Dike Data

Top Width = 20' Road Dike Volume = 87,000 cy

Side Slopes = 3:1 Height = 3'

Length = 27,000' Minimum Freeboard = 3'

4 - 42 RCP Culverts (From BPR Culvert Charts)

Allowable Headwater = 5.5'
Headwater/Depth = 1.57
Design Discharge = 340 cfs
Length = 50'
Slope = .0100 ft/ft
Upstream Invert Elevation = 1335.0

Weir Flow Through Existing Concrete Spillway Approximately 2,000' Northeast From Grand Avenue

Weir Length = 50'
Weir Coefficient = 3.0
Depth = 1.6'
Weir Flow = 304 cfs

SOLUTION 14.1 - Increase Capacity of McMicken Dam Outlet Channel

Schematic Plan: Sheet MC-19 and MC-23
Cost Estimate: Appendix B, Page B-12

Trapezoidal Channel Data

Flow Rate = 15,100 cfs
Slope = .0007 ft/ft
Mannings "N" = .025
Left Side Slope = 2:1
Right Side Slope = 2:1
Bottom Width = 130'
Length = 5,200'
Normal Depth = 12.59'
Critical Depth = 7.20'
Velocity = 7.49 ft/sec

Need to Widen Both Bridges At Grand Avenue and AT&SF Railroad Approximately 75'.

APPENDIX B

COST ESTIMATES

COST ESTIMATES
FOR
SOLUTIONS TO EXISTING DRAINAGE PROBLEMS

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 1.1 - Widen CAP1WEST Overchute				
Concrete Overchute Widening	S.F.	19,888	$50.00	$ 994,400.00
		Construction Cost		$ 994,400.00
		15% Contingencies		149,160.00
		Total Cost		$1,143,560.00
SOLUTION 1.2 - Redirect Flows From CAP1WEST to Ponding Area Behind CAP Canal East of Grand Avenue				
Channelization				
Excavation	C.Y.	66,130	$2.50	$ 165,325.00
Compaction of Dike	C.Y.	5,629	$1.50	8,444.00
Drop Structures (Gabion Baskets)	C.Y.	3 @ 705 = 2115	$65.00	137,475.00
		Construction Cost		$ 311,244.00
		15% Contingencies		46,687.00
		Total Construction Cost		$ 357,931.00
Right-of-way	S.F.	418,500	$.25	104,625.00
		Cost		$ 462,556.00
Build up Dike on CAP Canal Between CAP4EAST and CAP5EAST				
Excavation and Compaction	C.Y.	6,555	$2.50	$ 16,388.00
		Construction Cost		$ 16,388.00
		15% Contingencies		2,460.00
		Cost		$ 18,848.00
		Total Cost		$ 481,404.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 2.1 - Wittmann Wash Channelization North of Patton Road and 203rd Avenue Area				
Segment 1				
Excavation	C.Y.	24,061	$2.50	$ 60,153.00
Drop Structures	Ea.	1	$9,000.00	9,000.00
			Construction Cost	$ 69,153.00
			15% Contingencies	10,373.00
			Total Construction Cost	$ 79,526.00
Right-of-way	S.F.	237,300	$.25	59,325.00
			Cost	$ 138,851.00
Segment 2				
Excavation	C.Y.	51,079	$2.50	$ 127,698.00
Drop Structures	Ea.	5	$20,000.00	100,000.00
			Construction Cost	$ 227,698.00
			15% Contingencies	34,155.00
			Total Construction Cost	$ 261,853.00
Right-of-way	S.F.	442,800	$.25	110,700.00
			Cost	$ 372,553.00
Segment 3				
Excavation	C.Y.	41,463	$2.50	$ 103,658.00
			Construction Cost	$ 103,658.00
			15% Contingencies	15,548.00
			Cost	$ 119,206.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
6 Barrel 10' x 5' Box Culvert				
6 - 10' x 5' Box Culverts	C.Y.	408	$295.00	$ 120,360.00
Excavation	C.Y.	1,011	$8.00	8,088.00
Saw Cut & Remove Pavement	S.Y.	1,311	$2.00	622.00
Replace Pavement	S.Y.	311	$10.00	3,110.00
		Construction Cost		$ 132,180.00
		15% Contingencies		19,827.00
		Cost		$ 152,007.00
		Total Cost		$ 782,617.00

SOLUTION 2.2 - Contain Split Flow in Wittmann Wash With a Dike

Excavation and Compaction	C.Y.	5,000	$2.50	$ 12,500.00
		Construction Cost		$ 12,500.00
		15% Contingencies		1,875.00
		Total Construction Cost		$ 14,375.00
Possible Right-of-way	S.F.	75,600	$.25	18,900.00
		Total Cost		$ 33,275.00

SOLUTION 2.3 - Improve Patton Road Drainage to Contain the Split Flow

Berm Around Collection Ditch

Grouted Riprap	S.Y.	1,065	$25.00	$ 26,625.00
Excavation and Compaction	C.Y.	490	$2.50	1,225.00
		Construction Cost		$ 27,850.00
		15% Contingencies		4,178.00
		Cost		$ 32,028.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
3 Barrel 8' x 5' BC				
3 Barrel 8' x 5' BC	L.F.	110	$840.00	$ 92,400.00
Excavation	C.Y.	453	$8.00	3,624.00
Saw Cut and Remove Pavement	S.Y.	164	$2.00	328.00
Replace Pavement	S.Y.	164	$10.00	1,640.00
		Construction Cost		$ 97,992.00
		15% Contingencies		14,699.00
		Cost		$ 112,691.00
Channel to CAP2WEST Overchute				
Excavation	C.Y.	7,493	$2.50	$ 18,733.00
		Construction Cost		$ 18,733.00
		30% Appurtenances & Contingencies		5,620.00
		(Possible Relocation of Water Pipe)		
		Cost		$ 24,353.00
		Total Cost		$ 165,051.00

SOLUTION 3.1 - Channelization Through The Community of Wittmann

From Bridges Upstream to Start of Divided Flow

Excavation	C.Y.	5,600	$2.50	$ 14,000.00
Riprap Bank Protection	C.Y.	633	$25.00	15,825.00
		Construction Cost		$ 29,825.00
		15% Contingencies		4,474.00
		Total Construction Cost		$ 34,299.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
Northern Channel of Divided Flow				
Excavation	C.Y.	6,876	$2.50	$ 17,190.00
Riprap Bank Protection	C.Y.	1,576	$25.00	39,400.00
Gabion Basket Drop Structures	C.Y.	2 @ 138	$65.00	17,940.00
			Construction Cost	$ 74,530.00
			15% Contingencies	11,180.00
			Total Construction Cost	$ 85,710.00
Southern Channel of Divided Flow				
Excavation	C.Y.	7,090	$2.50	$ 17,725.00
Riprap Bank Protection	C.Y.	1,576	$25.00	39,400.00
Gabion Basket Drop Structures	C.Y.	2 @ 155	$65.00	20,150.00
			Construction Cost	$ 77,275.00
			15% Contingencies	11,591.00
			Total Construction Cost	$ 88,866.00
Upstream From Divided Flow on Wittmann Wash				
Excavation	C.Y.	18,583	$2.50	$ 46,458.00
Riprap Bank Protection	C.Y.	823	$25.00	20,575.00
Gabion Basket Drop Structures	C.Y.	2 @ 406	$65.00	26,390.00
			Construction Cost	$ 93,423.00
			15% Contingencies	14,013.00
			Total Construction Cost	$ 107,436.00
4 Barrel - 8' x 5' Box Culverts - Northern Crossing on Center Street				
4 Barrel - 8' x 5' Box Culvert	Ea.	1	$40,250.00	$ 40,250.00
			Construction Cost	$ 40,250.00
			15% Contingencies	6,038.00
			Total Construction Cost	$ 46,288.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
6 Barrel - 6' x 5' Box Culvert - Southern Crossing on Center Street				
6 Barrel - 6' x 5' Box Culvert	Ea.	1	$43,100.00	$ 43,100.00
			Construction Cost	$ 43,100.00
			15% Contingencies	6,465.00
			Total Construction Cost	$ 49,565.00
			Total Cost	$ 412,164.00

SOLUTION 4.1 - Channelization to Capture Flows North of Nadaburg School

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
Excavation	C.Y.	6,389	$2.50	$ 15,972.00
Drop Structures (Gabion Baskets)	C.Y.	4 @ 40 = 160	$65.00	10,400.00
			Construction Cost	$ 26,372.00
			15% Contingencies	3,956.00
			Total Construction Cost	$ 39,328.00
Right-of-way	S.F.	138,000	$.25	34,500.00
			Total Cost	$ 64,828.00

SOLUTION 4.2 - Dike Directing Flows Away From Nadaburg School

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
Excavation and Compaction of Dike	C.Y.	3,585	$2.50	$ 8,963.00
			Construction Cost	$ 8,963.00
			15% Contingencies	1,344.00
			Total Construction Cost	$ 10,307.00
Right-of-way	S.F.	59,400	$.25	14,850.00
			Total Cost	$ 25,157.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 5.1 - Extension of Existing Dike on Wittmann Wash Directing Flow to Bridge Crossings				
Excavation and Compaction of Dike	C.Y.	125	$10.00	$ 1,250.00
			Construction Cost	$ 1,250.00
			15% Contingencies	188.00
			Total Construction Cost	$ 1,438.00
Possible Right-of-way	S.F.	3,360	$.25	840.00
			Total Cost	$ 2,278.00

SOLUTION 6.1 - Box Culvert at Circle City Entrance Road

Circle City Entrance Road Culverts

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
2 - 10' x 3' B.C.'s	L.F.	60	$500.00	$ 30,000.00
Sawcut and Remove Pavement	L.F.	40	$5.00	200.00
Excavation and Backfill	C.Y.	167	$5.00	835.00
New Asphalt	S.Y.	37	$10.00	370.00
			Construction Cost	$ 31,405.00
			15% Contingencies	4,710.00
			Total Construction Cost	$ 36,115.00

SOLUTION 7.1 - Widen Iona Wash Overchute

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
Excavation and Compaction	C.Y.	17,546	$2.50	$ 43,865.00
Overchute Widening	S.F.	57.5'x180'=10,350	$50.00	517,500.00
			Construction Cost	$ 561,365.00
			15% Contingencies	84,205.00
			Total Cost	$ 645,570.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 8.1 - 10-year Design for CAP1WEST Wash Crossings				
Patton Road				
15 - 10' x 4' B.C.'s	L.F.	15x50' = 750	$260.00	$ 195,000.00
		Construction Cost		$ 195,000.00
		15% Contingencies		29,250.00
		Cost		$ 224,250.00
193rd Avenue				
6 - 10' x 6' B.C.'s	L.F.	6x50' = 300	$280.00	$ 84,000.00
		Construction Cost		$ 84,000.00
		15% Contingencies		12,600.00
		Cost		$ 96,600.00
Jomax Road				
8 - 10' x 5' B.C.'s	L.F.	8x50' = 400	$280.00	$ 112,000.00
		Construction Cost		$ 112,000.00
		15% Contingencies		16,800.00
		Cost		$ 128,800.00
Happy Valley Road				
17 - 10' x 3' B.C.'s	L.F.	17x50' = 850	$260.00	$ 221,000.00
		Construction Cost		$ 221,000.00
		15% Contingencies		33,150.00
		Cost		$ 254,150.00
		Total Cost		$ 703,800.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST

SOLUTION 8.2 - 50-Year Design for CAP1WEST Wash Crossings

Patton Road

25 - 10' x 4' B.C.'s	L.F.	25x50' = 1,250	$260.00	$ 325,000.00
		Construction Cost		$ 325,000.00
		15% Contingencies		48,750.00
		Cost		$ 373,750.00

193rd Avenue

9 - 10' x 8' B.C.'s	L.F.	9x50' = 450	$295.00	$ 132,750.00
		Construction Cost		$ 132,750.00
		15% Contingencies		19,912.00
		Cost		$ 152,662.00

Jomax Road

11 - 10' x 7' B.C.'s	L.F.	11x50' = 550	$290.00	$ 159,500.00
		Construction Cost		$ 159,500.00
		15% Contingencies		23,925.00
		Cost		$ 183,425.00

Happy Valley Road

21 - 10' x 4' B.C.'s	L.F.	21x50' = 1,050	$260.00	$ 273,000.00
		Construction Cost		$ 273,000.00
		15% Contingencies		40,950.00
		Cost		$ 313,950.00
		Total Cost		$1,023,787.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 8.3 - Extend Training Dike Upstream From Deer Valley Road				
Excavation and Compaction	C.Y.	16,750	$2.50	$ 41,875.00
		Construction Cost		$ 41,875.00
		15% Contingencies		6,281.00
		Total Construction Cost		$ 48,156.00
Possible Right-of-way	S.F.	207,700	$.25	51,925.00
		Total Cost		$ 100,081.00
SOLUTION 9.1 - Channelization Below CAP2WEST Overchute to Bridge at Deer Valley Road				
Excavation	C.Y.	1,329,055	$1.25	$1,661,319.00
		Construction Cost		$1,661,319.00
		15% Contingencies		249,198.00
		Total Construction Cost		$1,910,517.00
Possible Right-of-way	S.F.	13,662,000	$.25	3,415,500.00
		Total Cost		$5,326,017.00
SOLUTION 10.1 - Reconstruct Existing Dike				
Excavation and Compaction	C.Y.	9,809	$2.50	$ 24,523.00
Riprap Bank Protection	C.Y.	800	$25.00	20,000.00
		Construction Cost		$ 44,523.00
		15% Contingencies		6,678.00
		Total Construction Cost		$ 51,201.00
Possible Right-of-way For Dike and Channel	S.F.	1,200,000	$.25	300,000.00
		Total Cost		$ 351,201.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST

SOLUTION 10.2 - Construct Dike Along Existing Dike Alignment

Excavation	C.Y.	159,845	$2.50	$ 399,613.00
Drop Structures	C.Y.	1,447	$65.00	94,055.00
Riprap Bank Protection	C.Y.	800	$25.00	20,000.00
			Construction Cost	$ 513,668.00
			15% Contingencies	77,050.00
			Total Construction Cost	$ 590,718.00
Channel Right-of-way	S.F.	1,137,500	$.25	284,375.00
			Total Cost	$ 875,093.00

SOLUTION 11.1 - Remove Existing Dike Directing Flows to Lake Bonita

Excavation	C.Y.	27,391	$2.50	$ 68,477.00
			Construction Cost	$ 68,477.00
			15% Contingencies	10,271.00
			Total Cost	$ 78,749.00

SOLUTION 12.1 - Rebuild Training Dike That Directs Flows to Paddelford Wash Crossing Over Beardsley Canal

Excavation and Compaction	C.Y.	14,074	$2.50	$ 35,185.00
Clearing and Grubbing	Ac.	4	$2,000.00	8,000.00
			Construction Cost	$ 43,185.00
			15% Contingencies	6,478.00
			Total Construction Cost	$ 49,663.00
Possible Right-of-way if needed	S.F.	320,000	$.25	80,000.00
			Total Cost	$ 129,663.00

DESCRIPTION	UNIT	QUANTITY	UNIT COST	COST
SOLUTION 13.1 - Raise Beardsley Canal Bank, Clear Vegetation, and Replace Culverts				
Excavation and Compaction	C.Y.	87,000	$2.50	$ 217,500.00
Clear Vegetation	Ac.	40	$1,500.00	60,000.00
Replace 4 - 42" RCP	L.F.	4 @ 50 ft=200	$83.00	16,600.00
			Construction Cost	$ 294,100.00
			15% Contingencies	44,115.00
			Total Cost	$ 338,215.00
SOLUTION 14.1 - Increase Capacity of McMicken Dam Outlet Channel				
Excavation	C.Y.	175,260	$1.50	$ 262,890.00
Grand Avenue Bridge Widening	S.F.	60x75 = 4,500	$50.00	225,000.00
AT&SF Railroad Bridge Widening	S.F.	30x75 = 2,250	$40.00	90,000.00
			Construction Cost	$ 577,890.00
			30% Appurtenance & Contingencies (Possible Conflicts)	173,367.00
			Total Cost	$ 751,257.00